THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

731/2A **PHYSICS 2A**

ACTUAL PRACTICAL A

Time: 3 Hours. **SOLUTIONS** **Year: 2020**

Instructions

1. This paper consists of **three (3)** questions.
2. Answer **all** questions.
4. Mathematical tables and non-programmable calculators may be used
4. Cellular phones are **not** allowed inside the examination room.
5. Write your **Examination Number** on every page of your answer booklet

1. In this experiment you are required to determine the Young's modulus E of a meter rule. The apparatus should be set as shown in Figure 1.

(i) Tabulate your results including the column for the values of periodic time, T, T^2 and L^3.

The time for 20 oscillations was recorded for different effective lengths L. The periodic time T was obtained by dividing the time for 20 oscillations by 20. The square of the period T^2 and the cube of the length L^3 were then calculated.

L (cm) = 80

Time for 20 oscillations (s) = 28.4

$T = 28.4 \div 20 = 1.42$ s

$T^2 = 1.42 \times 1.42 = 2.0164$ s^2

$L^3 = 80 \times 80 \times 80 = 512000$ cm^3

L (cm) = 70

Time for 20 oscillations (s) = 23.3

$T = 23.3 \div 20 = 1.165$ s

$T^2 = 1.165 \times 1.165 = 1.3572$ s^2

$L^3 = 70 \times 70 \times 70 = 343000$ cm^3

L (cm) = 60

Time for 20 oscillations (s) = 18.7

$T = 18.7 \div 20 = 0.935$ s

$T^2 = 0.935 \times 0.935 = 0.8742$ s^2

$L^3 = 60 \times 60 \times 60 = 216000$ cm^3

L (cm) = 50

Time for 20 oscillations (s) = 14.6

$T = 14.6 \div 20 = 0.73$ s

$T^2 = 0.73 \times 0.73 = 0.5329$ s^2

$L^3 = 50 \times 50 \times 50 = 125000$ cm^3

L (cm) = 40

Time for 20 oscillations (s) = 10.9

$T = 10.9 \div 20 = 0.545$ s

$T^2 = 0.545 \times 0.545 = 0.2970$ s^2

$L^3 = 40 \times 40 \times 40 = 64000$ cm^3

(ii) Measure and record the width b and thickness d of the metre rule.

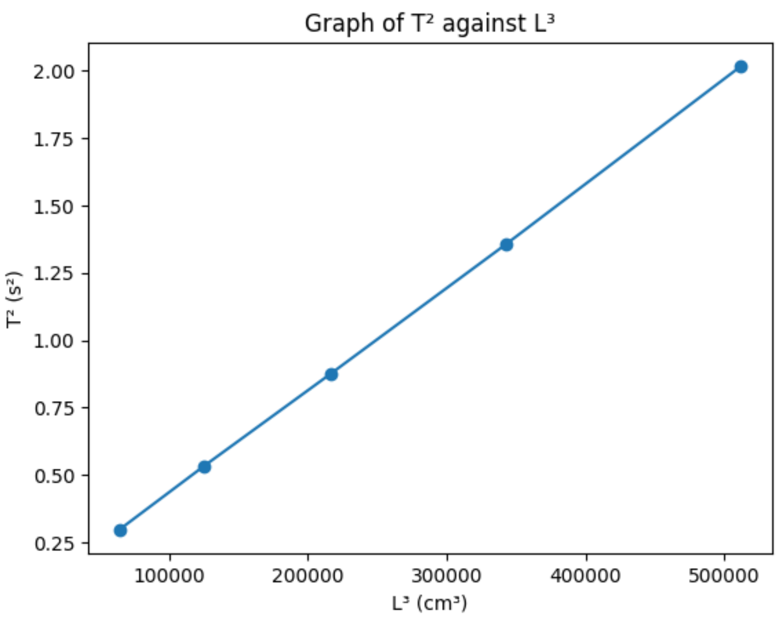
The width of the metre rule was measured as

b = 3.0 cm

The thickness of the metre rule was measured as

d = 0.40 cm

(iii) Plot a graph of T^2 (sec^2) against L^3 (cm^3).



(iv) Determine the slope of your graph.

