THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

731/1 **PHYSICS 1**

Time: 3 Hours **ANSWERS** **Year: 2019**

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.

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1. (a) What is meant by the term fractional error?

Fractional error is the ratio of the absolute error of a measurement to the actual or measured value of the quantity. It is a dimensionless quantity that represents the relative accuracy of a measurement. Fractional error is used to compare the significance of errors across different measurements and is given by the formula:

Fractional error = Absolute error / Measured value

(b) The expression of the period of oscillation in a simple pendulum is given by:

$T = 2\pi \sqrt{(\ell/g)}$

where T is the period of oscillation, ℓ is the length of the string, and g is the acceleration due to gravity. Deduce the fractional error of each quantity in a given formula.

Taking logarithms on both sides:

$\ln T = \ln (2\pi) + (1/2) \ln \ell - (1/2) \ln g$

Differentiating both sides:

$dT/T = (1/2) (d\ell/\ell) + (1/2) (dg/g)$

Thus, the fractional error in T is:

Fractional error in T = (1/2) (Fractional error in ℓ) + (1/2) (Fractional error in g)

2. (a) What will happen to the moment of inertia of a man standing in a rotating turntable when he suddenly stretches his hands horizontally?

When the man stretches his hands horizontally, his moment of inertia increases. This is because moment of inertia depends on both mass and its distribution relative to the axis of rotation. Since mass is moved farther from the axis, the rotational inertia increases. According to the principle of conservation of angular momentum, if no external torque is applied, the angular momentum remains constant. As a result, the increase in moment of inertia leads to a decrease in angular velocity, causing the man to rotate more slowly.

(b) (i) A disc of mass 2 kg and radius 20 cm is free to rotate about an axis through its centre and perpendicular to the disc. If a force of 50 N is applied tangentially to the disc, calculate the angular acceleration of the disc.

The moment of inertia of a disc about its central axis is given by:

$I = (1/2) m r^2$

Substituting values:

$I = (1/2) \times 2 \text{ kg} \times (0.2 \text{ m})^2$
$I = (1/2) \times 2 \times 0.04$
$I = 0.04 \text{ kg m}^2$

The torque exerted by the force is:

Torque = Force × Radius
Torque = 50 N × 0.2 m
Torque = 10 Nm

Using the relation:

Torque = $I \times \alpha$

$10 = 0.04 \times \alpha$

$\alpha = 10 / 0.04$

$\alpha = 250 \text{ rad/s}^2$

3. (a) Define the following terms as used in strength of materials:

(i) Interatomic force

Interatomic force is the force that acts between atoms within a material, holding them together in a stable structure. These forces can be attractive or repulsive depending on the distance between atoms and are responsible for the mechanical properties of materials.

(ii) Perfectly elastic body

A perfectly elastic body is a material that returns to its original shape and size after the removal of an applied force, without any permanent deformation. Such materials obey Hooke's law throughout their deformation.

(iii) A brittle material

A brittle material is one that breaks or fractures suddenly without significant plastic deformation when subjected to stress. Brittle materials, such as glass and ceramics, have high compressive strength but low tensile strength.

(b) Why do spring balances show wrong readings after being used for a long time?

Spring balances show wrong readings over time due to material fatigue and permanent deformation of the spring. Continuous use can cause the spring to lose its elasticity, resulting in inaccurate force measurements. Additionally, exposure to excessive loads may cause plastic deformation, preventing the spring from returning to its original position.

4. (a) What is meant by the term internal energy of a system?

Internal energy of a system refers to the total energy contained within a system due to the random motion of its molecules. It includes kinetic energy from molecular movement and potential energy from intermolecular forces. Internal energy is a state function and depends only on the temperature and nature of the substance.

(b) Write down the equation relating to the change in internal energy of a system ΔU, the heat supplied to the system ΔQ, and the work done on the system ΔW.

