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

731/2A **PHYSICS 2A**

Time: 3 Hours **ANSWERS** **Year: 2023**

Instructions.

1. This paper consists of **three (3)** questions.
2. Answer **all** questions.
3. Question one has **twenty (20)** marks and other questions has **fifteen (15)** marks.
4. Cellular phones are **note** allowed in the examination room.
5. Write your **examination Number** on every page of your answer booklet(s).

1. Suppose you are given an assignment to determine the gravitational pull strength of your school area so that you can be able to determine the weight of objects and you are given the following materials: metre rule, retort stand, stopwatch, inextensible string, pendulum bob and two wooden pads. Conduct the experiment through the following procedures and answer the questions that follow.

Procedures:

(a) Fix one end of an inextensible string on the retort stand. Tie a pendulum bob to the other end as shown in Figure 1.

(b) Measure the height, (h) = 10 cm from the ground to the centre of mass of the bob.

(c) Slightly displace the bob and release to let it oscillate freely and record the time for 20 complete oscillations.

(d) Repeat procedures in 1(b) to (d) for values of h = 20, 30, 40, 50, 60, 70 and 80 cm.

Questions

(i) Tabulate the results including the corresponding values of periodic time.

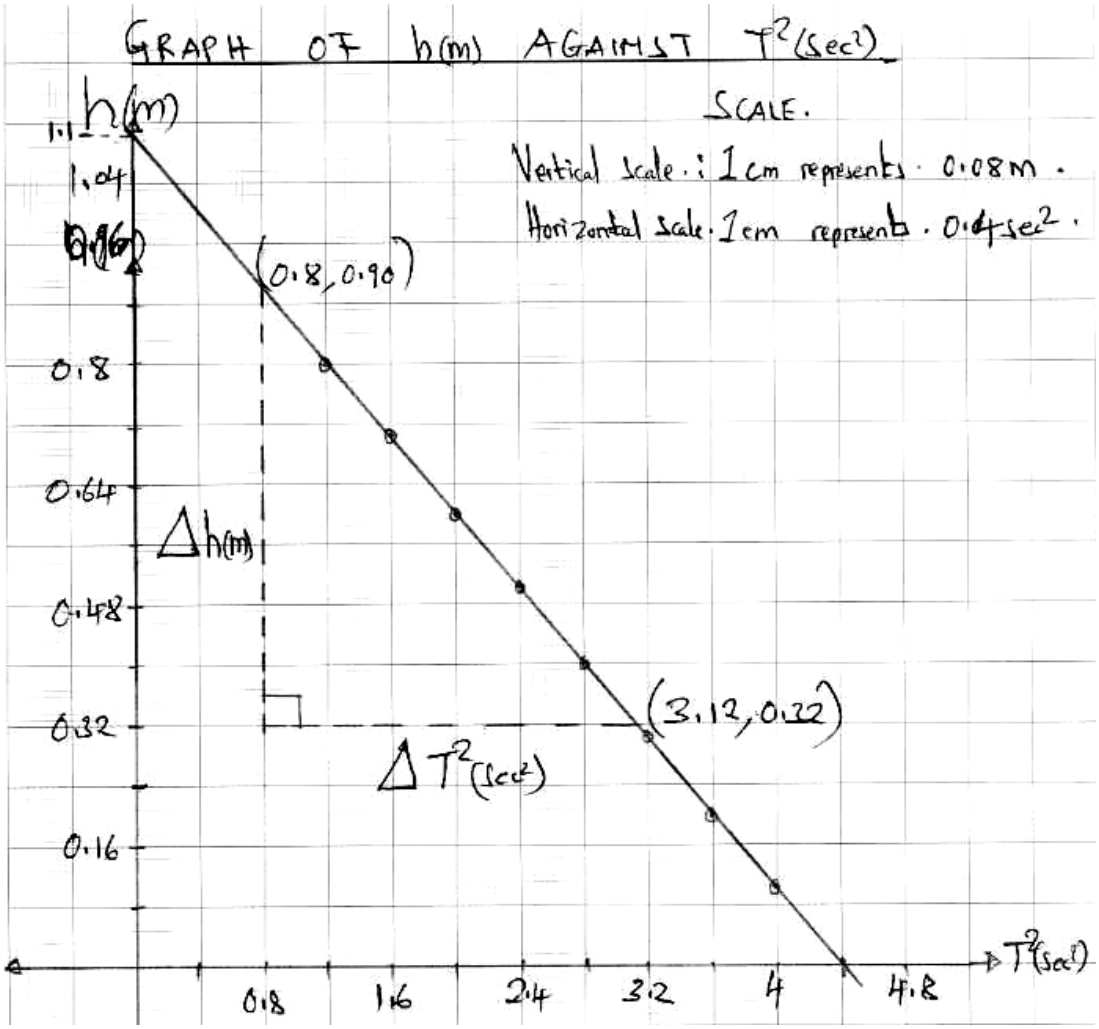
h (cm)	h (m)	Time for 20 Oscillations (s)	Period T (s)	T^2 (s^2)
10	0.10	40.00	2.000	4.000
20	0.20	37.14	1.857	3.450
30	0.30	35.78	1.789	3.202
40	0.40	33.46	1.673	2.798
50	0.50	30.98	1.549	2.400
60	0.60	28.28	1.414	2.000
70	0.70	25.38	1.269	1.610
80	0.80	21.90	1.095	1.199

