THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
DIPLOMA IN SECONDARY EDUCATTION EXAMINATION

731 **PHYSICS 1**

Time: 3 Hours **ANSWERS** **Year: 2022**

Instructions.

1. This paper consists of sections A and B with a total of **Fourteen (14)** questions.
2. Answer **all** questions from section A and **four (4)** questions from section B.
3. Section A carries **forty (40)** marks and section B Carries **sixty (60)** marks.
4. Cellular phones are **note** allowed in the examination room.
5. Write your **examination Number** on every page of your answer booklet(s).

SECTION A (40 Marks)

Answer all questions from this section. Each question carries 4 marks.

1. Refer a simple pendulum experiment in determining the acceleration due to gravity to:
(a) Obtain the relationship of physical quantities involved in that experiment by using dimensional knowledge.

In a simple pendulum experiment, the time period (T) for one complete oscillation is related to the length (L) of the pendulum and the acceleration due to gravity (g). By using dimensional analysis, we assume that T is proportional to some powers of L and g:
$T \propto L^a g^b$
The dimensions of each quantity are:
$[T] = T$
$[L] = L$
$[g] = LT^{-2}$
Substituting dimensions:
$[T] = [L]^a [LT^{-2}]^b$
$\Rightarrow T = L^a \times L^b \times T^{-2b}$
$\Rightarrow T = L^{a+b} \times T^{-2b}$
Equating powers of L and T on both sides:
For T: $1 = -2b \rightarrow b = -\frac{1}{2}$
For L: $0 = a + b \rightarrow a = \frac{1}{2}$
Therefore, the relation becomes:
$T \propto \sqrt{(L/g)}$
Or:
$T = 2\pi\sqrt{(L/g)}$

(b) Give two reasons that made students to commit systematic errors while conducting that experiment.

One reason for systematic errors is the improper calibration or zero error of the stopwatch used for timing the oscillations. If the stopwatch has an unnoticed delay or constant error in starting or stopping, it will consistently give measurements that are either too high or too low.

A second reason is the incorrect measurement of the pendulum's length. If students measure from the wrong point (like from the bottom of the bob instead of the point of suspension), all measurements will have a consistent error, leading to incorrect calculations of g.

2. (a) Briefly explain how is the pressure of a gas affected when its volume is reduced to half at constant temperature as the pressure of the gas varies inversely proportional to temperature.

When the volume of a gas is reduced to half while maintaining a constant temperature, according to Boyle's law, the pressure of the gas doubles. This is because pressure is inversely proportional to volume at constant temperature.
So if the initial volume is halved, the number of gas molecules per unit volume increases, causing more frequent collisions with the container walls, thereby increasing the pressure.

(b) Briefly justify the statement based on the temperature variation that "water exists in more than one form of matter."

Water exists in three physical states: solid (ice), liquid (water), and gas (vapour) depending on temperature variations. At low temperatures (0°C and below), water molecules slow down and arrange themselves into a rigid structure forming ice.
At moderate temperatures, molecules are loosely held and flow over each other as liquid water. At high temperatures (100°C and above), molecules gain enough kinetic energy to overcome intermolecular forces and exist freely as water vapour (gas).

3. (a) Give the two necessary conditions that enable a satellite to be stationary in space.

