THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

731/1 **PHYSICS 1**

Time: 3 Hours **ANSWERS** **Year: 2014**

Instructions

1. This paper consists of section A, B and C.
2. Answer all questions in section A, and two questions from each section B and C.

1. The pressure P was calculated from the relation $P = F/A$, where F is the force and A is the radius. If the percentage errors are 2% for F and 1% for R, calculate the percentage error for P.

Since A is the radius, the area A is proportional to the square of the radius. The percentage error in A is twice the percentage error in R.

Percentage error in A = 2 × 1% = 2%

The formula for percentage error in P is given by:

Percentage error in P = percentage error in F + percentage error in A
Percentage error in P = 2% + 2% = 4%

2. (a) Explain how the velocity of a body changes with displacement from mean position during S.H.M.

In simple harmonic motion, velocity is maximum at the mean position and decreases as the displacement increases toward the extreme position. At the mean position, all the energy is kinetic, and the restoring force is zero, allowing the body to move with maximum speed. As the body moves away from the mean position, the restoring force acts in the opposite direction, causing the velocity to decrease. At the extreme displacement, the velocity becomes zero as the body momentarily stops before reversing direction. The velocity is given by the equation:

$$v = \omega\sqrt{(A^2 - x^2)}$$

where ω is the angular frequency, A is the amplitude, and x is the displacement from the mean position.

(b) The period of oscillation of a body executing S.H.M. is 1.4 s. With what speed does the body pass through the halfway between the mean position and the position of maximum displacement if the amplitude of the motion is 1 cm?

The speed at any displacement in SHM is given by:

$$v = \omega\sqrt{(A^2 - x^2)}$$

The angular frequency is found from the relation:

$$\omega = 2\pi/T = 2\pi/1.4 = 4.49 \text{ rad/s}$$

At halfway displacement, $x = A/2 = 1 \text{ cm} / 2 = 0.5 \text{ cm}$

Substituting the values:

$$v = 4.49 \times \sqrt{(1^2 - 0.5^2)}$$

$v = 4.49 \times \sqrt{(1 - 0.25)}$
$v = 4.49 \times \sqrt{0.75}$
$v = 3.89$ cm/s

3. State Newton's laws of motion and from each law write one of its applications in real life.

Newton's first law states that a body at rest stays at rest, and a body in motion stays in motion with uniform velocity unless acted upon by an external force. This explains why passengers in a moving vehicle lurch forward when the brakes are suddenly applied, as their bodies tend to remain in motion.

Newton's second law states that the force acting on an object is equal to the rate of change of its momentum. This is applied in designing vehicle airbags, which reduce the impact force by increasing the time taken for a person to stop during a collision.

Newton's third law states that for every action, there is an equal and opposite reaction. This principle is used in rocket propulsion, where the ejection of gases downward produces an upward thrust that propels the rocket.

4. Explain the effect of the following actions to the surface tension of a liquid.

(a) Rise in temperature of the liquid

An increase in temperature decreases surface tension because the kinetic energy of the molecules increases, reducing intermolecular forces and making the surface molecules less tightly held.

(b) Addition of very soluble substances to the liquid

Highly soluble substances, such as salts, increase surface tension by strengthening intermolecular forces in the liquid due to ion-dipole interactions.

(c) Electrolyzing the liquid

Electrolyzing a liquid can either increase or decrease surface tension depending on the nature of the ions produced. If the ions disrupt intermolecular forces, surface tension decreases. If the ions enhance molecular attraction, surface tension increases.

5. (a) An oscillation of progressive wave in a stretched string is given by the formula $y = 5 \sin(2\pi t/0.04 - x/0.5)$ cm. By using this equation perform the following.

(i) Write the equation of an identical wave traveling in the opposite direction.

For a wave moving in the opposite direction, the sign before x should be reversed:

$y = 5 \sin(2\pi t/0.04 + x/0.5)$

(ii) Deduce the frequency and velocity of the wave.

The general wave equation is $y = A \sin(\omega t - kx)$. Comparing with the given equation,

$\omega = 2\pi/0.04$
$\omega = 50\pi$ rad/s

Since $\omega = 2\pi f$,

$f = 50\pi / 2\pi = 25$ Hz

The wave number is $k = 1/0.5 = 2$ rad/cm. The wave velocity is given by:

$v = f\lambda = 25 \times (2\pi/k)$
$v = 25 \times (2\pi/2)$
$v = 25\pi$ cm/s

6. (a) A parallel beam of X-ray with a wavelength of 1.54 Å strikes a glancing angle of 31° on a second-order diffraction is observed at this angle. Find the spacing between atomic planes of the crystals of the rock salt crystal.

Using Bragg's law:

$n\lambda = 2d \sin\theta$

Substituting the values:

$2 \times 1.54 \times 10^{-10} = 2d \sin 31°$

$d = (3.08 \times 10^{-10}) / (2 \sin 31°)$

$d = (3.08 \times 10^{-10}) / (1.026)$

$d = 3.00 \times 10^{-10}$ m

(b) Write down three electrical safety rules and regulations to be followed when one is in the Physics laboratory.

