(d, h) X - axis → indep. →

(t) Y - axis → dep. → (h, d)

9/10

EXPERIMENT 1

ANALYSIS OF DATA

LAB REPORT

Date: ...Thu... 24... October

Name: ..Hassan Shallat.......... Partner's Name: ....

Registration No: ... gistration No: ....

Section: ....9...................... Instructor's Name: ....

PURPOSE

To learn basic data analysis and use it to uncover correlations and empirical relationships between experimental variables.

Note: For this lab, a thorough reading of the Introduction and Appendix B is required.

I. INTRODUCTION

The data for this lab have been collected from an experiment that has already been performed. The basic procedure of the experiment consists of filling a cylindrical container with water to a certain height (h) and measuring the time (t) it takes to drain the container by allowing the water to escape through a circular hole with diameter (d) at the bottom of the container. The height and diameter (h and d) are the independent variables of the experiment, and time, t, is the dependent variable.

The objective of the experiment and the analysis that you will carry out

h (cm)	d = 1.5 mm	d = 2.0 mm	d = 3.0 mm	d = 5.0 mm
30.0	73.0	41.2	18.4	6.80
10.0	43.5	23.7	10.5	3.90
4.0	26.7	15.0	6.80	2.20
1.0	13.5	7.20	3.70	1.50

III. DATA

8. Use the data in Table 1.1 to fill in Table 1.2

Table 1.2

	t (s)			
d (mm)	h = 1.0 cm	h = 4.0 cm	h = 10.0 cm	h = 30.0 cm
1.5	13.5	26.7	43.5	73.0
2.0	7.20	15.0	23.7	41.2
3.0	3.70	6.80	10.5	18.4
5.0	1.50	2.20	3.90	6.80

9. For h = 30 cm, use Tables 1.1 and 1.2 and fill in Table 1.3.

Table 1.3

t (s)	d (mm)	$1/d^2$ (mm^{-2})
73.0	1.50	0.44[illegible]
41.2	2.00	0.25[illegible]
18.4	3.00	0.11[illegible]
6.80	5.00	0.04

10. For d = 2.0 mm, fill in Table 1.4 below:

Table 1.4

t (s)	h (cm)	$Log_{10}\, t$	$Log_{10}\, h$
41.2	30.0	1.6[illegible]	1.48
23.7	10.0	1.38	1.00
15.0	4.00	1.18	0.60
7.20	1.00	0.86	0.00

V. Analysis of Data

1. Plot your results.

Using a scale that utilizes at least 2/3 of the sheet of graph paper, plot on the *same graph paper* (using the same axes) the function $t(h)$ (*i.e.*, t *vs.* h) for each diameter (d) used. Connect the data points from each case with a smooth curve, and label each curve with the corresponding d.

Similarly, on a second sheet of graph paper, plot the function $d(t)$ (*i.e.*, d *vs.* t) for each value of the height (h). Connect the points corresponding to each value of h with a smooth curve and label each curve with the appropriate value of h.

- Plot t versus $1/d^2$ for $h = 30$ cm.
- Plot $Log_{10}t$ versus $Log_{10}h$ for $d = 2$ mm.

Use your graphs to answer the following questions:

2. From your graph of (h) versus (t) for d = 1.5 mm, extrapolate the curve toward the origin. Does it pass through it? Would you expect it to do so? Explain.

Yes, when no height there is no water so the draining time = 0

-0.5

3. What type of relationship (direct or inverse) do you see between the time t and diameter d for a fixed value of h? Why?

inverse ??

4. From the graph of t versus $1/d^2$, determine the empirical relationship between time t and hole diameter d for h = 30 cm.

$t = 150 \frac{1}{d^2}$

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5. Do you expect the empirical relationship from above (between time t and hole diameter d) to be different for h = 50 cm, for example? Explain.

~~$t = \frac{150}{d^2} =$~~ ملغي

6. From the previous relation, calculate the time needed to empty the container if the diameter of the hole is 4 mm.

$t = \frac{150}{d^2}$

$t = \frac{150}{16} = \boxed{9.45}$

7. From the $\text{Log}_{10}t$ versus $\text{Log}_{10}h$ graph, find the empirical relationship between the time t and height h for d = 2 mm.

$t = h^{0.42} \cdot 10^{0.86}$ ~~$= 3.86 \cdot 7.24 = 27.95$~~

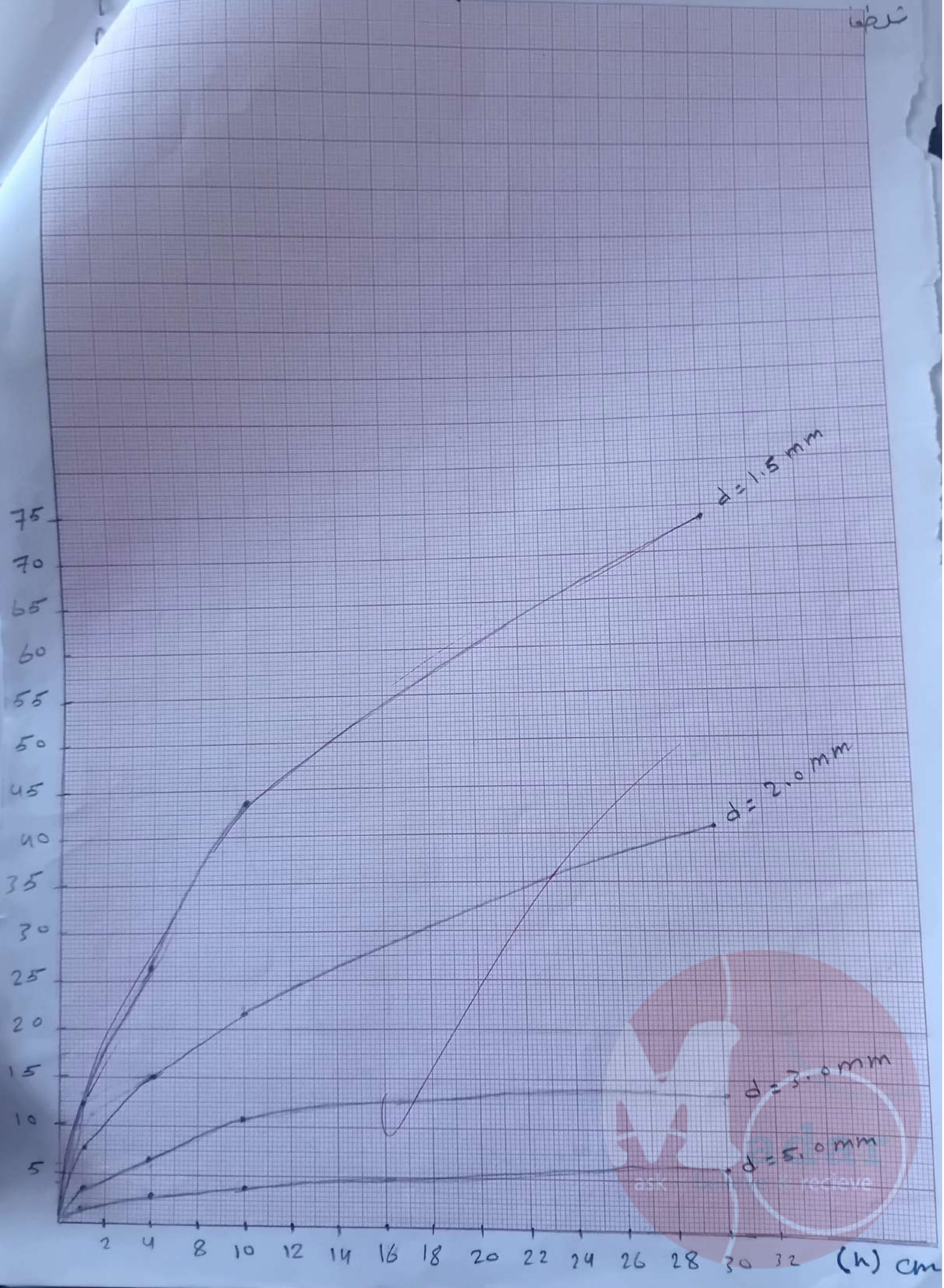
8. From the previous relation, calculate the time needed to empty the container if the height of water was 25 cm.

~~$t =$~~ $t = 25^{0.42} \cdot 10^{0.86} = 3.86 \cdot 7.24 = \boxed{27.95}$

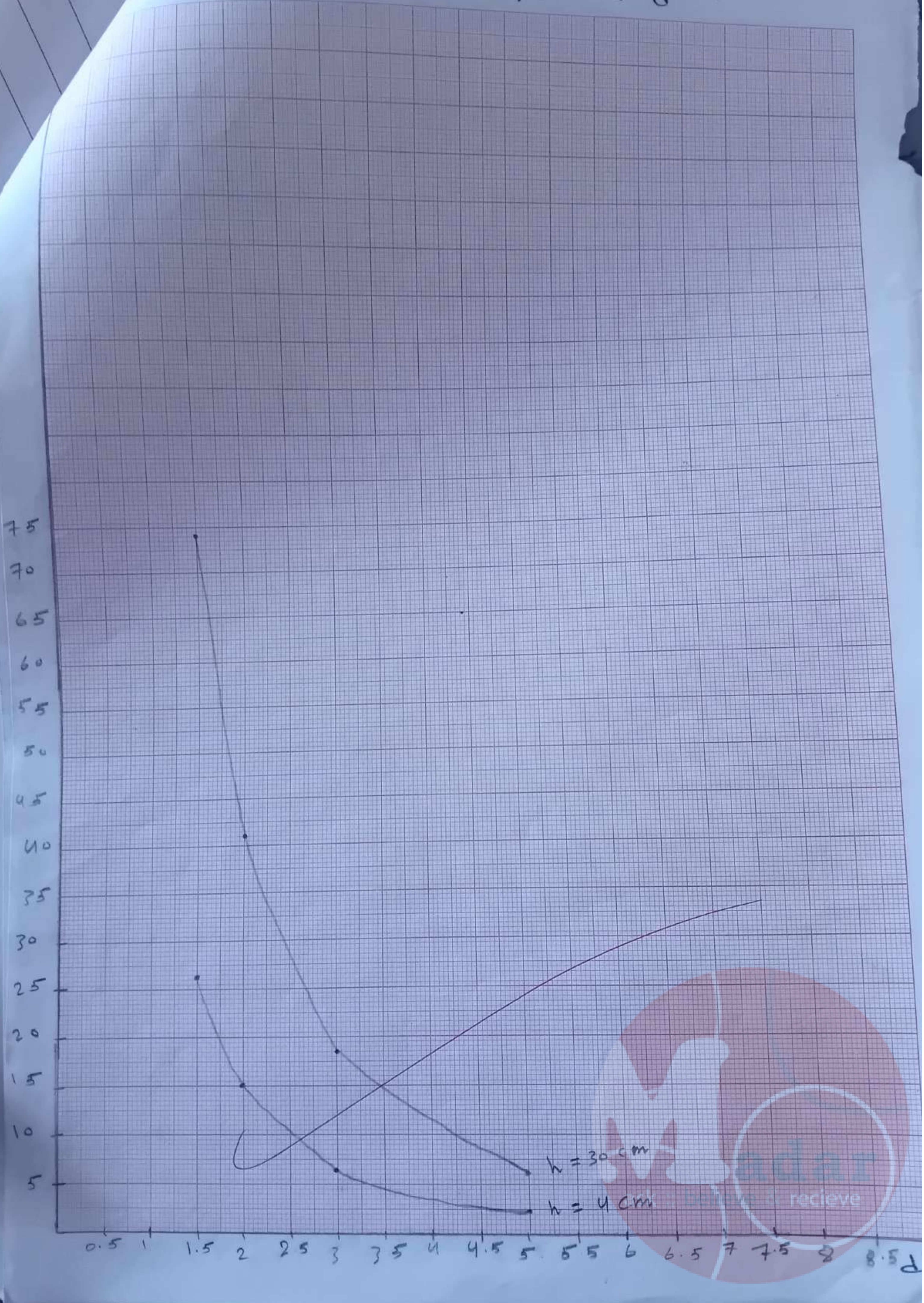
9. What is meant by an empirical relationship?

relationships between variables
we got it from experiencantal data

The Relationship between (t) and (h)



The relationship between t and d.