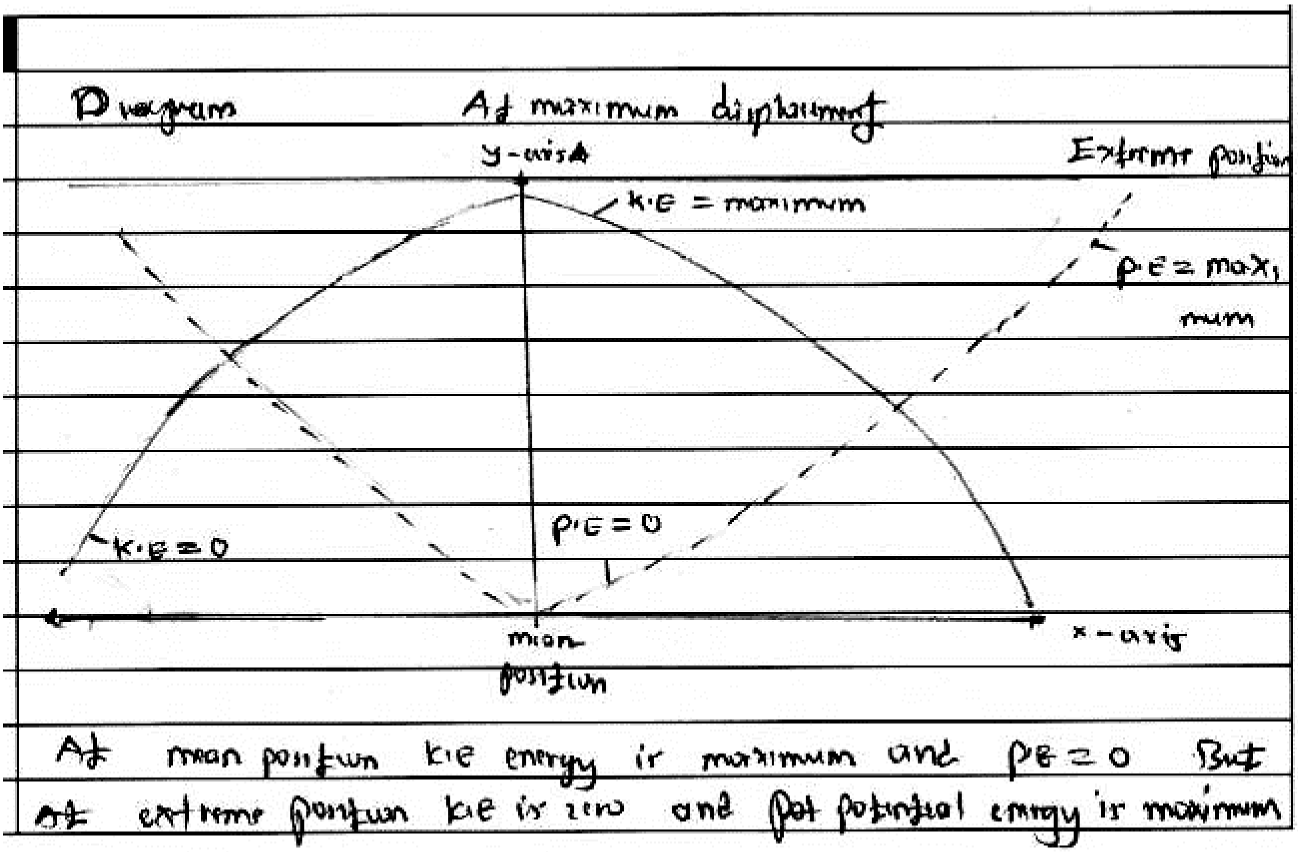
First, the satellite must revolve around the Earth in the same direction as the Earth's rotation, which is from west to east.

Second, the satellite must have an orbital period equal to the rotational period of the Earth, which is 24 hours. This allows the satellite to appear stationary from any point on Earth directly below it, known as a geostationary orbit.

(b) Calculate the orbital radius of the satellite if it takes a period of one day to go around its orbit and it rotates at the same speed as that of the moon.
We use the formula:
$T^2 = (4\pi^2 r^3)/(GM)$
Where:
$T = 24 \times 60 \times 60$ s = 86400 s
$G = 6.67 \times 10^{-11}$ N·m²/kg²
$M = 5.97 \times 10^{24}$ kg
Rearranging for r:
$r^3 = (GMT^2)/(4\pi^2)$
Substituting values:
$r^3 = (6.67\times10^{-11} \times 5.97\times10^{24} \times (86400)^2) / (4 \times (3.142)^2)$
$= 7.53 \times 10^{22}$
$r = \sqrt[3]{(7.53 \times 10^{22})}$
$\approx 4.23 \times 10^7$ m
So, the orbital radius is approximately 42,300 km from the Earth's center.

