NECTA Manual
Version 1.0 TZ

NECTA Resource Manual

Tanzania

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Questions or Comments?

Thank you for using the *Shika na Mikono* manual! If you have any questions, comments, or would like to request a copy of this manual, please use the contact information given below.

Shika na Mikono Primary Contact (shika.mikono.tz@gmail.com)

You may also contact any of the current members of the Shika na Mikono team directly using the following contact information.

Ed. 2017
Kyle Golden (kylegldn@gmail.com)
Kayla Huffman (kaylarhuffman@gmail.com)
Iain Laufer (iainlaufer360@gmail.com)
Mara McKown (marasmckown@gmail.com)
Brandi Rajala (brajala@mtu.edu)
Emily Slater (eslater6@gatech.edu)

Ed. 2016
Kalvin Croto (kmcroto@gmail.com)
Marguerite Daw (margueritedaw@gmail.com)
Katharine Kobylt (kat.kobylt@gmail.com)
Jonathan McClure (jonathanmcclure37@gmail.com)
Cailin McLaughlin (cailin_mac@yahoo.com)
Paige Van de Vuurst (paigevandevurrst29@gmail.com)

To download a digital version of this manual, please visit the digital download page at the following address: http://pctanzania.org/shika

Feedback and requests for revisions to the content of any of the manuals can be made using the primary contact information above, or by visiting the Shikamikonotz Project Page at GitHub: https://github.com/shikamikonotz/

About This Book

Since its original release in 2009, the Shika na Mikono manual has served as a teaching resource and guide to incorporating interactive learning methods into Tanzanian laboratories and classrooms using locally available materials.

Now that the Shika na Mikono mission has been around for nearly a decade, the team has paired up with the Education Advisory Committee and is moving its focus towards providing all the materials necessary to help students succeed both in and out of the classroom. Though previous manuals have offered some support for the NECTA, Shika na Mikono felt that there needed to be a concrete resource for all things NECTA, to help familiarize students as early as possible with questions, vocabulary, and practicals.

Information regarding actual exam questions from previous NECTA exams, percentage breakdown for each unit corresponding to prevalence on previous NECTAs, as well as how to approach the laboratory practicals is the focus of this Shika na Mikono NECTA resource manual. Further information on laboratory practicals can be found in the respective Shika na Mikono subject manual (e.g. Biology Manual, Chemistry Manual, or Physics Manual).

Much of the newly added content to the NECTA resources manual was collected by previous generations of Shika na Mikono and resided on the Shika na Mikono Google drive. These questions were either collected from previous NECTA exams or NECTA reference books.

This manual is the first of its kind, and is designed to take as much information as possible that exists on the Shika na Mikono Google drive and condense it to be more accessible to as many volunteers as possible. This manual will continue to be refined to reflect the changes of the NECTA exams as newer exams become available.

Continued development of the Shika na Mikono resources is made possible by a dedicated team of individuals made up of Peace Corps Volunteers and Tanzanian teachers and facilitators. This collaboration among volunteers and Tanzanian nationals is what makes the continued success and relevance of all of the Shika na Mikono teaching resources possible.

Kyle Golden
Iringa

Mara McKown
Iringa

Kayla Huffman
Mbeya

Brandi Rajala
Iringa

Iain Laufer
Mbeya

Emily Slater
Iringa

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Part I

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Biology

2.1 NECTA Biology Exam Format

2.1.1 Form II

The following format for the Form Two National Assessment (FTNA) is based on the revised version of the Biology Syllabus for Ordinary Secondary Education of 2005. The exam is intended to assess the competences acquired by the students after two years of study. The following information was taken from The National Examinations Council of Tanzania - Form Two National Assessment Formats

General Objectives

The general objectives of the Biology assessment are to test students' ability to:

1. Evaluate the role, influence and importance of biological science in everyday life
2. Demonstrate the capacity to improve and maintain their health, families and the community
3. Apply scientific skills and procedures in interpreting various biological data
4. Apply basic biological knowledge and appropriate skills in combating problems related to environment, health disorders and diseases such as HIV/AIDS, STIs, etc.
5. Demonstrate necessary biological practical skills

General Competences

The FTNA will specifically test the students' ability to:

1. Apply scientific procedures and practical skills in studying Biology
2. Demonstrate the appropriate use of biological knowledge, concepts, principles and skills in everyday life
3. Demonstrate preventive measures and precautions against common accidents and other related health problems
4. Apply biological knowledge in combating health related problems such as HIV/AIDS, STIs, malaria, cholera and other communicable diseases
5. Apply biological knowledge, skills and scientific principles to improve and maintain their own health, the health of the families and the community
6. Demonstrate biological skills in writing scientific procedures, observations and report writing
7. Analyze groups of organisms according to their similarities and differences
8. Preserve nature and ensure sustained interaction of organisms in the natural environment
9. Evaluate roles of various physiological processes, construct diagrams of biological structures and systems and indicate their functions in plants and animals

Assessment Rubric

The assessment consists of **one (1)** theory paper. The duration of the exam is **2 hours and 30 minutes**. The paper consists of **eleven (11)** questions categorized into sections A, B, and C. The students are required to attempt **all** questions from sections A and B and **one** question from section C.

1. **Section A**
   This section has **four (3)** objective questions. This section weighs a total of **thirty (30)** marks.
   (a) Question 1 is composed of 10 multiple choice items derived from various topics (10 marks)
   (b) Question 2 is composed of 10 true and false questions derived from various topics (10 marks)
   (c) Question 3 is composed of 5 matching items derived from one of the topics (5 marks)

(d) Question 4 is composed of 5 filling in the blanks derived from one of the topics (5 marks)

2. **Section B**
   This section has **five (5)** short answer questions (10 marks each). This section weighs a total of **fifty (50)** marks.

3. **Section C**
   This section has **two (2)** essay questions (20 marks each). This section weighs a total of **twenty (20)** marks.

2.1.2 Form IV

The following format for the Form Four Certificate of Secondary Education (CSEE) is based on the revised version of the Biology Syllabus for Ordinary Secondary Education of 2005. The exam is intended to assess the competences acquired by the students after four years of study. The following information was taken from The National Examinations Council of Tanzania - Certificate of Secondary Education Examination Formats

General Objectives

The general objectives of the Biology examination are to test students' ability to:

1. Evaluate the role, influence and importance of biological science in everyday life
2. Develop the capacity to improve and maintain their own health, of families and the community
3. Develop mastery of fundamental concepts, principles, and skills of biological science and related fields, such as agriculture, medicine, pharmacy and veterinary
4. Develop necessary biological practical skills
5. Ability to demonstrate scientific skills and procedures in interpreting various biological data
6. Acquire basic knowledge and apply appropriate skills in combating problems related to HIV/AIDS/STIs, gender, population, environment, drug/substance abuse, sexual and reproductive health
7. Develop the ability and desire for self-study, self-confidence and self-advancement in biological sciences and related fields

General Competences

The CSEE will specifically test the students' ability to:

1. Make appropriate use of biological knowledge, concepts, skills and principles in solving various problems in daily life
2. Record, analyze and interpret data from scientific investigations, using appropriate methods and technology to generate relevant information in biological science
3. Demonstrate knowledge and skills in combating health related problems such as HIV/AIDS, drugs and drug abuse, sexual and reproductive health
4. Access relevant information on biological science and related fields for self-study and life-long learning

Examination Rubric

The examination consists of **two (2)** papers. The first paper focuses on theory while the second focuses on practicals. This section will discuss the format for the Biology theory paper. To see the format of the Biology practical paper, please refer to Section 6.1.

The duration of the exam is **3 hours**. The paper consists of **thirteen (13)** questions categorized into sections A, B, and C. The students are required to attempt **all** questions from sections A and B and **one** question from section C.

1. **Section A**
   This section has **two (2)** objective questions (10 marks each). This section weighs a total of **twenty (20)** marks.

2. **Section B**
   This section has **eight (8)** structured short answer questions. Each question will be divided into two parts. This section weighs a total of **sixty (60)** marks. Mark allocation will be indicated at the end of each question.

3. **Section C**
   This section has **three (3)** long answer/essay questions (20 marks each). The answer for this question will have to be comprehensive and include as many points as possible. This section weighs a total of **twenty (20)** marks.

2.2 Form I Topics

2.2.1 Introduction to Biology

1. Why schools should have a Biology laboratory? Give a reason.
2. State six laboratory rules
3. The aim of experiment in the scientific investigation is to
   (A) Identify the problem
   (B) Test the hypothesis
   (C) Confirm the problem
   (D) Predict the results
   (E) Collect data

2.2.2 Safety in our Environment

1. Which of the following is NOT a component of First Aid Kit?
   (A) Razor blade
   (B) Panadol
   (C) Bandage
   (D) Soap
   (E) Microscope
2. State two principles of waste disposal
3. Suggest three proper ways of waste disposal in the community

2.2.3 Health and Immunity

1. Goitre is a deficiency disease caused by lack of which element in the diet?
   (A) Carbohydrate
   (B) Iodine
   (C) Vitamin E
   (D) Vitamin C
   (E) Protein
2. Which disease spread rapidly as a result of poor waste disposal?
   (A) Anemia
   (B) AIDS
   (C) Cholera
   (D) Leukemia
   (E) Small pox

3. Which of the following is NOT a component of blood?
   (A) Erythrocyte
   (B) Platelets
   (C) Leucocyte
   (D) Plasma
   (E) Vein
4. Write a descriptive report which you can use to educate the community about the mode of transmission, symptoms and prevention measures of malaria in Tanzania.
5. Match the phrases in **List A** with the responses in **List B** by writing the letter of the correct response from **List B** beside the item number of **List A** in your answer booklet provided.

List A		List B	
(i)	A disease caused by flatworms known as schistosome	A	Malaria
(ii)	A disease caused by a protozoan called *trypanosoma*	B	Syphilis
(iii)	A tropical disease caused by *plasmodiun*	C	Bilhazia
(iv)	A waterborne disease caused by *entamoeba histoystica*	D	AIDS
		E	Dysentery
(v)	An outbreak disease caused by *vibrio cholerae*	F	Gonorrhoea
(vi)	A sexually transmitted disease caused by bacteria known as *treponema palladium*	G	Typhoid
		H	Measles
(vii)	A communicable disease caused by *salmonella typhii*	I	Tuberculosis
(viii)	A sexually transmitted disease caused by bacteria known as *Neisseria gonorrhoea*	J	Cholera
		K	Trypanosomiasis
(ix)	A viral infection disease caused by HIV	L	Tetanus
(x)	A disease caused by *micobacterium tuberculosis*	M	Leprosy
		N	Polimyelitis
		O	Rabie

2.2.4 Cell Structure and Organization

1. The outer most living structure that identifies a plant cell is the presence of
   (A) Cytoplasm
   (B) Vacuole
   (C) Cell wall
   (D) Nuclear membrane
   (E) Cell membrane

2.2.5 Classification of Living Things

1. With the aid of a well labeled diagram, describe the structure of bacteria and give three advantages and disadvantages of bacteria in daily life

2.3 Form II Topics

2.3.1 Classification of Living Things

1. One of the most distinctive features used to place organisms in the Kingdom Fungi is the presence of
   (A) Gill structures
   (B) Hyphae
   (C) Cellulose
   (D) Cap
   (E) Exoskeleton

2.3.2 Nutrition

1. Describe the types of macronutrients needed in human body. In each type identify the source and function of food substances in human body
2. Which food substance can be tested by using iodine solution?
   (A) Protein
   (B) Starch
   (C) Carbohydrate
   (D) Non reducing sugar
   (E) Reducing sugar

2.3.3 Balance of Nature

1. With examples, state the meaning of ?abiotic“ and ?biotic“ factors of the environment
2. i) Differentiate the terms ?food chain“ from a ?tropic level“
   ii) Construct a food chain by using organisms named in the following list: Grass, Bacteria, Lions and Zebra.
3. With example, briefly explain how the following interactions of living organisms take place
   i) Predation
   ii) Parasitism

2.3.4 Transportation of Materials in Living Things

1. A term which best describes a condition of a plant cell that has lost too much water is
   (A) Haemolysis
   (B) Turgidity
   (C) Creanation
   (D) Plasmolysis
   (E) Osmosis
2. (a) Explain the functions of the vascular system in plants
   (b) State three importance of transportation of materials in living things

2.3.5 Gaseous Exchange and Respiration

1. The product of anaerobic respiration process in animals is
   (A) Lactic acid
   (B) Carbon dioxide
   (C) Alcohol
   (D) Water
   (E) Oxygen
2. Explain how gaseous exchange occurs across the alveolus
3. The main product of anaerobic respiration process in plants is
   (A) Uric acid
   (B) Lactic acid
   (C) Alcohol
   (D) Water

(E) Oxygen

4. List the organs responsible for gaseous exchange in the following organisms
   i) Goat
   ii) Grasshopper
   iii) Frog
   iv) Tilapia

2.4 Form III Topics

2.4.1 Classification of Living Things

1. A rapid growth in plants is mainly taking place in
   (A) Leaves
   (B) Cambium
   (C) Roots
   (D) Shoots and root tips
   (E) Stem
2. Which of the following is a seed bearing plant?
   (A) Liverwort
   (B) Prothallus
   (C) Fern
   (D) Sisal
   (E) Moses
3. A part of an onion bulb which is important for vegetative propagation is
   (A) Scale leaves
   (B) Foliage leaves
   (C) Terminal buds
   (D) Roots
   (E) Stem
4. i) What are the raw materials for photosynthesis?
   ii) List two products of photosynthesis.
5. (a) Define the terms ?classification“ and ?Taxonomy“
   (b) i) List the types of classification systems
   ii) Give two differences between the classification systems you have listed in (b) i)

2.4.2 Movement

1. A voluntary muscle that is capable of relaxing continuously and do not fatigue easily is known as
   (A) Skeletal muscle
   (B) Biceps
   (C) Triceps
   (D) Cardiac muscle
   (E) Smooth muscle
2. Name three types of muscles found in mammals

3. Briefly explain how muscles are adapted to their role. Give three points.
4. Briefly explain the functions of the following components of the skeleton:
   i) Skull
   ii) Ribs
   iii) Vertebral column
   iv) Pelvic girdle

2.4.3 Coordination

2.4.4 Excretion

1. The kidney in animals is mainly responsible for
   (A) Excretion
   (B) Digestion
   (C) Transportation
   (D) Respiration
   (E) Absorption
2. Bowman's capsule is found in which of the following organs?
   (A) Liver
   (B) Pancreas
   (C) Kidney
   (D) Spleen
   (E) Heart

2.4.5 Regulation

1. Explain how mammals regulate their internal body temperature in response to external environmental changes
2. Which of the following processes is involved in the regulation of body temperature in human beings?
   (A) Urination
   (B) Painting
   (C) Deamination
   (D) Sweating
   (E) Detoxification
3. The role of the optimum temperature in cellular activities is to
   (A) Change the chemical reactions
   (B) Balance the equilibrium of the reactions
   (C) Destroy many enzymes at once
   (D) Speed up the rate of chemical reaction
   (E) Create favourable environment for enzymes
4. Rise of body temperature in the human body is corrected mainly by
   (A) Dilating the skin arteries and sweating
   (B) Constructing the skin arteries and shivering
   (C) Dilating the skin veins and sweating
   (D) Constricting the skin veins and shivering

(E) Dilating of arteries and shivering

5. (a) Define the term "osmoregulation"
   (b) Briefly explain the mechanisms of regulating sugar level in the blood

2.4.6 Reproduction

1. Which part of the flower receives pollen grain during pollination?
   (A) Petal
   (B) Stigma
   (C) Stamen
   (D) Style
   (E) Ovary
2. Explain the process of fertilization in flowering plants
3. Give the meaning of the following terms:
   i) Vegetative propagation
   ii) Gamete
4. Explain the merits and demerits of a sexual reproduction in plants
5. Briefly explain how you would identify an insect pollinated flower
6. With the aid of illustrations, discuss the stages of mitosis

2.5 Form IV Topics

2.5.1 Growth

1. Define the following terms:
   i) Meiosis
   ii) Mitosis
   iii) Growth
2. i) Explain the significance of mitosis in growth
   ii) State three factors affecting growth in humans
3. Match each item in List A with the correct response in List B

List A		List B	
(i)	A stage of growth in humans, characterised by rapid growth and a lot of physical and mental changes	A	Meiosis
		B	Metamorphisis
(ii)	A type of seed germination whereby cotyledons are pushed above the ground	C	Radicle
		D	Plumule
(iii)	The ability of seed to germinate	E	Hypogeal germination
(iv)	The region of most active growth in plants		
(v)	A type of seed germination whereby cotyledons remain beneath in the ground	F	Adulthood
		G	Dormancy
(vi)	A pore which allows water into a seed during germination	H	Epigeal germination
(vii)	Inability of a seed to germinate	I	Adolescent
(viii)	Prevents a viable seed from germinating	J	Cotyledon
(ix)	A stage of family formation and parenthood in growth and development	K	Mitosis
		L	Microphyle
(x)	A type of cell division whereby the number of chromosomes is maintained from parent cell to daughter cell	M	Hard seed coat
		N	Stem and root apices
		O	Viability

2.5.2 Genetics

1. Tongue rollers in genetics is an example of

   (A) Gametogenesis
   (B) Continuous variation
   (C) Swallowing
   (D) Lubricating food
   (E) Discontinuous variation

2. The offspring produced by mating the F1 generation is known as

   (A) F3 generation
   (B) F1 products
   (C) F2 generation
   (D) New generation
   (E) Genetic generation

3. Differentiate complete dominance from incomplete dominance

4. In a laboratory experiment, tall pea plants were crossed with dwarf pea plants. F1 plants were then selfed to produce F2 generation

   i) Using appropriate symbols, work out a genetic cross for F1 generation
   ii) Give the phenotypic and genotypic ratio of F1 generation

5. Match the phrases in **List A** with the responses in **List B** by writing the letter of the correct response from **List B** beside the item number of **List A** in your answer booklet provided.

List A		List B	
(i)	External appearance of a given characteristic as a result of influence by a gene	A	Mutation
(ii)	Genetic disorder characterised by failure of blood clotting	B	Sex linked character
(iii)	A sudden genetic change which can be inherited	C	Genotype
(iv)	Characteristics that can pass on from parent to offspring	D	Dominant gene
(v)	The possession of the characteristics which are different from those of the parents and other offspring	E	Variation
(vi)	A gene that influences characteristics over another gene when in heterozygous state	F	Albinism
(vii)	A cross between individuals with homozygous parents	G	Phenotype
(viii)	A unit of inheritance which determine a specific characteristic	H	Test cross
(ix)	Genetic makeup of a given gene which determines a given characteristic	I	Loci
(x)	A disorder resulting from lack of melanin pigments	J	Haemophilia
		K	Homozygous
		L	Backcross
		M	Recessive
		N	Gene
		O	Co-dominance

2.5.3 Classification of Living Things

1. A phylum consisting of species with jointed appendages and exoskeleton is known as

   (A) Chordata
   (B) Anelida
   (C) Arthropoda
   (D) Platyhelminthesis
   (E) Nematoda

2. Which of the following parasitic organisms is typically ectoparasite?
   (A) Tick
   (B) Tapeworm
   (C) Plasmodium
   (D) Round worm
   (E) Lichen

2.5.4 Evolution

1. Which of the following represent the organisms with homologous structures?
   (A) Wings of Birds and Butterfly
   (B) Forelimbs of Bird and Bat
   (C) Tail of Rat and Scorpion
   (D) Sting of Honey bee and Mosquito
   (E) Beak of Duck of Hen
2. What do you understand by the following terms:
   i) Evolution
   ii) Acquired characteristics

2.5.5 HIV/AIDs and Sexually Transmitted Infections (STIs)

1. Give the long meaning of the following abbreviation terms:
   i) HIV
   ii) STIs
   iii) Tds
2. Briefly explain any two ways through which HIV is transmitted from one person to another

Chemistry

3.1 NECTA Chemistry Exam Format

3.1.1 Form II

The following format for the Form Two National Assessment (FTNA) is based on the revised version of the Chemistry Syllabus for Ordinary Secondary Education of 2010. The exam is intended to assess the competences acquired by the students after two years of study. The following information was taken from The National Examinations Council of Tanzania - Form Two National Assessment Formats.

General Objectives

The general objectives of the Chemistry assessment are to test students' ability to:

1. Apply Chemistry knowledge and skills to solve daily life problems
2. Understand nature and properties of matter
3. Apply Chemistry knowledge and skills in proper use and management of the environment
4. Apply Chemistry knowledge and skills in performing various activities in the laboratory

General Competences

The FTNA will specifically test the students' ability to:

1. Demonstrating Chemistry knowledge and skills in solving daily life problems
2. Identifying various Chemistry apparatus and its uses
3. Applying basic principles of scientific procedure
4. Using fuels efficiently, treating and purifying water with environment consideration
5. Explaining regulation and rules guiding proper use of laboratory
6. Explaining various concepts related to nature and matter

Assessment Rubric

The assessment consists of **one (1)** theory paper. The duration of the exam is **2 hours and 30 minutes**. The paper consists of **ten (10)** questions categorized into sections A and B. The students are required to attempt **all** questions from **all** sections.

1. **Section A**
   This section has **two (2)** objective questions. This section weighs a total of **twenty (20)** marks.
   (a) Question 1 is composed of 10 multiple choice items derived from various topics (10 marks)
   (b) Question 2 is composed of 10 matching or filling in the blank questions derived from various topics (10 marks)
2. **Section B**
   This section has **eight (8)** short answer questions (10 marks each) derived from various topics. This section weighs a total of **eighty (80)** marks.

3.1.2 Form IV

The following format for the Form Four Certificate of Secondary Education (CSEE) is based on the revised version of the Chemistry Syllabus for Ordinary Secondary Education of 2007. The exam is intended to assess the competences acquired by the students after four years of study. The following information was taken from The National Examinations Council of Tanzania - Certificate of Secondary Education Examination Formats.

General Objectives

The general objectives of the Chemistry examination are to test students' ability to:

1. Apply Chemistry knowledge, skills and principles in everyday life activities
2. Design and perform experiments
3. Understand symbols, formulae and equations to communicate in Chemistry
4. Apply the scientific principles and knowledge in exploitation of natural resources with conservation of the environment

General Competences

The CSEE will specifically test the students' ability to:

1. Ability to demonstrate Chemistry knowledge, skills and principles in solving daily life problems
2. Developing knowledge on Chemistry by doing various activities and/or experiments
3. Ability to demonstrate chemical symbols, formulae and equations to communicate in Chemistry
4. Using science and technological skills in conserving and making sustainable use of the environment

Examination Rubric

The examination consists of **two (2)** papers. The first paper focuses on theory while the second focuses on practicals. This section will discuss the format for the Chemistry theory paper. To see the format of the Chemistry practical paper, please refer to Section 7.1.

The duration of the theory exam is **3 hours**. The paper consists of **thirteen (13)** questions categorized into sections A and B. The students are required to attempt **all** questions from **all** sections.

1. **Section A**
   This section has **two (2)** objective questions. This section weighs a total of **twenty (20)** marks.
   (a) Question 1 is composed of 10 multiple choice items derived from various topics (10 marks)
   (b) Question 2 is composed of 10 matching questions derived from various topics (10 marks)
2. **Section B**
   This section has **nine (9)** short answer questions (6 marks each) derived from various topics. Each question will have **two (2)** items. This section weighs a total of **fifty-four (54)** marks.
3. **Section C**
   This section has **two (2)** essay questions without items derived from various topics. This section weighs a total of **twenty-six (26)** marks.

3.2 Form I Topics

3.2.1 Introduction to Chemistry

1. Define the term Chemistry
2. Which statement gives clear meaning of Chemistry?
   (A) The study of matter in relation to energy
   (B) The study of nature and properties of matter
   (C) The study of matter and arrangement of particles
   (D) The study of matter and chemical reactions

3.2.2 Lab Techniques and Safety

1. The apparati used for grinding granular chemicals is the laboratory include:
   (A) Crucible and watch glass
   (B) Mortar and pestle
   (C) Pestle and pair of tongs
   (D) Spatula and basin
2. The part of the Bunsen burner that controls the amount of air coming in is called:
   (A) Air hole
   (B) Barrel
   (C) Collar
   (D) Jet
3. Air entering the Bunsen burner barrel can be controlled by:
   (A) Metal ring
   (B) Air hole
   (C) Metal jet
   (D) Air ring
4. What do you understand of the following term: Bunsen Burner
5. What do you understand of the following term: Laboratory
6. Define the following term: First Aid
7. List two components of a first aid kit
8. Give the use of each of the following components which are found in the First Aid kit: plaster, a pair of scissors, cotton wool, gloves
9. Draw and state one function of each of the following apparatuses: Burette, Filter funnel, Beaker

3.2.3 Heat Sources

1. List four properties of each of the following: A luminous flame, A non-luminous flame
2. A non-luminous flame is obtained if the air hole is:
   (A) Fully opened
   (B) Partially open
   (C) Closed
   (D) Half opened
3. Fill in the blanks: A flame is a zone burning gas that produces _____ and _____.
4. Why a flame produced by a "spirit lamp" may not be good for heating in the laboratory? Give two reasons.
5. Name the type of flame produced by a spirit lamp.
6. Technicians prefer to use blue flame in welding because:
   (A) It is bright and non-sooty
   (B) It is light and non-sooty
   (C) It is very hot and large
   (D) It is very hot and non-sooty
   (E) It is not expensive

3.2.4 The Scientific Procedure

1. The second step in the scientific procedure is:

   (A) Data collection and alaysis

   (B) Datainterpretation

   (C) Experimentation and observation

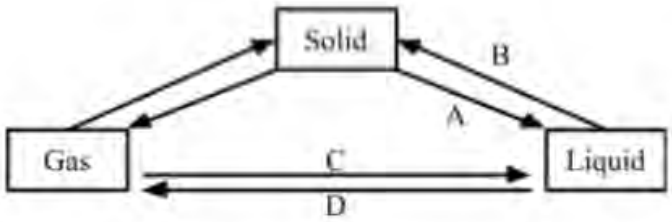
   (D) Hypothesis formulation

3.2.5 Matter

1. Categorize the following changes as either chemical or physical: Freezing of juice in a bottle, Rusting of iron, Burning of wood, Drying of wet clothes

2. Give three difference between the following: Compound and mixture, Suspension and solution

3. The figure below shows the relationship among three states of matter. Name the processes involved in A, B, C, and D.



4. Match each item in List A with the correct response in List B

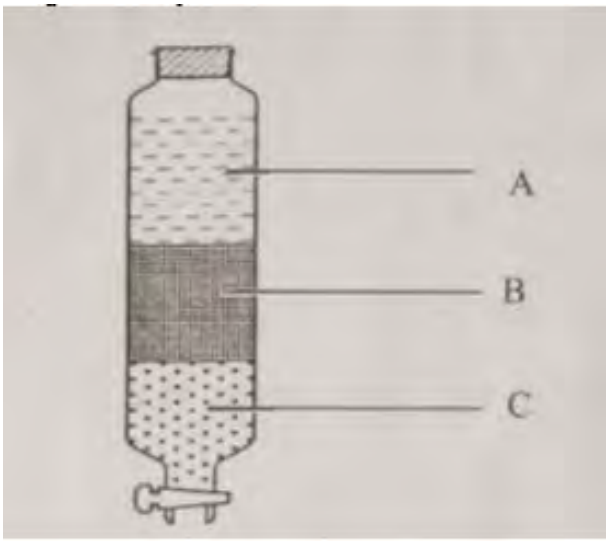
List A		List B	
I)	A process of separating a mixture of sodium chloride and ammonium chloride	A	Evaporation
		B	Filtration
II)	A method used to separate oil and water	C	Boiling
III)	A method by which coloured substances are separated and identified	D	Chrmoatography
		E	Distillation
IV)	A method by which salt and water can be separated	F	Layer separation
V)	A method used to get the solvent from the solution mixture	G	Decantation
		H	Sublimation

5. Define matter

6. Tell whether the following is a chemical change or physical change: Rotting of mango; Clouds changing into rain; Decaying of teeth

7. State four difference between a chemical change and physical change

8. The following figure shows the apparatus that can be used to separate three liquids: cooking oil, kerosene and water with density 0.92 g/cm^3, 0.65 g/cm^3, and 1.00 g/cm^3 respectively.



Name the apparatus shown by the given figure. Giving a reason, identify liquids A and C.

9. Which method could be used to separate the products in the following equation?

$$\underset{\textbf{colourless}}{Pb(NO_3)_{2(aq)}} + \underset{\textbf{colourless}}{2KI_{(aq)}} \rightarrow \underset{\textbf{yellow}}{PbI_{2(S)}} + \underset{\textbf{colourless}}{2KNO_{3(aq)}}$$

   (A) Chromatography
   (B) Crystallization
   (C) Distillation
   (D) Filtration
   (E) Condensation

10. Briefly explain why the mixture with equal boiling point cannot be separated by simple fractional distillation

11. Hygroscopic and deliquescent substances can be used as:
   (A) Oxidizing agents
   (B) Drying agents
   (C) Reducing agents
   (D) Weak electrolytes
   (E) Catalyst

12. Water can be obtained from a solution of common salt by:
   (A) Evaporation
   (B) Simple distillation
   (C) Filtration
   (D) Condensation
   (E) Fractional distillation

13. Suggest one best method for separating each of the following mixtures:
   i) Common salt and water
   ii) Iodine and sand
   iii) Pieces of iron and sand

3.2.6 Air Combustion, Rusting and Fire Fighting

1. The substances that can be used to extinguish fire are:
   (A) Carbon dioxide and sand
   (B) Carbon dioxide and sugar
   (C) Nitrogen and sand
   (D) Nitrogen and water
2. Flammable chemicals are those which:
   (A) Burn skin
   (B) Catch fire easily
   (C) Explode
   (D) Extinguish fire
3. What do you understand by the following term: Flame
4. The appropriate extinguisher used to put off fire caused by cooking oil is:
   (A) Water extinguisher
   (B) Carbon extinguisher
   (C) Wet chemical extinguisher
   (D) Dry air extinguisher
5. Fill in the blanks: Three components of the fire triangle are heat, fuel and _____.
6. By using locally available materials in your school, state how the fire can be extinguished in the following situations: Kerosene spilled on the floor catches fire; Friend's clothes catch fire which gets out of her control
7. Suggest the suitable method of preventing rust in the following: Moving parts of machines e.g. motorcycle chain; Motor vehicle (car) bodies
8. Which gas is the least abundant gas in the air?
   (A) Nitrogen
   (B) Oxygen
   (C) Neon
   (D) Carbon dioxide
9. Which type of a fire is associated with electrical equipment?
   (A) Class E
   (B) Class C
   (C) Class F
   (D) Class B
   (E) Class A
10. Which of the following is NOT among the composition of air?
    (A) Noble gases
    (B) Carbon dioxide
    (C)
    (D) Hydrogen
    (E) Water vapor
11. i) State two conditions required for iron to rust
    ii) List two methods which are used to prevent rusting of iron

3.3 Form II Topics

3.3.1 Oxygen

1. Write a word equation for each of the following reaction: Calcium burns in oxygen
2. Mention four chemical properties of Oxygen
3. Write the names and formulae of the two chemicals that can be used in the preparation of oxygen gas
4. State an appropriate method of collecting oxygen gas based on solubility and density of the gas in water
5. How can oxygen gas be tested?
6. List four uses of oxygen gas
7. Give the names or formula of the two chemicals that would be used in the laboratory to make each of the following gas. State a simple test that could be used to identify the gas.

    i) Oxygen

3.3.2 Hydrogen

1. Fill in the blank: A substance that speeds up a chemical reaction but remains chemically unchanged is called _____.
2. Hydrogen gas is prepared in the laboratory by reacting dilute hydrochloric acid and zinc granules
    a. Write an alternative acid that can be used to prepare hydrogen instead of dilute hydrochloric acid
    b. Give two physical and two chemical properties of hydrogen
3. What will happen if a burning wooden splint is lowered in a test tube containing hydrogen gas?
4. Give two uses of hydrogen gas in daily life
5. Give the names or formula of the two chemicals that would be used in the laboratory to make each of the following gas. State a simple test that could be used to identify the gas.

    i) Hydrogen

3.3.3 Water

1. When sugar is dissolved in water, a uniform mixture is formed. The resulting mixture is called a:
    (A) Solute
    (B) Solution
    (C) Solvent
    (D) Suspension
2. Write a word equation for each of the following reactions: Sodium reacts with water
3. What do you understand by the following terms: Water treatment; Water purification
4. Mention six uses of water in economic activities
5. How many atoms are their in a water molecule?
6. State three main physical properties of water and show the usefulness of each property

3.3.4 Fuels and Energy

1. Which of the following can be classified as a renewable source of energy?
   (A) Biomass
   (B) Coal
   (C) Coke
   (D) Petroleum

2. The process which produces energy in form of heat and light is called:
   (A) Decomposition
   (B) Combustion
   (C) Distillation
   (D) Sublimation

3. Fill in the blank: A type of gas fuel derived from decomposing biological waste is called _____.

4. Give three examples in each of the following:
   i) Solid fuel
   ii) Gaseous fuel

3.3.5 Atomic Structure

1. Define the following term: Element

2. The mass number of an atom is determined by:
   (A) Protons and neutrons
   (B) Protons and electrons
   (C) Neutrons and electrons
   (D) Protons alone

3. Fill in the blank: The arrangement of electrons in different shells in the atom is called _____.

4. An atom M has an atomic number 14 and mass number 28.
   i) What is the number of protons and neutrons?
   ii) Write the electronic configuration of atom M

5. The mass number of a carbon atom that contains six protons, eight neutrons, and six electrons is:
   (A) 6
   (B) 14
   (C) 8
   (D) 12
   (E) 20

6. Protons, neutrons and electrons particles are located in the atoms; fill in the missing information in below table about these particles.

Particles	**Relative Mass**	**Relative Charge**	**Location**
Proton			
Electron	$\frac{1}{1840}$		
Neutron		0	In the nucleus

3.3.6 Periodic Classification

1. An element X with atomic number 16 belongs to:
   (A) period 3, group III, valency of 2
   (B) period 3, group VI, valency of 2
   (C) period 3, group VI, valency of 6
   (D) period 6, group VI, valency of 6

2. Which of the following electron configurations are of metals?
   (A) 2:8:1 and 2:5
   (B) 2:8:2 and 2:6
   (C) 2:8:3 and 2:8:8:1
   (D) 2:8:6 and 2:8:8:7

3. Which of the following is a metal?
   (A) Water
   (B) Chlorine
   (C) Sodium
   (D) Nitrogen

4. Which neutral atom has the same number of electrons as Mg^{2+}?
   (A) Magnesium
   (B) Sodium
   (C) Neon
   (D) Argon

5. Which of the following is the electronic configuration of an element Y found in period 3 and group II of the periodic table?
   (A) 2:8
   (B) 2:8:2
   (C) 2:6
   (D) 2:8:8:2
   (E) 2:8:4

6. Use the knowledge of the periodic table to complete the table below.

List A		List B	
(i)	Its hydroxide is used in soil treatment	A	Barium
(ii)	It is obtained from its ore in the blast furnace	B	Lithium
(iii)	It gives a lilac colour when placed in a non-luminous flame	C	Iron
(iv)	It forms an insoluble sulphate	D	Potassium
(v)	It is in the same group in the periodic table with nitrogen	E	Oxygen
(vi)	It reacts with hydrogen to form a compound which is a liquid at room temperature	F	Fluorine
		G	Sulphur
(vii)	It is used in filament lamps	H	Argon
(viii)	It is the strongest oxidizing agent among the halogens	I	Phosphorus
(ix)	It exists in three main forms	J	Sodium
(x)	Its chloride is added to food in order to give taste	K	Magnesium
		L	Carbon
		M	Neon
		N	Silicon
		O	Calcium

3.3.7 Formula Bonding and Nomenclature

1. The simplest formulas of a compound formed when combining 13g of aluminium and 17g of chlorine is
   (A) AlCl
   (B) Al_2Cl
   (C) Al_3Cl_2
   (D) $AlCl_3$

2. A certain compound K contains 15.8% carbon and 84.2% sulphur. The molar mass of K is 76 g/mol. Determine its:
   i) simplest formula
   ii) molecular formula

3. Write the chemical formula for each of the following compounds:
   i) Sodium carbonate
   ii) Calcium nitrate
   iii) Ammonium chloride

4. State the valency of the following atoms: Aluminium, Neon, Sulphur, Potassium

5. Give the chemical formula for the combination of the following sets of ions: Mg^{2+}, PO_4^{3+}; Fe^{3+}, SO_4^{2-}

6. Find the oxidation number of each of the underlined elements in the following: $K\underline{Cl}O_3$; $\underline{Cr_2}O_7^{2-}$

7. Use the IUPAC system to name each of the following chemical compounds: CuO, $CaSO_4$, HNO_3, $ZnCl_2$

8. Ability of an atom to gain or attract electrons towards itself _____

9. Write the names of the following radicals: SO_3^{2-}; ClO_3^-; PO_4^{3-}

10. Calculate the oxidation state of the underlined element in the following compounds: $NH_4\underline{Cl}$; $Al_2\underline{O_3}$; $Na_2\underline{S}O_4$; $\underline{Ca}(NO_3)_2$

11. The following table shows the name and the chemical formula of the product formed when ions combine together. Complete filling the table.

Ion	Ion	Name	Formula
Ca^{2+}	Cl^-	Calcium chloride	
Al^{3+}	SO_4^{2-}		$Al_2(SO_4)_3$
H^+		Hydrogen sulphate	

12. Chlorine ion, Cl^- differs from chlorine atom because it has:
   (A) More protons
   (B) Less protons
   (C) More electrons
   (D) Less electrons
   (E) More neutrons

13. i) What type of a chemical bond is found between fluorine atoms in a fluorine molecule?
   ii) Name other type(s) of chemical bond formed by fluorine with other elements. Give an example of a compound in which fluorine form this type of bond.

3.4 Form III Topics

3.4.1 Chemical Equations

1. Calculate the volume of water which was produced when 1,120 cm^3 of oxygen at s.t.p. was liberated during the decomposition of hydrogen peroxide. The density of water = 1.0 g/cm^3.

3.4.2 Hardness of Water

1. With the aid of a chemical equation, briefly explain how
   i) temporary hardness of water can be removed by boiling
   ii) permanent hardness of water can be removed by chemical means
2. A student tested four samples of water, each 5 cm^3 from different areas of Kahama district by shaking with 3 drops of soap solution. The experiment was repeated by boiling each sample of water (5 cm^3) with 3 drops of soap solution. The observations were recorded in below table.

Sample	**Observation with Soap Solution**	**Observation for Boiled Sample with Soap Solution**
A	No lather	Lather
B	Lather	Lather
C	Lather	Lather
D	No lather	No lather

   i) Which samples contain hard water?
   ii) Which sample contains temporary hard water? Give a reason.

3.4.3 Acids, Bases and Salts

1. Using four examples, explain how the process of neutralization is important in day to day life.
2. A solution of pH 1.6 is best described as:
   (A) Weak acid
   (B) Strong base
   (C) Weak base
   (D) Strong acid
   (E) Neutral solution
3. Give three applications of the process of neutralization in daily life.

3.4.4 The Mole Concept and Related Calculations

1. A student attempted to prepare hydrogen gas by reacting zinc metal with dilute sulphuric acid. In this experiment zinc metal granules of about 0.5 cm diameter and 0.20 moles of acid were used. The rate of formation of hydrogen gas was found to be slow.
   i) Explain three ways in which the rate of formation of hydrogen gas could be increased.
   ii) If the student wanted 36 cm^3 of hydrogen gas at s.t.p., what amount of the acid would be required?
2. How many moles of oxygen are required for the complete combustion of 2.2 g of C_3H_8 to form carbon dioxide and water?
   (A) 0.050 moles
   (B) 0.15 moles
   (C) 0.25 moles
   (D) 0.50 moles

(E) 0.025 moles

3. Compound X contains 24.24% carbon, 4.04% hydrogen and 71.72% chlorine. Given that, the vapour density of X is 49.5.
   i) Calculate the molecular formula of the compound X
   ii) Draw and name the displayed/open structure formula of the possible isomer(s) from the molecular formula determined.

3.4.5 Volumetric Analysis

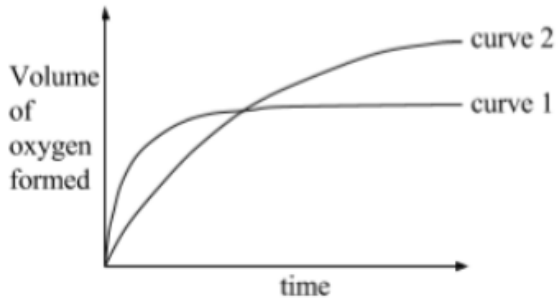
1. Suggest a suitable indicator for the following titrations:
   i) Hydrochloric acid against ammonia solution
   ii) Sulphuric acid against sodium hydroxide solution
   iii) Ethanoic acid against potassium hydroxide solution

3.4.6 Ionic Theory and Electrolysis

1. State three industrial applications of electrolysis
2. How long a current of 5A should be passed through a solution of silver chloride in order to deposit 3.24 g of silver metal at the cathode? Given that, the electrochemical equivalent of silver = 1.118×10^{-3} ge^{-1}.
3. A steady current of 2A was passed through a solution containing ions of a metal (X^{2+}) for nine minutes. The mass of metal X that was liberated were 0.3552 g. Calculate the molar mass of metal X.

3.4.7 Chemical Kinetics, Equilibrium and Energetics

1. Hydrogen peroxide breaks down slowly to form water and oxygen; the reaction can be speed up by using a catalyst.
   i) How does the catalyst speed up the rate of reaction?
   ii) Name a possible catalyst that can be used to speed up the reaction.
   iii) Show that the catalyst always remains unchanged at the end of the reaction.
2. Complete the following equations and determine the type of chemical reaction involved in each case.
   i) $Zn_{(S)} + H_2SO_{4(aq)} \rightarrow$
   ii) $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow$
   iii) $N_{2(g)} + H_{2(g)} \rightarrow$
3. In the graph below, curve 1 was obtained from the decomposition of 100 cm^3 of 1.0M hydrogen peroxide solution catalysed by manganese (IV) oxide, $2H_2O_2 \rightarrow 2H_2O + O_2$



Which alteration/change to the original experimental conditions would produce curve 2?

(A) Lowering the temperature

(B) Using less manganese (IV) oxide

(C) Increasing the temperature

(D) Adding some 0.1M H_2O_2

(E) Using a different catalyst

4. The reaction which produces methanol from carbon monoxide and hydrogen is represented by the equation $CO_{(g)} + 2H_{2(g)} \leftrightarrow CH_3OH_{(g)}$ ΔH = -94kJmol^{-1}. The reaction is carried out at high pressure to give a good yield of methanol

   i) Explain why increase in pressure gives a better yield of methanol

   ii) The value of ΔH is negative. What does this tell about the reaction?

   iii) With a reason, state whether a high temperature or low temperature will give a better yield of methanol.

3.4.8 Extraction of Metals

1. State four steps employed in the extraction of moderate reactive metals

2. Copper can be obtained from the ore, copper pyrites ($CuFeS_2$). The ore is heated in a limited amount of air giving the following reaction:

$$4CuFeS_2 + 11O_2 \rightarrow 4Cu + 2Fe_2O_3 + 8SO_2$$

   i) Calculate the maximum mass of copper that can be obtained from 367 kg of copper pyrites

   ii) State why the gaseous product from this reaction must not be allowed to escape into the atmosphere

3. How long must a current of 4.00 A be applied to a solution of Cu^{2+} (aq) to produce 2.0 grams of copper metal?

   (A) 2.4×10^4 s

   (B) 1.5×10^3 s

   (C) 7.6×10^2 s

   (D) 3.8×10^2 s

   (E) 12×10^4 s

4. State three properties that make aluminium useful in overhead cables

5. i) Explain, in terms of electronic configurations, why sodium and potassium elements have similar chemical properties.

   ii) State the trend in reactivity of group I elements in the Periodic Table and give reasons for it.

6. Describe the extraction of iron from the haematite ore and write all the chemical equations for the reactions involved in each stage of extraction.

3.4.9 Compounds of Metals

1. The metal nitrate which will NOT give a metal oxide on heating is:

   (A) Calcium nitrate

   (B) Silver nitrate

   (C) Lead nitrate

   (D) Copper nitrate

   (E) Zinc nitrate

2. Find the oxidation state of sulphur in the sulphate ion, SO_4^{2-}
3. List two classes of oxides. Give one example in each case.
4. Briefly explain what will happen when
   i) iron (II) sulphate is exposed to air for a long time?
   ii) a bottle containing $AgNO_3$ is left open?
5. Which of the following pairs of compounds can be used in the preparation of calcium sulphate?
   (A) Calcium carbonate and sodium sulphate
   (B) Calcium chloride and ammonium sulphate
   (C) Calcium hydroxide and barium sulphate
   (D) Calcium nitrate and lead (II) sulphate
   (E) Calcium chloride and barium sulphate

3.5 Form IV Topics

3.5.1 Nonmetals and their Compounds

1. Which of the following sets of elements is arranged in order of increasing electronegativity?
   (A) Chlorine, fluorine, nitrogen, oxygen, carbon
   (B) Fluorine, chlorine, oxygen, nitrogen, carbon
   (C) Carbon, nitrogen, oxygen, chlorine, fluorine
   (D) Nitrogen, oxygen, carbon, fluorine, chlorine
   (E) Fluorine, nitrogen, oxygen, chlorine, carbon
2. Write balanced chemical equations to show how chlorine reacts with the following:
   i) water
   ii) aqueous iron (II) chloride solution
   iii) hydrogen sulphide
3. Write the chemical formula of tetrachloromethane and state the type of bond that exists.
4. The preparation of ammonia in the laboratory is done by heating any ammonium salt with an alkali.
   i) Write a balanced chemical equation for the preparation of ammonia gas.
   ii) State two uses of ammonia.
5. Which among the following equations correctly shows the reaction between chlorine gas and water?
   (A) $Cl_{2(g)} + H_2O_{(l)} \rightarrow Cl_{2(g)}$
   (B) $2Cl^-_{2(g)} + 2H_2O_{(l)} \rightarrow 4Cl_{(aq)} + O_{2(g)} + 2H_{2(g)}$
   (C) $Cl_{2(g)} + H_2O_{(l)} \rightarrow HCl_{(aq)} + HOCl_{(aq)}$
   (D) $2Cl_{2(g)} + 2H_2O_{(l)} \rightarrow 2HOCl_{2(aq)} + H_{2(aq)}$
   (E) $2Cl_{2(g)} + 3H_2O_{(l)} \rightarrow Cl_{2(g)} + 2H_3O^+$
6. Which among the following pair of substances are allotropes?
   (A) H_2O and H_2O_2
   (B) ^{1}2C and ^{1}4C
   (C) P_4 and P_8
   (D) H_2 and $2H^+$
   (E) H^+ and H_3O

7. Briefly explain what will happen when
   i) concentrated sulphuric acid is exposed to the atomosphere.

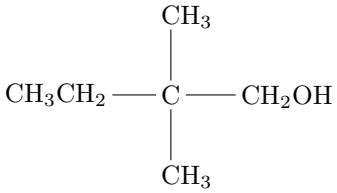
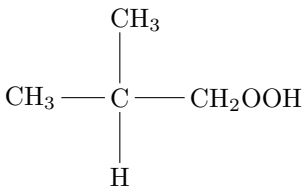
3.5.2 Organic Chemistry

1. Which of the following compounds does NOT belong to the alkane homologous series?
   (A) C_2H_4
   (B) CH_4
   (C) C_4H_{10}
   (D) C_3H_8
   (E) C_5H_{12}

2. You are provided with CH_3CH_2OH, $CH_3CH_2CH_3$, CH_3COOH, and $CH_2{=}CH_2$.
   i) Which compounds are gases at room temperature?
   ii) How can you distinguish compound $CH_3CH_2CH_3$ and $CH_2{=}CH_2$?
   iii) Which compound would react with sodium carbonate? Write the balanced chemical equation for the reaction.

3. Which of the following hydrocarbons does NOT belong to the same homologous series as the others?
   (A) CH_4
   (B) C_3H_8
   (C) C_4H_{10}
   (D) C_6H_{12}
   (E) C_2H_{12}

4. Give the names or formula of the two chemicals that would be used in the laboratory to make each of the following gas. State a simple test that could be used to identify the gas.
   i) Carbon dioxide

5. Name the following compounds according to the IUPAC system
   i) C_5H_{12}
   ii) 
   iii) 

3.5.3 Soil Chemistry

1. Define the following terms:
   i) Soil
   ii) Leaching
   iii) Denitrification

2. The table indicates the pH values of soil for some crops to grow

Crops	**Soil pH**	**Crops**	**Soil pH**
Tomato	7.0	Lettuce	6.1
Bean	6.0	Onions	5.7
Cabbage	5.4	Swede	5.3
Cauliflower	5.6	Parsley	5.1
Celery	6.3		

Which crop grows best in the:

i) Most acidic soil?

ii) Least acidic soil?

iii) Neutral soil?

3. Addition of inorganic fertilizers in the farm is not as important as addition of organic manure. Discuss the correctness of this statement in four points.

3.5.4 Pollution

1. Explain five methods to prevent terrestrial pollution.

3.5.5 Multiple Topics

1. Match the items in List A with the responses in List B

List A		List B	
(i)	An element with electronic configuration of 2:8	A	Flourine
(ii)	An element in which its oxide can be prepared by the action of nitric acid and heat	B	Rhombic
		C	Amorphous
(iii)	An element which acts as an oxidant or reductant	D	Diamond
(iv)	A gas that explodes when a flame is applied in the presence of air	E	Argon
		F	Zinc
(v)	A gas which is prepared in the laboratory by isolation from air	G	Phosphorus
(vi)	An element with atomic mass of 40	H	Nitrogen
(vii)	An element which reacts with water to produce hydroxide and hydrogen gas	I	Hydrogen
		J	Mercury
(viii)	An element which is used in making jewellers	K	Neon
(ix)	An element which is an allotrope of sulphur	L	Sulphur
(x)	The most electronegative element	M	Oxygen
		N	Potassium
		O	Chlorine

2. Match the items in List A with the responses in List B

List A		List B	
(i)	Its hydroxide is used in soil treatment	A	Barium
(ii)	It is obtained from its ore in the blast furnace	B	Lithium
(iii)	It gives a lilac colour when placed in a non-luminous flame	C	Iron
(iv)	It forms an insoluble sulphate	D	Potassium
(v)	It is in the same group in the periodic table with nitrogen	E	Oxygen
(vi)	It reacts with hydrogen to form a compound which is a liquid at room temperature	F	Fluorine
		G	Sulphur
(vii)	It is used in filament lamps	H	Argon
(viii)	It is the strongest oxidizing agent among the halogens	I	Phosphorus
(ix)	It exists in three main forms	J	Sodium
(x)	Its chloride is added to food in order to give taste	K	Magnesium
		L	Carbon
		M	Neon
		N	Silicon
		O	Calcium

Mathematics

4.1 NECTA Mathematics Exam Format

4.1.1 Form II

The following format for the Form Two National Assessment (FTNA) is based on the revised version of the Basic Mathematics Syllabus for Ordinary Secondary Education of 2005. The exam is intended to assess the competences acquired by the students after two years of study. The following information was taken from The National Examinations Council of Tanzania - Form Two National Assessment Formats

General Objectives

The general objectives of the Basic Mathematics assessment are to test students' ability to:

1. Perform computations on numbers, algebraic terms and radicals
2. Use approximations in solving simple problems
3. Convert and do computations on basic units, decimals, percentages and fractions
4. Construct and draw geometrical figures as well as finding angles, perimeters and areas of simple geometrical figures
5. Compute ratios, profit and loss
6. Draw graphs of linear equations, solve linear equations in one or two unknowns, solve linear inequalities in one unknown, solve quadratic equations and transpose formulae
7. Derive and apply the laws of exponents and logarithms
8. Do calculations using mathematical tables
9. Prove and apply congruence and similarity of figures
10. Represent reflections, rotations, translations and enlargement geometrically
11. Determine sine, cosine and tangent of angles and hence apply them in solving problems
12. Represent and interpret statistical data collected from real life situations
13. Perform operations on sets and apply sets to solve problems

General Competences

The FTNA will specifically test the students' ability to:

1. Distinguish different types of numbers
2. Estimate and compute numbers accurately
3. Convert units, decimals, percentages and fractions
4. Handle mathematical instruments in constructing and drawing geometrical figures
5. Solve problems on geometry, ratio, profit and loss
6. Draw graph and interpret linear equations
7. Find perimeters and areas of simple geometrical figures
8. Find relationships among logarithms, exponents, radicals, right angled triangles and trigonometric ratios
9. Use mathematical tables in computations
10. Verify laws and prove theorems
11. Do scale drawing and geometrical transformations
12. Solve problems on quadratic equations
13. Organize and interpret data

14. Apply set operations in solving problems

Assessment Rubric

The assessment consists of **one (1)** theory paper. The duration of the exam is **2 hours and 30 minutes**. The paper consists of **ten (10)** short-response questions (10 marks each). The students are required to attempt **all** questions, showing all work clearly.

4.1.2 Form IV

The following format for the Form Four Certificate of Secondary Education (CSEE) is based on the revised version of the Basic Mathematics Syllabus for Ordinary Secondary Education of 2005. The exam is intended to assess the competences acquired by the students after four years of study. The following information was taken from The National Examinations Council of Tanzania - Certificate of Secondary Education Examination Formats

General Objectives

The general objectives of the Basic Mathematics assessment are to test students' ability to:

1. Mathematical competences among candidates in solving practical problems in daily life have been developed
2. Mathematical concepts can be applied by candidates in interpreting situations at local and global levels
3. Candidates are able to use mathematical knowledge, techniques and life skills for studying mathematics and related subjects
4. Candidates have been adequately prepared for higher studies

General Competences

The FTNA will specifically test the students' ability to:

1. Think critically and logically in interpreting and solving problems
2. Use mathematical language in explaining and clarifying mathematical ideas
3. Apply mathematical knowledge and techniques in other fields

Examination Rubric

The examination consists of **one (1)** theory paper. The duration of the exam is **3 hours**. The paper consists of **sixteen (16)** short answer questions categorized into section A and B. Section A consists of **ten (10)**questions (6 marks each). Section B has **six (6)** questions (10 marks each). The students are required to attempt **all** questions in section A and **four (4)** in section B, clearly showing all workings.

Unlike other subjects present in this manual, the Basic Mathematics examination follows a special format. The format requires specific questions to cover specific topics (see table below). For example, Question 2 will *always* be about exponents, radicals, and/or logarithms. Similarly, Question 11 will *always* cover the topic of linear programming. Thus, it is possible for a student to effectively pass their exam, even by knowing just *two* topics very well (e.g Statistics and Accounts). Of course, it is not necessarily recommended to have students only focus on learning a few select topics, as this does not encourage thorough learning of the material, but it can be used as a motivator to students who have already written themselves off for the Math NECTA.

S/n	Topic(s)	Form(s)	Pts	Total
SECTION A (60 MARKS)				
1	Numbers/Fractions/Decimals and Percentages/Approximations	I	6	60
2	Exponents/Radicals/Logarithms	II	6	
3	Algebra/Sets	II	6	
4	Coordinate Geometry/Vectors	IV	6	
5	Geometry/Perimeter and Area/Congruence/Similarity	I/II	6	
6	Units/Rates and Variations	I/III	6	
7	Ratio, Profit and Loss	I	6	
8	Sequences and Series	III	6	
9	Trigonometry/Pythagoras Theorem	II/IV	6	
10	Quadratic Equations	II	6	
SECTION B (40 MARKS - CHOOSE 4)				
11	Linear Programming	IV	10	40
12	Statistics	III	10	
13	Three Dimensional Figures/Circles/Earth as a Sphere	III/IV	10	
14	Accounts	III	10	
15	Matrices and Transformations	IV	10	
16	Probability/Functions/Relations	III/IV	10	

4.2 Form I Topics

4.2.1 Numbers, Fractions, Decimals, Approximations

BODMAS

1. Evaluate $[9876 - 4321] \div 55 - 7 \times 6 + 3$
2. Evaluate $24 \times (10 + 54) \div 8 - 2$
3. Using mathematical tables, evaluate $\dfrac{(36.12)^3 \times 750.9}{(113.2)^2 \times \sqrt{92.5}}$
4. Given $x = 4.5 \times 10^{-7}$ and $z = 7.2 \times 10^5$, find y in standard form if $z = xy$.
5. Given $x = 1.6 \times 10^8$ and $y = 5.6 \times 10^4$, find z in standard form if $xz = y$.
6. Compute 0.678×145 and express the answer in standard form.
7. Given that $M = 4 \times 10^3$, express $\frac{1}{M}$ in standard form.

GCF, LCM

1. Find the LCM and GCF of 13, 52, and 104
2. Find the product of the LCM and GCF of 40, 120 and 240.
3. Find (a) GCF and (b) LCM of 15, 35 and 56.
4. Two numbers, 60 and n, have the lowest common multiple (LCM) of 420. If n is a multiple of 6 less than 90, find:
   i) the possible values of n.
   ii) the greatest common factor (GCF) of the two numbers.
5. The GCF and LCM of y, 18 and 60 are 6 and 360 respectively. Find the value of y.
6. The numbers 28, 41, 42, 59, 70 belong to the set of natural numbers. By using these numbers:
   i) calculate the difference between the least common multiple (LCM) of the prime numbers and the greatest common factor (GCF) of the remaining numbers.
   ii) express the answer obtained in i) above in the standard form $A \times 10^n$ correct to two significant figures where $1 \leq A < 10$ and n is an integer.

Integers

1. By using properties of integers, give reasons why each of the following expressions are equal:
   i) $(15 \times 17) \times 12 = 17 \times (15 \times 12)$
   ii) $15 \times (17 + 12) = (15 \times 17) + (15 \times 12)$
2. An aeroplane traveling at an altitude of 3200 metres makes a climb of 1500 metres, followed by a drop of 100 metres.
   (a) Represent the plane's altitude as a sum of positive and negative integers.
   (b) What is the planes altitude after the drop?

Fractions

1. Determine the improper fraction of $\frac{3}{5} \times 4\frac{1}{5} + \frac{18}{25}$
2. Evaluate $\frac{\frac{1}{25} + 0.28 + 1\frac{17}{25}}{3\frac{1}{5} \div \frac{0.32}{0.15}}$ Give your answer in fraction form.
3. Evaluate $\frac{0.0084 \times 1.23 \times 3.5}{2.87 \times 0.056}$ with using mathematical tables and express the answer as a fraction in its simplest form.

Recurring Decimals

1. Convert $\frac{1}{3}$ into a repeating decimal
2. Express $1.8\dot{6}$ as an improper fraction in its simplest form.
3. Change $0.\dot{1}2\dot{3}$ into a fraction.
4. Express $23.\dot{1}2\dot{3}$ as a fraction.
5. Express $2.\dot{1}35\dot{3}$ as a fraction.
6. Express $2.\dot{1}4\dot{6}$ as a fraction.
7. Change $0.0\dot{1}$ into a fraction.
8. Determine the fractional notation for $0.6\dot{3}$.
9. Express $1.\dot{2}1\dot{3}$ as a rational number.
10. Express the following recurring decimal number as a rational number: $0.\dot{6}5\dot{7}$.
11. Express $0.8\dot{3}$ in the form $\frac{a}{b}$ where a and b are integers such that $b \neq 0$.
12. Express $0.\dot{3}0\dot{3}$ as a fraction, i.e. $\frac{a}{b}$ where a and b are integers and $b \neq 0$.

Word Problems

1. Mr. Bean lived a quarter of his life as a child, a fifth as a teenager and a third as an adult. He then spent 13 years in his old age. How old was he when he died?
2. Mary received a certain amount of money from her father to go to school. She spent one third in her journey to school. At school she paid two thirds of the remaining amount as school fees and remained with 24,000 /= as her pocket money. Showing the procedure, calculate the total amount of money she received from her father.
3. A certain worker used his salary as follows: 20% on house rent, 45% on food, 10% on refreshment and 15% on school fees. If he/she was left with Tsh. 22,000, determine:
   i) the salary of the worker.
   ii) the amount of money which he/she spent on food.

4.2.2 Units

1. Change 15 km into centimeters

4.2.3 Approximations

1. By using mathematical tables, evaluate $\dfrac{\sqrt[3]{0.0072} \times (81.3)^2}{\sqrt{23140}}$ to three significant figures.

2. By using mathematical tables, evaluate $\dfrac{(28.32)^4 \times 0.03574}{87.57}$. Give your final answer in standard form, to three significant figures.

3. If $a = 2.432 \times 10^4$, $b = 7.42 \times 10^{-2}$ and $c = 0.0324 \times 10^{-2}$, find the value of R in standard form correct to two decimal places given that $R = \dfrac{ab}{c}$.

4. Using mathematical tables, evaluate the expression: $\dfrac{(28.32)^2 \times 0.3574}{\sqrt{8.732}}$. Give the answer correct to four decimal places.

5. By using mathematical tables evaluate the expression $\dfrac{237.8 \times 0.0873}{67890}$. Give the answer to four figures.

6. Given that $\sqrt{3} = 1.7321$, calculate the value of $\dfrac{2}{\sqrt{3} - 1}$ correct to 4 decimal places.

7. Estimate he value of $\dfrac{57.2 \times 110}{2.146 \times 46.9}$ correct to one (1) significant figure.

8. (a) Find the value of the expression $\left(\dfrac{4.75 + 1.31}{3.13}\right)^2$ giving your answer in three decimal places.

   (b) By rounding each term of the expression in (a) above to one significant figure, obtain a rough estimate of the expression.

9. (a) Round off each of the following numbers to one decimal place. $L = 20.354$, $M = 40.842$, $N = 10.789$

   (b) Use the result obtained in (a) above to find the value of x given that $x = \dfrac{LM}{N}$.

10. Round each of the numbers $x = 2.354$, $y = 4.843$ and $z = 1.789$ to one decimal place and then use the results obtained to find the value of A to two significant figures given that $A = \dfrac{xy}{z}$.

11. Round off the number 568,356 to the nearest thousands and ten thousands

12. Express 0.05473

    i) correct to three (3) significant figures

    ii) correct to three (3) decimal places

    iii) in standard form

13. Write 624.3278 correct to

    i) five significant figures

    ii) three decimal places

4.2.4 Geometry

1. i) What is the sum of the interior angles of an octagon?
   ii) Find the size of the exterior angle of a regular octagon.
2. Calculate the size of an interior angle of a regular nonagon.
3. A regular polygon has an exterior angle of 36°. Calculate:
   (a) the size of an interior angle
   (b) the number of sides of the polygon
4. An exterior angle of a regular polygon has degree measure of $22^1/_2$. Find the sum of degree measure of all the interior angles.
5. The interior angle of a regular polygon is 120° greater than the exterior angle. Find the number of sides of the polygon.
6. If the interior angle of a regular polygon is $6^1/_2$ times the exterior angle, how many sides does the polygon have?

4.2.5 Algebra

Simultaneous Equations

1. Solve the following equations simultaneously given that $z = 2$.
   $\begin{cases} x + 2y - z = -2 \\ 2x - y + 2z = 9 \end{cases}$
2. Solve $\begin{cases} \frac{x}{4} - \frac{y}{3} = 0 \\ \frac{x}{2} - \frac{y}{2} = 1 \end{cases}$
3. Solve the following simultaneous equations:
   $x = 4 - \frac{3y}{2}$; $-3x + \frac{y}{2} = 1$
4. Find the values of x, y and z given that:
   $\frac{x}{3} = \frac{y}{4} = \frac{z}{2}$ and $2x + 3y - z = 16$.
5. Solve the following system of equations:
   $2x + y - z = 3$
   $x - 2z = 7 + y$
   $y = x - 5$
6. Find the values of r and s in the following system of equations:
   $3r + s = 17$
   $27 - 3r - 6s = 0$
7. If $x : y = 3 : 2$ and $x + y = 40$, find x and y.
8. Solve the simultaneous equations given below by elimination method. $\begin{cases} 3x - y = 23 \\ 4x - 3y = 48 \end{cases}$
9. Find the coordinates of the point of intersection P of the two straight lines $4x + 3y = 7$ and $3x - 4y = -1$.
10. The sides of a rectangular plot PQRS in metres are such that $\overline{PQ} = 4x + 3$, $\overline{QR} = 3x + 1$, $\overline{RS} = x + 6y$ and $\overline{PS} = 4x - y$. Find the value of x and y and hence find the area of the plot in metres.

Inequalities

1. On a number line locate the region $-2 < x \leq 3$.
2. Solve for x if $5 - 2x \geq 7x - 4$
3. Solve the following inequality and show its solution on the number line: $4 - x < x + 8 < 5 - 2x$
4. Solve the inequality: $x^2 - 2x < 8$
5. Using the number line, show the solution set of:
   $\frac{1}{2}x - 5 \leq 3 - 3\frac{1}{2}x$

Word Problems

1. A shopkeeper sold 500 sweets. Some cost shs. 5 and some cost shs. 8. The cash received for the more expensive sweets was shs. 100 more than for the cheaper sweets. Find the number of each kind of sweet which were sold.
2. Two numbers are such that the first number plus three times the second number is 7, and the first number minus three times the second number gives 1. Find the two numbers.
3. The middle angle of a triangle exceeds the smallest angle by 20° and the largest angle is twice the middle angle. Find the size of the largest angle.
4. A trader planned to buy some computers from a wholesaler for a total of shs. 1,800,000. Before the trader could buy the computers the price per unit was reduced by shs. 4,000. This reduction in price enabled the trader to buy five (5) more computers using the same amount of money as originally planned. Determine the number of computers the trader bought.
5. A mathematics teacher bought 40 expensive calculators at shs. 16,400 each and a number of cheaper calculators costing shs. 5,900 each. She spent a total of shs. 774,000. How many of the cheaper calculators did she buy?
6. A rectangular garden is 6 m wide and 8 m long. What length added to the shorter side and reduced from the longer side will result in a rectangular garden with an area of 45 cm^2?