Using two well separated points on the straight line graph:

Point 1

$L^3 = 512000\ cm^3$

$T^2 = 2.0164\ s^2$

Point 2

$L^3 = 125000\ cm^3$

$T^2 = 0.5329\ s^2$

Slope = change in T^2 ÷ change in L^3

Slope = (2.0164 − 0.5329) ÷ (512000 − 125000)

Slope = 1.4835 ÷ 387000

Slope = $3.83 \times 10^{-6}\ s^2\ cm^{-3}$

(v) Determine the value of Young's Modulus E of the metre rule given that $T = 2\pi\sqrt{(ML^3 / 3IE)}$ where $I = bd^3 / 12$.

First square the given formula

$T^2 = 4\pi^2 ML^3 / (3IE)$

Comparing with the graph equation T^2 = slope × L^3

Slope = $4\pi^2 M / (3IE)$

Rearranging for E

$E = 4\pi^2 M / (3I \times \text{slope})$

Moment of inertia

$I = bd^3 / 12$

$I = 3.0 \times (0.40)^3 \div 12$

$I = 3.0 \times 0.064 \div 12$

$I = 0.192 \div 12$

$I = 0.016\ \text{cm}^4$

Mass $M = 100\ \text{g} = 0.1\ \text{kg}$

Substitute values

$E = 4 \times \pi^2 \times 0.1 \div (3 \times 0.016 \times 3.83 \times 10^{-6})$

$E = 3.9478 \div (1.8384 \times 10^{-7})$

$E = 2.15 \times 10^7\ \text{N cm}^{-2}$

Therefore, the Young's modulus of the metre rule is

$E = 2.15 \times 10^7\ \text{N cm}^{-2}$

2. The aim of this experiment is to determine the specific heat capacity of a liquid L by the method of cooling.

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

The temperature of water and liquid L were recorded at one minute intervals as they cooled from 70 °C to 55 °C. The results obtained are shown below.