One should never touch electrical equipment with wet hands to avoid electric shocks.

Electrical circuits should not be overloaded with excessive appliances to prevent overheating and fire hazards.

Fuses and circuit breakers should be used to protect electrical devices from overcurrent and short circuits.

7. (a) Mention three limitations of multiple-choice questions/items.

They encourage guessing, as students can select answers without knowing the correct solution.

They may not effectively test deep understanding since they focus on recognition rather than explanation.

They can be challenging to design, as incorrect options must be plausible but not misleading.

(b) Briefly explain how Physics is related to Chemistry and Mathematics.

Physics is related to Chemistry through concepts like thermodynamics, atomic structure, and quantum mechanics, which explain chemical reactions and bonding.

Physics is related to Mathematics because mathematical equations and formulas are used to describe physical laws and solve physics problems quantitatively.

8. List three functions of lesson notes in teaching Physics.

Lesson notes provide a structured guide for teachers, ensuring that all key topics are covered systematically.

They serve as reference material for students, helping them review concepts after lessons.

They assist in lesson planning and continuity, allowing teachers to track progress and adjust teaching strategies accordingly.

9. (a) What is meant by dimensions of physical quantities?

Dimensions of physical quantities refer to the fundamental units that express a physical quantity in terms of basic quantities such as mass (M), length (L), and time (T). These dimensions help in verifying equations and converting units.

(b) Using dimensional analysis, determine whether the following equations are dimensionally correct or not.

(i) A = vT

The dimensional formula for A (displacement) is [L]. The dimensional formula for velocity v is $[LT^{-1}]$, and the dimensional formula for time T is [T].

Multiplying dimensions: $[LT^{-1}] \times [T] = [L]$

Since both sides have the same dimensions, the equation is dimensionally correct.

(ii) F = mv/t

The dimensional formula for force F is $[MLT^{-2}]$. The dimensional formula for mass m is [M], velocity v is $[LT^{-1}]$, and time t is [T].

The right-hand side: $[M] \times [LT^{-1}] / [T] = [MLT^{-2}]$

Since both sides have the same dimensions, the equation is dimensionally correct.

(iii) P = F/A

The dimensional formula for pressure P is $[ML^{-1}T^{-2}]$. The dimensional formula for force F is $[MLT^{-2}]$, and the dimensional formula for area A is $[L^2]$.

Dividing: $[MLT^{-2}] / [L^2] = [ML^{-1}T^{-2}]$

Since both sides have the same dimensions, the equation is dimensionally correct.

(iv) $h = (1/2)\, g\, t^2$

The dimensional formula for height h is [L]. The dimensional formula for acceleration due to gravity g is $[LT^{-2}]$, and the dimensional formula for time t is [T].

Multiplying: $[LT^{-2}] \times [T^2] = [L]$

Since both sides have the same dimensions, the equation is dimensionally correct.

(c) Where P and h are lengths and $[F] = MLT^{-2}$. The other symbols have their usual meanings.

The statement confirms that the given equations involve physical quantities with their respective dimensions, ensuring consistency in unit conversions.

(d) The speed (V) of the ocean wave is given by $V = k\, g^{1/2} z^{3/2}$ where k is a constant, g is the acceleration due to gravity, z is the wavelength, and p is the density. Derive their relationship using the method of dimension.

The dimensional formula for velocity V is $[LT^{-1}]$. The dimensional formula for acceleration due to gravity g is $[LT^{-2}]$, and the dimensional formula for wavelength z is $[L]$.

Assume k is dimensionless. The equation can be written as:

$[L\ T^{-1}] = [L\ T^{-2}]^{(1/2)} \times [L]^{(3/2)}$

Expanding the powers:

$[L\ T^{-1}] = [L^{1/2}\ T^{-1}] \times [L^{3/2}]$

Multiplying dimensions:

$[L^{(1/2 + 3/2)}\ T^{-1}] = [L^2\ T^{-1}]$

Since the dimensions of velocity should be $[LT^{-1}]$, the equation is dimensionally incorrect unless k has units to balance the discrepancy.

10. (a) Define the following.

(i) Surface tension of a liquid

Surface tension is the force per unit length acting at the surface of a liquid, which causes it to behave like a stretched elastic sheet due to cohesive forces between molecules.

(ii) Free surface energy

Free surface energy is the work required to increase the surface area of a liquid by a unit amount, indicating the strength of molecular attraction at the surface.

(b) Describe how surface tension can be determined when a capillary tube is held vertically in the surface tension of water with the end of a clean glass capillary tube, having an internal diameter of 6×10^{-4} m, is dipped into a beaker containing water which rises up the tube a vertical height of 0.05 m above the water surface in the beaker.