4.2.6 Ratio, Profit and Loss

Ratio

1. An alloy consists of three metals A, B and C in the proportions $A : B = 3 : 5$ and $B : C = 7 : 6$. Calculate the proportion $A : C$.
2. Given the ratios:
   $A : B = 2 : 3$
   $B : C = 6 : 7$
   Calculate the ratio of $A : C$.
3. Express $2\frac{1}{2} : 3$ as integers in a simplified form.
4. If it is known that $x : y = 5 : 1$ find the value of $\dfrac{x + y}{3x - 4y}$.
5. Three numbers d, m and n are in the ratio of $3 : 6 : 4$ respectively. Find the value of $\dfrac{4d - m}{m + 2n}$.
6. A, B and C are to share Tshs. 120,000/= in the ratio $2 : 3 : 5$ respectively. How much will each get?
7. Three people share a property in the ratio $2 : x : y$. It is known that $y = x + 2$. If the largest shareholder had Tsh. 39,100/= in monetary terms, find the value of this property.
8. The ratio of men : women : children living in Mkuza village is $6 : 7 : 3$. If there are 42,000 women, find how many:

(a) i) children live in Mkuza village.
ii) people altogether live in Mkuza village.

(b) The 42,000 women is an increase of 20% on the number of women ten years ago. How many women lived in the village?

9. An amount of Tshs. 12,000 is to be shared among Ali, Anna and Juma in the ratio 2 : 3 : 5 respectively. How much will each get?

10. The are of two circles are in the ratio of 16 : 9. Calculate the radius of the smaller circle when the radius of the larger one is 24 cm.

11. The ratio of the areas of two circles is 50 : 72. If the radius of the smaller circle is 15 cm, find the radius of the larger circle.

12. The sides of a rectangle are in the ratio 3 : 5. If the perimeter of this rectangle is 800 cm, find the dimensions of the rectangle.

13. The distance between two towns on a map of scale 1 : 5,000,000 is 9 cm. Find the actual distance between the towns in kilometres.

14. A building 250 metres high is represented by a line segment of length 5 cm. Find the scale of drawing.

15. An area of 24.7 cm^2 was plotted on a map of a scale 1 : 50,000. What was this area, in square kilometres, on the Earth's surface?

Profit and Loss

1. (a) John and Paul started a tailoring business and invested shs 110,250/= and 220,500/= respectively. If the profit after the first six months was shs 50,970/=, how much did Paul get if they agreed to share it according to the amount they invested.

   (b) Mary paid shs 800,000/= for a computer and sold it the following year for shs 600,000/=. Find the percentage loss she got.

2. By selling an article at shs. 22,500/= a shopkeeper makes a loss of 10%. At what price must the shopkeeper sell the article in order to get a profit of 10%?

3. Neema bought a tray of eggs (containing 30 eggs) for shs. 2,000/=. She boiled the eggs using a litre of kerosene costing shs. 400/= and sold each egg at a price of 100/= each. Find her percentage profit.

4. A shopkeeper sells sugar at sh. 105.00 per kilogram. If he realizes a profit of 5% over the buying price, find the buying price per kilogram.

Simple Interest

1. Find the amount of money obtained after depositing 900/= for 2 years and 9 months at an annual rate of 6% simple interest.

2. How long will it take a sum of money to double itself at 5% per months, simple interest?

3. A certain amount of money was deposited for three years at the annual rate of 5% simple interest. The interest at the end of the three years was shs. 112.50. Find the principal.

4. For how long should Tshs. 1,200,000/= be invested at simple interest rate of 5% to get an interest of Tshs. 180,000/=?

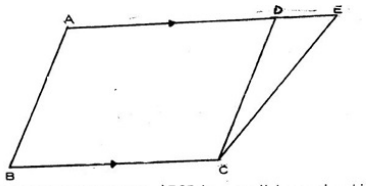
5. Mavuno wants to invest lump sum money so that its value after 4 years will be 812,000/=. How much should the investor invest at 4% per annum single interest?

4.2.7 Coordinate Geometry

1. Find the equation of the straight line passing through the points (3,5) and (7,9). (Express your answer in the form $y = mx + c$)
2. Find the y-intercept and the gradient of the line which passes through the points (7,5) and (2,3).
3. A line whose equation is $y = mx+c$ passes through (-1,4). If x-intercept for this line is 3, determine the values of m and c.
4. The straight line through the points C(1,-2) and D(3,4) meets the y-axis at point E. Find the coordinates of E.
5. Determine the slope of the line $\frac{7}{2}x - \frac{5}{3}y - 4 = 0$.

4.2.8 Perimeter and Area

1. Find the perimeter of a square, if its area is 25 cm^2
2. The height of a trapezium is 13 cm. If one of its parallel sides is 20 cm and the area of the trapezium is 390 cm^2, find the length of the other parallel side.
3. The diagonals of a rhombus are 16 cm and 12 cm long. Find the area and perimeter of the rhombus.
4. In the diagram drawn below, ABCD is a parallelogram in which AD is extended to E. The area of the parallelogram is 40 cm^2. Determine the area of $\triangle$ DCE given that AE = 11 cm and BC = 8 cm.



4.3 Form II Topics

4.3.1 Exponents and Radicals

Exponents

1. Find the value of x in the equation $9 \times 3^{4x} = 27^{(x-1)}$
2. Find the value of x for which $2^x \cdot 16 = \frac{1}{8^x}$.
3. Solve for x if $2^{x+1} = 32,768$.
4. Simplify $\frac{27^{n+2} - 6 \times 3^{3n+3}}{3^n \times 9^{n+2}}$
5. Solve for y if $\left(\frac{1}{9}\right)^{2y}\left(\frac{1}{3}\right)^{-y} \div \frac{1}{27} = 3^{(-5y)}$
6. If $\left[3^{(x-2)}\right]\left[2^{(3y-3)}\right] = 72$, find the values of x and y.
7. Solve for x if $\left(4^{(x+3)}\right)(16^x) = 8^{3x}$
8. Solve for x if $2^x = 0.25$.
9. Solve the following equations:
   (a) $(1/3)^x = 81^{-1}$

(b) $2^{x+1} = 2^5$

10. Find the value of t in the equation $3^{2t}(4^t) = 6$.
11. Use the substitution $y = 2^x$ to solve the equation $2^{2x+1} - 2^{x+1} + 1 = 2^x$.
12. If $(576)^{m-4} = 8^m \times 3^m$, find the value of m.
13. Solve for x given that $3^{x+2} - 5 = 76$.
14. If $2^x \times 3^y = 5184$, find x and y.
15. Determine the values of x and y from the following expression: $(1/2)^x (3)^{y-2} = 432$.
16. If $\left(2^{x-1}\right)\left(3^{y+1}\right) = \left(3^4\right)\left(2^5\right)$ find:

    i) $x + y$ ii) $\dfrac{y}{x}$
17. In the following equation solve for m: $m^8 = 3125$
18. Find the value of $(64)^{-2/3} \div \dfrac{(4)^0}{(16)^{1/2}}$
19. By using the properties of exponents simplify the expression $\dfrac{2^{18} - 2^{15} + 7}{2^{15} + 1}$ (Don't use tables)
20. Show that $\dfrac{x^m}{x^n} = x^{m-n}$ where $x \neq 0$ and m and n are integers.

Radicals

1. Rationalize the denominator of $\dfrac{\sqrt{2}}{\sqrt{10} - \sqrt{2}}$
2. Rationalize $\dfrac{2 + \sqrt{3}}{1 - \sqrt{3}}$.
3. Rationalize the denominator: $\dfrac{a - b}{\sqrt{a} + \sqrt{b}}$
4. Simplify the expression $\dfrac{5}{\sqrt{11} - 3} \div \dfrac{\sqrt{2}}{\sqrt{22} + 3\sqrt{2}}$
5. By rationalizing the denominator, simplify the following expression. $\dfrac{\sqrt{3} + \sqrt{2}}{\sqrt{5} + \sqrt{2}}$
6. Rationalize the denominator of the expression $\dfrac{6}{\sqrt{7} - 2}$
7. Simplify each of the following by rationalizing the denominator:

    (a) $\dfrac{2 + \sqrt{3}}{\sqrt{2} - \sqrt{5}}$

    (b) $\dfrac{\sqrt{3}}{3 + \sqrt{3}}$
8. i) Express each of the irrational numbers $\dfrac{1}{3 + \sqrt{5}}$ and $\dfrac{1}{3 - \sqrt{5}}$ with a rational denominator.

    ii) Show that the sum of the numbers specified in i) above is a rational number.
9. Rationalize the denominator of: $\dfrac{2}{2\sqrt{3} + \sqrt{2}}$

10. Express $\dfrac{3}{(\sqrt{2}+1)^2} - \dfrac{1}{\sqrt{2}+1}$ in the form $a + b\sqrt{c}$ where a, b and c are integers.

11. Rationalize the denominator of the number $\dfrac{2}{\sqrt{5}-\sqrt{3}}$

12. Find the value of the expression $\sqrt{50} - 2\sqrt{18} + \sqrt{8} + \sqrt{2}$.

13. Solve for x if $\sqrt[3]{(x-1)} + 3 = 0$.

14. Solve for x if $\sqrt{3^{x+2}} + 17 = 8$.

4.3.2 Algebra

Quadratic Simultaneous Equations

1. Find the solution of the following set of simultaneous equations. $\begin{cases} 4x - 2y = 10 \\ 8x^2 - 2y^2 = 30 \end{cases}$

2. If the sum of two numbers is 3 and the sum of their squares is 29, find the numbers.

3. Solve the following simultaneous equations: $\begin{cases} x^2 + y^2 = 9 \\ y + 6 = 2x \end{cases}$

4. Solve the simultaneous equations: $\begin{cases} x - y = 2 \\ 2x^2 - 3y^2 = 15 \end{cases}$

5. Find the value of ab if $a^2 + b^2 = 34$ and $a + b = 8$.

6. Find the truth set of the following simultaneous equations: $\begin{cases} x^2 - y^2 = 0 \\ 2x + 2y = 1 \end{cases}$

7. Find the values of x and y given that
   $3x - y = 3$ and $9x^2 - y^2 = 45$.

8. Determine the values of x and y given that $\dfrac{1}{x} + \dfrac{1}{y} = \dfrac{3}{2}$ when $\dfrac{1}{x^2} + \dfrac{1}{y^2} = \dfrac{5}{4}$.

9. Find the values of x and y which satisfy the following system of equations $\begin{cases} 2x + y = 3 \\ x^2 - 2y = 6 \end{cases}$

Inequalities

1. Find the solution set for the inequality $-4 < 5 - 3x \leq 17$.

2. Rewrite $|2x + 3| < 7$ without the absolute value sign and hence sketch a graph of the resulting inequality.

3. Find the solution of $|2x + 1| > 3$ and show it on the number line.

4. Find the solution set of the following inequality and show on separate number lines the solution of each inequality.
   $2 < |x - 3| < 5$

Binary Operations

1. If $x * y$ is defined as $\dfrac{1}{2}(x + y)$, find $(5 * -2) * (3 * -4)$.

2. The operation on the integers P and K is defined as $P * K = PK + 2P - 3K$.
   Find the value of

   (a) $3 * 2$

   (b) a if $5 * a = 20$

3. Given that $M * N = \dfrac{M-N}{2N} + \dfrac{M+N}{2M}$, find
   (a) $4 * 2$
   (b) a if $1 * a = 2$
4. Given $a * b = a^2 + b$, Find x if $(1 * 3) * x = 18$.
5. If $n * m = (n + m)^2 - m$, find the value of $(3 * 1) * 2$.
6. Ther operator $*$ is defined as $a * b = b^2 - a$. Find the value $1 * (3 * 2)$.
7. If $a * b = (a^2 - 2b)b$, find:
   (a) $3 * 2$
   (b) n if $4 * n = 0$.
8. If $m * n = mn$, find the value of
   (a) $9 * (-\frac{1}{2})$
   (b) $-27 * \frac{1}{3}$

Fractions in Algebraic Expressions

1. Solve the equation $2x + \dfrac{x+7}{3} = \dfrac{4x-19}{5}$.
2. If $\dfrac{a+2b}{a-2b} = \frac{1}{2}$, find the value of $\frac{a}{b}$.
3. If $x \div y = 7$, evaluate $\dfrac{y^2 + 4x^2}{xy}$
4. If $\dfrac{3a+b}{3b-2a} = 4$, calculate the value of ${}^{a}/_{b}$.
5. Given that $\left(a + \dfrac{1}{a}\right)^2 = 14$, find the value of $a^2 + \dfrac{1}{a^2}$.
6. It is known that ${}^{n}C_r = {}^{n}\,C_{n-r}$. Find x given that ${}^{20}C_{18} = {}^{20}\,C_x$

Changing the Subject of an Expression

1. Make x the subject of the formula in the equation: $y = \dfrac{ax+b}{cx+d}$
2. Make a the subject of the formula $P = W\dfrac{(1+a)}{1-a}$
3. Make p the subject of the formula $tp^{1/2} = q(p+r)^{1/2}$
4. If $a\sqrt{\left(\dfrac{x^2-n}{m}\right)} = \dfrac{a^2}{b}$ write x as a subject of the formula.
5. Make W the subject of the formula $T = W + \dfrac{WV^2}{gx}$
6. If $\dfrac{k}{v} - \dfrac{1}{u} = \dfrac{k-1}{r}$, write k as the subject of the formula.
7. Make t the subject of the expression $3t^2x - 2xy = 3t^2y$.
8. Make q the subject of the equation $pqy + x = c(p + q^2)$.

4.3.3 Quadratic Equations

Factorization

1. Factorize the expression $6x^2 - 11x + 4$ by splitting the middle term.
2. Factorize $(x+2)^2 - (x-4)^2$ and hence find the exact value of $(10003)^2 - (9997)^2$.
3. Factorize:
   (a) $(x-1)^2 - 4y^2$
   (b) $6x^2 - 11xy - 10y^2$
4. By factorization, find the solution set for $x^2 - x - 6 = 0$.
5. Find the solution of the quadratic equation $8x^2 - 34x + 21 = 0$. by using the factorization method.
6. Evaluate by factorization the expression $(365)^2 - (135)^2$.
7. Factorize completely the expression $12 + x - x^2$.
8. Solve by using factors:
   (a) $\dfrac{k+6}{k-4} = \dfrac{1}{k}$
   (b) $\log_b b^{(2x^2-x)} = 1$
9. Factorize completely each of the following:
   (a) $4t - 16t^3$
   (b) $6 - 17y - 3y^2$
10. Write the factors of $x^2 - 9y^2$ and hence or otherwise, solve the equations
    $x^2 - 9y^2 = 15$
    $x - 3y = 5$
11. Solve the equation $3x - 5 = \dfrac{5x-3}{x}$ by factorization.
12. (a) Factorize completely $pq + pr - rq - q^2$.
    (b) Find the value of the expression in (a) above, if $p = 11.1$, $q = 7.1$ and $r = 2.9$.
13. (a) Factorize each of the following expressions:
        i) $3a^2c - 5a^2d - 3b^2c + 5b^2d$
        ii) $3(2 - y^2) - 17y$
    (b) Find the value of y which satisfies the equation $3(2 - y^2) - 17y = 0$.
14. If K and L are the factors of a quadratic equation $x^2 + 3x - 11$, what will be the value of KL and K + L?

Completing the Square

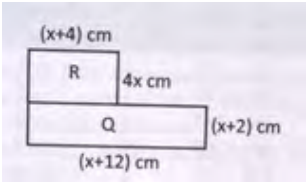
1. Solve the following equations by completing the square.
   (a) $ax^2 + bx + c = 0$
   (b) $9x^2 - 15x + 6 = 0$
2. What number must be added to $x^2 + 17x + 12$ to make the expression exactly divisible by $(x+5)$?
3. If $x^2 + ax + 4$ is a perfect square, find the value of a.
4. If $4x^2 + ax + 9$ is a perfect square, find the possible value of a.
5. Solve the expression $x^2 - 6x - 16 = 0$ by completing the square.
6. Find the values of r and s if:
   $9x^2 - 12x + r = (3x - s)^2$

Simplifying / Finding Roots

1. Solve the equation $6x^2 + 14x - 12 = 0$.
2. Solve for x if $\dfrac{6}{x-4} = 1 + \dfrac{4}{x}$.
3. Solve for x if $\dfrac{1}{x-2} - \dfrac{1}{x^2-4} = \dfrac{4}{5}$.
4. Simplify the expression:
$$\frac{9x^2 - 49}{2 - (3x - 5)}$$
5. Simplify the following:
$$\frac{1}{t^2 - 2t - 15} - \frac{1}{3t^2 + 10t + 3}$$
6. Given that one of the roots of the equation $2x^2 - k(x + 1) + 3 = 0$ is 4, find k.
7. If the equation $(2p + 2)x^2 + px + p = 4(px + 2)$ has the sum of its roots equal to the product of its roots, find:
   (a) the value of p
   (b) the roots of the equation, using the value of p found in (a).

Geometrical Problems

1. Study the following diagram carefully and answer the questions that follow.



   (a) i) Write down an expression for the area of rectangle R.
   ii) Show that the total area of rectangle R and O is $(5x^2 + 30x + 24)$ cm^2.
   (b) If the total area of R and Q is 64 cm^2, calculate the value of x correct to 1 decimal place.

4.3.4 Logarithms

1. Without using mathematical tables, find the value of $3\log_{10} 5 + 5\log_{10} 2 - 2\log_{10} 2$
2. Solve $\log_a(x^2 + 3) - \log_a x = 2\log_a 2$.
3. Evaluate without using mathematical tables $2\log 5 + \log 36 - \log 9$
4. Simplify $\dfrac{\log x^4 - \log x}{\log x^3 - \log x}$
5. Simplify $2\log_{10} 25 - 3\log_{10} 5 + \log_{10} 20$.
6. If $\log_a x = 7$, what is $\log_a \left(\dfrac{1}{x}\right)$?
7. Find the value of the expression $2\log 40 + \log\sqrt{81} - 2\log 12$.
8. Solve for m: $\log m = 3\log 6 - \frac{1}{3}\log 125 - 4\log 3 - \log\frac{16}{3}$
9. Express as a single logarithm the expression $\frac{1}{2}\log_c x - 7\log_c y + \log_c z$.
10. Without using tables, find the value of $3\log_{10} 5 + 5\log_{10} 2 - \frac{1}{2}\log_{10} 16$.

11. Evaluate: $\log_3 9 \times \log_4 \dfrac{1}{64} \times \log_7 \dfrac{1}{7}$

12. Simplify $\log_2 32 - \log_3 9$.

13. It is given that $\log_{10} x + \log_{10} 20 = 2$. Find the value of x.

14. Solve the equation $\log_4 5x - \log_4(x+2) - \log_4 3 = 0$.

15. Evaluate without using tables $\log_5 \sqrt[3]{605}$

16. If $\dfrac{\log k}{\log 9} = \dfrac{\log 256}{\log 16}$, find the value of k.

17. Solve for x in the logarithmic equation $2\log x = \log 4 + \log(2x-3)$

18. It is given that $n \log_5 125 = \log_2 64$. What is n?

19. Find x if $\log_x 32 = 5$.

20. Solve for x if $\log_{10}(x^2 - 3x - 44) = 1$

21. If $\log_4 x = y$, show that $\log_2 x = 2y$. Hence find the value of x given that $\log_2 x + \log_4 x = 9$.

22. Find the value of a if $\log_a 81 - \log_2 32 = -1$.

23. Solve for x, given that $\log_3 x - \log_3(x-8) = 2$.

24. Without using tables, calculate the value of
(a) $\log_{10} 6$ (b) $\log_{10} 0.9$
($\log_{10} 2 = 0.3010$, $\log_{10} 3 = 0.4771$)

25. If $\log 2 = 0.3010$, find the value of $\log 5$.

26. If $\log p = 1.813$ and $\log q = 2.513$, find the value of pq^2

27. Using properties of logarithms show that $\log_{10} 15 = 1.17609$ given that $\log_{10} 2 = 0.30103$ and $\log_{10} 3 = 0.47712$.

28. If $\log a = 1.3010$, $\log b = 1.4771$ and $\log c = 1.7782$, calculate $\log \sqrt{\dfrac{a^2 b}{c^2}}$

29. Evaluate $\log_{10} \dfrac{(0.1575 \times 27500)}{315}$ given that $\log_{10} 1.575 = 0.1973$, $\log_{10} 2.75 = 0.4393$ and $\log_{10} 3.15 = 0.4983$.

30. Use logarithms to calculate $(3.25)^{10} + \left(\dfrac{40.9}{6.692}\right)^3$
Express your answer in the form $A \times 10^n$, where $1 \leq A < 10$ and n is an integer, to 2 significant figures.

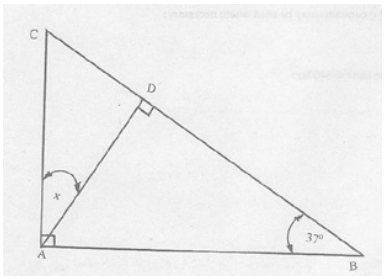
31. By using logarithm tables evaluate: $\sqrt{\dfrac{86.21 \times 2.734}{5.218 \times 0.724}}$

32. Use common logarithm tables to find the value of $\dfrac{2.055 \times 20.35 \times 6.325}{100.5 \times 0.045}$

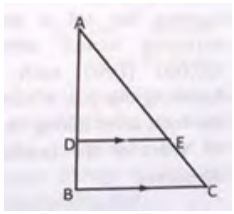
33. By using logarithm tables evaluate: $\dfrac{88.76 \times 0.0278}{5678 \times 875.8}$

4.3.5 Similarity and Congruence

1. In the figure drawn below find the value of x if $\hat{B} = 37°$.



2. In the figure below DE is parallel to BC, AD = 6 cm, BD = 3 cm, DE = 4 cm and $A\hat{B}C = 90°$.



Calculate:

i) the length of BC

ii) the ratio AE/AC

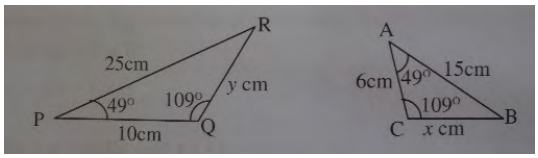
3. In $\triangle ABC$, M is the midpoint of $\overline{AB}$ and N is the midpoint of $\overline{AC}$. Prove that $\overline{MN} \parallel \overline{BC}$ and $\overline{MN} = \frac{1}{2}\overline{BC}$.

4. The ratio of the area of two similar triangles is 1 : 4. Find the ratio of their corresponding sides.

5. If polygons X and Y are similar and their areas are 16 cm^2 and 49 cm^2 respectively, what is the length of a side of polygon Y if the corresponding side of polygon X is 28 cm?

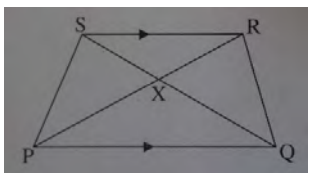
6. Triangles O and P are similar. A side of triangle O is 8 cm long, while the corresponding side of triangle P is 16 cm long. If the area of triangle O is 40 cm^2, what is the area of triangle P?

7. i) Show whether triangles PQR and ABC are similar or not.



ii) Find the relationship between y and x in the triangles given above.

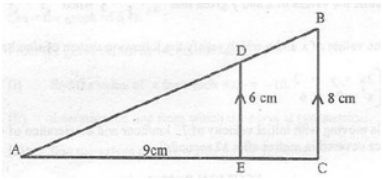
8. In the figure below, SR is parallel to PQ, SX = 3 cm, XQ = 8 cm, PQ = 12 cm and XR = 2.7 cm.



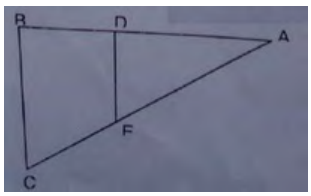
i) Show that $\triangle PQX$ and $\triangle RSX$ are similar.

ii) Calculate the length of SR and PX.

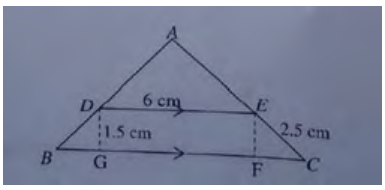
9. With reference to the figure below, calculate the length of segment $\overline{CE}$.



10. In the figure below, calculate the length $\overline{BC}$ if $\overline{AD} = 4$ cm, $\overline{DE} = 3$ cm, $\overline{CE} = 5$ cm and $A\hat{B}C$ and $A\hat{D}E$ are both right angles.



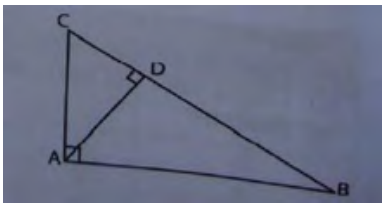
11. In the figure below, BC is parallel to DE, AB = AC and CE = 2.5 cm. DE = 6 cm. The height of trapezium BCED is 1.5 cm.



(a) Prove that the triangles ABC and ADE are similar.

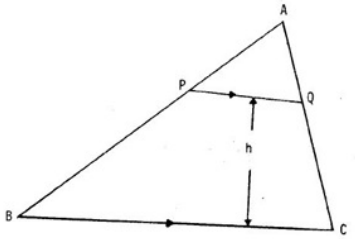
(b) Calculate the length of AE.

12. In the diagram below, show that $\dfrac{AD}{AB} = \dfrac{CD}{AC}$



13. $\triangle ABC$ is similar to $\triangle DEF$. AB = 8 cm while DE = 12 cm. Find the area of $\triangle ABC$ if that of $\triangle DEF$ is 45 cm^2.

14. In the figure below, $\overline{PQ} \parallel \overline{BC}$, $\overline{AP} = 3$ cm, $\overline{AQ} = 2$ cm and the area of $\triangle APQ = 8$ cm^2.



(a) Show that $\triangle APQ$ is similar to $\triangle ABC$

(b) Find the area of $\triangle ABC$

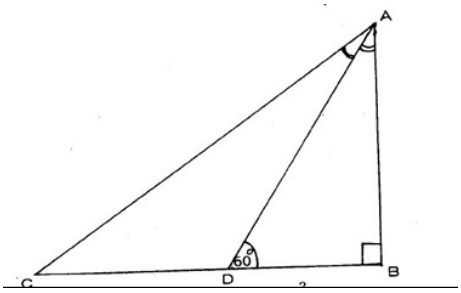
(c) Calculate the length of i) $\overline{PQ}$ ii) $\overline{QC}$

(d) Calculate the height h.

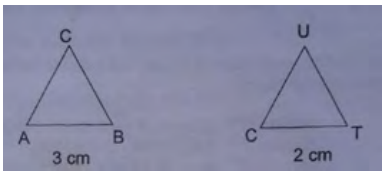
15. In the figure below, $m(A\hat{B}C) = 90°$. Point D on $\overline{BC}$ is such that $\overline{AD}$ bisects $B\hat{A}C$. If AD = 4 cm and $m(A\hat{D}B) = 60°$, calculate the length of:

    (a) $\overline{AB}$

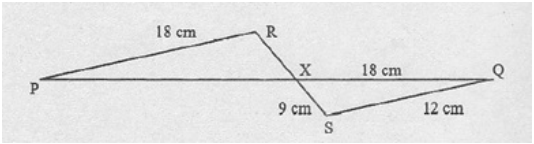
    (b) $\overline{DC}$



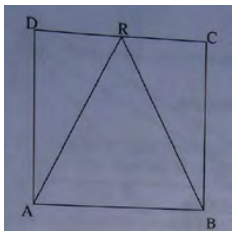
16. In the figure below, $\triangle ABC$ is similar to $\triangle CTU$, with AB = 3 cm and CT = 2 cm. The area of $\triangle CTU$ is 6 square cm. Find the area of $\triangle ABC$.



17. PXQ and RXS are straight lines and PR is parallel to SQ. Calculate PX and RX if PR = XQ = 18 cm, XS = 9 cm and SQ = 12 cm.

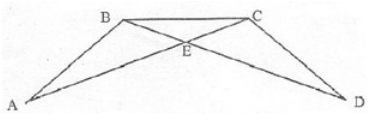


18. In the figure below, ABCD is a square. If $\overline{AR} = \overline{BR}$ prove that R is the midpoint of $\overline{DC}$.

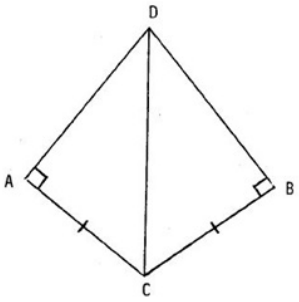


19. PQR is an isosceles triangle whereby $\overline{PQ} = \overline{PR}$ and $\overline{QS} = \overline{SR}$. If S is a point between Q and R prove that $\triangle PQS \equiv \triangle PRS$

20. ABCD is part of a regular polygon. Show that the triangles ABC and BCD are congruent.



21. In the figure below, $\overline{AC} = \overline{CB}$ and $D\hat{A}C$ and $D\hat{B}C$ are right angles. Prove that $\triangle ACD \equiv \triangle CBD$.



4.3.6 Geometric Transformations

Translation

1. A translation T maps the origin onto the point $(-2, 3)$. A second translation S maps the origin onto the point $(1, -2)$. Find where T followed by S will take the point $(4, -5)$.

2. A translation takes the point $(8, 5)$ to $(12, -4)$. Find where it will take the point $(5, 4)$.

3. A translation takes the point $(5, 8)$ to $(12, -4)$. Find where it will take the point $(8, 5)$.

Reflection

1. Reflect the vector $(1, 2)$ in the line $y = -x$.

2. Reflect the point $(1, 2)$ in the line $x + y = 0$.

3. Find the image of the point $(2, 4)$ when it is reflected about the line $y + x = 0$.

4. The vertices of triangle ABC are $A(1, 2)$, $B(3, 1)$ and $C(-2, 1)$. If triangle ABC is reflected on the x-axis, find the coordinates of the vertices of its image.

5. The vertices of a triangle are A(2,2), B(3,4) and C(4,3). If the triangle is reflected in the y-axis, write down the coordinates of the image of points A, B, and C.

Rotation

1. Find the image of the point $(2, 5)$ after rotation by $90°$ anticlockwise about the origin.

2. Find the image of the point $(2, 1)$ under rotation about the origin through $90°$ anticlockwise.

3. Find the image of the point $(2, 4)$ when it is rotated through $180°$ about the origin.

4. Find the image of the point $(9, 5)$ under a rotation of $90°$ followed by a rotation of $180°$ anticlockwise about the origin.

5. Find the image of $(7, 6)$ under a rotation through $180°$ followed by another rotation of $90°$.

Combined Transformations

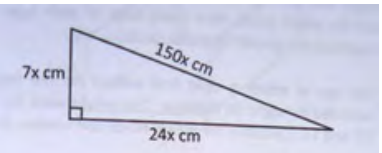
1. A point (x, y) is reflected on the line $y = x$ followed by a rotation through an angle of $180°$ clockwise about the origin. Find the image of $(2, 3)$ under this double transformation.

2. A point (x, y) is rotated through $90°$ and then reflected about the line $y = x$. Find:

   i) the image of the point $(3, 6)$ under this double transformation.

4.3.7 Pythagoras Theorem

1. The right angled triangle in the diagram below has sides of length 7x cm, 24x cm and 150x cm.



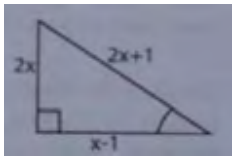
   i) Find the value of x

   ii) Calculate the area of the triangle

2. Given the right angled triangle below whose sides are measured in centimeters determine:

   i) The value of x

   ii) The area of the triangle



4.3.8 Trigonometry

1. Without using mathematical tables, find the exact value of $\dfrac{\tan 45^\circ + \tan 30^\circ}{1 - \tan 45^\circ \tan 30^\circ}$

2. Given that θ is an acute angle and $\sin\theta = \dfrac{3}{5}$, find the value of $\dfrac{\cos\theta - \sin\theta}{\tan\theta}$.

3. Given that $\sin A = \dfrac{3}{5}$ find the values of:

   i) $\cos A$

   ii) $\dfrac{\tan A - \sin A}{1 + \cos A}$

4. If $5\cos A = 3$ find the values of:
   i) $\sin A$ ii) $\tan A$

5. Let A be the acute angle of a right angles triangle ABC such that $\hat{B} = 90^\circ$ and $\cos\hat{C} = \dfrac{5}{13}$. Find the value of $\sin\hat{A}$.

6. Given that x is an acute angle and that $\sin x = \dfrac{p}{q}$, find the value of $\tan x$.

7. If $\tan A = 2\dfrac{2}{5}$ where A is an acute angle, find:
   i) $\sin A$ and ii) $\cos A$

8. If N is an acute angle and $\tan N = \dfrac{5}{13}$, without using tables, find the value of $\sin N + 5\cos N$.

9. Find the value of:

   i) $\sin A$

   ii) $\cos A$, if $\tan A = -\dfrac{5}{12}$ and it is known that A is obtuse.

   iii) Hence show that $13\sin A + 13\cos A = -7$.

10. If $\tan A = \frac{3}{4}$ and A is acute, find $\cos A$, $\sin A$ and hence verify the identity $\cos^2 A + \sin^2 A = 1$.

11. If $2\sin A = 1$ and A is an obtuse angle, find the value of
    (a) $\cos A$ (b) $\tan A$

12. A ladder reaches the top of a wall 18 m high when the other end on the ground is 8 m from the wall. Find the length of the ladder.

13. Joff is 30 m from a flag pole installed with its bottom end some distance below ground level. The angle of elevation of the top of the flag pole from Joff's eye level is 12.4° and the angle of depression of its bottom end is 2.1°. Calculate the height of the flag pole.

14. The angle of elevation of the top of a tower from a point on the ground 80 m from the foot of the tower is 45°. Find the height of the tower.

15. An observer on top of a cliff, 25 m above sea level, views a boat on the sea at an angle of depression of 75°. How far is the boat from the foot of the cliff?

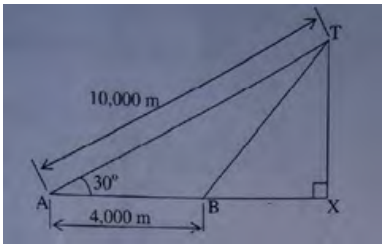
16. An observer on the top of a cliff, 25 m above sea level, views a boat on the sea at an angle of depression of 60°. How far is the boat from the top of the cliff?

17. The figure below represents plotting of two stations A and B which are 4,000 m apart. T is a stationary target in the same vertical plane as A and B. When the distance of the target from station A is 10,000 m the angle of elevation is 30°. Calculate:

    (a) the vertical height of the target, TX

    (b) the distance AX, BX and TB

    (c) the angle of elevation of the target, T, from B



18. A man is standing 10 metres from a tree which is perpendicular to the ground. The angle of elevation of the top of the tree from the point on the ground where the man is standing is 21°48′. What is the height of the tree?

19. To find the height of a tower a surveyor sets up his theodolite 100 m from the base of the tower. He finds that the angle of elevation to the top of the tower is 30°. If the instrument is 1.5 m above the ground, what is the height of the tower?

20. A man whose eye is 120 cm above the ground is standing 8 m from a tree 7 m tall. What is the angle of elevation of the top of the tree from his eye?

4.3.9 Sets

1. In a primary school of 150 pupils, 50 study Hisabati, 70 study Sayansi and 40 study both subjects. By using the appropriate formula, calculate the number of pupils who study neither Hisabati nor Sayansi.

2. A survey conducted at Omega secondary school showed that 15 students play volleyball, 11 play basketball and 6 play both volleyball and basketball. If everyone plays at least one of these games, find the number of students who play the following games (using a Venn diagram):

    (a) volleyball or basketball;

    (b) basketball but not volleyball;

(c) volleyball only.

3. In a class of 30 students, 17 participate in English debate, 12 participate in English debate and sports. If every student is required to participate in at least one of these two events, find the number of students who participate in:

   i) English debate only

   ii) sports only.

4. In a class of 42 students, 31 students study History and 26 study Physics. Using VVenn diagrams or otherwise, find the number of students who study Physics only.

5. In a certain school there are 50 pupils studying both Basic Mathematics and Additional Mathematics. School regulations require that an Additional Mathematics pupil must come from the Basic Mathematics class. In the school, 10 pupils do not study Basic Mathematics. If only 100 pupils study Basic Mathematics but not Additional Mathematics, how many pupils:

   i) are in the school?

   ii) study either Basic Mathematics or Additional Mathematics?

   iii) do not study Additional Mathematics?

   Hint: (Use Venn diagram)

6. There are 60 people at a meeting. 35 are businesspersons, 32 are employees and 15 are both businesspersons and employees.

   i) How many are businesspersons or employees?

   ii) How many are neither businesspersons nor employees?

7. There are 30 men at a wedding. Twenty are businessmen, twelve are fishermen and 6 are both businessmen and fishermen.

   i) How many are neither businessmen nor fishermen?

   ii) How many are either businessmen or fishermen?

8. (a) In a boys' school of 200 students, 90 play football, 70 play basketball and 50 play tennis; 26 play basketball and football, 20 play basketball and tennis, 16 play tennis and football while 10 play all three games. Represent this information in a well labeled Venn diagram.

   (b) From the information given in (a), how many students in the school do not play:

      i) football

      ii) basketball

      iii) tennis.

9. Student test results on three subjects; Mathematics, Physics and Chemistry show that 20 passed Chemistry, 5 passed all three subjects, 12 passed Mathematics and Physics and 16 passed Mathematics and Chemistry. Each student passed at least two subjects.

   i) Draw a well labeled Venn diagram to represent these results.

   ii) How many students passed Physics and Chemistry?

   iii) How many students did the test?

10. A survey of 240 houses showed that all of them kept a farm or a garden or both. If 180 kept gardens and 79 kept farms, how many houses kept both?

11. In a school of 75 pupils, 45% of the pupils take Biology but not Chemistry, 32% take both subjects and 10% of them take Chemistry but not Biology. How many pupils do not take either Biology or Chemistry?

12. In a Form four class of 24 students, 10 students take basic mathematics only, 12 students take physics and 4 students take both subjects. Using a Venn diagram, find:

i) The number of students taking physics only.

ii) The number of students taking mathematics.

iii) The number of students who take neither of the two subjects

13. In a class of 36 students, 24 take Chemistry whilst 17 take Physics. What is the least possible number of students who must be taking both Physics and Chemistry?

14. A and B are subsets of the universal set U. Find $\text{n}(A \cap B)$ given that $\text{n}(A) = 39$, $\text{n}(A' \cap B') = 4$, $\text{n}(B') = 24$ and $\text{n}(U) = 65$.

15. Given $A = \{(x, y) : 3x + 4y = 10\}$ and $B = \{(x, y) : 2x - 3y = 1\}$, find $A \cap B$.

16. If $\mu = \{x : 1 < x < 11\}$, $A = \{x : 2 < x \leq 9\}$, $B = \{x : 2 \leq x < 10\}$, list the elements belonging to:

i) $A \cup B$

ii) $A' \cap B$

17. P and Q are finite sets such that $\text{n}(P \cap Q') = 15$, $\text{n}(P \cup Q) = 90$ and $\text{n}(P \cap Q) = 30$. Without using a Venn diagram, find $\text{n}(Q)$.

18. If $A = \{a, b, c\}$, $B = \{b, c, d\}$ and $C = \{c, d, e\}$, show that $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$.

19. If $\xi = \{a, b, c, d, e\}$, $A = \{a, b, c\}$ and $B = \{e, d\}$, find:

i) $A' \cap B'$

ii) $(A \cap B)'$

20. If $\text{n}(A) = 8$, $\text{n}(B) = 12$ and $(A \cap B) = 5$, find $\text{n}(A \cup B)$.

21. If $\mu = \{p, q, r, s\}$, If $A = \{p, q, r\}$ and If $B = \{r, s\}$, find $(A' \cap B')$.

22. If A and B are subsets of S where
$S = \{x : x \text{ is a natural number less than } 20\}$
$A = \{x : x \text{ is an even number}\}$
$B = \{x : x \text{ is a multiple of } 3\}$
Find: (a) $\text{n}(A \cap B)$ (b) $\text{n}(A' \cup B')$

23. If A is the set of prime factors of 42 and B is the set of prime factors of 330, find $\text{n}(A \cap B)$.

24. Given sets $A = \{x : -5 \leq x < 2\}$ and $B = \{x : -1 < x < 4\}$, find the value of $A \cap B$.

25. Given $N = \{x : 1 \leq x \leq 20\}$. Find the following subsets of N:

i) $A = \{x : x \text{ is a multiple of } 3\}$

ii) $B = \{x : x \text{ is a multiple of } 4\}$

iii) A' iv) B' v) $(A \cup B)'$ and vi) $A' \cap B'$.

26. If A and B are any two disjoint sets, show the region represented by $A' \cap B'$ on a Venn diagram.

27. $U = \{10, 20, 30, 40\}$, $A = \{10, 30\}$, $B = \{40, 10\}$, find:

(a) i) $A' \cup B'$
ii) $A \cap B'$

(b) If A is a subset of B, represent the two sets in a Venn diagram.

28. If $\text{n}(A \cap B') = 8$, $\text{n}(B \cap A') = 5$ and $\text{n}(A \cup B) = 20$,

i) Display the information in a Venn diagram.

ii) Give the values of $\text{n}(A)$ and $\text{n}(B)$.

29. Given that $A = \{x : 0 \leq x \leq 8\}$ and $B = \{x : 3 \leq x \leq 11\}$, where x is an integer, in the same form, present in a Venn diagram:
    i) $A \cup B$ ii) $A \cap B$
    and hence find the elements in each set.

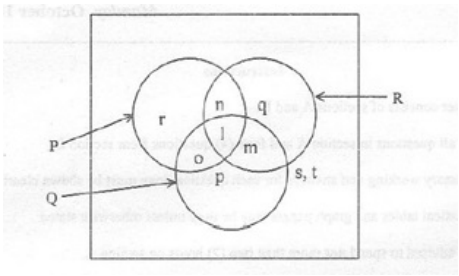
30. If $E = \{\text{integers between 1 and 11}\}$
    $A = \{x : 2 < x \leq 9\}$
    $B = \{x : 1 \leq x < 10\}$

    (a) Draw a Venn diagram to illustrate these sets.

    (b) List the elements belonging to:
    i) $A \cup B$ ii) $A' \cap B$

    (c) State $\text{n}(A \cap B')$

31. From the figure below, answer the following questions.

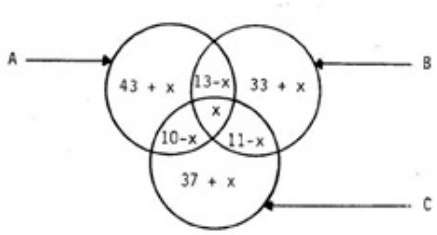


    (a) List down members of $(P \cup Q)'$

    (b) Find $\text{n}(P \cup Q \cup R)'$

    (c) Find $\text{n}(Q \cup R) - \text{n}(P \cap R)$

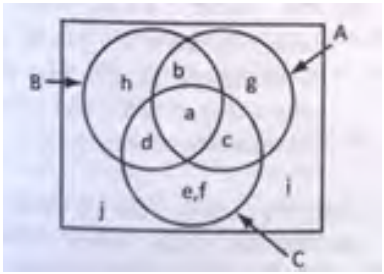
32. In the Venn diagram below, the number of elements in various regions are as indicated. If $\text{n}(A \cup B \cup C) = 150$, find the value of x.



33. In the figure drawn below, find the number of elements in sets:

    (a) $A' \cap (B \cup C)$

    (b) $(A' \cap B') \cup (B \cup C')$



4.3.10 Statistics

1. The marks of 61 students are represented in the following table:

Marks in %	30	35	45	50	60	75	80	85	90
Number of Students	3	5	7	10	18	9	4	3	2

   From the table answer the following questions:

   i) Which mark was scored by few students?

   ii) What was the highest mark?

   iii) If 50% was the pass mark in the examination, how many students passed the examination?

   iv) Which mark was scored by many students?

2. The table below show the distribution of the ages of boys in one class at Shivone secondary school.

Age in years	14 - 16	17 - 19	20 - 22	23 - 25
Number of boys	27	14	8	7

   (a) Draw a cumulative frequency polygon for this information.

3. In a survey of the number of children in 12 houses, the following data resulted: 1, 2, 3, 4, 2, 2, 1, 3, 4, 3, 5, 3.

   (a) Show this data in a frequency distribution table.

   (b) Draw a histogram and a frequency polygon to represent this data.

4. The following is a record of marks by a group of students in an examination.

23	63	82	71	12	63	38	17	23	44
54	19	70	45	70	43	18	03	02	64
45	42	40	70	63	28	18	27	58	53
23	81	70	58	31	83	19	43	72	71
48	63	62	44	38	37	46	81	73	38

   (a) Tabulate as a frequency distribution using intervals 0 - 9, 10 - 19, etc.

5. Carefully study the frequency distribution table which shows marks for 40 students in a mathematics examination.

Marks	1 - 20	21 - 40	41 - 60	61 - 80	81 - 100
Number of Students	3	11	12	8	6

   i) Draw a cumulative frequency curve.

6. A random sample of 100 students was chosen from a school. Each student's blood pressure was measured to the nearest milimetres of mercury as shown in the table below.

Blood pressure (mmHg)	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89
Number of students	1	3	8	17	30	25	16

   (a) Construct a cumulative frequency table and draw the ogive.

7. A survey was made on the number of the people attending conferences on one particular week. A random sample of 100 conference centres was taken and the results were as follows:

Number of people attending conference	**Number of conference centres**
150 - 154	8
155 - 159	16
160 - 164	43
165 - 169	29
170 - 174	4

i) Draw a histogram and a cumulative frequency curve to represent these results.

8. The following represents age distribution of members of a school choir.

Age	14	15	16	17	18	19
Frequency	2	1	3	6	5	3

(a) How many students are in the school class?

(b) Draw a pie chart to show the age distribution of the members of the school choir.

9. The data below represent masses in kg of 36 men: 51; 61; 60; 70; 75; 71; 75; 70; 74; 73; 72; 82; 70; 71; 76; 74; 50; 68; 68; 66; 65; 72; 69; 64; 83; 63; 83; 58; 80; 90; 50; 89; 55; 62; 62; 61.

i) Prepare a frequency distribution table of class interval of size 5 beginning with the number 50 taking into consideration that both the lower limit and upper class limit are inclusive.

10. The data below shows test scores of a certain class in mathematics.

21 21 21 22 22 22 22 23 23 24
24 24 21 24 24 25 26 27 27 27

Construct a frequency distribution table showing scores x and frequency f.

11. The table shows the masses of 100 students to the nearest kilogram.

Mass (kg)	60 - 62	63 - 65	66 - 68	69 - 71	72 - 74
Frequency	5	18	42	27	8

(a) Draw a cumulative frequency curve.

12. The table below shows the distribution of 100 shops and their profit per shop recorded in a certain month.

Profit per shop in thousands of shs.	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59
Number of shops	12	18	C	C - 7	C - 10	6

(a) Find the value of C.

(b) Prepare the frequency distribution.

(c) Draw a histogram and frequency polygon on the same diagram.

13. The frequency distribution of the length of a sample of 100 nails, measured to the nearest mm, is shown below.

Length	40 - 42	43 - 45	46 - 48	49 - 51	52 - 54	55 - 57	58 - 60
Frequency	4	9	13	20	34	18	2

(a) How many nails have length less than 51.5 mm?

(b) Draw a histogram.

14. The daily wages of one hundred men are distributed as shown below:

Wage in Tshs × 1000	3.0 - 3.4	3.5 - 3.9	4.0 - 4.4	4.5 - 4.9
Number of men	4	6	10	14

5.0 - 5.4	5.5 - 5.9	6.0 - 6.4	6.5 - 6.9
x	20	14	6

(a) Find x.

(b) Draw a histogram to represent this data.

15. The table below shows the distribution of scores of 46 students in a mathematics examination.

Marks in %	35 - 45	46 - 56	57 - 67	68 - 78	79 - 89
No. of students	20	12	7	6	1

(a) Draw a cumulative frequency curve.

16. The heights in centimetres of 100 students of a certain school were recorded as follows:

Height in cm	150	155	160	165	170	175	180	185	190
Frequency	4	9	12	16	25	20	8	4	2

From the above information answer the following questions:

(a) Draw a frequency polygon.

17. The following table shows the grade points scored by 50 students in a Mathematics test.

Grade points	0	1	2	3	4	5
Frequency	1	12	14	15	7	1

i) Represent this information by a frequency polygon.

18. The scores of a Physics test taken by 60 students were recorded as follows:

30	56	21	49	34	58	22	38	27	31	35	41	53
25	34	48	33	58	20	34	30	50	26	52	32	63
25	50	36	29	34	21	61	33	51	20	41	30	57
26	28	45	36	59	26	60	42	21	63	56	36	54
43	24	30	27	26	56	35	32					

(a) Arrange these scores into grouped frequency distribution table starting with the classes 20 - 24, 25 - 29, 30 - 34, ...

(b) Draw the histogram.

(d) Draw the ogive.

4.4 Form III Topics

4.4.1 Relations

1. Consider the relation $R = \{(x, y) : y = x^2 + 4x\}$

(a) Complete the following table for the relation R.

x	-6	-5	-4	-3	-2	-1	0	1	2	3
y										

(b) Plot the graph of the relation R.

(c) Use the graph to solve the equation $x^2 + 3 = -4x$.

4.4.2 Functions

1. A function f is defined by $f :\to 2x^2 - 2x - 1$ where x is the set $\{-2, -1, 0, 1, 2, 3\}$;

(a) Write down the set of ordered pairs $(x, f(x))$.

(b) Represent the set of ordered pairs $(x, f(x))$ in a pictorial diagram.

(c) Draw the graph of $f(x)$.

(d) Find the maximum or minimum value of the function $f(x) = 2x^2 - 2x - 1$.

2. A function f is defined by the formula $f(x) = \sqrt{x}$, where x is a whole number.

(a) Evaluate $f(9)$

(b) If $f(x) = 16$, find the value of x.

(c) Find the value of $\dfrac{f(200)}{f(2)}$

3. A function f is defined by: $f(x) = |x - 2|$.

   i) Evaluate $f(-3)$.

   ii) Find x if $f(x) = 6$.

4. If $f(x) = 5x^2 + 17x - 12$,

   (a) i) Evaluate $f(10) - f(5)$

   ii) Factorize $f(x)$

   (b) Determine the domain and range of $f(x)$

5. The curve $y = ax^2 + bx + c$ passes through the points (1,8), (0,5) and (3,20). Find the values of a, b and c and hence the equation of the curve.

6. If $f(x) = \dfrac{x + 2}{x^2 - x - 6}$, find the values of x for which the function is not defined.

7. The function f is defined by $f :\to ax + b$, for $x \in R$, where a and b are constants. It is given that $f(2) = 1$ and $f(5) = 7$.

   i) Find the value of a and b

   ii) Solve the equation $f \circ f(x) = 0$

8. Draw the graph of $x^2 = 2 + y$.

9. It has been specified that $f(x) = 2x^2 - 5x - 3$ ranges from $x = -2$ to $x = 4$.

   (a) Draw the graph of $f(x)$.

   (b) From the graph drawn in (a) above:

   i) find the value of x for which $f(x) = -10$.

   ii) determine the line from which the curve is symmetrical.

   iii) find the values of x by which $f(x)$ is negative.

   iv) solve the equation $2x^2 - 5x - 3 = 0$.

10. A function is defined by $f(x) = \dfrac{x}{x + 3}$; sketch the graph of f.

11. (a) On the same set of axes draw the graphs of $f(x) = x^2 - 4x$ and $y = x - 2$.

    (b) Using the two graphs in (a), estimate the values of x for which $x^2 - 5x + 2 = 0$, correct to 2 significant digits.

12. Without using a table of values, draw the graph of $y = -x^2 + 4x - 5$ and use it to solve the equation $-x^2 + 4x - 5 = -10$.

13. Sketch the graph of the function $f(x) = -1 + |x|$ and find:

    i) the domain and ii) the range, of $f(x)$.

14. Sketch the graph of the rational function $y = \dfrac{3x - 4}{x - 3}$ and determine its range.

15. (a) i) Draw the graphs of the functions $f(x) = x^2 - 4$ and $g(x) = x + 2$ in the same coordinate system.

    ii) Shade the region enclosed by the graphs in i) indicating the intercepts for both graphs.

    (b) From the graphs in (a) write the coordinates of the points where $f(x) = g(x)$.

    (c) State the domain and range of $f(x)$.

16. The functions f and g are defined for the domain: $\{2,3,4,5,6\}$ and the range of $f = \{8,10,12,14,16\}$ and that of $g = \{8,6,4,2,0\}$. Find $fg(3)$.
17. Find the domain and range of $f(x) = \sqrt{1-x^2}$.
18. Find the domain and range of the relation $y = 3x^2 + 2$.
19. Compute the range of the function $f(x) = x^2 - 4x + 3$ for which the domain is $\{-2,-1,0,1,2,3\}$.
20. Given the rational function $g(x) = \dfrac{mx^2}{x^2 - 3x + 2}$, determine its domain and range.
21. If f is a function such that:
$$f(x) = \begin{cases} 3 & \text{if } x \leq -1 \\ 1 & \text{if } -1 < x \leq 2 \\ 4 & \text{if } 2 < x \end{cases}$$
    (a) determine the domain and range of $f(x)$.
    (b) draw the graph of $f(x)$.

Inverse Functions

1. Write down the inverse of the function $f(x) = \frac{1}{2}x + 5$.
2. If $f(x) = \frac{1}{2}x + 5$, find $f^{-1}(6)$.
3. A function is defined by $f(x) = x^2 - 2$. Find:
    i) the inverse, $f^{-1}(x)$ of this function.
    (b) the value of $f^{-1}(-2)$.
    (c) the domain of $f^{-1}(x)$.
4. Find $g^{-1}(x)$ and hence evaluate $g^{-1}(18)$ given that $g(x) = 2^x + 2$.
5. Find the inverse of the relation $y = \dfrac{4x+1}{x-2}$.
6. Find the inverses of the following:
    (a) $\{R = (x,y) : y = 4x^2\}$
    (b) $f(x) = 20^x$
7. The functions f and g are defined by: $f(x) = |x|$ and $g(x) = 2 - 3x$.
    i) Evaluate $f(-3)$.
    ii) Find $g^{-1}(x)$ and hence evaluate $g^{-1}(8)$.
    iii) Draw on the same axes the graphs of f and g.
8. (a) If $f(x) = -2x + 3$ find $f^{-1}(3)$.
    (b) Draw the graph of $f(x) = |x - 1|$ for $-4 \leq x \leq 4$
    (c) State the domain and range of $f(x) = |x - 1|$.
9. If $f(x) = x^2 - 4x + 3$, find
    i) $f^{-1}(x)$ ii) the domain and range of $f(x)$
10. A function is defined by $f(x) = x^2 + 6$ and $g(x)$ is another function of x such that
    $g(x) = \dfrac{f(x) - f(4)}{x - 4}$.
    Find i) $g(-4)$ ii) $g^{-1}(5)$
11. Given that $g(x) = 5 + \dfrac{x}{2}$, find the values of:
    i) $g^{-1}(6)$ iii) $g^{-1}(-1)$
    ii) $g^{-1}(0)$ iv) $g^{-1}(a)$

Maximum, Minimum Values

1. Find the maximum value of the quadratic equation $2 + 30t - 5t^2$.
2. Draw a graph of the function $y = x^2 - 3x + 2$ for the values of x from -2 to 5. From your graph, find:
   (a) the range of the function.
   (b) the minimum value of y and the value of x at which this minimum value occurs.
   (c) the solution of the equation $x^2 - 3x - 4 = 0$.
   (d) the solution of the inequality $x^2 - 3x + 2 > 0$.

4.4.3 Statistics

1. The table below show the distribution of the ages of boys in one class at Shivone secondary school.

Age in years	14 - 16	17 - 19	20 - 22	23 - 25
Number of boys	27	14	8	7

   (a) Draw a cumulative frequency polygon for this information.
   (b) What is the mean age of the class?
   (c) State the median class.
   (d) Find the probability that a boy chosen at random from the class has age between 17 - 19 or 23 - 25.

2. In a survey of the number of children in 12 houses, the following data resulted: 1, 2, 3, 4, 2, 2, 1, 3, 4, 3, 5, 3.
   (a) Show this data in a frequency distribution table.
   (b) Draw a histogram and a frequency polygon to represent this data.
   (c) Calculate the mean and mode number of children per house.

3. The following is a record of marks by a group of students in an examination.

23	63	82	71	12	63	38	17	23	44
54	19	70	45	70	43	18	03	02	64
45	42	40	70	63	28	18	27	58	53
23	81	70	58	31	83	19	43	72	71
48	63	62	44	38	37	46	81	73	38

   (a) Tabulate as a frequency distribution using intervals 0 - 9, 10 - 19, etc.
   (b) Find the class which contains the median.
   (c) Find the modal class.
   (d) Calculate the mean mark using the grouped data.

4. The following frequency distribution table shows the monthly salaries for 33 workers in a certain company.

Salary (Tsh)	20000 - 29000	30000 - 39000	40000 - 49000	50000 - 59000	60000 - 69000
Number of Workers	1	4	6	10	8

Salary (Tsh)	70000 - 79000	80000 - 89000
Number of Workers	2	2

(a) By making the class mark of the class interval 50000 - 59000 as the assumed mean, calculate the mean salary.

(b) What is the mode for this distribution?

(c) Calculate the median.

(d) Find the number of workers whose salaries exceed Tsh 69,500/=.

5. The following table gives the scores of sixty students in a Basic Mathematics test.

Scores	Frequency
0 - 10	5
10 - 20	7
20 - 30	15
30 - 40	25
40 - 50	8

Calculate:

(a) The mean score if the assumed mean is obtained from the mid mark of the modal class.

(b) The median.

(c) The range.

6. Carefully study the frequency distribution table which shows marks for 40 students in a mathematics examination.

Marks	1 - 20	21 - 40	41 - 60	61 - 80	81 - 100
Number of Students	3	11	12	8	6

i) Calculate the mean score, given the assumed mean 50.5.

ii) Determine the modal class.

iii) Draw a cumulative frequency curve and use it to estimate the median.

7. A survey of 50 families showed the number of children per family as follows.

Number of children	1	2	3	4	5
Number of families	19	18	9	3	1

i) Write down the modal number of children per family.

ii) Find the median number of children per family.

iii) Calculate the mean number of children per family.

8. The age at which a child first walked (to the nearest month) was recorded for eight (8) children. The results were 12, 10, 16, 19, 10, 12, 12 and 13. Calculate the mean, mode and median of the data.

9. A random sample of 100 students was chosen from a school. Each student's blood pressure was measured to the nearest milimetres of mercury as shown in the table below.

Blood pressure (mmHg)	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89
Number of students	1	3	8	17	30	25	16

(a) Calculate the mean and mode of blood pressure.

(b) Construct a cumulative frequency table and draw the ogive. From the ogive estimate

i) the median blood pressure

ii) the percentage of students with blood pressure between 67 mmHg and 76 mmHg.

10. Carefully study the frequency distribution table for the scores of 68 students (in percentage) given here under.

Class Boundary (in percentage)	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
Frequency	6	12	14	16	8	6	6

(a) Determine the mode of the scores.

(b) Calculate the median of the scores.

(c) A student is chosen at random from the frequency distribution table above. What is the probability that his score is below 60%?

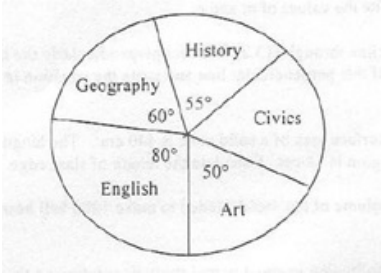
11. A survey was made on the number of the people attending conferences on one particular week. A random sample of 100 conference centres was taken and the results were as follows:

Number of people attending conference	**Number of conference centres**
150 - 154	8
155 - 159	16
160 - 164	43
165 - 169	29
170 - 174	4

i) Draw a histogram and a cumulative frequency curve to represent these results.

ii) Estimate the median of this data from the cumulative frequency curve in i) above.

12. The pie chart below shows the number of students in one examination centre in different subjects sat for the national examinations.



Given that 220 candidates did History, find:

i) The total number of candidates at this examination centre.

ii) The number of students who sat for Civics examination.

13. The following represents age distribution of members of a school choir.

Age	14	15	16	17	18	19
Frequency	2	1	3	6	5	3

(a) How many students are in the school class?

(b) What is the modal age?

(c) Calculate the mean age of the members of the school choir.

(d) What is the probability that a member chosen at random from the choir is

i) 17 years old?

ii) over or equal to 17 years?

(e) Draw a pie chart to show the age distribution of the members of the school choir.

14. The data below represent masses in kg of 36 men:
51; 61; 60; 70; 75; 71; 75; 70; 74; 73; 72; 82; 70; 71; 76; 74; 50; 68; 68; 66; 65; 72; 69; 64; 83; 63; 83; 58; 80; 90; 50; 89; 55; 62; 62; 61.

i) Prepare a frequency distribution table of class interval of size 5 beginning with the number 50 taking into consideration that both the lower limit and upper class limit are inclusive.

ii) Calculate the mean and mode from the frequency distribution table prepared in i) above by using assumed mean from the class mark of the modal class.

15. The data below shows test scores of a certain class in mathematics.

21	21	21	22	22	22	22	23	23	24
24	24	21	24	24	25	26	27	27	27

Construct a frequency distribution table showing scores x and frequency f.

16. Carefully study the frequency distribution table which shows marks for 40 students in a mathematics examination.

Marks	1 - 20	21 - 40	41 - 60	61 - 80	81 - 100
Number of Students	3	11	12	8	6

Determine:

i) The mean, given the assumed mean is 50.5

ii) The median

iii) Modal class and its corresponding class mark.

17. The table shows the masses of 100 students to the nearest kilogram.

Mass (kg)	60 - 62	63 - 65	66 - 68	69 - 71	72 - 74
Frequency	5	18	42	27	8

(a) Determine the mean of the masses.

(b) Find the mode.

(c) Draw a cumulative frequency curve and use it to determine the median of the masses.

18. The table below shows the distribution of 100 shops and their profit per shop recorded in a certain month.

Profit per shop in thousands of shs.	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59
Number of shops	12	18	C	C - 7	C - 10	6

(a) Find the value of C.

(b) Prepare the frequency distribution and use it to determine the modal class.

(c) Draw a histogram and frequency polygon on the same diagram.

19. The frequency distribution of the length of a sample of 100 nails, measured to the nearest mm, is shown below.

Length	40 - 42	43 - 45	46 - 48	49 - 51	52 - 54	55 - 57	58 - 60
Frequency	4	9	13	20	34	18	2

(a) How many nails have length less than 51.5 mm?

(b) Calculate the mean length.

(c) Draw a histogram and use it to estimate the modal length.

(d) State the modal class.

20. The daily wages of one hundred men are distributed as shown below:

Wage in Tshs $\times$ 1000	3.0 - 3.4	3.5 - 3.9	4.0 - 4.4	4.5 - 4.9
Number of men	4	6	10	14

5.0 - 5.4	5.5 - 5.9	6.0 - 6.4	6.5 - 6.9
x	20	14	6

(a) Find x.

(b) Calculate the daily mean wage of the 100 men.

(c) Draw a histogram to represent this data.

21. The table below shows the distribution of scores of 46 students in a mathematics examination.

Marks in %	35 - 45	46 - 56	57 - 67	68 - 78	79 - 89
No. of students	20	12	7	6	1

(a) i) Calculate the mean score.
ii) What is the modal class?

(b) Draw a cumulative frequency curve and estimate from it the median score.

22. The heights in centimetres of 100 students of a certain school were recorded as follows:

Height in cm	150	155	160	165	170	175	180	185	190
Frequency	4	9	12	16	25	20	8	4	2

From the above information answer the following questions:

(a) Draw a frequency polygon.

(b) Determine the mean, median and mode.

(c) Compute the variance and standard deviation.

(d) A student is chosen at random from this school. What is the probability that his height is greater than 160 cm?

23. The following table shows the grade points scored by 50 students in a Mathematics test.

Grade points	0	1	2	3	4	5
Frequency	1	12	14	15	7	1

i) Represent this information by a frequency polygon.

ii) Find the mode and median.

iii) Find the probability that, if a student is chosen at random, then her grade point score will be greater than or equal to 3.

24. The examination results (rounded to the nearest whole number %) are given for a group of students.

Mark (%)	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79
Frequency	5	3	20	2	10

(a) State the modal class.

(b) Estimate the mean score.

(c) Estimate the median score.

(d) Estimate the mode.