4. Use a sketched diagram to analyze the interchange between kinetic and potential energies of the particle that is in Simple Harmonic Motion.

In SHM, at the extreme positions, potential energy is maximum, and kinetic energy is zero. At the mean position, kinetic energy is maximum, and potential energy is zero. As the particle moves between these points, energy continuously converts between kinetic and potential while the total mechanical energy remains constant.



5. Describe the applications of radioactivity in daily life to first year student teachers.

Radioactivity is applied in several areas of life. In medicine, radioactive isotopes like cobalt-60 are used in cancer treatment through radiotherapy, while iodine-131 is used to diagnose and treat thyroid conditions.

In industry, radioactive tracers help detect leaks in pipelines and monitor the thickness of materials. In agriculture, radiation is used to improve crop yields by inducing beneficial mutations and controlling pests.

Lastly, in archaeology, carbon-14 dating is applied to determine the age of fossils and ancient artifacts.

6. Use slinky coil spring to explain the propagation behaviour of transverse and longitudinal waves.

When a slinky spring is moved side to side at one end, the coils move perpendicular to the direction of the wave’s travel, producing a transverse wave.

The crests and troughs travel along the slinky, while individual coils oscillate up and down. When the slinky is compressed and released along its length, the coils move back and forth in the same direction as the wave’s motion, creating a longitudinal wave. In this case, compressions and rarefactions propagate through the medium.

7. Draw a truth table for a room of three doors and associated three switches A, B and C which turned on light when one enters the room through any door and presses the associated switch. On leaving the room through any door and pressing the associated switch, the light goes off. Assume that the light is off when A = B = C = 0.

A	B	C	Light
0	0	0	0
1	0	0	1
0	1	0	1
0	0	1	1
1	1	0	0
1	0	1	0
0	1	1	0
1	1	1	1

8. Give four suggestions on how to reduce the running costs of a Physics laboratory.

One way is to carefully budget and only purchase essential equipment, prioritizing multipurpose and durable apparatus.

Another method is maintaining equipment regularly to avoid frequent breakdowns and costly replacements.

Additionally, energy-saving practices such as turning off appliances and lights when not in use reduce utility bills. Finally, recycling and reusing materials like wires, resistors, and glassware where possible cuts down on the need for constant new purchases.

9. Give four reasons why the school Physics laboratory technician preferred to use a mercury thermometer during the preparation for heat experiments.

Mercury thermometers have a high boiling point, allowing them to measure higher temperatures without vaporizing.

They also expand uniformly with temperature, providing precise and reliable readings. Furthermore, mercury does not wet the glass, ensuring clear meniscus and easy reading.

Lastly, mercury remains visible as a shiny metal inside the thermometer even under varying lighting conditions, aiding accurate observation.

10. Justify the following statement in two points: "Students learn Physics concepts best by doing."

When students physically perform experiments, they engage multiple senses, leading to better retention and understanding of abstract Physics concepts.

Practical involvement also develops students' problem-solving and critical-thinking skills, as they analyze results, identify errors, and draw conclusions based on observation.

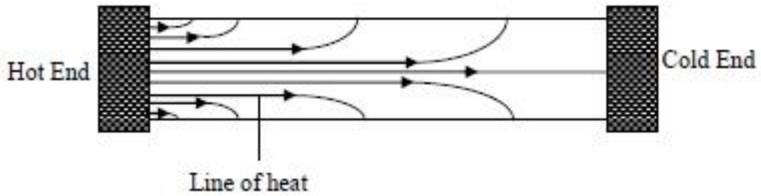
SECTION B (60 Marks)

Answer all questions from this section. Each question carries 15 marks.

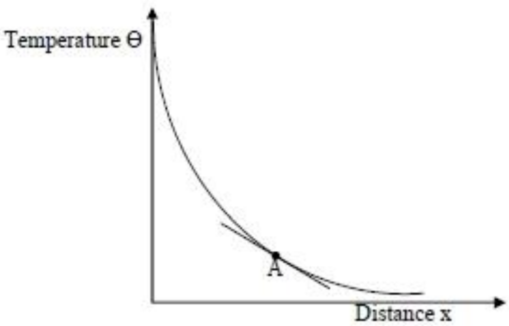
11. (a) Draw lines of heat flow and sketched graphs which show variation of the temperature of the rod along its length when the surface of the rod is (i) unlagged (ii) lagged.