(ii) Plot a graph of h (m) against T^2 (s^2).

Graph Description:
On the horizontal axis (X-axis): T^2 (s^2)
On the vertical axis (Y-axis): h (m)

The graph will be a straight line since from the formula:

$T^2 = (4\pi^2 / g)\ h$
So, $h = (g / 4\pi^2)\ T^2$



(iii) Find the intercept of your graph.

From the theory, if the experiment is done accurately, the graph should pass through 1.1 m at y.

(iv) Determine the slope S of your graph. What does it imply?

To calculate the slope:

Pick two points from the straight line, say:

Point 1: ($T^2 = 4.000$, $h = 0.10$)
Point 2: ($T^2 = 1.199$, $h = 0.80$)

Slope, $S = (h_2 - h_1) / (T^2_2 - T^2_1)$
$= (0.80 - 0.10) / (1.199 - 4.000)$
$= 0.70 / (-2.801)$
$= -0.2499$ m/s²

Since the slope is negative due to how the points are chosen, use absolute value:

$S = 0.2499$ m/s²

What it implies:
From the formula:
$T^2 = (4\pi^2 / g) \times h$

Comparing with:
$h = S \times T^2$

Then, $S = (g / 4\pi^2)$

So, the slope represents **$(g / 4\pi^2)$**

(v) What is the value of gravitational pull at your center?

From $S = g / 4\pi^2$

Then, $g = 4\pi^2 \times S$

Substituting:

$\pi^2 = 9.8696$
$4\pi^2 = 39.4784$

$g = 39.4784 \times 0.2499$
$g \approx 9.87$ m/s²

So, the value of gravitational pull at your center is approximately 9.87 m/s².

(vi) Suppose the amplitude of vibration diminishes due to increased air resistance, will the periodic time for 20 complete oscillations be different? Briefly explain.

No, the periodic time for 20 complete oscillations would **not be significantly different**.

Reason:
For small amplitudes, the time period of a simple pendulum is independent of amplitude, provided the angle is less than about 15 degrees. While increased air resistance may gradually reduce the amplitude, it doesn't noticeably affect the period unless the amplitude becomes excessively small or the damping is very strong.

2. In the heating experiment you observed that, when substances made of the same material are exposed at the same initial temperature and then allowed to cool, their rate of cooling differs depending on various factors. Then, you decide to carry out an experiment to investigate the rate of cooling. If you are provided with the following apparatuses and materials: a calorimeter with jacket and stirrer, thermometer, hot water (to be fetched from heat source) and stopwatch, perform the experiment through the given procedures and answer the questions that follow.

Procedures:

(a) Weigh and determine the mass of an empty calorimeter (without its outer jacket)

(b) Half fill (½) the calorimeter with hot water about 90 °C, and place the calorimeter in its jacket. Place the lid with stirrer and finally insert the thermometer. Wait for the temperature of the water to reach 85 °C.

(c) Observe and record the temperature of the contents for every 2 minutes as it cools from 85 °C to 50 °C. Remove the calorimeter from the jacket and measure the mass of calorimeter with water but without its outer jacket.

(d) Repeat the procedures in 2(b) and (c) with the calorimeter about three quarter (¾) full of water.