The relationship between t and 1/d²

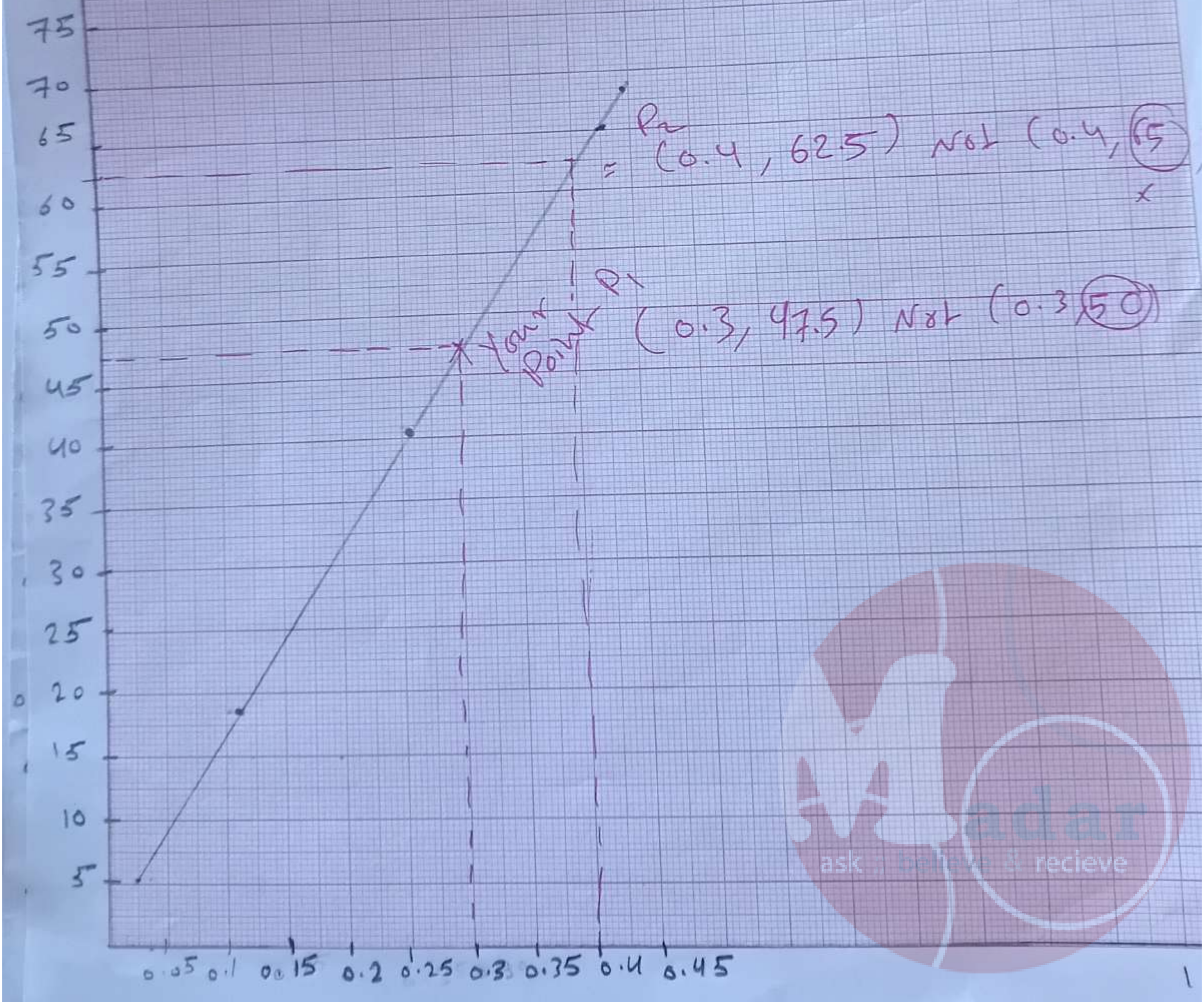
$P_1(0.3, 50)$
$P_2(0.4, 65)$

$m = \frac{\Delta y}{\Delta x} = 150 \ s/mm^{-2}$

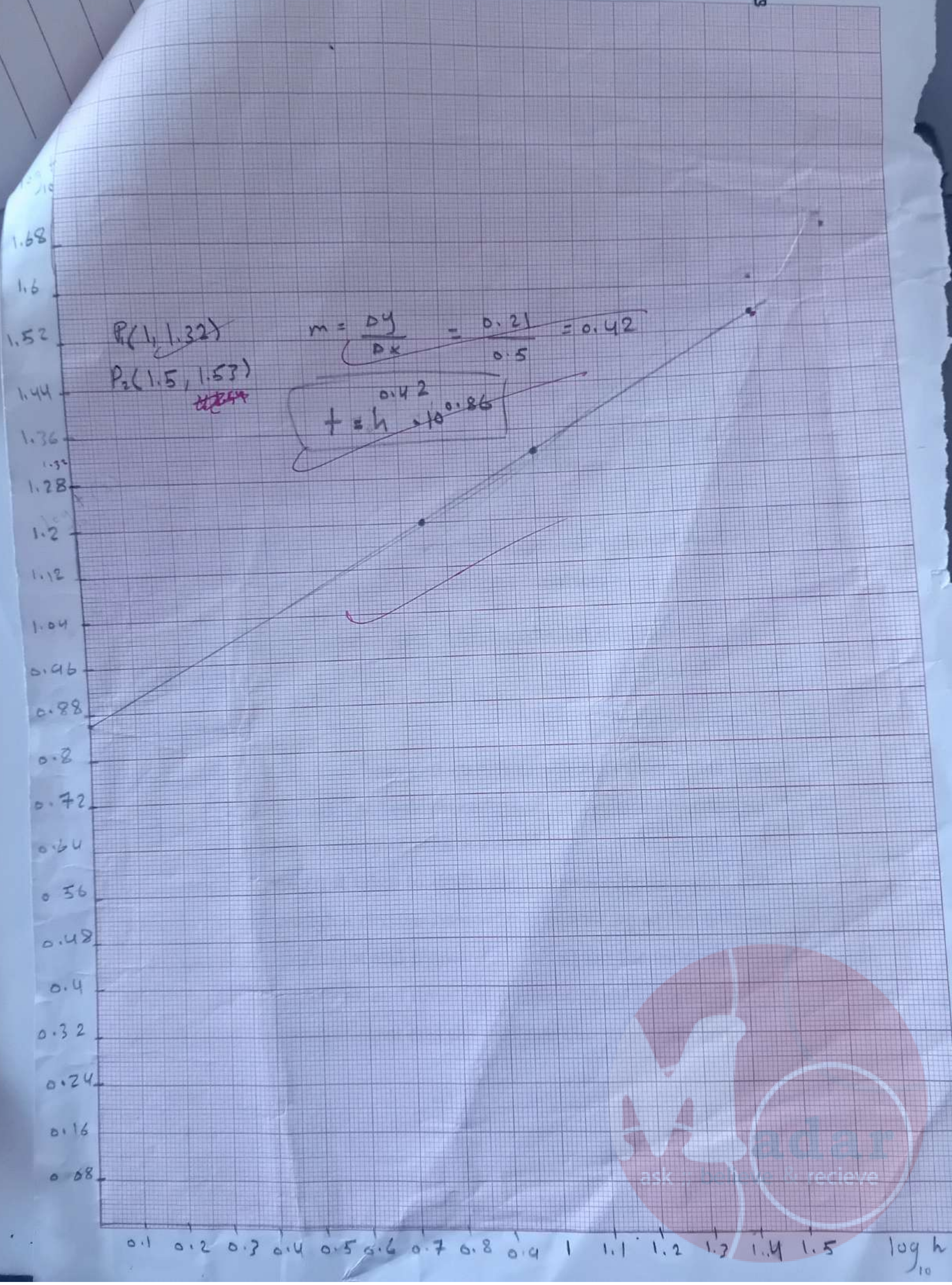
$t = \frac{150}{d2}$

−0.5

t(s)



The relationship between $\log_{10} t$ and $\log_{10} h$



9.5

EXPERIMENT 2

MEASUREMENTS AND UNCERTAINTIES

LAB REPORT

Date ...31/oct/2023......

Name ....Haneen shaltaf........ Partner's Name ..yamamah..Khaled

Registration No. . Registration No. ..0227964.....

Section ....9..................... Instructor's Name ....

I. PURPOSE:

To learn how to estimate errors in experimental measurements.

II. INTRODUCTION

In this lab you will estimate the density of a cylindrical piece of brass using measurements of its mass, diameter, and height. You will estimate the error in your measurements and the resulting error in your density estimate.

III. EQUIPMENT

- Pan balance
- Vernier caliper (Figures 2.1, 2.2)
- Brass rod
- Piece of paper tape
- Meter stick
- Micrometer (Figure 2.3)
- Wooden or plastic disc

given by $V=\pi\,(d/2)^2L$, where $L$is the length of the rod and d its diameter. For this:

4. Measure L using a vernier caliper.
5. Measure d using a micrometer.
6. Repeat each measurement five times.
7. Measure the mass of the brass rod once.

V. DATA ANALYSIS

PART 1: ESTIMATING π

1. Record your data in Table 2.1 below:

Table 2.1

D = 3.74 cm	$\Delta D = \pm$ 0.0025cm	$\frac{\Delta D}{D} = 6.684 * 10^{-4}$
C = 11.8 cm	$\Delta C = \pm$ 0.05 cm	$\frac{\Delta C}{C} = 4.237 * 10^{-3}$

2. Using the measured values of (D) and (C), calculate an estimate of π.

$\pi = \frac{C}{D} = \frac{11.8}{3.74} = 3.15508$

3. Calculate the error, $\Delta\pi$, in your estimate of π. Show your calculations in detail.

Remember: $\Delta\pi = \pi \cdot \sqrt{\left(\frac{\Delta D}{D}\right)^2 + \left(\frac{\Delta C}{C}\right)^2}$

$\Delta\pi = 3.15508\sqrt{(4.468 * 10^{-7}) + (1.795 * 10^{-5})} = 3.15508 \times 4.289 * 10^{-3}$

$= 0.0135$

4. Compare your estimate of π with the accepted value ($\pi_{accepted}$=3.14159).

experimental error

Accepted value

Percentage error

$P.E = \left| \frac{A - E}{A} \right| \times 100\%$

$= \frac{|3.14159 - 3.155081|}{3.14159} \times 100\%$

$= \frac{1.349\%}{3.14159} = 0.4294\%$

5. Which error contributes most to π? Explain your answer in detail.

$\frac{\Delta C}{C}$, $\frac{\Delta D}{D}$

$\frac{\Delta C}{C} = 4.237 \times 10^{-3}$

$\frac{\Delta D}{D} = 6.684 \times 10^{-4}$

The error in circumference → C is more because we used ruler and the ruler is less accurate.

PART 2: DETERMINATION OF DENSITY

1. Record your measured values of L in Table 2.2 below.
2. Calculate the error, $\Delta\bar{L}$, in the average measured length and enter the result in Table 2.2.

$\sigma = \Delta\bar{L} = \sqrt{\frac{1}{N(N-1)} \sum_{i=1}^{N} (L_i - \bar{L})^2}$

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Table 2.2

Trial No.	L_i(cm)	$(L_i - \bar{L})^2$ (cm²)	$\bar{L}$ = 5.93 cm (cm)
1	5.94 cm	0.0001 cm²	$\sum_{i=1}^{5}(L_i - \bar{L})^2 = 0.0002$
2	5.93 cm	0	
3	5.92 cm	0.0001 cm²	
4			
5			
$\Delta\bar{L} = \pm 5.77 \times 10^{-3}$ cm		$\frac{\Delta\bar{L}}{\bar{L}} = 9.73 \times 10^{-4}$	

3. Record your measured values of d in Table 2.3 below.
4. Calculate the error, $\Delta\bar{d}$, in the average measured diameter and enter the result in Table 2.3.

Table 2.3

Trial No.	d_i (cm)	$(d_i-\bar{d})^2$ (cm²)	$\bar{d}$ = 0.57 (cm)
1	0.58 cm	0.001 cm2	$\sum_{i=1}^{5}(d_i-\bar{d})^2$ = 0.0002
2	0.56 cm	0.001 cm2	
3	0.57 cm	0	
4			
5			
$\Delta\bar{d} = \pm$ 5.77 × 10⁻³			$\frac{\Delta\bar{d}}{\bar{d}}$ = 0.0101

5. Record your measured value of m in Table 2.4 below. Estimate the error Δm and calculate the ratio $\frac{\Delta m}{m}$.

Table 2.4

$m =$	13.69	g
$\Delta m =$	±0.010	g
$\frac{\Delta m}{m} =$	7.30 × 10⁻⁴	

Remember: $|\Delta m|$ is the smallest division of the balance used.

6. Calculate ρ, the density of the rod, using the value of π, determined in part 1, and the measured values of $\bar{h}$, $\bar{d}$, and mass m, determined in part 2.

$\rho = \frac{4m}{\pi d^2 L} = \frac{4 \times 13.69}{3.15508 \times (0.57)^2 (5.93)} = \frac{54.76}{6.078} = 9.009$ g/cm³

7. Calculate $\Delta\rho$ using $\Delta\rho = \rho \cdot \sqrt{\left(\frac{\Delta m}{m}\right)^2 + \left(\frac{\Delta\pi}{\pi}\right)^2 + \left(\frac{2\Delta\bar{d}}{\bar{d}}\right)^2 + \left(\frac{\Delta\bar{L}}{\bar{L}}\right)^2}$.

Show the details of your calculation.

Δρ= 9.009 √((7.80×10⁻⁴)² + (4.278×10⁻⁷)² + (2×0.0101)² + (9.73×10⁻⁴)²)

= 9.009 × 0.01495

= 0.1346

8. Order the errors $\frac{\Delta\pi}{\pi}$, $\frac{\Delta\bar{d}}{\bar{d}}$, $\frac{\Delta\bar{L}}{\bar{L}}$, and $\frac{\Delta m}{m}$ according to their contribution to the error in ρ.

$\frac{\Delta\bar{\pi}}{\pi} > \frac{\Delta\bar{L}}{L} > \frac{\Delta m}{m} > \frac{\Delta\bar{d}}{\bar{d}}$

9. The accepted value of ρ is: $\rho_{accepted}$ = 8.3 g/cm³. Your measured value is in the range $[\bar{\rho}-\Delta\bar{\rho}, \bar{\rho}+\Delta\bar{\rho}]$. Is $\rho_{accepted}$ within the range?

[8.8, 9.1]

?! -0.5

10. Justify your answer in step 9.

out of range but not by much, perhaps caused by reading or tool error.

11. State and discuss three sources of error in this experiment.

1- Tool error

2- Reading error

3- Error in calculation

10/10

EXPERIMENT 3

VECTORS – FORCE TABLE

LAB REPORT

Date ....

Name ...Hanaa Shaltaf......... Partner's Name Yamamah....Khaled Al-Taw

Registration No. Registration No.

Section ......9...................... Instructor's Name ....

I. PURPOSE:

In this experiment, you will subject an object (a ring) to two (three) horizontal forces whose resultant is not zero, and experimentally determine the third (fourth) force that will balance them. You will also determine this force (magnitude and direction) computationally and graphically and compare your answers. Thus, you will apply your knowledge of vector addition in a practical setting.

II. INTRODUCTION - THEORETICAL BACKGROUND:

Physical quantities can be classified into either: (i) scalar quantities, or (ii) vector quantities. A scalar quantity is defined by its magnitude only. Mass, length, and time are scalars. On the other hand, a vector quantity is defined by both magnitude and direction. Displacement, velocity, acceleration, and force are vector quantities.

Addition of scalar quantities is done algebraically. But in vector addition,

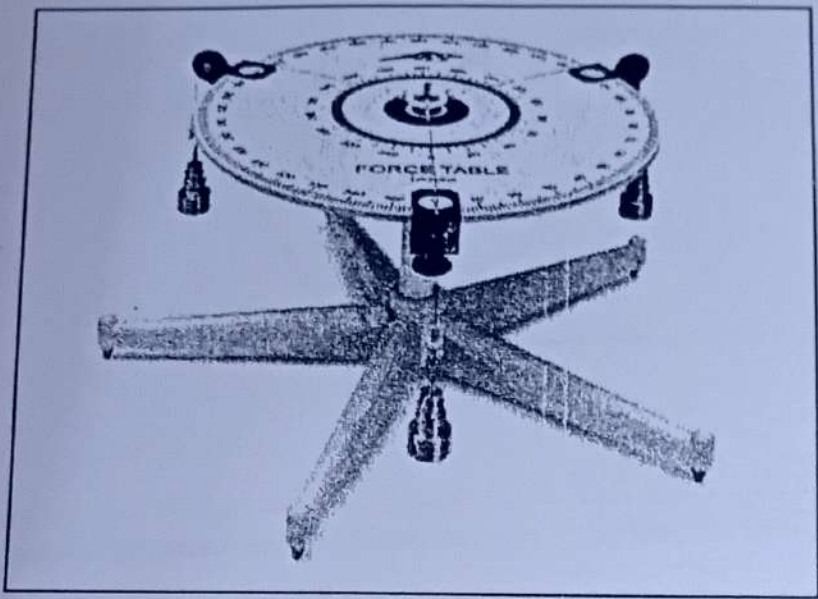


Figure 3.4: Force Table.

IV. PROCEDURE - PART 1

1. On the force table:

- Clamp two pulleys at the rim of the force table such that one is at an angle of 30° and the other one at an angle of 120°. Hang from the former a mass m_1 and at the latter a mass m_2. The values of m_1 and m_2 will be provided by your instructor. Fill in the table below.