25. The scores of a Physics test taken by 60 students were recorded as follows:

30	56	21	49	34	58	22	38	27	31	35	41	53
25	34	48	33	58	20	34	30	50	26	52	32	63
25	50	36	29	34	21	61	33	51	20	41	30	57
26	28	45	36	59	26	60	42	21	63	56	36	54
43	24	30	27	26	56	35	32					

(a) Arrange these scores into grouped frequency distribution table starting with the classes 20 - 24, 25 - 29, 30 - 34, ...

(b) Calculate the mean score.

(c) Draw the histogram and use it to estimate the mode.

(d) Draw the ogive and use it to estimate the median.

26. Florina sat for ten examinations. In the first six subjects she scored an average of 65 marks while in the last four subjects she scored an average of 60 marks. Find the average score for all the ten examinations.

27. The mean of n numbers is 20. If the same numbers together with 30 give a new mean of 22, find n.

28. Find the geometric mean and arithmetic mean of 18 and 72.

29. Calculate the geometric mean and arithmetic mean of $3 + \sqrt{5}$ and $3 - \sqrt{5}$.

30. The arithmetic mean and geometric mean of two numbers m and n are 17 and 15 respectively. Find the two numbers.

4.4.4 Rates and Variations

Variations

1. If y is directly proportional to x, find the value of each of a, b and c in the table below.

y	8	12	b	32
x	2	a	6	c

2. x is directly proportional to y^2 and inversely proportional to z. If $x = 10$ when $y = 2$ and $z = 2$, find x when $y = 6$ and $z = 9$.

3. Given that p varies directly proportional to q but inversely proportional to r and that, when $p = 35$, $q = 7$ and $r = 6$. Find the value of p when $q = 2$ and $r = 5$.

4. Given that y is inversely proportional to x and that when x is 6, $y = 8$, find the value of y when $x = 4$.

5. Given that y varies inversely as x^2 and that $y = 4$ when $x = 3$, calculate the value of y when $x = 6$.

6. y is inversely proportional to x. When $x = 3$, $y = 2$. Find the value of y when $x = \frac{1}{3}$.

7. Given that y varies inversely as the square root of x and $y = 2$ when $x = 25$, find the value of x when $y = 4$.

8. If V varies inversely with n and $V = 220$ when $n = 6$, find V when $n = 8$.

9. The number of workers needed to repair a road is inversely proportional to the time taken. If 12 workers can finish the repair in 10 days, how long will 30 workers take?

10. the power (P) used in an electric circuit is directly proportional to the square of the current (I). When the current is 8 Amperes (A), the power used is 640 Watts (W).

    i) Write down the equation relating the power (P) and the current (I);

    ii) Calculate the current I when the circuit uses 360 Watts.

11. The surface area of a sphere V mm^2 varies directly as the square of its diameter d mm. If the surface area is to be doubled, what ratio must the diameter be altered?

12. The number of eggs which a goose lays in a week varies as the cube root of the average number of hours of sleep she has. When she has 8 hours sleep, she lays 4 eggs. How long does she sleep when she lays 5 eggs?

13. The value V of diamond is proportional to the square of its weight W. It is known that a diamond weighing 10 grams is worth shs. 200,000/=.

    (a) Write down an expression which relates V and W.

    (b) Find the value of a diamond weighing 30 grams.

    (c) Find the weight of the diamond worth 5,000,000/=.

14. The number of square tiles needed to surface the floor of a hall varies inversely as the square of the length of a side of the tile used. If 2016 tiles of side 0.4 m would be needed to surface the floor of a certain hall, how many tiles of side 0.3 m would be required?

15. Two quantities P and Q are connected by a linear relation of the form $P = KQ + C$, where K and C are constants. Find the equation connecting P and Q if $Q = 60$ when $P = 10$ and $Q = 240$ when $P = 100$ and hence find the value of K and C.

16. A variable a varies directly as b and inversely as the square root of c. If $a = 0.2$ when $b = 4$ and $c = 100$, find the value of a when $b = 16$ and $c = 64$.

17. The distance of the horizon d km varies as the square root of the height h m of the observer above sea level. An observer at a height of 100 m above sea level sees the horizon at a distance of 35.7 km. Find:

    i) The distance of the horizon from an observer 70 m above sea level.

    ii) An equation connecting d and h.

18. The length of the shadow reduces at equal rate as time goes and the sun moves from East to West. If the rate is 2 m to every 3 hrs, at what time will the shadow be, if at 7:00 am the shadow was 8 m long?

19. If y varies inversely as $\sqrt{x}$, and x is multiplied by n, what is the ratio of the first y to the second y?

Rates

1. Taps A and B can fill a tank in 6 and 10 minutes respectively. How long will it take for both taps working together to fill the tank?

2. Three classes working 8 hours a day take 5 days to harvest maize from a school shamba. How long will it take if they were only two classes, but working for 10 hours a day?

3. Sixty people working 8 hours a day take 4 days to cultivate a village farm. How long will it take twenty people to cultivate the same farm if they work 15 hours a day?

4. If six people were to work on the farm, they would finish the work in 10 days. How many more people must be employed in order to finish the work in four days?

5. A radio is sold at Tshs. 40,500/=. This price includes 20% Value Added Tax (V.A.T.). Calculate the amount of V.A.T.

6. The price of a TV set which includes V.A.T. is shs 133,800.00. If the rate of V.A.T. is 30%, find the price of the TV before V.A.T. was added.

7. A settlement has a population of 1000 people. Each year 5% of the people leave the settlement. How many people will remain after 4 years?

8. In a certain bacteria colony there are 100 bacteria and each breaks into two after each hour. Find after how many hours will the size of the colony be 7500?

9. Water flow through a circular pipe of internal radius of 10 cm at 5 m/s. If the pipe is always half full, find the number of cubic metres discharged in half an hour. ($\pi = 3.142$)

10. Juma bought motor vehicle spare parts from Japan worth 5,900,000 japanese Yen. When he arrived in Tanzania he was charged custom duty of 25% on the spare parts. If the exchange rate were as follows:
    1 US dollar = 118 Japanese Yen.
    1 US dollar = 76 Tanzania Shillings
    Calculate the duty he paid in Tanzania Shillings.

4.4.5 Sequences and Series

Sequences

1. Write down the next two terms in the following sequence: $\frac{1}{2}, \frac{2}{3}, \frac{3}{5}, \frac{5}{8}, \frac{8}{13}, \ldots$
2. Write down the general term (n^{th} term) of the sequence $\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \ldots$ Hence find the 60^{th} term.
3. The n^{th} term of a certain sequence is $\frac{5}{2}$n - 1. Find the sum of the first five terms of the corresponding series.
4. Find general term and hence the 30^{th} term of the sequence 1, -2, 4, -8, ...

Arithmetic Progressions

1. Show that the numbers between 5 and 250 which are exactly divisible by 4, form an arithmetic progression and hence find the sum of all the numbers.
2. If the 5^{th} term of an arithmetic progression is 23 and the 12^{th} term is 37, find the first term and the common difference.
3. Compute the sum of the first ten terms of the series 1 + 5 + 9 + ...
4. Given the series 100 + 92 + 84 + ... Find:
    i) The 20^{th} term
    ii) The sum of the first 20 terms
5. The second term of an A.P. is 2 and the sixth term is -14. What is the
    i) first term
    ii) common difference?
6. The 5^{th} term of an arithmetic progression is 23 and the 12^{th} term is 37. Find:
    i) the eleventh term
    ii) the sum of the first eleven terms by using the values computed in i) above without using the common difference for this progression.
7. The first four terms of an AP are 2, (a-b), (2a + b + 7) and (a-3b) respectively where a and b are constants.
    i) Find the values of the constants a and b.
    ii) The sum of the first 10 terms.
8. If the first term of an arithmetical progression is 3 and the third term is 13, find the second term, the fourth term and the sum of the first ten terms.
9. In an arithmetical progression, the thirteenth term is 27, and the seventh term is three times the second term. Determine the sum of the first ten terms.
10. (a) The n^{th} term of an AP is 12 - 4n. Find the first term and the common difference.
    (b) In an AP the 1^{st} term is -10 the 15^{th} term is 11 and the last term is 41. Find the sum of all terms in the progression.
11. The sum of the first six terms of an AP is 72 and the second term is seven times the fifth term.

i) Find the first term and the common difference.

ii) Find the sum of the first ten terms.

12. The sum of the first n terms of an arithmetic progression is 2n. If the sum of the first 2n terms of this AP is 3n, what will be the sum of the first 3n terms of the AP?

Geometric Progressions

1. Find the value of t for which $t-6$, $2t$ and $8t+20$ are the first three consecutive terms of a geometric progression.
2. Find the sum of the first four terms of a geometric progression which has a first term of 1 and a common ratio of $\frac{1}{4}$.
3. If the third term of a geometric progression is 100 and the sixth term is 800, find the fifth term and the sum of the first two terms.
4. Find the number of terms in the geometric progression: $81 + 27 + 9 + \ldots + \frac{1}{27}$.
5. The common ratio of a geometrical progression is 2 and the sum of the first eight terms is 1020. Find the first term of the progression.
6. A certain geometric progression has a common ratio of 2 and the sum of the first five terms is 155. Find the first term and give the formula for the n^{th} term.
7. If 5, x, y and 40 are in geometrical progression, find x and y.
8. In a geometric progression (GP) the sum of the second and third term is 6, and the sum of the third and fourth terms is -12. Find the sum of the first 5 terms of the GP.
9. The 5^{th} term of a GP is 8, the third term is 4 and the sum of the first ten terms is positive. Find the first term, the common ratio and the sum of the first ten terms.
10. Find the k^{th} term of the series

$$10 + 5 + \tfrac{5}{2} + \tfrac{5}{4} + \tfrac{5}{8} + \ldots, \text{ where } k = 1, 2, 3, \ldots$$

11. The sum of the first two terms of a geometrical progression is 10 and the sum of the first four terms is 40. Given that all terms of the progression are positive, show that:

    i) the common ratio is $\sqrt{3}$.

    ii) the sum of the first n terms is $5(3^{n/2} - 1)$.

12. If the sum of n terms of a GP having first term 1 and common ratio $\frac{1}{2}$ is $\frac{31}{16}$, find the number of terms.
13. Find the difference between the sums of the first ten terms of the geometric progressions whose first terms are 7 and 9 and common ratios are 3 and 2 respectively.

AP / GP Combined

1. The fourth, fifth and sixth terms of the series are: $(2x + 10)$, $(4x - 4)$ and $(8x + 40)$ respectively. Calculate the values of x and find the sum of the first ten terms when the series is:

    i) an arithmetic progression

    ii) a geometric progression

2. The second, fifth and eleventh terms of an arithmetical progression are in geometrical progression, and the seventh term is 4. Find:

    (a) the common ratio of the geometrical progression.

    (b) the common difference of the arithmetical progression.

3. The 4^{th}, 6^{th} and 9^{th} terms of an arithmetical progression (A.P.) forms the first three terms of a geometric progression. If the first term of the A.P. is 3, determine the

   (a) common difference of the arithmetical progression.

   (b) common ratio of the geometrical progression.

4. The second, fifth and seventh terms of an arithmetic progression form three consecutive terms of a geometrical progression. Find the common ratio of the geometrical progression.

5. The second and third terms of an arithmetic progression (AP) are 20 and 22 respectively. Its first, fourth and eighth terms form the first three terms of a geometric progression (GP). Determine:

   i) The common ratio of the geometric progression

   ii) The sum of the first four terms of the GP

   iii) The tenth term of the AP

6. The second, fourth and eighth terms of an arithmetic progression form three consecutive terms of a geometric progression. If the sum of the third and fifth terms of the geometric progression is 20, find the sum of the first ten terms of the geometric progression.

7. If the 2^{nd}, 4^{th} and 7^{th} terms of an AP are the first consecutive terms of the GP, find:

   (a) The common ratio

   (b) The sum of the first 4 terms of the AP if the first term is 12.

Interest

1. The amount obtained after investing a principal P for 3 years was shs. 2519.40. If the amount was compounded annually at a rate of 8%, fiind the value of P.

2. John wants to invest a certain sum of money so that its value after 3 years will be sh. 100,000/=. How much should he invest at 5% p.a. compound interest?

3. How long would it take a sum of money to double itself at 5% per annum compound interest?

4. If sh. P is invested at $r\%$ compound interest, it amounts to sh. A after n years, where:

$$A = P(1 + \tfrac{r}{100})^n$$

   Find A, if $P = 250$, $r = 4$, and $n = 12$.

5. A small business sells products worth 1,000,000 Tshs during its first year. The owner of the business has set a goal of increasing annual sales by 750,000 Tshs each year. Assuming this goal is met, find the total sales during the first 10 years of the business in operation.

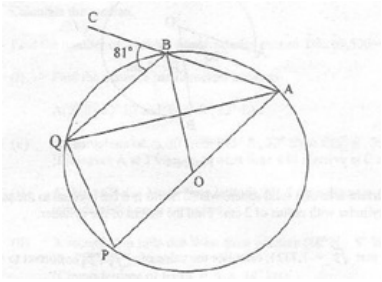
4.4.6 Circles

1. Given two circles having radius 14 cm and 7 cm,

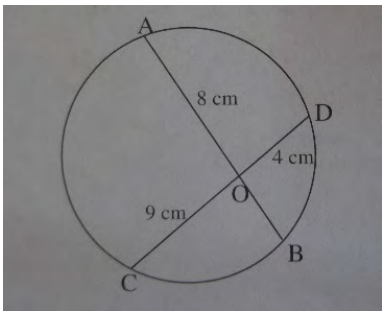
   i) find their corresponding area.

   ii) verify that the ratio of the areas of any two circles equals the square of the ratio of their radii $\left(\text{use } \pi = \dfrac{22}{7}\right)$.

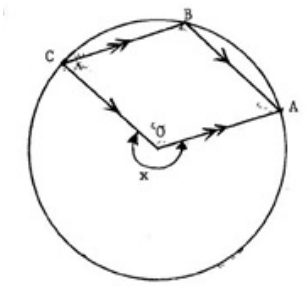
2. AOP is the diameter of a circle with centre 0.
   Given that ABC is a straight line and angle $Q\hat{B}C = 81°$, calculate the value of angle $P\hat{A}Q$.



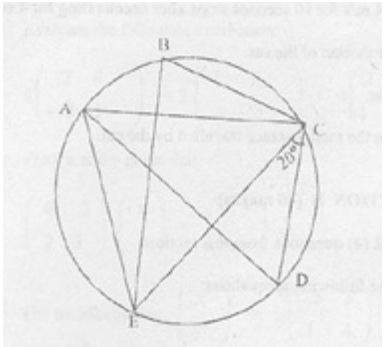
3. The chords AB and CD of the circle given below meet at point O inside the circle. Given that AO = 8 cm, OC = 9 cm and OD = 4 cm, find OB.



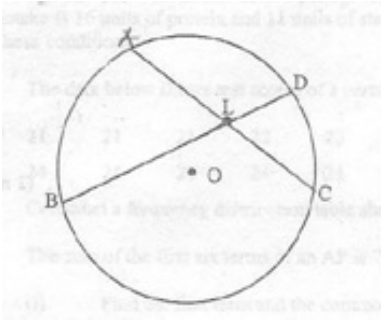
4. In the figure below, O is the centre of the circle. Find the value of x.



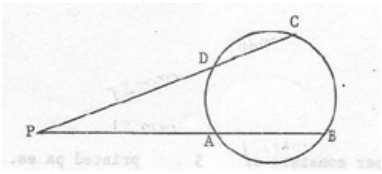
5. In the figure below ACD is an equilateral triangle and ABCD is a cyclic quadrilateral. Given that $E\hat{C}D = 20°$, find the size of angle $E\hat{B}C$.



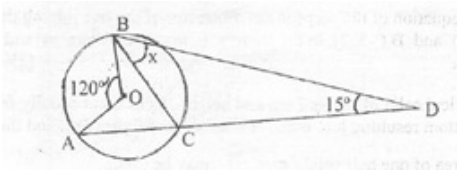
6. In the circle ABCD below, AB is an arc of 43° and CD is an arc of 25°. O is the centre of the circle. What is the degree measure of $D\hat{L}C$?



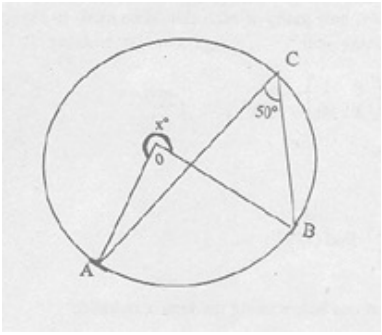
7. In the figure drawn here under, $\overline{AB} = 156$ mm, $\overline{CD} = 96$ mm and $\overline{PA}$ is 12 mm shorter than $\overline{PD}$. Find the length of $\overline{PA}$.



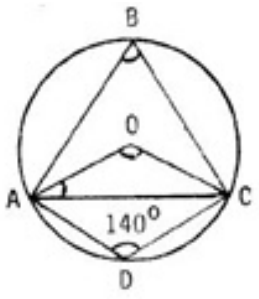
8. In the figure below, O is the centre of the circle, $A\hat{O}B = 120°$ and $C\hat{D}B = 15°$. Find the value of x.



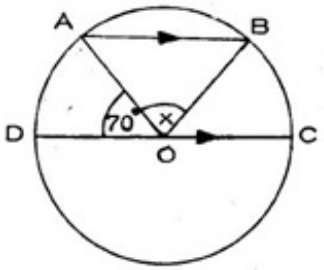
9. Determine the value of x in the figure below where O is the centre of the circle.



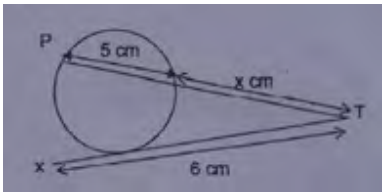
10. If, in the diagram below, ABCD is a cyclic quadrilateral, O is the centre and m$(A\hat{D}C) = 140°$, find:
    (a) m$(A\hat{B}C)$ (b) m$(A\hat{O}C)$ (c) m$(O\hat{A}C)$



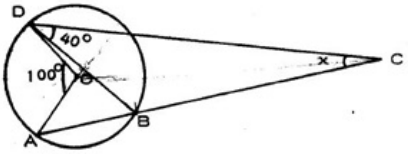
11. In the diagram below, $\overline{DC}$ is a diameter of the circle with centre O. The chord $\overline{AB}$ is parallel to $\overline{DC}$. Find the value of x given that $\text{m}(A\hat{O}D) = 70°$.



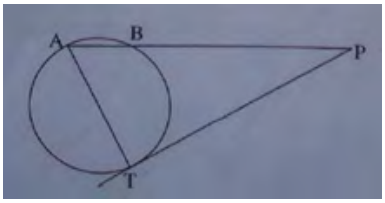
12. In the figure below find x.



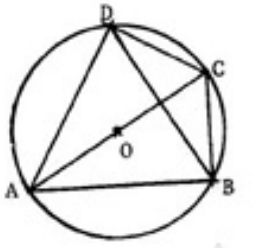
13. In the figure shown below, O is the centre of the circle, $A\hat{O}D = 100°$ and $C\hat{D}B = 40°$. Find the value of x if AC is a line segment.



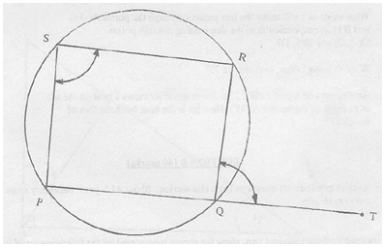
14. In the figure below, $\overline{AT}$ is the diameter of the circle. Points A, B and P lie on a straight line. $\overline{PT}$ is a tangent to the circle at T. If $AP = x$, $BP = b$ and $AT = y$, show that $y^2 = x^2 - bx$.



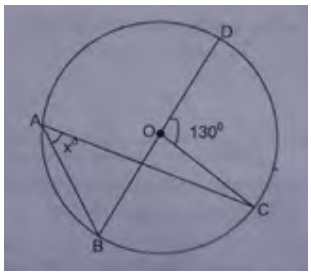
15. In the figure below, AC is the diameter of the circle ABCD and $\text{m}(D\hat{B}C) = 25°$. Find $\text{m}(A\hat{C}D)$.



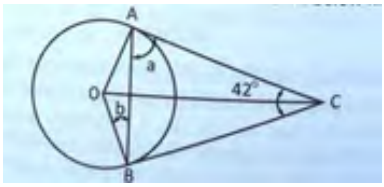
16. PQRS is a cyclic quadrilateral and PQ is produced to T. Prove that $R\hat{Q}T = P\hat{S}R$.



17. If ABCD is a circle with centre O and angle $C\hat{O}D = 130°$, BD is a diameter and angle $B\hat{A}C = x°$, calculate the value of $x°$.



18. The two tangents AC and BC to the circle drawn below meet at C.



If O is the centre of the circle, calculate the size of the angles marked a and b.

19. Prove that the angles in the same segment of a circle are equal.

20. Prove that the opposite angles of any quadrilateral inscribed in a circle are supplementary.

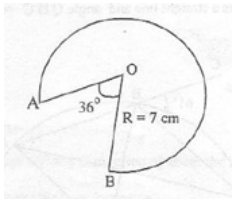
21. Prove that the two tangents from an external point to a circle are equal.

22. The end of a 60 cm pendulum describes an arc 5 cm long. Find the angle, in degrees, through which the pendulum swings.

23. i) Change 315° into radians (leave π as π).

    ii) Show that the radius of a circle with an arc of length π m and central angle $\frac{\pi}{6}$ is 6 m.

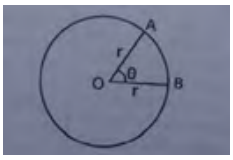
24. The figure below shows that AO = OB = 7 cm, $A\hat{O}B = 36°$ and O is the centre of the circle. Calculate the perimeter of the figure.



25. (a) Below is a circle with centre O and radius r units. By considering the circumference of the circle, the area of the circle, the given angle θ and the degree measure of the circle (360°), develop the formula for finding:

    i) Arc length AB

    ii) Area of sector AOB.



(b) Find:

i) The length of arc AB

ii) The area of the sector AOB

If θ is 57° and r is 5.4 cm $\left(\text{use } \pi = \frac{22}{7}\right)$.

26. Change each of the following angles which are in radians into degrees.

i) $\frac{7\pi}{4}$

ii) $\frac{5\pi}{9}$

27. Find the perimeter of a sector of a circle of radius 3.5 cm if the angle of the sector is 144°.

4.4.7 The Earth as a Sphere

1. Find the distance (in km) between towns P(12.4°S, 30.5°E) and Q(12.4°S, 39.8°E) along a line of latitude, correctly to 4 decimal places.

2. The location of Morogoro is 7°S, 38°E and that of Dar es Salaam is 7°S, 39°E. Find the distance between the two towns in kilometres.

3. i) Find the distance in kilometres between A(9°S, 33°E) and B(5°S, 33°E).

   ii) An aeroplane takes off from B(5°S, 33°E) to C(5°S, 39°E) at a speed of 332 km/h. If it leaves B at 3:00 pm, at what time will it arrive at C airport?

4. i) A ship sails due North from latitude 20°S for a distance of 1440 km. Find the latitude of the point it reaches.

   ii) A second ship sails due West from position (60°N, 5°W) for a distance of 1200 km. Find its new position.

   (Circumference of Earth $= 4 \times 10^4$ km).

5. A and B are two towns on latitude 42°N. If A is on the meridian 23°E and B is on 53°E,

   i) Find the angle subtended by an arc AB

   ii) Find the length of the arc AB in km.

6. Find the distance in km between Mbeya (9°S, 33°E) and Tabora (5°S, 33°E).

7. Calculate the surface distance along latitude 30°N covered between longitudes 60°E and 65°W.

8. Find the distance between A(30°N, 39°E) and B(45°S, 39°E) in

   i) Nautical miles

   ii) Kilometres

9. Calculate the volume of the earth.

10. An aeroplane takes off from Tabora (5°S, 33°E) to Tanga (5°S, 39°E) at a speed of 332 km/h. If it leaves Tabora at 3:00 pm, at what time will it arrive at Tanga airport?

11. (a) A speed boat traveling from Zanzibar (6°S, 45°E) to Mtwara (9°S, 45°E) using 30 knots left Zanzibar at 11:30 am. At what time did it reach Mtwara?

    (b) Calculate the length of diameter (in kilometres) of the parallel of latitude 64°N.

(c) Define the following terms:

i) Nautical mile

ii) Knot

12. Given that the radius of the earth is 6400 km, find:

i) the length of the parallel latitude 30°N

ii) the shortest distance along the surface of the earth from town Q whose position is (30°N, 10°E) to town P whose position is (30°N, 50°W).

13. A and B are two points on latitude 70°N. Their longitudes are 62°W and 118°E respectively. Calculate the distance in kilometres from A to B if the Earth's diameter is 12800 km for the following cases:

i) Along a great circle route over the north pole.

ii) Along a parallel of latitude.

14. two place P and Q, both on the parallel of latitude 26°N differ in latitude by 40°. Find the distance between them along their parallel of latitude.

4.4.8 Accounts

1. After Joachim completed form four in October 2010, he started chips business and he recorded the following transactions:

November	1	Started with capital of 260,000/=
	2	Purchased potatoes for cash 70,000/=
	3	Sold chips for cash 90,000/=
	7	Purchased cooking oil for cash 30,000/=
	13	Bought aluminum foil for cash 5,000/=
	19	Paid transport charge for cash 3,500/=
	20	Bought more potatoes for cash 20,000/=
	24	Paid rent for cash 6,000/=
	27	Sold chips for cash 60,000/=

(a) Enter the above transactions in a Cash Account and show the business at 1st December.

(b) Open a Capital Account for the above business.

2. (a) The following balances were extracted from the ledgers of Mr & Mrs Mkomo business on 31st January. Prepare the trial balance.

Capital	30,000/=	Insurance	3,000/=
Furniture	25,000/=	Cash	18,000/=
Motor vehicle	45,000/=	Discount received	7,000/=
Sales	68,000/=	Discount allowed	4,000/=
Purchases	54,000/=	Drawing	12,000/=
Creditors	76,000/=	Electricity	5,000/=
Debtors	15,000/=		

(b) Determine the gross profit and the net profit from the information given below.

Sales	38,000/=
Opening stock	8,000/=
Purchases	25,000/=
Electricity	4,000/=
Discount allowed	2,000/=
Closing stock	5,000/=

3. On 1st September 2006, the assets and liabilities of ABC Company were as follows:

Cash in hand	500 000
Cash at bank	1 400 000
Debtor: T	440 000
Debtor: Z	400 000
Creditor: X	670 000
Creditor: Y	650 000
Stock	450 000
Equipment	700 000
Fixture and Fitting	1 000 000
Motor Vehicle	3 200 000
Premises	5 200 000

Prepare the Balance Sheet of ABC Company as at 30 September 2006.

4. Study the given trial balance and answer the questions that follow.

Trial Balance as at 31 December 2007

S/N	Account Name	Debit (Dr)	Credit (Cr)
1	Cash	185 000	
2	Capital		200 000
3	Purchases	110 000	
4	Sales		104 000
5	Water Bills	3 000	
6	Advertising	2 000	
7	Telephone Bills	1 000	
8	Salaries	3 000	
		304 000	**304 000**

Prepare the following for the year ending 31 December 2007:

(a) Trading Account

(b) Profit and Loss Account

(c) Balance Sheet

5. From 1st January to 29th January 2006 Mr. Bin decided to keep record of his business as follows:

Jan	1	Mr. Bin started business with capital in cash	500 000/=
	5	Purchased goods	254 000/=
	6	Sold goods	290 000/=
	9	Purchased goods	204 000/=
	10	Expenses	24 000/=
	29	Sold goods	320 000/=

You are required to:

(a) Prepare the Trial Balance

(b) Open the Capital and Cash Account

N.B. *All payment and receipt were made in cash.*

6. The following information relates to Mr. Kazimoto, a trader, as at 30th July 2004:

Sales:	shs. 340 000
Cost of sales:	75% of sales
Opening Stock:	shs. 90 000
Net Profit:	20% of sales
Closing Stock:	20% of cost of goods sold

Calculate:
(a) Purchases
(b) Cost of sales
(c) Closing Stock
(d) Net Profit
(e) Expenses

7. At the bearing of August 2008, Nguvumpya Secondary School started up a school project shop with a capital of Tshs. 1,800,000/=. The school project manager made the following transactions.

On August 6th	she bought some stationeries for the shop worth Tshs. 180,000/=
On August 9th	she sold goods to the students worth Tshs. 270,000/=
On August 11th	she bought soft drinks for the shop from the IPP Company worth Tshs. 630,000/=
On August 13th	she sold foodstuffs to teachers worth Tshs. 450,000/=
On August 15th	she sold foodstuffs to villagers worth Tshs. 360,000/=
On August 17th	she bought loaves of bread for the shop worth Tshs. 450,000/=
On August 19th	paid transport charges Tshs. 50,000/= and the shop management paid wages to the shop manager Tshs. 90,000/= on August 28th.

   (a) Enter these transactions in a cash book.

   (b) Bring down the balance at the end of August 28th 2008.

8. Enter the following items in a cash a/c balance, off at the end, and bring the balance.

Jan 1996:

January 1st	balance of cash in hand	6,000/=
January 2nd	we paid for repairs	250/=
January 3rd	we paid garage expenses	750/=
January 4th	cash sales	2,500/=
January 5th	we paid wages	300/=
January 6th	we paid Anna	150/=
January 7th	we paid John	1,300/=
January 8th	we paid office expenses	175/=
January 9th	cash sales	1,500/=
January 10th	Samwel paid us	1,400/=
January 11th	we received from Asha	1,500/=
January 12th	we paid Peter	2,500/=
January 13th	we paid for office expenses	75/=
January 14th	cash sales	2,300/=

9. Record the following transactions per the month of February 2010.

February:

1	Started business with 50,000/= in the bank
2	Bought motor van paying by cheque 12,000/=
6	Took 20,000/= out of the bank and put it into the cash
10	Bought office equipment paying by cash 6,000/=
18	Cash sales 8,000/=
19	Paid motor expenses for cash 4,700/=
27	Paid rent for cash 540/=
28	Komba paid us a cheques of 9,800/=

4.5 Form IV Topics

4.5.1 Coordinate Geometry

Slope / Equation of a Line

1. The coordinates of the points O, P, Q and R are (0,0), (2,-1), (3,2) and (13,4) respectively and $\overline{OR} = a\overline{OP} + b\overline{OQ}$. Find the value of each of the scalars a and b.

2. Write down the equation of the line which passes through (7,3) and which is inclined at 45° to the positive direction of the x-axis.

3. Find an equation of a line passing through point (3,4) and its inclination is 45°.

Midpoint

1. Find the coordinates of the midpoint of the line joining the points (-2,8) and (-4,-2).
2. Find the equation of the straight line joining the point O(0,0) to the mid-point of the line joining A(3,2) and B(5,-1).
3. The line defined by the equation $x + y = 12$ crosses the y-axis at A and meets the line $x = 6$ at B. If C is the point (0,3) and M is the midpoint of $\overline{AB}$, find:
   (a) the coordinates of A, B and M
   (b) the equation of the line $\overline{CM}$
   (c) the equation of the line which is perpendicular to the line $\overline{CM}$ passing through M.

Distance Between Two Points

1. Find the distance between the point (-3,-2) and the point midway between (2,13) and (4,7). Write your answer in the form $a\sqrt{c}$ wher a and c are positive real numbers.
2. Find the distance between the points A(3,7) and B(-2,-5).
3. The coordinates of the points A, B and C are (4,3), (3,-2) and (7,-1) respectively. From this information find the:
   (a) length of AB
   (b) equation of the line BC. (Write your answer in the form $ax + by + c = 0$).
4. Find the coordinates of a point of a line presented by $2x - 3y + 7 = 0$, which is equi-distant from the points (-4,-8) and (7,1).

Parallel / Perpendicular Lines

1. Find the equation of a straight line that is parallel to the line $3x + 4y = 1$ and cuts the x-axis where $x = -1$. Express your answer in the form $ax + by + c = 0$ where a, b and c are constants.
2. Determine the equation of a line which passes through the point N(5,0) and is parallel to the line $3x + 4y = 12$.
3. The line passing through the points A(k,4) and B(3,2k) is parallel to the line $y + 3x - 4 = 0$. Find the value of k.
4. The gradient of line l_1 is -2. Another line, l_2, is perpendicular to l_1 and passes through (-3,-2). What is the equation of l_2?
5. (a) What value of K will make the line containing the points (K,5) and (-2,3) parallel to the line containing the points (6,K) and (2,0)?
   (b) What value of K will make the lines perpendicular to each other?
6. The line l is perpendicular to the line $y = 4x - 5$. If l passes through the point (-4,4), find its equation.
7. Find the equation of the line passing through the point (-3,8) which is perpendicular to the line defined by the equation $y = 3x - 4$.
8. Both lines "r" and "s" pass through the point (k,9). Line "r" has a slope of $-\frac{4}{3}$ and passes through the point (5,-3). Determine the:
   (a) value of k.
   (b) equation of "s" in standard form of $ax + by + c = 0$, if its x-intercept is -14.
   (c) equation of line "t" perpendicular to line "r" which passes through the point (k,9) if form of $y = mx + c$.

9. Find the equation of the perpendicular bisector of the line joining a line segment whose end-points have coordinates (0,2) and (3,6). Put it in the form $y = ax + b$.

10. Find the equation of the perpendicular bisector of the line joining the points A(3,-1) and B(-5,2), in the form $y = mx + c$ where m and c are constants.

11. Find the equation of a line through the point (2,3) perpendicular to the line whose equation is $4y - 3x + 1 = 0$.

12. What value of t will make the line passing through the points A(-5,t) and B(1,2) perpendicular to the line passing through points C(-1,-2) and D(5,1)?

13. A straight line through (13,2) intersects perpendicularly the line $3x - 2y + 4 = 0$. Find the equation of this perpendicular line and write the equation in standard form.

14. Line L is perpendicular to the line joining the points (-3,2) and (5,6). If it passes through the point of intersection of the lines $2x - y = 1$ and $3x + 3y - 6 = 0$, determine the equations of line L.

15. (a) L_1 and L_2 are two lines which intersect each other at a right angle at the point (1,3). L_1 cuts the y-axis at the point (0,2). Find the equation of L_1 and L_2.

    (b) By plotting the equations L_1 and L_2 on the same axes, demonstrate that the solution of simultaneous equations can be obtained graphically.

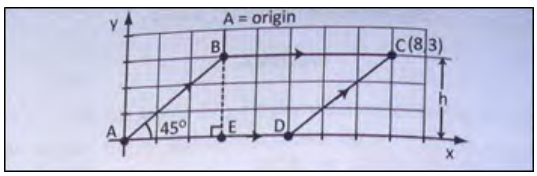
16. Determine the coordinates of the point P(x,y) on the y-axis such that the line joining it to the point (3,-1) forms a right angle with the line through the points (3,-1) and (-5,-5).

17. The point A(5,-7) is the vertex of the right angle of a right angles triangle whose hypotenuse lies along the line $6x - 13y = 39$. A second vertex of the triangle is B(0,-3). Find the remaining vertex C(x,y).

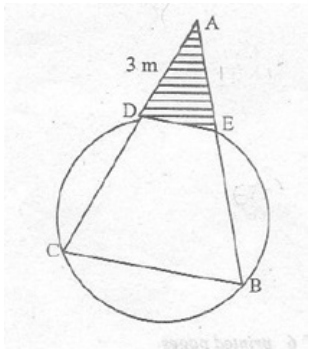
4.5.2 Areas and Perimeters

1. Calculate the perimeter of a regular polygon whose angle is 160° and whose side is 5 cm.

2. Find the area and the perimeter of the parallelogram ABCD given in the figure below if $B\hat{A}D = 45°$.



3. In the figure below, the area of the shaded part DEA is 15 m^2. If DA = 3 m and AB = 6 m, find the area of the quadrilateral BCDE.

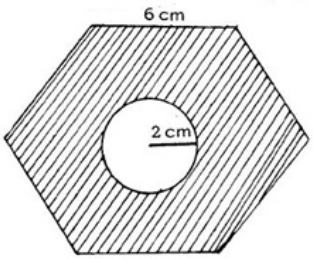


4. A regular pentagon is inscribed in a circle of radius 10 cm.

    (a) Draw a diagram to show the regular pentagon inscribed in the circle.

(b) Calculate the area of the region outside the regular pentagon but inside the circle. (use $\pi = 3.14$)

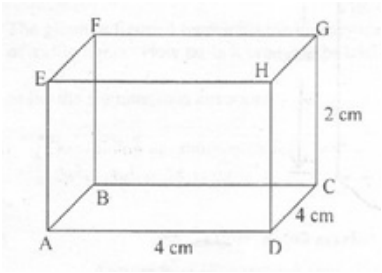
5. Find the area of triangle $\triangle ABC$ if $\overline{AB} = 4$ cm, $\overline{BC} = 7$ cm and $\text{m}(A\hat{B}C) = 30°$.
6. What is the area of a regular 45 sided polygon inscribed in a circle of radius 6 cm?
7. What is the area of a regular 36 sided polygon inscribed in a circle of radius 10 cm?
8. A regular hexagonal piece of paper has a circular hole of radius 2 cm at the centre. Each side of the regular hexagon is 6 cm long. Find the area of this piece of paper in cm^2 correct to 1 decimal place.



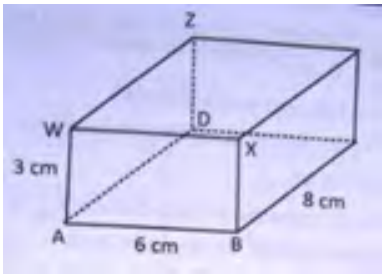
9. A circle of radius 10 units is circumscribed by a right-angled isosceles triangle. Find the lengths of the sides of the triangle and hence its perimeter (all in 2 decimal places).

4.5.3 Three Dimensional Figures

1. An open rectangular box measures externally 32 cm long, 27 cm wide and 15 cm deep. If the box is made of wood 1 cm thick, find the volume of wood used.
2. For a tank given in the figure below, calculate the angle between $\overline{DF}$ and the base ABCD.



3. The volume of a rectangular box is 1008 cm^3. If its length is 14 cm and its breadth is 9 cm, find its height.
4. A rectangular box with top WXYZ and base ABCD has AB = 6 cm, BC = 8 cm and WA = 3 cm.

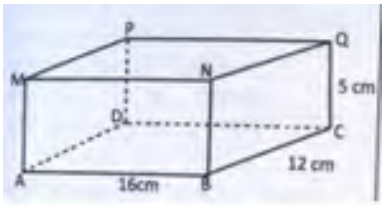


Calculate:

i) Length of AC

ii) Angle between WC and AC

5. The figure below shows a rectangular prism in which $\overline{AB} = 16$ cm, $\overline{BC} = 12$ cm and $\overline{QC} = 5$ cm.



Calculate:

(a) its total surface area

(b) the angle between $\overline{PB}$ and the base ABCD

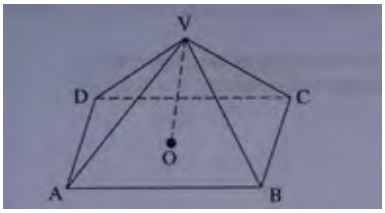
(c) the volume in litres the prism can hold (1 litre = 1000 cm^3)

6. In the figure below ABCD is a rectangle in which AB = 3 cm and BC = 2 cm. V is a point such that VA = VB = VC = VD = 6 cm and AO = OC. Find:

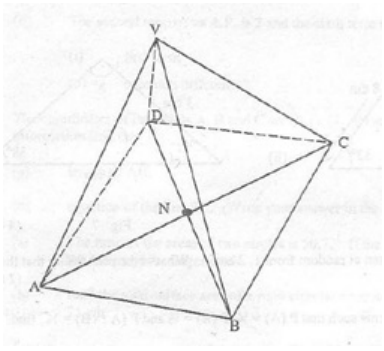
(a) The angle VAD

(b) The length of AC

(c) The angle between VA and the plane ABCD



7. In the diagram below, VABCD is a pyramid whose base ABCD is a square with sides 6 cm. The vertex V is vertically above N, the centre of the base and VN = 3 cm.



Calculate:

(a) length VA

(b) angle between the line VA and the plane ABCD

(c) volume of the pyramid.

8. A pyramid has a square base ABCD of side 10 cm. The vertex V is 12 cm above the centre of the base E.

i) Find the angle of inclination of VA to the horizontal.

ii) Calculate the volume of the pyramid.

9. ABCDV is a right square pyramid where ABCD is the square base with BC and AD being diagonals and V the vertex which is 6 cm vertically above the centre E of the base.

   (a) Draw a three dimensional diagram of the pyramid.

   (b) Calculate:

      i) the length BV

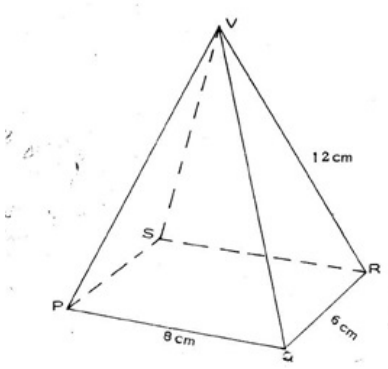
      ii) the angle between the planes AVC and BVD

      iii) the volume of the pyramid.

10. The diagram below represents a right pyramid with a rectangular base PQRS and vertex V. Each slanting edge is 12 cm long. PQ = 8 cm and QR = 6 cm. Calculate:

    (a) the angle between VPQ and the base PQRS.

    (b) the total surface area of the pyramid.



11. The surface area of a solid sphere whose radius is 6 cm is equal to the surface area of a solid right cylinder with radius of 2 cm. Find the height of the cylinder.

12. (a) The total surface area of a solid cylinder is 748 cm^2. The surface area of the circular faces is 308 cm^2. Find the height of the cylinder.

    (b) Given that the surface area of a sphere is given by $S = 4\pi r^2$ and volume by $V = \frac{4}{3}\pi r^3$, show that $V = \frac{1}{6}\left(\frac{\sqrt{s^3}}{\pi}\right)$.

13. Find the volume of the metal needed to make 1000 ball bearings of diameter 4 mm.

14. A sphere of diameter 4 cm is beaten out into a circular sheet 0.03 cm thick. Find the radius of the sheet.

15. Calculate the volume and surface area of a sphere of radius 210 cm.

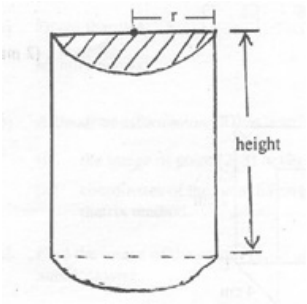
16. A sphere is cut by a horizontal plane so that the area of the cross section is 81π cm^2. If the distance from the plane to the centre is 15 cm, find the radius of the sphere.

17. The volume of two similar cylinders is 125 cm^3 and 512 cm^3. If the radius of the larger cylinder is 8 cm, find the radius of the smaller cylinder.

18. A cylinder of base radius of 14 cm has a height of 28 cm. Calculate its volume.

19. The curved surface area of a cylinder is 264 cm^2. If the height of the cylinder is 14 cm, calculate its volume and radius.

20. A cylindrical solid of radius 7 cm and height 25 cm is cut equally from the top to bottom resulting into equal half solids (see figure below). Find the total surface area of one half solid. $\pi = \frac{22}{7}$ may be used.



21. Find the capacity in litres of a bucket 24 cm in diameter at the top, 16 cm in diameter at the bottom and 18 cm deep.
22. A piece of metal 12 cm long, 8 cm wide and 3 cm thick is melted and recasted into a cone whose base area is 36 cm^2. Find the height of this cone.
23. The total surface area of a solid cone is 440 cm^2. The length of the diameter of its circular region is 14 cm. Calculate the length of the slant edge.
24. Find the total surface area of a right circular cone whose height is 24 cm and slant height is 25 cm.
25. Find the area of the curved surface of a cone whose base radius is 3 cm and whose height is 4 cm.

4.5.4 Probability

1. A bag contains 4 red, 2 white and 2 blue balls. A ball is drawn at random from the bag. Find the probability that it is not blue.
2. A box has 8 red balls and 11 white balls of the same size. A ball is drawn at random from the box. What is the probability that it is
   i) red
   ii) white?
3. A fair die is tossed once and the number showing up is recorded. What is the probability of an even number greater than two showing up?
4. The four congruent faces of a tetrahedron are marked 1, 2, 3 and 4 respectively. What is the probability that when the tetrahedron is tossed it will show a prime number?
5. An integer is selected at random from the numbers lying between 50 and 60 inclusive. Find the probability that the selected number is:
   i) prime
   ii) a multiple of four
   iii) a multiple of five
   iv) a square of a whole number.
6. Find the probability that a number chosen at random from a set of integers between 10 and 20 inclusive is either a prime number or a multiple of five.
7. The numbers 1 to 20 are each written on a card. The 20 cards are then mixed together. One card is chosen at random from the pack. Find the probability that the number on the card is:
   i) Even
   ii) A factor of 24
   iii) Prime
8. If $D = \{x : 80 \leq x \leq 100\}$, find the probability that the number selected from D is:
   i) divisible by 7

ii) a prime number

iii) an odd number.

9. Find the probability that a number selected at random from the numbers -3, -2, 0, 3, 4 and 6 will be a solution set of the equation $x^2 - x - 6 = 0$.

10. Two numbers are chosen at random from 1, 2 and 3. What is the probability that their sum is odd?

11. A pair of dice is thrown. Find the probability that the sum is 10 or greater if a 5 appears on the first die.

12. Two dice are rolled together. Find the probability of the following:

    (a) that both faces show even numbers

    (b) that one face shows an even number and the other one an odd number

    (c) that the sum of the scores on the two faces is 9.

13. A fair die and coin are tossed once. What is the probability of a head on the coin and an even number of the die showing up?

14. A black die and a white die are thrown at the same time. Find the probability of obtaining a total of i) 5 ii) 11.

15. A box contains 7 red balls and 14 black balls. Two balls are drawn at random without replacement.

    (a) Draw a tree diagram to show the results of the drawing.

    (b) Find the probability that both are black.

    (c) Find the probability that they are of the same colour.

    (d) Find the probability that the first is black and the second is red.

    (e) Verify the probability rule $P(A) + P(A') = 1$ by using the results in part (b).

16. A box contains 4 white balls and 5 black balls. Two balls are drawn at random from the box. Find the probability that both balls drawn are:

    i) white

    ii) black

17. (a) A fraction is written by selecting the numerator from the digits 1, 2, 3 and the denominator from the digits 6, 8.
    Find the probability that the fraction written is less than $\frac{1}{2}$.

    (b) Box A contains 8 items of which 3 are defective and Box B contains 5 items of which 2 are defective. An item is drawn at random from each box. What is the probability that:

        i) both items are non-defective?

        ii) one item is defective and one item is not defective?

18. A box has 8 red balls and 11 white balls of the same size. Two balls are drawn at random from the box one after another without replacement. What is the probability that:

    i) All balls are red

    ii) At least one white ball is drawn

19. A box contains 9 oranges, 7 mangoes and 2 lemons. A fruit is drawn at random and then replaced. Another draw is made. What is the probability that both fruits drawn are not mangoes?

20. (a) A two digit number is written using the numbers 2, 3 and 4 without repetition.
    Find the probability that the number is:

        i) even.

        ii) less than 30.

    (b) A family has four children. By using a tree diagram, find the probability that the family has:

i) all boys.
ii) two boys and two girls.

21. Three defective transistors and two good transistors are mixed in a box. Two transistors are randomly selected. Find the probability that they are both defective if the selections are made

    i) with replacement
    ii) without replacement

22. Box A has 10 light bulbs of which 4 are defective and box B has 6 light bulbs of which 1 is defective. If a box is selected at random and then a bulb is randomly drawn, calculate the probability that both drawn are defective.

23. At a second-hand car show, 20% of the cars have no engine, 40% have bad tyres and 15% have no engine and have bad tyres. What is the probability that a car chosen at random has good tyres and an engine?

24. The table shows a distribution of students in each age group in a class.

Age group	16	17	18	19
Number of students	7	22	13	0

    What is the probability that a student chosen from a class

    i) is 17 years old?
    ii) is over 16 years old?

25. The probability that Rose and Juma will be selected for A-level studies after completing O-level studies are 0.4 and 0.7 respectively. Calculate the probability that:

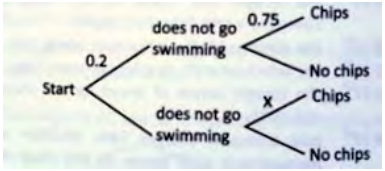
    i) both of them will be selected
    ii) either Rose or Juma will be selected

26. (a) If the probability that Ali will pass Mathematics is 0.3 and the probability that he will pass Biology is 0.6, find the probability that:
        i) He will pass both subjects
        ii) He will fail both subjects
    (b) If A is the event "Ali will pass Mathematics" and B is the event "Ali will pass Biology" show whether or not A and B are independent events (Use the information given in part (a) above).

27. Juma and Gadi are about to sit for CSEE. Juma says, "I have a 50% chance of passing my examinations." Gadi says, "Probability of failing my examinations is $\frac{1}{4}$." Find the probability that:

    i) Gadi will pass the examinations.
    ii) Either Juma will pass the examinations or Gadi will fail the examinations.

28. The probability that Joti goes swimming on any day is 0.2. On a day when he goes swimming, the probability that he has chips for supper is 0.75. On a day when he does not go swimming the probability that he has chips for supper is x. This information is shown on the following tree diagram.



    The probability that Joti has chips for supper on any day is 0.5.

i) Find x.

ii) Suppose that Joti has chips for supper. Find the probability that he went swimming that day.

29. A box contains 40 identical discs, some of them being white and the rest blue. If a disc is drawn at random, the probability that it is white is $\frac{4}{5}$.

    (a) How many blue discs are there in the box?

    (b) How many blue discs should be added into the box to make the probability of drawing a blue disc $\frac{1}{3}$?

    (c) After removing 2 white and 3 blue discs from the box what will be the probability of drawing a white disc?

30. (a) How many different three-digit numerals can be formed by using the digits 3, 4, 6, 7 and 9 if no digit may be repeated in the same numeral?

    (b) How many numerals formed in part (a) are greater than 500?

    (c) Hence find the probability of forming a three-digit numeral greater than 500 using the digits 3, 4, 6, 7 and 9 without repeating a digit in the same numeral.

    (d) Answer part (c) if digits may be repeated.

31. (a) How many four digit numbers can be formed from the digits 2, 3, 4, 5 and 6 if the digits may not be repeated in the same numeral?

    (b) How many four digit numbers greater than 3000 can be formed from the digits 2, 3, 4, 5 and 6 if the digits may not be repeated in the same numeral?

    (c) Find the probability of forming a four digit number greater than 3000, if digits may not be repeated in the same numeral.

    (d) Repeat (c) above if the digits may be repeated in the same numeral.

32. A two-digit numeral is written using the digits {2,3,4,5,6}. What is the chance that a numeral written is less than 40 if a digit may not be repeated?

33. How many even numbers greater than 2000 can be formed with the digits 1, 2, 4 and 8 if each digit may be used only once?

34. How many arrangements are there of the letters of the word "SOLOPAGA"?

35. In a class of thirty pupils, one prize is awarded for English, another for Kiswahili, and a third for Mathematics. In how many ways can the winners be chosen?

36. A girl has two jackets, four nice blouses, and three pairs of good shoes. How many different outfits, consisting of a jacket, blouse, and a pair of shoes, can she make out of these?

37. A boy has five different flags. In how many ways can he fly them one above the other?

38. Given that $P(A') = \frac{1}{6}$, $P(B') = \frac{3}{5}$ and $P(A \cap B) = \frac{1}{4}$. Find $P(A \cup B)$.

39. If A and B are two events such that $P(A) = \frac{1}{4}$, $P(B) = \frac{1}{2}$ and $P(A \cap B) = \frac{1}{8}$, find:

    i) $P(A \cup B)$

    ii) $P(A \cup B)'$

4.5.5 Trigonometry

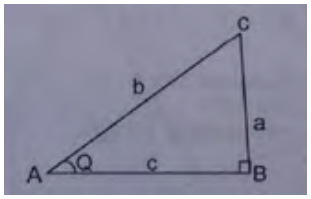
1. Show that $\sin(x+10^\circ) = \cos(80^\circ - x)$ and hence find the value of x for which $\sin(x+10^\circ) = \cos 4x$.

2. Find the values of θ between 0° and 360° which satisfy the equation:
   $\cos^2\theta = 3(1+\sin\theta)$.

3. Given the value of $\tan\theta = -1$, find the possible values of θ in the interval $0^\circ \leq \theta \leq 360^\circ$.

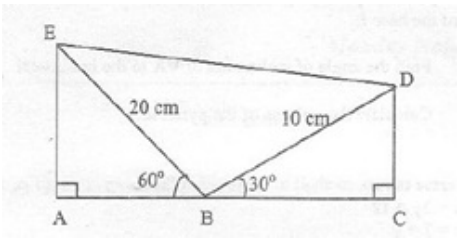
4. Find the truth set of $\sin\theta = -\dfrac{1}{2}$ in the domain $0^\circ \leq \theta \leq 360^\circ$.

5. Without mathematical tables, find the numerical value of
$$\frac{1}{\sin^2 45^\circ} + \frac{2}{\cos^2 45^\circ} + \frac{3}{\tan^2 45^\circ}$$
6. Without using tables, simplify: $\dfrac{\sin 30^\circ \cos 30^\circ}{\tan 30^\circ}$.
7. If $\tan^2 A + 2\tan^2 B + 3 = 0$, show that $\cos^2 B + 2\cos^2 A = 0$.
8. Solve for x if $2\sin^2 x - \cos x - 1 = 0$, for $0^\circ \leq x \leq 360^\circ$.
9. Solve for x if $\sin 3x = \cos 2x$ and $0^\circ \leq x \leq 90^\circ$.
10. Without using tables, evaluate $\sin 75^\circ$.
11. Factorise the expression: $\cos^4 x - \sin^4 x$.
12. Simplify the expression: $\dfrac{\sin^4 x - \cos^4 x}{\sin^2 x - \cos^2 x}$
13. Show that $(\cos\theta + \sin\theta)^2 + (\cos\theta - \sin\theta)^2 = 2$.
14. Verify that for any angle A°: $\cos(90^\circ - A^\circ) = \sin A^\circ$.
15. Given that $\cos(90^\circ - \theta) = \frac{1}{2}\sqrt{3}$ where θ is an acute angle, without using tables, find the value of $\cos\theta$.
16. Find without using tables, the value of $\tan\theta$, given that:
$\tan(\theta - 45^\circ) = \dfrac{1}{3}$.
17. (a) Use the figure below to show that $\cos^2 Q + \sin^2 Q = 1$.

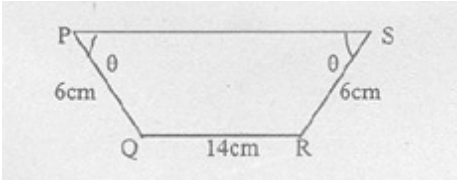


(b) Using the formula shown in (a) above, find $\cos A$ and $\tan A$, given that:
$\sin A = \dfrac{4}{9}$, $0^\circ \leq A \leq 90^\circ$

18. In the diagram below, ABC is a straight line. BE = 20 cm, BD = 10 cm, $A\hat{B}E = 60^\circ$ and m$(C\hat{B}D)$ $= 30^\circ$. Calculate the area of the quadrilateral ABDE.

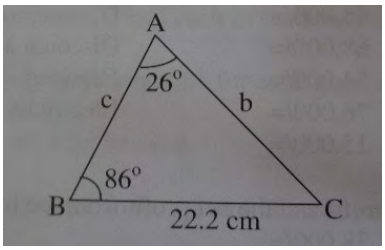


19. A water trough is to be constructed so that its cross-section is a trapezium PQRS in which PQ = RS = 6 cm, QR = 14 cm and $S\hat{P}Q = P\hat{S}R = \theta$, as shown in the diagram below.



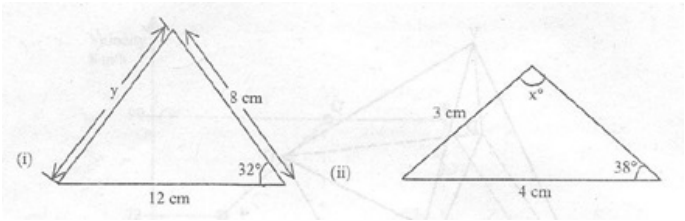
Show that the area of PQRS is given by:
$A = 84\sin\theta + 18\sin 2\theta$ given that $2\sin\theta\cos\theta = \sin 2\theta$.

20. Find the length $\overline{AC}$ from the figure below.



21. Calculate the value of angle A in a triangle for which $a = 5$, $b = 8$ and $c = 7$.

22. Find the values of length y and angle x in the figures below.



4.5.6 Vectors

1. If $\underline{a} = (3, 4)$, $\underline{b} = (1, -4)$ and $\underline{c} = (5, 2)$, determine:
   (a) $\underline{d} = \underline{a} + 4\underline{b} - 2\underline{c}$;
   (b) magnitude of vector $\underline{d}$, leaving your answer in the form $m\sqrt{n}$;
   (c) the direction cosines of $\underline{d}$ and hence show that the sum of the squares of these direction cosines is one.

2. (a) If $|x\underline{i} + 2x\underline{j} = 15$, find the value of x.
   (b) If the position vectors of points A, B are $(-2, 5)$ and $(4, 2)$ respectively;
      i) draw on the same diagram the vectors $\overline{OA}$,$\overline{OB}$ and $\overline{BA}$;
      ii) find the unit vector in the direction of vector $\overline{BA}$.

3. If $\underline{a} = 3\underline{i} + 2\underline{j}$, $\underline{b} = 2\underline{i} - 3\underline{j}$ and $\underline{c} = -4\underline{i} - 3\underline{j}$, find:
   i) $\underline{a} + 2\underline{b} - 3\underline{c}$
   ii) $|\underline{a} + 2\underline{b} - 3\underline{c}|$

4. If $\underline{a} = 5\underline{i} + 4\underline{j}$, $\underline{b} = -3\underline{i} + 3\underline{j}$ and $\underline{c} = -2\underline{i} + 5\underline{j}$, find:
   (a) $\underline{v} = 2\underline{a} + \underline{b} - 3\underline{c}$
   (b) the magnitude of $\underline{v}$

5. If $\underline{u} = 4\underline{i} + 6\underline{j}$ and $\underline{v} = \frac{1}{2}\underline{i} - 3\underline{j}$, find:
   (a) $\underline{w}$ for which $\underline{w} = \frac{1}{2}\underline{u} - 2\underline{v}$.
   (b) $|\underline{w}|$ correct to two decimal places.
   (c) the angle that $\underline{w}$ makes with the positive direction of the x-axis to the nearest degree.

6. If $\underline{a} = (3, 5)$, $\underline{b} = (2, -7)$ and $\underline{c} = (1, -4)$, evaluate $|2\underline{a} - 3\underline{b} + \underline{c}|$.

7. Given the vectors $\underline{a} = 5\underline{i} + 4\underline{j}$, $\underline{b} = -2\underline{i} + 3\underline{j}$ and $\underline{c} = 3\underline{i} + 6\underline{j}$, find:
   (a) $\underline{v} = 2\underline{a} + \underline{b} - 3\underline{c}$

(b) the magnitude of $\underline{v}$

8. If $\underline{u} = 3\underline{i} - \underline{j}$, $\underline{v} = -2\underline{i} + 3\underline{j}$ and $\underline{w} = -2\underline{i}$, find the value of $|\underline{u} + \underline{v} - \underline{w}|$.
9. The vectors $\underline{a} = (1, 4)$, $\underline{b} = -3\underline{i} + 4\underline{j}$ and $\underline{v} = 8\underline{i} - 5\underline{j}$ are position vectors. Find the coordinates of vector $\underline{c}$ such that $\underline{v} = \underline{a} + \underline{c} - 2\underline{b}$.
10. If $\underline{a} = 4\underline{i} + 5\underline{j}$, $\underline{b} = 6\underline{i} + 9\underline{j}$ determine the magnitude and direction of the vector $\underline{v} = \frac{1}{2}\underline{a} + \frac{1}{6}\underline{b}$.
11. If $\underline{a} = \underline{i} + 2\underline{j}$, $\underline{b} = \underline{i} - 2\underline{j}$ and $\underline{c} = 5\underline{i} + 14\underline{j}$, find the values of scalars p and q such that $p\underline{a} + 2q\underline{b} = \underline{c}$.
12. If $\underline{a} = 3\underline{i} + 4\underline{j}$ and $\underline{b} = x\underline{i} + y\underline{j}$,
    (a) Find the value of x and y, if $\underline{b} = 3\underline{a}$.
    (b) Find $|\underline{Z}|$ given that $\underline{Z} = \underline{a} + \underline{b}$
13. If $\underline{A}$ and $\underline{B}$ are two vectors such that $\underline{A} = 2\underline{i} + 5\underline{j}$ and $\underline{B} = -4\underline{i} + \underline{j}$, find the position vector $\overline{OM}$ where M is the midpoint of $\overline{AB}$.
14. If $\underline{a} = (2, 3)$ and $\underline{b} = (-2, 6)$ are two position vectors, find the magnitude of $\underline{c}$ where $\underline{c} = 3\underline{a} + \frac{1}{2}\underline{b}$.
15. Given $\underline{a} = (2, 1)$, $\underline{b} = (-1, 3)$ and $\underline{c} = (1, 11)$, find scalars p and q such that $p\underline{a} + q\underline{b} = \underline{c}$.
16. Calculate $|\underline{a} + \underline{b}|$ given that $\underline{a} = 2\underline{i} + \underline{j}$ and $\underline{b} = -6\underline{i} + 2\underline{j}$.
17. If $\underline{u} = 4\underline{i} + 3\underline{j}$ and $\underline{v} = 2\underline{i} + 4\underline{j}$, find:

    i) $2\underline{u} + 3\underline{v}$ ii) $7|\underline{u}|$ iii) t if $\dfrac{u}{|u|} = t\underline{u}$
18. The position vector P is $\binom{3}{6}$ and the position vector Q is $\binom{-3}{2}$. Find the vector $2PQ$ and the position vector M which is the midpoint of PQ.
19. Given the vectors $\underline{a} = 5\underline{i} - \underline{j}$, $\underline{b} = 3\underline{i} + 4\underline{j}$ and $\underline{c} = 2\underline{i} - 3\underline{j}$, calculate the resultant of $\underline{a} + \underline{b} + \underline{c}$ and the unit vector in the direction of $\underline{a} + \underline{b} + \underline{c}$.
20. Given the vectors $\underline{x} = 3\underline{i} + 2\underline{j}$, $\underline{y} = 5\underline{i} - 3\underline{j}$ and $\underline{z} = 4\underline{i} - 2\underline{j}$,
    i) Find the resultant vector $\underline{r} = \underline{x} + \underline{y} + \underline{z}$ and its direction.
    ii) Plot the three vectors on the same axes and hence indicate the magnitude of each vector (do not perform any calculation).
21. The position vectors of the points A, B and C are $4\underline{i} - 3\underline{j}$, $\underline{i} + 3\underline{j}$ and $-5\underline{i} + \underline{j}$ respectively. Find the vectors $\overline{AB}$, $\overline{BC}$ and $\overline{AC}$ and hence verify that $\overline{AB} + \overline{BC} = \overline{AC}$.
22. The resultant of two vectors $\underline{P} = (a, b)$ and $\underline{V} = (16, -8)$ is $\underline{R} = (12, -5)$. Find the magnitude and direction of vector $\underline{P}$.
23. Given $\underline{a} = \frac{1}{2}\underline{i} + \frac{1}{3}\underline{j}$, $\underline{b} = \frac{2}{3}\underline{i} + \frac{1}{3}\underline{j}$ and $\underline{c} = \underline{i} + 6\underline{j}$, determine a unit vector in the direction of the vector $\underline{d}$ where $\underline{d} = 6\underline{a} + 3\underline{b} - \underline{c}$.
24. Given the vectors $\underline{a} = -\underline{i} + 3\underline{j}$, $\underline{b} = 5\underline{i} - 2\underline{j}$ and $\underline{c} = 4\underline{a} + 3\underline{b}$.
    (a) Find the magnitude of vector $\underline{c}$.
    (b) Find the unit vector in the direction of vector $\underline{d}$ where $\underline{d} = 2\underline{a} - 3\underline{b} + \underline{c}$.
25. Calculate, to the nearest degree, the direction of the resultant velocity of a man who walks at 1.5 m/s eastwards across the deck of a ship which is moving at 4.5 m/s due north.
26. A student walks 500 m in the direction S45°E from the classroom to the basketball ground, and then she walks 200 m due west to her dormitory. What is her displacement from the classroom?
27. An aeroplane which flies at 100 km/hr in still air is flying on a day on which the wind is blowing from the South at 40 km/hr.
    (a) Find the time taken to fly north for a distance of 70 km.
    (b) i) Find the direction which the pilot must set his plane in order to fly due east.
    ii) Find the ground speed, to the nearest km/hr, and the time taken to fly due east a distance of 276 km.