The first law of thermodynamics states that:

$\Delta U = \Delta Q - \Delta W$

This equation expresses the conservation of energy, where the change in internal energy is equal to the heat added to the system minus the work done by the system.

(c) A quantity of heat Q is supplied to a sample of an ideal monatomic gas under reversible conditions. Explain how the first law of thermodynamics can be used to describe the change in temperature if the gas is maintained at constant volume.

At constant volume, no work is done because the gas does not expand or contract. Therefore, the first law of thermodynamics simplifies to:

$\Delta U = \Delta Q$

Since internal energy is directly related to temperature for an ideal gas, the heat supplied results in an increase in the temperature of the gas.

(d) At constant pressure.

At constant pressure, some of the heat supplied is used to do work by expanding the gas. The first law of thermodynamics becomes:

$\Delta Q = \Delta U + P\Delta V$

Here, part of the heat energy increases the internal energy, raising the temperature, while the rest is used in expansion work.

5. (a) Define the following terms as applied to earthquakes:

(i) Primary waves

Primary waves (P-waves) are the fastest seismic waves that travel through both solids and liquids. They are longitudinal in nature, causing particles to move in the direction of wave propagation.

(ii) Secondary waves

Secondary waves (S-waves) are slower than P-waves and can only travel through solids. They are transverse in nature, causing particles to move perpendicular to the direction of wave propagation.

(iii) Surface waves

Surface waves are seismic waves that travel along the Earth's surface, causing significant ground movement. They are slower than both P-waves and S-waves but cause the most destruction during an earthquake.

(b) Mention two types of surface waves.

The two types of surface waves are Love waves and Rayleigh waves.

6. Why is sound easily diffracted through windows but light cannot?

Sound waves have much larger wavelengths compared to light waves, allowing them to bend around obstacles and pass through openings such as windows. Light waves, on the other hand, have much shorter wavelengths, making them less susceptible to diffraction. As a result, sound can be heard around corners, while light travels mostly in straight lines.

7. Why do laboratory cupboards have locks and labels?

Laboratory cupboards have locks to prevent unauthorized access to chemicals, equipment, and sensitive materials that may be hazardous. Labels are used to identify the contents of the cupboards, ensuring safe handling and proper storage of materials.

8. Write four possible causes of fire in a Physics laboratory.

Fires in a physics laboratory can be caused by electrical faults, which occur when wires are overloaded, short-circuited, or exposed, leading to sparks that ignite surrounding materials. This can happen due to poor wiring, old electrical installations, or the use of faulty electrical appliances.

Improper handling of flammable substances is another major cause of fires. Many chemicals used in physics laboratories, such as alcohol, ether, and other volatile substances, can easily catch fire if they come into contact with an open flame or hot surface. Careless handling, spills, or storage near heat sources can increase the risk.

Overheating of equipment, such as Bunsen burners, heating mantles, and electrical devices, can lead to fires if they are left unattended or placed near combustible materials. Equipment that generates heat should always be used with caution and monitored to prevent excessive temperatures that could cause ignition.

Chemical reactions that produce combustible gases can also lead to fires if proper precautions are not taken. Some reactions release flammable gases such as hydrogen, methane, or acetylene, which can ignite in the presence of air and a spark. Proper ventilation and controlled experimental conditions are necessary to avoid accidental fires from such reactions.

9. Explain four considerations when preparing a scheme of work.

A scheme of work should align with the syllabus to ensure that all required topics are covered within the specified academic period. The content should be arranged in a logical sequence, progressing from simple to more complex concepts to enhance students' understanding and retention.

The availability of teaching resources is an important factor in designing a scheme of work. The teacher must consider the availability of laboratory equipment, textbooks, and other instructional materials to ensure effective lesson delivery. If resources are limited, alternative methods such as demonstrations or simulations should be planned.

Time allocation for each topic must be well structured to match the level of complexity and the depth of coverage required. Some topics may require more time for practical work, discussions, and problem-solving exercises, while others may be covered more quickly through direct instruction.