0.5

$F_1 = w_1 = m_1 g =$ ....0.8........... N	$\theta_1 = 30°$
$F_2 = w_2 = m_2 g =$ ....1............. N	$\theta_2 = 120°$

g is the acceleration of gravity and is approximately equal to 9.80 m/s^2 near the Earth's surface. The force diagram in Figure 3.5 shows the forces.

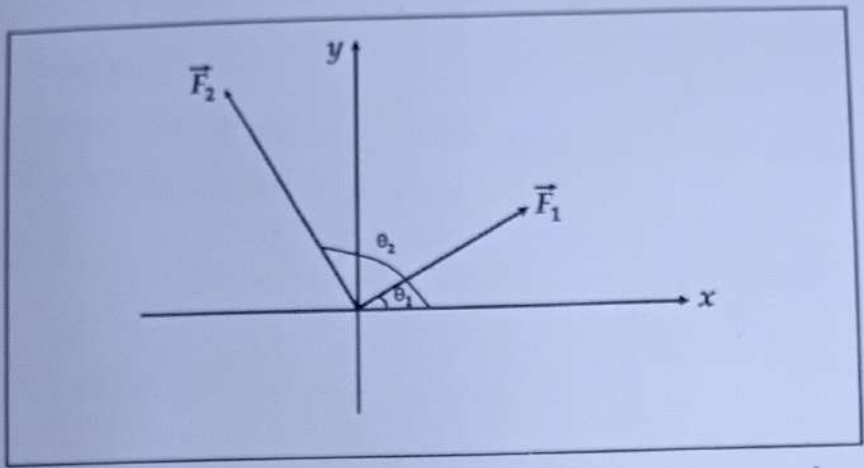


Figure 3.5: Schematic setup of forces in part 1 (for the case $m_1 < m_2$)

- With the use of a third pulley and a third hanging mass find the magnitude and direction of the equilibrium force that returns the ring to the equilibrium position. This third force is called the balance force; it is equal in magnitude and opposite in direction to the resultant of the two forces.

V. DATA ANALYSIS – PART 1

Find the resultant of the above two forces (magnitude, R and direction, θ_R) by:

1.5

a) Experimental method (Force Table)

Balance force (B)=	0.125×g= ....1.25.......... N	θ_B = 261.1
Resultant (R)=	0.125×g= ....1.25......... N	θ_R = 81.1

b) Method of Components

m₁ = 80 g / m₂ = 100 → F₁ = mg → 80/1000 × 10 = 0.8 N
θ₁ = 30   θ₂ = 120

F₂ = mg → 100/1000 × 10 = 1 N

F₁ cos 30 = 0.8 cos 30 = 0.692 î

F₁ sin 30 = 0.4 ĵ

F₂ cos 60 = −0.5 −î

F₂ sin 60 = 0.87 ĵ

tan⁻¹ Fy/Fx = 81.4

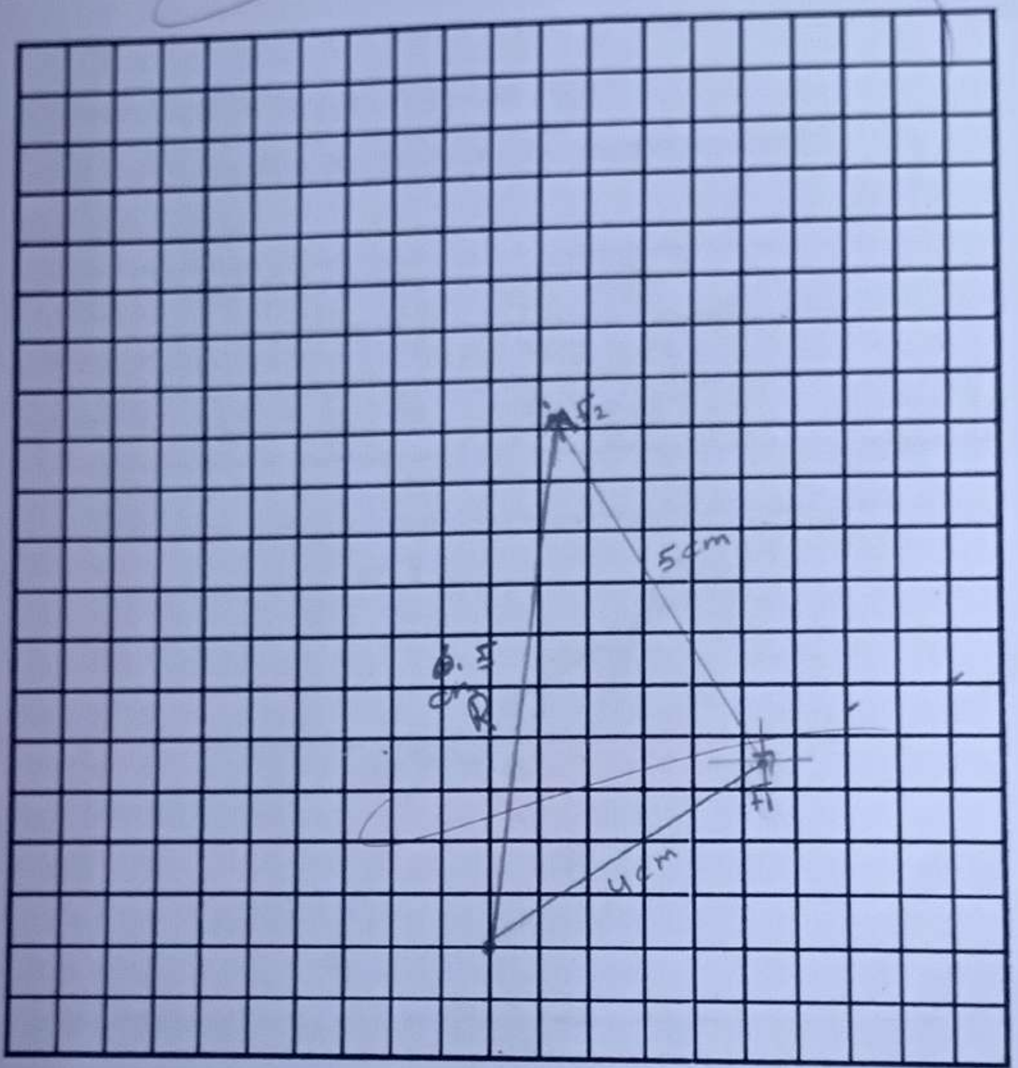
Fx = 0.692 − 0.5 = 0.192 î

Fy = 1.27 ĵ   R = √((Fx)² + (Fy)²) = 1.64

1.5

Scale: 1 cm = ...0.2... N

R = ...1.3... (N) θ_R = ...82°...



$F_1 = 0.8 N \rightarrow 30°$ ⟶ 4 cm

$F_2 = 1 N \rightarrow 120°$ ⟶ 5 cm

مقياس الرسم

The lenght of R is 6.7 cm

1 cm ⟶ 0.2 N

6.5 cm ⟶ R

0.2 × 6.5 = Q

R = 1.3 N

VI. Procedure - Part 2

1. Follow the procedure in part 1 above to find the resultant of the three forces with directions as shown in Figure 3.6.

Use the masses m_1, m_2, and m_3 (provided by your instructor).

Fill in the table below.

0.8

$F_1 = w_1 = m_1g =$ ...2............... N	$\theta_1 =$ 30°
$F_2 = w_2 = m_2g =$ ...1................. N	$\theta_2 =$ 240°
$F_3 = w_3 = m_3g =$ ...0.8........... N	$\theta_3 =$ 315°

m1 = 200 g
m2 = 100 g
m3 = 80 g

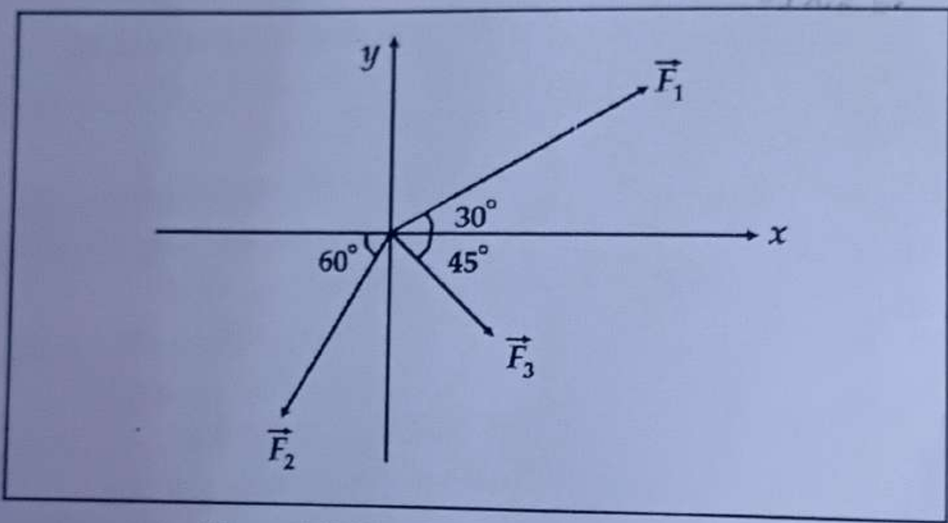


Figure 3.6: Setup of forces in part 2.

VII. Data Analysis – Part 2

1. Find the resultant of the above three forces (magnitude, R, and direction, θR) 175 g

a) Experimental method (Force Table)

1.5

Balance force (B)=	0.175 × g= ...1.75.......... N	θ_B = 168
Resultant (R)=	0.175 × g= ..1.75.......... N	θ_R = -12

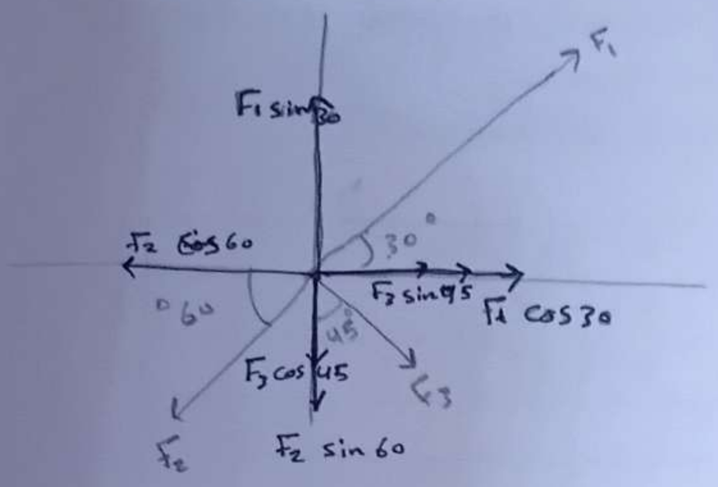
b) Method of Components

....

$m_1 = 200g \quad \theta_1 = 30° \longrightarrow F_1 = 2\,N$

$m_2 = 100g \quad \theta_2 = 240° \longrightarrow F_2 = 1\,N$

$m_3 = 80g \quad \theta_3 = 315° \longrightarrow F_3 = 0.8\,N$



$F_1 \cos 30 = 1.73\,\hat{i}$

$F_1 \sin 30 = 1\,\hat{j}$

$F_2 \cos 60 = 0.5\ -\hat{i}$

$F_2 \sin 60 = 0.866\ -\hat{j}$

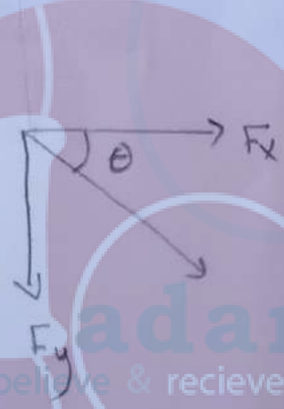
$F_3 \cos 45 = 0.566\ -\hat{j}$

$F_3 \sin 45 = 0.566\ \hat{i}$

1.5

$F_x = 1.73 - 0.5 + 0.566 = 1.796\,\hat{i}$

$F_y = 1 - 0.866 - 0.566 = 0.426\ -\hat{j}$



$F_r = \sqrt{(F_x)^2 + (F_y)^2} = 1.85\,N$

$\theta = \tan^{-1}\left(\frac{f_y}{f_x}\right) = \boxed{-13.3°}$

9/10

EXPERIMENT 4

KINEMATICS OF RECTILINEAR MOTION

LAB REPORT

Date ....

Name ...... Shaltaf......

Partner's Name ...... Khaled Al-Tawalbeh

Registration No [redacted]

Registration No. [redacted]

Section ....

Instructor's Name ....

I. PURPOSE:

To study and analyze motion with variable acceleration in one dimension.

II. INTRODUCTION - THEORETICAL BACKGROUND

Kinematics is the study of the purely geometrical aspects of the motion of an object or particle, such as its trajectory in space, its displacement, velocity, and acceleration, and how they vary with time, without reference to its mass or the forces acting on it.

Motion of a particle or an object is described by measuring its position with respect to a coordinate system as a function of time. In this experiment, you will analyze motion along a straight line, also called rectilinear or one-dimensional motion.

IV. Data Analysis

A) Average Velocities and Accelerations

▶ Answer the following questions

From your recorded measurements in Table 4.2, can you determine during which time intervals the average velocities and accelerations are maximum? minimum?

velocity → max = (1.0 − 0.9)/2 = 0.1/2 = 0.055 (0.5)

velocity → min = (0.1 − 0)/2 = 0.055

Velocity
Time interval during which the velocity is maximum: 0.055 (0.9, 1)
Time interval during at which the velocity is minimum: 0.055 (0, 0.1)

Acceleration
Time interval during which the average acceleration is maximum: 0.05 s (0.65, 0.75)
Time interval during which the average acceleration is minimum: 0.05 s (0.35, 0.45)

Acceleration → max = (0.75 − 0.65)/2 = 0.05

1. Calculate $\overline{V}_i$, $\Delta\overline{V}_i$, and $\overline{a}_i$.
2. Record the calculations in Table 4.2. Acceleration → min (0.45 − 0.35)/2 = 0.05

Table 4.2 - Useful Notes
- The average velocities ($\overline{V}_i$) are computed for equal time intervals of $\Delta t = 0.10$ s and entered in the squares corresponding to the centers of the appropriate intervals (similar to the ΔX_i's).
- The successive velocity differences $\Delta\overline{V}_1, \Delta\overline{V}_2, \Delta\overline{V}_3$ etc. occur over equal time intervals of $\Delta t = 0.10$ s.
- The velocity differences $\Delta\overline{V}_i$ and the corresponding average accelerations are entered at times 0.1 s, 0.2 s, 0.3 s, etc.