4.5.7 Matrices

1. If $A = \begin{pmatrix} 1 & 2 \\ 5 & 4 \end{pmatrix}$ and $B = \begin{pmatrix} 3 & 0 \\ 6 & -1 \end{pmatrix}$
   i) Find AB, BA and comment on your results;
   ii) By expanding the brackets first, find the value of $(B - A)^2$.
2. If $A = \begin{pmatrix} 9 & 7 \\ 8 & 6 \end{pmatrix}$ and $B = \begin{pmatrix} 6 & -1 \\ -2 & 5 \end{pmatrix}$, find
   i) AB
   ii) BA
3. Given that $A = \begin{pmatrix} 6 & -1 \\ -3 & 2 \end{pmatrix}$ and $B = \begin{pmatrix} 4 & 2 \\ -5 & -1 \end{pmatrix}$ calculate
   i) AB
   ii) BA
   iii) B^{-1}
4. Evaluate the following expression:
   $3\begin{pmatrix} 2 & 4 \\ -3 & 1 \end{pmatrix} - 2\begin{pmatrix} 1 & 7 \\ 2 & -3 \end{pmatrix} + 4\begin{pmatrix} 2 & -3 \\ 1 & -2 \end{pmatrix}$
5. If $A = \begin{pmatrix} 2 & -3 \\ 1 & -2 \end{pmatrix}$, $B = \begin{pmatrix} 3 & 4 \\ -3 & 1 \end{pmatrix}$ and $C = \begin{pmatrix} 1 & 7 \\ 2 & -3 \end{pmatrix}$, find the value of $4A - 3B + 2C$.
6. Given that $A = \begin{pmatrix} 4 & -3 \\ 1 & -2 \end{pmatrix}$, $B = \begin{pmatrix} 3 & 2 \\ -4 & 0 \end{pmatrix}$ and $C = \begin{pmatrix} -1 & 3 \\ 5 & -2 \end{pmatrix}$; find $|3A - 2B + C|$.
7. Find the matrix B in the equation $AB = C$, where $A = \begin{pmatrix} 7 & 5 \\ 4 & 3 \end{pmatrix}$ and $C = \begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$.
8. Given that $A = \begin{pmatrix} 0 & 2x \\ x & 0 \end{pmatrix}$, find the values for x if $|A| = -8$.
9. Given that $A = \begin{pmatrix} 1 & 2 \\ -1 & 4 \end{pmatrix}$, find $A^2 + 5A + 6I$ where I is the identity matrix.
10. If $A = \begin{pmatrix} 2 & 4 \\ 3 & 5 \end{pmatrix}$ and $B = \begin{pmatrix} 6 & 8 \\ 9 & 5 \end{pmatrix}$, find i) A^{-1} ii) B^{-1}
11. Find the value of k such that the matrix $\begin{pmatrix} 2k + 2 & k \\ 4k - 3 & k + 3 \end{pmatrix}$ is singular.
12. Find the values of x for which the matrix $\begin{pmatrix} 2x - 5 & 24 \\ 3 & x + 1 \end{pmatrix}$ has no inverse.
13. Given the matrix $\begin{pmatrix} 27 & x \\ x & 3 \end{pmatrix}$ is singular, find the value of x.
14. (a) Determine the inverse of the matrix $A = \begin{pmatrix} 4 & 2 \\ 1 & 3 \end{pmatrix}$
    (b) Solve the following simultaneous equations by using the inverse of the matrix obtained in (a) above.
    $\begin{cases} 4x + 2y = 40 \\ x = 35 - 3y \end{cases}$
15. If the matrix $A = \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix}$ find $(A^2)^{-1}$.

16. Find the inverse, T^{-1}, of the matrix $T = \begin{pmatrix} 1 & 2 \\ -3 & -4 \end{pmatrix}$

17. It is given that $A = \begin{pmatrix} 2 & 4 \\ 3 & 1 \end{pmatrix}$, $I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ and k is a real number.

    i) Find the matrix $A - kI$.

    ii) Show that the matrix in i) above has no inverse if $k^2 - 3k - 10 = 0$.

18. For what value of n will the matrix $\begin{pmatrix} n-1 & n+3 \\ 1 & 6n \end{pmatrix}$ be non-singular?

19. Determine the value of k for which the matrix $\begin{pmatrix} k+3 & 0 \\ 0 & 2 \end{pmatrix}$ has no inverse.

20. Find the inverse of the matrix $A = \begin{pmatrix} 5 & 6 \\ 7 & 8 \end{pmatrix}$ and use it to solve the simultaneous equations:
    $\begin{cases} 5x + 6y = 11 \\ 7x + 8y = 15 \end{cases}$

21. If $\begin{pmatrix} 13 \\ 11 \end{pmatrix} = \begin{pmatrix} x & y \\ 2x & 3 \end{pmatrix} \begin{pmatrix} -2 \\ 5 \end{pmatrix}$, find the value of $x + y$.

22. Find x and y given that:
    $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 4 & -1 \\ 2 & 0 \end{pmatrix} \begin{pmatrix} 3 \\ -2 \end{pmatrix} + \begin{pmatrix} 1 \\ 6 \end{pmatrix}$

23. Solve the following simultaneous equations by matrix method.
    $\begin{cases} 2x + 3y - 2 = 0 \\ -9y + 8x - 1 = 0 \end{cases}$

24. Solve the simultaneous equations below using the matrix method:
    $\begin{cases} 4x + 2y = 40 \\ x + 3y = 35 \end{cases}$

25. Use the matrix method to solve the following simultaneous equations:
    $\begin{cases} 2x - 2y = 7 \\ 4x - 5y = 2 \end{cases}$

26. Find x and y given that $\begin{pmatrix} 4 & 5 \\ 2 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 3 \\ -1 \end{pmatrix}$

27. (a) Write the pair of simultaneous equations below as a matrix equation:
    $\begin{cases} x + 2y = 8 \\ 15y + x = 47 \end{cases}$

    (b) Solve for x and y in (a) above by inverse matrix.

28. Solve for x and y in: $\begin{pmatrix} x \\ 3 \end{pmatrix} = \begin{pmatrix} 2 \\ x + y \end{pmatrix}$.

29. Solve the equation $2\begin{pmatrix} x \\ y \end{pmatrix} + 3\begin{pmatrix} x \\ 2y \end{pmatrix} = \begin{pmatrix} 40 \\ 32 \end{pmatrix}$

30. Solve, by matrix method, the pair of simultaneous equations:
    $\begin{cases} 2x - 3y = 13 \\ 5y + 2x = 11 \end{cases}$

31. Use inverse matrix method to solve the following system of equations:
    $\begin{cases} 2x + 3y = 12 \\ 3x = 7 + y \end{cases}$

32. Use matrix method to solve for x and y for the following system:
    $\begin{cases} 2x + 3y - 8 = 0 \\ x - 2y + 3 = 0 \end{cases}$

4.5.8 Geometric Transformations

Enlargement

1. Find the enlargement matrix which maps the point $(-3, 4)$ into $(18, -24)$.
2. Find the image of $(6, 9)$ under enlargement by the matrix $\begin{pmatrix} 1/3 & 0 \\ 0 & 1/3 \end{pmatrix}$
3. A triangle with vertices $O(0, 0)$, $B(2, 0)$ and $C(2, 3)$ is enlarged by the matrix $\begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix}$ to a triangle with vertices O', B' and C'. Draw on the same set of axes the triangles OBC and $O'B'C'$.
4. Find the matrix which enlarges the vector $r = (3, 4)$ to $r' = (18, 24)$.
5. What is the image of vector $(-2, 1)$ under the transformation $\begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix}$ followed by $\begin{pmatrix} 4 & 0 \\ 0 & 4 \end{pmatrix}$?

Translation

1. Find the image of the point $(2, 4)$ when it is translated by the vector $\underline{a} = (2, 4)$.
2. A translation T maps the point $(-3, 2)$ onto $(4, 3)$. Find where T maps
   i) the point $(0, 0)$
   ii) the point $(7, 4)$
3. R is the point $(1, 2)$. It is translated onto the point S by the vector $\begin{pmatrix} 3 \\ -4 \end{pmatrix}$. Write down:
   i) The coordinates of S
   ii) The vector which translates S onto R.

Reflection

1. State a matrix T which represents a reflection on the line $y + x = 0$.
2. If $M = \begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ \sin 2\alpha & -\cos 2\alpha \end{pmatrix}$ is the matrix of reflection in a line inclined at α°, where $\alpha = 135^\circ$, $\underline{u} = (6, 1)$ and $t = 4$, find $M(t\underline{u})$.
3. Find the image of a line $5x + 10y + 9 = 0$ under a reflection in the line $y = x$.
4. Find the image of the line $2x - 7y + 14 = 0$ under a reflection in the x-axis.
5. By using the intercepts of a line $y = 2x + 5$, find the equation of the image of this line when it is reflected in the line $y - x = 0$.
6. Find the image of point $A(3, 4)$ after its reflection in the line $y+x = 0$ followed by another reflection in the line $y = 0$.

Rotation

1. Matrix B represents a rotation about the origin through 30° anticlockwise of any point (x, y). Where will matrix B map point $(-4, 4)$?
2. Find the image of the line $2x - 7y + 14 = 0$ under a rotation of 180° clockwise about the origin.
3. The circle $(x - 2)^2 + (y + 3)^2 = 4$ is rotated through an angle 90° about the origin $(0, 0)$. Find the equation of the image circle.

Combined Transformations

1. If M_2 denotes a reflection in the y-axis and R_{180} is a rotation about the origin through an angle of $180°$ for any point (x, y),
   i) Find $R_{180}M_2(x, y)$ and $M_2R_{180}(x, y)$
   ii) Is $R_{180}M_2$ commutative? Give reasons.
2. A point (x, y) is rotated through $90°$ and then reflected about the line $y = x$. Find:
   i) a single matrix for this double transformation
   ii) the image of the point $(3, 6)$ under this double transformation.
3. Let T denote a translation by the vector $(-3, 2)$ and M a reflection in the line $y = x$. Find the image of the point $(2, -1)$ under the composite transformation MT.
4. The point $A(-4, 5)$ is translated by vector $(2, 1)$ to point P and point P is reflected in the line whose equation is $x + y = 0$ to give point B. Then point B is transformed by matrix $\begin{pmatrix} 5 & 0 \\ 1 & 2 \end{pmatrix}$ to give point Q.
   Find the coordinates of i) P ii) B and iii) Q

Linear Transformations

1. A linear transformation T maps $\underline{u} = (3, -4)$ into $(-5, 3)$ and $\underline{v} = (3, 1)$ into $(5, 18)$.
   Find i) the matrix T ii) $T[3\underline{u} - 2\underline{v}]$
2. Suppose T is a linear transformation such that: $T[U] = (1, -2)$; $T[V] = (-3, -1)$; for any vectors U and V. Find
   i) $T[U + V]$
   ii) $T[8U]$
   iii) $T[3U - 2V]$
3. If vectors $\underline{u} = \underline{i} - 8\underline{j}$ and $\underline{v} = 5\underline{i} + 2\underline{j}$ and a linear transformation T has a property that $T[\underline{u}] = \begin{pmatrix} 3^1/_2 \\ 2^1/_4 \end{pmatrix}$ and $T[\underline{v}] = \begin{pmatrix} -1 \\ -5 \end{pmatrix}$; find $T[3(\underline{u} + 2\underline{v})]$.
4. The matrix $\begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$ represents a single transformation.
   i) Describe fully this transformation
   ii) Find the coordinates of the image of the point $(5, 3)$ after this transformation.
5. A transformation T has the matrix, $T = \begin{pmatrix} 1 & x \\ r & -2 \end{pmatrix}$. Under the same transformation T, the point $(-4, 1)$ is mapped onto the point $(6, 3)$. Find x and r.
6. A linear transformation T has matrix $\begin{pmatrix} 2 & -1 \\ 1 & 1 \end{pmatrix}$. Find
   i) the image of point $(2, 3)$ under T.
   ii) coordinates of the point having an image of $(7, 2)$ under T by using the matrix method.
7. Find the image of the vector $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$ under the transformation given by the matrix $M = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$.
8. A quadrilateral has its vertices at $O(0, 0)$, $A(0, 2)$, $B(2, 2)$ and $C(2, 0)$. Given the transformation T defined by $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$
   Find the coordinates of the figure $O'A'B'C'$ obtained by transforming the quadrilateral $OABC$, hence draw $OABC$ and its image on the same axes.

9. The transformation $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 5 & 2 \\ 1 & 4 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$ maps the triangle $A(3,2)$, $B(7,2)$ and $C(3,8)$ onto the triangle $A'B'C'$. Find the coordinates of A', B' and C'.

10. Given $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 2 & -2 \\ -3 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} -4 \\ 5 \end{pmatrix}$, find the image of $(2,3)$ under this mapping.

11. A linear transformation M maps the point (x, y) onto (x', y') where
$x' = x - y$
$y' = 2x + y$

    i) Write the matrix M of this transformation.

    ii) What is the matrix M^{-1} or the inverse of M?

    iii) Compute the product matrix MM^{-1}.

12. A linear transformation T maps (x, y) onto (x', y') such that $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 2 & -4 \\ -1 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} 8 \\ -4 \end{pmatrix}$. Find the image of $(2, -3)$ under T.

13. A linear transformation T maps the point (x, y) onto (x', y') where $(x', y') = (x + y, -x + 2y)$. Determine the matrix T of this transformation. Find the determinant and inverse of T.

14. A linear transformation T maps (x, y) onto (x', y') where $x' = x - y$ and $y' = x + 2y$.

    i) Write down the matrix of T

    ii) Find the image of $(5, 3)$ under T

    iii) Find the point (x, y) whose image under T is $(-5, 16)$.

4.5.9 Linear Programming

1. M & P Contractor has 150 tons of sand and 90 tons of cement for building structures A and B for business. Structure A requires 1 ton of sand and 2 tons of cement whereas structure B requires 3 tons of sand and 1 ton of cement. If structure A is sold at shs. 40,000/= and structure B at shs. 60,000/=, how many structures of each type should be made in order to get maximum profit?

2. Anna and Mary are tailors. They make x blouses and y skirts each week. Anna does all the cutting and Mary does all the sewing. To make a blouse it takes 5 hours of cutting and 4 hours of sewing. To make a skirt it takes 6 hours of cutting and 10 hours of sewing. Neither tailor works for more than 60 hours a week.

    (a) For sewing, show that $2x + 5y \leq 30$.

    (b) Write down another inequality in x and y for cutting.

    (c) If they make at least 8 blouses each week, write down another inequality.

    (d) Using 1 cm to represent 1 unit on each axis, show the information in parts (a), (b) and (c) graphically. Shade only the required region.

    (e) If the profit on a blouse is shs. 3,000/= and on a skirt is shs. 10,000/=, calculate the maximum profit that Anna and Mary can make in a week.

3. In order to obtain an adequate supply of vitamins and proteins, we need to have portions of food_1 and food_2. Food_1 contains 3 units of vitamins and 2 units of proteins per portion, while food_2 contains 2 units of vitamins and 5 units of proteins per portion. We need a minimum of 10 units of proteins and a minimum of 12 units of vitamins. What are the least number of portions of food_1 and food_2 that will fit the requirement?

4. A bread dealer can buy up to 150 loaves of bread. Premium bread costs 200/= per loaf and Royal bread costs 250/= per loaf. The dealer can spend not more than 36,000/= in the business. Premium bread sells at a profit of 40/= per loaf, while Royal bread sells at a profit of 50/= per loaf. How many loaves of bread of each type should the dealer buy in order to generate a maximum profit?

5. Two tailors A and B spend shs 15,000/= and shs 20,000/= per day to make a shirt and gown respectively. A can stitch 6 shirts and 4 gowns per day while B can stitch 10 shirts and 4 gowns per day. How many days shall each work if it is desired to stitch at least 60 shirts and 32 gowns at a minimum cost?

6. A manufacturer has 150 and 90 kilograms of wood and plastic respectively. Product A requires 1 kg of wood and 2 kg of plastic. Product B requires 3 kg of wood and 1 kg of plastic. If A is sold for Tsh. 4000/= and B for Tsh. 6000/=, how many of each should be made to obtain the maximum gross income?

7. A certain secondary school intends to buy two types of Basic Mathematics reference books. The school wants between 10 and 15 books (inclusive) of author A which cost 8,000/= each. Books from author B cost 10,000/= each. If the school has 240,000/=, what is the maximum number of books that the school can buy?

8. Kissay has 12 hectares of land available for growing maize and rice. Each hectare of maize that she plants costs 70/= and involves her 18 hours of labour, while each hectare of rice that she plants costs her 150/= and involves her five hours of labour. She has 1050/= and 90 hours of labour available. Show that te lady can not use all the land that is available and use your graph to estimate the largest amount of land she can grow maize and rice.

9. Two types of food, A and B, contain 4 and 6 units of proteins, and 5 and 3 units of starch per kg respectively. The cost of A is shs. 400.00 per kg. The cost of B is shs. 500.00 per kg. If the minimum daily intake is 16 units of protein and 11 units of starch, how much food should be bought in order to meet these conditions?

10. A person requires 15 and 14 units of chemical A and B respectively for his garden. A liquid product contains 5 and 2 units of A and B respectively, per jar, a dry product contains 1 and 4 units of A and B respectively, per carton. If the liquid product costs Tshs 3000/= per jar and the dry product costs Tshs 2000/= per carton, how many of each should a person purchase to minimize the cost and meet the requirements?

11. A girl wishes to buy skirts for herself. A white skirt costs 2,400/= per piece, while a coloured one costs 3,000/=. She intends to buy at most four white skirts. If she is prepared to spend up to 48,000/= in her shopping, find the largest number of skirts she can buy.

12. A shopkeeper buys two types of sugar; white sugar and brown sugar. The white sugar is sold at shs. 40,000/= per bag and the brown sugar is sold at shs. 60,000/= per bag. He has shs. 1,500,000/= available and decides to buy at least 30 bags altogether. He has also decided that at least one third of the bags should be brown sugar. He buys x bags of white sugar and y bags of brown sugar.

    (a) Write down three (3) inequalities which will summarize the above information.

    (b) Represent these inequalities graphically.

    (c) The shopkeeper makes a profit of shs. 10,000/= from a bag of white sugar and shs. 20,000/= from a bag of brown sugar. Assuming he can sell his entire stock, how many bags of each type should he buy to maximize his profit? Find that profit.

13. The number of units of proteins and starch contained in each of two types of food A and B are shown in the table below:

Type of Food	Units of Protein Per kg	Units of Starch Per kg	Cost per kg
A	8	10	400/=
B	12	6	500/=
Minimum daily requirement	32	22	

    What is the cheapest way of satisfying the minimum daily requirement?

14. Two types of products namely A and B are manufactured on machines M_1 and M_2. The following table shows the requirements for the production of these products.

Product	**Processing time on M_1**	**Processing time on M_2**	**Unit profit**
A	1 minute	2 minutes	200/=
B	1 minute	1 minute	200/=
Total machine hours available	6 hours and 40 minutes	10 hours	

Formulate a linear programming mathematical model and use it to find the number of both products to be manufactured for maximum profit.

15. Siti is thinking of two whole numbers x and y. Twice the first is greater than or equal to 3. But the first number is greater than three times the second. Furthermore, three times the first number is at most equal to 6 plus the second number. Find the two numbers.

16. By shading the unshaded part, show the region represented by the following set of inequalities:

    $y \leq 4$

    $x \leq 5$

    $5x + 4y \leq 20$

    $x \geq 0$ and $y \geq 0$

17. Find the maximum value of $2x + 3y$ is the region defined by:

    $x + y \leq 12$

    $y \leq 6$

    $x \geq 0$ and $y \geq 0$

18. Maximize $f = 2y - x$ subject to the following constraints:

    $x \geq 0$

    $y \geq 0$

    $2x + y \leq 6$

    $x + 2y \leq 6$

19. Find the greatest value of the function $f(x, y) = 7x + 3y$ subject to the constraints:

    $2x + 3y \leq 12$

    $x + 3y \geq 9$

    $x \geq 0$, $y \geq 0$

    (a) Draw using the same set of axes the following inequalities:
    $2x + y \leq 16$
    $x + 2y \leq 11$
    $x + 3y \leq 15$
    $x \geq 0$
    $y \geq 0$

    (b) From the graph in (a) find the points which will make the function $f(x, y) = 3x + 5y$ either a maximum or a minimum.

4.6 Advance Level - Basic Applied Mathematics (BAM) Topics

4.6.1 Calculating Devices

1. (a) By using a scientific calculator evaluate,

    i) $\log_{0.75} 7.5 - \ln 5\sqrt{3}$ correct to five significant figures

    ii) $\begin{vmatrix} 1 & 1 & 1 \\ 2 & -2 & -1 \\ 1 & 3 & -2 \end{vmatrix}^{2.356}$ correct to four decimal places

(b) The following data are the weight of 37 members in a National Boxing Club.

62	78	40	70	58	65	54	69	71	67	74	64
65	59	68	70	66	80	54	62	83	77	51	72
79	66	83	63	67	61	71	64	59	76	67	58
64											

With the aid of a scientific calculator,

i) Compute the mean weight

ii) Find the variance

iii) Calculate the standard deviation of the data

2. (a) $\dfrac{458.4^3 \times 0.00274 - 7560 \div 3567^3}{458.4^3 \times 0.00274 + 9681 \div 1516^2}$

(b) $\frac{547}{250}[\sum_{i=1}^{3} i(i+3)(i+4)]^{1/2}$

i) Find $\log y$, if $y = \dfrac{-\sqrt[3]{3.14}}{\sin 45^\circ - \log 7}$ correct to six decimal places

ii) Determine the value of q if $2.37q^3 + 0.625e^{\pi} = 314$

3. Evaluate the following expressions with the help of a calculator (write your answers correct to 2 decimal places).

(a) $\cos^{-1}\left(\frac{2}{3}\right) + \sin^{-1}\left(\frac{3}{4}\right)$

(b) $\sqrt[3]{8\sin 25^\circ \cos 55^\circ}$

(c) $\log_8 17 - \ln\left(\frac{5}{12}\right)$

(d) $T(t) = 280 + 920e^{-0.9108}$ at $t = 10$ given that $e \cong 2.72$

(e) The number of ways for 20 people to be seated on a bench if only 5 seats are available.

(f) The value of the function $f(x) = \left(1 + \dfrac{1}{x}\right)^x$ when x = 10, 100, 1,000, 10,000 and hence comment on the value of $f(x)$ when x gets very large

4.6.2 Functions

1. (a) A function is defined by the equation $f(x) = mx^2 + nx + k$. If $f(2) = 7$, $f(0) = -3$, and $f(-1) = 2$,

i) Determine the values of m, n, and k.

ii) Find the domain and range of $f(x)$

(b) i) Sketch the graph of the rational function $g(x) = \dfrac{1}{4x - 8}$

ii) What are the values of x and y for which $g(x)$ is defined?

2. (a) Given that $f(x) = 3x - 1$ and $g(x) = \sqrt{2x - 1}$. Find,

i) $f \circ g(25)$

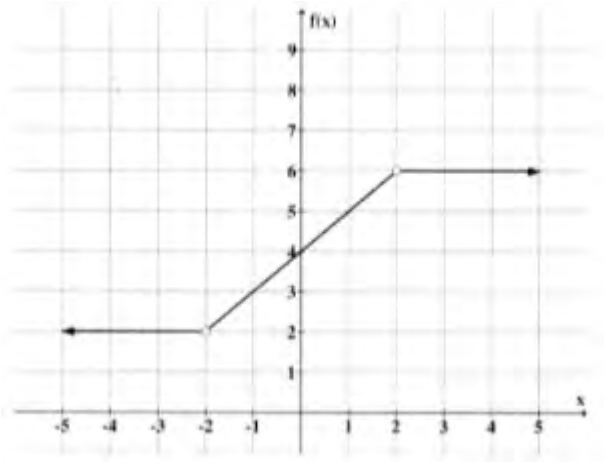
ii) $g \circ f(14)$

(b) i) Verify that $x + 4$ is not a factor of the polynomial function $f(x) = 2x^3 - 15x^2 + 24$

ii) Describe the nature of the stationary points of the function $f(x) = 2x^3 - 15x^2 + 24x$, hence show them one the graph

3. (a) Find the coordinates of the points where the line $y - 2x + 5 = 0$ meets the curve $3x^2 - 4y^2 = 10 + xy$.

(b) The graph of the function $f(x)$ is given below,



Use the graph to determine:

i) The function $f(x)$

ii) The domain and range of $f(x)$

(c) Find the asymptotes and the intercepts of the function $f(x) = \dfrac{3x-7}{x+2}$ and then sketch its graph.

4.6.3 Algebra

1. (a) The roots of the polynomial equation $P(x) = x^3 - 7x^2 + Ax - 8$ form a geometric progression. Find,

   i) The roots of the polynomial equation

   ii) The value of A

   iii) The abscissa at the turning points on the curve

   (b) Solve the following simultaneous equations by substitution method

$$\begin{cases} xy = 16 \\ x^2 + x^2 = 32 \end{cases}$$

2. (a) A series is given by $S_n = \sum_{r=1}^{n}(2r-3)$,

   i) Determine the value of S_{50} in series

   ii) Find the value of n such that $S_n = 624$

   (b) Determine the values of x and y in the following simultaneous equations

$$\begin{cases} \log(x+y) = 1 \\ \log_2 x + 2\log_4 y = 4 \end{cases}$$

3. (a) Given the series $-1 + 1 + 3, ...$

   i) Express it in the form $S_n = \sum_{r=1}^{n} f(r)$

   ii) Give one reason as to whether the series is an arithmetic or a geometric progression.

   iii) Determine the value of n for which $S_n = 575$

   (b) If in a geometric progression, the second term exceeds the first term by 20 and the fourth term exceeds the second term by 15, find the possible values of the first term.

4.6.4 Differentiation

1. (a) Show that $\dfrac{d}{dx}(\sin^{-1}(x-1)) = \dfrac{1}{\sqrt{2x-x^2}}$

   (b) A relation is defined by the equation $y^2 - 4x^3 - 4 = 0$. Find

i) The slope of the curve at a point where $x = 2$

ii) The equations of the tangent to the curve at a point where $x = 2$

(c) Find $\frac{dy}{dx}$ if $y = x^2\left(1 - \frac{1}{\sqrt{x}}e^{\tan x}\right)$

2. (a) Find $\frac{dy}{dx}$ in the following equations:

i) $y = \frac{e^x\sqrt{\cos x}}{(2x+3)^2}$, when $x = 2\pi$

ii) $yx^2 - y^2 + 5y - 20x = 14$

(b) Differentiate the function $f(x) - 4x^3 + 3x - 4$ from first principles.

(c) A 13 m long ladder leans against a wall. The bottom of the ladder is pulled away from the wall at the rate of 6 m/s. How fast does the heigh on the wall decrease when the foot of the ladder is 5 m away from the base of the wall?

3. (a) Find $\frac{dy}{dx}$ from first principle given $y = 2x^2$

(b) If $x = 2t + 9$ and $y = (t + 1)^4$, find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ in terms of x

(c) Given $f(x) = x^3 - 2x^2 + x - 7$

i) Find the stationary values of the function

ii) Find the equation of the tangent line to the curve at the point (0,-7)

iii) Draw the graph of this function for $-2 \leq x \leq 3$ and indicate on the graph the stationary points and the equation of the tangent line obtained in part (c) ii).

4.6.5 Integration

1. (a) If $f'(z) = ze^{x^2}$ and $f(0) = \frac{9}{2}$, find $f(z)$

(b) i) Calculate the area of the region bounded by the curve $y = x^2 + 3x - 18$ and the line $y = 0$

ii) The marginal cost of producing x units of a product are given by the equation $c'(x) = 0.6x^2 + 4x$. If the fixed cost is 30,000/=, find the cost function.

2. (a) Evaluate the following integrals:

$$\int_0^{0.5\pi} \cos^3 x \; dx$$

(b) The slope of a curve at any point is defined by the equation $\frac{dy}{dx} = 3x - \frac{1}{x^2}$, where $x \neq 0$. Find the equation of the curve.

(c) The area bounded by the lines $y = mx$, $y = h$, $y = 0$, and $x = 0$ is rotated about the y-axis. If $x = r$ when $y = h$. Find the volume of the figure generated in terms of h and r.

3. (a) Evaluate the following integrals

i) $\int x(x + 9)^{1/2} \; dx$

ii) $\int x\cos(5x + 9) \; dx$

(b) Given that $\int_2^4 \left(3x^2 - ax - \frac{16}{x^2}\right) \; dx = 40$, find the values of the constant a.

(c) Sketch the graph of the curve $y = x^3 - 3x^2 + 2x$ and hence find the area bounded by the curve and the x-axis.

4.6.6 Statistics

1. (a) The number of motorcycle accidents which were recorded in one region in Tanzania for seven weeks during November and December 2013 were 14, 2, 12, 4, 10, 6, and 8. Find

i) The mean number of accidents

ii) The variance of the accidents

(b) The table below shows the height of avocado trees in an orchard

Height ($\times 10^{-1}$ m)	2 - 6	7 - 11	12 - 16	17 - 21	22 - 26	27 - 31
Frequency	12	14	18	15	4	8

i) Use the data to draw the histogram

ii) Estimate the mode from the histogram in (b) i) above.

2. (a) Define the following terms as they are used in statistics:

i) Range

ii) Class size

(b) The manager of Gold Mining Company recorded the number of absent workers in 52 working days as shown in the table below:

Number of absent workers	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29
Frequency	6	9	18	16	3

Use this data to construct the cumulative frequency curve.

(c) The following data shows time in seconds which was recorded by a teacher in a swimming competition of students from Precious Beach High School.

32	31	27	30	29	27	25	29	26	26	32
32	25	31	31	27	24	26	26	32	33	28
26	33	24	28	32	29	32	24	31	27	30
31	25	29	25	27	30	26				

i) Prepare the frequency distribution using the class intervals of 0-4, 5-9, etc.

ii) Determine the standard deviation.

3. The following were the scores obtained by 22 students from Sarawak Secondary School in a mathematics classroom test:

49, 64, 38, 60, 46, 64, 68, 42, 28, 68, 57, 63, 57, 63, 76, 51, 54, 66, 62, 63, 58, 59, 47, 55

(a) Summarize the scores in a frequency table with equal class intervals of size 5. Take the lowest limit to be 35.

(b) Find the mean score by using the data in part (a)

(c) Find the interquartile range

(d) How many students scored above the mean score?

4.6.7 Probability

1. (a) A fair coin is tossed once and the results are recorded, the a fair die is tossed.

i) Draw a tree diagram to show the possible outcomes

ii) Find the probability that, the outcome contains a head and even number.

(b) Events X and Y are independent such that $P(X) = \frac{2}{3}$ and $P(X \cap Y)' = \frac{3}{4}$. Find,

i) $P(X/Y)$

ii) $P(X \cup Y)$

2. (a) If $P(n, 4) = 42P(n, 2)$

i) Find n.

ii) Evaluate $P(n, 2)$ and $P(n, 4)$.

(b) Events A, B, and C are such that A and B are independent, while B and C are mutually exclusive. If $P(A) = \frac{1}{2}$, $P(B) = \frac{1}{4}$, and $P(C) = \frac{1}{3}$, find:

i) $P(A \cap B)$

ii) $P(A \cup B)$

iii) $P(A \cup C)$

3. (a) If A and B are two events such that $P(A) = \frac{1}{4}$, $P(B) = \frac{1}{2}$ and $P(A \cap B) = \frac{1}{8}$, find $P(A \cup B)$ and $P(A' \cap B')$

(b) A fair die was rolled and the events A and B were recorded as follows: A = {1, 3, 5} and B = {2, 3, 4, 5}. Find $P(A/B)$.

(c) In Section B of CSEE Basic Mathematics Examination each candidate has to choose and answer four out of six questions. How many choices are there for each candidate?

(d) A box contains 4 ripe mangoes and 9 non-ripe mangoes. If two mangoes are randomly chosen from the box, find the probability that both will be ripe mangoes.

4.6.8 Trigonometry

1. (a) Define the following terms

i) Sine

ii) Tangent

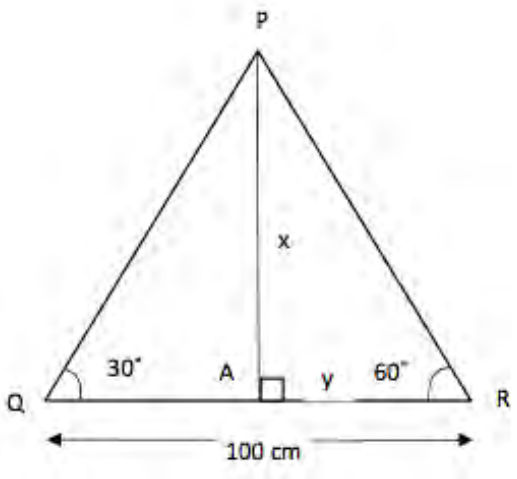
(b) Evaluate $\tan 15^\circ + \cot 75^\circ$. Give the answer in simplest form.

(c) Prove that $(1 - \cos A)(1 + \cos A) = \sin A \tan A$

2. (a) i) Express $\sin 3\theta$ in terms of $\sin \theta$

ii) Show that $\sqrt{\frac{(1 - \cos \phi)}{1 + \cos \phi}} = \csc \phi - \cot \phi$

(b) Given the figure below,



i) Determine the values of x and y

ii) Find $\sin(Q\hat{P}A)$

3. (a) Without using a mathematical table or calculator, evaluate:

i) $\cos(165^\circ)$

ii) $\tan(A + B)$ given that A and B are acute angles having $\sin(A) = \frac{7}{25}$ and $\cos(B) = \frac{5}{13}$

(b) i) Find the values of x that satisfy the equation $\sin 2x + \cos x = 0$ for $0^\circ \leq x \leq 360^\circ$

ii) Verify that the solution of the equation in part (b) i) can be obtained graphically by plotting the graph of $y = \sin 2x + \cos x$ for $0° \leq x \leq 360°$

4.6.9 Exponents and Logarithms

1. (a) Find a if $2^{2a+8} - 32(2^a) + 1 = 0$

   (b) If $2\log_8 N = p$, $\log_2 2N = q$, and $q - p = 4$, find N.

4.6.10 Matrices

1. (a) If $f(m) = m^2 - 4m - k$, find $f(N)$ when $k = \begin{pmatrix} 11 & -5 \\ -4 & 12 \end{pmatrix}$ and $N = \begin{pmatrix} 2 & 5 \\ 3 & 1 \end{pmatrix}$

   (b) Use Cramer's rule to solve the following system of linear equations

$$\begin{aligned} 5x - 7y + z &= 11 \\ 6x - 8y - z &= 15 \\ 3x + 2y - 6z &= 7 \end{aligned}$$

2. Given the system of linear equations below

$$\begin{aligned} x + y + z &= 7 \\ x - y + 2z &= 9 \\ 2x + y - z &= 1 \end{aligned}$$

   i) Write the system of equations in matrix form

   ii) Find the determinant and the inverse of the matrix

   iii) Determine the values of x, y, and z

3. (a) Given:

$$A = \begin{pmatrix} 1 & 2 \\ 3 & 4 \\ -1 & 5 \end{pmatrix}, B = \begin{pmatrix} -2 & 3 & 4 \\ 3 & 2 & 1 \end{pmatrix}, \text{ and } C = \begin{pmatrix} 3 & 5 \\ 1 & 2 \end{pmatrix}$$

   i) State with one reason as to whether the matrix operations AB, BA, and BC are defined or not.

   ii) Find $2A + 3B^T$

   (b) Verify that $\begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^2 & b^2 & c^2 \end{vmatrix} = (a-b)(b-c)(c-a)$

   (c) If $D = \begin{pmatrix} a & -4 & -6 \\ -8 & 5 & 7 \\ -5 & 3 & 4 \end{pmatrix}$ is the inverse matrix $E = \begin{pmatrix} 1 & 2 & -2 \\ 3 & b & 1 \\ -1 & 1 & -3 \end{pmatrix}$, find the values of a and b.

4.6.11 Linear Programming

1. (a) Given the linear inequalities: $2y \leq 4x$, $x \leq 6$, $y \geq 2$, and $2x + 3y \leq 30$

   i) Draw the corresponding graph

   ii) List the corner points of the feasible region

   (b) The daily prophet obtained by Fruits Beverages Company in its business is given by the objective function $f(x, y) = 250x + 350y - 2200$ and the constraints:

$$\begin{aligned} x + y &\geq 5.5 \\ 4x + 2y &\geq 16 \\ x + 2.5y &\geq 9 \end{aligned}$$

i) Represent the linear programming problem graphically

ii) Determine the minimum and maximum profit of the company

2. (a) Define the following terms:

i) Linear programming

ii) Constraints

(b) A trader has 15,000, 9,000m and 1,920 units of ingredients X, Y, and Z for production of cakes and loaves. The requirements of units of a loaf of bread and a cake are indicated in the table below:

Foodstuffs	**Units**		
	X	Y	Z
Bread	25	10	30
Cake	15	18	30

A loaf of bread is sold at 4,200/= shillings and a cake is sold at 2,000/= shillings.

i) Sketch the graph to illustrate this information

ii) What is the maximum amount of money obtained if both cakes and loaves of bread must be prepared?

iii) What should the trader do to obtain that maximum profit?

3. (a) Mr. Taramise owns 480 acres of land on which he grows either maize or beans during the farming period. He normally expects a profit of Tshs 40,000/= per acres on maize and Tshs 30,000/= per acre on beans and he has 800 hours of labor available. If maize requires 2 hours per acre to raise and beans require 1 hour per acre to raise, find how many acres of maize and beans he should plant to get maximum profit.

Physics

5.1 NECTA Physics Exam Format

5.1.1 Form II

The following format for the Form Two National Assessment (FTNA) is based on the revised version of the Physics Syllabus for Ordinary Secondary Education of 2007. The exam is intended to assess the competences acquired by the students after two years of study. The following information was taken from The National Examinations Council of Tanzania - Form Two National Assessment Formats

General Objectives

The general objectives of the Physics assessment are to test students' ability to:

1. Demonstrate laboratory practice and safety
2. Develop skills on basic principles of scientific investigation
3. Develop skills for making physical measurements
4. Recognize behavior and properties of matter
5. Understand concepts and principles of magnetism and electricity
6. Comprehend the laws of motion
7. Understand principles of simple machines
8. Develop knowledge on sustainable energy for environmental conservation

General Competences

The FTNA will specifically test the students' ability to:

1. Practice safety rules in daily life
2. Apply basic principles of scientific investigation
3. Make appropriate measurements of physical quantities
4. Use scientific skills to identify nature and properties of matter
5. Apply electricity and magnetism knowledge in daily life
6. Apply laws of motion in dealing with moving objects
7. Use simple machines to simplify work
8. Practice environmental conservation by adopting appropriate sustainable energy sources

Assessment Rubric

The assessment consists of **one (1)** theory paper. The duration of the exam is **2 hours and 30 minutes**. The paper consists of **ten (10)** questions categorized into sections A, B, and C. The students are required to attempt **all** questions from **all** sections.

1. **Section A**
   This section has **three (3)** objective questions. This section weighs a total of **thirty (30)** marks.
   (a) Question 1 is composed of 20 multiple choice items derived from various topics (20 marks)
   (b) Question 2 is composed of 5 matching items (5 marks)
   (c) Question 3 is composed of 5 filling in the blank items derived from various topics (5 marks)
2. **Section B**
   This section has **five (5)** short answer questions (10 marks each). This section weighs a total of **fifty (50)** marks.

3. **Section C**
   This section has **two (2)** questions (10 marks each). The questions are aimed at assessing students' knowledge and skills in drawing and management of Physics apparati and simple technological devices in everyday life. This section weighs a total of **twenty (20)** marks.

5.1.2 Form IV

The following format for the Form Four Certificate of Secondary Education (CSEE) is based on the revised version of the Physics Syllabus for Ordinary Secondary Education of 2007. The exam is intended to assess the competences acquired by the students after four years of study. The following information was taken from The National Examinations Council of Tanzania - Certificate of Secondary Education Examination Formats

General Objectives

The general objectives of the Physics examination are to test students' ability to:

1. Develop knowledge of concepts, laws, theories and principles of Physics
2. Use procedures of scientific investigation
3. Use scientific principles on conservation and suitable use of the environment
4. Demonstrate manipulative skills to manage various technological appliances
5. Develop the language of communication in physics

General Competences

The CSEE will specifically test the students' ability to:

1. Use Physics knowledge, principles and concepts in daily life
2. Demonstrate scientific methods in solving problems in daily life
3. Demonstrate technological skills in conservation and sustainable use of the environment
4. Manage simple technological appliances
5. Use the language of Physics in communication

Examination Rubric

The examination consists of **two (2)** papers. The first paper focuses on theory while the second focuses on practicals. This section will discuss the format for the Physics theory paper. To see the format of the Physics practical paper, please refer to Section 8.1.

The duration of the theory exam is **3 hours**. The paper consists of **eleven (11)** questions categorized into sections A, B, and C. The students are required to attempt **all** questions from sections A and B and **one** question from section C.

1. **Section A**
   This section has **three (3)** objective questions. This section weighs a total of **thirty (30)** marks.
   (a) Question 1 is composed of 10 multiple choice items derived from various topics (10 marks)
   (b) Question 2 is composed of 10 matching items (10 marks)
   (c) Question 3 is composed of 10 filling in the blank items derived from various topics (10 marks)
2. **Section B**
   This section has **six (6)** long answer questions (10 marks each). This section weighs a total of **sixty (60)** marks.
3. **Section C**
   This section has **two (2)** questions (10 marks each). The questions are aimed at assessing students' knowledge and skills in drawing and management of Physics apparati and simple technological devices in everyday life. This section weighs a total of **ten (10)** marks.

5.2 Form I Topics

5.2.1 Introduction to Laboratory Practice

1. Which of the following scientific statements need to be proved through scientific research?
   (A) Hypothesis
   (B) Principle
   (C) Conclusion
   (D) Proposal
   (E) Measurement
2. Results obtained from Physics experiment can form
   (A) Scientific Laws
   (B) Scientific Principles
   (C) Scientific Theories
   (D) Scientific Procedures
3. Which of the following are used to stop fire?
   (A) Matches
   (B) Extinguishers
   (C) Fuels
   (D) Brushes

5.2.2 Measurement

1. Micrometer screw gauge reads 5.0mm and 0.95mm for sleeve and thimble respectively, the length of object will be
   (A) 5.95mm
   (B) 59.5mm
   (C) 0.595mm
   (D) 0.0595mm
2. In laboratory, the diameter of a piece of wire can accurately be measured by:
   (A) Vernier caliper
   (B) Micrometer screw gauge
   (C) Engineer's caliper
   (D) Rate meter
   (E) Thread wound round it once
3. The relative density of a liquid can be easily determined by _____
4. i) What effect does an increase in temperature have on the density of most liquids?
   ii) Explain the procedure for using methylated spirit, water and a pendulum bob to find the relative density of spirit.
5. i) Define relative density
   ii) In an experiment using Hare's apparatus, the lengths of methanol and water columns were found to be 16 cm and 12.80 cm respectively. Find the relative density of methanol.
   iii) If the length of methanol column was altered to 21.50 cm what would be the new height of the water column?
6. (a) The mass of a density bottle is 15g. When it is filled full with a fluid of density 1.2 g/cm^3, its mass is 51 g. Find the volume of the bottle.

5.2.3 Force

1. Which one is an example of a force?
   (A) Weight
   (B) Atom
   (C) Mass
   (D) Magnet
2. Briefly explain, when does a force become weight?
3. Mass and weight of an object were determined while on the earth and then when on the moon. Suggest reason(s) for variation shown by one of the two quantities

5.2.4 Archimedes' Principle and Law of Floatation

1. Buoyant force is mainly determined by
   (A) volume and density
   (B) volume and mass
   (C) weight and mass
   (D) weight and density
2. Apparent loss in weight is known as
   (A) upthrust
   (B) Apparent weight
   (C) Pressure
   (D) Weight
3. An upthrust experienced by the body which weights 5.0N in air and 3.2N when is completely immersed in a liquid is
   (A) 0.4N
   (B) 0.6N
   (C) 1.6N
   (D) 1.8N
4. (a) i) State Archimedes' principle
      ii) Briefly explain why a ship sinks deeper in fresh water than in sea water
   (b) When a piece of wood is put in a graduate cylinder containing water, the level of water rises from 17.7 cm^3 to 18.5 cm^3. Calculate the:
      i) mass of the piece of wood
      ii) total volume of a piece of wood given that its relative density is 0.60
5. (a) Why does a solid body weigh more in air than when immersed in a liquid?
   (b) An ordinary hydrometer of mass 27g floats with 4cm of its stem out of water. If the cross sectional area of the stem is 0.75cm^2 calculate:
      i) the total volume of the stem just under the surface of the liquid
      ii) the relative density of the liquid
6. (a) A piece of cork with volume 100 cm^3 is floating on water. If the density of cork is 0.25 g/cm^3,
      i) calculate the volume of cork immersed in water
      ii) what force is needed to immerse the cork completely? (Assume a mass of 1g has a weight of 0.01N)
   (b) Ice has a density of about 0.9 g/cm^3. What fraction of the volume of an iceberg is submerged in water?

5.2.5 Structure and Properties of Matter

1. A physical phenomenon observed when a tea bag is dropped into a cup of hot water is called
   (A) Diffusion
   (B) Capillarity
   (C) Osmosis
   (D) Solution
2. A spiral spring of natural length 1.50m is extended to 1.505m by a force of 0.80N. What will be its extension when the applied force is 3.20N?
   (A) 0.005m
   (B) 6.020m
   (C) 0.020m
   (D) 4.520m
   (E) 1.57m
3. Water spreads and wets a surface when spilled on it because the:
   (A) Adhesive forces between water molecules and surface molecules are large
   (B) Cohesive forces between water molecules and surface molecules are large
   (C) Adhesive forces between water molecules are small
   (D) Cohesive forces between water molecules and surface molecules are small
   (E) Cohesive forces are greater than adhesive forces
4. The materials which return to their original shape and size after removing the stretching force is called _____
5. The kinetic theory of matter has been used to account for elasticity, surface tension and _____
6. The property of a liquid to form a layer which supports a pond skater to walk on it is called _____
7. The movement of particles from a region of high concentration to one of low concentration is called _____
8. Define
   i) Capillarity
   ii) Osmosis
9. (a) What is the essential of kinetic theory of matter?
   (b) Sketch a graph showing how force applied in a stretched string varies with its extension
   (c) State Hooke's Law
   (d) A scale pan of weight 0.4N was attached on a spring balance and produced an extension of 24mm when a load of 2N was placed on it. Calculate the load on the scale pan when the extension is 16mm.
10. (a) Explain two situations in which the phenomenon of surface tension is exhibited.
    (b) An oil drop of volume $10^{-9}m^3$ spreads out on water to form a film of area $0.2m^2$.
       i) Estimate the length of an oil drop
       ii) What assumptions have you made in calculating part (b) i) above?

5.2.6 Pressure

1. The walls of a dam are mad thicker at the bottom than at the top because
   (A) pressure of water at the bottom is greater

(B) pressure of water at the bottom is less

(C) weight of water at the bottom is greater

(D) weight of water at the bottom is less

2. A gas of volume 900cm^3 at 27°C when warmed at constant pressure to 87°C will occupy a new volume of

   (A) 900cm^3

   (B) 720cm^3

   (C) 1080cm^3

   (D) 540cm^3

   (E) 727cm^3

3. When a gas is compressed at constant temperature, the gas molecules:

   (A) Move faster than air outside and the pressure is increased

   (B) Move with uniform speed and the pressure is unchanged

   (C) Gain more kinetic energy and the pressure is decreased

   (D) Increase slightly in size and its pressure remains constant

   (E) Make more impacts per second on the walls of the container

4. The automatic flushing tank uses the working principle of _____

5. (a) Define the following terms:

      i) Pressure

      ii) Atmospheric pressure

   (b) List two factors in which pressure in liquids depend on.

   (c) A rectangular tank which measures 5m y 4m contains water to a height of 10m. Calculate:

      i) Pressure on the base

      ii) Thrust on the base

6. (a) What is an altimeter?

   (b) Briefly explain the reasons for the following:

      i. A person at great height suffers from nose bleeding

7. Briefly explain the reasons for the following:

   i) It is painful to walk barefoot on a road that is covered by pebbles

8. A cube of sides 2cm is completely submerged in water so that the bottom of the cube is at a depth of 10cm. Calculate:

   i) The difference between the pressure on the bottom of the cube and the pressure on its top

   ii) The weight of water displaced by the cube

9. A rectangular log of wood of density 200 kg/m^3 has dimensions: 0.3m × 0.5m × 6.0m

   i) Calculate the maximum pressure it can exert on the ground. How is it experienced?

   ii) Calculate the minimum pressure it can exert on the ground. How can this be observed?

5.2.7 Work, Energy and Power

1. i) Define the term energy

   ii) A ball of mass 0.2kg is dropped from a height of 20m. On impact with the ground it loses 30J of energy. Calculate the height it reaches on the rebound.

2. A car of mass 2000kg is travelling along a straight road at a constant velocity of 10m/s developing 2.0 kilowatts. If the engine of the car is switched off:

i) Calculate the energy lost by the car in coming to rest

ii) Briefly explain the energy changes in the process stated in i) above.

3. (a) Mention two practical examples in our daily life in which the principle of conservation of energy is applied

(b) i) What is a simple pendulum?

ii) Describe the energy changes that take place when a simple pendulum swings from one side to another

(c) Name a machine or an apparatus used to change the following forms of energy:

i) Heat energy to mechanical energy

ii) Mechanical energy to electrical energy

iii) Electrical energy to sound energy

iv) Sound energy to electrical energy

v) Heat energy to electrical energy

5.2.8 Light

1. In Figure 1 the angle of reflection is equal to

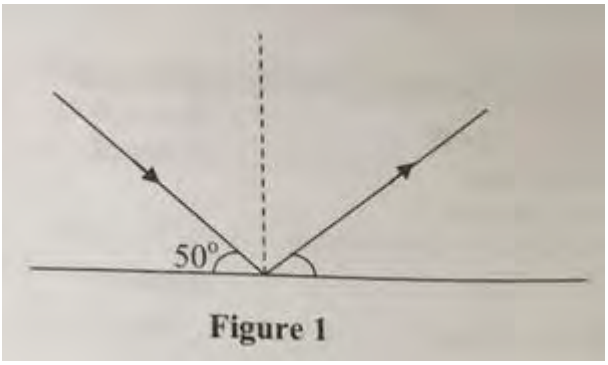


Figure 1

(A) 50°

(B) 40°

(C) 130°

(D) 45°

2. When illuminated by a certain lamp, the shadow of a table-tennis ball on a white screen is uniformly dark. This is because the lamp used is

(A) Very bright

(B) Fluorescent

(C) Very small

(D) Very weak

(E) Very large

3. A total eclipse of the sun is due to

(A) The moon coming between the earth and sun

(B) The earth coming between the moon and the sun

(C) The moon reflecting light away from the earth

(D) The sun coming between the earth and the moon

(E) The earth reflecting light away from the moon

4. The images formed by plane mirrors are always:

(A) Real, magnified, and laterally inverted

(B) Virtual, laterally inverted, and same size as the object

(C) Magnified, virtual, and erect

(D) Laterally inverted, same size as object, and real

(E) Erect, real, and magnified

5. Laterally inverted is one of the property of the image formed by _____

6. _____ is an instrument which can be used in submarines to view distant objects which are out of direct vision.

7. i) State two ways in which the image formed in a plane mirror differs from that in a pin hole camera

   ii) What is the effect of moving the pinhole camera closer to the object?

8. i) Explain the terms opaque and translucent and give an example of each

   ii) Danger signs along the road as well as tail and brake lamps of motor vehicles rear are painted in red. Briefly explain the reason why

5.3 Form II Topics

5.3.1 Static Electricity

1. A rod brought close to the cap of a charged electroscope causing the leaves of the electroscope to collapse. This indicates that:

   (A) the rod and the electroscope must be oppositely charged

   (B) the rod and the electroscope must have the same charge

   (C) the rod must be uncharged

   (D) the rod may have an opposite charge to the charge on the electroscope or may be uncharged

   (E) the rod must be charged

2. The presence of electric charge in a body can be detected by means of _____

3. (a) Briefly explain why:

      i) Nylon clothes crackle when undressed?

      ii) Petrol road tankers usually have a length of metal chain hanging and touching the ground?

   (b) What would happen when:

      i) An ebonite rod is rubbed with fur?

      ii) A glass rod is rubbed with silk?

4. i) State briefly the variation of the potential over a pear-shaped conductor and the variation of density of the charge.

   ii) An electron passes between two plates, one of which A, carries a positive charge, and the other B, a negative charge. What is the effect on the electron?

5.3.2 Current Electricity

1. The resistance of an operating lamp rated 115V and 0.25A is

   (A) 460 Ω

   (B) 29 Ω

   (C) 114.75 Ω

   (D) 230 Ω

2. If 120 volts are used to light a 20-watt light bulb, what will be the current flowing through that bulb?
   (A) 40 A
   (B) 30 A
   (C) 0.25 A
   (D) 4 A
   (E) 0.30 A

3. The electric current can pass through an electric component due to the existence of _____

4. In order to measure the current passing through an electric component, an ammeter is always connected in _____

5. i) State Ohm's Law
   ii) Explain briefly, with the aid of a circuit diagram, how you would verify Ohm's law in the laboratory.

6. (a) Define the following terms as applied in Physics:
      i) Electric current
      ii) Coulomb
   (b) Find the equivalent resistance if two resistors of value 5 are connected in
      i) Parallel
      ii) Series
   (c) Study carefully Figure 2 and then answer the question that follows:

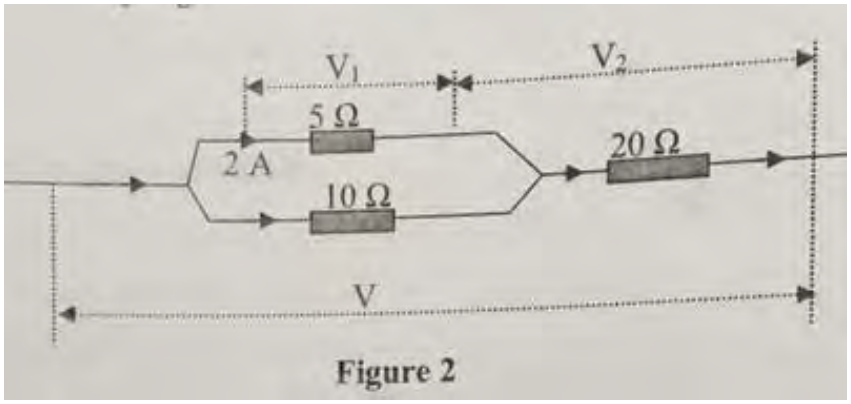


Figure 2

   Calculate the values of V, V_1 and V_2

7. i) Two cells each of emf 6V and internal resistance of 5 Ω and 6 Ω respectively are connected in parallel to a resistor of 10 Ω. Find the current flowing in the 10 Ω resistor.

5.3.3 Magnetism

1. The force which exist between two closely bar magnets with like poles is known as
   (A) attractive
   (B) repulsive
   (C) friction
   (D) compressional

2. Unlike magnetic poles as well as unlike electric charges, when they brought close to each other they tend to
   (A) attract each other

(B) repel each other

(C) exist in pairs

(D) separate

3. In which region does the north pole of a magnet can be directed?
   (A) Towards the geographic North Pole
   (B) Toward geographic South Pole
   (C) Along the Equatorial
   (D) Along the Coast of Antarctica
4. Which of the following are non-magnetic metals?
   (A) Iron and steel
   (B) Aluminum and zinc
   (C) Nickel and cobalt
   (D) Nickel and steel
   (E) Iron and cobalt
5. The suspended magnetic needle always comes to rest with its axis in a vertical plane called
   (A) geographic meridian
   (B) magnetic meridian
   (C) geographic declination
   (D) magnetic declination
   (E) geographic north pole
6. The angle between the horizontal component of the earth's magnetic field and the true north is called _____

5.3.4 Forces in Equilibrium

1. Ability of man to walk properly along a road is one of the applications of
   (A) stable equilibrium
   (B) unstable equilibrium
   (C) neutral equilibrium
   (D) neutral and stable equilibrium
2. A body is said to be in equilibrium if
   (A) It moves with uniform speed
   (B) The net force acting on it is zero
   (C) The upward and downward forces are equal
   (D) Its center of gravity is low positioned
   (E) Its center of gravity is high positioned
3. Match each item in List A with the correct response in List B

List A		List B	
(i)	A state of balance of a body	A	Centre of gravity
(ii)	The sum of the forces in one direction must be equal to the sum of the forces in opposite direction	B	Unstable equilibrium
		C	Translational motion
		D	Rotational motion
(iii)	A point where the force of gravity can be considered to act	E	Condition for equilibrium
		F	Point of application
(iv)	The object with high centre of mass	G	Equilibrium
(v)	All points in a body moves around a single line	H	Stable equilibrium

4. A force which causes anticlockwise rotation is said to have a positive _____
5. The parallel forces which are equal in magnitude but acting in opposite direction to each other are known as _____
6. (a) What is meant by the moment of a force about a point?
   (b) Why the door handles are placed at the end of the door and not at the centre of the door?
   (c) A line of action of a force of 48N is at a perpendicular distance of 1.5m from a point. Find the moment of the force about the point.
7. i) State the principles of moments
   ii) A heavy metal beam AB of mass 25kg is supported at its ends. The beam carries a mass of 150kg at a distance of 0.75mm from end A. If the beam is 2m long, determine the thrust at supports A and B.
   iii) What assumption will you make to support your calculations in ii) above?
8. A meter rule is pivoted at its mid-point. If two objects of weight 1.0N and 2.0N are suspended at 30cm and 90cm respectively from one end, calculate the position where an upward force of 3.0N must be applied in order for the meter rule to balance horizontally.
9. The diameter of a uniform cylinder is 0.2m and its height is 0.4m. The cylinder is placed on an inclined plane. Calculate the maximum angle to the horizontal to which the plane can be inclined before the cylinder falls down.

5.3.5 Simple Machines

1. How can you distinguish a lever from a pulley?
   (A) Lever turns a pivot while a pulley turns on an axle
   (B) Lever changes direction of applied effort while pulley does not
   (C) M.A. of a lever is effort arm over load arm while M.A. of pulley is $\frac{R}{r}$
   (D) V.R. of a lever is $\frac{2\pi R}{P}$ while that of a pulley is $\left(\frac{R}{r}\right)^2$
2. In Figure 1, a hydraulic press P is used to raise a load of 10,000N. A force F of 25N is applied at the end of a lever pivoted at O to just raise the load.

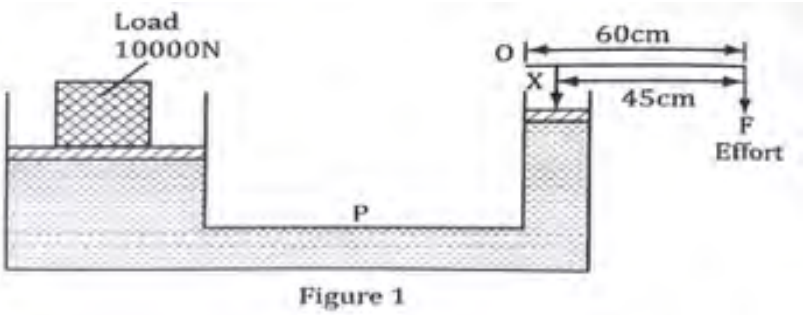


Figure 1

   What will be the value of force X applied to the press?
   (A) 1500 N
   (B) 100 N
   (C) 1125 N
   (D) 33.33 N
   (E) 13.33 N
3. The lever, pulley, inclined plane, bottle opener and see saw are examples of _____

4. Wheelbarrows and bottle openers are in _____ class of levers.
5. Study Figure 3 and then answer the questions that follow

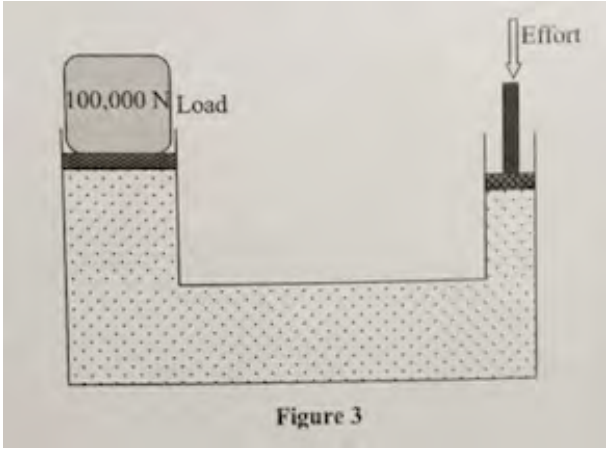


Figure 3

   (a) Give the name of Figure 3
   (b) The machine in Figure 3 is used to lift a container weighing 100,000 N. The radius of effort piston is 20 cm and the radius of load piston is 5m. If the efficiency of the machine is 90%, calculate the velocity ratio and its mechanical advantage (M.A.)

6. (a) What peculiar property does the effort has in all classes of levers?
   (b) A metre rule of weight 1.0N is supported horizontally on two knife edges each placed 10.0cm from its ends. If the weight of 1.5N is placed at its midpoint calculate the reaction at the supports?

5.3.6 Motion in a Straight Line

1. The term displacement means
   (A) a distance covered in a given direction
   (B) a distance covered without direction
   (C) a rate of distance
   (D) a rate of velocity
2. When an object moves around a horizontal circle of centre O with a constant speed its acceleration will be:
   (A) Zero
   (B) Towards the center
   (C) Away from the center
   (D) Along the tangent to the circle
   (E) Along the direction of rotation
3. What will be the acceleration of the car while its speed was increasing as shown in Figure 1?

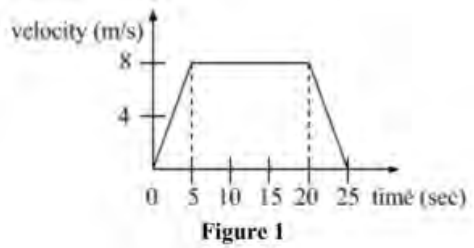


Figure 1

   (A) 0.8 m/s^2

(B) 0.4 m/s^2

(C) 2.5 m/s^2

(D) 1.25 m/s^2

(E) 3.125 m/s^2

4. The rate of change of displacement is called _____

5. (a) Differentiate between the following terms:
   i) Constant acceleration and constant velocity
   (b) How long does a car accelerate from rest to 30 m/s if its acceleration is 4.5 m/s^2

6. A car of mass 1200 kg is brought to rest by a uniform force of 300N in 80 seconds. What was the speed of the car?

7. Two stones are thrown vertically upwards from the same point with the same velocity of 20 m/s but at an interval of 2 seconds. When they meet, the second stone is rising at 10 m/s. Calculate:
   i) The time taken by the second stone in the air before they meet
   ii) The velocity of the first stone when they meet.

5.3.7 Newton's Law of Motion

1. Which of the following is the most closely related to inertia?
   (A) Weight
   (B) Acceleration
   (C) Mass
   (D) Force

2. A loaded car of mass 25000kg is moving at 20 m/s, its linear momentum is _____

3. The product of mass and velocity of a body is called its _____

4. Define the following terms:
   i) Newton
   ii) Inertia
   iii) Linear momentum
   iv) acceleration due to gravity

5. (a) Differentiate between the following terms:
   i) Momentum and impulse of a force
   (b) Explain one application of the law of inertia in everyday life.

6. (a) State Newton's laws of motion
   (b) Why passengers in a car surge backward when a car start moving and forward when it stopped suddenly
   (c) A rocket expels gas at a rate of 0.5kg/s. If the force produced by the rocket is 2000N. What is the velocity with which the gas is expelled?

7. (a) Give two practical examples where impulse and momentum play an important role
   (b) i) Distinguish between elastic collision and inelastic collision
   ii) A box of mass 50kg is raised vertically with a uniform acceleration a when a force of 700N is acting in a rope. Calculate the uniform acceleration a.

8. A stationary bomb of mass 5kg explodes into one part A of mass 2kg flying off with a velocity of 60 m/s and another part B of mass 3kg flying off with a certain velocity in the opposite direction. Calculate:

i) velocity of part B

ii) total kinetic energy produced by the explosion

5.3.8 Temperature

1. Why is water unsuitable for a thermometer liquid?
   (A) It does not wet a glass
   (B) It wets a glass
   (C) It is opaque
   (D) It is a good conductor of heat
2. Mention **three** differences between temperature and quantity of heat
3. What are the fixed points of a thermometer?
4. What is the use of a clinical thermometer?
5. In a mercury centigrade thermometer, the distance between 0°C and 20°C is 4cm. What is the distance between 0°C and 100°C?

5.3.9 Sustainable Energy Sources

1. The energy which is obtained from the hot rocks underground is called
   (A) Geothermal energy
   (B) Solar energy
   (C) Water energy
   (D) Wind energy
2. Which of the following sources of energy are non-renewable?
   (A) Water, wind, and natural gas
   (B) Fossils, sun, oil, and nuclear
   (C) Natural gas, water, nuclear, and wood
   (D) Wind, sun, fossils, and oil
   (E) Oil and all natural gases
3. What are sustainable energy sources?
4. State four applications of energy generated from water.
5. i) What is a windmill?
   ii) Mention three disadvantages of energy caused by wind
6. i) Define geothermal energy
   ii) Briefly explain how geothermal energy can be harnessed.

