THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

131/3B **PHYSICS 3B**

(For Both School and Private Candidates)

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

Instructions

1. This paper consists of THREE questions.
2. Answer all questions.

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1. Suppose the weighing balance at your school is not working properly and you are required to determine the mass of an empty glass beaker.

Proceed as follows:

(a) Use the masking tape to firmly wrap the thread on the beaker and suspend it to the lower end of the spiral spring as shown in Figure 1 when an optical pin hits 'S' shape.

The setup forms a vertical spring-mass system where oscillations are measured to determine the mass.

(b) Measure volume $V = 25\ cm^3$ of water and pour it into the suspended beaker. Gently pull the beaker a small distance downward and release it so that it performs vertical oscillations. Measure and record time t for 30 oscillations and determine its periodic time T.

T is calculated using $T = t / 30$.

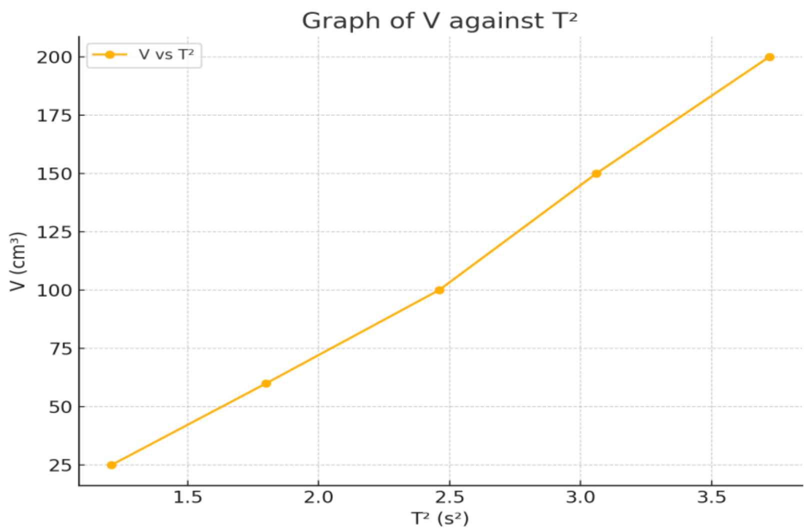
(c) Repeat procedures in 1 (b) for $V = 60\ cm^3$, $100\ cm^3$, $150\ cm^3$ and $200\ cm^3$.

(i) Tabulate your results including values of T and T^2.

Assume the time for 30 oscillations was measured as follows:

V (cm^3)	t (s)	T (s)	T^2 (s^2)
25	33.0	1.10	1.21
60	40.2	1.34	1.80
100	47.0	1.57	2.46
150	52.5	1.75	3.06
200	58.0	1.93	3.72

(ii) Plot a graph of V (cm^3) against T^2 (s^2).
V on the y-axis, T^2 on the x-axis. A straight line is expected showing $V \propto T^2$.



(iii) Establish the equation governing this experiment.

From theory of mass-spring system:
$T^2 = (4\pi^2/k) \times m$, and since volume V corresponds to mass (ρV), then:
$T^2 \propto V$
So the equation is: $V = k' T^2$

(iv) Use the graph and the equation obtained in 1 (iii) to determine the mass of an empty glass beaker.

Extrapolate the graph to where $T^2 = 0$. Suppose the intercept on V-axis is 20 cm^3.
Mass of empty beaker = $\rho \times V = 1\ g/cm^3 \times 20\ cm^3 = 20\ g$

(v) What will happen to the floating object if it is put in oscillating beaker at the bottom position of its oscillation? Briefly explain.

The floating object will experience maximum upward force when the beaker reaches the bottom of its oscillation due to increased acceleration, and may temporarily sink deeper or oscillate within the beaker depending on damping.

2. Hotel owner heats water for his customers every morning using electric heaters and noticed hot water remains hot but normal water heats quickly when placed in hot water. Prove this using an experiment.

(a) Fill the beaker with 100 ml of hot water at about 90°C.

(b) Pour 50 ml of normal water at room temperature into a calorimeter.

(c) Insert the calorimeter containing water into a beaker with hot water of 85°C placed on a wooden block. Quickly close the beaker with a lid.

This helps to maintain insulation.

(d) Read and record the temperature of water in the calorimeter every half minute until it reaches about 55°C.

This shows how the cold water heats up using surrounding hot water.

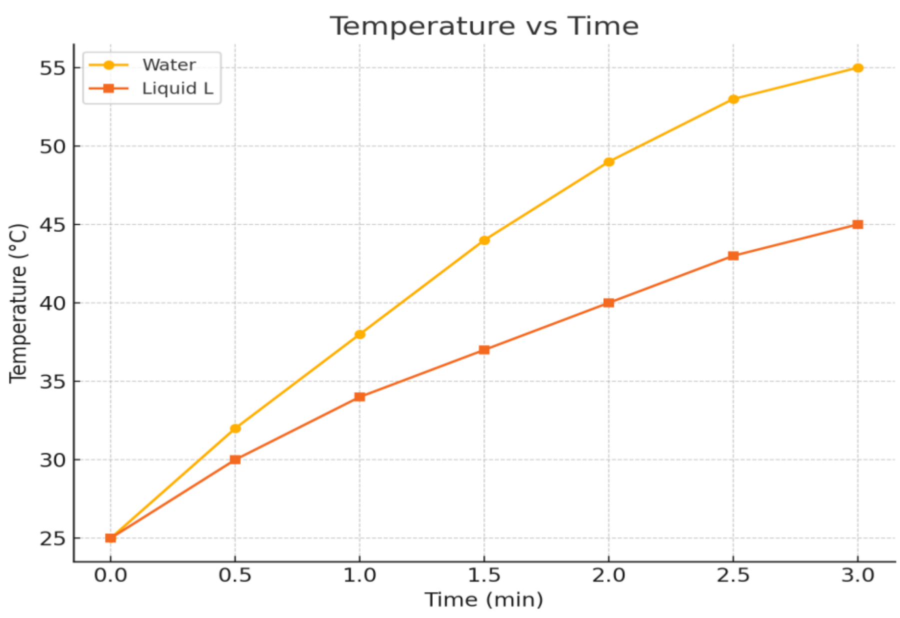
(e) Empty the calorimeter and the beaker.