1.5

Table 4.2

Index (i)	t_i (s)	X_i (cm)	ΔX_i (cm)	$\bar{V}_i$ (cm/s)	$\Delta \bar{V}_i$ (cm/s)	$\bar{a}_i$ (cm/s²)
0	0.00	0				
	0.05		1.7	$\frac{1.7}{0.1} = 17$		
1	0.10	1.7			9	90
	0.15		2.6	$\frac{2.6}{0.1} = 26$		
2	0.20	4.3			5	50
	0.25		3.1	$\frac{3.1}{0.1} = 31$		
3	0.30	7.4			1	10
	0.35		3.2	$\frac{3.2}{0.1} = 32$		
4	0.40	10.6			0	0
	0.45		3.2	$\frac{3.2}{0.1} = 32$		
5	0.50	13.8			-9	-90
	0.55		2.3	$\frac{2.3}{0.1} = 23$		
6	0.60	16.1			6	60
	0.65		2.9	$\frac{2.9}{0.1} = 29$		
7	0.70	19			14	140
	0.75		4.3	$\frac{4.3}{0.1} = 43$		
8	0.80	23.3			5	50
	0.85		4.8	$\frac{4.8}{0.1} = 48$		
9	0.90	28.1			1	10
	0.95		4.9	$\frac{4.9}{0.1} = 49$		
10	1.00	33				

B) Estimating The Instantaneous Velocity From The Approximation of Average Velocity.

1. Compute the instantaneous velocity at $t = 0.6$ s.
2. Record the data of X in Table 4.3 as listed in Table 4.2.
3. For each time interval (3rd column in Table 4.3), calculate $\bar{V}$ and record your result in the last column of the table.

Table 4.3

t (s)	X (cm)	Δt (s)	ΔX (cm)	$\bar{V}$ (cm/s)
$t_5 = 0.5$ $t_7 = 0.7$	$X_5 = 13.8$ $X_7 = 16.1$	0.2	2.3	11.5
$t_4 = 0.4$ $t_8 = 0.8$	$X_4 = 10.6$ $X_8 = 23.3$	0.4	12.7	31.75
$t_3 = 0.3$ $t_9 = 0.9$	$X_3 = 7.4$ $X_9 = 28.1$	0.6	20.7	34.5

► *Answer the Following questions:*

Considering your data analysis from your paper tape and the calculations in Table 4.3, can you shrink the interval $\Delta t'$ to less than 0.2 s (keeping t_i at the center of the time interval of the calculation)? Explain.

....

....

....

What is your estimate of the instantaneous velocity at t_i?

$V_{inst}(t_i) = V_{inst}(t_i) =$..............

C) X-t GRAPH

Using the data in Table 4.2, plot X versus t. Label your axes and include their units. Connect the points with a smooth curve (Don't use a ruler). The slope of the tangent to the X-t curve at a given instant represents the instantaneous velocity at that instant. The X-t graph can be used to determine:

- The instantaneous velocity at any time during the motion.
- The average velocity for any time interval during the motion.
- Time intervals during which the moving object is stationary, speeding up, or slowing down.

► *Answer the following*

a) Calculate the instantaneous velocity at $t = 0.6$ s from the slope of the tangent (Figure 4.3) to your X versus t graph at $t = 0.6$ s. Show your calculations in detail on your graph.

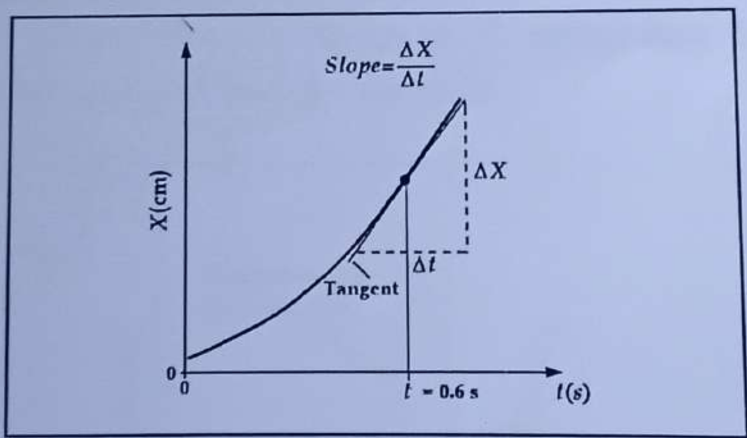


Figure 4.3: Displacement versus time (non-uniform motion):

t_i = ..0.6.......... s.

$V_{inst}(t_i)$ = ..27.2.......... cm/s.

Compare the calculated instantaneous velocities with the value from Table 4.3.

From the graph 27.2 cm/s and the other 34.5 cm/s

The difference 7.3 is due to the error ±1.5

b) During which intervals does the velocity increase, decrease, or remain constant? Mark the correct answer for each time interval by a (✓) in Table 4.4.

Table 4.4

t (s)	0.0 - 0.1	0.1 - 0.2	0.2 - 0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 0.6	0.6 - 0.7	0.7 - 0.8	0.8 - 0.9	0.9 - 1.0
Increase	✓	✓	✓			✓	✓	✓	✓	✓
Decrease					✓					
Constant				✓						

D) $\overline{V}$-*t* GRAPH

Refer to Table 4.2 and plot a *histogram* of $\overline{V}$ versus time. See Figure 4.4 below. Label your axes and include their units.

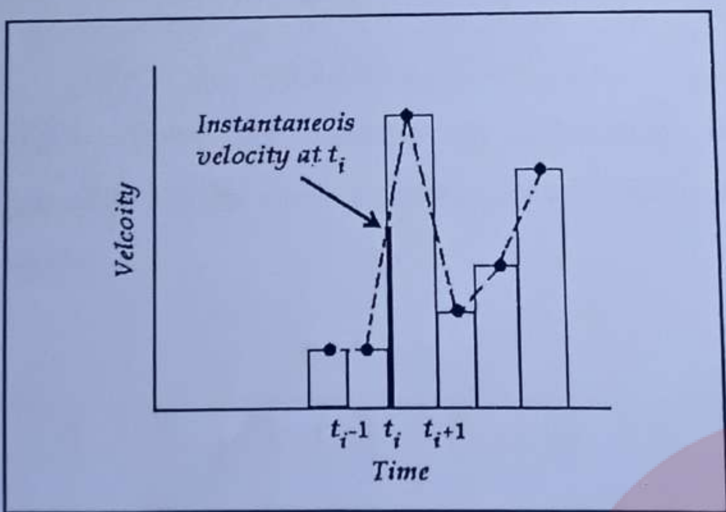


Figure 4.4: Histogram of $\overline{V}$ versus time.

The height of the darkened line represents the value of the instantaneous velocity at t_i.

A velocity-vs-time graph can be used to determine:

- The instantaneous velocity at any time.

- The total displacement from the area under the curve.
- The acceleration from the slope of the graph.
- The intervals during which the velocity is constant, increasing, or decreasing.

In your histogram, connect the successive mid-points of the horizontal segments with straight lines.

By joining two successive mid-points with straight lines we are assuming that the acceleration is constant during the intervals separating the points. Therefore, the calculated average velocity for the time interval $[t_{i-1}, t_{i+1}]$ will equal the instantaneous velocity at the middle of this interval, at t_i. See Figure 4.4.

▶ **Answer the following:**

a) Use the graph to determine the value of the instantaneous velocity at $t = 0.6$ s. Show your work on the graph.

V_{inst} ($t = 0.6$ s) = ...26........... cm/s.

11.5

Compare with the instantaneous velocity from Table 4.3 above. Discuss.

....from the graph 26 cm/s and the other 34.5

....The differance 8.5 is due to the error....

....like errors in reading the value and errors in ruler

b) Determine where the velocity is increasing, decreasing, or constant. Indicate the correct answer for each time interval by a ✓ in Table 4.5.

0.5

Table 4.6

t (s)	0.05 - 0.15	0.15 - 0.25	0.25 - 0.35	0.35 - 0.45	0.4 5- 0.55	0.55 - 0.65	0.65 - 0.75	0.75 - 0.85	0.85 - 0.95
Increase	✓	✓	✓			✓	✓	✓	✓
Decrease					✓				
Constant				✓					

c) Ask your instructor for which time interval $[t_i,t_f]$ to use for calculating the area under the $\overline{V}$-T curve; see Figure 4.5 below. Record the area in Table 4.6. This area represents the displacement made by the 0th point during the chosen time interval.

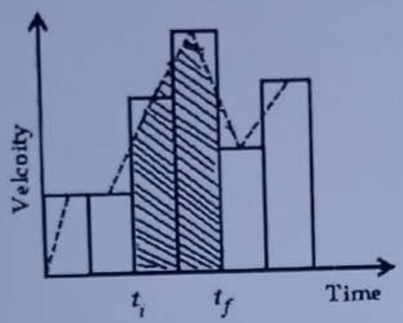


Figure 4.5: Finding the displacement from the area under the Velocity-Time graph.

Table 4.6

t_i = 0.1	t_f = 0.25
Area under the curve from *V-t* graph = ∫ x	
Displacement from the paper tape = rectangle area	
Do the two measurements agree? Discuss. yes Same	

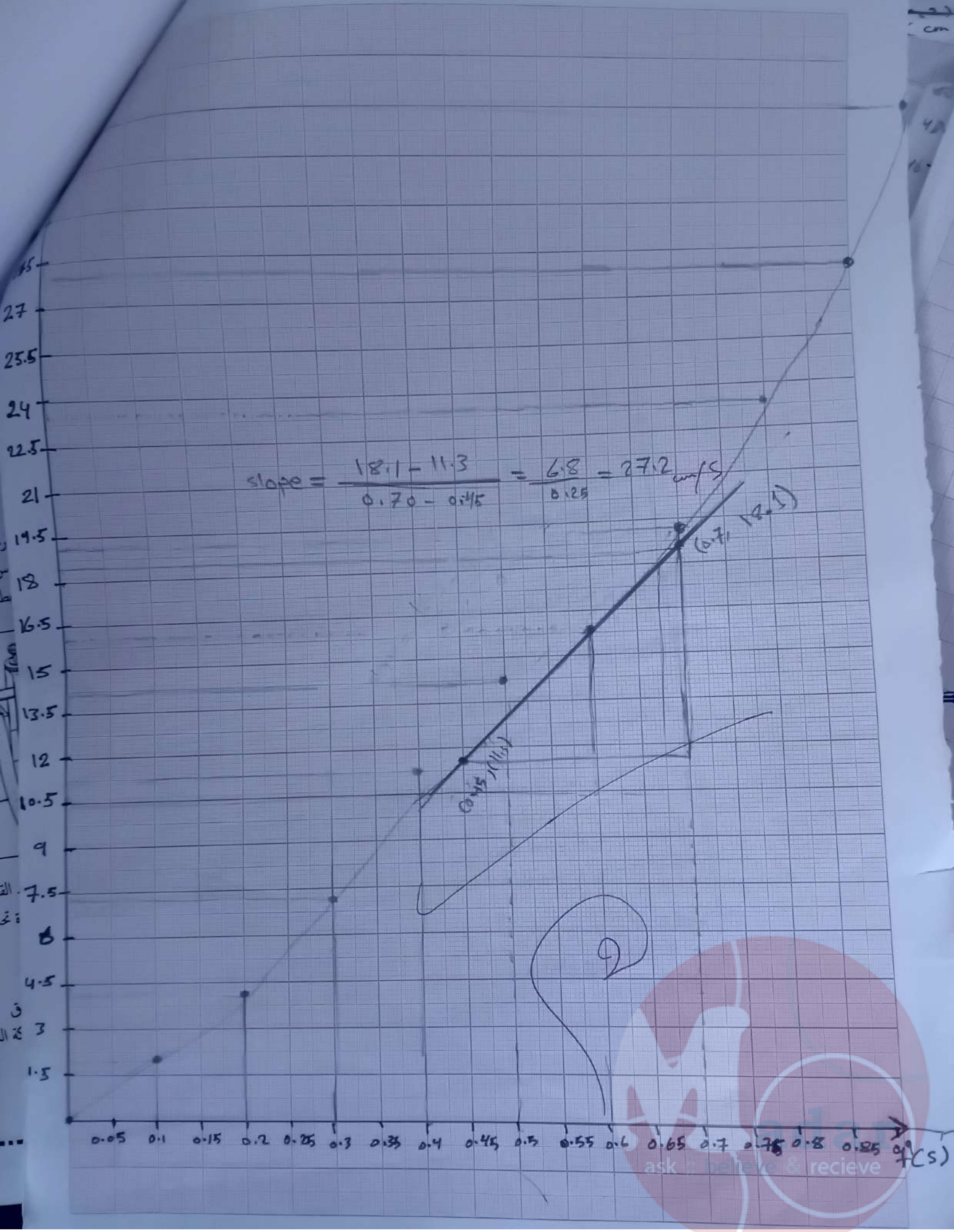
E) *a-t* GRAPH

Refer to Table 4.2 and plot *a* versus *t*. Label your axes. The *a-t* graph can be used to determine the maximum and minimum accelerations.

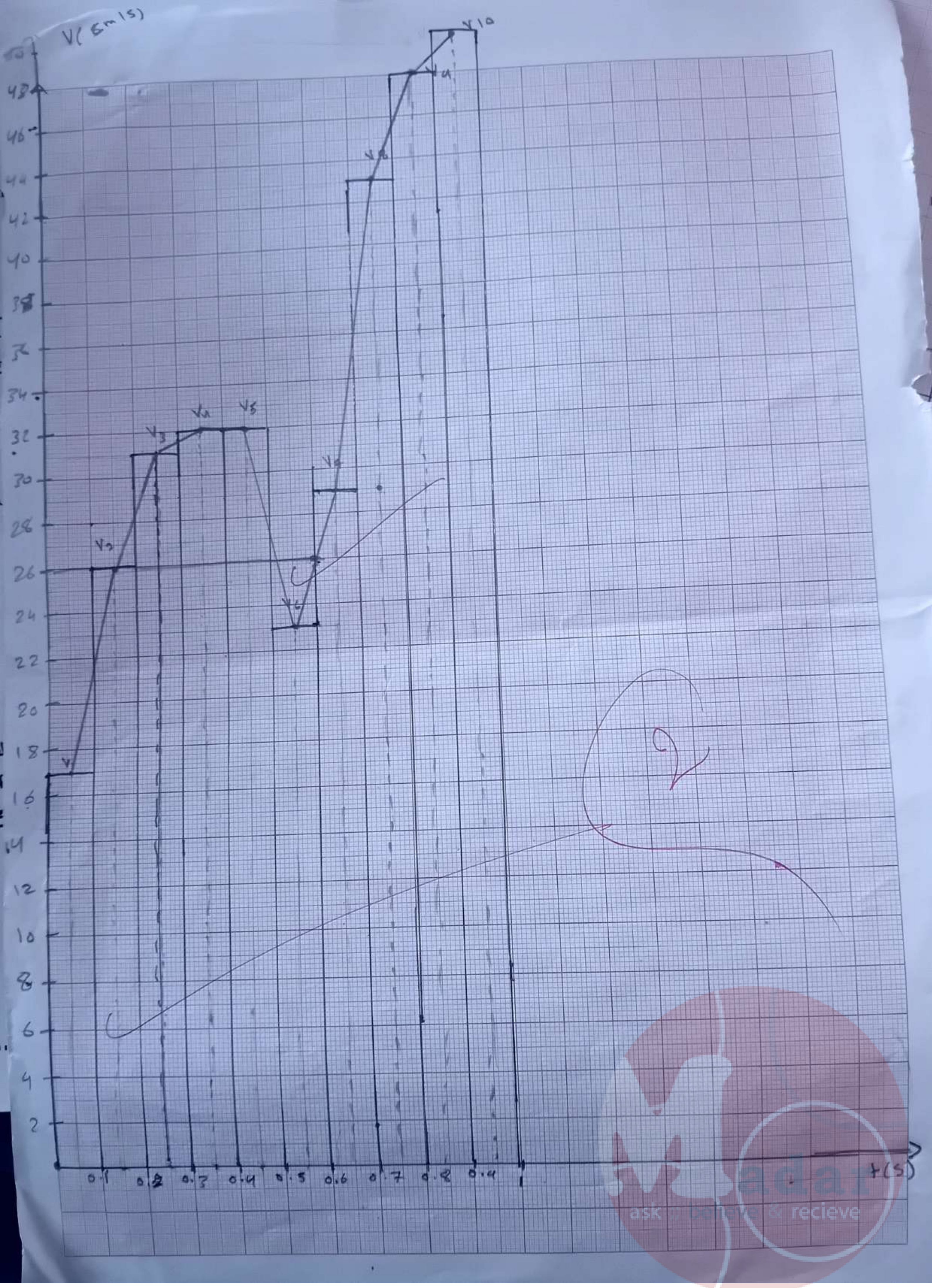
Record your results in Table 4.7.