5.4 Form III Topics

5.4.1 Applications of Vectors

1. Two forces of 5N and 8N are acting at the same point and are inclined at 45° to each other. What will be their resultant force?
   (A) 11.2 N
   (B) 12 N
   (C) 22.4 N

(D) 1.2 N

(E) 1.12 N

2. The velocity of the body as noted by a non-stationary observer is called _____

3. What do you understand by resolution of a force?

4. (a) Stat the parallelogram law of forces

   (b) i) Distinguish between absolute velocity and relative velocity

   ii) Wind is blowing 30° west of north at 20km/hr. A bird is flying in the wind and its velocity relative to the ground is 90km/hour at 75° west of north. Calculate the velocity and direction of the bird

5.4.2 Friction

1. A car moving at steady speed has a frictional force on its surface whose size depends on its:

   (A) Speed and surface area

   (B) Speed

   (C) Surface area

   (D) Weight

   (E) Wheels speed

2. i) Define coefficient of dynamic friction

   ii) A body of mass 40kg is placed in a straight track sloping at an angle of 45° to the horizontal. If the body is held from slipping by friction, calculate the normal reaction and the force of friction.

5.4.3 Light

1. What will the size of the image formed if an object 4cm tall is placed in 20cm in front of a concave mirror of focal length 15cm?

   (A) 60cm

   (B) 40cm

   (C) 24cm

   (D) 12cm

   (E) 3cm

2. How many number of images will be formed if the angle between two mirrors is 0°

   (A) 2

   (B) 3

   (C) 4

   (D) 5

   (E) Infinite

3. Colours are produced when white light passes through glass prism because:

   (A) light waves interference

   (B) glass prisms colour the light

   (C) in glass different colours travel at different speeds

   (D) different colours are filtered

   (E) diffraction of light occurs

4. A green card with red flowers when viewed in a red light will appear:

(A) completely red

(B) completely yellow

(C) completely green

(D) yellow with red flowers

(E) green with red flowers

5. Refractive index is a constant involved in _____

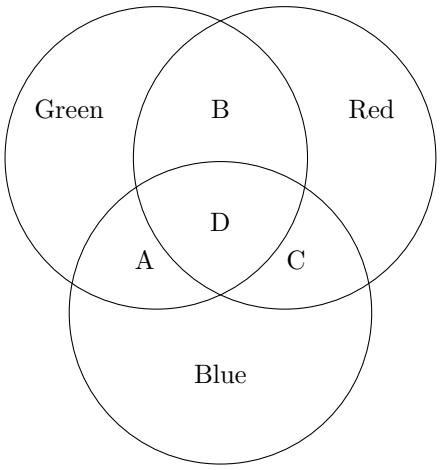
6. Colours which when mixed in a definite ratio yield white colour are known as _____

7. The defects of the image formed by a single lens is called _____

8. (a) Distinguish between light spectrum and dispersion of light

   (b) Briefly describe how a light ray passes through an equilateral glass prism

   (c) Study the figure below which represents three primary colours combined together and answer the following questions



   i) Identify the colours represented by the letters A, B, C, and D.

   ii) What general name is given to the colours obtained by mixing two primary colours?

   iii) Name the colour produced as a result of mixing three primary colours

9. List 3 rules used to locate images in curved mirrors

10. (a) What is the basic difference between real and virtual image as formed by curved surfaces?

    (b) i) Give two reasons why convex mirrors are used as driving mirrors

    ii) A convex mirror of focal length 18cm produces an image on its axis 6cm away from the mirror. Calculate the position of the object.

11. A mirage i often seen by a motorist as a pool of water on the road some distance ahead.

    i) Draw a sketch diagram to show the formation of such a mirage

    ii) Briefly explain how a mirage is formed.

12. (a) i) What is meant by refraction of light?

    ii) Mention three points to be considered when drawing a ray diagram to show the formation of images on a concave mirror

    (b) i) Briefly explain why part of the road ahead of a person apparently looks as if it has a pool of water on a sunny day

    ii) A pin is at the bottom of a vessel 16cm deep. When the vessel is filled with water the pin appears to rise when viewed from above. Find the height to which the pin appears to rise.

(c) A paraffin has a greater refractive index than water. What can you about the:
   i) relative velocity of light in paraffin and in water?
   ii) path of a ray of light when passing from the water into a layer of paraffin?

13. What name is given to an angle of incidence when the angle of reflection is 90°?

5.4.4 Optical Instruments

1. The device which operates under the principle of total internal reflection of light is called

   (A) magnifying lens
   (B) plan mirror
   (C) telescope
   (D) optical fibre
   (E) pin-hole camera

2. A part of human eye that corresponds to the film in a camera is called:

   (A) cornea
   (B) iris
   (C) lens
   (D) pupil
   (E) retina

3. Short-sightedness in a human eye is due to:

   (A) Eyeball being too short
   (B) Eyeball being too large
   (C) Eye lens being too weak
   (D) Eye lens being smaller than retina
   (E) Eyeball being larger than retina

4. The process whereby the eye can alter its focal length in order to form images of objects at different distances is known as _____

5. Give two similarities and two differences that exist between the human eye and a lens camera

6. (a) How many people with short-sighted defect differ from those with long-sighted defect?
   (b) Calculate the focal length of a lens with a projector is used to produce a sharp image of an object being at a distance of 120cm from the screen.

7. Match each item in List A with the correct response in List B

List A		List B	
(i)	The eye-lens becomes thick when contracted and thin when relaxed	A	Short sight
		B	Long sight
(ii)	Prevent the internal reflection of light in the eye	C	Ciliary Muscles
(iii)	The thick and transparent protective cover in front of the eye-lens which refracts light most	D	Suspensory ligaments
(iv)	Hold the eye-lens in position	E	Binocular vision
(v)	Provides two images of the same object which are slightly different in perspective	F	Retina
		G	Aqueous humour
(vi)	The light sensitive area of cells at the back of the eye	H	Vitreous humour
(vii)	Images of distant objects which are focused in front of the retina	I	Pupil
		J	Fovea centralis
(viii)	The circular opening in the iris through which light passes	K	Iris
		L	Cornea
(ix)	The most light sensitive spot on the retina	M	Slim lens
(x)	The coloured circle round the eye-lens	N	Choroid layer
		O	Fatter lens

5.4.5 Thermal Expansion

1. What do you find when conducting an experiment of expansion of solids, liquids, and gases at the same temperature change?
   (A) solids and gases expand at the same rate
   (B) solids expand more than liquids and gases
   (C) liquids expand more than gases and solids
   (D) gases expand more than solids and liquids
   (E) all expand at the same time
2. The correct arrangement of metals in ascending order of their linear expansivities is
   (A) Iron, Copper, Invar, Brass, Nickel
   (B) Nickel, Brass, Invar, Copper, Iron
   (C) Brass, Copper, Nickel, Iron, Invar
   (D) Invar, Iron, Nickel, Copper, Brass
   (E) Nickel, Brass, Iron, Invar, Copper
3. A temperature at which solids change to liquids at constant temperature is referred to as _____
4. _____ of water is the decrease in the density of water as it is cooled from 4°C to 0°C
5. Explain the following: Most materials become less dense as the temperature increases
6. Heat and temperature are closely related but they are different. State how they are related and how they differ
7. What is meant by the terms:
   (a) Bimetallic strip
   (b) Linear expansivity of the solid
8. Define the following terms:
   i) coefficient of superficial expansion
   ii) anomalous expansion of water
9. (a) i) Use the kinetic theory to explain why solids expand when heated
      ii) Mention two experiments which can be done in the laboratory to verify thermal expansion of solids
   (b) i) A bimetallic thermostat

ii) A bimetallic thermometer

10. (a) Mention four application of thermal expansion of solids
    (b) Briefly explain why holes left below chimneys of kerosene lamp or kitchen
    (c) A steel tyre of diameter 150cm and 10°C is to be fitted on to a train wheel of diameter 151cm. What temperature must the tyre be heated to just fit the wheel?
11. i) Define coefficient of linear expansion and give its SI unit
    ii) A metal pipe which is 1m long at 40°C increases in length by 0.3% when carrying a steam at 100°C
12. An iron rivet of radius 8.95mm at 20°C is to be inserted into the hole of an iron plate of radius 8.92mm at 20°C. What temperature must the rivet be heated to in order to fit the hole?
13. The temperature of the melting point of ice and that of steam above water boiling at 760mmHg pressure are marked as 20 and 80 respectively on a certain thermometer. Calculate the thermometer reading when the temperature is 60°C

5.4.6 Transfer of Thermal Energy

1. The temperature of a liquid in a thermos flask remains unaltered for a long time because heat loss by:
   (A) conduction is minimized
   (B) convection and radiation are reduced
   (C) radiation and convection are minimized
   (D) conduction and radiation are reduced
   (E) all modes of heat transfer are reduced
2. A teapot with a silvery surface keeps the water hot for some time because it conduct heat by _____
3. Radiant energy can be detected by means of _____
4. Which method of heat transfer does not involve the actual movement of practices from their mean position?

5.4.7 Measurement of Thermal Energy

1. Heat is supplied at equal rates to equal masses of water and aluminum. The temperature of aluminum rises more quickly than that of water because the aluminum has:
   (A) a lower latent heat
   (B) a higher heat capacity
   (C) a higher specific heat capacity
   (D) a higher latent heat
   (E) a lower specific heat capacity
2. When a person perspires on a hot day:
   (A) Evaporation occurs and helps to cool the body
   (B) Heat is conducted away from the body
   (C) Latent heat keeps the body warm
   (D) The body is insulated from the warm air
   (E) Convection cools the body
3. The specific latent heat of fusion of a substance is defined as the energy required to:
   (A) change a unit mass of the substance from solid to liquid

(B) change a unit mass of a substance from solid to liquid at constant temperature

(C) change the mass of a substance from solid to liquid at constant temperature

(D) cause a unit temperature rise of a substance

(E) cause a unit mass of water to freeze at 0°C

4. What happens when a liquid changes into a gaseous state?

(A) Some surface molecules absorb latent heat of vaporization and escape

(B) It gives its own latent heat that can be used to heat up the surrounding

(C) The potential and kinetic energies of the molecules increase

(D) The molecules attractive forces to one another increase and their average kinetic energy decreases

(E) There is no adhesive force between molecules

5. _____ is a freezing process which demonstrates the effect of pressure on the melting point of ice

6. The physical state of a substance normally depends on _____

7. Latent heat of vaporization is responsible for changing the state of a substance from liquid to vapor without changing of _____

8. Mention three difference between boiling and evaporation

9. (a) Define latent heat of fusion of a substance

(b) A copper block of mass 0.68kg is suspended in a freezing mixture at -50°C for some time and then transferred to a large volume of water at 0°C. Calculate the mass of ice formed.

10. (a) What is meant by the terms heat capacity and specific heat capacity? State how they are related.

(b) Explain briefly how heat losses have been prevented in the vacuum flask

(c) A heater of 500W is used to raise the temperature of 50kg of material of specific heat capacity of 960 J/kg·K, from 19°C to 38°C. Assume that all the heat from the heater is given to the material. Calculate:

i) Heat capacity of the material

ii) Time taken in seconds

11. i) How much heat is needed to change 340g of ice at 0°C to water at 0°C?

ii) What is the name of heat lost by ice in i) above?

5.4.8 Vapour and Humidity

1. Briefly explain reasons for the following:

i) When a cold bottle is brought into a warm room, it becomes misted over

ii) Frost is more likely to occur on a clear night than on a cloudy night

2. Give reason why it is not sensible to rub the canvas of a tent in wet weather

3. Match each item in List A with the correct response in List B

List A		List B	
(i)	Mass of water vapour which is actually present in a unit volume of air at constant temperature	A	Hygrometery
		B	Bimetallic thermometer
		C	Latent Heat
(ii)	Rate at which a material transfers heat energy	D	Liquid-in-glass thermometer
(iii)	Measurement of the amount of moisture present in the atmosphere	E	Relative humidity
(iv)	Mass of water vapour present in a unit volume of air	F	Leslies cube apparatus
(v)	Difference between readings of the two thermometers	G	Specific heat capacity
(vi)	A measure of the extent to which the atmosphere contains water vapour	H	Wet bulb deression
		I	Humidity
(vii)	It can be found by the method of mixture or electrical heating	J	Thermal conductivity
		K	Latent heat of fusion
(viii)	Amount of heat energy required to change the state of a substance	L	Thermistor thermometer
		M	Absolute humidity
(ix)	Measures temperature of inaccessible structures	N	Bi-metallic strip
		O	Thermal expansivity
(x)	Depends on the electrical properties of materials varying with temperature	P	Absolute temperature

5.4.9 Thermal Current Electricity

1. When a lead-acid accumulator is freshly made it has an electromotive force (e.m.f) of
   (A) 1.5V
   (B) 1.25V
   (C) 2V
   (D) 3V
   (E) 1V

2. Which of the following statements is true when the resistance, R, of a wire is measured using an ammeter, voltmeter and rheostat?
   (A) the ammeter is in parallel with R
   (B) the voltmeter is in series
   (C) graph of V against I has a gradient equal to R
   (D) graph of I against V has a gradient equal to R
   (E) the rheostat is in parallel with R

3. A solid metal cube has each side doubled to make a solid cube of the same metal eight times bigger in volume. The ratio resistivity of the new cube to resistivity of the old cube is:
   (A) 8:1
   (B) 6:1
   (C) 1:1
   (D) 1:6
   (E) 1:8

4. The cost of electricity for a 2000W electric fire used for 10.30 hours at the rate of Shs. 800 per KWh is:
   (A) Shs. 160
   (B) Shs. 80
   (C) Shs. 168
   (D) Shs. 1600

(E) Shs. 3200

5. One advantage of the lead-acid accumulator is that:
   (A) Its internal resistance is high
   (B) Its p.d. is less than 2V
   (C) It can be recharged
   (D) Its emf is more than 10V
   (E) It supplies only a small current
6. The Wheatstone bridge is an electric device used to measure _____
7. The speech current along the telephone line can be converted into sound waves in the air by means of _____
8. A blue cable in the three-pin plug of electrical circuit represents _____
9. A device that opens and closes in a circuit in response to changes in temperature is called _____
10. Define: resistivity
11. What is meant by the internal resistance of a cell?
12. Which type of a resistor is used to convert moving coil galvanometer into voltmeter?
13. Differentiate between resistance and resistivity of a conductor.
14. Distinguish between a cell and a batter
15. (a) i) What is meant by a fuse?
    ii) Briefly explain why fuses are made of very thin wire but heaters are made of thick wires
    (b) i) State how a short circuit occurs in a house
    ii) Mention two causes of an electrical short-circuit
    (c) i) Fuse wires are labelled 3A, 5A, 10A, 12A, 18A, and 20A. Select the best fuse for a 240V; 2.856kW electric kettle
    ii) Describe, with the aid of a circuit diagram, how you would determine the resistance of a conductor using the ammeter-voltmeter method
16. (a) i) What is "1 kilwatt-hour" as applied to current electricity?
    ii) If you find a domestic electric bulb rated 60W, 240V what does this mean?
    (b) Find the cost of running five 60W lamps and four 100W lamps for 8 hours if electric costs Tshs. 27/= per unit.
17. (a) How does the increase of length and cross-section area of a conductor affect is resistance?
    (b) State the function of a circuit breaker in a wiring system
    (c) Determine the ratio of resistance of wire A to that of wire B which made of the same material such that wire A has half the length and twice the diameter of wire B
    (d) An electrical kettle contains 720 W heating units
    i) What current does it take from 240 V mains?
    ii) How long will the kettle take to raise the temperature of 2 kg of water 30°C to its boiling point?
18. A current of 3.0A passes through a coil of resistance 5Ω which is connected to the terminals of a cell of constant emf, E volts, and internal resistant, r Ω. If a uniform wire of length, L cm, is joined across the ends of the 5Ω coil to form a parallel arrangement of resistance 4Ω, the current is reduced to 0.25A. Determine the:
    i) internal resistance of the cell item[ii)] emf of the cell

19. Two resistors each of 5Ω are connected in parallel across the same battery of e.m.f. 5V and negligible internal resistance. If the battery is fully charged and then discharged within 20 hours, calculate the storage capacity of the batter.

20. i) Draw a well labeled diagram of a dry cell (Leclanche)
    ii) Identify three disadvantages of a Leclanche cell over lead-acid accumulators

21. How would you test whether a car battery needs recharging? (Give three points)

22. Is it possible for two cells in parallel arrangement to drive more current through a resistor than one cell? Give a reason.

23. (a) Explain what will happen when three 1.5V cells are connected:
        i) in series
        ii) in parallel
    (b) If the resistance of the ammeters in Figure 2 are ignored, explain each of the following observations:

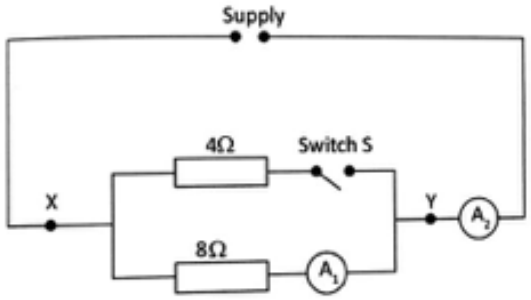


Figure 2

        i) When switch S is closed, the current through A_1 is less than through A_2
        ii) When switch S is opened, the current through A_2 falls
        iii) When switch S is opened, the current through each ammeter is the same

5.5 Form IV Topics

5.5.1 Waves

Introduction to Waves

1. Light waves differ from sound waves because:
   (A) light is an electromagnetic wave but sound is a mechanical wave
   (B) sound waves do not travel in water but light waves do
   (C) the speed of light is independent of the medium it travels but the speed of sound depends on the medium
   (D) interference is obtained with light waves but not with sound waves
   (E) the speed of sound waves is greater than that of light waves in the same medium

2. i) List four main parts of a ripple tank
   ii) What role does a stroboscope play in a ripple tank experiment?

Behavior of Waves

1. A basic condition for diffraction of wave when it passes through an opening is that
   (A) the wavelength of the incident wave must be greater than the size of the opening

(B) the amplitude of the wave must be less than the size of the opening

(C) the wavelength of the wave must be shorter than the corresponding size of the opening

(D) the wavelength of the wave must be almost equal to the size of the opening

(E) the amplitude of the wave must be greater than the opening

2. Waves which travel perpendicularly to the direction of vibrations are called _____

Propagation of Waves

1. For an oscilloscope just to display the wave form of a.c. supply which controls should be adjusted:

(A) Y-shift then X-time base

(B) X-time base then Y-shift

(C) Y-shift then brightness

(D) X-time base then T-gain

(E) Y-gain then focus

2. The process of converting sinusoidal wave forms into unidirectional (non-zero) waveforms is known as _____

3. i) Briefly explain how resonance tube works item[ii)] Calculate the frequency of vibration in a resonance tube of shortest length of 0.22 m when the next resonance length is 0.47 m.

4. Figure 1 illustrates part of the displacement-time graph of a wave travelling across water at a particular place with a velocity of 2 m/s. Calculate:

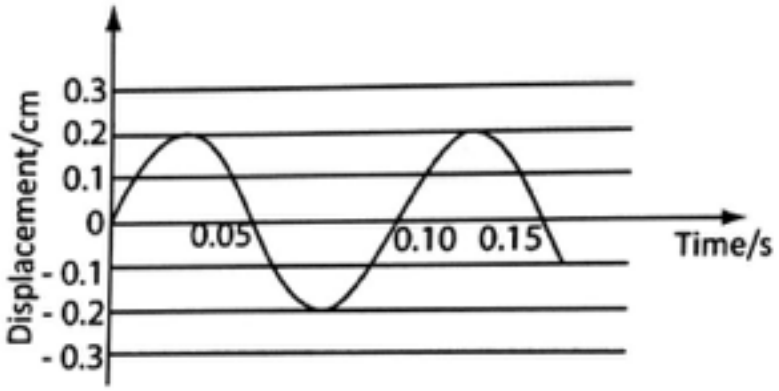


Figure 1

i) The amplitude

ii) The frequency

iii) The wavelength

5. (a) Define the term wavelength

(b) How does the size of the gap in the barrier affect the diffraction of waves?

(c) State two ways in which visible light differs from radio waves

(d) List two applications of gamma rays

(e) Figure 2 and 3 show a wave travelling across water. Carefully study it then answer the questions that follow

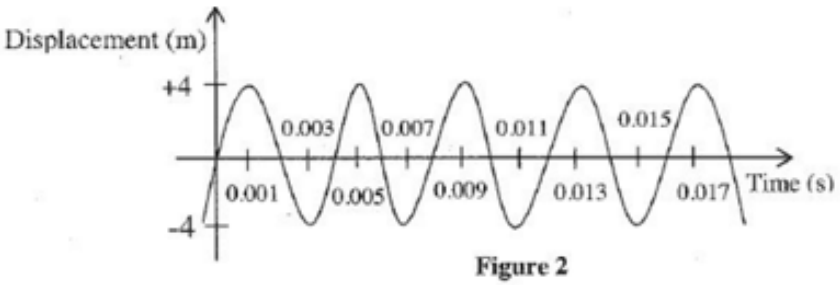


Figure 2

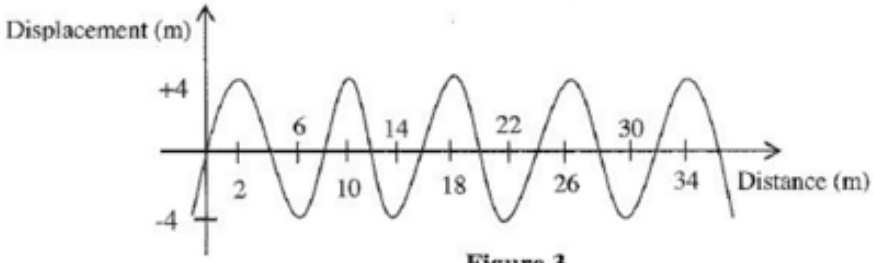


Figure 3

i) Determine the frequency of the wave

ii) Determine the velocity of the wave

Sound Waves

1. The loudness of a note produced by a vibrating object depends on
   (A) the number of vibrations per second
   (B) the overtones present
   (C) the quality of sound
   (D) the wavelength between two nodes
   (E) the amplitude of vibration

2. The correct statement about sound waves is that they:
   (A) are transverse waves
   (B) can travel in vacuum
   (C) can be polarized
   (D) cannot be polarized
   (E) do not require medium

3. The multiple reflections of sound waves when they are placed in an enclosed room or cavity is called _____

4. (a) What is meant by the following terms?
      i) Resonance
      ii) Overtones
   (b) Briefly give reasons for the following:
      i) The fundamental frequency may alter during the day
      ii) Notes of the same pitch played on a violin and a flute sound different
   (c) The frequency obtained from a plucked string of 400 Hz when the tension is 2N. Calculate:
      i) The frequency when the tension is increased to 8N
      ii) The tension needed to produce a note of frequency 600 Hz

5. (a) i) What is a sonometer?

ii) Briefly explain when resonance is said to occur

(b) Two boys at 200m apart stand on one side of a high vertical cliff at the same perpendicular distance from it. When one fires a gun, the other hears the sound 0.6 seconds after the flash and the second sound 0.25 seconds after the first sound. Calculate the perpendicular distance of the boys from the cliff.

Muscial Sound

1. The note from a plucked guitar will have a low pitch if the string is:
   (A) thick and long
   (B) thick and slack
   (C) thin and slack
   (D) thin and short
   (E) thick and short
2. A regular rise and fall in loudness of a music player at a distance is called:
   (A) intensity
   (B) timbre
   (C) pitch
   (D) beats
   (E) resonance
3. When a pipe is played a sound wave x is produced inside the pipe and a sound Y is heard outside the pipe, then
   (A) x is transvers and Y is longitudinal transverse
   (B) x and Y are both transverse
   (C) x is progressive and Y is stationary
   (D) x is stationary and Y is progressive
   (E) x is progressive and Y is longitudinal
4. The quality of a note produced by a musical instrument depends on its fundamental frequency and _____
5. The timbre of a sound is also referred to as _____
6. The combination of multiple echoes in the listener's ear produces a louder and more sustained sound called _____
7. i) Explain why there are four strings of different thickness on a violin
   ii) What does a violinist do to change the note emitted by a particular string?

Electromagnetic Spectrum

1. The correct statement about radio waves is that
   (A) They have shortest wavelength
   (B) They can be produced by comets in space
   (C) They don't undergo reflection
   (D) They require medium on transmission
   (E) They have smallest frequency
2. Which of the following electromagnetic waves have largest wavelength?
   (A) Ultraviolet
   (B) Infrared

(C) Gamma Rays

(D) Radio waves

(E) X-rays

3. Which region in electromagnetic spectrum has lowest frequency?

5.5.2 Electromagnetism

Magnetic Fields due to Current

1. Which of the following are good examples of ferromagnetic materials?
   (A) Iron and ceramic
   (B) Zinc and copper
   (C) Copper and nickel
   (D) Nickel and cobalt
   (E) Cobalt and ceramic
2. A conductor becomes a magnet when:
   (A) It is wrapped with a coil of wire
   (B) A soft iron core is used
   (C) An electric current flows through it
   (D) Its resistance is increased
   (E) It is passed through an electric field
3. The rule used to deduce the direction of the magnetic field lines due to solenoid or circular coil is called _____
4. The function of an induction coil is to produce _____
5. Which rule summarized the relation of force, current and field being mutually perpendicular to each other?

Electromagnetic Induction

1. What is the main function of a step up transformer?
   (A) to change AC to DC current
   (B) to decrease resistance in a circuit
   (C) to increase AC voltage
   (D) to decrease AC voltage
   (E) to increase AC current
2. Lenz's law can be applied to predict the:
   (A) Magnitude of back emf in a circuit
   (B) Magnitude of induced current in a circuit
   (C) Direction of induced emf in a cross circuit
   (D) Direction of induced emf in a circuit
   (E) Direction of the applied emf within a circuit
3. _____ is a coil of low resistance used to control an alternating current
4. The simple AC generator works on the converse principle of _____
5. The production of an emf in a conductor as a result of changing current in the same conductor is referred to as _____

6. Which quantity is induced whenever there is a change in the magnetic flux linked with a circuit?

7. i) What is an induction coil?
   ii) Describe the structure of an induction coil and briefly explain its mode of action.

8. (a) i) State the laws of electromagnetic induction
   ii) Mention two advantages of AC generator over DC generator
   (b) i) Briefly explain why the core of a transformer is made of thin layers of metal insulated from one another
   ii) Describe the structure of a step-up transformer and state how it works
   (c) A transformer with 4,800 turns in the primary coil is designed to work from a 240V AC mains to give a supply of 8V in order to ring a bell.
   i) What would happen if the transformer were connected to a 240V DC mains?
   ii) Briefly explain why the primary current increases when a bell is being rung?

9. (a) What is meant by mutual induction?
   (b) Illustrate how the right hand grip rule is used to determine electric current and magnetic field directions
   (c) Draw the diagram of direct current (DC) generator showing its important parts
   (d) Briefly explain how simple AC dynamo can be converted to simple DC dynamo

10. (a) Mention three uses of induction coil
   (b) Briefly explain the working principle of a bicycle dynamo

11. (a) State the purpose of a dynamo
   (b) Briefly explain why an e.m.f. is induced in a coil as it rotates
   (c) At what position of the coil is the induced e.m.f. zero (as it rotates)?
   (d) Explain the function of each of the following features of a simple electric motor:
   i) Split-ring commutator
   ii) Brushes

12. (a) i) State the function of the hairsprings in a moving coil galvanometer
   ii) Explain why a moving galvanometer is unsuitable for measuring alternating currents
   (b) i) Draw the magnetic field lines in a horizontal plane due to a current carrying straight conductor when a DC flows through it
   ii) What would happen on the pattern if AC were used instead of DC?
   (c) i) What should be done in order to increase the speed of ration in a DC electric motor?
   ii) An electric motor is connected by a cable to a generator and produces a current of 10A at 240V. Calculate the resistance of the cable.

13. (a) i) What is meant by the terms solenoid electromagnetic inductor?
   ii) List down two applications of electromagnetism
   (b) Describe the structure and mode of action of a simple DC motor
   (c) i) Draw a diagram of an electric bell showing the polarity of the electromagnet, the direction of the current, the core of the yoke, spring, and the armature
   ii) Explain what will happen to the mode of action of the electric bell if the core and yoke are made of steel instead of soft iron

14. (a) i) What is meant by a transformer?
   ii) Why does a transformer work with alternating current (AC) only?
   (b) State **two** ways in which power is lost in a transformer

(c) A 240V main transformer has 1000 turns in primary and N turns in secondary. It is used to supply energy to a 12V, 24W lamp.

i) How many turns are there in the secondary?

ii) What is the efficiency of the transformer if the current drawn from 240V supply is 125mA?

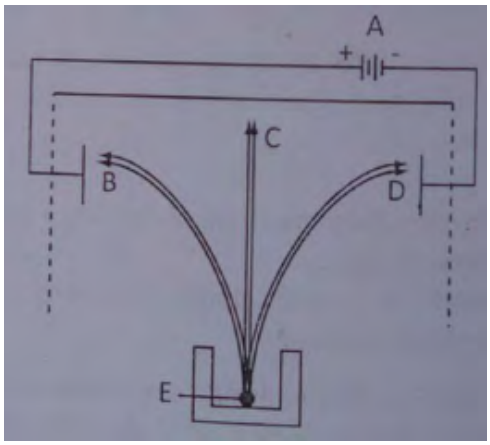
5.5.3 Radioactivity

Nucleus of an Atom

1. The mass of an atom depends on the number of:
   (A) Protons only
   (B) Neutrons, electrons, and protons
   (C) Electrons and protons
   (D) Neutrons and protons
   (E) Electrons and neutrons

2. i) Define the term isotope of an element
   ii) One isotope of carbon has the symbol $^{6}_{14}C$. Calculate the charge in Coloumbs on the nucleus of this isotope.

3. (a) Define the terms:
   i) radioactivity
   ii) mass number
   (b) Study the figure below, then answer the questions that follow:



   i) What does each of the letters represent?
   ii) Suggest a chemical element for symbol **E**
   iii) Write the basic differences between the rays represented by symbols **B** and **D**

4. How does the rate of escape of electrons from a metal relate to its temperature?

Natural Radioactivity

1. Which among the following radiations can be absorbed by a metal plate?
   (A) Alpha (α) particle
   (B) Gamma (γ) Rays
   (C) Beta (β) Rays
   (D) X-Rays
   (E) Cathode Rays

2. The most probable radiation forming a well-defined track when passed in a cloud chamber is called:
   (A) gamma rays
   (B) beta rays
   (C) cathode rays
   (D) alpha rays
   (E) x-rays

3. In a cloud chamber, straight-line trails of vapour are produced by a source emitting
   (A) Beta-particles
   (B) Gamma-rays
   (C) Electrons
   (D) Alpha-particles
   (E) Light rays

4. The half-life of a certain radioactive element is 12 hrs. What fraction of the element will have disintegrated in 72 hrs?
   (A) 1/64
   (B) 1/16
   (C) 1/32
   (D) 1/8
   (E) 1/72

5. What fraction of the atoms would have been disintegrated by 72 hours when the half-life of an element is 24 hours?
   (A) 1/8
   (B) 1/2
   (C) 3/4
   (D) 7/8
   (E) 1/4

6. Which statement is correct regarding alpha particles?
   (A) they carry a negative charge
   (B) they are hardly deflected by magnetic fields
   (C) they travel a long distance in air
   (D) they are very penetrating
   (E) they are identical with the nuclei of hydrogen atoms

7. Which one of the following statements about alpha and beta particles is correct?
   (A) they carry the same charge
   (B) each alpha particle has four times the mass of a beta particle
   (C) alpha particles have a larger range in air than beta particles
   (D) when in motion, they are deflected in opposite directions by a magnetic field
   (E) alpha particles cause ionization while beta particles do not

8. The successive decays of an unstable nucleus until a stable fragment is achieved is known as _____

9. Figure 1 shows a comparison of the penetrating power of three types of radiation

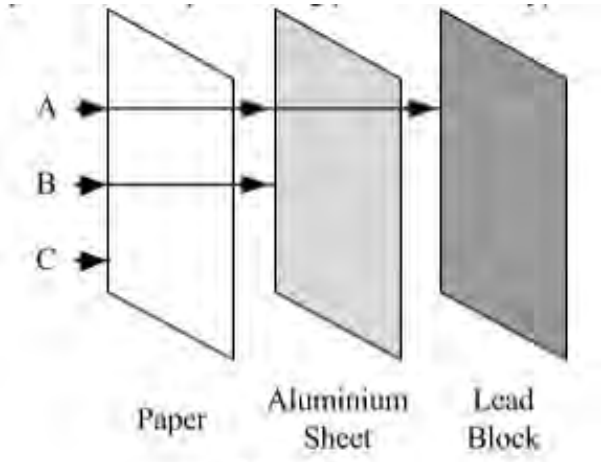


Figure 1

i) Identify the name of the radiations represented by letters A, B, and C

ii) Write two properties of each type of radiation named in i) above

iii) What effect does radiation B have on the nucleus of an atom?

10. i) What is meant by a radioactive decay?

ii) Give two effects of beta (β) particle on the nucleus of an atom

11. (a) The half-life of a certain radioactive substance is 64 days. Explain the meaning of this statement.

(b) A certain radioactive material has a half-life of 2 minutes. If the initial count rate is 256 per minute:

i) How long does it take to reach a count rate of 32 per minute?

ii) What fraction of the original number of atoms is left undecayed?

(c) A uranium nucleus, U-238 with atomic number 92, emits two α-particles and two β-particles and forms a thorium (Th) nucleus. Write the nuclear equation for this process.

12. (a) A sample containing 400g of iodine-131 has a half-life of 8 days. How much of the sample will remain undecayed after 40 days?

(b) A radioactive material is denoted by the symbol ${}^{88}_{226}\text{X}$. Write down the composition of the nucleus during the end of the following stages of disintegration

i) The emission of an alpha-particle

ii) The further emission of a beta-particle

iii) The further emission of a gamma-radiation

13. (a) A radioactive source is known to emit one type of radiation only, i.e. α, β, or γ. The source was placed in a holder as shown in Fig. 4 below, first without a magnet and then a magnet was introduced. A detector was placed at positions 1, 2, and 3 and the count rates recorded in the Table below.

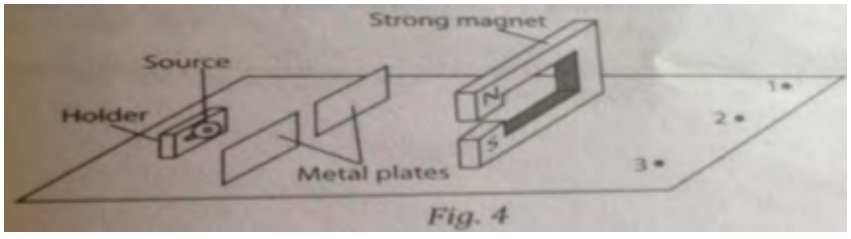


Fig. 4

Detector Position	**Counts per minute**	
	Magnet not present	Magnet present
1	26	295
2	300	28
3	28	26

i) What is the reason for placing the two metal plates in front of the source?

ii) What is the value of the background counts per minute?

iii) Define background count.

(b) What is meant by half-life of a radioactive element?

(c) A radioactive element has an initial count rate of 1200 counts per minute measured by a scale and this falls to 150 counts per minute after 15 hours

i) Determine the half-life of this element

ii) If the initial number of atoms in another sample of this element is 3.0×10^{20}, how many atoms will have decayed in 25 hours?

14. (a) What is meant by radioactive element?

(b) Name three instruments which are used to detect radiation from radioactive source

(c) Figure 2 shows the deflection of radiations from a radioactive element by an electric field

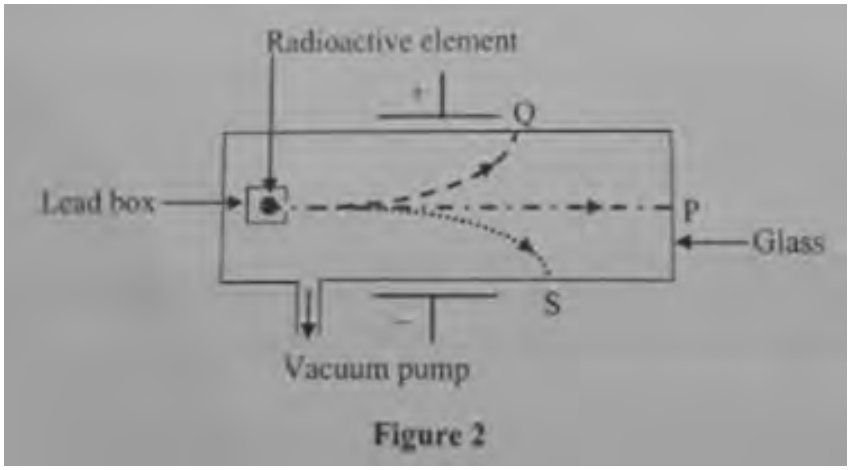


Figure 2

i) Identify the radiations Q, P, and S, giving reasons for your answers

ii) Briefly explain why the radioactive source is kept inside a lead box leaving only a small hole?

(d) What are radioisotopes?

(e) State two important applications of radioisotopes

Radiation Hazards and Safety

1. What is meant by background count? Give two sources of radiation always present in a neighborhood of a detector

Nuclear Fission and Fusion

1. The sun generates its energy by a process called:

(A) thermonuclear fission

(B) thermonuclear fusion

(C) geothermal energy

(D) geothermal fusion

(E) geothermal fission

2. Which of the following particles is used to cause fission in an atomic reaction?
   (A) Proton
   (B) Deuteron
   (C) Neutron
   (D) Beta-particle
   (E) Alpha-particle

3. i) Define nuclear fission
   ii) Mention 2 products of nuclear fission

4. Define the following terms:
   i) binding energy
   ii) thermonuclear fusion

5.5.4 Thermionic Emission

1. What particles are emitted in thermionic emission? Explain why they are emitted.

Cathode Rays

1. What is the function of cathode in x-ray tube?
   (A) To control heat produced on the target
   (B) To accelerate the speed of electrons
   (C) To conduct heat away from the target
   (D) To control brightness on the screen
   (E) To focus electrons on the target

2. In order to produce electrons in a discharge tube the:
   (A) Anode should be at a higher potential than the cathode
   (B) Potential difference at the anode should be low
   (C) Cathode should be heated indirectly at low voltage supply
   (D) Electrodes should be at the same potential
   (E) Electrons must be accelerated at higher potential

3. Cathode ray tube is used in the production of _____

4. (a) List four properties of cathode rays
   (b) Describe how x-ray tube is used to produce x-rays

5. Draw a well labelled diagram of a cathode ray oscilloscope

6. i) Explain why cathode ray tubes (CRT) are evacuated
   ii) What happens to the CRT when a gas is maintained?
   iii) If a gas is maintained in a CRT, will the image be formed onto the screen? Explain.

X-Rays

1. Which of the following electromagnetic waves is used to detect flaws and defects in steel plates?
   (A) infrared waves
   (B) ultraviolet waves
   (C) x-rays

(D) gamma rays

(E) microwaves

2. X-rays are electromagnetic waves of very short _____

3. (a) i) Define thermionic emission

ii) What are x-rays?

iii) Mention two uses of x-rays

(b) With the aid of diagram, explain how x-rays are produced

4. (a) In the production of X-rays what are the roles of:

i) low voltage?

ii) high voltage?

iii) tungsten target?

(b) How are X-rays produced?

5.5.5 Electronics

General

1. Match each item in List A with the correct response in List B

List A		List B	
(i)	The lowest energy level were electrons are normally present	A	Light-emitting diode (LED)
(ii)	The amplitude level which usually occurs in any digital signal	B	Transducers
(iii)	The energy level where electrons may not occupy	C	Rectification
(iv)	Increases the electrical conductivity of a semiconductor	D	Bipolar transistor
(v)	Produces an abundance of mobile electrons in the material	E	Semiconductors
(vi)	The region near the boundary which is fairly free of majority charge carriers	F	Valence Bond
(vii)	Materials which have significant electrical conductance at room temperature	G	Nodes
(viii)	Increases the region or width of the depletion layers and raise the potential barrier	H	Fermi level
(ix)	Convert an input signal to one form into an output signal of another form	I	Reverse bias
(x)	The relationship between input signal and output signal of an amplifier	J	Transfer function
		K	n-type doping
		L	Dopants
		M	Forbidden
		N	Thermistors
		O	Depletion layer

Semiconductors

1. Which of the following circuit elements has ability to produce gain as used in electronics

(A) inductor

(B) diode

(C) resistor

(D) capacitor

(E) amplifier

2. A semiconductor diode is used for:

(A) Producing AC from DC power supply

(B) Rectification

(C) Controlling energy losses

(D) Amplification

(E) Supplying heat in some electrical devices

3. A p-type semiconductor is formed when silicon is replaced by _____

4. (a) Define the term semiconductors

(b) How do intrinsic semiconductors differ from extrinsic semiconductors?

5. (a) i) Mention **two** methods of making a semiconductor more conductive.

ii) What are the charge carriers in P-type doped semiconductors?

(b) One end of an N-type doped semiconductor is heated.

i) State what is expected to develop between the heated and cooled ends

ii) Identify the negative end of the two ends

(c) i) Explain the property of a semiconducting diode that makes it ideal in the rectification of an alternative current

ii) Sketch a graph of voltage against time for half-wave rectification of an alternating current

6. i) Discuss the differences between conductors and semiconductors in terms of their sensitivities and conduction bands

ii) Use the following information to calculate the current gain of a C-E amplifier

$I_B \times 10^{-6}$ A	100	200	300	400	500
$I_C \times 10^{-3}$ A	5	10	15	20	25

Diodes

1. The effect of adding an acceptor impurity to a silicon produce a crystal called:

(A) P-type

(B) N-type

(C) PN-type

(D) NP-type

(E) PNP-type

2. i) What is meant by saturation current?

ii) Give one peculiar property of a diode as a rectifier

3. i) List down two types of diodes

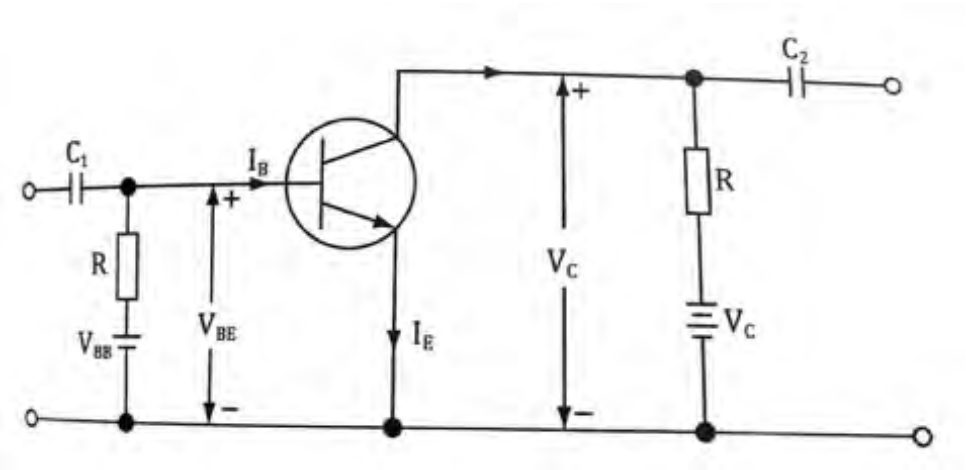
ii) Briefly explain the mode of action of a forward bias in a p-n junction

Transistors

1. (a) i) What is a transistor?

ii) Mention two applications of transistors

(b) Figure 2 shows a common emitter amplifier circuit



i) Why is the circuit named so?

ii) Explain the function of capacitors C_1 and C_2

2. (a) What do you understand by the term transistor?

   (b) i) How is a common emitter arrangement of a transistor stabilized for temperature changes?

   ii) Show the circuit-symbol for PNP-transistor and NPN-transistor

3. (a) Draw a fully stabilized common emitter amplifier circuit and explain the function of the components used

   (b) Draw the graphs for the common emitter transistor characteristics

5.5.6 Elementary Astronomy

Introduction to Astronomy

1. Where do asteroids found in the solar systems?

   (A) Between Mercury and Venus

   (B) Between Earth and Mars

   (C) Between Mars and Jupiter

   (D) Between Saturn and Uranus

   (E) Between Neptune and Pluto

2. Most stars in the universe which are visible in the night sky are within our own _____

3. Which is the term given to a glowing asteroid in space which can be seen with naked eyes? _____

4. Geocentric theory under astronomy study was based on _____

5. _____ is a large celestial body made up of hot gases known as plasma

6. (a) What is meant by the following terms:

   i) asteroids

   ii) astronomy

   (b) Distinguish between:

   i) constellation and galaxy

   ii) meteor and meteorite

7. (a)] Distinguish between:

   i) a planet and star

   ii) a comet and a meteor

(b) Which planet in the solar system is:

i) closest to the sun?

ii) furthest from the sun?

iii) closest to the earth?

iv) surrounded by rings?

v) the second largest planet?

Solar System

1. Which statement explains the basis of heliocentric theory?
   (A) The earth was known to revolve around the sun
   (B) The earth was stationary
   (C) The sun was known to revolve around the earth
   (D) The sun was stationary
   (E) The earth was known to revolve around its axis

2. Saturn as a member of the solar system:
   (A) is the largest planet with no known satellites
   (B) is the planet seen by the naked eye satellites with a temperature of -200°C
   (C) is the planet only seen through a telescope and is the furthest from the sun
   (D) has five moons and a ring-system
   (E) is the second largest planet with known satellites and a ring system

3. The name of a collection of heavenly bodies that revolve around the sun is _____

4. A group of stars that forms a definite shape or pattern when viewed from the earth is called _____

5. (a) What is zodiacal light?
   (b) Mention three uses of earth satellite
   (c) Give two examples of a Jovial planet and two examples of a terrestrial planet
   (d) How are the bodies in the solar system kept in normal positions
   (e) Which planet is often called "Morning Star"?
   (f) Briefly explain how astronomy gave rise to the 12 months of the year

Constellations

1. What is constellation?

Earth and Moon

1. Which of the following is the correct weight of a body of mass 48kg when placed on the moon surface
   (A) 0.480N
   (B) 4.8N
   (C) 0.80N
   (D) 0.048N
   (E) 80.0N

2. Ocean tides are caused by:
   (A) rotation of the earth about the sun

(B) rotation of the moon about the earth

(C) gravitational force of the earth on the moon

(D) rotation of the earth about its axis

(E) gravitational force of the moon on sea water

5.5.7 Geophysics

General

1. Match each item in List A with the correct response in List B

List A		List B	
(i)	the region nearest the earth of which most weather phenomenon occur	A	stratosphere
		B	atmosphere
(ii)	the layer in which the ozone layer is found	C	ionosphere
(iii)	the boundary which separates stratosphere and other layers	D	stratopause
		E	magnetosphere
(iv)	the boundary which separates troposphere and stratosphere	F	troposphere
		G	exosphere
(v)	the region found in exosphere where satellites orbit the earth	H	thermosphere
		I	hydrosphere
(vi)	the outermost region of the atmosphere	J	lithosphere
(vii)	the layer which is also known as the upper atmosphere	K	mesopause
(viii)	the collective name given to the troposphere and stratosphere	L	mesosphere
		M	lower atmosphere
(ix)	the layer just above the stratosphere in which most meteors burn while entering the earth's atmosphere	N	tropopause
(x)	the layer of gases containing numerous small suspended solid and liquid particles that surrounds the earth		

Structure and Composition of Earth

1. The interior structure of the earth is composed of three major zones which are:

   (A) Magma, mantle, and the core

   (B) Lava, crust, and magma

   (C) Hypocenter, crust, and the mantle

   (D) The core, lava, and hypocenter

   (E) Crust, mantle and the core

2. Which among the following is a reason for the sky to appear blue while being observed from the earth?

   (A) Regular reflection of sunlight

   (B) Irregular refraction of sunlight

   (C) Diffuse refraction of sunlight

   (D) Selective scattering of sunlight

   (E) Regular diffraction of sunlight

3. The suspended magnetic needle always comes to rest with its axis in a vertical plane called

   (A) geographic meridian

   (B) magnetic meridian

   (C) geographic declination

   (D) magnetic declination

   (E) geographic north pole

4. A part of the Earth's mantle and crust containing liquids, crystals and dissolved gases is known as _____

Earthquakes and Volcanoes

1. The following is an important sign that can be observed before an earthquake occurs:
   (A) The average temperature keeps decreasing daily
   (B) Television signals and radio stations are received at a frequency that is below normal
   (C) The entire animal kingdom becomes highly disturbed and restless
   (D) The level of water in the ocean decreases by one third
   (E) Formation of backward rivers due to sudden shaking of the earth
2. The instrument used to record ground movements caused by an earthquake is called _____
3. (a) What is meant by the following terms?
      i) volcanoes
      ii) non-renewable sources of energy
   (b) i) Mention two merits and two demerits of volcanoes
      ii) Briefly explain two hazards associated with earthquakes
   (c) i) List down two disadvantages of non-sustainable energy sources
      ii) State two applications of energy generated from water
4. (a) Define the term earthquake
   (b) Briefly explain the meaning of the following terms as used on earthquakes:
      i) Hypocenter
      ii) Epicenter
5. What is meant by the following terms used in geophysics:
   i) tsunami
   ii) magma

Structure and Composition of the Atmosphere

1. The layer in the atmosphere where weather phenomena are formed is called:
   (A) Stratosphere
   (B) Magnetosphere
   (C) Thermosphere
   (D) Troposphere
   (E) Exosphere
2. A point within the earth where an earthquake begins is called _____
3. i) List down the various layers of the atmosphere starting from the earth's surface
   ii) Which layer in part i) above is nearest to the earth? Explain two importances of it.

Greenhouse Effect and Global Warming

1. The increase in the average temperature of the world's atmosphere refers to _____
2. The process in which the emission of radiation by the atmosphere warms the earth's surface is called _____
3. (a) What is meant by the following terms:
      i) Global warming

ii) Greenhouse effect

iii) Earthquake

(b) Mention three effects of global warming

(c) i) What is the major cause of global warming?

ii) Briefly explain three measures that can be taken to control global warming

4. Name four gases that contribute to global warming and give one source of each.

5.5.8 Miscellaneous Problems

1. In a black and white television, the image is formed on the screen by:
   (A) Varying the intensity or brightness of the electron beam
   (B) Adjusting the number of stations using a remote control
   (C) Limiting the flow of electrons between the cathode and anode
   (D) Increasing the grid's voltage to its maximum value
   (E) Adjusting the antenna to capture waves of short wavelength

2. The element that is heaviest than all natural elements is called _____

3. Briefly explain the function of each of the following apparatus:
   i) Geiger-Muller (G-M) tube
   ii) Diffusion cloud chamber

4. A resistor of low resistance used to convert a moving coil galvanometer into an ammeter is called _____

5. The addition of impurities to elements such as silicon is aimed at:
   (A) Making p-n junction
   (B) Increasing the conductivity of the element
   (C) Stabilizing the temperature of the element
   (D) Making the element heavier
   (E) Increasing the resistivity of the element

6. Which of the following devices work on DC only?
   (A) An electric bell
   (B) A step-down transformer
   (C) A transistor
   (D) An induction coil
   (E) A step-up transformer

7. When a metal X is copper plated in electrolysis:
   (A) X is the cathode and alternating current is used
   (B) X is the anode and direct current is used
   (C) X is the cathode and direct current is used
   (D) X is the cathode and very high current is used
   (E) X is the anode and should first be cleaned

8. Match each item in List A with the correct response in List B

List A		List B	
(i)	Mirage	A	The force of friction between molecules of the same substance which exist on the surface of water
(ii)	Refractive index	B	Caused by total internal refraction of light
(iii)	Critical angle	C	Liquids which are difficult to stir and do not flow easily
(iv)	Floating body	D	Angle of reflection for which the angle of incidence is 90°
(v)	Brownian Movement	E	A very thin pipe which enables the hydrometer to float upright in liquid
(vi)	Viscosity	F	The ratio of sine of angle of refraction to the sine of angle of incidence
(vii)	The siphon	G	Attraction force which allows the moon to move around the earth
(viii)	A couple	H	The property of water surface to support the needle
(ix)	Capillarity	I	A glass tube used for releasing an accurate amount of liquid
(x)	Surface tension	J	Angle of incidence for which the angle of refraction is 90°
		K	Consists of two equal and opposite parallel forces and has turning effect
		L	Force that causes elastic material to twist
		M	Apparent weight is zero
		N	Upthrust of a liquid is equal to the apparent weight of the floating body
		O	The pull that resist the flow of liquids
		P	The ratio of speed of light in air to that in media
		Q	Tendency of liquid to be drawn into small openings
		R	Random motion of water molecules
		S	The chain and ball flushing tank
		T	Irregular motion of tiny particles suspended in fluid
		U	Bending of light which makes objects appear at an incorrect position

9. Match each item in List A with the correct response in List B

List A		List B	
(i)	surface tension effect	A	a resistor connected to the output circuit
		B	floating object displaces its own weight
(ii)	maximum displacement of pendulum bob	C	frequency of oscillation
		D	refractive index
		E	bar magnet
(iii)	cooling by evaporation	F	SI unit of magnetic flux
		G	amplitude
(iv)	thermopile	H	a property of solid materials that are strongly affected by magnetism
(v)	impuls		
(vi)	Tesla	I	solid-state detector
(vii)	ferromagnetism	J	detects radiant energy
(viii)	Geiger-Muller counter	K	product of force and time
		L	radioactive element
(ix)	Snell's Law	M	capacitor connected in parallel to the resistor in the emitter
(x)	voltage amplification	N	detects radioactive radiation
		O	SI unit of magnetic flux density
		P	floating without wetting
		Q	dogs hang out their tongues during hot weather
		R	materials that are attracted by strong magnetic field
		S	depends on the boiling temperature
		T	force of attraction between liquid molecules

Part II

NECTA Practicals

Biology

6.1 Introduction to Biology Practicals

6.1.1 Format

The theory portion of the Biology exam comprises 100 marks, while the practical carries 50 marks. A student's final grade for Biology is thus found by taking her total marks from both exams out of 150.

As of now, the Biology practical has 2 questions and students must answer **both**. Question 1 can come from any of the following topics: Nutrition, Movement, Transport of Living Things, Respiration, Reproduction, Coordination, Regulation or Growth. Question 2 is on Classification of Living Things. Each question is worth 25 marks, and students have $2\frac{1}{2}$ hours to complete the exam.

Note This information is current as of the time of publication of this manual. Updated information may be obtained by contacting the Ministry of Education.

6.1.2 NECTA Advance Instructions for Teachers

There are two sets of advance instructions. One set of advance instruction are given to teachers at least one month before the date of the exam. These instructions contain the list of specimen, apparatus, and other materials required for setting up the Biology practical questions. The instructions also suggest how many specimen to acquire for each candidate or group of candidates. It is imperative that the collection and storage of specimen for the practical be kept confidential.

The second set of instructions should be given 24 hours before the time of the practical. It includes how to label each specimen and which materials should be given to each candidate (or shared among candidates).

Usually if the instructions include a scalpel of some sort, this means students will be required to do some form of dissection. In most cases, the dissection is of a maize seed or bean to show whether is it a monocotyledon or dicotyledon. If the advance instructions include any form of glass apparatus or test tubes, there will most likely be a question on food tests.

6.1.3 Common Practicals

Food Tests test a food solution for starch, sugars, fats, and protein

Classification name and classify specimens, then answer questions about their characteristics

Respiration use lime water to test air from the lungs for carbon dioxide

Transport investigate osmosis by placing leaf petioles or pieces of raw potato in solutions of different solute concentrations

Photosynthesis test a variegated leaf for starch to prove that chlorophyll is necessary for photosynthesis

Coordination students look at themselves in the mirror and answer questions about the sense organs they see

Movement name bones and answer questions about their structure and position in the body

Note These are the most common practicals, but they are not necessarily the only practicals that can occur on the national exam. Food tests and Classification are by far the most common, but there are many eligible topics. Be sure to ask your school for past practicals to get an idea of the kind of questions that can occur.

6.2 Food Tests

In this practical, students test a solution of unknown food substances for starch, protein, reducing sugars, non-reducing sugars, and lipids. They record their procedure, observation, and conclusions, then answer questions about nutrition and the digestive system.

This section contains the following:

- Preparation of Chemical Solutions
- Preparation of Food Solutions
- Performing the Food Tests
- Examination Room
- Student Report
- Sample Food Test Practical

6.2.1 Preparation of Chemical Solutions

Always make sure the chemicals work before performing the food tests with students.

Benedict's Solution

This solution can be bought at a chemical store already prepared or you can make it yourself.

Using Sodium Carbonate:
- Add about 1 L of water to a plastic bottle
- Add 5 spoons of sodium carbonate ($NACO_3$)
- Add 3 spoons of citric acid
- Add 1 spoon of copper sulphate

Using Bicarbonate of Soda:
- Add 1 L of water to a cooking pot
- Add a box (70 g) of bicarbonate of soda
- Boil the mixture for 5-10 minutes. This makes sodium carbonate.
- Let cool and transfer to a plastic water bottle
- Add 3 spoons of citric acid
- Add 1 spoon of copper sulphate. Cap and shake to mix

Label as: BENEDICT'S SOLUTION FOR FOOD TESTS
The solution may be stored in any plastic or glass bottle and will keep indefinitely.

Copper (II) Sulphate

- Add one spoon of copper (II) sulphate to a 1.5 L bottle.
- Add 1 L of water and shake until chemicals are fully dissolved.

Label as: 1% COPPER (II) SULPHATE SOLUTION FOR FOOD TESTS
The solution may be stored in any plastic or glass bottle and will keep indefinitely.

Iodine Solution

Make sure to use iodine tincture from a pharmacy. The tincture must not contain ethanol/alcohol/spirit.

- Add 1 part iodine tincture to 10 parts water.

  Example: In a 500 mL bottle, add 40 mL iodine tincture, then and 400 mL of water.

- Cap the bottle and shake.

Label as: IODINE SOLUTION FOR FOOD TESTS
The solution may be stored in any plastic or glass bottle and will keep indefinitely.

Dilute NaOH

- Using a PLASTIC teaspoon, add one level teaspoon of NaOH to a 500 mL water bottle. Caustic soda (NaOH) reacts with metal. DO NOT TOUCH.

  SAFETY NOTE: Prepare about 100 mL of citric acid or ethanoic acid solution to neutralize sodium hydroxide spills on skin or lab tables. One spoon of citric acid in 100 mL of water is suitable. Ethanoic acid solutions are sold in stores as vinegar.

- Add 250 mL of water.

  SAFETY NOTE: This reaction can cause the solution to become very warm. Avoid chemical burns by wearing gloves.

- Cap well and shake. This makes 1 M sodium hydroxide solution.

Label as: 1 M SODIUM HYDROXIDE SOLUTION FOR FOOD TESTS (CORROSIVE)
The solution will react with carbon dioxide in the air if not well sealed. Do not store in glass bottles with glass stoppers as these will stick. The solution may be stored in plastic bottles indefinitely.

Dilute Acid

Your school may have dilute hydrochloric acid or you may have to make it yourself.

Using Hydrochloric Acid (HCl):
- Add 1 part HCl to 9 parts water.
Example: In a 1.5 L water bottle, add 900 mL of water, then add 100 mL of HCl
-Shake well

Using Citric Acid:
- Add 500 mL of water to a 1 L or 1.5 L water bottle
- Add 5 spoons of citric acid
- Cap well and shake. This makes 0.5 M citric acid

Label as: 0.5 M CITRIC ACID FOR FOOD TESTS
The solution may be stored in any plastic or glass bottle and will keep indefinitely.

Sudan III Solution

Using Sudan III solution takes a long time to show results. It may be replaced by iodine tincture solution for the lipids test.

- Combine 0.5 g of Sudan III powder with 100 mL of 70% ethanol solution (30 mL water and 70 mL ethanol).
- Place the solution in a warm water bath to help the Sudan III dissolve.
- Filter to remove any remaining solid.

Label as: SUDAN III SOLUTION FOR FOOD TESTS
The solution may be stored in any plastic or glass bottle and will keep indefinitely.

6.2.2 Preparation of Food Solutions

For the NECTA and mock exams you may have to set up the food test solutions. The instructions will tell you which ones you'll need to prepare in order to make 'Solution X.' Solution X consists of a mixture of at least 3 of the different food substances and is given to each student in at least 3 test tubes. Make sure food solutions are well-dissolved and colorless so that students don't know what is in the mixture. You don't need to measure the ingredients, but make sure to test the solutions before the practical.

Food Test	Preparation
Reducing Sugar	Use glucose powder and dissolve in water. Make sure the substance is fully dissolved so that students don't know what is in the mixture.
Non-reducting Sugar	Use sugar and dissolve in water. Make sure the substance is fully dissolved so that students don't know what is in the mixture.
Lipids	Mix sunflower oil with water. Shake immediately before use. Sunflower oil is best since it is liquid at room temperature.
Protein	Mix an egg white with water.
Starch	Save the water you use to boil potatoes, rice, or pasta. Make sure to remove the bits of food. You can also just mix flour in water, but it would be obvious.

6.2.3 Performing the Food Tests

Reducing Sugars Test

- Add a small amount of Benedict's solution to the food solution.
- Boil the solution and allow it to cool. Observe the colour changes from blue to green, yellow, then deep orange/brick red precipitate if reducing sugars are present.

Always do the reducing sugars test first because a non-reducing sugar will always test positive for a reducing sugar.

Non-reducing Sugars Test

- Add a small amount of dilute acid (HCl) to the solution.
- Boil the solution for about 30 seconds and allow it to cool.
- Add a small amount of NaOH to the solution and shake.
- Add a small amount of Benedict's solution and boil.
- Allow the solution to cool and observe as the solution changes from green to yellow, then to deep orange/brick red precipitate if non-reducing sugars are present.

Lipids Test

- Add a small amount of Sudan III or iodine solution to the food solution and shake.
- A red ring will form at the top of the test tube if lipids are present.

Using Sudan III colours the whole solution red whether it contains lipids or not. Use iodine solution to get a more distinct result.

Protein Test

- Add an *equal* amount of sodium hydroxide (NaOH) to the solution and shake.
- Add a small amount of copper (II) sulphate to the solution and shake.
- Observe the solution turn violet/purple in colour if protein is present.

Starch Test

- Add a small amount of iodine solution to the food solution.
- Observe the solution turn blue-black in colour if starch is present.

6.2.4 Examination Room

The NECTA practical exam is done in the school's lab or any other suitable room. Heat sources (jiko, etc.) should be spread evenly in the exam room so that students don't have to go far to heat their test tubes; this also cuts down on cheating. Spread students out and distribute supplies as you see fit.

Each student gets:
- 3 or more test tubes (to carry out 5 tests)
- A beaker containing Solution X
- A test tube rack (or a cut out water bottle with sand to hold the tubes)

Students may share the racks, but shouldn't share the cut out bottles

Each station should have:
- Copper II sulphate
- Water
- Dilute acid (HCl, etc.)
- Dilute base (sodium hydroxide)
- Iodine solution
- Sudan III solution (can be replaced by iodine solution)
- Benedict's solution

6.2.5 Student Report

Food test data is recorded in a table containing four columns: Test for, Procedure, Observation and Inference. (see table below)

Students should write the Procedure using the passive voice in the past tense. For example, "A small amount of Benedict's solution was added to the solution. Then the solution was boiled and allowed to

cool." In the Observation column, the student should write what they observed using the past tense and passive voice. For example, "A violet colour was observed." In the Inferences column, the students should write what they saw in the past tense and passive voice. For example, "Reducing sugars were not (or were) present."

Note that every column is worth marks on the exam. Even if students fail to do the food tests correctly, they can still get marks for writing what they are testing for and what the procedure should be.

An example of a completed food test results table is given below. Assume the solution contains proteins, reducing sugars, non-reducing sugars and starch.

Food Tested	Procedure	Observation	Inference
Lipids	A few drops of Sudan III solution (or iodine solution) were added to solution X. The solution was shaken and allowed to stand.	A red ring did not form at the surface.	Lipids were not present.
Proteins	An equal amount of NaOH was added to solution X and shaken. A few drops of copper (II) sulphate were added to solution X and shaken again.	A violet colour was observed.	Proteins were present.
Reducing sugars	A small amount of Benedict's solution was added to solution X. The solution was heated and allowed to cool.	A brick red precipitate was observed.	Reducing sugars were present.
Non-reducing sugars	A small amount of dilute acid was added to solution X. The solution was heated and allowed to cool. Then a small amount of NaOH solution was added, and the solution was shaken. Finally, a small amount of Benedict's solution was added. The solution was boiled and let cool.	The solution changed from green to yellow, then to a deep orange/brick red precipitate.	Non-reducing sugars were present.
Starch	A few drops of iodine solution were added to solution X and shaken.	A blue-black colour was observed.	Starch was present.

6.2.6 Sample Food Test Practicals

Sample Practical #1

You have been provided with solution **B**.

(a) Identify the food substances present in solution **B** by using the reagents provided. Tabulate your work as shown in the following Table:

Food Tested	Procedure	Observation	Inference

(b) For each food substance identified in 1(a);

(i) Name two common sources.

(ii) State their role in the body of human being.

(c) The digestion of one of the identified food substance in 1(a) starts in the mouth.

(i) Name this food substance.

(ii) Identify the enzyme responsible for its digestion in the mouth.

(d) The digestive system of human being has several parts.

(i) Name the part of digestive system in which most of digestion and absorption of food takes place.

(ii) Explain how the named part in (d) (i) is adapted for absorption of digested food substances.