When a rod is heated at one end and cooled at the other, heat flows from the hot end to the cold end. If the rod is **unlagged**, heat escapes along its length to the surroundings, making the temperature fall gradually and unevenly. The temperature gradient would be steepest near the hot end and more flattened near the cooler end because of heat loss to the environment.

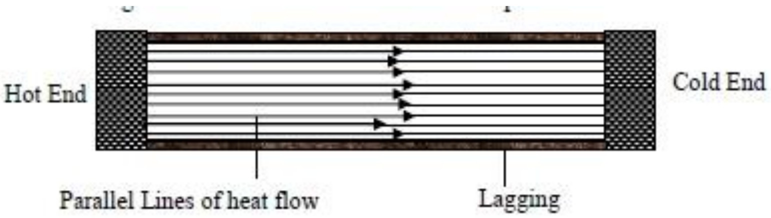
When the rod is **lagged** (insulated), heat does not escape to the surroundings. It flows entirely along the rod from the hot end to the cold end. The temperature then drops linearly along the length of the rod because no heat is lost sideways.

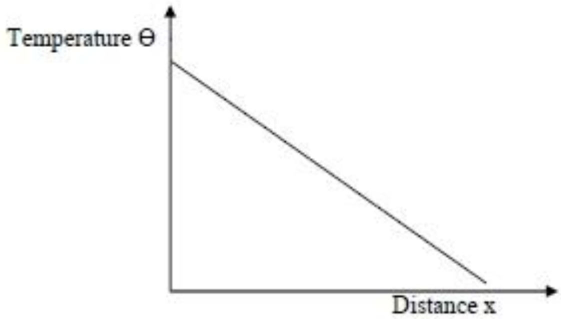


Sketch for unlagged rod:
A curve starting at high temperature at one end, sloping down but more gently at the cold end.



Sketch for lagged rod:
A straight line descending uniformly from the hot end to the cold end.





(b) Deduce the rate of heat flow through a plaster ceiling, measuring 5 m × 3 m × 15 mm, in contact with 45 mm thick layer of insulating material. If the inside and outside surfaces are at the surrounding air temperature of 15 °C and 5 °C respectively, the thermal conductivity of plaster ceiling is 0.60 $Wm^{-1}K^{-1}$ and that of insulating material is 0.040 $Wm^{-1}K^{-1}$.

We use the formula for rate of heat transfer through composite slabs:

$Q/t = (A \times \Delta T) / (\Sigma (d/k))$

Where:
$A = 5 \times 3 = 15\ m^2$
$\Delta T = 15 - 5 = 10\ K$
$d_1 = 0.015\ m$
$k_1 = 0.60\ Wm^{-1}K^{-1}$
$d_2 = 0.045\ m$
$k_2 = 0.040\ Wm^{-1}K^{-1}$

Now, $\Sigma(d/k) = (0.015/0.60) + (0.045/0.040)$
$= 0.025 + 1.125$
$= 1.15\ m^2K/W$

$Q/t = (15 \times 10) / 1.15$
$= 150 / 1.15$
$\approx 130.43\ W$

Therefore, the rate of heat flow is approximately **130.4 W**.

12. (a) Derive an expression related to the experiment conducted by Rural Electrical Agency (REA) on the Ohmic conductors and ended up with a conclusion that the resistance of a conductor depends on the two factors.

In the REA experiment, the resistance (R) of a conductor was found to depend on its **length (l)** and **cross-sectional area (A)**. From experimental observation and dimensional reasoning:

$R \propto l$
$R \propto 1/A$

Combining both:
$R \propto l/A$

Introducing the constant of proportionality ρ (resistivity of the material):

$R = \rho\,(l/A)$

Where ρ depends on the nature of the material and temperature. This shows resistance increases with length and decreases with a larger cross-sectional area.