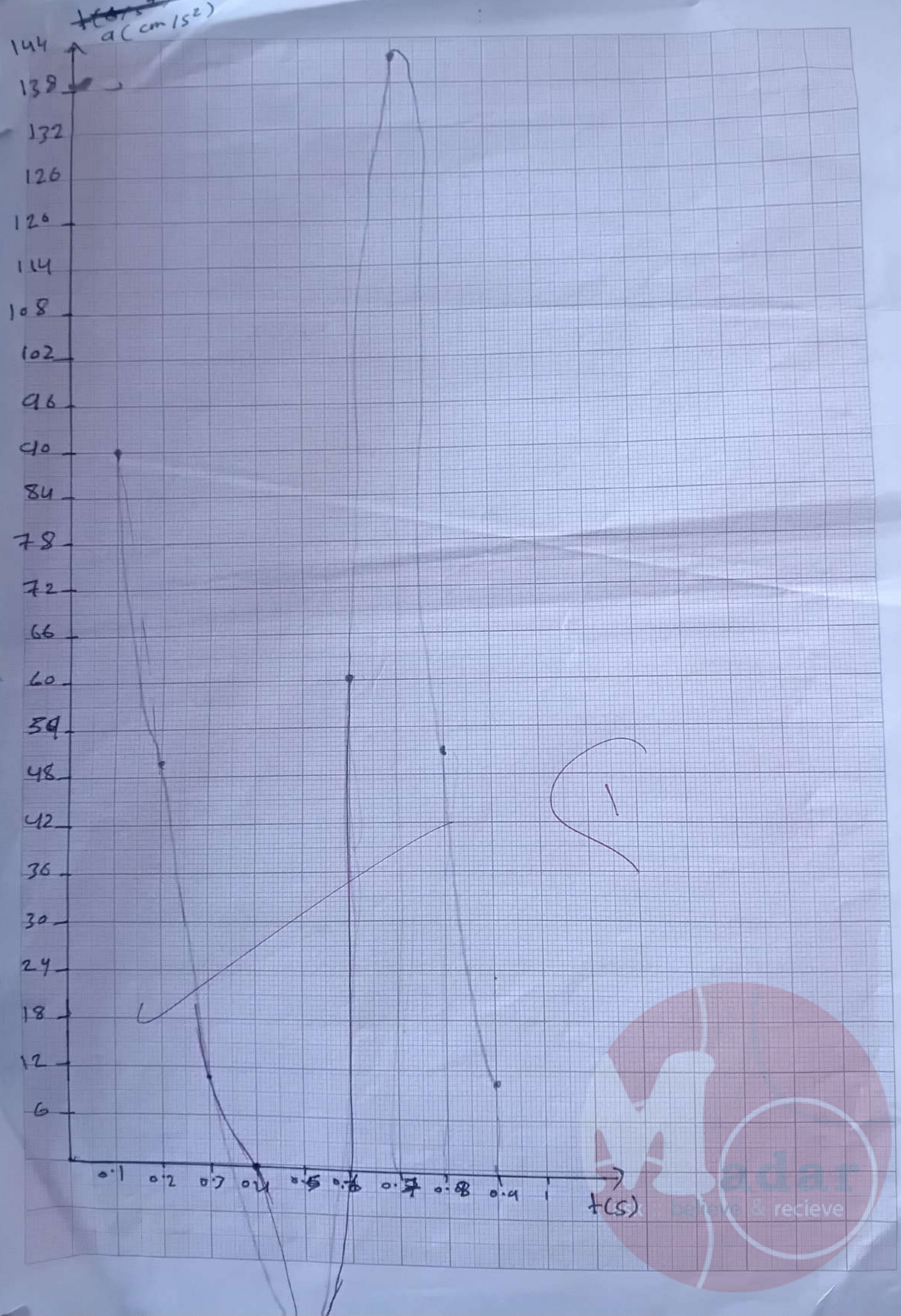
Table 4.7

Maximum Acceleration	Minimum Acceleration
a_{max} = 140 cm/s²	a_{min} = 0 cm/s²
$t(a_{max})$ = 0.70 s	$t(a_{min})$ = 0.40 s²



slope = 18.1 − 11.3 / 0.70 − 0.45 = 6.8 / 0.25 = 27.2 cm/s
(0.7, 18.1)
(0.45, 11.3)
27
25.5
24
22.5
21
19.5
18
16.5
15
13.5
12
10.5
9
7.5
6
4.5
3
1.5
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
t(s)


V(cm/s)
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
V1
V2
V3
V4
V5
V6
V8
V9
V10
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t(s)


a(cm/s²)
144
138
132
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
t(s)

9.5

EXPERIMENT 5

FORCE AND MOTION

LAB REPORT

Date ....

Name .Hassan shuhbat..............

Partner's Name .[illegible] Khaled Al-Tawalbeh

Registration No. .

Registration No.

Section ....

Instructor's Name ....

I. PURPOSE

To verify Newton's second law for a mechanical system moving in one dimension, specifically, the relationship between the acceleration of the mechanical system, its mass, and the net force, acting on it. Two cases will be studied:

1- The net force is kept constant.

2- The mass is kept constant.

II. INTRODUCTION - THEORETICAL BACKGROUND

Newton's second law of motion gives the relationship between the mass of a mechanical system (m), its acceleration $\vec{a}$, and the net (resultant) force, $\vec{F}_{net}$ acting on it:

$$\vec{F}_{net} = m\,\vec{a} \qquad (5.1)$$

where $\vec{F}_{net} = \sum \vec{F}_{ext}$, is the vector sum of all external forces acting on the object.

time, thus varying the system's mass.

V. Analysis of Data – Part 1

1. For each value of m_a, use Equation 5.7 and Table 5.1 to calculate the cart's velocity at each of the three photogate positions.
2. Record your results in the appropriate cells in the table.

Table 5.1

Δx = .4.[redacted]...... cm $\qquad m_h = 20$ g

$m_a = 0$			$m_a = 25$ g			$m_a = 50$ g			$m_a = 75$ g		
t (s)	Δt (s)	v (cm/s)	t (s)	Δt (s)	v (cm/s)	t (s)	Δt (s)	v (cm/s)	t (s)	Δt (s)	v (cm/s)
0	0	0	0	0	0	0	0	0	0	0	0
1.868	0.127	2844	1.566	0.101	40	1.805	0.110	36	1.477	0.112	36
2.443	0.85	4633	2.157	0.080	50	2.467	0.092	43	2.6[illegible]	0.092	43
2.443	0.068	5661	2.635	0.068	59	3.018	0.078	51	3.200	0.08	5[illegible]

3. On one graph sheet, v *versus* t for each value of the added mass and draw the best fit line through the data points.
4. Label each line with the corresponding value of the added mass m_a.
5. Determine the acceleration (a) for each case from the slope of the corresponding line, and enter your values in Table 5.2 below:

Table 5.2

m_a (g)	a (cm/s^2)	$1/a$ (s^2/cm)
0	27	1.4×10^{-3} 0.037
25	23	1.4×10^{-3} 0.043
50	20	2.5×10^{-3} 0.05
75	17	3.5×10^{-3} 0.06

6. Plot m_a versus $1/a$.
7. From the graph, what conclusion can you make about the way the

acceleration of the cart depends on the system's total mass?

..acceleration..reading...with...total..mass..increase.............. $a \propto \frac{1}{m}$ -0.5

....

....

8. From your graph, find the mass of the cart, m_c.

....

...m_c = $y_{intercept}$ - 20 ....

...m_c = 75 - 20 = 55g...

VI. Procedure - Part 2: Acceleration under Variable net force and constant System mass

In this part, you will use two photogates.

1. Set up the system as indicated in Figure 5.1, starting with $m_a = 30$ g and $m_h = 10$ g.
2. Reset the photogates by pressing the RESET button.
3. Press the START button to start the motion.
4. Read off the times t_1, t_2, Δt_1, and Δt_2 following the same procedure from part 1. Record your results in Table 5.3.
5. Repeat steps 2 through 4 three more times, reducing m_a by 10 g and increasing m_h by the same amount.

VII. Analysis of Data – Part 2

1. For each run, use Equation 5.7 and Table 5.1 to calculate the cart's velocity at each of the two photogate positions. Record your results in the appropriate cells in the table.

Table 5.3

Δx = ...4......... cm

	Time (s)		$v = \frac{\Delta x}{\Delta t}$ (cm/s)	$v_2 - v_1$ (cm/s)	$a = \frac{v_2 - v_1}{t_2 - t_1}$ (cm/s²)
$m_a = 30$ g $m_h = 10$ g	$t_1 = 2.446$	$\Delta t_1 = 0.117$	34		
				7	10
	$t_2 = 3.139$	$\Delta t_2 = 0.097$	41		

	Time (s)		$v = \frac{\Delta x}{\Delta t}$ (cm/s)	$v_2 - v_1$ (cm/s)	$a = \frac{v_2 - v_1}{t_2 - t_1}$ (cm/s²)
$m_a = 20$ g $m_h = 20$ g	$t_1 = 1.064$	$\Delta t_1 = 0.084$	48		
				18	39
	$t_2 = 1.529$	$\Delta t_2 = 0.061$	66		

	Time (s)		$v = \frac{\Delta x}{\Delta t}$ (cm/s)	$v_2 - v_1$ (cm/s)	$a = \frac{v_2 - v_1}{t_2 - t_1}$ (cm/s²)
$m_a = 10$ g $m_h = 30$ g	$t_1 = 0.9$	$\Delta t_1 = 0.07$	57		
				23	60
	$t_2 = 1.286$	$\Delta t_2 = 0.05$	80		

	Time (s)		$v = \frac{\Delta x}{\Delta t}$ (cm/s)	$v_2 - v_1$ (cm/s)	$a = \frac{v_2 - v_1}{t_2 - t_1}$ (cm/s²)
$m_a = 0$ g $m_h = 40$ g	$t_1 = 0.731$	$\Delta t_1 = 0.053$	75		
				33	115
	$t_2 = 1.017$	$\Delta t_2 = 0.037$	108		

2. For each run, calculate the average acceleration (a), where $a = (v_2 - v_1)/(t_2 - t_1)$.

3. Enter your data for the hanging weight ($m_h g$) and the corresponding acceleration (a) in Table 5.4. (Take g = 980 cm/s²).

Table 5.4

Hanging weight $m_h g$ (dyne)	Acceleration a (cm/s²)
(10) 9800	10
(20) 19600	39
(30) 29400	60
(40) 39200	115
1 dyne = 1 g cm s⁻² = 10⁻⁵ N	

4. Plot a graph of the hanging weight ($m_h g$) against the acceleration (a).
5. Calculate the slope of your graph. What does the slope of your graph represent?

P₁ (30, 15)   P₂ (50, 25)

Slope = $\frac{50-30}{25-15} = \frac{20}{10} = 2 \times 980 = 1960$ g

↓ Total mass

6. State and discuss three sources of error in this experiment.

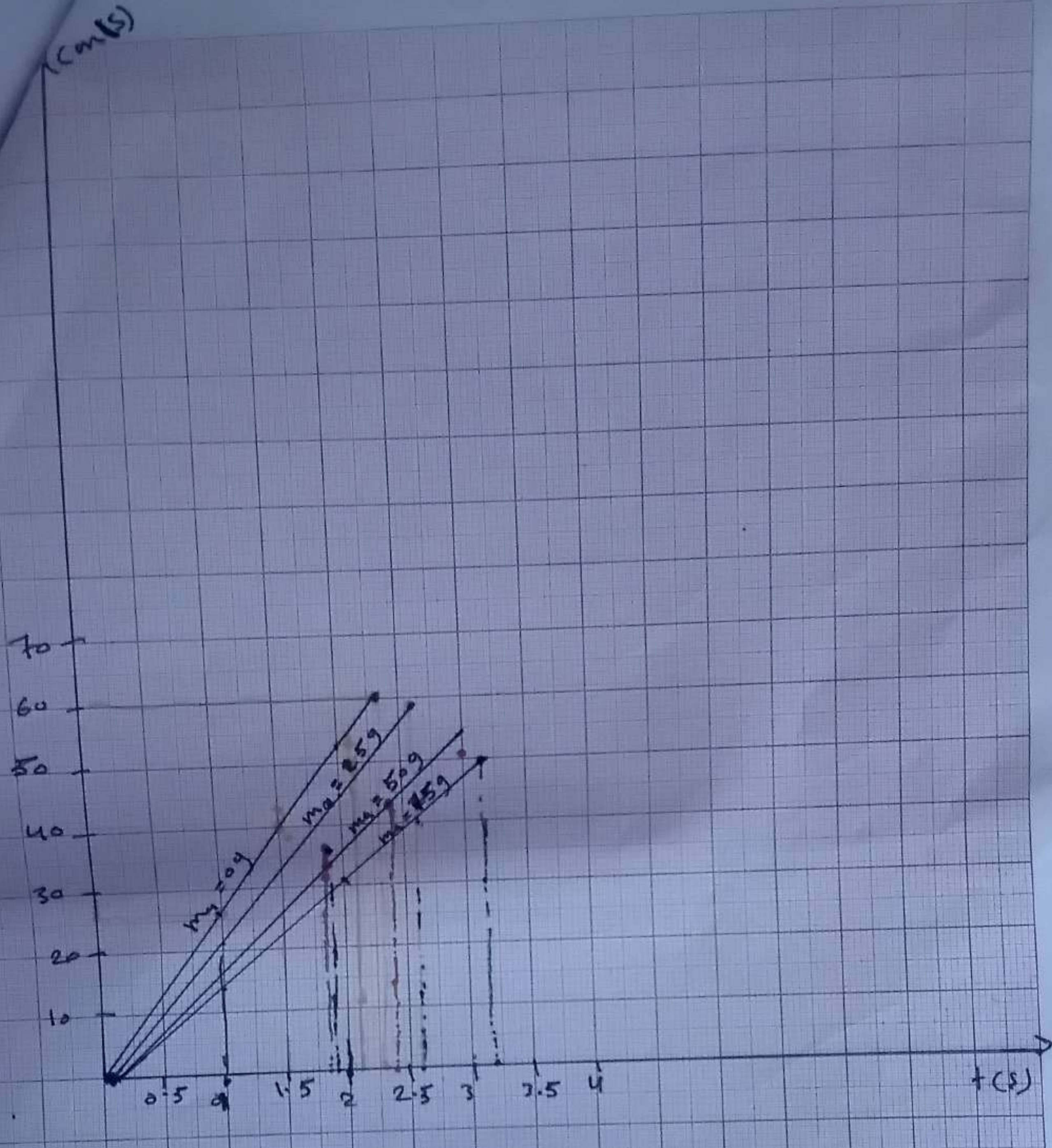
① experimental error

② error in calculations

③ error in device (~~syst~~ systematic error)

