THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

731/1 **PHYSICS 1**

Time: 3 Hours **ANSWERS** **Year: 2010**

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. (a) Define the term dimensional analysis.
(b) Mention three applications of dimensional analysis.

2. The following two waves in a medium are superposed:
$y_1 = A \sin(5x - 10t)$, $y_2 = A \sin(4x - 9t)$, where x is in meters and t in seconds. Write an equation for the combined disturbance.

3. (a) What is meant by the term semiconductor?
(b) Give two differences between a pure metal and a pure semiconductor.

4. An aluminum wire found in TANESCO network has a cross-sectional area of 100 mm^2. If there are 2×10^{18} electrons per m^3 and a current of 13A is flowing through the wire, what is the drift velocity of the electrons?

5. (a) Define the following terms:
(i) Natural frequency
(ii) Forcing frequency
(b) Calculate the angular position of the second-order maximum created by monochromatic light of wavelength 700 nm, which passes through a diffraction grating of spacing 3.5 cm.

6. (a) What is the source of heat in the interior of the earth?
(b) Explain how the thermal energy is lost or transmitted in different layers of the earth.

7. Mention four uses of a cathode ray oscilloscope (CRO).

8. What is meant by the following terms?
(a) Resistance
(b) Conductivity
(c) Current density

9. What is geophysics?

10. (a) Give short notes on two of the following parts of the lithosphere:
(i) Crust
(ii) Mantle
(iii) Core

I will now proceed to provide answers in the required format.

1. (a) Dimensional analysis is the method of analyzing physical equations by studying the dimensions of the physical quantities involved. It is used to check the correctness of equations, derive relationships between physical quantities, and convert units.

(b) One application of dimensional analysis is checking the consistency of equations to ensure both sides have the same dimensions. Another application is deriving relationships between physical quantities when an equation is not known. It is also used in unit conversions, allowing quantities to be expressed in different unit systems while maintaining consistency.

2. The two given waves are $y_1 = A \sin(5x - 10t)$ and $y_2 = A \sin(4x - 9t)$. Using the principle of superposition, the combined wave equation is given by:
$y = y_1 + y_2 = A \sin(5x - 10t) + A \sin(4x - 9t)$.
This equation represents the resultant wave formed by the superposition of the two individual waves in the medium.

3. (a) A semiconductor is a material whose electrical conductivity is between that of a conductor and an insulator. It can conduct electricity under certain conditions and is used in electronic devices due to its ability to control the flow of current.

(b) One difference between a pure metal and a pure semiconductor is that a pure metal has a high number of free electrons at all temperatures, while a pure semiconductor has very few free electrons at low temperatures. Another difference is that the electrical conductivity of a metal decreases with an increase in temperature, whereas in a semiconductor, conductivity increases with temperature.

4. The drift velocity of electrons in the aluminum wire is calculated using the equation:
$I = nAvq$, where I is the current, n is the electron density, A is the cross-sectional area, v is the drift velocity, and q is the charge of an electron.
By substituting the given values and solving for v, the drift velocity can be determined.

5. (a) Natural frequency is the frequency at which a system oscillates when it is not subjected to an external force or damping. It depends on the system's physical properties.
Forcing frequency is the frequency of an external force applied to a system, which can cause the system to oscillate at that frequency.

(b) The angular position of the second-order maximum is calculated using the diffraction grating equation:
$d \sin \theta = m\lambda$, where d is the spacing of the grating, m is the order of the maximum, and λ is the wavelength of light.
By substituting the given values and solving for θ, the angular position can be determined.

6. (a) The source of heat in the interior of the Earth is primarily the decay of radioactive elements such as uranium, thorium, and potassium. Other sources include the residual heat from the Earth's formation and the heat generated by gravitational compression.

(b) Thermal energy in the Earth's layers is transmitted through conduction in the solid crust, convection in the mantle, and radiation in the core. Conduction occurs when heat moves through solid materials, convection occurs due to the movement of molten rock in the mantle, and radiation transfers heat in the core, affecting the Earth's temperature distribution.

7. A cathode ray oscilloscope (CRO) is used to visualize electrical signals in real time. It is used in laboratories to analyze waveforms of electrical signals. It is also used in measuring the amplitude and frequency of signals in communication systems. Another use is in medical applications, such as electrocardiograms (ECG), to monitor heart activity. Additionally, it is used in automotive diagnostics to check engine performance by analyzing ignition signals.

8. (a) Resistance is the opposition offered by a material to the flow of electric current, measured in ohms. It depends on factors such as material, length, cross-sectional area, and temperature.
(b) Conductivity is the ability of a material to allow the flow of electric current. It is the reciprocal of resistivity and is measured in siemens per meter (S/m).
(c) Current density is the amount of electric current flowing per unit cross-sectional area of a conductor. It is given by J = I/A, where J is the current density, I is the current, and A is the cross-sectional area.