6.3 Classification

The classification practical requires students to identify specimens of animals, plants, and fungi. The students must write the common name, kingdom, phylum, and sometimes class of each specimen. They also answer questions about the characteristics and uses of the specimens.

This section contains the following:

- Common specimens
- Where to find specimens
- Storage of specimens
- Sample practical with solutions
- Additional classification questions

6.3.1 Common Specimens

Fungi Mushroom, yeast, bread mold

Plants Fern, moss, bean plant, bean seed, maize plant, maize seed, pine tree, cactus, sugar cane, Irish potato1, cypress tree, acacia tree, hibiscus leaf, cassava

Animals Millipede, centipede, grasshopper, lizard, tilapia (fish)3, scorpion, frog, tapeworm, liver fluke, cockroach, spider

6.3.2 Storage of Specimens

- Insects and mushrooms can be dried and stored in jars. However, they become brittle and break easily.
- A 10% solution of formaldehyde is the best way of storing specimens. Formaldehyde is often sold as a 40% solution. It should be stored in glass jars and out of the sun. Check specimens periodically for evaporation. Formaldehyde works because it is toxic; handle carefully.
- In a pinch, a 70% solution of ethanol can also be used to store insects, lizards, and worms. However, specimens sometimes decay in ethanol.

6.3.3 Sample Classification Practicals

Sample Practical #1 (With Sample Solutions)

You have been provided with specimens L, M, N, O, and P.

1. Identify the specimens by their common names.

L: maize plant
M: bean plant
N: yeast
O: millipede
P: moss

2. Classify each specimen to the phylum level.

Specimen	Kingdom	Phylym
L (maize plant)	Plantae	Angiospermophyta
M (bean plant)	Plantae	Angiospermophyta
N (yeast)	Fungi	Ascomycota
O (millipede)	Animalia	Arthropoda
P (moss)	Plantae	Bryophyta

3. Further classification:
   (a) Write the classes of specimens L and M.

   Specimen L (maize plant): Class Monocotyledonae
   Speciment M (bean plant): Class Dicotyledonae

   (b) List two observable differences between specimens L and M.

Specimen	Vein structure	Root structure
L (maize plant)	Parallel veins	Fibrous roots
M (bean plant)	Net veins	Tap roots

   The answers to this question should be differences between monocots and dicots that the student can see by observing the plants with their naked eyes. Hence answers such as "vascular bundles in a ring" are not correct.

4. Explain why specimen P cannot grow taller.

   Specimen P (moss) cannot grow taller because it has no xylem and phloem. If it grew taller, it would not be able to transport food and water throughout the plant.

5. Write down two distinctive characteristics of the phylum to which specimen O belongs.

   Characteristics of phylum Arthropoda:

   - jointed legs
   - segmented body
   - exoskeleton made of chitin

6. Reproduction:
   (a) List the modes of reproduction in specimens M and N.

   Specimen M (bean plant) reproduces by sexual reproduction. Specimen N (yeast) reproduces by asexual reproduction.

   (b) What are two differences between these modes of reproduction?

Method	Genetic variation	Parents	Gametes
Asexual reproduction	There is no genetic variation between offspring.	Requires one parent only.	No gametes are involved.
Sexual reproduction	There is genetic variation between offspring.	Usually requires two parents.	Involves fusion of two gametes.

Additional Classification Questions

- Identify specimen X, Y, and Z by their common names.
- Classify specimens X, Y, and Z to the class level. (This means write the kingdom, phylum, and class.)
- Write the observable features of specimen X.
- List three observable differences/similarities between specimens X and Y.
- State the economic importance of specimen X.
- What characteristics are common among specimens X and Y?
- Why are specimens X and Y placed in different classes/phyla/kingdoms?
- Why are specimens X and Y classified under the same class/phylum/kingdom?
- What distinctive features place specimen X in its respective kingdom/phylum/class?
- How is specimen X adapted to its way of life?
- Suggest possible habitats for specimens X and Y.

- Which specimen is a primary producer/parasite/decomposer?
- For mushroom, yeast, bread mold, grasshopper, moss, tilapia, liver fluke, and tapeworm: Draw and label a diagram of specimen X.
- For tilapia: Draw a big and well-labeled diagram showing a lateral view of specimen X.
- For maize and bean:
  - Mention the type of pollination in specimen X [wind pollinated or insect pollinated].
  - How is specimen X adapted to this type of pollination?
  - Mention the type of germination [hypogeal or epigeal] in specimen X.
- For bean seed:
  - List three observable features of specimen X and state their biological importance.
  - Split specimen X into two natural halves. Draw and label the half containing the embryo.
- For fern:
  - Observe the underside of the leaves of specimen X
  - What is the name of the structures you have observed?
  - Give the function of the structures named above.
  - Draw specimen X and show the structures named above.

6.4 Respiration

The purpose of this practical is to investigate the properties of air exhaled from the lungs. This section contains the following:

- Limewater (properties and preparation)
- Apparatus
- Cautions and advice when using traditional materials
- Sample practical with solutions

6.4.1 Limewater

Limewater is a saturated solution of calcium hydroxide. It is used to test for carbon dioxide. When carbon dioxide is bubbled through limewater, the solution becomes cloudy. This is due to the precipitation of calcium carbonate by the reaction:

$$CO_{2(g)} + Ca(OH)_{2(aq)} \longrightarrow CaCO_{3(s)}$$

Limewater can be prepared from either calcium hydroxide or calcium oxide. Calcium oxide reacts with water to form calcium hydroxide, so either way you end up with a calcium hydroxide solution. Calcium oxide is the primary component in cement. Calcium hydroxide is available from building supply shops as *chokaa*.

To prepare lime water, add three spoons of fresh *chokaa* or cement to a bottle of water. Shake vigorously and then let stand until the suspended solids precipitate. Decant the clear solution. *Chokaa* produces a solution much faster than cement.

The exact mass of calcium hydroxide or calcium oxide used is not important. Just check whether some calcium hydroxide remains undissolved at the end – a sign that you have made a saturated solution.

Test limewater by blowing air into a sample with a straw. It should become cloudy. If it does not, then the concentration of $Ca(OH)_2$ is too low.

6.4.2 Cautions and Advice When Using Traditional Materials

If you use a delivery tube and pass it through a rubber stopper, do not use a single-holed stopper. This is what the pictures on NECTA practicals suggest, but it is a terrible idea. A single-holed stopper has no space for air to escape. So when a student blows air into the solution, the pressure in the test tube increases. The high pressure air then pushes limewater up the straw into the student's mouth. Alternatively, the student blows the stopper out of the test tube. If you use a stopper, use a double-holed

stopper so that the extra air has a place to escape.

Q: Is a glass delivery tube stuck in a rubber stopper? Do not pull hard on it. Just soak the stopper in warm water for a few minutes. The rubber will soften and the tube will come out.

Q: Are your test tubes and delivery tubes cloudy after the practical? Clean them with dilute acid. This will dissolve any calcium carbonate that has been deposited on the glass.

6.4.3 Sample Respiration Practicals

Sample Practical #1 (with Sample Solutions)

You have been provided with Solution B in a test tube. Use a delivery tube to breathe (exhale) into the solution until its color changes.

1. What is the aim of this experiment?

   The aim of this experiment is to test exhaled air for carbon dioxide

2. What is Solution B?

   Solution B is limewater

   (a) What changes did you observe after breathing into Solution B?

   Solution B became cloudy (or milky)

   (b) What can you conclude from these changes?

   Conclusion: exhaled air contains carbon dioxide

3. Breathe out over the palm of your hand. What do you observe?

   Air breathed out over the palm of the hand is warm

4. Breathe out over a mirror. What do you observe?

   Droplets of water condense on the mirror

5. Using your observations in the three experiments above, list three properties of exhaled air.

   Conclusions:

   - exhaled air contains carbon dioxide
   - exhaled air contains water
   - exhaled air is warm

6. Explain why exhaled air is different from inhaled air. Where do the substances you identified in exhaled air come from?

   Exhaled air contains the waste products of aerobic respiration. The carbon dioxide and water in exhaled air are products of respiration.

6.5 Transport

The purpose of this practical is to investigate osmosis by observing the changes in a leaf petiole placed in a hypotonic solution (water) and a hypertonic solution (water containing salt or sugar).

This section contains the following:

- Materials
- Sample practicals with solutions
- Additional questions

6.5.1 Materials

The petiole is the stalk which attaches a leaf to a branch. The papaya leaf petioles in this practical should be soft petioles from young leaves, not stiff petioles from older leaves. Cut the petioles into pieces, and give each student two pieces of about 6 cm in length. Cylinders cut from a raw potato may be used instead of petioles.

The hypertonic solution may be made with by mixing either salt or sugar with water. The hypotonic solution is tap water.

6.5.2 Sample Transport Practicals

Sample Practical #1 (with Sample Solutions)

Instructions
You have been provided with two pieces of a papaya leaf petiole, Solution A, and Solution B.

Use a razor blade to split the pieces of petiole longitudinally, up to a half of their length. You should have four strips at one end of each petiole, while the other end remains intact.

Place one petiole in solution A, and place the other petiole in solution B. Let the petiole sit for about ten minutes, then touch them to feel their hardness or softness.

Draw a sketch of each petiole after sitting in its respective solution for ten minutes.

Record your observations and explanations about the petioles in the table below.

Solution	Observation	Explanation
A		
B		

Questions

Solution	Observation	Explanation
A	The petiole became hard (turgid)	Water diffused into the petiole cells
B	The petiole became soft (flaccid)	Water diffused out of the petiole cells

1. What was the aim of this experiment?

   The aim of the experiment was to investigate the effect of osmosis on plant cells

2. What was the biological process demonstrated by this experiment?

   The experiment demonstrated osmosis

3. What is the importance of this process to plants?

   Importance of osmosis in plants:

   - Water enters plant cells by osmosis so that they become turgid. Turgor helps support the plant and hold it upright
   - Water diffuses into the xylem from the soil via osmosis

4. Which solution contained:
   (a) pure water

   Solution A

   (b) a high concentration of solutes

   Solution B

5. What happened to the cells of the petioles in each solution? Illustrate your answer.

6. What would happen to the cells of the petioles in solution A if their cell walls were removed?

   The petiole cells would burst in Solution A if their cell were removed.

Additional Questions

You can extend this experiment by giving students two pieces of meat in addition to the petioles. The piece of meat placed in pure water should expand and become soft due to the cells bursting. The piece placed in salt water should shrink and become hard due to water diffusing out of the cells. This experiment helps to teach the different effects of osmosis on plant and animal cells. If your school has a good microscope, try observing plant cells under the microscope after letting them sit in hypotonic and hypertonic solutions.

You can add critical thinking questions to the practical that require the student to use their knowledge of osmosis. For example:

- Why does a freshwater fish die if it is placed in salt water?
- Why do merchants spray vegetables with water in the market?
- You can die if a doctor injects pure water into your bloodstream. Why?

6.6 Photosynthesis

The purpose of this practical is to prove that chlorophyll is required for photosynthesis. This is done by using iodine to test a variegated leaf for starch. The parts of the leaf containing chlorophyll are expected to contain starch, while the parts lacking chlorophyll are expected to lack starch.

This section contains the following:

- Procedure
- Cautions
- Materials and where to find them
- Sample practical with solutions
- Additional practicals

6.6.1 Procedure

1. Use iodine tincture from the pharmacy without dilution.
2. Prepare hot water bathes. The water should be boiling.
3. While the water gets hot, send the students to gather small leaves. The best have no waxy coating and are varigated (have sections without green).
4. The leaves should be boiled in the hot water bath for one minute.
5. Each group should then move its leaf into their test tube and cover it with methylated spirit.
6. Each group should then heat their test tube in a water bath. Over time, the leaf should decolorize and the methylated spirit will turn bight green. The chlorophyll has been extracted and moved to the spirit. A well chosen leaf should turn completely white, although this does not always happen.
7. After decolorization, dips the leaves briefly in the hot water.
8. For leaves that turn white, students should test them for starch with drops of iodine solution.

6.6.2 Cautions

Ethanol is flammable! It should never be heated directly on a flame. Use a hot water bath – place a test tube or beaker of ethanol in a beaker or bowl of hot water and let it heat slowly. The boiling point of ethanol is lower than the boiling point of water, so it will start boiling before the water. If the ethanol does catch fire, cover the burning test tube with a petri dish or other non-flammable container to extinguish the flame.

6.6.3 Materials and Where to Find Them

- Variegated leaf: this is a leaf that contains chlorophyll in some parts, but not in others. Often variegated leaves are green and white or green and red. Look at the flower beds around the school and at the teachers' houses – they often contain variegated leaves. Test the leaves before the

practical, as some kinds are too waxy to be decolorized by ethanol. Also, check for chlorophyll by looking at the underside of the leaves; the leaves you use have at least a small section of white on their undersides, signifying a lack of chlorophyll.
- Source of heat: anything that boils water – Motopoa is best, followed by kerosene and charcoal
- Ethanol: use the least expensive strong ethanol available; this is probably methylated spirits unless your village specializes in high proof gongo.

6.6.4 Sample Photosynthesis Practicals

Sample Practical #1 (with Sample Solutions)

You have been provided with specimen G.

1. Identify specimen G.

   Specimen G is a varigated leaf

2. Make a sketch showing the color pattern of specimen G. Carry out the following experiment:

   I. Place specimen G in boiling water for one minute.

   II. Boil specimen G in ethanol using a hot water bath. Do not heat the ethanol directly on a flame.

   III. Remove specimen G from the ethanol. Dip it in hot water.

   IV. Spread specimen G on a white tile and drip iodine solution onto it. Use enough iodine to cover the entire specimen.

   V. Make a sketch showing the color pattern of specimen G at the end of the experiment.

3. What was the aim of this experiment?

   The aim of this experiment was to investigate whether chlorophyll is required for photosynthesis.

4. Why was specimen G

   (a) Boiled in water for one minute

   Specimen G was boiled in water to kill the cells and stop all metabolic processes

   (b) Boiled in ethanol

   Specimen G was boiled in ethanol to decolorize it (to remove the chlorophyll)

   (c) Dipped in hot water at the end of the experiment

   Specimen G was dipped in hot water to remove the ethanol. (If ethanol is left on the leaf it will become hard and brittle)

5. What was the purpose of the iodine solution?

   The purpose of the iodine solution was to test for starch.

6. Why was the ethanol heated using a hot water bath?

   The ethanol was heated using a hot water bath because ethanol is flammable.

7. What can you conclude from this experiment? Why?

   The experiment shows that chlorophyll is required for photosynthesis. We know this because the parts of the leaf containing chlorophyll also contained starch, which is a product of photosynthesis. Thus, the parts of the leaf containing chlorophyll performed photosynthesis. The parts of the leaf lacking chlorophyll lacked starch. Hence, these parts of the leaf did not perform photosynthesis.

Additional Practicals

To test if light is required for photosynthesis
Take a live plant, and leave it in the dark for 24 hours to destarch all leaves. Then, cover some of its leaves with cardboard or aluminum foil, while leaving others uncovered. Let the plant sit in bright light for several hours. Give each group of students one leaf that was covered in cardboard, and one leaf that was uncovered. Have them use the procedure above to test for starch. They should find that the covered leaf contains no starch, while the uncovered leaf contains starch.

A cool variation on this experiment is to cover leaves with pieces of cardboard that have letters or pictures cut out of them. The area where the cardboard is cut out will perform photosynthesis and produce starch. When the students do a starch test, a blue-black letter or picture will appear on the leaf.

To prove that oxygen is a product of photosynthesis
This experiment requires a water plant. Basically, place a live water plant under water[1], then cover it with an inverted funnel. Place an upside-down test tube filled with water on top of the funnel. Let the plant sit in bright light until the water in the test tube is displaced and the test tube fills with gas. Use a glowing splint to test the gas – if it is oxygen, it will relight the splint.

[1] some books suggest putting sodium bicarbonate (baking soda) in the water.

Chemistry

7.1 Introduction to Chemistry Practicals

7.1.1 Format

The theory portion of the Chemistry exam comprises 100 marks, while the practical carries 50 marks. A student's final grade for Chemistry is thus found by taking her total marks from both exams out of 150.

As of now, the Chemistry practical has 3 questions and students must answer **all** of them. Question 1 is on Volumetric Analysis and Laboratory Techniques and Safety. Question 2 is taken from Ionic Theory and Electrolysis/Chemical Kinetics, Equilibrium and Energy. Question 3 is on Qualitative Analysis. Question 1 is worth 20 marks, while Questions 2 and 3 carry 15 marks each. Students have $2\frac{1}{2}$ hours to complete the exam.

Students are allowed to use Qualitative Analysis guidesheet pamphlets in the examination room. The tables for the Qualitative Analysis guidesheet are also included in this manual (See Section 7.3)

7.1.2 NECTA Advance Instructions for Teachers

There are two sets of advance instructions. One set of advance instructions are given to teachers at least one month before the date of the exam. These instructions contain the list of apparatus, chemicals, and other materials required for preparing the Chemistry practical questions. The instructions also give suggestions on the amount of chemicals that should be available for each candidate to use.

The second set of instructions should be given 24 hours before the time of the practical. It includes which chemicals and apparatus should be given to each candidate (or shared among candidates) for each of the three practical questions. These instructions also state how to label each solution and/or compound.

The bottom of the 24 Hours Advance Instructions also states that the Laboratory Technician or Head of Chemistry Department should perform some of the experiments immediately after the last session of the examination. It is only required to perform the titration and chemical kinetics experiments. This is required to be done for every school and is used as a reference for the markers in case the water, chemicals, and apparatus are not the same at every school. This is enclosed and submitted together with the students' test papers and may be used as a marking scheme. It is also advised that any notes, comments or concerns for the markers be included at this time.

7.1.3 Common Practicals

Volumetric Analysis determine the concentration of a solution of a known chemical by reacting it with a known concentration of another solution

Qualitative Analysis systematically identify an unknown salt through a series of chemical tests

Chemical Kinetics and Equilibrium observe changes in chemical reaction rates by varying conditions such as temperature and concentration

Note These are the most common practicals, but they are not necessarily the only practicals that can occur on a NECTA exam. Although the updated exam format lists Questions 1 and 3 as Volumetric Analysis and Qualitative Analysis respectively, Question 2 can come from a variety of topics which may not yet have been used in older past papers. Be sure to regularly check the most recent past NECTA papers to get a good idea of the types of questions to expect.

7.2 Volumetric Analysis

This section contains the following:

- Volumetric Analysis Theory
- Traditional Volumetric Analysis Technique
- Common Calculations in Titration Experiments
- Tips and Tricks
- Sample Practical Questions

7.2.1 Volumetric Analysis Theory

Volumetric Analysis is a method to find the concentration (molarity) of a solution of a known chemical by comparing it with the known concentration of a solution of another chemical known to react with the first. For example, to find the concentration of a solution of citric acid, one might use a 0.1 M solution of sodium hydroxide because sodium hydroxide is known to react with citric acid.

The most common kinds of volumetric analysis are for acid-base reactions and oxidation-reduction reactions. Acid-base reactions require use of an indicator, a chemical that changes color at a known pH. Some oxidation-reduction reactions require an indicator, often starch solution, although many are self-indicating, (one of the chemicals itself has a color).

The process of volumetric analysis is often called *titration.*

7.2.2 Traditional Volumetric Analysis Technique

The Volumetric Analysis practical consists of an acid that is being titrated acid against a base until neutralization, in order to determine the concentration of the base. On NECTA practical exams, titrations are done four times: a pilot followed by three trials. The pilot is done quickly and is used to determine the approximate volume needed for neutralization to speed up the following trials.

Ex: If the pilot gives an end point of 25.00 mL, then for the three subsequent trials, 20.00 mL can quickly be added from the burette. Then begin to add solution slowly until the endpoint is reached.

Note Results from the pilot are not accurate and are not included when doing calculations. Students should also know that not all three trials are always used in calculating the average volume used. Values of trials must be consistent and within $\pm$ 02 cm^3 of each other to be valid for average volume determination.

Volumetric Analysis Using Burettes

Preparation

1. After washing Burettes thoroughly, rinse the Burette with 3 mL of the acidic solution that will be used during the titration (Acid usually goes in the Burette).
   - Cover the entire inside surface of the Burette.
   - Discard 3 mL of solution properly when finished .
   - Why? This prevents dilution of acid by water.
2. After washing the flask thoroughly, rinse the flask with 3 mL of solution that will be used during the titration (Base usually goes in the flask).
   - Cover the entire inside surface of the flask.
   - Discard 3 mL of solution properly when finished.

Procedure

1. Clean the burette with water.
2. Rise the burette with the acid that will be used for the titration.
3. Fill the burette with the acid. Let a little run out through the stopcock.

4. Record the initial burette reading.
5. Use a syringe to transfer the base solution into a conical flask.
6. Record the volume moved by the syringe.
7. If you are using an indicator, add a few drops to the flask.
8. Slowly add the acid from the burette to the flask. Swirl the flask as you titrate. Be careful. Avoid acid drops landing on the sides of the flask.
9. Stop titration when the slight color change become permanent. This is the end point.
10. Record final reading of the burette.
11. Repeat for remaining titrations.

Notes

- Burettes tell you the volume of solution used, not the volume present.
  Ex: Initial Reading - 4.23 mL
  Final Reading - 20.57 mL
  You used 16.34 mL of acid during the titration.
- Reading Measurements
  - Always read burettes at eye level.
  - Always read from the bottom of the meniscus. In a plastic apparatus, there is often no meniscus.
  - Burettes are accurate to 2 decimal places. Students should estimate to the nearest 0.01 mL
- For Acid-Base indicators: The less indicator used, the better. To change color, the indicator must react with fluid in the burette. If you add too much, it uses more chemical than necessary for neutralization, creating an indicator error.
- For starch indicators: use 1 mL. Starch is not titrated; indicators are, and you must use more to get a good color change.

7.2.3 Common Calculations in Titration Experiments

All NECTA practical experiments require students to determine some unknown in the titration procedure. Common calculations that the problem statement will ask for include:

- Concentration (molarity) of an acid or base
- Relative atomic mass of unknown elements in an acid or base
- Percentage purity of a substance
- Amount of water of crystallization in a substance

Concentration of an Acid or Base

The problem statement may have the student find either the unknown molarity (moles per litre) or concentration (grams per litre) of the acid or the base. As an example, the following steps are used to calculate the unknown concentration of an acid:

1. *Calculate the average volume of acid used.*
   Remember to not use the pilot trial or any trials that are not within $\pm$ 0.2 cm^3 of each other.

2. *Calculate the number of moles of the base used.*

$$\text{Molarity} = \frac{\text{number of moles}}{\text{volume of solution}}$$

   These values can usually be taken from the solutions listed on the test paper. Also be sure that the units of volume of solution are in litres or dm^3.

3. *Write a balanced chemical equation for the reaction.*
   The chemical equation can also be written as an ionic equation.

4. *Calculate the number of moles of acid used from the mole ratio taken from the balanced chemical equation.*
   Both ionic and full formulae equations give the same mole ratio.

5. *Work out the molar concentration of the acid.*
   The molar concentration can be determined using the calculated number of moles of acid (found in the previous step) and the average volume of acid used (found in step 1), using the equation in step 2.
   Alternatively, the following equation can be used:

$$\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$$

   where:
   C_A is the molar concentration of the acid,
   V_A is the volume of the acid used,
   n_A is the number of moles of the acid used,
   C_B is the molar concentration of the base,
   V_B is the volume of the base used, and
   n_B is the number of moles of the base used.

Similar steps are used to calculate the unknown concentration of a base.
Repeat steps 1 through 5, but with the following changes:

- Step 2: Calculate the moles of the acid used.
- Step 4: Calculate the moles of the base from the mole ratio.
- Step 5: Find the molar concentration of the base, either using the molarity calculation or the equation above.

Relative Atomic Mass of Unknown Elements

Atomic mass of unknown elements, as well as molecular mass of compounds with unknown elements may need to be calculated in the problem statement. Most unknown elements will be a metal of a basic compound. As an example, the following steps are used to calculate the relative atomic mass of an unknown metal element of a metal carbonate:

1. *Calculate the average volume of acid used.*
   Remember to not use the pilot trial or any trials that are not within $\pm$ 0.2 cm^3 of each other.

2. *Calculate the number of moles of the acid used.*

$$\text{Molarity} = \frac{\text{number of moles}}{\text{volume of solution}}$$

   These values can usually be taken from the solutions listed on the test paper. Also be sure that the units of volume of solution are in litres or dm^3.

3. *Write a balanced chemical equation for the reaction to get the mole ratio.*

4. *Determine the number of moles of the metal carbonate used.*
   This can be taken from the balanced chemical equation.

5. *Work out the molecular concentration of the metal carbonate solution.*
   Use the formula as shown in step 2.

6. *Calculate the mass of the metal carbonate in one litre of solution.*
   This can be done using the following ratio:

$$\frac{\text{mass given in problem statement}}{\text{volume given in problem statement}} = \frac{\text{mass of unknown metal}}{\text{one litre}}$$

Make sure the units correspond because sometimes the problem statement will be expressed in dm^3 or cm^3.

7. *Using the molarity of the solution and the mass of the metal carbonate per litre of solution, work out the relative molecular mass of the metal carbonate.*
   The following equation can be used to calculate molar mass:

$$\text{molar mass} = \frac{\text{mass per litre}}{\text{molarity}}$$

8. *Calculate the relative atomic mass of the metal based on the formula of the carbonate.*
   Use the total molar mass of the compound found in step 7 and the molar mass of each element in the compound to find the molar mass of the unknown element.

Some problem statements may require the student to identify the unknown element from its molecular mass.

Note Similar steps should be followed if the unknown element is of an acidic compound. Just replace the steps that include the metal carbonate solution with the acid solution.

Percentage Purity of a Substance

Problem statements that require the student to find percentage purity will usually contain one solution in the list provided that specifically states it is impure or that it is a hydrated compound (seems very low in concentration). Again, it is possible to determine percentage purity of an acid or a base. As an example, the following steps are used to calculate the percentage purity of a base:

1. *Determine the average volume of the acid used.*
   Remember to not use the pilot trial or any trials that are not within $\pm$ 0.2 cm^3 of each other.

2. *Calculate the number of moles of the acid used.*

$$\text{Molarity} = \frac{\text{number of moles}}{\text{volume of solution}}$$

   These values can usually be taken from the solutions listed on the test paper. Also be sure that the units of volume of solution are in litres or dm^3.

3. *Write a balanced chemical equation for the reaction to get the mole ratio.*

4. *Determine the number of moles of base used in the reaction.*
   This can be taken from the mole ratio from the previous step.

5. *Calculate the mass of the base used in the reaction.*
   The mass can be determined by the number of moles calculated and the following relationship:

$$\text{mass} = \text{number of moles} \times \text{molar mass}$$

6. *Work out the percentage purity of the base solution sample.*
   The following equation for percentage purity should be used:

$$\text{percentage purity} = \frac{\text{mass of pure substance in sample}}{\text{mass of the impure sample}} \times 100\%$$

   It is very important to note that when calculating percentage purity, the amount of volume in the concentration of base must be equal to the volume of concentration of acid used. For example, if there was 0.424 g of sodium carbonate in 25 cm^3 of solution reacting with a 250 cm^3 solution of acid, the mass of sodium carbonate must be converted to know the mass in 250 cm^3. Therefore, 250 cm^3 of base solution will contain 4.24 g, not 0.424 g.
   The value for the mass of the impure sample comes from the list of provided solutions and the mass of the pure sample will come from the calculations.

Note Similar steps can be followed to find the percentage purity of a the acid solution sample. Instead of finding the mass of the base, use the calculated moles of acid used to find the mass of acid in the actual reaction.

Amount of Water of Crystallization

Water of crystallization is the water that is bound within crystals of substances. Most hydrated substances and solutions contain water of crystallization. Problem statements that ask students to determine the amount of water of crystallization will have a solution with a formula similar to [base]·xH_2O, and they have to solve for x. As an example, the following steps are used to determine the number of molecules of water of crystallization in a hydrated base compound sample:

1. *Calculate the average volume of the acid used.*
   Remember to not use the pilot trial or any trials that are not within ± 0.2 cm^3 of each other.

2. *Calculate the number of moles of the acid used.*

$$\text{Molarity} = \frac{\text{number of moles}}{\text{volume of solution}}$$

   These values can usually be taken from the solutions listed on the test paper. Also be sure that the units of volume of solution are in litres or dm^3.

3. *Write a balanced chemical equation for the reaction to get the mole ratio.*

4. *Calculate the number of moles of the base used.*
   This can be determined from the mole ratio in the previous step.

5. *Determine the molar concentration of the base.*
   The molarity can be calculated using the volume of base used in the experiment and the equation from step 2.

6. *Calculate the relative molecular mass (R.M.M.) of the base compound.*
   The following equation can be used to calculate molar mass:

$$\text{molar mass} = \frac{\text{mass per litre}}{\text{molarity}}$$

7. *Determine the number of molecules of water of crystallization in the sample.*
   Using the relative atomic masses of the various atoms in the base compound, subtract the mass of the compound from the total mass of the hydrated compound. Water molecules always have a total molecular mass of 18 g/mol, so the remaining mass will be composed of multiples of 18. For example, if a hydrated carbonate (Na_2CO_3 ·xH_2O) has a total mass of 286 g, the molecules of water can be determined as follows:
   $2\text{Na} + \text{C} + 3\text{O} + x(2\text{H} + \text{O}) = 286$
   $(2 \times 23) + 12 + (3 \times 16) + x[(2 \times 1) + 16] = 286$
   $106 + 18x = 286$
   $18x = 180$
   $x = 10$

   Therefore, in this example, there are 10 molecules of water of crystallization in the hydrated sodium carbonate (Na_2CO_3 ·10H_2O) sample.

7.2.4 Tips and Tricks

The following are some tips and tricks for successfully performing the Volumetric Analysis practical:

- Create a table for the titration values (should contain the pilot and the three trials)
- Put 25 mL of the acid or base that will be in the flask
- Titrate until you see a PERMANENT color change
- Do a pilot titration to know about how many mL you will need

- For titrations after the pilot, when you get close to the pilot value add the acid or base SLOWLY and mix between drops
- Swirl flask to mix them thoroughly
- Only use values between ±0.02, and do not use the pilot values in calculations

7.2.5 Sample Practical Questions

The following are two sample practical questions:

Sample Practical #1

You are provided with the following:
PP: A solution of 0.1 M hydrchloric acid;
RR: A solution of 1.39 g of impure sodium carbonate anhydrous dissolved in 250 cm^3 of solution;
MO: Methyl orange indicator

Questions:

(a) i) Titrate solution PP against 20 cm^3 or 25 cm^3 of RR until the colour change. Record the burette ratings. Repeat the procedure to obtain three accurate readings and record your results in a tabular form.

ii) Why did the colour of the solution change?

iii) Determine the average title volume

iv) _____ cm^3 of solution RR required _____ cm^3 of solution PP for a complete reaction

v) Assume that sulphuric acid of the same molarity was used in the place of hydrochloric acid, would it be a difference in the title volume used? Give reason.

(b) i) Name the apparatus you used for measuring volume of PP

ii) Why the apparatus in (b) i) is the best recommended for its function?

(c) Write a balanced chemical equation of the reaction between the solutions PP and RR

(d) Calculate the following and write your answer in two decimal places

i) molarity of RR

ii) percentage purity of RR

(e) State two applications of volumetric analysis

Sample Practical #2

You are provided with the following:
S: A solution containing 0.125 M sulphuric acid (H_2SO_4);
T: A solution made by dissolving 15 g of impure sodium hydroxide (NaOH) in distilled water making up to 1000 cm^3 of the solution;
MO: Methyl orange indicator

Questions:

(a) i) Titrate S (from the burette) against T (in the titration flask) using MO up to the end point. Repeat the procedure to obtain three accurate readings and record your results in a tabular form.

ii) Calculate average volume of S used

iii) _____ cm^3 of T required _____ cm^3 of S for a complete reaction

iv) The color changed at the neutralization point was from _____ to _____.

(b) Write a balanced chemical equation for the reaction taking place between S and T.

(c) Calculate the percentage purity and percentage impurity of sodium hydroxide

7.3 Qualitative Analysis

This section contains the following:

- Overview of Qualitative Analysis
- The Steps of Qualitative Analysis
- Tips and Tricks
- Sample Practical Questions

7.3.1 Overview of Qualitative Analysis

The salts requiring identification have one cation and one anion. Generally, these are identified separately although often knowing one helps interpret the results of tests for the other. For ordinary level in Tanzania, students are confronted with binary salts made from the following ions:

- Cations: NH_4^+, Ca^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Na^+
- Anions: CO_3^{2-}, HCO_3^-, NO_3^-, SO_4^{2-}, Cl^-

At present, ordinary level students receive only one salt at a time. The teacher may also make use of qualitative analysis to identify unlabeled salts.

7.3.2 The Steps of Qualitative Analysis

The ions are identified by following a series of ten steps, divided into three stages. These are:

Preliminary tests: These tests use the solid salt. They are: appearance, action of heat, action of dilute H_2SO_4, action of concentrated H_2SO_4, flame test, and solubility.

Tests in solution: The compound should be dissolved in water before carrying out these tests. If it is not soluble in water, use dilute acid (ideally HNO_3) to dissolve the compound. The tests in solution involve addition of NaOH and NH_3.

Confirmatory tests: These tests confirm the conclusions students draw from the previous steps. By the time your students start the confirmatory tests, they should have a good idea which cation and which anion are present. Have students do one confirmatory test for the cation they believe is present, and one for the anion you believe is present. Even if several confirmatory tests are listed, students only need to do one. When identifying an unlabelled container, however, you might be moved to try several, especially if you are new to this process.

PRELIMINARY TESTS

The preliminary tests are generally for solid samples. As shown in Table 7.1, the tests include appearance (colour, texture, and deliquescence), flame test, action of heat, solubility in water and action of dilute and concentrated acids.

[**Safety Precautions**: *Avoid direct smelling of any chemical in the laboratory*]

Table 7.1 – Preliminary Tests

Experiment to be Performed	Expected Observations	Inference
1. **Appearance of Solid Sample** (Texture and colour)	White; crystalline or powder	NH_4^+, Ca^{2+}, Zn^{2+}, Pb^{2+} may be present or Transition metals Fe^{2+}, Fe^{3+}, Cu^{2+} may be absent
	Blue or green	Cu^{2+} may be present
	Pale or light green	Fe^{2+} may be present
	Yellowish or brownish	Fe^{3+} may be present
	White or coloured deliquescent crystals	NO_3^-, Cl^- may be present

Continued on next page

Table 7.1 – continued from previous page

Experiment to be Performed	Expected Observations	Inference
2. **Action of Heat on a Solid Sample** [***Safety Precautions:*** *Hold the test-tube in a slanting position and away from observers and neighbours*] Transfer about 0.5 g of the solid sample in a dry test-tube. Heat strongly until no further change. Test for gas evolved	White sublimate and a colorless gas evolve, which turn wet litmus paper from red to blue	NH_4^+ may be present
	Reddish brown fumes evolve and a gas which rekindles a glowing wooden splint	NO_3^- may be present except those of Na^+ and of NH_4^+
	Colourless gas evolves, which relights a glowing splint	NO_3^- of Na^+ may be present
	Colourless gas evolves, which turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- may be present
	Colourless gas evolves, which turns filter paper dipped in acidified potassium dichromate solution from yellow to green	SO_4^{2-} of Zn^{2+}, Fe^{2+}, Cu^{2+} may be present
	Colourless gas evolves, which gives dense white fumes with ammonia solution	Cl^- of hydrated Zn^{2+}, Cu^{2+}, Fe^{2+}, Fe^{3+} salts may be present
	No gas evolves	SO_4^{2-} of Na^+, Ca^{2+}, Pb^{2+} may be present
		Cl^- of Na^+, Pb^{2+} may be present
		CO_3^{2-} of Na^+ may be present
	Colourless droplets forming on the cooler parts of the test-tube, which turn anhydrous $CuSO_4$ blue or $CoCl_2$ pink	Hydrated salt, HCO_3^- may be present
	Cracking sound with brown gas	NO_3^- of Pb^{2+} may be present
	Cracking sound with no gas evolving	Cl^- of Na^+ may be present
	Residue yellow when hot and white when cold	Zn^{2+} may be present
	Residue reddish brown when hot and yellow when cold	Pb^{2+} may be present
	Black residue	Cu^{2+} may be present
	Reddish brown residue	Fe^{2+}, Fe^{3+} may be present
	White residue	Ca^{2+}, Na^+ may be present
3. **Action of Dilute HCl Acid on a Solid Sample** Transfer about 0.5 g of solid sample in a test-tube followed by 3 drops of dilute HCl	Effervescence of a colourless gas evolves, which turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- may be present
4. **Action of Concentrated H_2SO_4 on a Solid Sample** [***Safety Precautions:*** *Concentrated H_2SO_4 is corrosive. (a) Handle with care (b) Do not boil (c) Hold the test-tube in a slanting position and away from observers and neighbours*]	Effervescence of a colourless gas evolves, The gas turns lime water milky and wet litmus paper from blue to red	CO_3^{2-}, HCO_3^- may be present
	Colourless gas evolves, which forms white dense fumes with ammonia	Cl^- may be present

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Table 7.1 – continued from previous page

Experiment to be Performed	Expected Observations	Inference
Transfer about 0.5 g of a solid sample into a test-tube followed by 3 drops of concentrated H_2SO_4 acid. Dip a glass rod in concentrated ammonia solution and pass it to the mouth of a test tube containing the mixture.	Evolution of brown fumes, which turn wet litmus paper from blue to red and intensify on addition of copper turnings	NO_3^- may be present
If no reaction warm the contents gently. Add copper turnings. Hold wet litmus paper on the mouth of the test-tube containing the mixture.	No gas evolves	SO_4^{2-} may be present
5. **Flame Test** *Cleaning the test apparatus:* Dip a nichrome wire or glass rod or back side of the test-tube in concentrated HCl (in a watch glass) then heat it in a non-luminous flame. *Test:* Dip the cleaned wire (or glass rod or test-tube) in concentrated HCl to allow a small sample to adhere on it. Pick up a small amount of the smaple using a wet wire (or glass rod or test-tube) and heat it on a flame	Golden yellow flame	Na^+ may be present
	Brick red flame	Ca^{2+} may be present
	Bluish-green flame	Cu^{2+} may be present
	Bluish-white (pale-blue) flame	Pb^{2+} may be present
	Yellow (orange) sparks	Fe^{2+}, Fe^{3+} may be present
	No definite colour seen	Zn^{2+}, NH_4^+ may be present
6. **Solubility of Solid Samples** Transfer about 0.5 g of the solid sample into the test tube and add enough cold distilled water to dissolve the solid sample. If the sample does not dissolve warm the contents.	Soluble forming colourless solution	Na^+, NH_4^+, NO_3^- may be present
		CO_3^{2-}, HCO_3^-, of Na^+, NH_4^+ may be present
		Cl^- of Zn^{2+} or Ca^{2+} may be present
		SO_4^{2-} of Zn^{2+} may be present
	Soluble forming blue solution	Cu^{2+} may be present
	Soluble forming pale green solution	Fe^{2+} may be present
	Soluble forming yellowish-brown solution	Fe^{3+} may be present
	Insoluble in cold water but soluble in hot water. Crystals reappear on cooling	Cl^- of Pb^{2+} may be present
	Insoluble	CO_3^{2-} of Ca^{2+}, Pb^{2+}, Zn^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+} may be present
		SO_4^{2-} of Ca^{2+}, Pb^{2+} may be present

TESTS IN SOLUTION

Preparation of the Stock Solution of the Sample

Transfer about 1 g of the solid sample in a test-tube. Add enough amount of distilled water (15-20 cm^3) and shake thoroughly. If the sample is insoluble in cold water, warm the contents. If the sample is insoluble in hot water, transfer about 1 g of the new solid sample in a test-tube, and then dissolve it in dilute nitric acid (to about 15-20 cm^3 of the final solution). Peform the tests shown in Table 7.2

Table 7.2 – Tests in Solution

Experiment to be Performed	Expected Observations	Inference
1. **Action of NaOH Solution on a Sample Solution** To about 1 cm^3 of the original sample solution, add sodium hydroxide solution drop-wise until in excess	White precipitate is formed, soluble in excess	Zn^{2+}, Pb^{2+} may be present
	White precipitate is formed, insoluble in excess	Ca^{2+} may be present
	Blue precipitate is formed, insoluble in excess	Cu^{2+} may be present
	Green precipitate is formed, insoluble in excess, which turns brown on standing	Fe^{2+} may be present
	Reddish-brown precipitate is formed, which is insoluble in excess	Fe^{3+} may be present
	No precipitate is formed; on warming, a colourless gas with a pungent choking smell which turns wet litmus paper from red to blue evolves	NH_4^+ may be present
	No precipitate is formed, even on warming	Na^+ may be present
2. **Action of NH_3 Solution on a Sample Solution** To about 1 cm^3 of the original sample solution, add ammonia solution drop-wise until in excess	White precipitate is formed, insoluble in excess	Pb^{2+} may be present
	White gelatinous precipitate is formed, soluble in excess	Zn^{2+} may be present
	No precipitate is formed	Ca^{2+}, Na^+, NH_4^+ may be present
	Pale blue precipitate is formed, soluble in excess forming deep blue solution	Cu^{2+} may be present
	Green precipitate is formed, insoluble in excess	Fe^{2+} may be present
	Reddish-brown precipitate is formed, insoluble in excess	Fe^{3+} may be present

CONFIRMATORY TESTS

Table 7.3 – Confirmation Tests for Cations

Experiment to be Performed	Expected Observations	Inference
1. **Confirmatory Tests for Ca^{2+}** (i) To about 1 cm^3 of the original sample solution, add excess ammonia solution followed by ammonium oxalate.	White precipitate is formed	Ca^{2+} confirmed
(ii) Perform flame test	Brick-red	Ca^{2+} confirmed
2. **Confirmatory Tests for Pb^{2+}** (i) To about 1 cm^3 of the sample solution, add K_2CrO_4	Yellow precipitate is formed	Pb^{2+} confirmed
(ii) To about 1 cm^3 of the sample solution, add KI solution. Warm and cool the mixture.	Yellow precipitate which disappears on warming but reappears on cooling	Pb^{2+} confirmed
3. **Confirmatory Tests for Zn^{2+}** (i) To about 1 cm^3 of the sample solution, add potassium hexacyanoferrate (II) solution followed by few drops of dilute HCl.	Bluish white precipitate insoluble in dilute HCl	Zn^{2+} confirmed

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Table 7.3 – continued from previous page

Experiment to be Performed	Expected Observations	Inference
(ii) To about 1 cm^3 of the sample solution, add dilute NaOH solution until excess	White precipitate soluble in excess	Zn^{2+} confirmed
4. **Confirmatory Tests for NH_4^+** (i) To about 1 cm^3 of the original sample solution, add about 2-3 drops of Nessler's reagent.	Reddish-brown precipitate is formed	NH_4^+ confirmed
(ii) Transfer about 0.2 g of the original solid sample in a test-tube, add sodium hydroxide solution just to cover the whole solid then warm gently. Test for gas evolved.	Colourless gas evolves which turns wet litmus paper from red to blue	NH_4^+ confirmed
5. **Confirmatory Test for Na^+** Perform flame test	Yellow flame	Na^+ confirmed
6. **Confirmatory Tests for Cu^{2+}** (i) To about 1 cm^3 of the original sample solution, add ammonia solution drop-wise until in excess.	Pale blue precipitate soluble in excess of aqueous ammonia forming deep blue solution.	Cu^{2+} confirmed
(ii) To about 1 cm^3 of the original sample solution, add potassium hexacyanoferrate (II)	Reddish-brown precipitate	Cu^{2+} confirmed
7. **Confirmatory Tests for Fe^{2+}, Fe^{3+}** (i) To about 1 cm^3 of the sample solution, add few drops of potassium hexacyanoferrate (III).	Deep blue precipitate	Fe^{2+} confirmed
(ii) To about 1 cm^3 of the sample solution, add few drops of potassium hexacyanoferrate (II).	Deep blue precipitate	Fe^{3+} confirmed
(iii) To about 1 cm^3 of the sample solution, add few drops of potassium or ammonium thiocyanate solution.	Deep blood-red solution	Fe^{3+} confirmed

Table 7.4 – Confirmation Tests for Anions

Experiment to be Performed	Expected Observations	Inference
1. **Confirmatory Tests for SO_4^{2-}** (i) Transfer about 1 cm^3 of the original sample solution into the test-tube. Add barium chloride followed by dilute HCl or barium nitrate followed by dilute HNO_3.	White precipitate	SO_4^{2-} confirmed

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Table 7.4 – continued from previous page

Experiment to be Performed	Expected Observations	Inference
(ii) Transfer about 1 cm^3 of the original sample solution into the test-tube. Add ethanoic acid followed by lead ethanoate. Divide the resulting mixture into two portions. In one portion add dilute HCl and in another add ammonium ethanoate solution.	White precipitate insoluble in dilute HCl but soluble in ammonium ethanoate solution	SO_4^{2-} confirmed
2. **Confirmatory Tests for NO_3^-** (i) Transfer about 1 cm^3 of the original sample solution into the test-tube. Add dilute H_2SO_4; then add freshly prepared $FeSO_4$ solution followed by **careful** addition of concentrated H_2SO_4 along the side of the test-tube.	Brown ring is formed at the junction of the liquids	NO_3^- confirmed
(ii) Transfer about 0.5 g of the original solid sample into the test-tube. Add copper turnings followed by concentrated H_2SO_4 then warm.	Brown fumes evolve	NO_3^- confirmed
3. **Confirmatory Tests for CO_3^{2-}, HCO_3^-** (i) Transfer about 1 cm^3 of the original sample solution into a test-tube. Add few drops of $MgSO_4$ solution. If no precipitate is formed, warm the contents.	White precipitate is formed before warming the contents	CO_3^{2-} confirmed
	White precipitate is formed after warming the contents	HCO_3^- confirmed
(ii) Transfer about 1 cm^3 of the original sample solution into a test-tube. Add $BaCl_2$ solution. If the precipitate forms, add dilute HCl.	White precipitate soluble in dilute HCl is formed	CO_3^{2-} confirmed
(iii) Transfer about 0.5 g of water-insoluble solid sample in a test-tube. Add about 1 cm^3 of dilute nitric acid.	Effervescence of a colourless gas, which turns lime water milky	CO_3^{2-} confirmed
4. **Confirmatory Test for Cl^-** To about 1 cm^3 of the original sample solution, add about 3 drops of dilute nitric acid followed by about 3 drops of silver nitrate solution	White precipitate is formed	Cl^- confirmed

7.3.3 Tips and Tricks

The following are some tips and tricks for successfully performing the Qualitative Analysis practical:

- Make sure you use a qualitative analysis guide sheet; if your school does not have some request them
- Do all the steps
- Do two confirmation steps; one for the cation you think you have and one for the anion you think you have

7.3.4 Sample Practical Question

The following are two sample practical questions:

Sample Practical #1

Sample H contains one cation and one anion. Using systematic qualitative analysis procedures record carefully your experiments, observations and inferences as Table 7.5 shows. Finally, identify the anion and cation present in sample H.

Table 7.5

S/n	Experiment	Observation	Inference

Conclusion:

i) The cation in sample H is:

ii) The anion in sample H is:

Sample Practical #2

Sample Q is a simple salt containing one cation and one anion. Carefully carry out all the experiments described in the Table 7.6. Record all your observations and make appropriate inferences to identify the ions present in sample Q.

Table 7.6

S/n	Experiments	Observation	Inference
(a)	Observe sample Q		
(b)	Put a spatulaful of sample Q in a test tube and add distilled water		
(c)	Transfer 0.5 g of sample Q in a test tube, add dilute HCl		
(d)	Transfer 0.5 g of sample Q in a test tube, add concentrated sulphuric acid		
(e)	Dissolve sample Q then divide the resulting solution into three portions. (i) To the first portion add sodium hydroxide solution		
	(ii) To the second portion add ammonia solution		
	(iii) To the third portion add potassium ferricyanide solution $[K_3Fe(CN)_6]$		
	(iv) To the fourth portion add lead acetate solution followed by acetic acid solution		

Conclusion:

(a) i) The cation in sample Q is _____.

ii) The anion in sample Q is _____.

iii) The compound Q is _____.

(b) Write the reaction equation that took place at experiment (c).

(c) State three chemical properties of the metal in Q.

(d) State two uses of Q.

7.4 Chemical Kinetics and Equilibrium

This section contains the following:

- Chemical Kinetics and Equilibrium Theory
- Tips and Tricks
- Sample Practical Questions

7.4.1 Theory

Compared to the other two NECTA chemistry practicals - Acid/Base Titration (i.e. Volumetric Analysis) and Qualitative Analysis - Chemical Kinetics has few alternative chemicals that can be used.

The chemical reaction in the NECTA exam is a precipitation of sulphur.

$$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + SO_{2(g)} + S_{(s)}$$

The preparation and procedure for Chemical Kinetics is very simple.

7.4.2 Tips and Tricks

The following are some tips and tricks for successfully performing the Chemical Kinetics and Equilibrium practical:

- If you have a low concentration the test may take over 4 minutes
- Normally the NECTA will ask for the reaction that goes from opaque to translucent, but it could be the other way around
- Make sure you start the stop watch IMMEDIATELY after combining the reactants
- Most common question is how concentration affects the rate of reaction

7.4.3 Sample Practical Question

The following are two sample practical questions:

Sample Practical # 1

You are provided with the following:
Solution M: 0.2 M sodium thiosulphate ($Na_2S_2O_3$);
Solution N: 2 M hydrochloric acid (HCl);
Distilled water labeled W;
A sheet of water paper marked X;
Stop watch.

Procedure

i) Put a small beaker (100 cm^3) on top of the mark X on a sheet of paper in such a way that the mark is clearly seen through the top of the beaker.

ii) Measure 50 cm^3 of solution M and pour into a small beaker.

iii) Using different measuring cylinder measure 10 cm^3 of solution N.

iv) Start a stop watch simultaneously as you pour solution N in the beaker containing solution M.

v) Stir the mixture with glass rod until the cross disappears

vi) Stop the watch when the cross is out of sight. Record the time taken.

vii) Repeat the whole process using 40 cm^3, 30 cm^3, 20 cm^3 and finally 10 cm^3 of solution M as shown in the Table 7.7. Top up solution M with W to make 50 cm^3 in each experiment before adding solution N.

Table 7.7

Volume of M (cm^3)	Volume of water (cm^3)	Volume of N (cm^3)	Conc. of M after adding water ($moldm^{-3}$)	Time for cross to disappear (sec)	Rate (sec^{-1})
50	00	10			
40	10	10			
30	20	10			
20	30	10			
10	40	10			

Questions

(a) Complete filling the Table 7.7

(b) Write down a balanced chemical equation for the reaction between M and N.

(c) What substance was produced during the reaction which obscured the cross?

(d) Use the data in Table 7.7 to draw the following graphs:

i) Concentration-time graph; concentration on the y-axis and time on the x-axis

ii) Concentration-rate graph; concentration on the y-axis and rate on the x-axis

(e) What conclusion can you draw from the results of the experiment?

Sample Practical # 2

You are provided with the following:
E: A solution made by dissolving 20 g of sodium thiosulphate in 1 dm^3 of the solution;
F: A solution of 2 M nitric acid;
G: Distilled water;
A sheet of white paper;
Thermometer;
Stop watch.

Procedure

i) Put a beaker (100 cm^3) on top of the cross drawn on the given sheet of paper.

ii) Measure 25 cm^3 of E using a measuring cylinder and pour it into the beaker in i)

iii) Using another measuring cylinder measure 5 cm^3 of F and pour it into a beaker containing E and instantly start a stop watch.

iv) Stir the mixture with a glass rod while you keep on observing the cross from above; record the time taken for the cross to disappear

v) Repeat the procedures for different concentrations of E by taking 20 cm^3, 15 cm^3, 10 cm^3, and 5 cm^3 of the original E and making the total volume up to 25 cm^3 by adding G. Record the results as shown in the Table 7.8

Table 7.8

Volume of E (cm^3)	Volume of G (cm^3)	Time taken for the cross to disappear (sec)
25		
20		
15		
10		
5		

Questions

(a) Complete filling the Table 7.8

(b) i) Using the data in the table, plot a volume-time graph (volume on the y-axis and the time in seconds on the x-axis)

ii) What does the shape of the graph indicate?

(c) Write down the ionic equation of the reaction between E and F

(d) Why did the cross disappear?

(e) Write two uses of the product which obscured the cross.

Physics

8.1 Introduction to Physics Practicals

8.1.1 Format

The Physics practical has 2 questions and students must answer **both**. Question 1 comes from Mechanics, and Question 2 can come from Heat, Light, Waves or Electricity. Each question is worth 25 marks, and students have $2\frac{1}{2}$ hours to complete the exam.

The theory portion of the Physics exam comprises 100 marks, while the practical carries 50 marks. A student's final grade for Physics is thus found by taking her total marks from both exams out of 150.

8.1.2 NECTA Advance Instructions for Teachers

There is only one set of advance instructions for the Physics practical. Advance instructions are given to teachers at least one month before the date of the exam. Unlike Biology and Chemistry, **there are no 24 hour advance instructions given for Physics**. The advance instructions will state exactly how many and which apparatus candidates should be provided with for each practical question.

Words of Advice

The Physics practical is different from the Chemistry and Biology practicals in that the exams feature a greater variety of questions. That means we need to teach it all, even if the teacher before you never found his or her way into the classroom and you realize at the end of Form Four that the students still have not studied the Form Two syllabus. If you are teaching all forms, do not wait to start practicals until later forms; always do a practical when the corresponding topic comes up. In addition, train the students well in the general principles of collecting data, graphing data, and writing up experimental points. These skills are required in every physics practical, and carry most of the points.

The practical section of the exam is a third of a student's total score, and fully half of that is graphing and labeling experimental data. Though the practical is varied, a student does not necessarily need a deep understanding of the concept in question. If they are familiar with the apparatus and the process of drawing and interpreting a graph, the practical should be quite simple. Whenever possible, allow the students to play and experiment with the apparatus, whether it is a metre bridge, mirror, pendulum, etc. If they have done each of these experiments several times, they will be confident in their ability.

The more familiar your students are with these techniques, the better they will do. Perform these practicals as often as possible: when the topic comes up, when preparing for the mock and NECTA exams, and any time you can get them to come in for an evening session or a weekend. They will make many, many mistakes the first couple of times through but that is exactly what you want as they will learn from their mistakes and remember them.

8.1.3 Common Practicals

Mathematics a brief overview of some of the mathematical and graphing skills required to perform many of the common physics practicals

Mechanics

- **Hooke's Law (Form 1)** use a spring and various masses to determine either the spring constant or the value of an unknown mass graphically
- **Simple Pendulum (Form 2)** find the acceleration due to gravity using a pendulum and stopwatch
- **Principle of Moments (Form 2)** verify the Principle of Moments using masses and a ruler on a knife edge, or calculate the mass of a metre rule

Light

Plane Mirror (Reflection) (Form 1) generally 3 varieties: find image distance, verify the Laws of Reflection, or find the number of images produced by two plane mirrors placed at different relative angles

Rectangular Prism (Refraction) (Form 3) find the refractive index or critical angle for a glass block by varying the angle of incidence and measuring the corresponding angles of refraction

Electricity

Potentiometers find the drop in potential along a length of resistance wire

Metre Bridges determine the value of an unknown resistor using a known resistor and a galvanometer to find a point of equal potential along a resistance wire

Ohm's Law (Form 2) verify Ohm's Law or determine the internal resistance of a cell

Note These are the most common practicals, but they are not necessarily the only practicals that can occur on a NECTA exam. Physics practical questions can come from a variety of topics which may not yet have been used in older past papers.

8.1.4 Recent Practicals

Given below is an attempt to characterize the Physics practical questions from recent years according to category and topic. Each question is given with its corresponding topic on top and the objective, or what is to be solved for, on bottom. This information can be used to try and find trends in what exam writers like to test students on, and what topics are most likely to occur on an exam. However, nothing should be assumed to be a guarantee, and students should be well-prepared in all practicals so that they can take on any question they may face on the NECTA.

Note a few things from the table below:

- Beginning in 2011, the format of the exam changed to consist of only 2 problems, one of which must come from Mechanics.
- The exam committee has a tendency to repeat some problems. For example, the Mechanics questions from 2004 and 2011 are nearly identical, as are the Light questions from 2004 and 2008.

Table 8.1 – Past Topics of Physics Practicals (2004-2017)

Year	Mechanics	Light	Electricity
2017	Young's Modulus *verify* $\frac{Sb}{4g} = \frac{1}{Y} \times \left(\frac{L}{t}\right)^3$	Refraction *ref. index of glass*	—
2016	Principle of Moments *mass of meter rule*	—	Potentiometer *current*
2015	Hooke's Law *find K using graph*	—	Ohm's Law *verify* $V = IR$
2014	Principle of Moments *verity*	Plane Mirror *angles*	—
2013	Principle of Moments *verify*	Plane Mirror *object, image dist.*	—
2012	Density *verify* $\rho = \frac{m}{V}$	Plane Mirror *number of images*	—
2011	Principle of Moments *mass of "AA" battery*	—	Ohm's Law *e.m.f., int. resistance*
2010	Hooke's Law *unknown mass, k*	Refraction *refr. index of water*	Ohm's Law *ρ of a wire*
2009	Simple Pendulum *relate* $l \to T$	Refraction *refr. index of glass*	Ohm's Law *verify* $V = IR$

Continued on next page

Table 8.1 – continued from previous page

Year	Mechanics	Light	Electricity
2008	Hooke's Law *verify* $F = kx$*, find* k	Refraction $\frac{d\cos r}{\sin(i-r)}$	Ohm's Law *verify* $V = IR$
2007	Hooke's Law *unknown mass,* k	Refraction *refr. index of glass*	Potentiometer ΔV *along wire*
2006	Hooke's Law *unknown mass,* $F = kx$	Plane Mirror *object, image dist.*	Metre Bridge *unknown* R
2005	Elasticity *unknown mass,* k	Refraction *critical angle*	Ohm's Law *e.m.f., int. resistance*
2004	Principle of Moments *mass of "AA" battery*	Refraction $\frac{d\cos r}{\sin(i-r)}$	Potentiometer ρ *of wire, int. res.*

8.2 Mathematics

No physics experiment is complete without a healthy dose of graphing and formulas. As math is typically the worst subject for most students, it is often upon the physics teacher to drive home the understanding of how to draw and interpret graphs, as well as how to apply formulas to those graphs. It comes down to a few simple things: correctly setting up a graph (scales, units, labels, etc.), plotting points from a table of data, and fitting a best-fit line. After this, the students need to find the slope of this line and its y-intercept.

8.2.1 Graphing

Most of the graphs will be linear, meaning the slope is constant, so we apply the standard equation for a line

$$y = mx + c$$

where y represents the vertical axis, x represents the horizontal axis, m is the slope of the line and c is the point on the vertical axis where the line crosses. Almost every practical will make use of this equation, so be sure that your students understand it inside and out. It often helps to do repetitive practice using just the mathematical symbols before introducing physics concepts. Note that very rarely non-linear graphs appear, e.g. cooling curves in heat practicals. In this case students will not have to find a mathematical relationship, just describe and explain the trend in the data.

8.2.2 Formulas

Now comes the physics; all the practicals will involve an equation that can be rewritten in this linear form. The exam question will dictate which variable is independent (x) and which is dependent (y). It is up to the student to simply rewrite the formula with each variable on its respective side and then infer what m, the slope, and c, the y-intercept, must be.

The common formulas used for mechanics, light and electricity are as follows:

Hooke's Law	$F = ke$ or $F = ke - B$
Period of a Pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$
Principle of Moments	$(F \times d)_{\text{clockwise}} = (F \times d)_{\text{anticlockwise}}$
Density	$D = \frac{m}{V}$
Snell's Law	$n_1 \times \sin i = n_2 \times \sin r$ or ${}_a\mu_b = \frac{sin(i)}{sin(r)}$
Apparent Depth	${}_a\mu_b = \dfrac{\text{real depth}}{\text{apparent depth}}$
Law of Reflection	$\theta_i = \theta_r$
Ohm's Law	$V = IR$ or $V = I(R + r)$
Resistance of a Wire	$R = \frac{\rho l}{A}$
Wheatstone Bridge	$\dfrac{R_1}{L_1} = \dfrac{R_2}{L_2}$

In each case, one quantity will be changed (independent) and another will be measured (dependent) over the course of the experiment. The student will therefore need to rearrange the equation so that the dependent variable is the subject in the form

$$y = mx + c$$

Example Problem - Snell's Law

As an example, in an experiment to measure the index of refraction of a glass block, a student will be measuring angles of incidence and refraction. This means we need to use Snell's Law

$$n_1 \times \sin i = n_2 \times \sin r$$

The question will typically ask students to plot a graph of their measurements, with $\sin i$ on the y-axis and $\sin r$ on the x-axis, or vice-versa. To rewrite Snell's law in the form of $y = mx + c$ is simple; we get

$$\sin i = \sin r \times \frac{n_2}{n_1}$$

and we can see that the value corresponding to m is the ratio $\frac{n_1}{n_2}$, and c must be zero.

Since we are trying to find n_2 (the refractive index of glass), and we know n_1 is 1.0, we simply measure the slope and solve to find n_2.

The approach itself is relatively simple, but students will need lots of practice with graphing, rewriting equations in linear form, and determining what corresponds to m and c in each case. The same approach is used to find the quantities in each of the equations above.

A complete list of each equation in its most commonly found $y = mx+c$ form, along with its corresponding dependent variable y, independent variable x, slope m and y-intercept c, is given below. Note that these equations are not always used in the given form on practicals. It is up to the student to determine how each equation must be analyzed during an exam. The variables used and methods of graphing change from year to year, and so the following table should by no means be memorized or assumed to be applicable for a given problem.

Name of Law	**Equation**	$\boldsymbol{y = mx + c}$	$\boldsymbol{y}$	$\boldsymbol{x}$	$\boldsymbol{m}$	$\boldsymbol{c}$
Hooke's Law	$F = ke$	$F = ke - B$	F	e	k	$-B$
Period of a Pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$	$T^2 = 4\pi\frac{l}{g}$	T^2	l	$\frac{4\pi}{g}$	0
Principle of Moments	$(F \times d)_{\text{cw}} = (F \times d)_{\text{acw}}$	$a = \left(\frac{m_2+x}{m_1}\right) b$	a	b	$\left(\frac{m_2+x}{m_1}\right)$	0
Snell's Law	$n_1 \times \sin i = n_2 \times \sin r$	$\sin i = \frac{n_2}{n_1} \sin r$	$\sin i$	$\sin r$	$\frac{n_2}{n_1}$	0
Ohm's Law	$V = IR$ $V = I(R + r)$	$V = IR$ $R = \frac{E}{I} - r$	V R	I $\frac{1}{I}$	R E	0 $-r$
Resistance of a Wire	$R = \frac{\rho l}{A}$	$V = \frac{I\rho l}{A}$	V V	l I	$\frac{I\rho}{A}$ $\frac{\rho l}{A}$	0 0
Wheatstone Bridge	$\frac{R_1}{L_1} = \frac{R_2}{L_2}$	$R_2 = \frac{100R_1}{L_1} - R_1$	R_2	$\frac{100}{L_1}$	R_1	$-R_1$

8.2.3 Units

Be sure to always stress the importance of units when performing practicals, especially in graphing. Using the wrong units can lead to inaccurate interpretations of graphical data. For example, when using Hooke's Law, a spring constant is typically given in units of $^{\text{N}}/_{\text{m}}$. But if a student is graphing mass (in g) against extension (in cm), then the slope will be in units of $^{\text{g}}/_{\text{cm}}$. In order to get units of $^{N}/_{\text{m}}$, one would have to first convert the slope into units of $^{\text{kg}}/_{\text{m}}$ and then multiply by the acceleration of gravity ($g = 10\ ^{N}/_{\text{kg}}$). A problem may or may not ask for specific units in its answers, but regardless, students should always be conscious of what units they are using when making calculations.

Thinking of units can also help students to understand a problem they are struggling with. If they can remember that slope is *change in y over change in x*, then they may be able to deduce the meaning of

the slope of a graph by looking at the units of the y and x axes.

The most important part of any experiment, though, is following directions. If a student can follow directions, which usually are clearly provided by the exam, and can graph data, they can easily perform any experiment. If anything, the practical exam is a test in a student's ability to follow instructions.

8.3 Mechanics

The mechanics section is mandatory on every exam and typically falls into three categories: Hooke's Law, Simple Pendulum, and Principle of Moments. However, other topics are possible, as evidenced by a question on Archimedes' Principle on the 2012 exam. These experiments use the following materials:

Metre Rules If unavailable, go to a local fundi to mass produce them.

Masses If unavailable, look for local varieties.

Springs Can be bought at lab stores, or can use substitutes such as rubber bands or strips of elastic from a tailor.

Retort Stands May be available or can be made using a filled 1.5 L water bottle with a bamboo stick taped at the top and extending to one side.

Eureka Can Cut off the bottom of a 500 mL water bottle and cut a slit at the top that can be folded downward to make a curved spout.