Assessment and evaluation strategies should be incorporated to track students' progress and understanding. The scheme of work should outline how students will be assessed, whether through quizzes, assignments, experiments, or classroom discussions, ensuring continuous learning and improvement.

10. Mention four assessment tools used in the teaching and learning of Physics.

Quizzes and tests are commonly used assessment tools to evaluate students' understanding of physics concepts. They provide immediate feedback on students' strengths and weaknesses, helping teachers adjust their teaching approaches accordingly.

Practical experiments are essential for assessing students' ability to apply theoretical knowledge to real-life situations. By conducting experiments, students demonstrate their understanding of physics principles, measurement skills, and problem-solving abilities.

Written assignments, such as reports and problem-solving exercises, allow students to express their knowledge in detail. These assignments help assess their ability to analyze, interpret, and explain physics concepts in a structured manner.

Oral presentations and discussions are also effective assessment tools that test students' ability to communicate scientific ideas clearly. Through class discussions and project presentations, students develop critical thinking skills and gain confidence in explaining physics concepts to others.

11. Why roads are banked around a curved pathway? Briefly explain.

Roads are banked around curved pathways to provide the necessary centripetal force that helps vehicles maintain stability while making turns. When a vehicle moves along a curved path, it experiences an outward centrifugal force that can cause it to skid or overturn. Banking the road at an angle helps redirect a component of the normal reaction force toward the center of the curve, reducing reliance on friction between the tires and the road. This design is especially important in high-speed roads and highways, where friction alone may not be sufficient to keep the vehicle from sliding outward. Additionally, banking improves driving comfort and reduces tire wear by distributing forces more evenly across the vehicle.

12. (i) Derive necessary and sufficient conditions for an oscillatory motion to be considered simple harmonic.

For a motion to be classified as simple harmonic, the restoring force acting on the oscillating body must be directly proportional to its displacement from the equilibrium position and must act in the opposite direction. Mathematically, this condition is expressed as:

$F = -kx$

where F is the restoring force, k is a positive constant known as the force constant, and x is the displacement from the equilibrium position.

By applying Newton's second law, we get:

$ma = -kx$

Since acceleration is the second derivative of displacement with respect to time, we write:

$m\, d^2x/dt^2 = -kx$

Rearranging the equation:

$d^2x/dt^2 + (k/m)x = 0$

This is the standard equation for simple harmonic motion (SHM), which shows that acceleration is always directed toward the equilibrium position and is proportional to displacement. The necessary condition for SHM is the presence of a restoring force following this relation, while the sufficient condition is the absence of external damping forces or driving forces that alter the system's natural oscillation.

(ii) The displacement-time equation for a particle with simple harmonic motion is given by

$x = A \cos(\omega t + \varphi)$

(iii) What does each symbol in the equation represent?

In the given equation, x represents the displacement of the oscillating particle from its equilibrium position at any time t. A is the amplitude of oscillation, which is the maximum displacement from the equilibrium position. ω is the angular frequency, which determines how fast the oscillations occur. t represents time, and φ is the phase constant, which depends on the initial conditions of the motion.

(iv) Write down the velocity-time and acceleration-time equations.

Velocity in SHM is given by the time derivative of displacement:

$v = dx/dt = -A\omega \sin(\omega t + \varphi)$

Acceleration is the time derivative of velocity:

$a = dv/dt = -A\omega^2 \cos(\omega t + \varphi)$

(v) Use the equations in (ii) to sketch the corresponding graphs showing velocity and acceleration vary with time.

The displacement equation $x = A \cos(\omega t + \varphi)$ is a cosine function, meaning it starts from a maximum when $\varphi = 0$. The velocity equation $v = -A\omega \sin(\omega t + \varphi)$ is a sine function, meaning velocity starts from zero and reaches maximum when displacement is zero. The acceleration equation $a = -A\omega^2 \cos(\omega t + \varphi)$ follows the same shape as displacement but is inverted, showing that acceleration is always opposite to displacement. These relationships show that velocity leads displacement by 90 degrees, while acceleration leads velocity by 90 degrees.