When a clean capillary tube is dipped into water, the liquid rises due to adhesion between water molecules and the tube. The height h of the liquid column is related to surface tension γ by the equation:

$\gamma = (h\rho g\ r) / 2$

where ρ is the density of water, g is gravitational acceleration, and r is the tube's radius (half of the diameter). Substituting the given values allows the calculation of surface tension.

(c) A 120V motor for a power saw is known to have an internal resistance of 1.5 Ω while operating, it draws 12 A. What is the back emf it generates?
The back EMF (E) of a motor can be calculated using the formula:

$E = V - IR$

where:
V = Supply voltage = 120 V
I = Current drawn = 12 A
R = Internal resistance = 1.5 Ω

Substituting the values:

$E = 120 - (12 \times 1.5)$
$E = 120 - 18$
$E = 102$ V

The back EMF generated by the motor is 102 V.

14. (a) The mode of action of a fluorescent tube involves the excitation of mercury vapour within the tube by an electric current. When the current flows through the tube, it excites mercury atoms, causing them to emit ultraviolet (UV) light. This UV light then strikes the phosphor coating on the inside of the tube, causing the phosphor to emit visible light. The efficiency of a fluorescent light depends on the phosphor used and the amount of mercury vapour inside the tube.

(b) (i) In an inverting amplifier configuration using an operational amplifier (op-amp), the input signal is applied to the inverting input of the op-amp through a resistor. The non-inverting input is typically grounded. The feedback resistor is connected from the output to the inverting input, and the input resistor connects the signal to the inverting input. The output signal is inverted relative to the input, and its amplitude is determined by the ratio of the feedback resistor to the input resistor.

(b) (ii) In a non-inverting amplifier configuration, the input signal is applied to the non-inverting input of the op-amp. The inverting input is connected to the output via the feedback resistor. The input resistor connects the inverting input to ground. The output signal is not inverted, and its amplitude is determined by the ratio of the feedback resistor to the input resistor, but it does not invert the phase of the input signal.

(c) The amplification in both cases can be calculated as follows:
(i) For the inverting amplifier, the voltage gain is given by the formula:
Gain = -Rf / Ri
where Rf is the feedback resistor and Ri is the input resistor.
(ii) For the non-inverting amplifier, the voltage gain is given by the formula:
Gain = 1 + (Rf / Ri)
where Rf is the feedback resistor and Ri is the input resistor.

15. For a 40-minute lesson plan on "Propagation and Transmission of Light" to Form Three students, the lesson can be divided into four main segments:

Time	Activity	Description
0-5 minutes	Introduction	Briefly introduce the topic, define key concepts like light propagation, transmission, and speed of light.
5-15 minutes	Explanation	Explain how light travels through different mediums (solid, liquid, gas) and how the speed changes depending on the medium. Use diagrams to demonstrate light refraction and reflection.
15-30 minutes	Demonstration	Perform simple experiments showing light transmission through various materials (e.g., glass, water). Show examples of refracted and reflected light.
30-40 minutes	Discussion and Conclusion	Summarize the key points. Discuss real-life examples where understanding light propagation and transmission is important (e.g., fibre optics, microscopes). End with a question-and-answer session.

16. (a) The importance of keeping records of students' examination results includes:
- Tracking individual progress over time.
- Identifying areas where students may need additional help.
- Ensuring transparency and accountability in grading.
- Assisting in academic planning and decision-making.
- Providing data for assessments and evaluations of teaching effectiveness.

(b) Various means of keeping students' achievements records include:
- Physical record books where teachers manually enter grades.
- Digital spreadsheets or databases where grades are logged and analyzed.
- Online learning management systems (LMS) where results are uploaded and tracked.
- Report cards sent home to parents.
- E-portfolios where students track their own progress.

17. (a) Pressure on the surface of contact depends on the force applied and the area over which it is distributed. The pressure is inversely proportional to the surface area for a given force. This means that for the same force, a smaller surface area will result in a higher pressure, and a larger surface area will result in lower pressure. This relationship is given by the formula:

Pressure = Force / Area

(b) The variation of pressure with depth in a liquid increases as the depth increases. This is because the weight of the liquid above a given point adds to the pressure at that point. The pressure at a depth in a liquid is directly proportional to the density of the liquid and the depth of the liquid, as described by the equation:

Pressure = ρgh
where ρ is the density of the liquid, g is the acceleration due to gravity, and h is the depth.

18. (a) The purposes of a classroom test in Physics include:
- Assessing students' understanding of the material taught.
- Providing feedback to students about their performance and areas of improvement.
- Offering a way for teachers to evaluate the effectiveness of their teaching methods.
- Motivating students to study and engage with the material more deeply.
- Establishing a basis for grading and awarding academic credits.

(b) The characteristics of effective assessment include:
- Validity: The test measures what it is intended to measure.
- Reliability: The test consistently produces the same results under similar conditions.
- Fairness: The assessment is free from bias and gives all students an equal opportunity to perform well.
- Relevance: The assessment reflects the material taught and the skills expected to be developed.
- Clarity: The instructions and questions are clear and understandable to all students.