(f) Repeat procedures 2 (a) to (d) by filling the calorimeter with 50 ml of liquid L.

(i) Tabulate your results.

Time (min)	Temp of water (°C)	Temp of liquid L (°C)
0	25	25
0.5	32	30
1.0	38	34
1.5	44	37
2.0	49	40
2.5	53	43
3.0	55	45

(ii) Plot the graphs of temperature against time for water and liquid L on the same axes.



(iii) Determine the rate of temperature rise (°C/minute) for water and liquid L at 42°C.

From the table:
Water: between 1.0 and 1.5 min, rise from 38 to 44°C: rate = (44 - 38)/(1.5 - 1.0) = 6/0.5 = 12°C/min
Liquid L: from 34 to 37°C: rate = (37 - 34)/0.5 = 6°C/min

(iv) Suggest any two improvements that will result into increase in temperature gained by liquid L.

Use a better insulating lid to prevent heat loss from the beaker.
Increase initial temperature or quantity of hot water used in the surrounding beaker.

3. You are required to investigate the value of the unknown resistance R which was coupled parallel to a wire labelled W by means of a Wheatstone metre bridge.

(a) Connect the standard resistor of 2 Ω in the left-hand gap, and the parallel combination of R and W in the right-hand gap.

(b) With x = 1.0 m, close the switch, find balance point L. Then determine R.

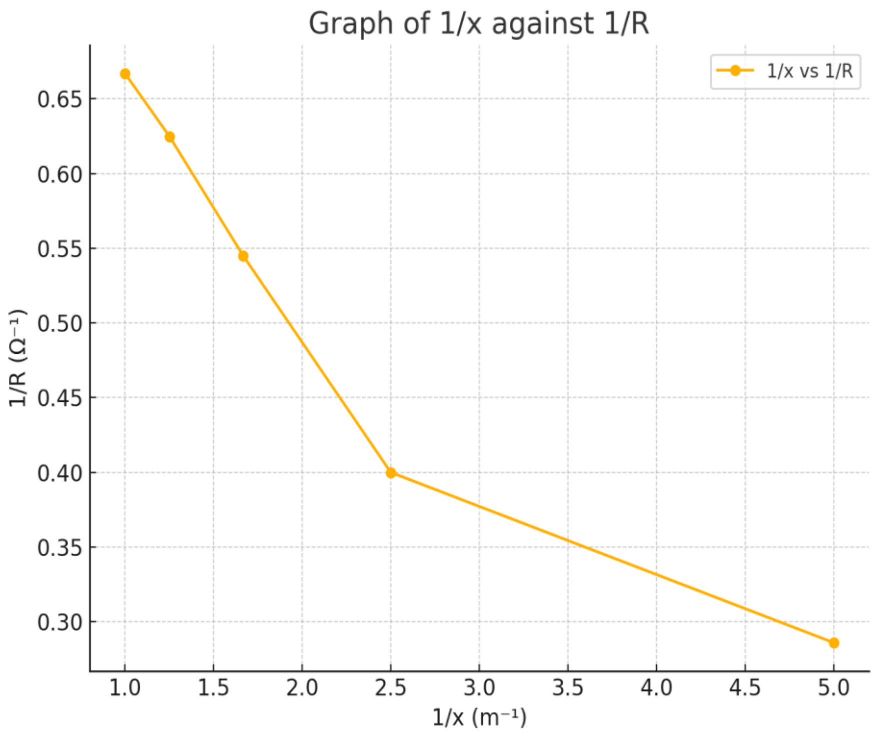
(c) Repeat for x = 0.8 m, 0.6 m, 0.4 m, and 0.2 m.

(i) Tabulate your results including values of x (m), 1/x (m^{-1}), L (cm), and 1/R (Ω^{-1}).

Assuming values:

x (m)	1/x (m^{-1})	L (cm)	1/R (Ω^{-1})
1.0	1.000	66.7	0.667
0.8	1.250	62.5	0.625
0.6	1.667	54.5	0.545
0.4	2.500	40.0	0.400
0.2	5.000	28.6	0.286

(ii) Plot a graph of 1/x against 1/R.



(iii) Determine the slope S.

Use points (1.0, 0.667) and (5.0, 0.286)
Slope = (0.286 - 0.667) / (5.0 - 1.0) = -0.381 / 4 = -0.0953

(iv) Deduce an equation that governs this experiment.

From Wheatstone bridge and parallel combination:
1/R = m/x
So equation becomes: 1/R = m (1/x)

(v) Compute the value of the unknown resistance R.

From slope m = 1/R → R = 1 / 0.667 = 1.5 Ω

(vi) Determine the specific resistance of the given wire W.

Use ρ = R A / L
Suppose $A = \pi r^2 = \pi (0.015)^2 = 0.000706\ cm^2$ and L = 100 cm
$\rho = 1.5 \times 0.000706 / 100 \approx 1.06 \times 10^{-5}\ \Omega cm$