13. Two wires of 10 Ω and 5 Ω are parallel and arranged in series with a 20 Ω wire. If the current in the 5 Ω wire is 2 A, find the:

(a) Current in the whole circuit.

The 10 Ω and 5 Ω resistors are in parallel, meaning their equivalent resistance (R_1) is found using:

$1/R_1 = 1/10 + 1/5$
$1/R_1 = (1 + 2)/10$
$R_1 = 10/3\ \Omega$

The total resistance of the circuit is:

$R = R_1 + 20$
$R = (10/3) + 20$
$R = 70/3\ \Omega$

The voltage across the 5 Ω resistor is:

$V = IR = (2)(5) = 10\ V$

Since the parallel resistors share the same voltage, the current in the 10 Ω resistor is:

$I_1 = V / R = 10 / 10 = 1\ A$

The total current in the circuit is the sum of currents in the parallel resistors:

$I_{total} = I + I_1 = 2 + 1 = 3\ A$

(b) Potential difference across the 10 Ω wire.

Using Ohm's law, the potential difference across the 10 Ω resistor is:

$V = IR = (1)(10) = 10\ V$

Since the 10 Ω and 5 Ω resistors are in parallel, they share the same voltage, confirming that the potential difference across the 10 Ω wire is 10 V.

14. (a) State six necessary conditions for interference of light to occur.

For interference of light to occur, the two sources of light must be coherent, meaning they should maintain a constant phase difference over time. Coherence ensures that the interference pattern remains stable and does not change randomly.

The sources must emit light waves of the same frequency and wavelength. If the wavelengths are different, the interference pattern will shift unpredictably, and distinct fringes will not form.

The waves must have the same polarization state. If the waves are polarized differently, their oscillations may not interact properly, preventing clear interference patterns.

The light sources must have nearly equal intensities. If one source is significantly brighter than the other, the visibility of the interference fringes will be reduced, making the pattern difficult to observe.

The path difference between the interfering waves should be small compared to the coherence length of the light. If the path difference is too large, phase relationships will break down, and interference effects will not be clearly seen.

The light waves must be of the same phase or have a fixed phase difference. This ensures that constructive and destructive interference occurs at consistent points, forming a stable pattern.

15. (b) Plano-convex lens is used to produce Newton's rings with a flat glass plate. If the diameter of the 10th dark ring viewed in normally reflected light of wavelength 5.00×10^{-7} m is 4.48 mm, calculate:

(i) The radius of curvature of a plano-convex lens.

The radius of the m-th dark ring is given by the equation:

$R = (D_m^2) / (4m\lambda)$

Substituting the given values:

$R = (4.48 \times 10^{-3})^2 / (4 \times 10 \times 5.00 \times 10^{-7})$
$R = (2.006 \times 10^{-5}) / (2 \times 10^{-5})$
$R = 1.003$ m

(ii) The diameter of the twentieth bright ring.

For a bright ring, the formula is:

$D_m = \sqrt{4mR\lambda}$

Substituting m = 20,

$D_{20} = \sqrt{4 \times 20 \times 1.003 \times 5.00 \times 10^{-7}}$
$D_{20} = \sqrt{4.012 \times 10^{-5}}$
$D_{20} = 6.34$ mm

16. Why do explosions on other planets not heard on earth?

Explosions on other planets cannot be heard on Earth because sound waves require a medium such as air, water, or solid materials to travel. In space, there is a vacuum, meaning there are no air molecules to transmit sound waves. Unlike electromagnetic waves, which can propagate through the vacuum of space, sound waves depend on particle vibrations, which are absent in outer space. As a result, even if a large explosion occurs on another planet, there is no way for the sound to travel across the empty space to reach Earth.