Questions

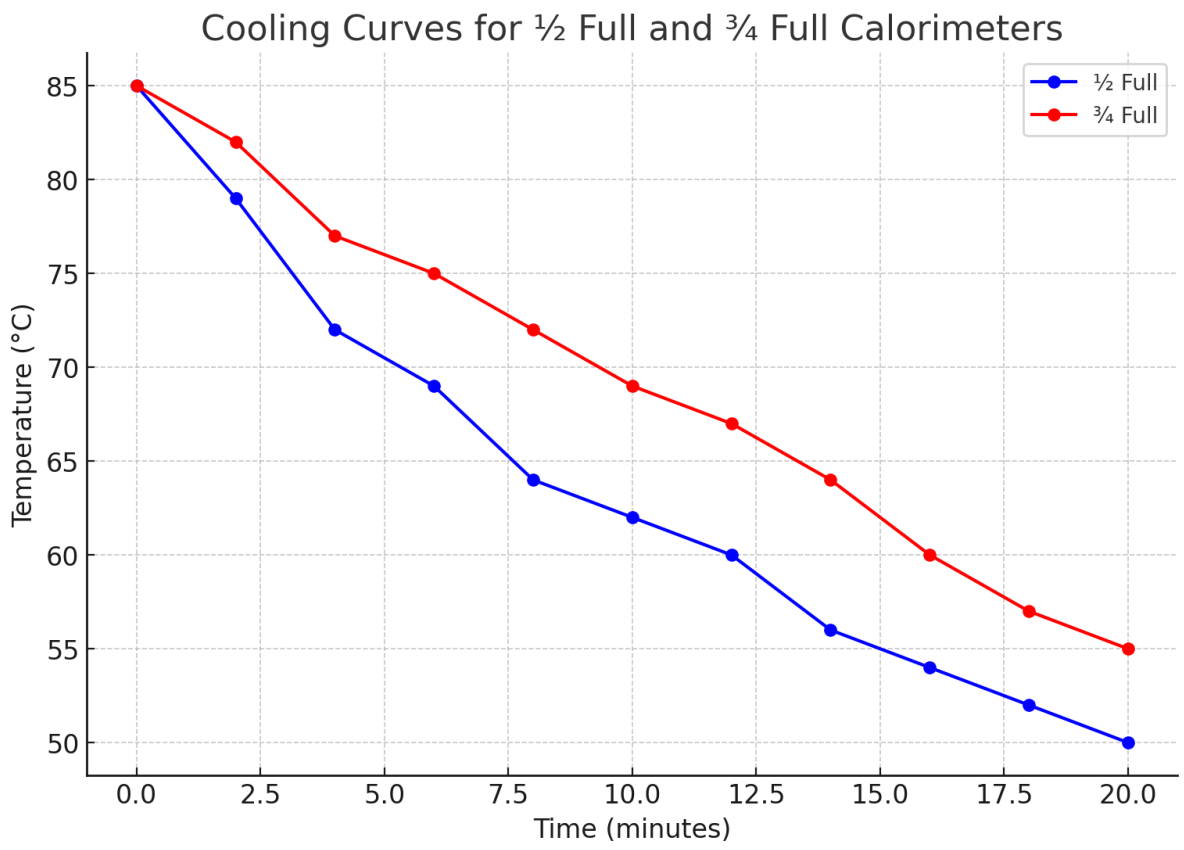
(i) Tabulate the results for both half and three quarter full including time and temperature for each case.

Results:

Time (min)	Temperature (°C) for ½ Full	Temperature (°C) for ¾ Full
0	85	85
2	79	82
4	72	77

6	69	75
8	64	72
10	62	69
12	60	67
14	56	64
16	54	60
18	52	57
20	50	55
22	—	53

(ii) Plot the cooling curves for both half and three quarter full in the same frame of axes.



(iii) Use the two curves to obtain the ratio ½ full : ¾ full of the times taken for both to cool from 85 °C to 60 °C.

From the table:

For ½ full:
85 °C to 60 °C takes **12 minutes**

For ¾ full:
85 °C to 60 °C takes **16 minutes**

Now, the ratio:

Ratio = 12 : 16
Simplify by dividing both by 4

= 3 : 4

So, the ratio is 3:4

(iv) What conclusion can you draw on the ratio obtained in 2(iii)?