8.3.1 Hooke's Law

This is the most common practical, usually involving a spring but sometimes a rubber band or piece of string. This experiment can be tricky simply because NECTA likes to switch it up every year; try to give your students as much practice with different variations. It is likely that NECTA will require a spring of known spring constant, and you will need known masses. Either can be bought at a laboratory supply store in town, but it is possible to make your own. The practical is simple to perform, but there are some common mistakes: be sure the students understand that the extension is the change in length, not the ultimate length shown on the ruler. Also, do not confuse mass and weight, as is common.

An example question from the 2007 NECTA is shown below. After reviewing the topic with your students, let them try this on their own. You will need to repeat it several times before they are comfortable, using different springs and masses each time.

Sample Practical Question - 2007

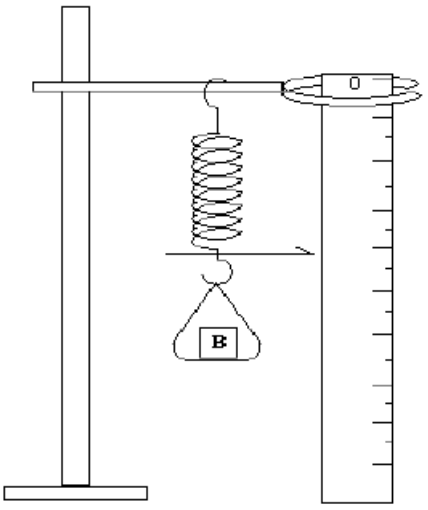
The aim of this experiment is to determine the mass of a given object "B", and the constant of the spring provided.

Directions for experiment:

(i) Set up the apparatus as shown in the figure with zero mark of the metre-rule at the top of the rule and record the scale reading by the pointer, S_0.

(ii) Place the object "B" and standard weight (mass) W equal to 20 g in the pan and record the new pointer reading S_1. Calculate the extension, $e = S_1 - S_0$ in cm.

(iii) Repeat the procedure in (ii) above with W = 40 g, 60 g, 80 g and 100 g.



(a) Record your results in tabular form as shown below:

$S_0 =$			
Mass (kg)	Force, F (N)	Pointer reading S_1 (cm)	Extension $= S_1 - S_0$ (cm)
0			
0.02			
0.04			
0.06			
0.08			
0.10			

(b) Plot graph of Force F (vertical axis) against extension e (horizontal axis).

(c) Use your graph to evaluate

(i) mass of B

(ii) spring constant, K, given that force, extension, constant and weight of B are related as follows: F = Ke - B

Discussion

This practical has two parts: the first is to find the spring constant k, the second is to find the mass of an unknown object B. By looking at the equation above, we can see that F is the dependent variable, e is the independent variable, K is the slope and $-B$ is the intercept. When the graph is drawn, K and B can be found easily. Note that the intercept on the graph will be negative.

The procedure is simply to start from a certain point on the metre rule (it does not need to be a specific number) and to add masses one at a time, measuring the distance from your starting point to the new position. This distance is called the extension, e. Be sure that you are not simply reading the metre rule, but are measuring the distance from the starting point.

Sample Practical Question - 2016

The aim of the experiment in Figure 1 is to determine the effective mass of the spring and its spring constant K.

(a) Suspend the spiral spring to the retort stand

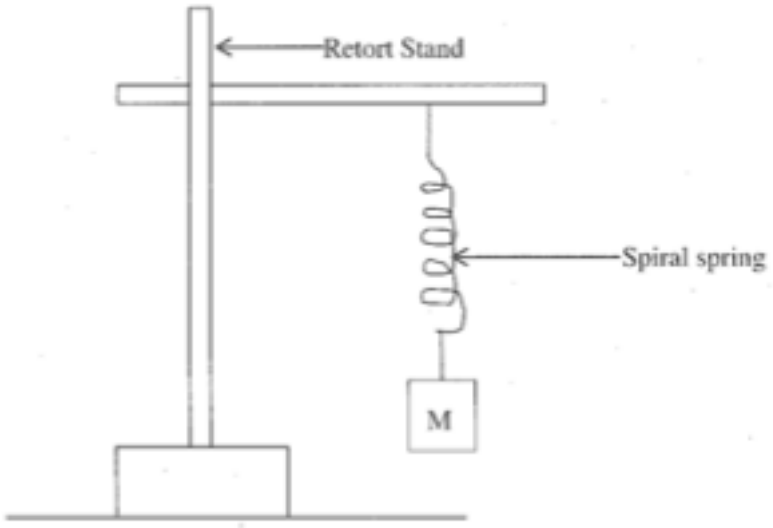


Figure 1

(b) Load the lower end of the spring with a mass of M = 200g and then pull the mass slightly vertically downwards through a short distance from an equilibrium position and release it so that the system executes vertical oscillations of small amplitudes.

(c) Use a stop watch to record the time t (sec) for 20 vertical oscillations and then determine the periodic time T (sec), hence determine T^2 (sec^2).

(d) Repeat this procedure for the other four (4) masses in steps of 50 grams

(e) Tabulate your results

(f) It is found that the period T of oscillations and the spring constant K are related by the equation

$$\frac{T^2}{4\pi^2} = \frac{M+S}{K}$$

where S is the effective mass of the spring.

i) Plot a graph of T^2 against M

ii) Calculate the slope of the graph

iii) Using the given equation and the graph, determine the value of S and K.

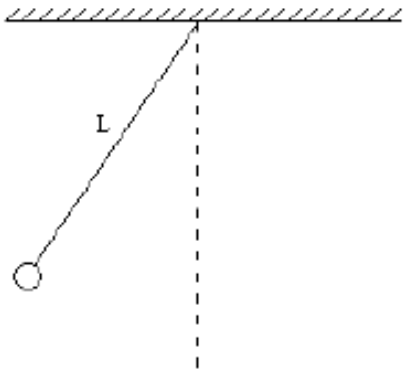
8.3.2 Simple Pendulum

With some practice, this experiment should be simple for anyone to perform. The trick comes with the math and graphing (again, an example is shown below). The materials can all be local (string, stones, ruler) except for the stopwatches (for which you should consult the materials section).

The practical usually has one objective: to find the acceleration due to gravity, g. We know that the mass of a pendulum and its angle of deflection (for small angles) do not affect its period. Therefore we vary only the length L of the pendulum and measure its period, as shown in the following example question.

Sample Practical Question

The aim of this experiment is to determine the magnitude of the acceleration due to gravity, g. Proceed as follows:



1. Make a simple pendulum by suspending a weight on a string 10 cm long from a retort stand.
2. Allow the pendulum to swing for twenty oscillations, using a stopwatch to record the time. Repeat this procedure for pendulum lengths of 20 cm, 30 cm, 40 cm, and 50 cm.
3. Record your results in tabular form as shown below

Pendulum Length l (m)	Time for 20 oscillations (s)	Period $T = \frac{t}{20}$ (s)	T^2 (s^2)
0.1			
0.2			
0.3			
0.4			
0.5			

4. Plot a graph of T^2 (vertical axis) against Pendulum Length (horizontal axis).

5. Calculate the slope of the graph.
6. Use the slope to calculate the value of g.
7. What are possible sources of error in this experiment?

Discussion

The period of a pendulum can be calculated using

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum, T is the period and g is the acceleration due to gravity. By squaring both sides, we get a much easier equation to graph:

$$T^2 = 4\pi\frac{l}{g}$$

In this equation we see that T^2 is the dependent variable (y-axis) and l is the independent variable (x-axis), so the slope must be

$$\text{slope} = \frac{4\pi}{g}$$

When the graph is complete, the value of g can be calculated easily.

Many students are confused by the difference between the time for many oscillations and the period, which is the time for one oscillation. Be sure that they can change between the two easily.

Note Pendulum practicals do not always require students to find g. Sometimes they are just required to find the relationship between l and t. Again, it is essential that students read and understand the examination question, rather than memorize past solutions, and that they have lots of practice in collecting, organizing, and graphing data from a variety of experiments.

8.3.3 Principle of Moments

This experiment is used to verify the Principle of Moments, or equilibrium, by balancing a meter rule on a knife-edge with masses at various distances. For this experiment, students need a solid understanding of the Center of Gravity, the Moment of a force, and equilibrium. Questions can range from finding the mass of an object to asking for the mass of the metre rule. They are all variations on the same practical: using the condition of equilibrium to find mass.

Finding the Mass of an Object

The following example is from the 2011 NECTA exam and asks students to find the mass of a battery using the Principle of Moments. Following is a brief explanation of the alternative practical of finding the mass of a metre rule.

Sample Practical Question
The aim of this experiment is to determine the mass of a given dry cell size "AA". Proceed as follows:

(a) Locate and note the centre of gravity C of the metre rule by balancing it on the knife edge.

(b) Suspend the 50 g mass at length 'a' cm on one side of the metre rule and the 20 g mass together with the dry cell at length 'b' cm on the other side of the metre rule. Fix the 50 g mass at length 30 cm from the fulcrum and adjust the position of the 20 g mass together with the dry cell until the metre rule balances horizontally. Read and record the values of a and b as a_0 and b_0 respectively.

(c) Draw the diagram for this experiment.

(d) By fixing $a = 5$ cm from fulcrum C, find its corresponding length b.

(e) Repeat the procedure in (d) above for $a = 10$ cm, 15 cm, 20 cm and 25 cm. Tabulate your results.

(f) Draw a graph of 'a' against 'b' and calculate its slope G.

(g) Calculate X from the equation $50 = \dfrac{b_0}{a_0}(20 + X)$.

(h) Comment on the value of $\dfrac{b_0}{a_0}$.

(i) Sate the principle governing this experiment.

Discussion
This practical utilizes the Principle of Moments to find the mass of a "AA" battery. Initially, a known mass of 50 g is balanced with the (battery + 20 g mass) system. Note that 'a' and 'b' are measured *from the fulcrum* and so students should be careful not to just read the cm mark on the ruler where each object is suspended.

Also note that students are required to actually find the centre of gravity C of the ruler rather than assuming it to be the 50 cm mark. This measured value of C is to be used as the starting point for all future measurements of a and b.

In part (g), students should recognize the equation $50 = \dfrac{b_0}{a_0}(20 + X)$ as coming from the Principle of Moments. Starting with

$$F_{\text{clockwise}} \times d_{\text{clockwise}} = F_{\text{anticlockwise}} \times d_{\text{anticlockwise}}$$

we get

$$(mg)_{\text{clockwise}} \times d_{\text{clockwise}} = (mg)_{\text{anticlockwise}} \times d_{\text{anticlockwise}}$$

or

$$(50\text{g})(g) \times a_0 \text{ cm} = (20\text{g} + X\text{g})(g) \times b_0 \text{ cm}$$

Canceling g and dividing by a_0 reveals

$$50 = \frac{b_0}{a_0}(20 + X)$$

where $\dfrac{b_0}{a_0}$ is the ratio of the lever arm distances for the two weights being used. If the mass of the battery X is less than 30 g, this ratio should be greater than 1, but if the mass is greater than 30 g, the ratio should be less than 1.

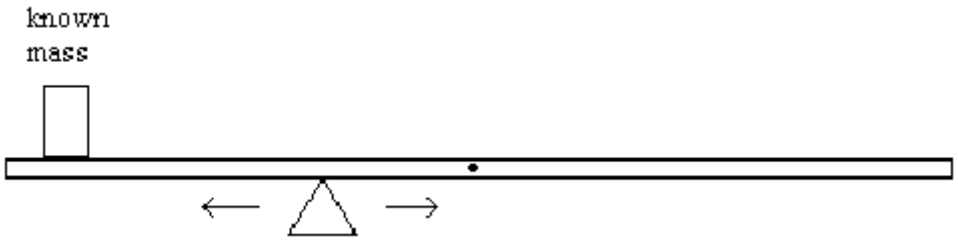
Finding the Mass of a Metre Rule

This utilizes the same principles as finding the mass of an unknown object and can help ensure students understand the concept of the principle of moments.

The mass of a uniform solid object, like a metre rule, is assumed to be at the center of the object. In the case of the metre rule, we can say that the center of mass is at the 50 cm mark, directly in the center. If we want it to be in equilibrium, the moments on either side of a pivot must be equal, or

$$\text{Clockwise moment} = \text{Anticlockwise moment}$$

To find the mass of the metre rule itself, we begin by placing a known mass at one point on the metre rule. We then move the pivot to one side or another until the metre rule is perfectly balanced in equilibrium. As shown in the diagram below, the pivot will not be at the 50 cm mark.



If the metre rule is in equilibrium, we know that the moments must be equal, or that

$$F_{\text{clockwise}} \times d_{\text{clockwise}} = F_{\text{anticlockwise}} \times d_{\text{anticlockwise}}$$

In this case, the anticlockwise force is the weight of the object, and the distance is that from the pivot to the object. The clockwise force is the weight of the metre rule, and the distance is that from the 50 cm mark (center of mass) to the pivot. Therefore our equation is:

$$W_{\text{rule}} \times d_{\text{rule}} = W_{\text{object}} \times d_{\text{object}}$$

Because the weight of the object is known, and the two distances can be measured, we can easily calculate the mass and therefore the weight of the metre rule:

$$W_{\text{rule}} = \frac{W_{\text{object}} \times d_{\text{object}}}{d_{\text{rule}}}$$

From this we can calculate mass of the metre rule using $F = mg$.

8.3.4 Young's Modulus

While Young's Modulus has not been seen in past practicals, it was the mechanics questions for the 2017 Form IV NECTA. It is unknown if this practical will be seen in future examinations, but to be cautious, it may be wise to teach your students the basics to understand the problem even if you do not teach the theory behind Young's Modulus.

The following is the mechanics problem from 2017.

Sample Practical Question

The aim of the experiment in Figure 1 is to demonstrate the Young's Modulus, Y, of a wooden metre rule.

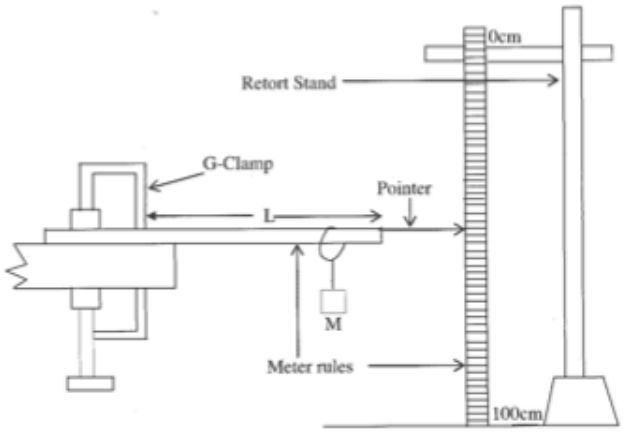


Figure 1

(a) Clamp a metre rule along the top of the bench with its graduated face upwards and with a length L of about 85cm projecting beyond the edge of the bench. Record the length of L.

(b) Attach the pointer to the free end of the metre rule and note its position X_0 on a meter rule clamped vertically in retort stand when unloaded.

(c) Suspend a load M of 50g at a distance 1.0cm from the free end. Note the new position X of the pointer and then deduce the depression, d, of the pointer on the metre rule scale.

(d) Repeat procedure (c) above for M equal to 100g, 150g, 200g, and 250g.

(e) Tabulate your results

(f) Plot the graph of d against M

(g) Find the slope, S, of the graph

(h) Use the vernier caliper to measure the breadth, b, and the thickness, t, of the metre rule

(i) Calculate Young's modulus for the wooden metre rule from the expression

$$\frac{Sb}{4g} = \frac{1}{Y} \times \left(\frac{L}{t}\right)^3$$

(j) Mention two sources of errors and two precautions taken in this experiment

8.4 Light

The light practical typically involves plane mirrors or glass blocks (rectangular prisms). Presumably you will have already done these practicals with the students in Form three (refraction) and Form 1 (plane mirrors), but a little practice will make the theory and execution clear, especially if they can work in groups. The materials you will need are as follows:

Cork Board Use cardboard for this, about 0.5 to 0.75 cm thick.

Optical pins Use sewing pins or syringe needles. If using syringe needs, be sure to crimp the ends so students do not prick themselves.

Protractors These are cheap and students are supposed to have them anyway. Small ones come in local mathematical sets.

Glass Block / Rectangular Prism A simple rectangular piece of 6 mm glass, about 8 cm by 12 cm, will work.

Plane Mirror You can buy mirror glass in town in small sections for 200/= or less; it should be available in villages through the local craftsmen if they work on windows. Alternately, you can smoke one side of a piece of glass to make the other side like a mirror.

8.4.1 Plane Mirror (Reflection)

These are not as common as the rectangular prism, but they come in a variety of questions:

- Placing pins in front of a mirror at different distances and finding the distance of the image.
- Verifying the Law of Reflection at plane mirrors.
- Placing two mirrors at different relative angles to find the number of images produced.
- Looking at reflection angles.

These are not overly complicated, but you should definitely practice with your students creating images in mirrors – they are not as accustomed to playing with mirrors as you might be. Given below is an example practical from the 2006 NECTA exam which asks students to find a relationship between object distance and image distance in a plane mirror.

Sample Practical Question - 2006

Set up the experiment as shown in the diagram below using plane mirror, soft board, three pins and a white sheet of paper.

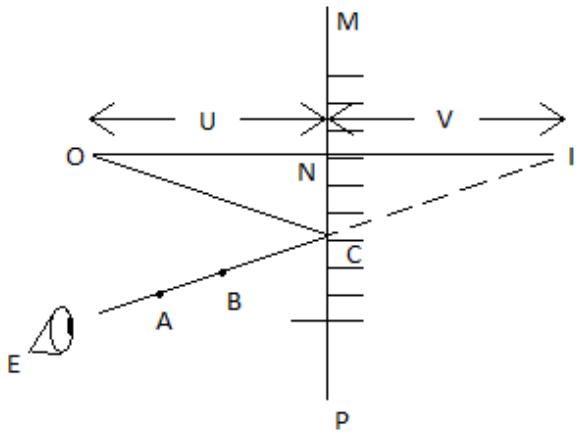


Fig. 2

Fix a white sheet of paper on the soft board. Draw a line across the width at about the middle of the white sheet (MP). Draw line ONI perpendicular to MP.

Fix optical pin O to make ON = U = 3 cm. By using plasticine or otherwise, fix plane mirror along portion of MP with O in front of the mirror. With convenient position of eye, E, look into the mirror and fix optical pins A and B to be in line with image, I, of pin O.

Measure and record NI = V. Repeat procedure for U = 6 cm, 9 cm and 12 cm.

(a) Tabulate your results as follows:

U (cm)	3	6	9	12
V (cm)				

(b) Plot graph of U against V.

(c) Calculate slope, m of the graph to the nearest whole number.

(d) State relationship between U and V.

(e) Write equation connecting U and V using numerical value of m with symbols U and V.

(f) From your equation give position of the image when object is touching the face of the mirror.

Discussion

For a plane mirror, object distance and image distance are equal. That is, U and V should be approximately equal values for this practical. Note that students should extend line ONI far behind the mirror since they don't know where exactly the image I is going to be. The location of I is found at the intersection of the extended line ONI and the extended line AB connecting the two optical pins.

From the graph, the slope should be found to be 1 after rounding to the nearest whole number. From this, we can see that U = V. When the object is touching the face of the mirror, the object distance U is 0, and so the image distance V will also be 0.

Sample Practical Question - 2014

You are provided with a white sheet of paper, drawing board, plane mirror with holders, transparent ruler, protractor, optical pins, office pins and thumb pins. Proceed as follows:

(a) Put the drawing paper on the drawing board using thumb pins and draw two straight lines AB and CD to enclose an angle of $\alpha = 10°$. Draw the line through O making 75° with AB. Then insert two optical pins P and Q on this line (see Figure 1).

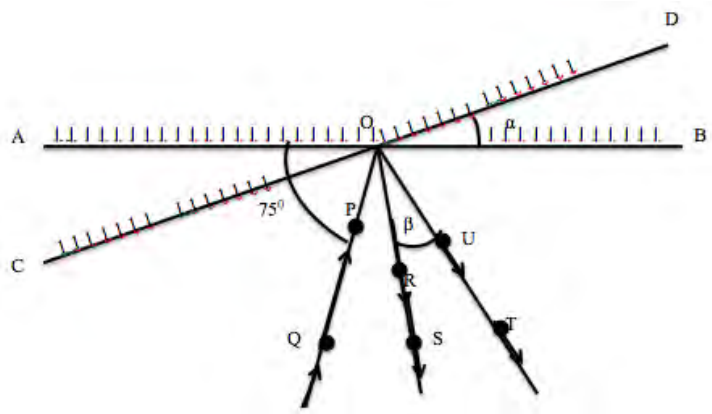


Figure 1

(b) Place the reflecting surface of the mirror along AB. Place other optical pins R and S to appear in straight line with images of P and Q. Remove the pins R and S and join the line ORS.

(c) Turn the mirror through an angle $\alpha = 10°$ so that its reflecting surface lies along CD. Stick pins T and U to appear in line with the images of P and Q. Join the line OUT. Record the angle $\beta°$ formed by RS and UT.

(d) Repeat the experiment for $\alpha = 15°, 20°, 25°$, and $30°$.

(e) Tabulate your results.

(f) Plot a graph of $\beta°$ against $\alpha°$.

(g) Determine the slope of your graph.

(h) Find the reciprocal of the slope.

(i) What does the answer in 2 (h) represent?

(j) From you graph deduce the relationship between $\alpha°$ and $\beta°$.

Note: Attach your diagrams with the answer booklet.

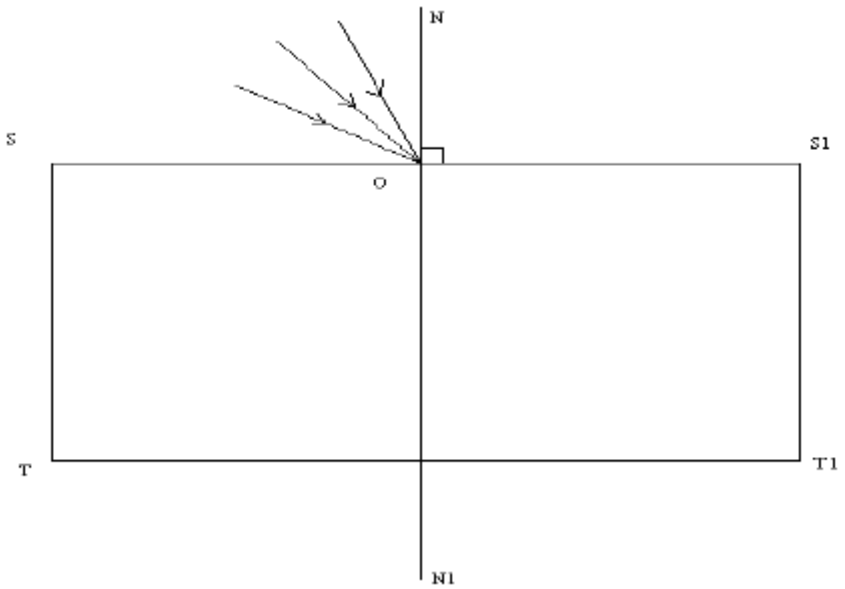
8.4.2 Rectangular Prism (Refraction)

Students will be asked to find the refractive index and/or critical angle of the glass block by varying the angle of incidence i and measuring the corresponding angles of refraction r as described in the Mathematics section earlier. They will do this by placing two pins in front of the prism, which together form a 'ray' (the light ray), and then placing two more pins on the other side of the prism so that, when observed through the prism from either side, the four pins line up exactly. By drawing the lines that the pins make on the paper, the refracted ray inside the prism can be easily traced, and the refracted angle measured. An example question from the 2007 NECTA is given below.

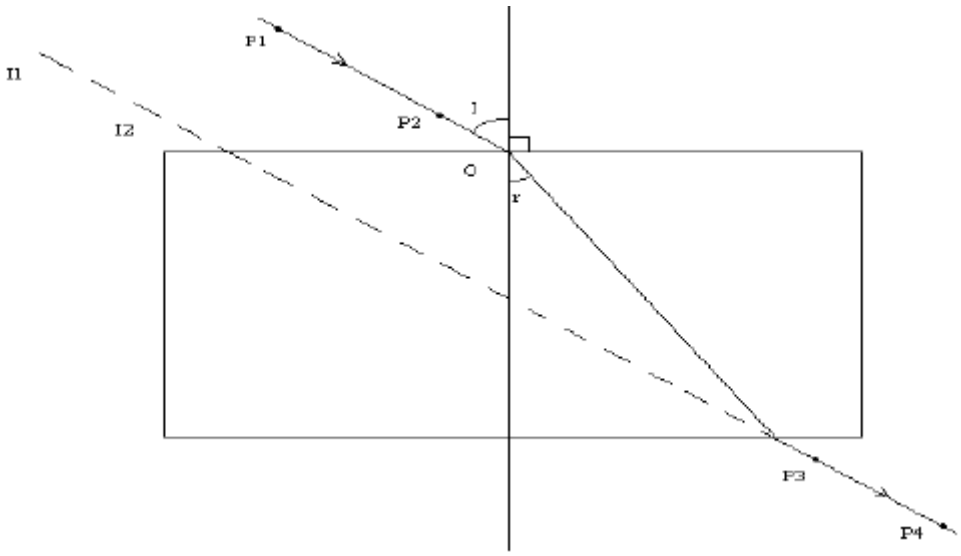
Sample Practical Question - 2007

The aim of this experiment is to find the refractive index of a glass block. Proceed as follows:

Place the given glass block in the middle of the drawing paper on the drawing board. Draw lines along the upper and lower edges of the glass block. Remove the glass block and extend the lines you have drawn. Represent the ends of these line segments as SS_1 and TT_1. Draw the normal NN_1 to the parallel lines SS_1 and TT_1 as shown in the figure below:



Draw five evenly spaced lines from O to represent incident rays at different angles of incidence (10°, 20°, 30°, 40°, and 50° from the normal). Replace the glass block carefully between SS_1 and TT_1. Stick two pins P_1 and P_2 as shown in the figure as far apart as possible along one of the lines drawn to represent an incident ray. Locate an emergent ray by looking through the block and stick pins P_3 and P_4 exactly in line with images I_1 and I_2 of pins P_1 and P_2. Draw the emergent ray and repeat the procedure for all the incident rays you have drawn. Finally draw in the corresponding refracted rays.



(a) Record the angles of incidence i and the measured corresponding angles of refraction r in a table. Your table of results should include the values of $\sin i$ and $\sin r$.

(b) Plot the graph of $\sin i$ (vertical axis) against $\sin r$ (horizontal axis).

(c) Determine the slope of the graph.

(d) What is the refractive index of the glass block used?

(e) Mention any sources of errors in this experiment.

Discussion

In this experiment, pins are used to simulate a ray of light. If all of the pins are aligned as you look through the block, they act as a single ray. It takes practice to be able to align the pins while looking through the block, so practice often with your students.

Light slows down as it enters a denser medium, so in order to minimize the time required to pass through that medium, it changes direction until it moves back into its original medium. In this case, light is moving from air into glass and then back into air, so its direction changes while inside the glass, then returns to its original direction when passing back into air. This effect is called refraction and it depends on the nature of the media, in this case air and glass. Snell's law gives us the relationship between the nature of the media and the resulting angles of incidence and refraction:

$$n_1 \times \sin i = n_2 \times \sin r$$

In this experiment, the incident angle i is being changed and the refracted angle r is being measured. The refractive index of medium 1 (air) is known as 1.0, so we can use these three to find the refractive index of medium 2 (glass). On the graph, $\sin i$ is the dependent variable and $\sin r$ is the independent variable, so the equation becomes

$$\sin i = \sin r \frac{n_2}{n_1}$$

In this case the slope must be $\frac{n_2}{n_1}$. The refractive index of medium air is simply 1.0, so the slope is the refractive index of medium 2.

This practical is one of the easiest to perform with students because it does not require much preparation. Syringe needles should be readily available and glass blocks are cheap, so it is possible to have every students try this themselves many times before taking the exam.

Sample Practical Question - 2016

The aim of this experiment is to determine the refractive index n of a glass block.

(a) Fix the plane sheet of paper provided on the soft board using optical pins

(b) Place the glass block on the sheet of paper so that the largest face is topmost as shown in Figure 2 and trace out the outline of the glass block.

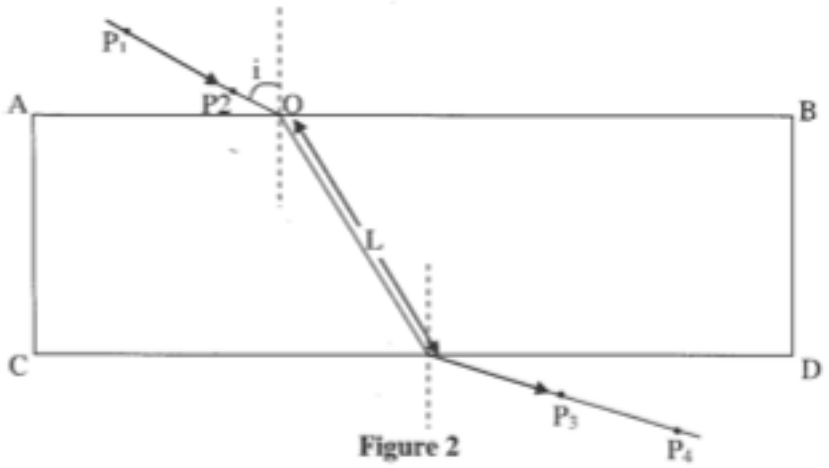


Figure 2

(c) Stick pins P_1 and P_2 in the soft board in such a way that the angle of incidence i is 25° and make sure that AO is less than one third of AB

(d) Place pins P_3 and P_4 so that they appear to be in line with the images of P_1 and P_2 as observed through the face CD of the block.

(e) Remove the block and trace the ray through it.

(f) Measure and record the distance L

(g) Replace the block and repeat procedures (c) to (f) for the angles of incidence $i = 35°$, 45°, 55°, and 65°

(h) Tabulate results including the values of $\sin^2 i$ and $\frac{1}{L^2}$

(i) Plot a graph of $\sin^2 i$ against $\frac{1}{L^2}$

(j) Determine the slope, s, of your graph and the intercept C_1 on the $\sin^2 i$ axis.

(k) Find the values of 'n' from the relation $n = \sqrt{C_1}$ and the breadth b of the glass block from the relations $b = \dfrac{\sqrt{(-s)}}{n}$

Finding the Critical Angle

Some questions may ask students to find the critical angle of a glass block in addition to its refractive index. The relationship between critical angle, C, and refractive index, n, for a particular medium is given by

$$n = \frac{1}{\sin C}$$

or

$$\frac{\sin i}{\sin r} = \frac{1}{\sin C}$$

.

Thus a graph of $\sin i$ against $\sin r$ can be used to find the critical angle. However, take care to note that we must first take the reciprocal of the slope, i.e.

$$\sin C = \frac{1}{n}$$

.

This gives us $\sin C$, so to get C by itself, we need to use mathematical tables. Turn to the page for Natural Sines and search the table for the 4-figure value you obtained above by taking $\frac{1}{\text{slope}}$. The corresponding row gives the angle in degrees and the column gives the additional minutes of the angle.

For example, say we plot our graph of $\sin i$ (y-axis) against $\sin r$ (x-axis) and we calculate the slope to be 1.43. This is the refractive index of the glass block (since we can remember that glass has a refractive index of 1.5, we can do a quick mental check to make sure this makes sense). Then $\sin C = \frac{1}{1.43} = 0.6993$. From the mathematical tables, we get $C = 44°22'$ [6993 falls between 6984 ($18'$) and 6997 ($24'$), so we use the Mean Differences table to add on $4'$ giving a total of $22'$].

Note that the method of finding n and C changes if we are instead told to graph $\sin r$ (y-axis) against $\sin i$ (x-axis). Be sure to practice both versions with students to ensure their understanding.

Sample Practical Question - 2016

The aim of the experiment in Figure 2 is to determine the critical angle A of the given glass block.

(a) Fix a sheet of paper on a soft board using drawing pins

(b) Place the glass block provided on the sheet of paper with its largest face upper most and trace its outline EFGH

(c) Remove the block and on its outline, draw a perpendicular BI

(d) Draw a ray AB such that angle $\beta = 35°$

(e) Replace the glass block

(f) Stick two pins P_1 and P_2 along AB and looking through the glass block from the opposite face HG, stick two other pins P_3 and P_4 in line with P_1 and P_2. Remove the glass block.

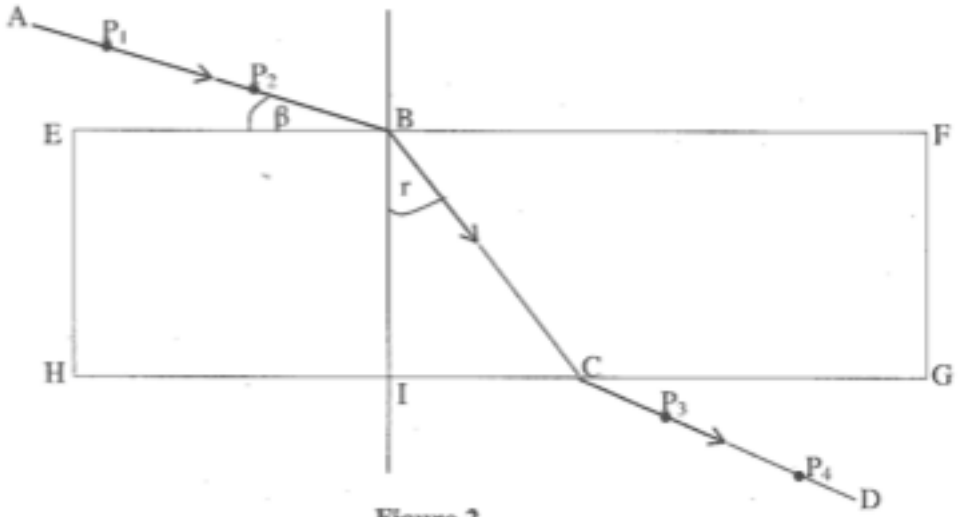


Figure 2

(g) Draw a straight line DC through P_4 and P_3 and join up C to B.

(h) Measure the angle of refraction r and then calculate the value of $\cos\beta$ and $\sin r$

(i) Repeat the procedure (d) to (h) for values of $\beta = 45°$, $55°$, $65°$, and $75°$

(j) Tabulate your results

(k) Plot a graph of $\sin r$ against $\cos\beta$

(l) Determine the gradient G of the graph

(m) Calculate the value of the critical angle A from $G = \sin A$

NOTE: The diagrams for this question should be attached to answer booklet(s)

8.5 Electricity

This is by far the least attempted practical on the exam, but not because it is difficult. The electricity practical, if properly set up, is one of the easiest to perform. It can appear in many different forms but will typically involve a simple circuit and some kind of variable resistor in order to measure current or EMF for different resistances. The materials you will probably need are as follows:

Connecting Wires Use speaker wire; it is cheap and available in most villages and towns.

Voltmeters, Ammeters, Galvanometers This is unavoidable; you can get full digital multimeters in town for about 10,000/=, galvanometers can be found in any lab store or can be made using a compass and insulated copper wire.

Batteries Two to four D-size batteries should easily be enough for these experiments. Try to avoid Tiger brand if possible. Panasonic is highly superior in quality for roughly the same price.

Resistance Wire These are used to make small resistors for the metre bridge or potentiometer. The most common type of wire to use is nichrome, which can be found in a hardware or lab store. Steel will also work, though it is less resistant and therefore harder to measure.

Metre Bridges See the activity that describes the construction of a metre bridge and potentiometer. It is best to make both together as the construction is almost identical and both are used frequently.

Variable Resistor (Rheostat) This is optional as it is typically only used to set a level that can be easily read by the voltmeter. However, if you are using a multimeter, you can simply change the magnitude setting on the multimeter to account for unusually low or high resistances.

Soldering Iron Not required, but may be a good investment for making reliable battery connections. Using electrical tape can lead to inconsistencies. Check large towns.

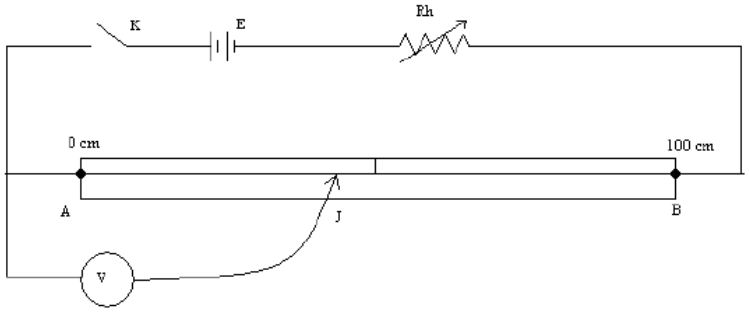
8.5.1 Potentiometers

This experiment is very simple but requires the correct materials, namely the meter bridge/potentiometer described above. A complete circuit is created with a switch (optional), power source, variable resistor and 1 m of bare resistance wire, all in series.

The potentiometer itself is simple to construct; all preparation is done by the teacher, so the student simply follows the instructions as shown in the following example from the 2007 NECTA.

Sample Practical Question - 2007

The aim of this experiment is to determine the potential fall along a uniform resistance wire carrying a steady current. Proceed as follows:



Connect up the circuit as shown in the figure. Adjust the rheostat so that when the sliding contact J is near B and the key is closed the voltmeter V indicates an almost full scale of deflection. Do not alter the rheostat again. Close key K and make contact with J, so that AJ = 10 cm. Record the potential difference V volts between A and J as registered on the voltmeter. Repeat this procedure for AJ = 20 cm, 30 cm, 50 cm, and 70 cm.

(a) Tabulate your results for the values of AJ and V.

(b) Plot a graph of V (vertical axis) against AJ (horizontal axis).

(c) Calculate the slope of the graph.

(d) What is your comment on the slope?

(e) State any precautions on the experiment.

Discussion

This is a simple test of the relationship between the length of a wire and its resistance, which we know is

$$R = \frac{\rho l}{A}$$

Where l is the length of the wire, ρ is the resistivity of the wire, and A is the cross-sectional area of the wire. We expect that as the length of wire increases, its potential difference will also increase. This is because the resistance (and therefore potential difference) of a wire is directly related to its length. The voltmeter in this experiment is measuring just the potential difference over the length of wire (10 cm, 20 cm, etc.), so if we use Ohm's Law to say that $V = IR$, we can write:

$$V = \frac{I\rho l}{A}$$

In this experiment, I, ρ and A are all constant, so the slope is

$$\text{slope} = \frac{I\rho}{A}$$

Though it is not asked for directly in the question, we can find the resistivity, ρ, by measuring I with an ammeter/galvanometer and A with vernier calipers or a micrometer screw gauge.

Sample Practical Question - 2016

You are provided with a potentiometer, a dry cell, a key, a jockey, and a voltmeter.

(a) Connect a potentiometer to a cell and key in series.

(b) Connect the zero end of the potentiometer to the positive terminal of the voltmeter.

(c) Connect the negative terminal of the voltmeter to a pencil jockey through a long connecting wire.

(d) Close the key and record potential difference by pressing the jockey at 10cm intervals of length of the potentiometer wire. Record the length L as well as potential difference V.

(e) Repeat the experiment for five (5) different lengths of potentiometer wire and record the corresponding potential difference.

(f) Tabulate your results as shown in the following table

Potential difference (volts)						
Length (cm)	10	20	30	40	50	60

(g) Plot graph of potential difference V against length L.

(h) Determine the slope of the graph.

(i) What is the nature of the graph?

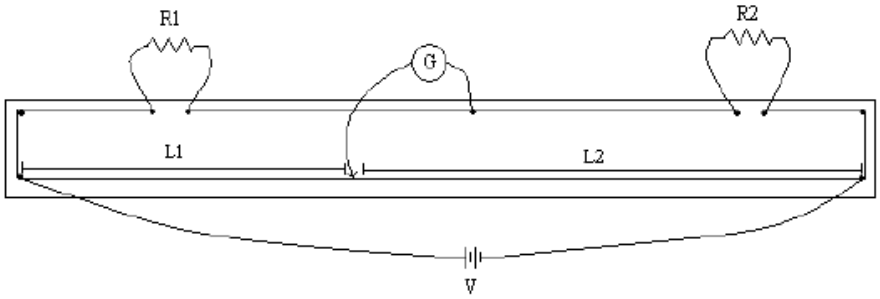
(j) Show that the slope of the graph represents the current flowing through the circuit.

(k) Give the aim of this experiment and state the method used.

(l) Mention two expected source of errors and two precautions to be taken in the experiment.

8.5.2 Metre Bridges

A metre bridge resembles a potentiometer, except that it uses a galvanometer to measure the difference in current between two points on the circuit, hence the name "bridge." The same materials can be used as with the potentiometer, though it is best to use small coils of resistance wire for the small resistors (between 3Ω and 20Ω is a good resistance). A galvanometer can be made easily if one is not available.



Resistors R_1 and R_2 have different resistances, but they should be somehow similar so that one resistor does not take all of the current (this will make it difficult to measure the length to the galvanometer). About 5Ω and 10Ω, for example, would work well.

However, for the sake of the practical, one resistor should not be known; the objective of the practical is to find the unknown resistance. The long wire along the bottom edge is a metre of nichrome wire or other resistance wire. One terminal of the galvanometer is connected between the two resistors, and the other terminal is connected to a flying wire (or jockey) that is free to move along the length of the nichrome wire.

The practical instructs you to move the galvanometer's flying wire back and forth along the nichrome wire until it reads zero. At this point, we know that no current is passing through the galvanometer, so the potential difference across it is zero. This means that the current flowing through R_1 is the same as that current flowing through R_2, and the current flowing through the nichrome wire is constant. From this we can conclude that

$$\frac{R_1}{L_1} = \frac{R_2}{L_2}$$

or that the ratio of the two resistors is equal to the ratio of distances from the flying wire to either end of the nichrome wire. The resistance of one resistor (say, R_1) is known and the lengths L_1 and L_2 can be measured from the flying wire to either side of the nichrome wire. Using the ratio above, we can easily calculate the unknown resistance R_2.

An example is given below from the 2006 NECTA exam.

Sample Practical Question

You are required to determine the unknown resistance labeled X using a metre bridge circuit. Connect your circuit as shown below, where R is a resistance box, G is a galvanometer, J is a jockey and others are common circuit components.

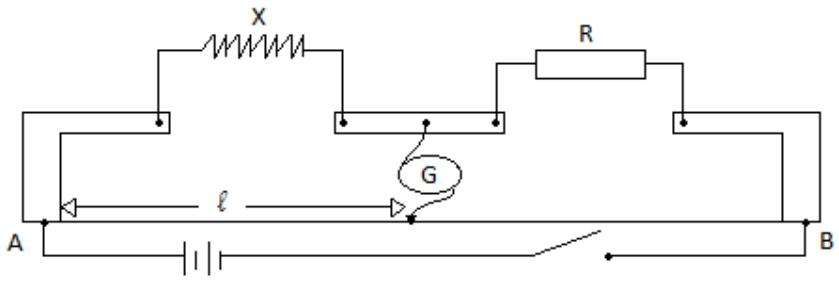


Fig. 3

Procedure:

With $R = 1\ \Omega$, obtain a balance point on a metre bridge wire AB using a jockey J. Note the length l in centimetres. Repeat the experiment with R equal to 2 Ω, 4 Ω, 7 Ω and 10 Ω.

Tabulate your results for R, l and $^1/_l$.

(a) (i) Plot a graph of R (vertical axis) against $^1/_l$ (horizontal axis).
(ii) Determine the slope S of your graph.
(iii) Using your graph, find the value of R for which $^1/_l = 0.02$.

(b) Read and record the intercept R_0 on the vertical axis.

(c) Given that,
$R = \dfrac{100\text{X}}{l} - \text{X}$
Use the equation and your graph to determine the value of X.

(d) Comment on your results in (a)(iii), (b) and (c) above.

Discussion

The procedure for this question is similar to most other wheatstone bridge problems: vary a known resistor and see how it affects the relative lengths in resistance wire required to balance the potential difference and give no current through the galvanometer. It may not be obvious at first, however, where the equation $R = \frac{100\text{X}}{l}$ - X comes from.

Starting with the balancing ratio for a wheatstone bridge,

$$\frac{R_1}{L_1} = \frac{R_2}{L_2}$$

we can solve for the unknown resistor

$$R_2 = R_1 \left(\frac{L_2}{L_1} \right)$$

.
Recall that L_1 and L_2 are the corresponding lengths from either end of the metre rule to the jockey (in cm), and so taking them together, we get

$$L_1 + L_2 = 100$$

. Dividing both sides by L_1 gives

$$1 + \frac{L_2}{L_1} = \frac{100}{L_1}$$

. Then solving for $\frac{L_2}{L_1}$,

$$\frac{L_2}{L_1} = \frac{100}{L_1} - 1$$

. Now substitute this into our previous equation for R_2:

$$R_2 = R_1 \left(\frac{100}{L_1} - 1 \right)$$

. Replacing R_2 with R, L_1 with l and R_1 with X for this problem and distributing gives,

$$R = \frac{100\text{X}}{l} - \text{X}$$

.
From this equation, we have dependent variable R, independent variable $\frac{1}{l}$, slope 100X and y-intercept $-$X. So we can obtain the value of the unknown resistor X either by using the y-intercept (note the resistance is a positive value) or by taking the slope divided by 100.

8.5.3 Ohm's Law

The practical may give any kind of experiment to use or verify Ohm's Law in a simple circuit. Finding the e.m.f. and internal resistance of cells appears frequently. Students should be very familiar with the law, as well as the factors that determine resistance in a wire and the effect of internal resistance of a cell on a circuit. Given below is an example problem taken from the 2011 NECTA exam.

Sample Practical Question

You are provided with an ammeter, A, resistance box, R, dry cell, D, a key, K and connecting wires. Proceed as follows:

(a) Connect the circuit in series.

(b) Put $R = 1\ \Omega$ and quickly read the value of current I on the ammeter.

(c) Repeat procedure (b) above for $R = 2\ \Omega$, $3\ \Omega$, $4\ \Omega$ and $5\ \Omega$. Record your results in a tabular form.

(d) Draw the circuit diagram for this experiment.

(e) Plot the graph of R against $\frac{1}{I}$.

(f) Determine the slope of the graph.

(g) If the graph obeys the equation $R = \frac{E}{I} - r$, then

  (i) suggest how E and r may be evaluated from your graph.

  (ii) compute E.

  (iii) compute r.

(h) State one source of error and suggest one way of minimizing it.

(i) Suggest the aim of this experiment.

Discussion

To see where the equation $R = \frac{E}{I} - r$ comes from, first start with Ohm's Law, $V = IR$. Accounting for the internal resistance of the cell, r, this becomes

$$V = I(R + r)$$

. To solve for resistance, we divide both sides by I, which gives

$$(R + r) = \frac{V}{I}$$

. From this we can see that, using E as e.m.f. for this problem,

$$R = \frac{E}{I} - r$$

.
In this form, the equation resembles the classic $y = mx + c$, where R is the dependent variable, $\frac{1}{I}$ the independent variable, E is the slope and $-r$ is the y-intercept (note the internal resistance is a positive value).

8.6 Guide to the NECTA Physics Practical

8.6.1 Remarks

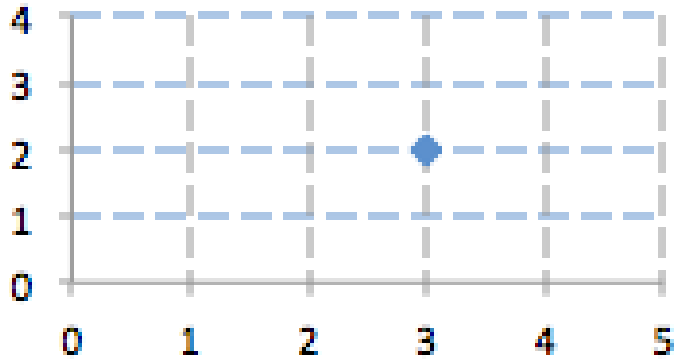
This guide is intended to provide a plan for preparing students for NECTA Physics Practical Examination. The practical is worth one-third of a students overall physics score. Despite this, most students spend four years preparing for the written examination and only weeks or days preparing for the practical. This is unfortunate. Due to the predictable format of the practical, thorough preparation almost ensures that students will receive full marks.

This section is intended to prepare students for the practical regardless of what experiments show up on the exam. Nearly every experiment requires the same analysis: plotting data, calculation and interpreting slope, giving the equation of the line, and identifying sources of error. This section is intended to show students how to perform this analysis–not how to perform the experiments themselves. Practicing the the common experiments (such as balance of forces, refraction of light through a glass block, etc.) is also essential. I would recommend working through this section with your students, then performing as many past practicals as possible.

There are many benefits to focusing on the data analysis by itself before adding in the actual performance of the experiments. First, it allows students to understand the data analysis can be applied to any experiment–event if they've never been able to do that experiment before. Second, the data analysis requires no equipment or lab space, you can practice data analysis with 80 students at a time in a regular classroom, if necessary.

8.6.2 Plotting Points

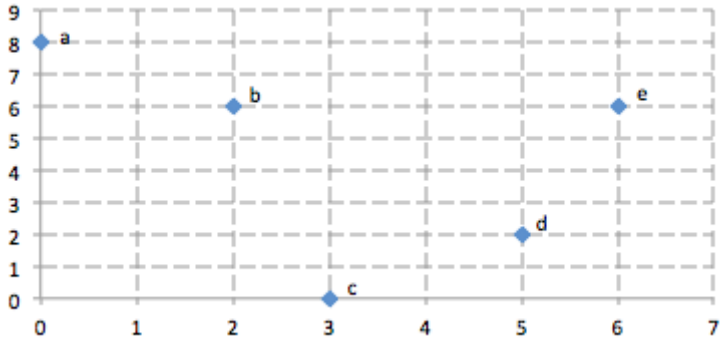
The coordinate plane consists of a horizontal x-axis and a vertical y-axis. The intersection of these axes [the point (0,0)] is called the origin. The coordinates of a point tell you where the point is located on the plane. The coordinates are typically written as an ordered pair. The ordered pair is of the form (x,y). For example, the point (3,2) is located three units along the x axis and 2 units along the y axis. The point (3,2) is plotted on the coordinate plane below. Note that the NECTA Physics Practical typically requires only the first quadrant of the plane.



Exercises:

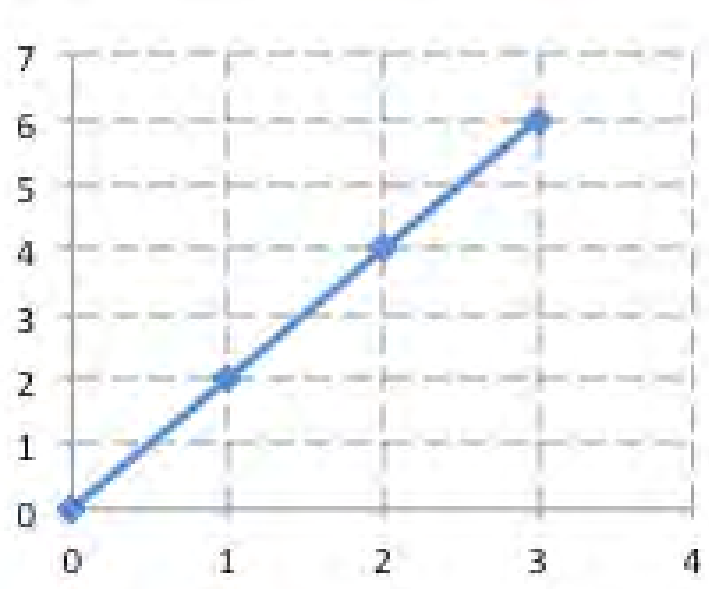
1. Create a coordinate plane and plot the following points. Label each point as a,b,c, or d.
   a. (6, 4) b. (0, 5) c. (5, 0) d. (4, 6)

2. Write the ordered pair for each point shown below.



8.6.3 Equation of a Line

Typically, the data gathered for a NECTA practical will be linear. This means that the data points all fall on a straight line. When data is linear, a straight line can be drawn through all of the points. This is shown below.



The equation of the line can be written in slope-intercept form. The general equation of a line in slope-intercept form is

$$y = mx + c$$

In this form, y represents the y-values, x represents the x values, m represents slope, and c represents y-intercept. For example, the line y=2x+4 has a slope of 2 and a y-intercept of 4.

Exercises:
Write the equation of a line with:

a. Slope= 2 and Y-intercept= 1

b. Slope= 5 and Y-intercept= -3

c. Slope= 1/2 and Y-intercept= 4

d. Slope= 1 and Y-intercept= 2

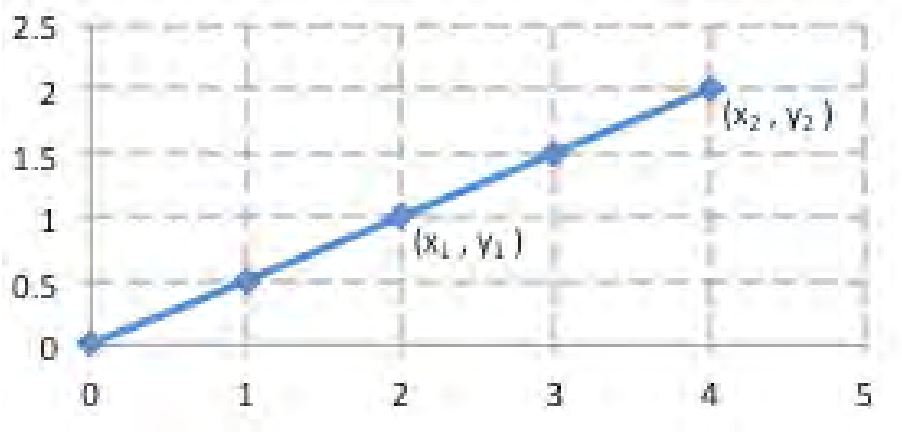
e. Slope= 2 and Y-intercept= 0

8.6.4 Slope

The slope or gradient of a line represents the change in y values over the change in x values. For any two points on a line [(x2,y2) and (x1,y1)], the equation for slope (m) is:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Using this equation, we can calculate the slope of the line shown on the graph below.



First, any two points on the line are selected. Then, they are used in our slope equation.

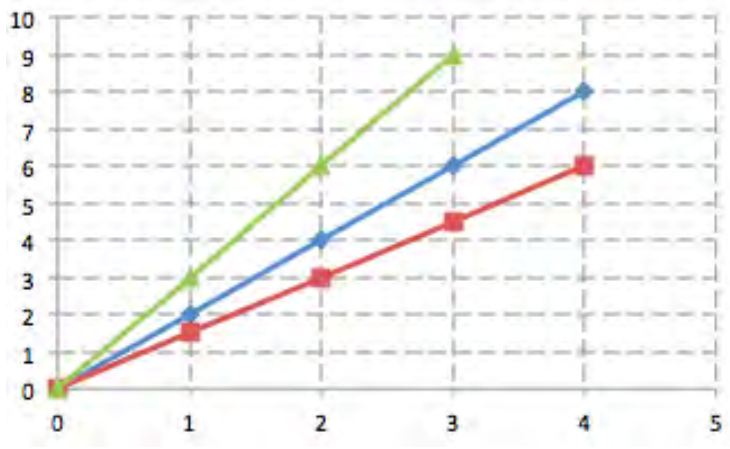
$$(x_1, y_1) = (2, 1) \text{ and } (x_2, y_2) = (4, 2)$$

$$m = \frac{2 - 1}{4 - 2}$$

$$m = \frac{1}{2}$$

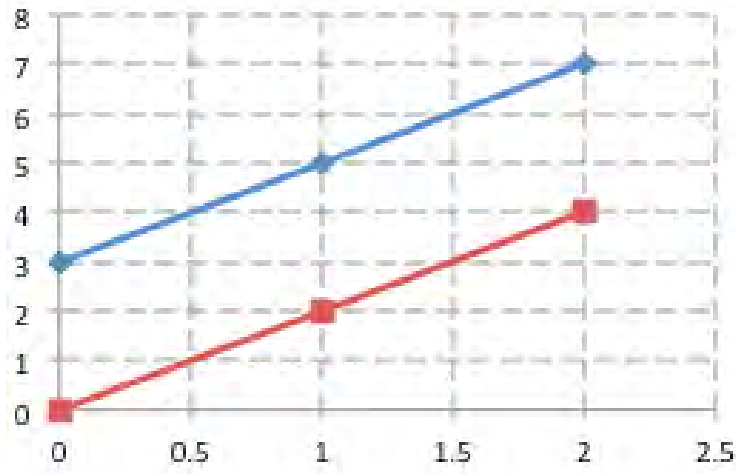
$$m = 0.5$$

Exercises:
Calculate the slopes of the lines shown below:



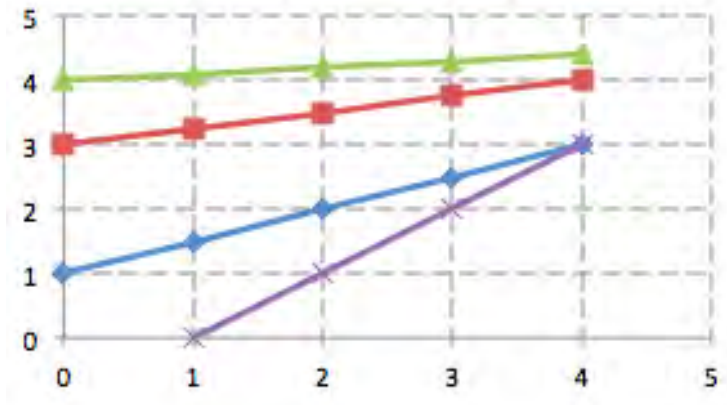
8.6.5 Y-Intercept

The y-intercept of a line represents the points where the line intercepts, or touches, the y-axis. The y-intercept of the bottom line in the graph shown below is 0. The y-intercept of the top line is 3.



Exercises:

1. Identify the y-intercepts of the lines shown below:



2. Graph a line with the equation y=2x+1.

8.6.6 Graphing Data

Data Table

Data from an experiment should be collected in a table. This table must have the general format:

Variable, symbol (unit)	Number	Number	Number	Number
Variable, symbol (unit)	Number	Number	Number	Number

In order to graph this data, the x and y variables must be determined. The x variable is the independent variable. This is the variable that the experimenter changes during the experiment. The y variable is the dependent variable. This is the variable that is measured after changing the independent variable. It is useful to write a small x and a small y next to the appropriate variables in the table.

Example: Joseph is doing an experiment to test Ohm's Law. He builds a simple circuit consisting of wire, a battery, a resistance box, and an ammeter. He first sets the resistance to 5 ω and measures the resulting current. He then increases the resistance to 10 ω and measures the resulting current. He repeats this procedure many times. What are the independent and dependent variables in this experiment?

Solution: The independent variable is the resistance because Joseph, the experimenter, changes the resistance during the experiment. The dependent variable is the current because Joseph measures it after he changes the resistance.

Setting up the Graph

An appropriate graph requires:

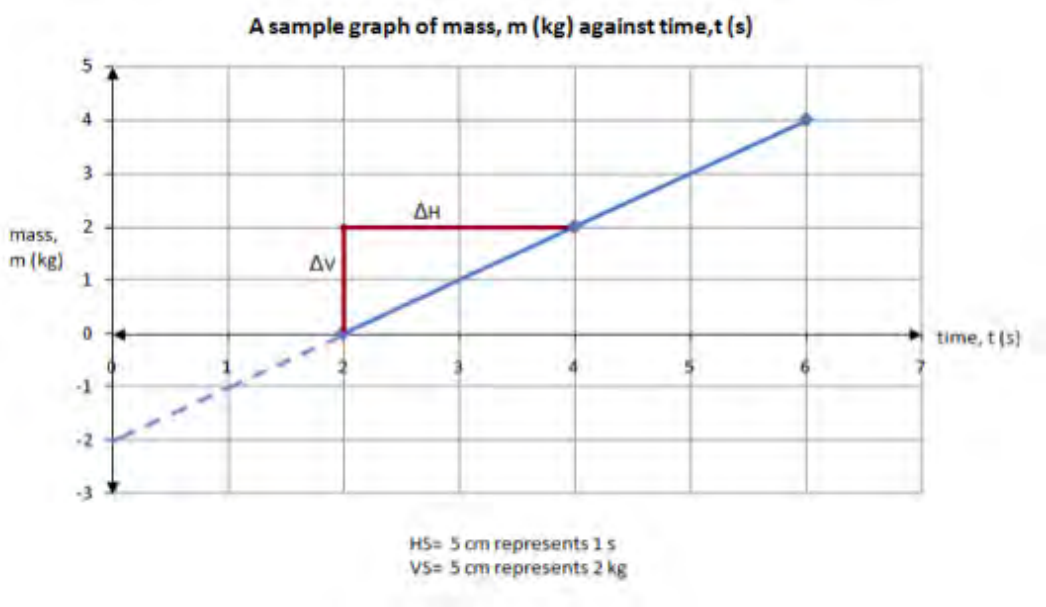
- A title at the top of the form "A graph of [Variable, symbol (unit)] Vs. [Variable, symbol (unit)]"
- Axis labels of the form "Variable, symbol (unit)"
- Horizontal and vertical scales given below the graph. This should be of the form

$$HS = X \text{ cm represents } X \text{ units}$$

$$VS = X \text{ cm represents } X \text{ units}$$

- Arrows at the ends of the x- and y- axes
- All words in ink and all drawings in pencil
- A minimum size of 2/3 of the page
- Data points as dots, X's, or crosses
- An appropriate trend line
- The slope should be shown on the graph as perpendicular lines touching the trend line and labeled H (for the horizontal line) and V for the vertical line.
- If the y-intercept is negative, the portion of the lines below the +x axis must be shown as a dashed line.

Below is an example of an acceptable graph using this general format (except it is not 2/3 of the page).



Exercises:

1. Is the format of the following tables correct or incorrect?

a)

Force, F (Newtons)	2	4
Time, T (seconds)	10	20

b)

Mass, Kilograms (kg)	0.1	0.2	0.3
Weight, Newtons (N)	1	2	3

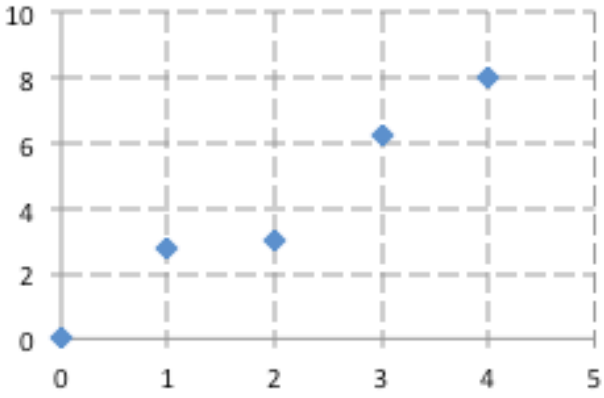
2. Happyness is doing an experiment to verify Hooke's Law. She attaches a 20g mass to the end of her spring. She then measures the extension of the spring. Next, she adds another 20g mass to the spring and measures the extension. She repeats this procedure many times. What are the independent and dependent variables in this experiment?

3. Create an acceptable graph(ie. Use a title, axis labels, scale, etc.) for the data below.

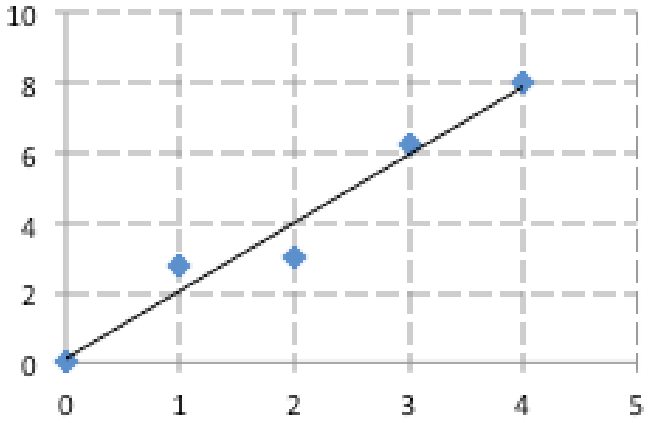
Force, F (newtons)	0	1	2	3
Extension, S (centimeters)	0	3	6	9

8.6.7 Trend Lines

As was stated previously, the data obtained during the practicals should be linear. However, due to error, the data obtained may not be exactly linear. We can only determine slope and y-intercept using our previous methods for linear data. How, then, could an experimenter determine the slope and y-intercept given these data?



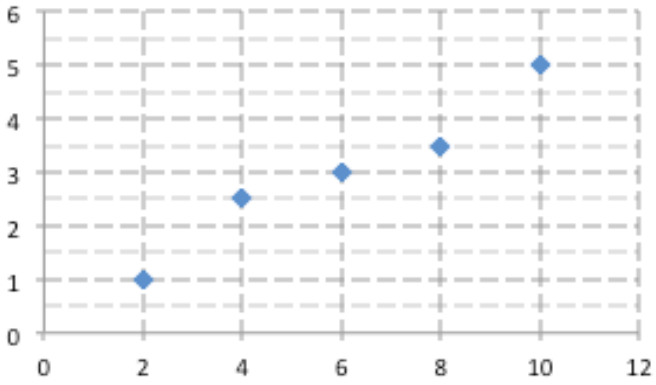
The solution is to create a trend line. A trend line or "line of best fit" is a line that.... For the NECTA physics practical, the accepted way to create a trend line is to simply connect the first (lowest x value) and last (highest x value) data points. By this method, the trend line for the graph above would appear as follows:



Note that the trend line does not touch every point. Instead, it connects the first and last points. This line can now be used to calculate slope and y-intercept. Be careful to use only values on the line to calculate slope.