(b) Given an electrical circuit represented in Figure 1 for a staff room lighting and then asked to determine (i) the potential difference (p.d) between A and C and (ii) the amount of current pass through B.

(i) Potential difference between A and C:

In Figure 1, moving from point A to B, the p.d. increases by 12 V due to the battery, then drops across the 1.0 Ω resistor. Then from C to D, the p.d. increases by 10 V and drops across the 3.0 Ω resistor.

By Kirchhoff's second law, total e.m.f = total potential drop.

Total e.m.f = 12 V + 10 V = 22 V
Total resistance = 1.0 Ω + 3.0 Ω = 4.0 Ω

Total current:
$I = V/R = 22/4 = 5.5$ A

Now, potential drop across 1.0 Ω resistor:
$V = IR = 5.5 \times 1.0 = 5.5$ V

Therefore, p.d. between A and C is 12 V - 5.5 V = 6.5 V

(ii) Current through B:

As calculated, total current in the loop is 5.5 A. Since it's a series circuit, the same current flows through B.

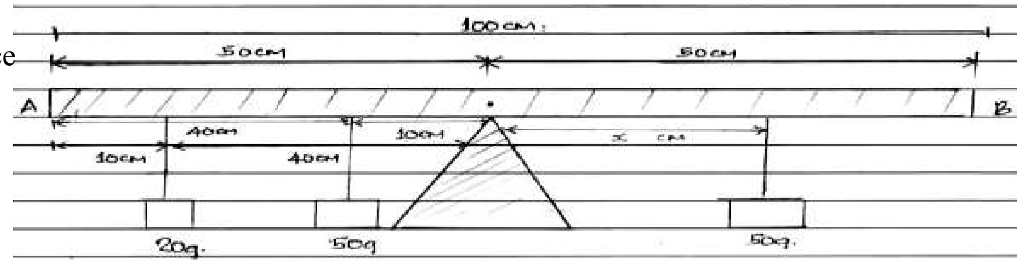
So, current through B is **5.5 A**

13. Use a diagram of the moment of force to prepare a comprehensive marking scheme from the following monthly test question “A uniform metre rule is pivoted at its centre. If 20 g mass is placed at the 10 cm mark and a 50 g mass at the 40 cm mark from one end of the ruler, at what distance must a second 50 g mass be placed for the system to be in rotational balance?”

Marking Scheme

1. Draw the metre rule, marking the 0 cm, 10 cm, 40 cm, and the position of unknown distance x from pivot at 50 cm.

2. Take clockwise moment = anticlockwise moment about pivot.



Moment = force × distance

Clockwise moment:
$50\text{ g} \times (x - 50)$

Anticlockwise moment:
$20\text{ g} \times (50 - 10) + 50\text{ g} \times (50 - 40)$

=> $50x = (20 \times 40) + (50 \times 10)$
=> $50x = 800 + 500$
=> $50(x) = 1300$
=> $50x = 1300 / 50$
=> $x = 26$
=> $x = 26$ cm

The second 50 g mass should be placed at **26 cm mark**

14. Use six factors to support the statement that “A good Physics teacher must consider the factors for selecting teaching method that enable the students to understand well certain concepts before teaching sessions.”

Firstly, the **nature of the content to be taught** determines the method. Topics involving practical or visual processes like optics or electrical circuits require demonstration or lab experiments, while theoretical topics can be handled through discussion.

Secondly, the **students’ ability and academic level** matters. Advanced learners might cope well with inquiry-based or problem-solving methods, while beginners would need more guided, structured approaches.

Thirdly, the **availability of teaching resources and facilities** influences the choice. Practical-based teaching demands apparatus, models, and equipment, which may not be available in all schools.

Fourthly, the **number of students in the class** affects method selection. Large classes make group discussions and experiments difficult, necessitating lectures or demonstrations.

Fifth, the **time allocated for a lesson** is important. Complex, time-consuming activities like experiments might not be suitable for short periods.

Lastly, the **learning objectives to be achieved** guide the method. If the aim is knowledge recall, a lecture works. If the goal is skill acquisition, demonstration and practical activities become more effective.