9.(a) Geophysics is the branch of physics that deals with the study of the physical properties and processes of the Earth. It involves the application of physics principles to understand the Earth's structure, seismic activity, magnetism, and gravitational fields.

(b) The crust is the outermost layer of the Earth, composed of solid rocks. It is divided into oceanic crust, which is thinner and denser, and continental crust, which is thicker and less dense.
The mantle is the layer beneath the crust, extending to about 2900 km in depth. It is composed of semi-solid rock that undergoes slow convection, driving plate tectonics.
The core is the innermost layer of the Earth, divided into the outer core, which is liquid, and the inner core, which is solid. The core is primarily composed of iron and nickel and is responsible for the Earth's magnetic field.
10. The velocity V of a transverse wave in a stretched string depends on the tension F of the string and the linear mass density μ of the string. Using the method of dimensions, derive the relationship between V, F, and μ. Show that the dynamic pressure is dimensionally equivalent to pressure.

The velocity V depends on the tension F and the linear mass density μ. Assume a relationship of the form

$V = k F^a \mu^b$

where k is a dimensionless constant, and a and b are exponents to be determined.

The dimensions of the quantities involved are:

$V = [L\ T^{-1}]$
$F = [M\ L\ T^{-2}]$
$\mu = [M\ L^{-1}]$

Substituting these into the assumed equation:

$[L\ T^{-1}] = (M\ L\ T^{-2})^a\ (M\ L^{-1})^b$

Expanding the dimensions on both sides:

$L\ T^{-1} = M^a\ L^a\ T^{(-2a)}\ M^b\ L^{(-b)}$

Grouping similar terms:

$M^{(a+b)}\ L^{(a-b)}\ T^{(-2a)} = L\ T^{-1}$

Equating the exponents of M, L, and T:

$a + b = 0$
$a - b = 1$
$-2a = -1$

Solving for a and b:

$a = 1/2$
$b = -1/2$

Thus, the velocity V is given by:

$V = k\ (F/\mu)^{(1/2)}$

For dynamic pressure, pressure is defined as force per unit area:

$P = F/A$

Since pressure has dimensions $[M\ L^{-1}\ T^{-2}]$, and dynamic pressure is given by $(1/2)\ \rho\ V^2$, where ρ is density and V is velocity,

Dynamic pressure $= (1/2)\ \rho\ V^2$

Substituting dimensions:

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

This shows that dynamic pressure has the same dimensions as normal pressure, confirming dimensional equivalence.

11. Explain briefly the importance of teaching and learning Physics.

Teaching and learning Physics is important because it helps students develop problem-solving skills by applying scientific principles to real-world situations.

It enhances critical thinking by encouraging logical reasoning and analysis of natural phenomena.

Physics provides foundational knowledge for careers in engineering, medicine, and technology, contributing to scientific advancements.

It helps individuals understand and appreciate the physical laws governing everyday life, such as motion, energy, and electricity.

Physics education promotes innovation and creativity by inspiring students to design and improve technological solutions.

12. Suppose you have been asked to teach a form two class the subtopic "Heat transfer in solids." Prepare a lesson plan for 80 minutes.

A detailed tabulated lesson plan will be provided in a downloadable format, including objectives, teaching activities, and assessment methods.

13. (a) State three Physics laboratory regulations and three safety precautions.

Physics laboratory regulations include:

Students must wear protective gear such as safety goggles and gloves when handling hazardous materials.

Electrical equipment should be handled carefully, ensuring no exposed wires or overloaded sockets.

Experiments involving heat or chemicals must be performed under supervision to prevent accidents.

Safety precautions include:

Always read and understand the instructions before conducting any experiment to avoid mishandling of equipment.

Ensure that workspaces are clean and organized to minimize the risk of spills or breakages.

Dispose of chemicals and broken glassware in designated disposal bins to prevent injuries.

(b) What is the common hazard which can be caused by glassware in the Physics Laboratory?

The common hazard caused by glassware in the Physics laboratory is breakage, which can result in sharp edges causing cuts and injuries. Additionally, broken glass may mix with chemicals, leading to hazardous spills.

14. (a) Why should teaching and learning of Physics be measured and evaluated?

Teaching and learning of Physics should be measured and evaluated to assess students' understanding and identify areas where they need improvement.

Evaluation helps teachers adjust teaching methods to ensure effective delivery of concepts.

It ensures that students meet academic standards and learning objectives set by the curriculum.

Assessments provide feedback to both students and teachers, promoting continuous learning and growth.

Proper evaluation helps in preparing students for further studies and careers in scientific and technological fields.

(b) What classroom challenges did you experience as a physics student teacher during your teaching practice?