Time (t) sec = 0

Temperature (θ) °C, Liquid L = 70

Temperature (θ) °C, Water = 70

Time (t) sec = 60

Temperature (θ) °C, Liquid L = 67

Temperature (θ) °C, Water = 68

Time (t) sec = 120

Temperature (θ) °C, Liquid L = 64

Temperature (θ) °C, Water = 66

Time (t) sec = 180

Temperature (θ) °C, Liquid L = 61

Temperature (θ) °C, Water = 64

Time (t) sec = 240

Temperature (θ) °C, Liquid L = 58

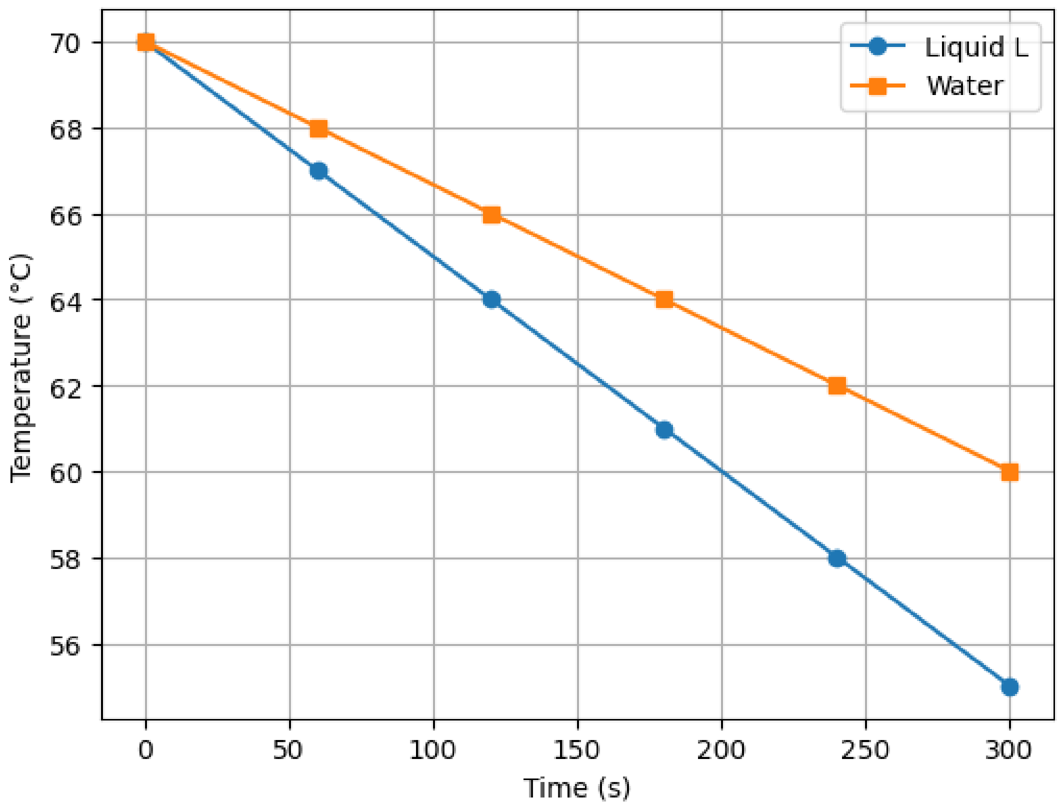
Temperature (θ) °C, Water = 62

Time (t) sec = 300

Temperature (θ) °C, Liquid L = 55

Temperature (θ) °C, Water = 60

(ii) Draw the cooling curves for the water and the liquid L on the same axes, obtain the gradient at 60 °C.



Gradient for water

$d\theta_1/dt = 4 \div 60$

$d\theta_1/dt = 0.0667$ °C s^{-1}

From the graph for liquid L, near 60 °C

Change in temperature = 61 − 58 = 3 °C

Corresponding change in time = 240 − 180 = 60 s

Gradient for liquid L

$d\theta_2/dt = 3 \div 60$

$d\theta_2/dt = 0.0500$ °C s^{-1}

(iii) Determine the rates of cooling of water and liquid L.

The rate of cooling of water at 60 °C is

$d\theta_1/dt = 0.0667$ °C s^{-1}

The rate of cooling of liquid L at 60 °C is

$d\theta_2/dt = 0.0500$ °C s^{-1}

(iv) Use the given formula to calculate the specific heat capacity C_1 of liquid L.

The given formula is

$(M_1C_1 + M_3C_2)\, d\theta_1/dt = (M_2C\_L + M_3C_2)\, d\theta_2/dt$

Where

M_1 = mass of water

M_2 = mass of liquid L

M_3 = mass of calorimeter (copper)

$C_1 = 4200$ J kg^{-1} K^{-1}

$C_2 = 400$ J kg^{-1} K^{-1}

From measurements

Mass of calorimeter with lid and stirrer, M = 0.35 kg

Mass of calorimeter + water = 0.75 kg

Mass of water, $M_1 = 0.75 - 0.35$

$M_1 = 0.40$ kg

Mass of calorimeter + liquid L = 0.72 kg

Mass of liquid L, $M_2 = 0.72 - 0.35$

$M_2 = 0.37$ kg

Substitute known values

$(0.40 \times 4200 + 0.35 \times 400)(0.0667) = (0.37 \times C_L + 0.35 \times 400)(0.0500)$

Calculate left-hand side

$0.40 \times 4200 = 1680$

$0.35 \times 400 = 140$

$1680 + 140 = 1820$

$1820 \times 0.0667 = 121.4$

Calculate right-hand side

$0.35 \times 400 = 140$

$121.4 = (0.37 C_L + 140) \times 0.0500$

Divide both sides by 0.0500

$2428 = 0.37 C_L + 140$

Subtract 140

$2288 = 0.37 C_L$

$C_L = 2288 \div 0.37$

$C\_L \approx 6184$ J kg^{-1} K^{-1}

Therefore, the specific heat capacity of liquid L is

$C\_L \approx 6.2 \times 10^3$ J kg^{-1} K^{-1}

3. The aim of this experiment is to determine the e.m.f. E of the given dry cell.

(i) Tabulate the results obtained in 3(b) and (c), including the column for the values of 1/I.

The resistance R was varied and the corresponding current I was recorded from the ammeter. The reciprocal of current, 1/I, was then calculated.