Exercises:

1. Create a trend line for the data graphed below.



2. a) Graph the data below assuming that force is independent and acceleration is dependent. Follow all procedures for creating a graph (ie. Use a title, axis labels, scale, etc.)
   b) Create a trend line
   c) Calculate the slope
   d) Calculate the y-intercept

Force, F (N)	2	4	6	8	10
Acceleration, a (m/s^2)	0.5	1.5	2	2	2.5

8.6.8 Sources of Error

Often, the final question in a section will ask the student to identify sources of error. The following general sources of error can be applied to most experiments.

Experimental Error

Instrument Error
Instrument error occurs when the instruments which are used to perform the experiment are poorly made or damaged. For example, many experiments use a metre rule. If the metre rule is poorly constructed, it may be only 99cm long. As an additional example, a battery labeled 12V may only provide 11V.

Zero Error
Zero error occurs when measurements do not begin at the zero mark. The figure below illustrates zero error.

Environmental Factors
Environmental factors such as humidity, temperature, etc can affect the results of an experiment. For example, when performing a Hooke's Law experiment, the spring is expected to expand only due to the force applied. However, it may expand slightly due to heating (caused either by an increase in air temperature or heat from the experimenter's hands).

Human Error

Human error occurs when the person performing the experiment makes a mistake. For example, they may set up the experiment incorrectly or they may perform their calculations incorrectly.

Parallax Error

Parallax error occurs when the observer takes a measurement with their eye in the wrong position. When taking a measurement, the eye should be aligned perpendicular to the instrument. The figure below illustrates parallax error.

Exercises:
1. Abdulrahim performs an experiment to determine the index of refraction of a glass block. He places optical pins on one side of the glass block at a given angle. He then tries to align pins on the other side of the block. If the pins are not exactly aligned, his results will be inaccurate. He then uses a ruler to draw the incident and refracted rays. Finally, he uses a protractor to measure the angle of refraction. What are possible sources of error in this experiment?

Part III

Form VI - Past NECTA Examinations

Biology 2017 - Day #1

SECTION A

1. (a) Study Figure 1 and answer questions which follow.

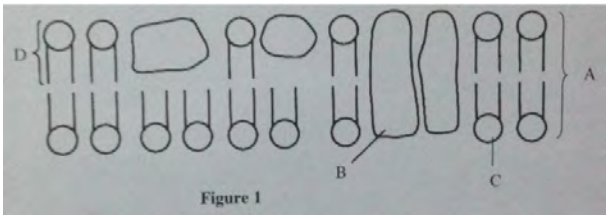


Figure 1

   i) What structure does Figure 1 represent?
   ii) Identify the parts labels A, B, C, and D.
   iii) State four functions of the structure labeled B.

   (b) Describe three functions of microtubules

2. (a) Analyze the difference between cyanobacteria and yeast cells based on the following criteria:
   i) Cell division
   ii) Respiration
   iii) Photosynthesis
   iv) Protein synthesis

   (b) Enumerate five similarities between mitochondria and chloroplast

3. (a) i) Briefly explain how to test for the protein in a given solution using Biuret test
   ii) What is the basis of protein test?

   (b) Explain how each of the following factors cause protein denaturation:
   i) Heat
   ii) Acid
   iii) Alkalis
   iv) Mechanical force

4. (a) Figure 2 shows a certain stage of synaptic transmission

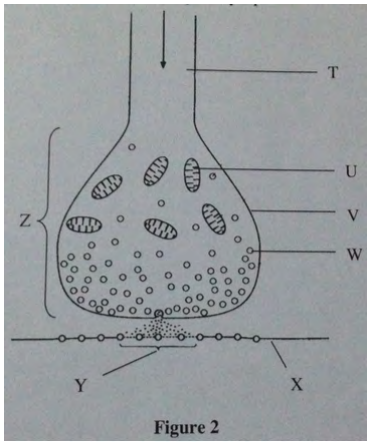


Figure 2

   i) Identify each of the parts labeled T, U, V, W, X, and Z
   ii) What is the state of the region shown by letter Y?
   iii) State the role played by structure labeled U and W respectively.

   (b) Why do some impulses arriving at the pre-synaptic membrane fail to produce an action potential in the post synaptic neuron whereas several impulses arriving in succession can do so?

5. (a) Briefly explain the roles of the following in photosynthesis:
   i) NADP
   ii) Ribulose diphosphate
   iii) Photosystems I and II (PSI and PSII)
   (b) Giving reason, explain the effect of lowering oxygen concentrations on:
   i) C3 photosynthesis
   ii) C4 photosynthesis
   (c) Why the rate of photosynthesis decreases at high temperatures?
6. (a) Draw the structure of animal cell as seen under electron microscope
   (b) i) Name a double membrane organelle found in plant cells only
   ii) How is the organelle adapted to its role?
7. (a) What is meant by natural system of classification?
   (b) Why is it difficult to achieve a complete natural system of classification?

SECTION B

8. Elaborate the main adjustments that occur to the heart rate and circulatory system just before during and after a 100 m race.
9. (a) i) Briefly explain the concept of capacitation as it is related to reproduction
   ii) Outline two protective role of mammalian placenta to the fetus
   (b) The chromosomes number in a radicle of a certain species of a flowering plant is 16. Giving reason, calculate the number of chromosomes in each of the following cells:
   i) Pollen tube nucleus
   ii) Antipodel cell
   iii) Endosperm
   iv) Integument cell
10. Identify the vascular tissues in plants and explain how they are adapted to their roles.

Biology 2017 - Day #2

SECTION A

1. (a) Classify the following organisms to the class level
   i) Bean
   ii) Crab
   iii) Elephant grass
   iv) Mouse
   (b) Giving six reasons, justify the:
   i) Phylum to which mouse belongs
   ii) Class to which bean plant belongs
   (c) Briefly explain why liverworts and mosses have sometimes been described as the amphibians of the plant world.

2. (a) Study Figure 1 and answer questions which follow.

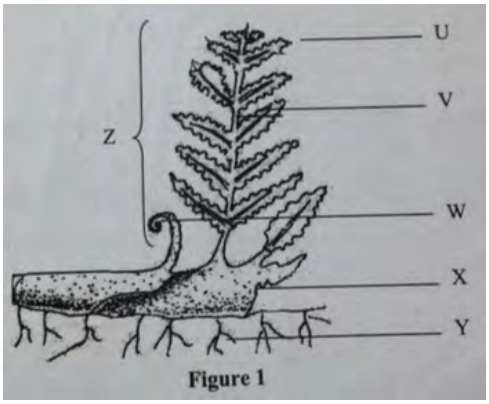


Figure 1

   i) Name the organism
   ii) Classify the organism to division level
   iii) Explain four general and three distinctive features of the kingdom to which the organism belongs
   (b) i) Identify the parts labeled U, V, W, X, Y, and Z
   ii) State three roles played by the part labeled Y
   iii) Give five ways in which the organism structurally adapts to its mode of life

SECTION B

3. (a) Describe the location, role and effects of apical, lateral and intercalary meristems. Tabulate your answer as shown in the following table:

Type of meristem	Location	Role	Effect

   (b) Figure 2 shows relative changes in dry mass of endosperm and embryo during germination of barley. Explain the results shown by endosperm, embryo and total mass curves.

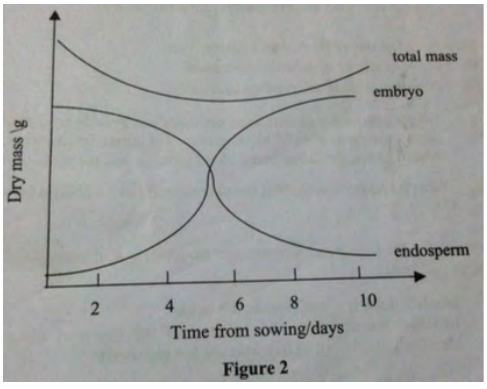


Figure 2

4. (a) i) State two main roles played by the kidney
   ii) The table below summarizes the relationship between excretory product and the habitat of the representative animal group. Complete the table.

Animal	Excretory product	Habitat
Protozoan		
Terrestrial insect		
Freshwater bony fish		
Marine bony fish		
Bird		
Mammal		

   (b) Enumerate three symptoms of each of the following disorders of urinary system in human:
      i) Bladder infection
      ii) Kidney stone
      iii) Kidney gout
      iv) Kidney failure

SECTION C

5. (a) State three features of DNA which enable it to:
      i) Serve as a store of genetic information
      ii) Transmit genetic information accurately
   (b) i) Using appropriate genetic symbols carry out genetic crosses to show the percentages phenotype of blood group of children, whose parents are both heterozygous, the father being blood group A and the mother AB.
      ii) What is the probability that the parents will have a child with blood group O?
   (c) Why the rate of photosynthesis decreases at high temperatures?

6. (a) Explain how the formation of messenger ribonucleic acid takes place during protein synthesis
   (b) i) Identify three types of ribonucleic acids
      ii) Describe the structure and location of the types of ribonucleic acids identified in (b) i). (Diagrams are not required)

SECTION D

7. (a) i) Name three theories of origin of life
      ii) Explain the origin of life based on the theories named in (a) i).
   (b) Explain the mechanism of organic evolution according to Lamarck theory and state strengths and weakness of the theory

8. (a) i) Define the term population explosion and explain three causes of it
      ii) State five negative consequences of population explosion
   (b) i) What is capture recapture method?
      ii) Outline nine procedures used to estimate population under capture recapture method.

Chemistry 2016

SECTION A

1. (a) State the following:
   i) Postulates of Bohr's atomic model
   ii) Shortcomings of the Bohr's atomic model
   (b) An electromagnetic radiation of wavelength 2,420 $\dot{A}$ is sufficient to ionize the sodium atom. Calculate the ionization of energy of sodium atom in kJ·mol^{-1}
   (c) Calculate the wave number of the longest wavelength transition in Balmer series of atomic hydrogen

2. (a) Define the following:
   i) Principal quantum number
   ii) Azimuthal quantum number
   (b) Given the quantum number, n = 3. Answer the following questions:
   i) List all possible orbitals present in this quantum energy
   ii) Write possible values of m_l and m_s for this quantum number
   (c) The mass spectrum of an element enables the relative abundance of each isotope of the element to be determined. Data relating to mass spectrum of an element X whose atomic number is 35 appear as indicated in the table below. Study the data and answer the questions that follows:

Mass Number of Isotopes	Relative Abundance
79	50.5%
81	49.5%

   i) Define the term isotope
   ii) Write the conventional symbols for the two isotopes of element X
   iii) Calculate the relative atomic mass of X to three significant figures

3. (a) Give reasons for the following observations:
   i) Both sodium and hydrogen occur in group IA of the periodic table, yet the melting point of sodium chloride in 800°C while that of HCl is -114°C
   ii) Sodium chloride is soluble in water but not in benzene
   iii) Although both oxygen and sulphur are in the same group of the periodic table, the hydride of oxygen (H_2O) is a liquid but the hydride of sulphur (H_2S) is a gas at room temperature
   (b) i) Study the following compounds: hydrogen sulphide (H_2S), ammonia (NH_3), hydrogen fluoride (HF), chloroform ($CHCl_3$), and ethanoic acid (CH_3COOH).. With reasons, briefly describe the compounds which contain and those which do not contain hydrogen bond
   ii) Briefly explain why dimethyl ether is more volatile than ethanol although their molecular weights are the same

4. (a) State why was it necessary to modify the ideal gas equation and show how the modified equation looks like. Define all symbols in the equation
   (b) Briefly explain why beyond certain temperatures gases cannot be liquified
   (c) One mole of diethyl ether occupies 1.5 liters at 227°C. Calculate the pressure if the Van der Waals constants for diethyl ether are: a = 17.38 atm·liter^2·mol^{-1} and b = 0.134 liter·mol^{-1}

5. (a) Define the following terms with reference to gases:
   i) Critical temperature
   ii) Critical volume
   iii) Critical pressure

(b) From ideal gas equation, derive the relationship between density of a gas in grams per dm^3, the gas pressure in atmospheres, the temperature (T) in Kelvin, the relative molecular mass of a gas (Mr) and the gas constant, R.

(c) A certain dry gas is composed of 21% by volume of oxygen, 1% of argon and 78% of nitrogen. Find its density in $g \cdot dm^{-3}$ at 20°C and 98.65 $k \cdot N \cdot m^{-2}$ pressure

6. (a) Give two differences between osmosis and diffusion

(b) When 15 g of glucose ($C_6H_{12}O_6$) was dissolved in 50 g of a certain solvent with a relative molecular mass of 180 g, the freezing point was depressed by 8.0°C. Using these data, calculate the freezing point depression constant, for the solvent.

(c) An aqueous solution of sugar containing 19.15 g of sugar per dm^3 has osmotic pressure of 136,300 NM^{-2} at 20°C. Calculate the relative molecular mass of sugar

SECTION B

7. (a) Give a brief molecular explanation of positive and negative deviations from Raoult's law for non-ideal binary solutions

(b) What vapor pressure lowering difference(s), if any, would you expect for 1 M aqueous solutions of i) $CaCl_2$, ii) KBr, and iii) Na_3PO_4? Justify your answer

(c) Benzene (C_6H_6) and toluene ($C_6H_5CH_3$) form an ideal solution. At 333 K, the vapor pressure of pure benzene is 53.3 kPa while that of pure toluene is 26.7 kPa. If a solution is prepared by mixing two moles of benzene and three moles of toluene:

i) Find the partial pressure of each component in the vapor phase in equilibrium with this solution at 333

ii) Calculate the total vapor pressure of the solution

iii) Explain which substance will be collected from the top of the distillation column, if a mixture of benzene and toluene is distilled

8. (a) Pure ethanol, (C_2H_5OH) boils at 78.3°C and at pressure of 760 mmHg. When 2.51 g of an organic compound M (Mwt = 146 g) is dissolved in 100 g of ethanol, the solution boils at 85.9°C and 760 mmHg

i) Explain why the boiling point of ethanol was raised

ii) Calculate the molal boiling point, K_b for ethanol

(b) A solution was prepared by dissolving 2.40 g of biphenyl ($C_{12}H_{10}$) in 75.00 g of benzene. Calculate the boiling point of the solution given that K_b = 2.53 °C/m; K_f = 5.12 °C/m; boiling point of pure benzene = 80.1 °C and freezing point of pure benzene is 5.5 °C

9. (a) i) Briefly explain the dynamic nature of equilibrium reaction

ii) Use hydrogen (H_2) and iodine (I_2) gases which produce hydrogen iodide (HI) gas to illustrate the point mentioned in (a) i)

(b) i) Mention the four common stresses explained by Le Chateliers' principle to help maximize the yield of ammonia gas in the Haber process

ii) The equation for production of ammonia gas is as follows:

$$N_{2\ (g)} + 3H_{2\ (g)} \leftrightarrow 2NH_{3\ (g)}\ \Delta H^\circ = -92.6\ kJ$$

From the given equation, explain how maximum yield of ammonia can be achieved

10. (a) State the following:

i) Heat of reaction

ii) Exothermic reaction

iii) Endothermic reaction

(b) 1.5 g of ammonium nitrate (NH_4NO_3) was added to 35.0 g of water in a plastic beaker and stirred until the salt dissolved. The temperature of the solution dropped from 22.7°C to 19.4°C. Basing on the given information respond to the following questions:

i) Is the process endothermic or exothermic? Explain

ii) Calculate the heat of solution of NH_4NO_3 in kJ/mol, given that specific heat capacity of water = 4.184 J/g°C

SECTION C

11. (a) Briefly explain the following terms and give an example of family of organic compounds in each case:
    i) Hydrocarbon
    ii) Saturated hydrocarbon
    iii) Unsaturated hydrocarbon

    (b) 10 cm^3 of a gaseous hydrocarbon Q required 45 cm^3 of oxygen for complete combustion. Q reacts with 1 mole of bromine gas to form a brominated compound of relative molecular mass of 200.02 which contains 79.2% bromine
    i) Determine the molecular formula of Q
    ii) Give the structural formula of Q

12. (a) Define the following:
    i) Isomers
    ii) Isomerism

    (b) Write the structural formula of the following:
    i) 3-methyl-1-pentene
    ii) 2-methyl-2-pentene
    iii) 2,2-dimethyl pentane
    iv) 4-methyl pent-2-yne

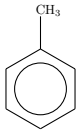
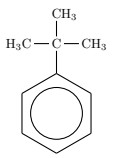
    (c) Identify a simple chemical test that can be used to distinguish between the following compounds
    i) 1-butyne and 2-butyne
    ii) Butane and butene

13. (a) i) Outline the stages in the formation of chloromethane from methane and chlorine at 450°C
    ii) Give reason why the chloromethane obtained in (a) i) is not pure

    (b) Bromoalkanes may react with alcoholic potassium hydroxide solution to form alkenes. Basing on this statement answer the following questions:
    i) What type of organic reaction is this reaction?
    ii) Write an equation for the reaction of 1-bromobutane with alcoholic potassium hydroxide. Show all mechanisms involved
    iii) Draw the structural formula of the alkene obtained by reaction between 2-bromobutane and alcoholic potassium hydroxide

14. (a) Briefly explain the following:
    i) The C-C bonds are all equal and intermediate in length between a single and a double bond in benzene
    ii) Dry ether is necessary in the preparation and use of the Grignard reagent

    (b) The chlorination of methyl benzene and 1,1-dimethylethyl benzene yield the following isomers:

	2	3	4
	60%	0.5%	39.5%
	22%	8%	70%

    Study the isomers and then explain the observed different product ratio

Chemistry 2017 - Day #1

SECTION A

1. (a) Distinguish between the following:
   i) Isotopes and isotopy
   ii) Azimuthal quantum number and magnetic quantum number
   iii) Atomic mass unit and relatie atomic mass

   (b) The mass spectrographic measurements of an element X whose atomic number is 31 indicated peaks at 79.21, 11.2, and 9.59. The isotopic masses are 69, 70, and 71 atomic mass unit (a.m.u.) respectively.
   i) Write the conventional symbols for the three isotopes
   ii) Calculate the relative atomic mass of X
   iii) Explain why atomic weights of elements are not whole numbers

   (c) The mass number of two atoms, A and B with the same atomic number are 235 and 238 respectively. If A contains 143 neutrons in its nucleus, find the number of neutrons and electrons in B.

2. (a) Define the following:
   i) Dative bonding
   ii) Ionic bonding
   iii) Valence electrons

   (b) Summarize three major ideas of the Valence Shell Electron Pair Repulsion (VSEPR) theory

   (c) Outline four difference between sigma and pi bonds

   (d) Determine the name of a geometrical structure and one example of the molecule formed from the following hybridized orbitals
   i) Sp^3
   ii) Sp^2
   iii) Sp

3. (a) i) Write two similarities between diffusion and effusion
   ii) The rate of effusion of unknown gas was measured to be 24.0 mL/min. Under the same conditions, the measured rate of effusion of pure methane was 47.8 mL/min. What is the molar mass of the unknown gas?

   (b) Using the kinetic theory of gases, state four properties of an ideal gas

   (c) A sample of ammonia gas with a volume of 3.5 dm^3 at a pressure of 1.68 atm was compressed to a volume of 1.35 dm^3 at constant temperature.
   i) Calculate the final pressure of the gas
   ii) Name and state the governing gas law in (c) i)

4. (a) Define the following:
   i) Relative density of a gas
   ii) Normal density of a gas

   (b) Show that the relative molecular mass of a gas is twice its relative vapor density

   (c) i) A determination of the density of ethanoic acid vapor at 1 atm pressure and 400 K gave a result of 2.74 g/dm^3. Assuming ideal condition, calculate the apparent molecular weight of ethanoic acid under these conditions.
   ii) What can you deduce from your results in (c) i). Briefly explain.

5. (a) i) Give the meaning of osmotic pressure of a solution

ii) Briefly explain in terms of vapor pressure why the freezing point of a solution is lower than that of a pure solvent.

(b) When water and ice are mixed, the temperature of the mixture is 0°C, but if methanol (CH_3OH) and ice are mixed, a temperature of +10°C is readily attained. Explain why the two mixtures show such different temperature behaviors.

(c) Calculate the molar mass of Y given that a solution of 60 g of Y in 1 dm^3 of water exerts an osmotic pressure of 4.31×10^5 N/m^2 at 25°C.

(d) A 0.003 kg of acetic acid (CH_3COOH) is added to 500 cm^3 of water. If 23% of the acid is dissociated, what will be the depression in freezing point? (K_f for water = 1.86 °C·kg/mol, density of water = 0.997 g/cm^3)

6. (a) i) Define vapor pressure

ii) Using Raoult's law of vapor pressure, show that the lowering of vapor pressure is proportional to the mole fraction of the solute

(b) Briefly explain why the solution becomes ideal when it is made more dilute

(c) Two liquids A and B form an ideal solution when mixed. At 298 K, the vapor pressure of pure A and B for a mixture of 1 mole of A and 3 moles of B are 32 kPa and 16 kPa, respectively. Calculate:

i) The vapor pressure of the mixture

ii) The mole fraction of A in the vapor which is in equilibrium with the mixture

SECTION B

7. (a) i) Briefly explain the principle of solvent extraction

ii) Compare and contrast fractional distillation from steam distillation

(b) Steam distillation of a mixture of an organic compound B and water at 98°C and pressure of 10,320 Pa yielded a distillate containing 31.6% by volume of B. The vapor pressure of pure water at this temperature is 94,260 Pa. The densities of B and water are 0.961 g/cm^3 and 1.000 g/cm^3, respectively. Calculate the relative molecular mass of B.

8. (a) Define the following:

i) Standard enthalpy change of neutralization

ii) Heat of solution

iii) Bond energy

iv) Standard enthalpy change of combustion

(b) Differentiate between:

i) Lattice energy and energy of reaction

ii) Standard molar enthalpy change of dissolution and heat of combustion

(c) Given the standard enthalpy change of combustion of hydrogen, ΔH° = -286 kJ/mol; carbon, ΔH° = -394 kJ/mol; methane, ΔH° = -890 kJ/mol; ethane, ΔH° = -1,390 kJ/mol and heat of formation of CH_3CH_3OH is -276 kJ/mol, calculate in kJ/mol the enthalpy change;

i) of formation of methane

ii) of formation of ethane

iii) for the reaction $CH_2{=}CH_2$ (g) + H_2O (g) → CH_3CH_2OH (g)

iv) of combustion of 4.48 dm^3 of ethane.

9. (a) Study carefully the information in the following table and then answer the questions that follow.

Process	ΔH 298 K° (kJ/mol)
Na (s) → Na (g)	+108
$\frac{1}{2}Cl_2$ → Cl (g)	+121
Na (g) → Na^+ (g) + e^-	+496
Cl (g) + e^- → Cl^- (g)	-349
NaCl (s) → Na^+ (g) + Cl^- (g)	+787
NaCl (s) + H_2O (l) → Na^+ (aq) + Cl^- (aq)	+4.0

i) Calculate the enthalpy change for the process $2Cl\ (g) \rightarrow Cl_2\ (g)$

ii) Calculate the standard molar enthalpy change for the process:
$Na\ (s) + \frac{1}{2}Cl_2\ (g) \rightarrow Na^+\ (g) + Cl^-\ (g)$

iii) Compare the difference between enthalpy change for the processes:
$NaCl\ (s) \rightarrow Na^+\ (g) + Cl^-\ (g)$ and $NaCl\ (s) + H_2O\ (l) \rightarrow Na^+\ (aq) + Cl^-\ (aq)$, and then comment on the differences.

(b) Magnesium will displace copper from copper (II) sulphate solution according to the equation:

$$CuSO_4\ (aq) + Mg\ (s) \rightarrow Cu\ (s) + MgSO_4\ (aq)$$

When an excess of magnesium was added to 100 cm^3 of 0.1 mol dm^3 copper (II) sulphate, the temperature increased by 46.3 °C. It is known that density and specific heat capacity of the solution are 1.0 g/cm^3 and 4.18 J/g·°C, respectively. Calculate:

i) The molar enthalpy change for the reaction

ii) Minimum quantity of magnesium required

iii) The change in temperature if only 0.8 g magnesium was added

10. (a) Differentiate between the following:

i) Equilibrium constant, K_c, and rate constant K

ii) Equilibrium position and rate of reaction

(b) Consider the following reversible equilibrium:

$$2C_2H_6\ (g) + 7O_2 \leftrightarrow 4CO_2\ (g) + 6H_2O\ (l)$$

i) Write down the K_c and K_p expressions

ii) Derive the relationship between K_c and K_p

(c) A 7.52 cm^3 of a gas H was mixed with 7.0 cm^3 of a gas Q in a one liter flask at 298 K. At equilibrium, 10.93 cm^3 of gas HQ was formed. Calculate the equilibrium constant, K_c, for the reaction:

$$H_2\ (g) + Q_2 \leftrightarrow 2HQ\ (g)$$

SECTION C

11. (a) Using one appropriate example in each case, briefly explain the meaning of the following terms:

i) Homologous series

ii) Functional group

iii) Unsaturated hydrocarbon

iv) Alkyl group

(b) Write the formula of the following alkyl groups:

i) Methyl group

ii) Butyl group

iii) Ethyl group

iv) Propyl

(c) Complete the following reactions:

i) $CaC_2\ (s) + 2H_2O\ (l) \xrightarrow[\text{cold}]{} $

ii) $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4}$

iii) $CH_3CH_2Cl + KOH \xrightarrow[\text{Heat}]{\text{Alcohol}}$

iv) $CH_3CH{=}CH_2 + H_2O \xrightarrow{H^+}$

12. (a) Define the following terms:

i) Resonance energy

ii) Aromatic compound

(b) Briefly explain why methyl benzene (toluene) is more reactive that benzene

(c) Write equations to show what will happen when methyl benzene is

i) treated with chloromethane (CH_3Cl) is presence of aluminum chloride ($AlCl_3$)

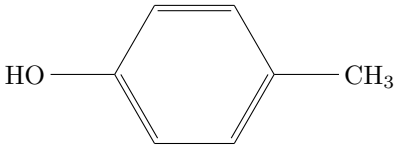
ii) treated with chlorine in presence of ultraviolet (uv) light

iii) refluxed with potassium manganate (VII) ($KMnO_4$) in the presence of an acid

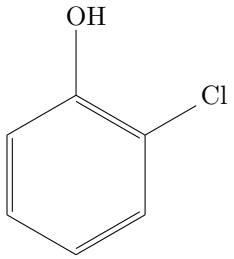
iv) burnt in excess oxygen

(d) Indicate in the following aromatic compounds, which substituent group entered first. Give reason(s) for your answer.

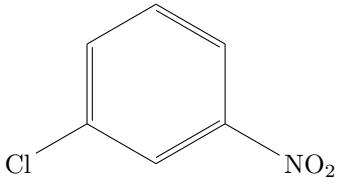
i)



ii)



iii)



13. (a) Briefly explain why alkyl chlorides are not friendly to the environment

(b) Write the structures of the following alkyl halides:

i) 2-chloro-3-methylpentane

ii) Pent-2-ene

(c) Give IUPAC names of the following compounds:

i) $CH_3\underset{\displaystyle Cl}{\underset{|}{C}}H\underset{\displaystyle Br}{\underset{|}{C}}HCH_3$

ii) $ClCH_2C{\equiv}CCH_2Br$

iii) $CHF_2CBrClF$

iv) $CCl_3CHClCCl_3$

(d) A primary alkyl halide, A, (C_4H_9Br) reacted with alcoholic KOH to give compound B. Compound B reacted with HBr to give C which is an isomer of A. When C (in ether solution) reacted with Na metal, it gave compound D (C_8H_{18})

i) Give the structure of A

ii) Write equations for all the reactions

14. (a) State Markovnikoff's rule

(b) By indicating whether the reaction will involve side chain, aromatic ring or both, write chemical equations showing the reaction between phenylethane (styrene) and:

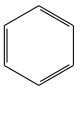
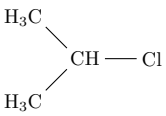
i) Br_2

ii) H_2, (Pt) at 25°C

iii) H_2, (Pt) at 200°C

(c) Complete the following reactions:

i)  + Conc. HNO_3 $\xrightarrow[50^\circ C]{\text{Conc. } H_2SO_4}$

ii)  +  $\xrightarrow{AlCl_3}$

iii)  + $3H_2$ $\xrightarrow[200^\circ C]{Ni}$

(d) Arrange the following set of compounds in order to decreasing relative reactivity to an electrophile E^+:

i) chlorobenzene, 2,4-dinitrobenzene, 4-nitrochlorobenzene

ii) methylbenzene, 4-nitromethylbenzene, 2,4-dinitromethylbenzene

Chemistry 2017 - Day #2

SECTION A

1. (a) Distinguish between the following terms:
   i) Average rate and instantaneous rate
   ii) Elementary step and rate-determining step
   iii) Molecularity and order of reaction
   iv) Activated complex and activation energy

   (b) Determine the rate law and the rate constant, k, for the following reaction using the data provided: $2N_2O_5\ (g) \rightarrow 4NO_2\ (g) + O_2\ (g)$

Initial $[N_2O_5]$ M	**Initial rate ($M \cdot s^{-1}$)**
0.186	9.68×10^{-4}
0.372	19.34×10^{-4}
1.490	77.67×10^{-4}

   (c) The reaction between methane and diatomic sulphur is given by the equation

$$CH_4\ (g) + 2S_2\ (g) \rightarrow CS_2\ (g) + 2H_2S\ (g)$$

   At 550°C the rate constant for this reaction is 2.2 $L \cdot mol^{-1} \cdot s^{-1}$ and at 625°C the rate constant is 12.8 $L \cdot mol^{-1} \cdot s^{-1}$. Calculate E_a (activation energy) for the reaction.

2. (a) Give the oxidation numbers of all atoms in the following compounds:
   i) Cl_2
   ii) Cl_2O_7
   iii) $Na_2Cr_2O_7$

   (b) Balance the following equations for redox reactions:
   i) $Cr_2O_7^{2-}\ (aq) + Br^-\ (aq) + H^+\ (aq) \rightarrow Cr^{3+}\ (aq) + H_2O\ (l) + Br_2\ (s)$
   ii) $MnO_4^-\ (aq) + I^-\ (aq) \rightarrow MnO_2\ (s) + I_2\ (s)$ in basic medium

   (c) 25 cm^3 containing 3.16 g per liter of $KMnO_4$ were acidified and mixed with 20 cm^3 of KI solution. The liberated iodine was titrated against $Na_2S_2O_3 \cdot 10H_2O$ solution containing 31.64 g/L.
   i) Write balanced ionic equations representing the reactions described
   ii) Calculate the molarity of $Na_2S_2O_3 \cdot 10H_2O$ if 26.70 cm of it were required to reach the end point

   (d) The molar conductivities at infinite dilution at 25°C of NH_4Cl, NaOH and NaCl are 129.8, 217.4 and 108.9 $S \cdot cm^2 \cdot mol^{-1}$, respectively. For 0.01 M NH_4OH molar conductance is 9.33 $S \cdot cm^2 \cdot mol^{-1}$. Calculate the ionization constant of NH_4OH

3. (a) Define the following:
   i) Common ion effect
   ii) Buffer solutions
   iii) Ionic product of water
   iv) Salt hydrolysis

   (b) Briefly explain each of the following observations:
   i) Ammonia (NH_3) is one of the Lowry-Brønsted bases
   ii) Al^{3+} ion behaves as a Lewis acid when it is in water
   iii) Lead (II) chloride is soluble in concentrated HCl solution
   iv) Aqueous aluminum nitrate solution turns blue litmus paper red

   (c) For each of the following pairs, write an equation to show how the pair reacts to form a conjugate acid and a conjugate base. For each reaction, identify the acid, base, conjugate acid, and conjugate base
   i) Bicarbonate ion and water
   ii) Ammonia and water

iii) Nitrous ion and hydroxonium ion
iv) Ammonium ion and carbonate ion

(d) Briefly explain how an acidic buffer solution works to maintain its pH value when a small amount of acid is added to it

4. (a) Silver chloride has a measured solubility of 1.024×10^{-4} mol/dm^3 at 18°C. Calculate its K_{sp} value.

(b) i) Briefly describe the term "common ion effect"
ii) Calculate the solubility of solid CaF_2 in a 0.05 M NaF solution. The K_{sp} of is 4.0×10^{-11}

(c) Should a precipitate of barium fluoride be obtained when 100 mL (milliliters) of 0.25 M NaF and 100 mL of 0.015 M $Ba(NO_3)_2$ are mixed? Support your answer by calculations. The K_{sp} of BaF_2 is 1.7×10^{-6}

SECTION B

5. (a) i) State the periodic law
ii) What is the advantage of arranging elements in the periodic table on the basis of atomic numbers rather than atomic masses?
iii) Give three (3) diagonal similarities between Be and Al

(b) Basic characters of elements in the modern periodic table always increase down the group. Justify this statement by considering the oxides of group V elements

(c) Explain the following:
i) Silicon has a higher melting point that it is expected
ii) Graphite is used as a lubricant as well as a cell electrode by not diamond
iii) The first ionization energy of boron is lower than that of beryllium although boron is towards the right across period 2 in the periodic table

(d) A researcher decided to place a newly discovered element at the bottom of group (VII). What would be the expected physical and chemical properties of the new element? Give your answers based on
i) the state of the element at room temperature and pressure
ii) redox properties of the element
iii) atomicity
iv) reaction with alkali

6. (a) Identify four general principles or steps which are followed during metal extraction

(b) With the aid of chemical equation(s), analyze the process of extracting tin (Sn) from its ore cassiterite under the following subheadings:
i) Thermal reduction of the ore
ii) Purification of the ore from the impurities
iii) Its two uses in real life

(c) Extraction of aluminum and its purification from bauxite ($Al_2O_3 \cdot 2H_2O$) can be represented by sequence of steps of events using boxes with relevant information. Design and formulate the major events sequentially to summarize the extraction which eventually leads to purification of this metal. (Diagram of the electrolytic cell and details of chemical reactions involved are not required).

7. (a) With reference to the elements of period III of the periodic table, give the formula of the oxide with the following properties:
i) The most basic oxide
ii) The amphoteric oxide

(b) Briefly explain the action of water on chlorides of period III elements

(c) Give reasons to support the following:
i) When salts of iron are exposed in air they turn from blue green color to brown

ii) Concentrated nitric acid renders aluminum passive
iii) Zinc and tin are used to protect iron from rusting

(d) With the help of chemical equations, state the physical changes that will be observed and their inference in each of the following experiments:
i) Sodium oxalate solution is added into potassium permanganate solution in acidic medium
ii) A hydrogen sulphide solution is added into potassium dichromate solution

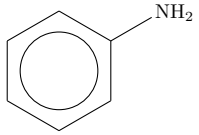
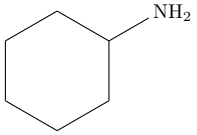
SECTION C

8. (a) Briefly describe the following:
i) Ozone layer
ii) Greenhouse effect
iii) Acid rain

(b) With the aid of chemical equations, describe how the ozone layer is formed and depleted or destroyed

(c) Outline six effects of ozone layer depletion

9. (a) For the following pairs of organic compounds, briefly explain which compound in each pair is more basic than the other

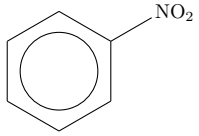
i)  and 

ii) CH_3-NH_2 and $CH_3-NH-CH_3$

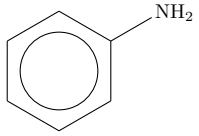
(b) Give the products of the following organic reactions:

i) $CH_3C{\equiv}N + H_2O, H^+ \rightarrow$

ii) $CH_3CH_2CONH_2 + LiAlH_4, H_2O \rightarrow$

iii)  $+$ Conc. HCl, Sn $\rightarrow$

iv) $CH_3CH_2NH_2 + HN_2$ (aq) $\rightarrow$

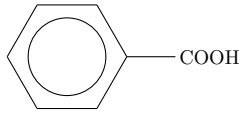
v)  $+ NaNO_2$, conc. HCl $\rightarrow$

vi) $CH_3CH_2-\overset{\overset{O}{\|}}{C}-NH_2 \xrightarrow{Br_2/OH^-}$

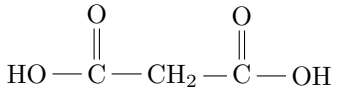
(c) Briefly describe the laboratory preparation of dimethylamine from methane

(d) An organic compound **A** was treated with nitrous acid and yielded compound **B** and nitrogen gas was evolved. Compound **B** has a composition of 60% C, 13.33% H, and 26.67% O. Compound **B** has a vapor density of 30. When compound **B** was oxidized using H_2CrO_4 it yielded compound **C**. Compound **C** forms oxime with hydroxylamine. Compound **C** also reacts with Fehling's solution to form brick red precipitate.

10. (a) Name the following organic compounds:

i) 

ii) $CH_3-\underset{\underset{CH_3}{|}}{C}HCH_2CH_2COOH$

iii) 

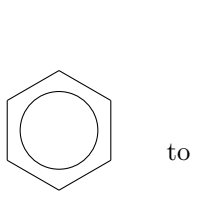
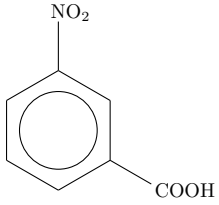
iv) $CH_3CH_2CH(OH)–CH_2CH_2COOH$

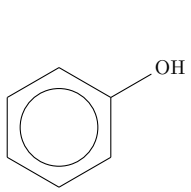
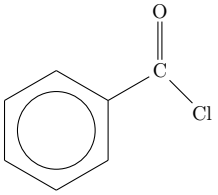
(b) What are the effects of the following on the acidity of carboxylic acids?

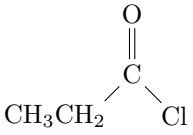
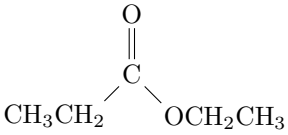
i) Chlorine as a withdrawing atom

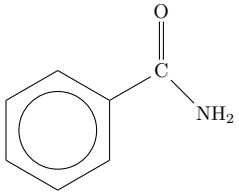
ii) Large sized alkyl group

(c) Show how the following conversions can be carried out:

i)  to 

ii)  to 

iii)  to 

iv) CH_3CH_3 to 

(d) Lactic acid ($CH_3CH(OH)CO_2H$) occurs naturally in sour milk. The compound can be synthesized from ethanol by the following route:

$$\begin{aligned} CH_3CH_2OH &\xrightarrow{U} CH_3CHO \\ CH_3CHO &\xrightarrow{V} CH_3CH(OH)CN \\ CH_3CH(OH)CN &\xrightarrow{W} CH_3CH(OH)COOH \end{aligned}$$

i) Give the reagents and conditions if any, for steps U,V, and W above

ii) Give the names of the organic reactions represented by steps V and W

iii) Name the lactic acid by IUPAC system

Applied Mathematics (AM) 2017 - Day #1

1. (a) By using a scientific calculator compute:
   i) $\frac{\sqrt{240}\times e^{\ln\frac{1}{3}}\sin 22^\circ}{\sqrt{\tan 17^\circ}\times 3^{4\ln 11}}$ correct to 3 significant figures
   ii) $\ln\frac{\sqrt{98.2}\times(0.0076)^{-1}\times 10^7}{\tan\frac{\pi}{3}\times\cos^3\frac{\pi}{3}}$ correct to 6 significant figures
   iii) $\sqrt{\frac{(0.485)^6+\tan^{-1}(1.54)e}{(62.54)^4\sin^{-1}(0.4561)}}$ correct to 4 decimal places

   (b) If $M^d = \frac{p}{\pi t^2}\left[\frac{4}{3}\ln(\frac{D}{d}) + \sqrt{\log p}\right]^{1/3}$, with the aid of a non-programmable calculator evaluate D given that $p = 1.6\times 10^3$, $t = 56\times 10^{-2}$, $M = 50.6\times 10^2$ and $d = \lim_{x\to\infty}\left(\frac{\cosh x}{e^x}\right)$ correct to four decimal places.

2. (a) If $x = \ln\left\{\tan(\frac{\pi}{4}+\frac{\theta}{2})\right\}$, find e^x and e^{-x} and hence show that $\sinh x = \tan\theta$
   (b) If $a\cosh x + b\sinh x = c$, show that the value of $x = \ln\left(\frac{c\pm\sqrt{c^2+b^2-a^2}}{a+b}\right)$
   (c) Use the approximate hyperbolic substitution to evaluate $\int_{0.1}^{0.8}\sqrt{x^2+4x+3}\,dx$

3. Following an illness, a patient is required to take pills containing minerals and vitamins. The contents and costs of two types of pills, Feelgood and Getbetta, together with the patient's daily requirement, are shown in the following table:

	Mineral	**Vitamin**	**Cost**
Feelgood	80 mg	4 mg	3,000/=
Getbetta	20 mg	3 mg	1,500/=
Daily requirement	430 mg	31 mg	

   If the daily prescription contains x Feelgood pills and y Getbetta pills, find the cheapest way of prescribing the pills and the cost.

4. (a) The following table shows distribution of marks in a matriculation examination of communication skills:

Marks	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 - 100
Frequency	8	12	18	25	40	28	31	30	8

   i) Given that the assumed mean is 75.5, use the coding method to find the average marks
   ii) Determine the lower quartile of the distribution
   iii) Calculate the 75^{th} percentile correct to four significant figures

5. (a) Use the laws of algebra to simplify:
   i) $[A\cap(B\cap C')]\cup C$
   ii) $(X\cap Y')\cup(X\cap Y)\cup(Y\cap X')$

   (b) Out of a group of 17 girl guides and 15 boy scouts, 22 play handball, 16 play basketball, 12 of the boy scouts play handball, 11 of the boy scouts play basketball, 10 of the boy scouts play both and 3 of the girls play neither of the two.
   i) How many girls play both handball and basketball?
   ii) How many in the group play handball only and basketball only?

6. (a) Draw the graph of $f(x) = x^3 - 3x^2 - 6x + 8$ in the interval $[-5, 6]$. Hence tell how $f(x)$ behaves for positively and negatively large values of x.
   (b) Find $f\circ g(x)$ given that $f(x) = 2x^2+1$ and $g(x) = \frac{4x}{x^2-2}$, hence
   i) Determine the vertical and horizontal asymptotes of $f\circ g(x)$

ii) Draw the graph of $f \circ g(x)$

iii) State the domain and range of $f \circ g(x)$

7. (a) Show that the Newton Raphson Formulat of finding the roots of the equation $12x^3+4x^2-15x-4=0$ is $x_{n+1} = \frac{(24x_n+4)x_n^2+4}{(36x_n+8)x_n-15}$ and use this formula to find the roots of $12x^3+4x^2-15x-4=0$ correct to the three decimal places.

   (b) Approximate the area under the curve $y = \frac{1}{x-2}$ between $x = 2$ and $x = 3$ with six ordinates by:

   i) Trapezoidal rule

   ii) Simpson rule

8. (a) Find the value of k such that $k(x^2 + y^2) + (y - 2x + 1)(y + 2x + 3) = 0$ is a circle. Hence obtain the center and radius of the resulting circle.

   (b) The circle $x^2 + y^2 - 2x - 4y - 5 = 0$ has a center C and is cut by the line $y = 2x + 5$ at A and B. Show that BC is perpendicular to AC and hence find the area of triangle ABC.

   (c) Find the equation of the straight line which passes through the intersection of the lines $3x + 2y + 4 = 0$ and $x - y = 2$ and forms the triangle with the axes whose area is 8 square units.

9. (a) Evaluate $I_{ab} = \int \sin ax \cos bx \; dx$ if $a \neq b$ and use it to find the value of n in $\int_0^n \sin 3x \cos 2x \; dx = \frac{3-\sqrt{3}}{5}$

   (b) Find the length of arc of the semi-cubical parabola $y^2 = x^3$ between the points (1,1) and (4,8).

10. (a) If $x\sqrt{1+y} + y\sqrt{1+x} = 0$, prove that $\frac{dy}{dx} = -\frac{1}{(1+x)^2}$

    (b) Given that $f = \sin xy$, find $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$

    (c) Using Taylor?s theorem, expand $\sin\left(\frac{\pi}{6} + h\right)$ in ascending power of h up to the h^4 term and hence evaluate $\sin 31^\circ$ correct to three decimal places.

Applied Mathematics (AM) 2017 - Day #2

SECTION A

1. (a) Use the Demoivre's theorem to find the value of $\left(\frac{1}{2}+\frac{1}{2}i\right)^{10}$

   (b) Show that $[r(\cos\theta+i\sin\theta)]^n = r^n e^{in\theta}$ and hence find in form of $re^{i\theta}$ all complex numbers z, such that $z^3 = \frac{5+i}{2+3i}$

   (c) i) Solve the equation $x^4+1=0$ and leave the roots in radical form.

   ii) If $w = \frac{z+2}{2}$ and $|z| = 4$, find the locus of the w

2. (a) i) Write the contrapositive of the inverse of $p \to q$

   ii) Use the truth table to verify that the statement is a contradiction

   (b) i) Use the laws of algebra of propositions to simplify the statement and hence draw the corresponding simple electrical network

   ii) Use the truth table to show that $p \leftrightarrow q$ logically implies $p \to q$

   (c) Without using the truth tables, prove that the proposition is tautology

3. (a) i) If $a = 3i-5j-2k$ and $b = 7i+j-2k$ are non-zero vectors. Find the projection of a onto b.

   ii) Use vectors to prove the sine rule

   (b) If θ is the angle between two-unit vectors a and b show that $\frac{1}{2}|a+b| = \cos\left(\frac{\theta}{2}\right)$

   (c) i) If $G(t) = e^t i + \cos tj + tk$, find $\frac{d}{dt}[(\sin t)G(t)]$

   ii) Integrate the vector $e^t i + 2tj + \ln tk$ with respect to t

   (d) Two vectors a and b have the same magnitude and an angle between them is $60°$. If their scalar product is $\frac{1}{2}$, find their magnitude.

4. (a) i) Solve the equation $\log_3 x - 3 + \log_x 9 = 0$

   ii) The equations $x^2+9x+2=0$ and $x^2+kx+5=0$ have common root. Find the quadratic equation giving two actual possible values of k

   (b) Find the sum of the series $\frac{5}{1\times2\times3}+\frac{8}{2\times3\times4}+\frac{11}{3\times4\times5}+\cdots+\frac{3n+2}{n(n+1)(n+2)}$, hence find $\sum_{r=1}^{\infty}\frac{3r+2}{r(r+1)(r+2)}$

   (c) If $A = \begin{pmatrix}2 & 1 & 0\\ 1 & 5 & 2\\ 1 & -1 & 1\end{pmatrix}$ and $B = \begin{pmatrix}-1 & 2 & 0\\ 1 & 3 & 2\\ 2 & 0 & 1\end{pmatrix}$, find the value of $A^{-1}B$

SECTION B

5. (a) i) Use trigonometric identities to prove that $16\sin^5\theta - 21\sin^3\theta + 5\sin\theta = \sin 5\theta$

   ii) If $x\sec\theta + y\tan\theta = 3$ and $x\tan\theta + y\sec\theta = 2$, eliminate θ from the equations

   (b) i) If $\tan\theta = \frac{4}{3}$ and $0° \le \theta \le 360°$, find without using tables the value of $\tan\left(\frac{1}{2}\theta\right)$

   ii) Show that $\frac{\cos 3x - \cos 5x}{4\sin 2x\cos 2x} = \sin x$

   (c) Given that $\tan^{-1}A + \tan^{-1}B + \tan^{-1}C = \pi$, verify that $A+B+C = ABC$

   (d) Express the sum of $\sec x$ and $\tan x$ as the tangent of $\left(\frac{\pi}{4}+\frac{x}{2}\right)$ and hence find in surd form the value of $\tan\frac{\pi}{12}$

6. (a) Define the following terms and write one example for each term:

   i) Continuous random variable

   ii) Discrete random variable

   iii) Probability density function

   (b) i) A group of students consist of 4 girls and 7 boys. In how many ways can a team of 5 members be selected if the team has at least a boy and a girl?

   ii) If $P(A) = \frac{1}{4}$, $P(A/B) = \frac{1}{2}$, and $P(B/A) = \frac{2}{3}$. Verify whether A and B are independent events or are mutually exclusive events.

   (c) Rehema and Seni play a game in which Rehema should win 8 games for every 7 games won by Seni. Prove that if they play three games, the probability that Rehema wins at least two games is approximately to 0.55.

(d) In a family, the boy tells a lie in 30 percent cases and the girl in 35 percent cases. Find the probability that both contradict each other on the same fact.

7. (a) i) Solve the differential equation $\frac{r\tan\theta}{a^2-r^2}\frac{dr}{d\theta}=1$ given that $r=0$ when $\theta=\frac{\pi}{4}$

ii) Verify that $y=10\sin 3x+9\cos 3x$ is a solution of the differential equation $\frac{d^2y}{dx^2}+9y=0$ if $y=0$, $\frac{dy}{dx}=0$ when $x=0$

(b) The population of a certain country doubles in 15 years. In how many years will it be six times under the assumption that the rate of increase is proportional to the number of inhabitants?

(c) Find the particular solution of the differential equation $\frac{d^2y}{dx^2}+3\frac{dy}{dx}+2y=\cos x$

(d) Form a differential equation whose general solution is $y=Ae^{mx}+Be^{-mx}$ where A, B, and m are constants.

8. (a) i) The ellipse has its foci at the points (-1,0) and (7,0) when its eccentricity is $\frac{1}{2}$. Find its Cartesian equation.

ii) Convert $y^2=4a(a-x)$ into polar equation

iii) Use the equation $y=2x^2-6x+4$ to determine its directrix and the focus.

(b) A cable used to support a swinging bridge approximates the shape of a parabola. Determine the equation of a parabola if the length of the bridge is 100 m and the vertical distance from where the cable is attached to the bridge to the lowest point of the cable is 20 m.

(c) i) Define the term hyperbola

ii) Show that the latus rectum of the equation $\frac{(x-h)^2}{a^2}-\frac{(y-k)^2}{b^2}=1$ is $\frac{2b^2}{a}$

(d) Sketch the graph of $r=2+4\cos t$

Physics 2017 - Day #1

SECTION A

1. (a) Give the meaning of the following terms as used in error analysis:
   i) Absolute error
   ii) Relative error

   (b) The force F acting on an object of mass m, traveling at velocity V in a circle of radius r is given by: $F = \frac{mV^2}{r}$. If the measurements are recorded as $m = (3.5 \pm 0.1)$ kg, $V = (20 \pm 1)$ m/s, $r = (12.5 \pm 0.5)$ m; find the maximum possible:
   i) Fractional error
   ii) Percentage error in the measurement of force

   (c) Show how you will record the reading of force F in part (b)

2. (a) i) Define the term dimensions of a physical quantity
   ii) Identify two uses of dimensional equations

   (b) i) What is the basic requirement for a physical relation to be correct?
   ii) List two quantities whose dimension is $[ML^2T^{-1}]$

   (c) i) The frequency f of vibration of a stretched string depends on the tension F, the length l and the mass per unit length μ of the string. Derive the formula relating the physical quantities by the method of dimensions.
   ii) Use dimensional analysis to prove the correctness of the relation, $\rho = \frac{3g}{4\pi RG}$ where by $\rho =$ density of the earth, $g =$ acceleration due to gravity, $R =$ radius of the earth and $G =$ gravitational constant.

3. (a) i) Why does the kinetic energy of an earth satellite change in the elliptical orbit?
   ii) Give two factors which determine whether a planet has an atmosphere or not

   (b) A spacecraft is launched from the earth to the moon. If the mass of the earth is 81 times that of the moon and the distance from the center of the earth to that of the moon is about 4.0 $\times 10^5$ km:
   i) Draw a sketch showing how the gravitational force on the spacecraft varies during its journey
   ii) Calculate the distance from the center of the earth where the resultant gravitational force becomes zero.

4. (a) i) Justify the statement that 'If no external torque acts on a body, its angular velocity will not be conserved'
   ii) A car is moving with a speed of 30 ms^{-1} on a circular track of radius 500 m. If its speed is increasing at the rate of 2 ms^{-2}, find its resultant linear acceleration

   (b) An object of mass 1 kg is attached to the lower end of a string 1 m long whose upper end is fixed and made to rotate in a horizontal circle of radius 0.6 m. If the circular speed of the mass is constant, find the:
   i) Tension in the string
   ii) Period of motion

5. (a) A 75 kg hunter fires a bullet of mass 10 g with a velocity of 400 ms^{-1} from a gun of mass 5 kg. Calculate the:
   i) Recoil velocity of the gun
   ii) Velocity acquired by the hunter during firing

   (b) A jumbo jet traveling horizontally at 50 ms^{-1} at a height of 500 m from sea level drops a luggage of food to a disaster area.
   i) At what horizontal distance from the target should the luggage be dropped?

ii) Find the velocity of the luggage as it hit the ground

6. (a) The equation of simple harmonic motion is given as $x = 6\sin 10\pi t + 8\cos 10\pi t$ where x is in centimeter and t in second. Determine the:
   i) Amplitude
   ii) Initial phase of motion

   (b) i) Show that the total energy of a body executing simple harmonic motion is independent of time
   ii) Find the periodic time of a cubical body of side 0.2 m and mass 0.004 kg floating in water then pressed and released such that it oscillates vertically.

SECTION B

7. (a) i) Give a common example of adiabatic process
   ii) What happens to the internal energy of a gas during adiabatic expansion?

   (b) A mass of an ideal gas of volume 400 cm^3 at 288 K expands adiabatically. If its temperature falls to 273 K:
   i) Find the new volume of the gas
   ii) Calculate the final volume of the gas if it is then compressed isothermally until the pressure returns to its original value

8. (a) State the following according to heat exchange:
   i) Prevost's theory
   ii) Wien's displacement law

   (b) Briefly explain why:
   i) Steam pipes are wrapped with insulating materials?
   ii) Stainless steel cooking pans fitted with extra copper at the bottom are more preferred?

   (c) The value of the property X of a certain substance is given by:
   $X_\theta = X_0 + 0.5\theta + 2 \times 10^{-4}\theta^2$, where θ is the temperature in degrees Celsius. What would be the Celsius temperature defined by the property X which corresponds to a temperature of 50 °C on the gas thermometer scale?

9. (a) i) What is the advantage of using a greater length of potentiometer wire?
   ii) Why is Wheatstone bridge not suitable for measuring very high resistance?

   (b) Study the circuit diagram in Figure 1 then answer the questions that follow:

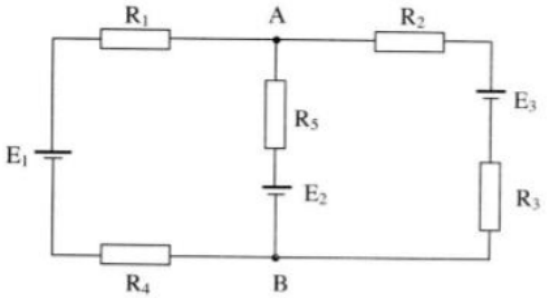


Figure 1

If the value of $R_1 = R_2 = R_3 = R_4 = 1.0\Omega$, $R_5 = 2\Omega$, $E_2 = E_3 = 4V$, $E_1 = 2.0V$, calculate the:
   i) Current flowing through the circuit
   ii) Potential difference V_{ab}

10. (a) i) List two factors on which the resistivity of a material depends
   ii) A wire of resistivity, ρ, is stretched to double its length. What will be its new resistivity? Give reason for your answer

(b) i) Why a high supply should have high internal resistance?
ii) Justify the statement that 'it is not possible to verify Ohm's law by using a filament lamp'

(c) A potential difference of 4V is connected to a uniform resistance wire of length 3.0 m and cross-sectional area 9×10^{-9}, when a current of 0.2 A is flowing in the wire. Find the:
i) Resistivity of a wire
ii) Conductivity of a wire

SECTION C

11. (a) Briefly explain the function of the following:
i) Oscilloscope
ii) Op-amps

(b) Study Figure 2 then construct a truth table showing the output P, Q, and R.

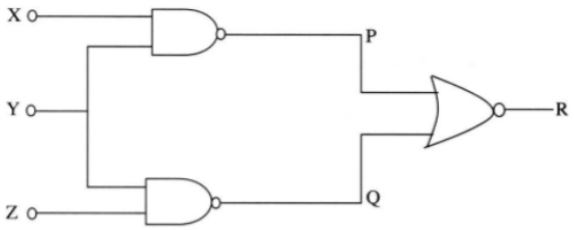


Figure 2

(c) i) List three basic elements of communication system
ii) Explain the advantage of using optical fiber systems than coaxial cable system in telecommunication processes

12. (a) i) Define the term semiconductor
ii) Give three examples of semiconductor materials

(b) i) Outline two factors on which electrical conductivity of a pure semiconductor depends
ii) How does the forbidden energy gap of an intrinsic semiconductor vary with increase in temperature?

(c) Figure 3 is a circuit diagram containing an ideal diode

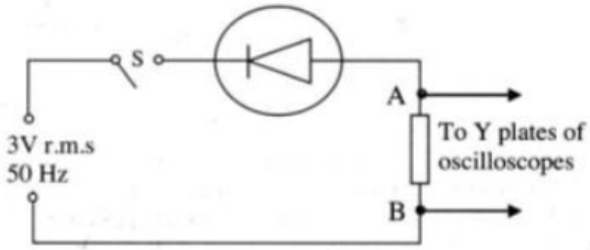


Figure 3

Calculate:
i) The peak voltage
ii) The period

13. (a) Explain the meaning of the following terms:
i) P-type semiconductor
ii) N-type semiconductor

(b) i) List three types of transistor configuration
ii) Why is collector of a transistor made wider than emitter and base?

(c) A change of 100μA in the base current produces a change of 3mA in the collector current. Calculate:

i) The current amplification factor, β

ii) The current gain, α

14. (a) i) State three sources of heat energy within the interior of the earth

ii) Discuss two advantages of windbreaks to plant environment

(b) Briefly explain the major causes of the following types of environmental pollution:

i) Water pollution

ii) Air pollution

Physics 2017 - Day #2

SECTION A

1. (a) i) State Bernoulli's theorem for the horizontal flow
   ii) On which principle does the Bernoulli's theorem based
   iii) A pipe is running full of water. At a certain point A, it tapers from 30 cm diameter to 10 cm diameter at B, the pressure difference between point A and B is 100 cm of water column. Find the rate of flow of water through the pipe.

   (b) i) What is the terminal velocity?
   ii) Derive an expression for the terminal velocity of a spherical body falling from rest through a viscous fluid

   (c) Two capillaries of the same length and radii in the ratio of 1:2 are connected in series and the liquid flow through the system under stream line conditions. If the pressure across the two extreme ends of the combination is 1 m of water, what is the pressure difference across the first capillary?

2. (a) A cyclist and a railway train are approaching each other with a speed of 10 ms^{-1} and 20 ms^{-1} respectively. If the engine driver sounds a warning siren at a frequency of 480 Hz, calculate the frequency of the note heard by the cyclist:
   i) Before the train has passed
   ii) After the train has passed

   (b) i) The equation $y = a\sin(\omega t - kx)$ represents a plane wave traveling in a medium along the x-direction, y being the displacement at the point x at time t. Deduce whether the wave is traveling in the positive x-direction or in the negative x-direction.
   ii) If $a = 1.1 \times 10^{-7}$ m, $\omega = 6.5 \times 10^{3}$ s^{-1}, $k = 19$ m^{-1}; determine the speed of the wave.

   (c) i) Briefly explain why diffraction is common in sound by not in light
   ii) A 40 cm long wire is in unison with a tuning fork of frequency 256 Hz, when stretched by a load of density 9 gm^{-3} hanging vertically. The load is then immersed in water. By how much the length of wire should be reduced to bring it again in unison with the same tuning fork.

3. (a) i) In a Young's double-slit experiment a total of 23 bright fringes occupying a total distance of 3.9 mm were visible in traveling microscope, which was focused on a plane being at a distance of 31 cm from the double slit. If the wavelength of light being used was 5.5×10^{-7} m; determine the separation of the double slit.

   (b) When grating with 300 lines per millimeters in illuminated normally with parallel beam of monochromatic light a second order principal maximum is observed at 18.9° to the straight through direction. Find the wavelength of the light.

   (c) A white light fall on a slit of width a; for what value of a will the first minimum of light falling at the angle of 30° when the wavelength of light is 6,500 nm?

SECTION B

4. (a) A steel rod of length 0.60 m and cross-sectional area 2.5×10^{-5} m^2 at a temperature of 100°C is clamped so that when it cools was unable to contract. Find the tension in the rod when it has cooled to 20°C

   (b) A spring 60 cm long is stretched by 2 cm for the application of load of 200 g. What will be the length when a load of 500 g is applied?

   (c) Calculate the percentage increase in length of a wire of diameter 2.2 mm stretched by a load of 100 kg. (Young's modulus of wire is 12.5×10^{10} Nm^{-2})

5. (a) i) Define the terms capacitance and electric potential
   ii) The capacitance C of a capacitor is full charged by a 200 V battery. It is then discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity 2.5×10^{2} $J{\cdot}kg^{-1}K^{-1}$ and of mass 0.1 kg. If the temperature of the block rises by 0.4 K, what is the value of C?

(b) A parallel plate capacitor has plates each of are 0.24 m^2 separated by a small distance 0.50 mm. If the capacitor is full charged by a battery of electromotive force of 24 V, calculate:

i) The capacitance of the capacitor

ii) The energy stored in the capacitor

(c) i) Comment on the assertion that, the safest way of protecting yourself from lightning is to be inside a car.

ii) Find the total potential energy of the system of point charges shown in Figure 1.

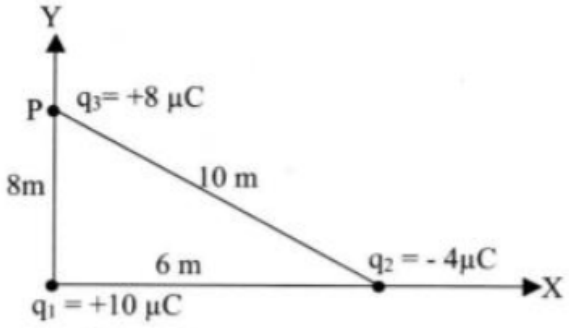


Figure 1

6. (a) i) Define tensile stress and tensile strain

ii) Calculate the work done in a stretching copper wire of 100 cm long and 0.03 cm^2 cross-sectional area when a load of 120 N is applied

(b) i) Mention any two factors on which modulus of elasticity of a material depends?

ii) A 45 kg traffic light is suspended with two steel wires of equal lengths and radii of 0.5 cm. If the wires make an angle of 15° with the horizontal, what is the fractional increase in their length due to the weight of the light?

(c) i) Define free surface energy in relation to the liquid surface

ii) Explain what will happen if two bubbles of unequal radii are joined by a tube bursting

iii) A spherical drop of mercury of radius 5 mm falls on the ground and breaks into 1,000 droplets. Calculate the work done in breaking the drop.

SECTION C

7. (a) What is meant by the following?

i) Atomic mass unit (a.m.u.)

ii) Binding energy

iii) Mass defect

(b) Calculate the binding energy per nucleon for phosphorus ${}^{31}_{15}P$ given that ${}^{31}_{15}P = 30.97376$ a.m.u. and ${}^{1}_{1}H = 1.00782$ a.m.u.

(c) It is observed that thorium nucleus ${}^{226}_{90}Th$ originally at rest decays to form a radium nucleus ${}^{222}_{88}Ra$, α-particle and γ-rays.

i) Write down the equation for the disintegration

ii) Determine the energy of the γ-ray, if the α-particle is emitted with energy of 2.38 MeV. Given that rest mass of ${}^{226}_{90}Th = 226.0249$ a.m.u., ${}^{222}_{88}Ra = 222.0154$ a.m.u. and α-particle = 4.0026 a.m.u.

(d) When a nucleus of deuterium (hydrogen-2) fuses with a nucleus of tritium (hydrogen-3) to helium nucleus and a neutron, 2.88×10^{-12} J of energy is released. The equation for the reaction is represented as ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$. Calculate the mass of helium nucleus produced.

8. (a) State the law of force acting on a conductor of length l, carrying an electric current in a magnetic field.

(b) i) Draw the diagram of the solenoid with certain number of turns placed in the magnetic field and indicate any suitable directions of the flow of current in it

ii) Write down the formula for the magnetic field induced at the center of solenoid

(c) It is desired to design a solenoid that produces a magnetic field of 0.1 T at the center. If the radius of solenoid is 5 cm, its length is 50 cm and carries a current of 10 A. Calculate:

i) The number of turns per unit length of the solenoid

ii) The total length of a wire required

(d) i) State the Biot-Savart law

ii) In a hydrogen atom, an electron keeps moving around its nucleus with a constant speed of 2.18×10^6 m·s^{-1}. Assuming that the orbit is a circular of radius 5.3×10^{-11} m, determine the magnetic flux density produced at the site of the proton in the nucleus.

9. (a) Use the Rydberg constant, $R_H = 1.0974 \times 10^7$ m^{-1} to calculate the shortest wavelength of the Balmer series

(b) Use the Bohr's theory for hydrogen atom to determine the:

i) Radius of the first orbit of the hydrogen atom in $\dot{A}$ units

ii) Velocity of the electron in the first orbit

(c) i) What is ionization potential of an atom?

ii) Show that the ionization potential of hydrogen is 13.6 eV

iii) How can you account for the chemical behavior of atoms on the basis of the atomic electrons and shells?