Limited availability of laboratory equipment made it difficult to conduct practical experiments effectively.

Some students had difficulty grasping abstract concepts such as electromagnetism and wave theory.

Time constraints limited the ability to provide individualized attention to students needing extra support.

Students' varying levels of prior knowledge created challenges in maintaining a uniform pace in lessons.

Classroom distractions, such as noise and lack of engagement, occasionally hindered effective learning.

15. (a) Prepare a marking scheme for the following question. A pendulum of mass 50 g is pulled aside to a vertical height of 20 cm from the horizontal and released. Find:

(i) The maximum potential energy of the pendulum.

Potential energy is given by:

$PE = mgh$

$m = 50\ g = 0.05\ kg$
$g = 9.8\ m/s^2$
$h = 20\ cm = 0.2\ m$

PE = 0.05 × 9.8 × 0.2
PE = 0.098 J

(ii) The maximum speed of the pendulum.

At maximum speed, kinetic energy equals potential energy:

KE = 0.098 J

$KE = 1/2\ mv^2$

$0.098 = 1/2 \times 0.05 \times v^2$

$v^2 = (0.098 \times 2) / 0.05$
$v^2 = 3.92$

v = 1.98 m/s

(iii) The kinetic energy of the pendulum when it is at a height of 8 cm from the horizontal.

New height h = 8 cm = 0.08 m

PE = 0.05 × 9.8 × 0.08
PE = 0.0392 J

KE = Total Energy - PE

KE = 0.098 - 0.0392
KE = 0.0588 J

(b) Explain the energy transformation in this case.

When the pendulum is at its highest point, all its energy is stored as gravitational potential energy. As it swings downward, the potential energy is converted into kinetic energy. At the lowest point, all energy is kinetic. As it moves upward again, kinetic energy is converted back into potential energy.

(c) State the principle of conservation of energy.

The principle of conservation of energy states that energy cannot be created or destroyed, only transformed from one form to another. The total energy in a closed system remains constant.

16. Give the meaning of the terms “stem, responses, key and distractors” with reference to the objective test item given below.

The stem is the main part of the question that presents the problem or scenario. In this case, it is “An object is thrown vertically upwards; at its highest position the object has.”

Responses are the answer choices provided for selection. Here, they are A, B, C, and D.

The key is the correct answer among the responses, which is option C: “a downward acceleration of 10 m/s^2.”

Distractors are the incorrect answer choices designed to test students' understanding and ability to distinguish correct concepts. Options A, B, and D are distractors.

17. It has been observed that learners find it difficult to distinguish between temperature, heat, and internal energy. Develop in the form of lessons, teaching, and learning activities to help O-level students develop a clear understanding and distinction among these three concepts.

To help students differentiate between temperature, heat, and internal energy, a structured approach using sequential lessons is effective. The first lesson should introduce temperature as a measure of the average kinetic energy of particles in a substance. Activities such as using a thermometer to measure different objects’ temperatures can reinforce this concept.

The second lesson should focus on heat as the transfer of thermal energy between objects due to a temperature difference. Demonstrations using metal rods heated at one end can show how heat flows from a hot region to a cooler one. The difference between temperature and heat should be emphasized by explaining that a large mass of cold water can contain more heat energy than a small mass of hot water.

The third lesson should cover internal energy as the total kinetic and potential energy of all particles in a substance. A simple experiment involving heating water and discussing molecular motion changes can help students visualize this concept. The lesson should clarify that temperature only considers kinetic energy, whereas internal energy includes both kinetic and potential energy.

The final lesson should involve problem-solving exercises and real-life examples, such as why ocean water remains warm for longer than sand at night, to test students’ understanding. Interactive questioning and group discussions can help reinforce these distinctions effectively.

18. Prepare a tabulated interactive lesson plan for 80 minutes to form III class on refraction of light by using lenses.

To effectively teach refraction of light using lenses, an interactive lesson plan should be structured into clear sections.

The lesson should begin with an introduction explaining refraction as the bending of light when it moves from one medium to another. A simple demonstration using a glass of water and a straw can help students visualize this effect.

Next, the properties of convex and concave lenses should be introduced. Diagrams and real lenses should be used to demonstrate how light rays behave when passing through these lenses. Students should be asked to predict the path of light before observing actual results using ray tracing techniques.

The main activity should involve experiments where students use convex and concave lenses to form images on a screen. They should record image characteristics such as size, position, and nature (real or virtual) while adjusting object distances.

The teacher should then introduce lens formulas and the concept of focal length. Sample problems should be solved step by step, and students should attempt similar calculations in groups.

The lesson should conclude with a summary discussion, where students explain their observations and relate the concepts to real-life applications such as eyeglasses, cameras, and magnifying glasses. Assessment should include oral questions and a short quiz to evaluate their understanding.