The conclusion is that the calorimeter with a **greater quantity of water (¾ full)** takes a **longer time to cool** through the same temperature range compared to the one that is **½ full**. This means that the **rate of cooling decreases as the quantity of the substance increases** because a larger mass has a higher thermal capacity, thus losing heat more slowly.

(v) Using your graph, comment how a quantity of a body/substance affects its rate of cooling.

From the graph, it is clear that the **cooling curve for the ¾ full calorimeter declines more gradually** compared to the steeper curve for the ½ full calorimeter. This indicates that a **larger quantity of a substance cools more slowly than a smaller quantity** when exposed to the same conditions. The greater the mass, the slower the rate of temperature fall because it takes more time to lose the same amount of heat energy.

3. You were assigned to install electricity to a new secondary school building. The district electric department provided you with two standard resistors labeled R_1 and R_2 each having 1 Ω, four standard resistors (2 Ω, 3 Ω, 4 Ω and 5 Ω), switch (K), voltmeter (V), ammeter (A) and connecting wires. Design a circuit having two loads labeled R_1 and R_2 connected in such a way that the voltage drop across the two loads is the same. Following the procedures provided, perform an experiment and then answer the questions that follow.

Procedures:

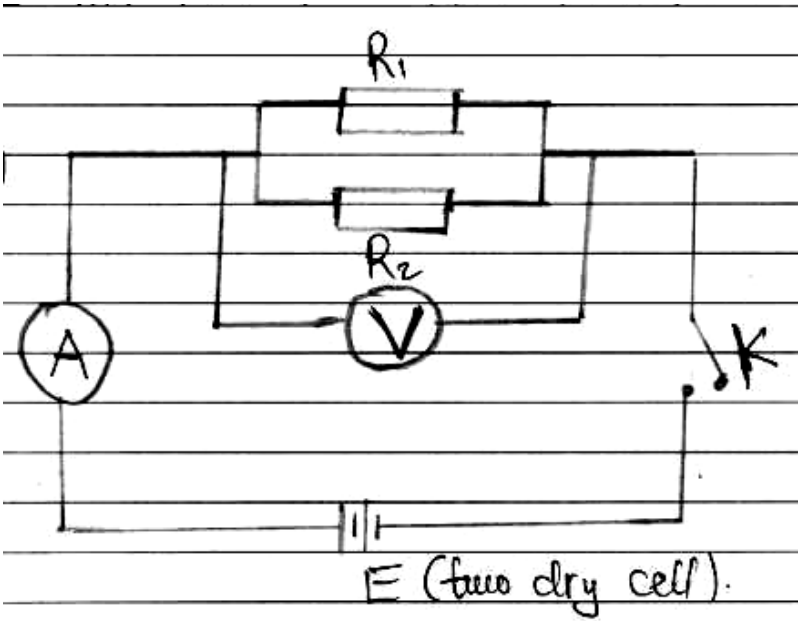
(a) Complete a design by connecting a switch and two dry cells provided.
(b) Close the switch, K and quickly record the reading on the ammeter and voltmeter.
(c) Replace R_2 with $R_0 = 0\ \Omega$ and quickly record simultaneously the reading on the ammeter and voltmeter.
(d) Repeat procedure 3(c) for $R_0 = 2\ \Omega$, $3\ \Omega$, $4\ \Omega$ and $5\ \Omega$.

(i) Tabulate your results as shown in the following table

Table:

R_0 (Ω)	P.d (V)	I (A)
0	—	2.0
1	—	—
2	1.6	1.9
3	1.7	1.8
4	1.8	1.7
5	1.8	1.6

(ii) Draw a well labelled diagram for the experimental set-up



(iii) Evaluate the validity of Ohm's law in this experiment.

Ohm's law states:
The potential difference (V) across a conductor is directly proportional to the current (I) through it, provided physical conditions like temperature remain constant.

In this experiment, by observing the readings:

As current decreases, voltage rises in steps.

If you plot V against I, the graph should be a straight line.

Hence, if the graph from this data is linear and passes through the origin (or very close), **Ohm's law is valid** under these conditions.

(iv) Deduce mathematical relation that can be used to evaluate the equivalent resistance (R_eq) when $R_o = 10\ \Omega$.

In a parallel connection:

$$1/R_eq = 1/R_1 + 1/R_o$$

$$R_{eq} = (R_1R_O)/(R_1 + R_O)$$

(v) Plot a graph of P.d (V) against I (A) and then comment on the numerical values of slope and intercept.