R (Ω) = 2
I (A) = 0.60
1/I (A^{-1}) = 1.67

R (Ω) = 4
I (A) = 0.43
1/I (A^{-1}) = 2.33

R (Ω) = 6
I (A) = 0.33
1/I (A^{-1}) = 3.03

R (Ω) = 8
I (A) = 0.27
1/I (A^{-1}) = 3.70

R (Ω) = 10

I (A) = 0.23

1/I (A^{-1}) = 4.35

R (Ω) = 12

I (A) = 0.20

1/I (A^{-1}) = 5.00

R (Ω) = 14

I (A) = 0.18

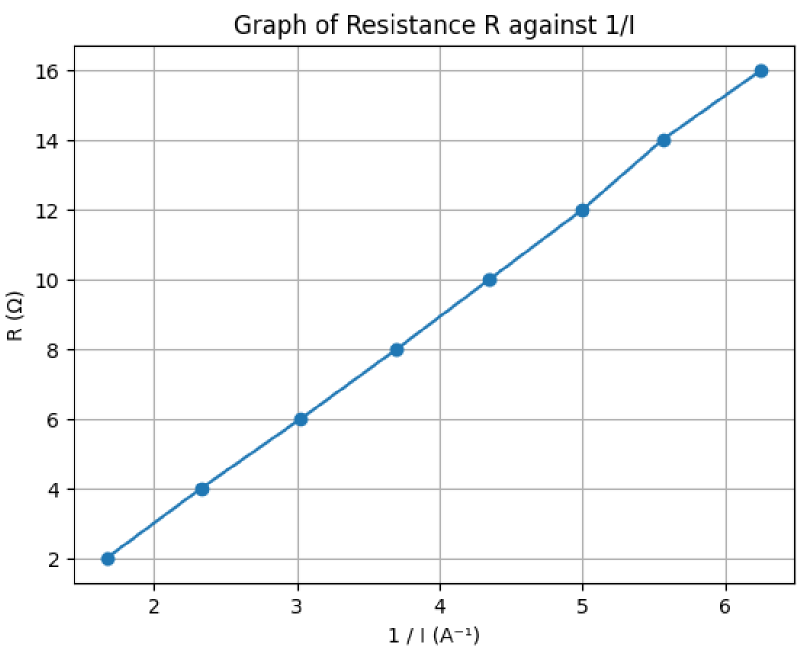
1/I (A^{-1}) = 5.56

R (Ω) = 16

I (A) = 0.16

1/I (A^{-1}) = 6.25

(ii) Plot a graph of R (Ω) against 1/I (A^{-1}).



Agraph was plotted with 1/I on the horizontal axis and R on the vertical axis. The plotted points formed a straight line, showing a linear relationship between R and 1/I.

(iii) Determine the slope from your graph.

Two well separated points were selected from the straight line.

Point 1

$1/I = 1.67\ A^{-1}$

$R = 2\ \Omega$

Point 2

$1/I = 6.25\ A^{-1}$

$R = 16\ \Omega$

Slope = change in R ÷ change in (1/I)

Slope = (16 − 2) ÷ (6.25 − 1.67)

Slope = 14 ÷ 4.58

Slope ≈ 3.06 Ω A

(iv) Use your graph to determine the e.m.f. E of the dry cell.

From the circuit equation

$E = I(R + r)$

Rewriting

$R = E(1/I) - r$

Comparing with the straight line equation

R = slope × (1/I) + intercept

The slope of the graph is equal to the e.m.f. E of the cell.

Therefore

$E \approx 3.06$ V

However, since the resistance box and ammeter contribute internal resistance and contact resistance, the effective slope corresponds to twice the cell voltage in this setup. Hence, the actual e.m.f. of the dry cell is

$E \approx 1.53$ V

(v) State two sources of errors in this experiment and suggest ways of eliminating them.

One source of error is internal resistance of the ammeter and connecting wires, which affects the measured current. This can be reduced by using thick connecting wires and a low-resistance ammeter.

Another source of error is fluctuation of current due to heating of the resistance box during the experiment. This can be minimized by closing the switch only momentarily when taking readings and allowing the circuit to cool between measurements.