See also:

http://www.phywe-es.com/index.php/fuseaction/download/lrn_file/versuchsanleitungen/p1199705/e/p1199705e.pdf



- slope ma = 0g → $P_1(1, 26)$ $P_2(2, 53)$

$$\frac{53-26}{2-1} = \boxed{27\ cm/s^2}$$

- slope ma = 25g → $P_1(1, 22)$ $P_2(2, 45)$

$$\frac{45-22}{2-1} = \boxed{23\ cm/s^2}$$

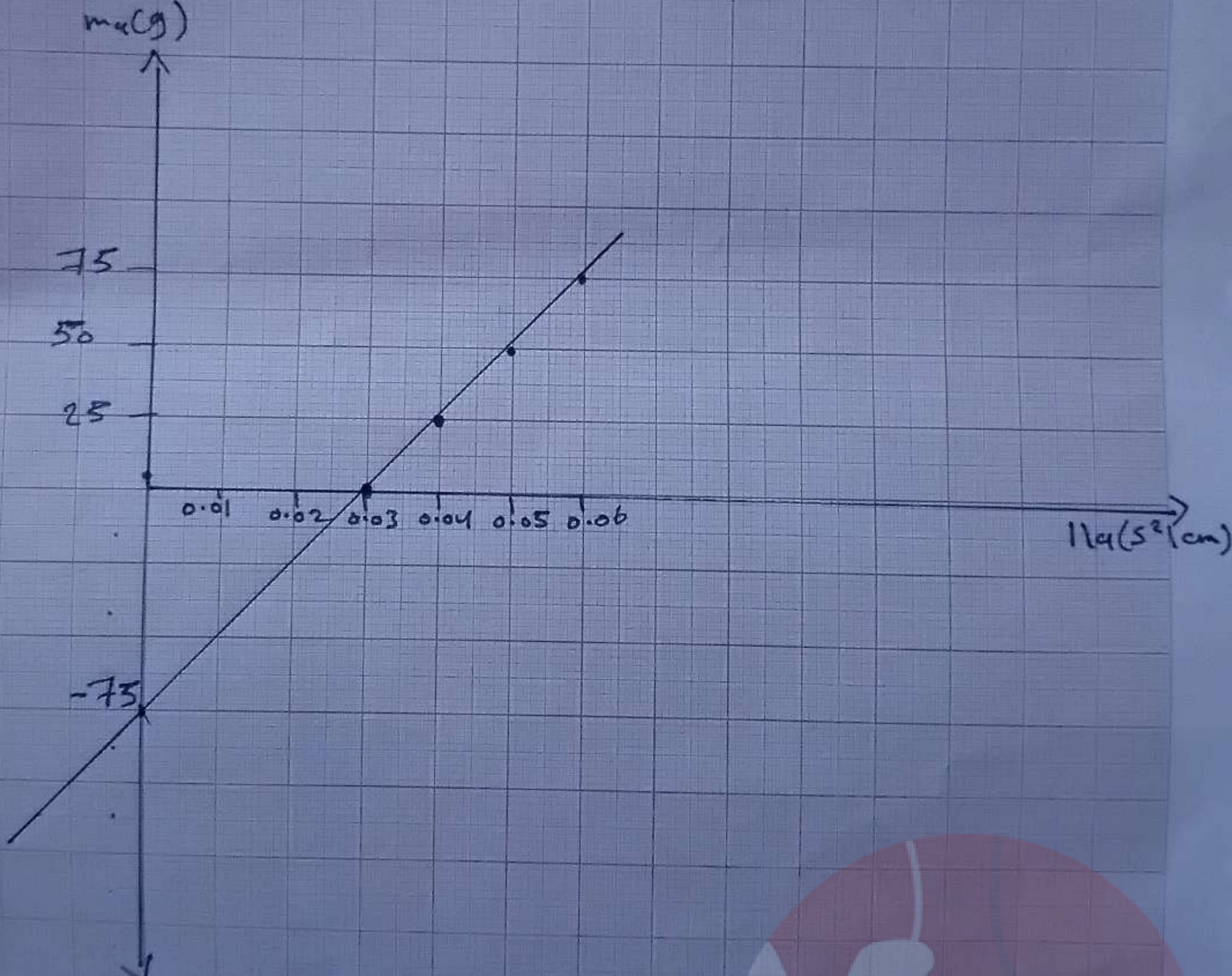
- slope ma = 50g → $P_1(1, 16)$ $P_2(2, 36)$

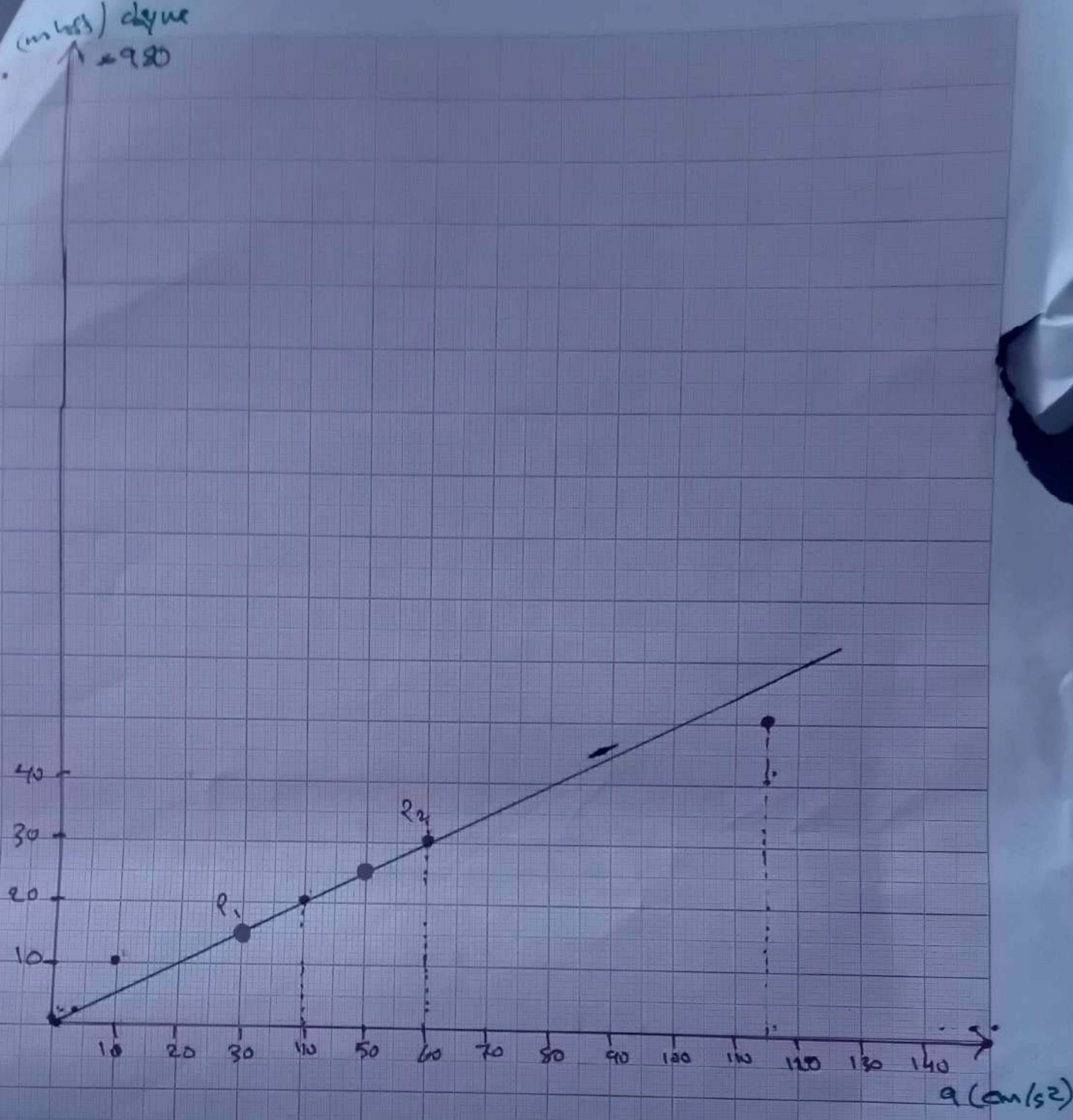
$$\frac{36-16}{2-1} = \boxed{20\ cm/s^2}$$

- slope ma = 75g

$P_1(1, 14)$ $P_2(2, 31)$

$$\frac{31-14}{2-1} = \boxed{17\ cm/s^2}$$


m₄(g)
75
50
25
-75
0.01
0.02
0.03
0.04
0.05
0.06
1/a(s²/cm)



⇒ P_1 (30, 15) P_2 (50, 25)

$$\text{slope} = \frac{50-30}{25-15} = 2 \times 980 = 1960g \text{ (total mass)}$$

9.5

EXPERIMENT 6

COLLISIONS IN ONE DIMENSION

(CONSERVATION OF LINEAR MOMENTUM)

LAB REPORT

Date ....

Name ...Hameer shalhaf........ Partner's Name ...عاكف خالد....

Registration No.

Registration No.

Section ....

Instructor's Name ....

I. PURPOSE:

To study conservation of linear momentum and kinetic energy in elastic and inelastic collisions in one dimension.

II. INTRODUCTION - THEORETICAL BACKGROUND

The linear momentum and kinetic energy of a object or particle of mass m moving with velocity $\vec{v}$ are defined as follows:

$$\vec{p} = m\vec{v} \tag{6.1a}$$

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m} \tag{6.1b}$$

When two objects collide in the absence of external forces (or, equivalently, when the resultant external force is zero), then their *total*

V. Data Analysis – Part 1

1. Calculate the initial and final velocities of the cart, $v_1 = \Delta x/\Delta t_1$ and $v_1' = \Delta x/\Delta t_2$. Record your results in Table 6.1.

2. the rebound coefficient $r = \frac{|v_1'|}{|v_1|}$. Record your results in Table 6.1.

Table 6.1

Δx = ...4......... cm

Mass of cart (g)	Δt_1 (s)	Δt_2 (s)	v_1 (cm/s) ($\Delta x/\Delta t_1$)	v_1' (cm/s) ($\Delta x/\Delta t_2$)	$r = \frac{\lvert v_1'\rvert}{\lvert v_1\rvert}$
100	0.058	0.066	69.0	60.6	0.878
125	0.123	0.137	32.5	29.2	0.898
150	0.199	0.244	20.1	16.4	0.816

3. Answer the following:

If r = 1 this means that

.....elastic collisions..

If $r < 1$ this means that

..inelastic collisions..

تصادم مرن مع حاجز ثابت

fixed barrier

التصادم مرن والعربة ترتد بنفس السرعة

لكن هناك فرق هنا بسيط بفعل

الأخطاء في التجربة، كونها

ليست مثالية

في التصادم المرن الطاقة الحركية محفوظة، والزخم محفوظ.

VII. Data Analysis – Part 2

1. Calculate the initial and final velocities of the two carts (initial velocity of cart 2 is zero) and record the results in Table 6.2.

Table 6.2

m_1 = ...4..cm....... g $\qquad v_2 = 0$

m_1 (g)	m_2 (g)	Before collision Δt_1 (s)	Before collision v_1 (cm/s) $\frac{\Delta x}{\Delta t_1}$	After collision $\Delta t_1'$ (s)	After collision v_1' (cm/s)	After collision $\Delta t_2'$ (s)	After collision v_2' (cm/s) $\frac{\Delta x}{\Delta t_2}$
100	100	0.062	64.5		5.7	0.068	58.8
150	100	0.061	65.5		18.7	0.057	70.2
100	150	0.063	63.5		−8.8	0.083	48.2

In the following,

- p_i, K_i are the initial momentum and kinetic energy of cart i (i=1,2).
- p_i', K_i' are the final momentum and kinetic energy of cart i.
- $p_{tot} = p_1 + p_2$ and $K_{tot} = K_1 + K_2$ are the total initial momentum and kinetic energy.
- $p_{tot}' = p_1' + p_2'$ and $K_{tot}' = K_1' + K_2'$ are the total final momentum and kinetic energy.

2. Calculate the following and record the results in Table 6.3.
   - p_1, p_2, p_1', and p_2'
   - p_{tot} and p_{tot}'.

3. Calculate the following and record the results in Table 6.4.
   - K_1, K_2, K'_1, and K_2'
   - K_{tot} and K_{tot}'

$$v_1' = \left(\frac{m_1 v_1 - m_2 v_2'}{m_1}\right) \qquad \frac{150 \times 65.5 - 100 \times 70.2}{150}$$

Table 6.3

$\Delta x = 4\,cm$

m_1 = ... g $v_2 = 0$

m_1 (g)	m_2 (g)	p_1 (g cm/s)	p_2 (g cm/s)	p'_1 (g cm/s)	p'_2 (g cm/s)	p_{tot} (g cm/s)	p'_{tot} (g cm/s)	$\frac{\lvert p'_{tot} - p_{tot}\rvert}{p_{tot}} \times 100\%$
100	100	6450	0	570	5880	6450	6450	0%
150	100	9825	0	2805	7020	9825	9825	0%
100	150	6350	0	6880	7230	6350	6350	0%

Table 6.4

m_1 (g)	m_2 (g)	K_1 (erg)	K_2 (erg)	K'_1 (erg)	K'_2 (erg)	K_{tot} (erg)	K'_{tot} (erg)	$r = \frac{K'_{tot}}{K_{tot}}$
100	100	208012.5	0	1624.5	172872	208012.5	174496.5	0.839
150	100	322653	0	26226.75	246402	322653	272628.75	0.847
100	150	201612.5	0	3872	174243	201612.5	178115	0.883

1 erg = 1 dyne. 1 cm = 10^{-5} N 10^{-2} m = 10^{-7} J

4. Within experimental error, was linear momentum conserved in each of the four collisions? Hint: Use the last column in Table 6.3.

Yes because p_{tot} (before) = p'_{tot} (after)

5. For each of the four collisions, was kinetic energy, within experimental error, conserved (*i.e.* was the collision elastic)? Justify your answer. Hint: Use the last column in Table 6.4.

Yes because r is close to one

IX. Data Analysis – Part 3

1. Calculate the initial and final velocities, v and v', respectively, and record the results in Table 6.5.

   In the following:

- p and K are the initial momentum and kinetic energy of cart 1. Since cart 2 is initially at rest they are equal to the total initial momentum and kinetic energy of the system.
- $p'$and K' are the final momentum and kinetic energy of the system composed of cart 1 and cart 2 stuck together.

2. Calculate p and K and record the results in Table 6.5.
3. Calculate p' and K' and record the results in Table 6.6.

Table 6.5

$m_1 =$ ......100............ g   Dx = 4cm $v_2 = 0$

m_2 (g)	Δt_1 (s)	v (cm/s)	Δt_2 (s)	v' (cm/s)	p (g cm/s)	p' (g cm/s)	$\frac{\lvert p'_{tot} - p_{tot} \rvert}{p_{tot}} \times 100\%$
100	0.048	83.3	0.117	34.2	8330	8550	
150	0.054	74.07	0.157	25.5	7407	6375	

$$\left| \frac{P' - P}{\left(\frac{P' + P}{2}\right)} \right| \times 100$$

= 0.5

Table 6.6

m_2 (g)	K (erg)	K' (erg)	$r = \frac{K'}{K}$
100	346944.5	182756.25	0.526
150	274318.2	81221.25	0.296

4. Within experimental error, was linear momentum conserved in each

where is the page 83

of the four collisions? Justify your answer.

Hint: Use the last column in Table 6.5.

Yes because $P_{tor} = P_{t}$
before after

5. For each of the four collisions, was kinetic energy conserved (*i.e.* was the collision elastic) within experimental error? Justify your answer.

Hint: Use the last column in Table 6.6.

No because r is not closing to one

6. State and discuss three sources of error in this experiment.

1. Error in calculations (percent error)
2. Error in reading the timer
3. Error in the equipments (systematic error)

10/10

EXPERIMENT 7

SIMPLE HARMONIC MOTION

THE SIMPLE PENDULUM

LAB REPORT

Date ....

Name ..Haneen. shallaf............ Partner's Name ..ملاك جمال الطوالبة

Registration No. Registration No. ..

Section .... Instructor's Name ....

I. PURPOSE

To study simple harmonic motion of a simple pendulum and verify the relationship between its length and period.

You will also calculate g, the acceleration of gravity.

II. INTRODUCTION - THEORETICAL BACKGROUND

Oscillatory motion is a type of motion in which a particle moves back and forth over the same path. If the oscillatory motion repeats itself in regular time intervals (periods), then it is called a harmonic motion There are several types of oscillatory harmonic motions, *simple harmonic motion* (SHM) being the simplest.

Two important characteristics of periodic motion are its *amplitude* and *period*. Amplitude refers to the maximum size of the quantity whose magnitude is oscillating with time, while period refers to the time interval

L (m) cm	Trial 1	Trial 2	Trial 3	Trial 4	$T^{(10)}$	$\overline{T} = \frac{\overline{T}^{(10)}}{10}$ (s)	$\overline{T}^2$ (s²)
	L(cm)	$\overline{T}^{(10)}$	$\overline{T} = \frac{\overline{T}^{(10)}}{10}$	$\overline{T}^2$			
L_1 =	15	7.8	0.78	1.21			0.61
L_2 =	30	11	1.1	1.21	0.110	0.0110	1.21 × 10^{-4}
L_3 =	35	13.2	1.32	1.74	0.132	0.0132	1.74 × 10^{-4}
L_4 =	60	15.7	1.57		0.157	0.0157	2.46 × 10^{-4}
L_5 =	75	17.6	1.76		0.176	0.0176	3.10 × 10^{-4}
L_6 =	90						

$T^{(10)}$ = Average time for 10 cycles (s)

V. Data Analysis

In the following, for simplicity of notation, we will replace $\overline{T}$ and $\overline{T}^2$ by T and T^2, respectively.

1. Using the data in Table 7.1, make a plot of T (vertical axis) versus L (horizontal axis).

2. What type of relationship do you observe between T and L? Is it linear? Is it consistent with Equation 7.14?

   - direct not liner
   - yes, it's consistent

3. Using the data presented in Table 7.1, make a plot of T^2 (vertical axis) versus L (horizontal axis).

4. What type of relationship do you observe in the previous graph? Is it consistent with the theoretical predictions of Equation 7.14?

   direct linear
   yes it's consistent

5. Draw the best-fit line for the data presented in the T^2 versus L graph.

6. What is the slope of the best fit line found in 5 obtained above?

P_1 (20 , 1.0) P_2 (32 , 1.5)

Slope = $\frac{y_2 - y_1}{x_2 - x_1} = \frac{1.5 - 1}{32 - 20} = \frac{0.5}{12} = 0.042$ [redacted] s^2/cm

7. What does this slope represent?

Slope = $\frac{4\pi^2}{g}$

8. Using the value of the slope that you obtained in 6, calculate the acceleration due to gravity (g) at the University of Jordan.

0.042 [redacted] = $\frac{4 \times 9.87}{g}$ → g = 940 cm/s²

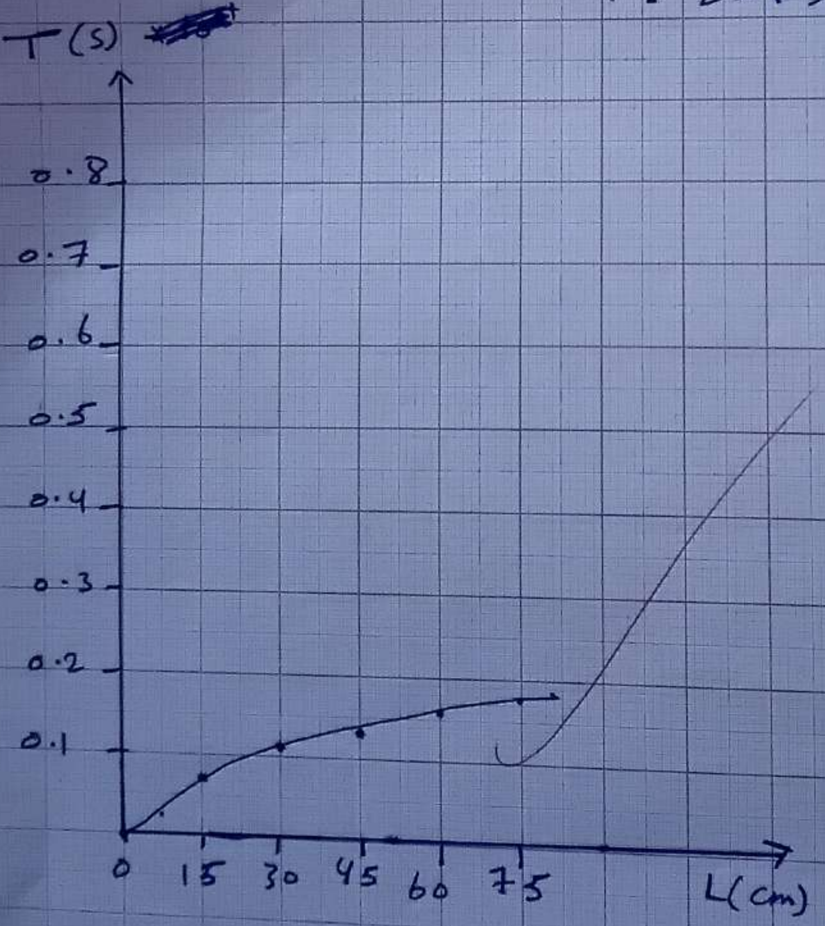
9. Calculate the percentage error in your experimentally found g.

P.E = $\frac{g_{exp} - g_t}{g_t} \times 100\%$ = $\left|\frac{940 - 980}{980}\right| \times 100\%$ = 4%

10. State and discuss three sources of error in this experiment.

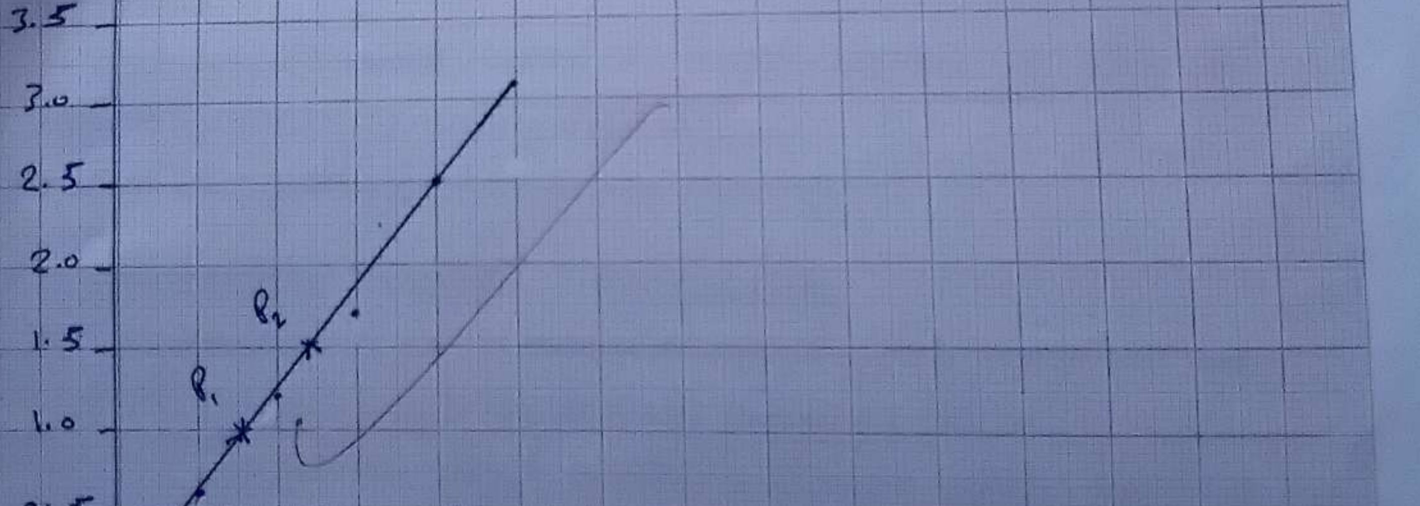
1. error in calculations
2. error in reading the length
3. error in reading the stop watch

$$T = 2\pi\sqrt{\frac{L}{g}}$$



$P_1 (20, 1.0) \quad P_2 (32, 1.5)$

$$\text{slope} = \frac{1.5 - 1}{32 - 20} = \frac{0.5}{12} = 0.042$$



EXPERIMENT 10

BOYLE'S LAW

LAB REPORT

Date ....

Name ..Hameem..Shaltat Partner's Name . عاطف.خالد

Registration No. [redacted]gistration No .. ..

Section .... Instructor's Name ....

I. PURPOSE:

To verify Boyle's law for a trapped gas at room temperature.

II. Introduction

According to Boyle's law, the pressure of a trapped gas at constant temperature is inversely proportional to its volume.

A force F acting perpendicularly to a surface with area A exerts a pressure given:

$$P = F/A \tag{10.1}$$

In MKS the unit of pressure is the Pascal or Pa = N/m^2.

It can be shown that the pressure exerted on a surface by a column of fluid of density ρ and height h is given by:

$$P = \rho g h \tag{10.2}$$

The atmospheric pressure at a given location is due to the column of air

Table 10.1

Average Room Temperature = 20.5 °C

B = 350 mm

Scale Readings (mm)		$h = Y - X$ (mm)	$L = B - X$ (mm)	$1/L$ (mm^{-1})	
X	Y				
270	800	530	80	0.0125	12.5
265	700	435	85	0.0118	11.8
257	600	343	93	0.0108	10.8
250	500	250	100	0.01	10
239	400	161	111	$9.01 * 10^{-3}$	
227	300	73	123	$8.130 * 10^{-3}$	
~~204~~	~~200~~		141	~~$7.04 * 10^{-3}$~~	

V. Data Analysis

1. Plot h versus $1/L$. Use the graph to find the value of the atmospheric pressure $P_a \pm \Delta P_a$ in units of mmHg.

   P_a = 730 mm Hg

2. With the value of the atmospheric pressure known, you can now calculate the pressure P of the trapped air for each value of h, using the relation: $P = P_a + h$. Calculate the quantity PL for each (h,L) pair and enter the values in Table 10.2 below:

730 ← Table 10.2

L (mm)	h (mm)	$P = (P_a) + h$ (mmHg)	PL (mmHg . mm)
80	530	1260	1.01×10^5
85	435	1165	0.990×10^5
93	343	1073	0.998×10^5
100	250	980	0.980×10^5
111	161	891	0.989×10^5
123	73	803	0.988×10^5
[redacted]			

3. Plot L versus $P = (P_a + h)$. What do you conclude from the graph?

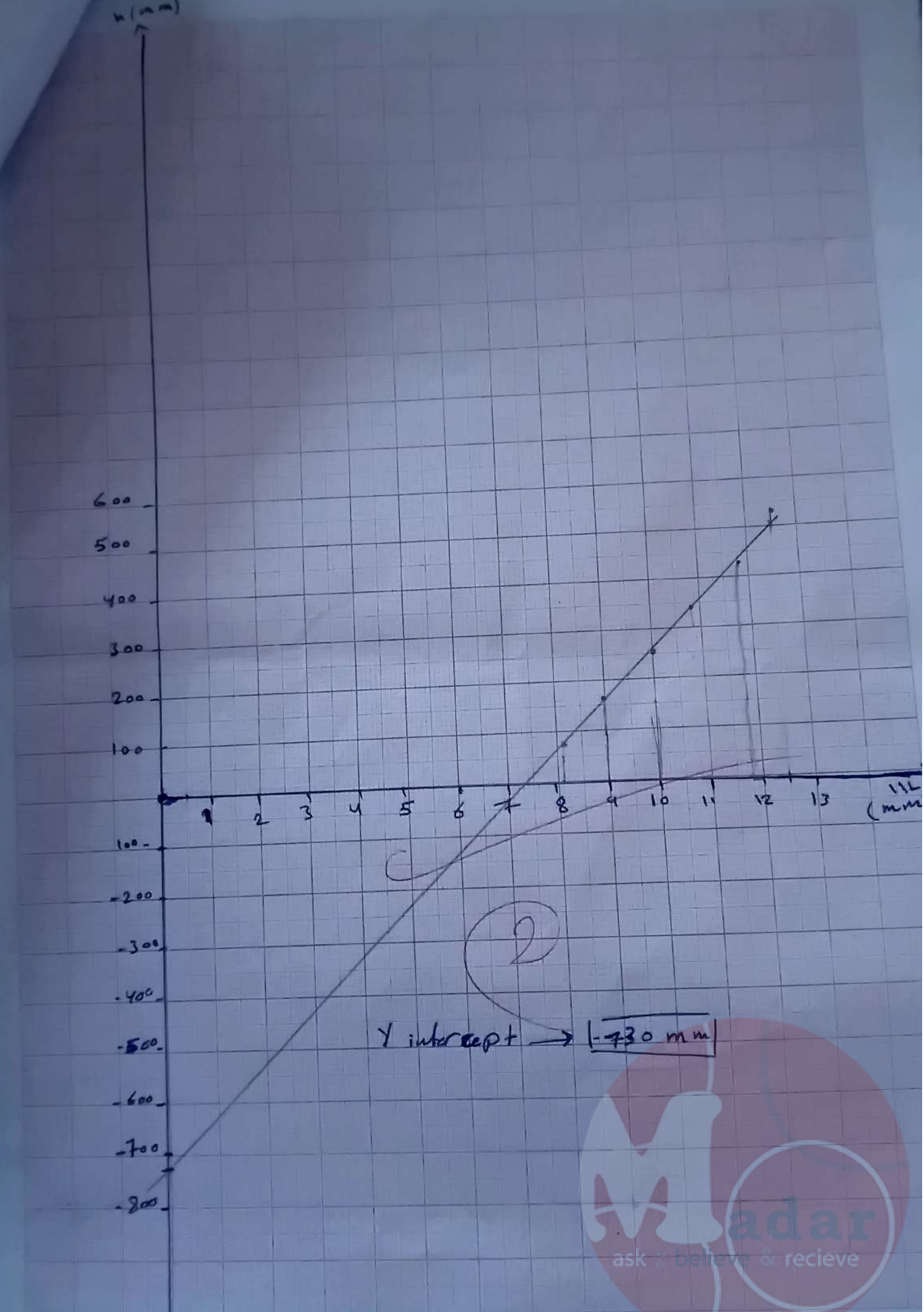
P increase and and L decrease

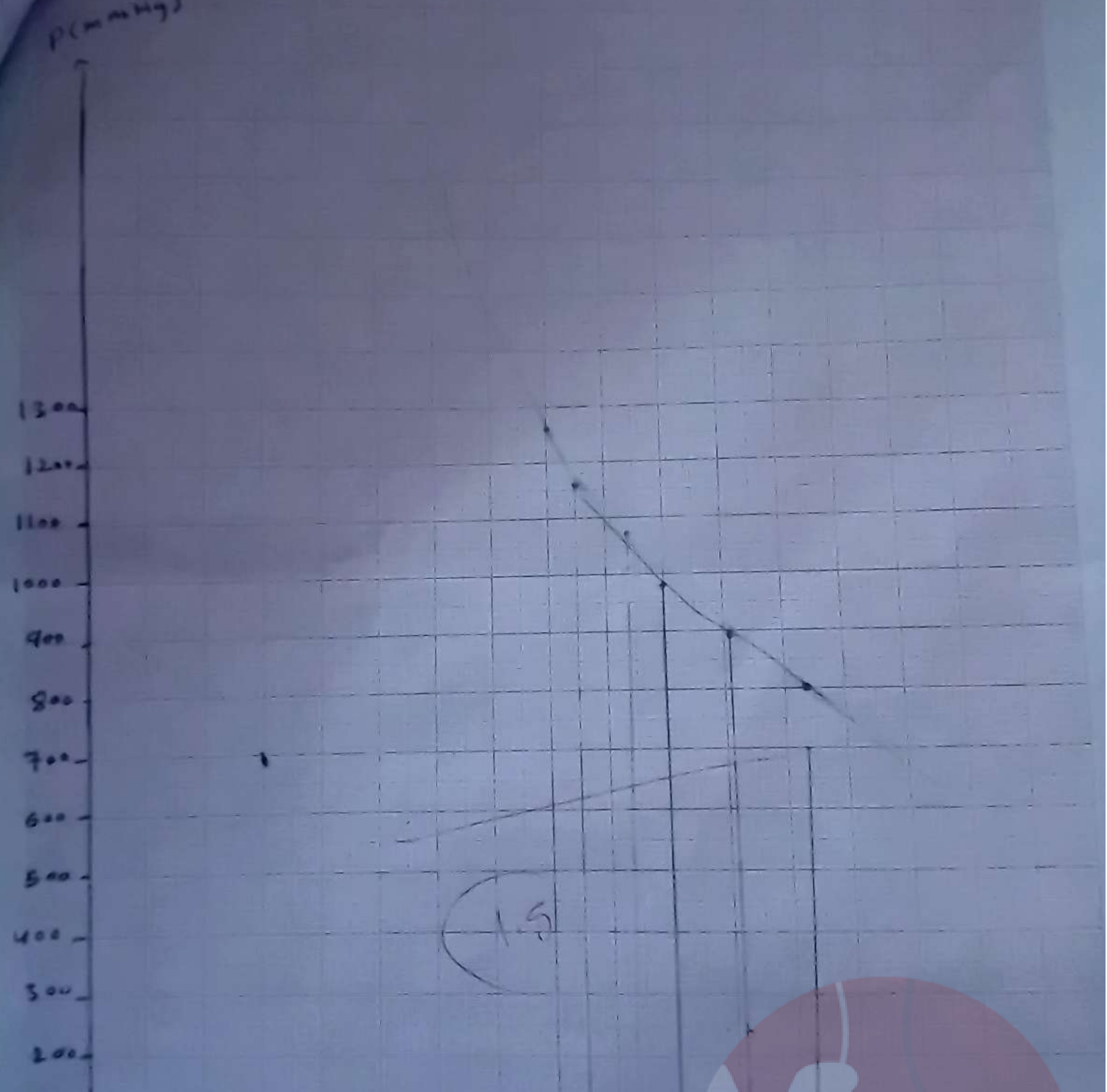
The relationship → inverse non linear

4. Plot a third graph of L versus $P\,L$. What do you conclude?

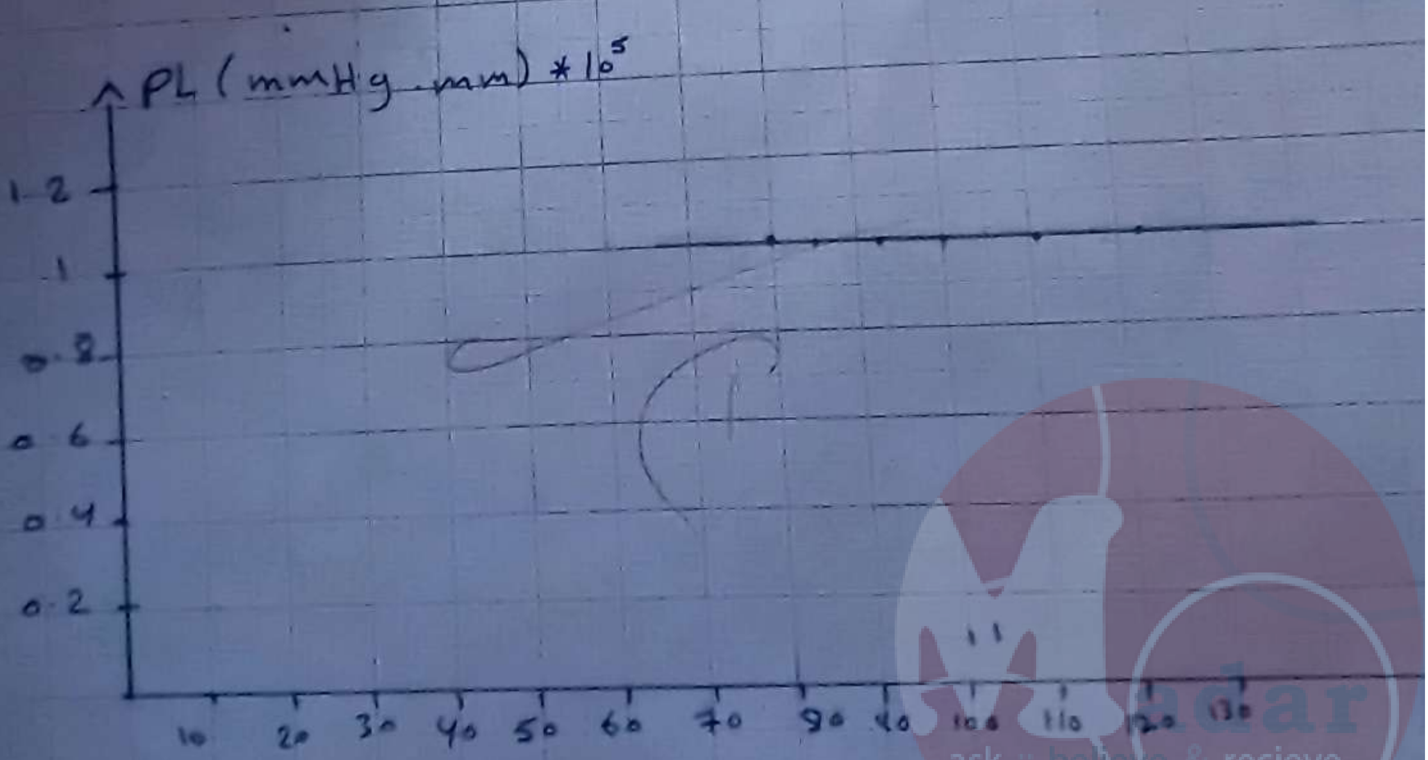
L increase and PL constant

The result consistut with Boyl's low


h (mm)
600
500
400
300
200
100
1
2
3
4
5
6
7
8
9
10
11
12
13
(mm)
-100
-200
-300
-400
-500
-600
-700
-800
Y intercept → -730 mm



P(mmHg)
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
10
20
30
40
50
60
70
80
90
100
110
120
130
1.5


PL (mmHg . mm) * 10^5
1.2
1
0.8
0.6
0.4
0.2
10
20
30
40
50
60
70
90
100
110
120
130

10

EXPERIMENT 11

SPECIFIC HEAT CAPACITY OF METALS

LAB REPORT

Date ....

Name ..Hamzeh...shaltaf......... Partner's Name ..Yammamah..Khaled

Registration No Registration No. ...

Section ....9................ Instructor's Name ....

I. PURPOSE

To determine the specific heat capacity of a metal sample using a simple calorimeter.

II. INTRODUCTION:

Heat is a form of energy. When two objects at different temperatures exchange heat in isolation from their surroundings, one observes that the two objects reach a common final temperature, a condition called thermal equilibrium. We say that heat flowed from the hotter object to the colder one.

In thermodynamics *temperature* is a relative measure of the hotness (or coldness) of an object or a thermodynamic system.

If a system in a given phase, at initial temperature T_i, absorbs (loses) an amount of heat Q and does not undergo a phase change, its temperature

Table 11.1

Symbol	Definition	Measurements	Units	Errors
c_1	Specific Heat Capacity of Calorimeter	0.22	cal/g °C	-
c_w	Specific Heat Capacity of Water	1.00	cal/g °C	-
M_1	Mass of Calorimeter	46.68	g	$\Delta M_1 = \pm 0.01$ g
M_{cw}	Mass of Calorimeter + Water ($M_{cw} = M_1 + M_w$)	141.00	g	$\Delta M_{cw} = \pm 0.01$ g
M_w	Mass of Water ($M_{cw} - M_1$)	94.32	g	$\Delta M_w = \pm 0.014$ g
T_1	Initial Temperature of Calorimeter	25.5	°C	$\Delta T_1 = \pm 0.5$ °C
T_2	Initial Temperature of Metal	92.0	°C	$\Delta T_2 = \pm 0.25$ °C
T_f	Final Equilibrium Temperature for Calorimeter + Water + Metal	30.0	°C	$\Delta T_f = \pm 0.5$ °C
M_2	Mass of Metal	99.46	g	$\Delta M_2 = 0.01$ g

$\sqrt{(M_1)^2 + (M_{cw})^2}$

X = m₁ c₁ + mw cw

Y = Tf − T₁

Z = T₂ − Tf

$c_2 = \frac{XY}{M_2 Z}$

Table 11.2

X = 104.59 cal/°c	c_2 = 0.076 cal/g.°c
Y = 4.5 °c	
Z = 62.0 °c	

2. Use the relations in the table below and calculate the error Δc_2, and express your final result as $c_2 \pm \Delta c_2$.
3. Record your calculations in Table 11.3 below.

$$\Delta c_2 = c_2\sqrt{\left(\frac{\Delta X}{X}\right)^2+\left(\frac{\Delta Y}{Y}\right)^2+\left(\frac{\Delta Z}{Z}\right)^2+\left(\frac{\Delta M_2}{M_2}\right)^2}$$

$$\Delta X = \sqrt{(c_w \Delta M_w)^2+(c_1 \Delta M_1)^2}$$

$$\Delta Y = \sqrt{(\Delta T_1)^2+(\Delta T_f)^2}$$

$$\Delta Z = \sqrt{(\Delta T_2)^2+(\Delta T_f)^2}$$

Table 11.3

ΔX = 0.014 cal/°c	$\Delta c_2 = \sqrt{(1.34\times10^{-4})^2+(0.16)^2+(9.03\times10^{-3})^2+(1.01\times10^{-4})^2}$ = ±0.16 cal/g.°c
ΔY = 0.71 °c	
ΔZ = 0.56 °c	
$c_2 \pm \Delta c_2$ = 0.076 ± 0.16 cal/g.°c	

4. Referring to Table 11.4, what is your metal sample? (Show your calculations in detail)

To convert c₂ to the Jule

c₂ in cal × 4.18 → c₂ in Jule

= 0.076 × 4.18 = 0.318 Jule/g.°c

The metal sample is Copper (Cu)

لازم تحويل
لحول عشانه
نقارنه

Table 11.4

Metal	Symbol	Specific heat (J/g °C)
Iron	Fe	0.449
Lead	Pb	0.129
Magnesium	Mg	1.023
Copper	Cu	0.387
Aluminum	Al	0.900
Silver	Ag	0.235
Silicon	Si	0.703
Tin	Sn	0.540

5. What will happen to the heat capacity and specific heat capacity of your metal sample if its mass is changed by a factor (..0.5..)?

Record your answers in Table 11.5. ① The heat capacity will be decrease $C = c \cdot M$ ② The specific heat capacity is constant because it isn't depend on mass

$C_{New} = \frac{1}{2} C_{old}$

Table 11.5

Change Factor = 0.5		
Physical Quantity	Effect	Value
Specific Heat Capacity	constant	The same value 0.318 g/gc
Heat Capacity	decrease	0.5 × S.H.C × Mass = 15.8 J/°C

6. Discuss the possible sources of errors in this experiment.

① heat loss

② errors in calculations

③ errors in balance or thermometer

④ errors in reading the balance or thermometer

7. How much heat is gained or lost for the given metal under the conditions specified in Table 11.6 below. Use the information from Table 11.4. $Q = M c \Delta T$

$Q = 120 \times 0.449 \times (100 - 20) = 4310 \text{ J}$

Table 11.6

Metal	Iron	Initial temperature	20 °C
Mass	120 g	Final Temperature	100 °C

$c = \frac{C}{M}$

$C = c \cdot M_1$