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EXPERIMENT 1: MEASUREMENTS AND

Aim

The experiment was aimed at introducing:

- Introducing some measuring instrument callipers, and micrometer screw gauge
- giving an idea about uncertainties (experimental errors).
- Making Significant figures familiar

APPARATUS

- Flat plate, hollow cylinder, blind-hole cylin Vernier callipers and micrometer screw ga

PROCEDURE

PART 1 :

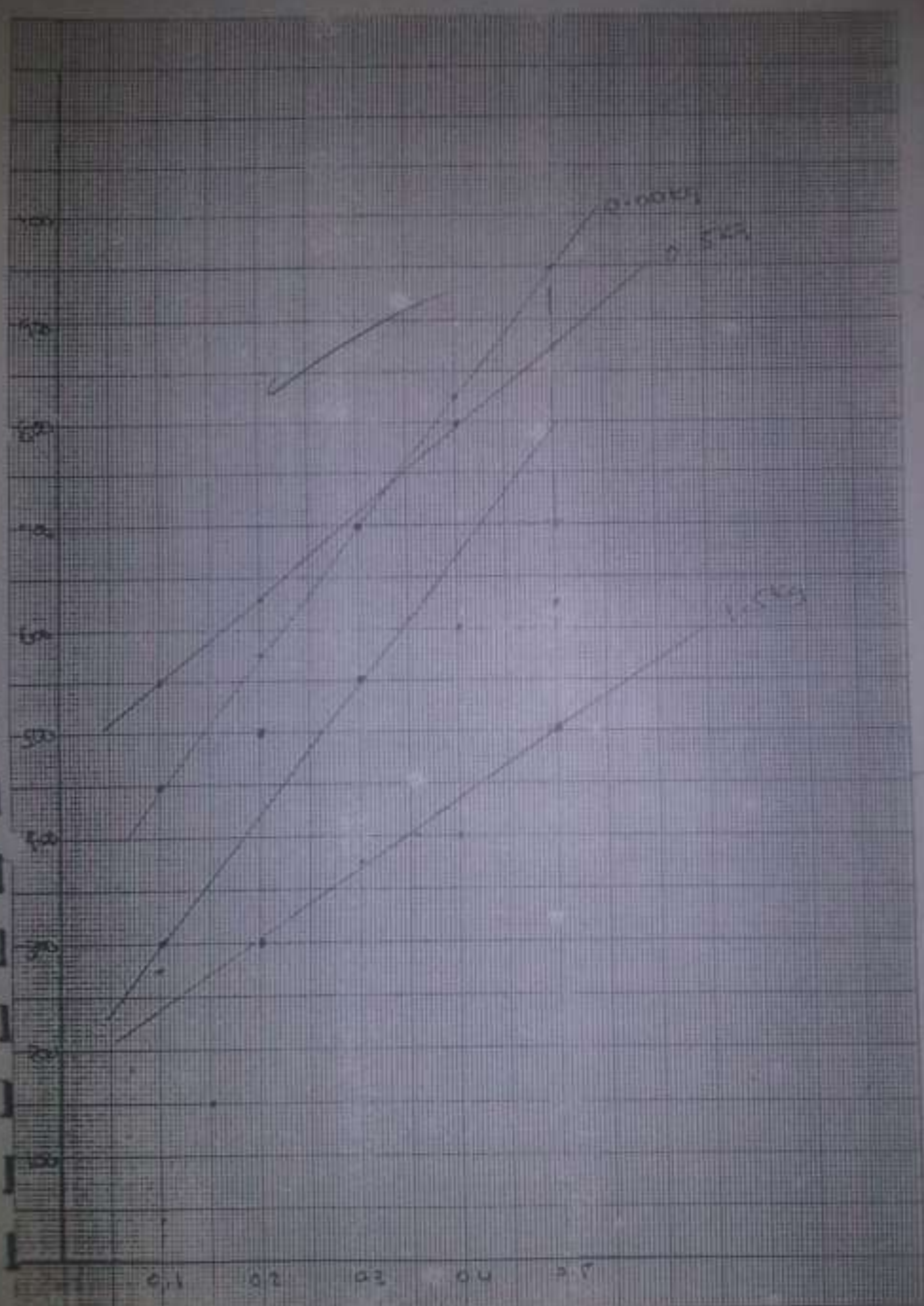
A) THE METER RULE (MR) : The meter rule was
Each division on the meter rule =
Experimental error for the meter rule Δ

B) The vernier Callipers (VC): The vernier cal and the following were noted before scale such that the zero of the vernier scale the 1cm mark of the main scale At The number divisions which coincides with the main ! were also read.

Number of main scale divisions =
Number of vernier scale divisions =
There fore, each division on the vernier scale =
Least count of vernier callipers =

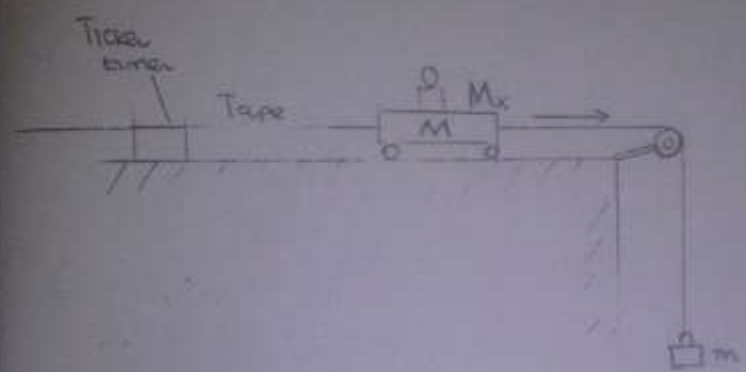
Velocity time graph

Scale X-axis [illegible]
Y-axis [illegible]



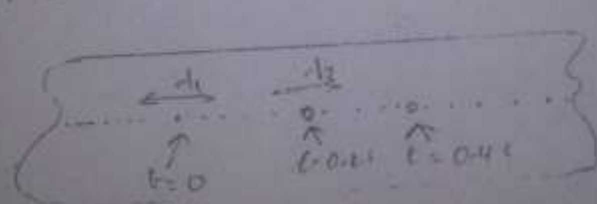
...paring equation (iii) with the usual equation
Newton's Second law, F = mass x acce...
... see that in the above statement, mg is the
... applied force and the mass that
undergoes the acceleration is (Mx + M + m)

~~PROCEDURE~~ figure 1.



PROCEDURE

The procedure was followed and the experiment as arranged in figure 1 above. Masses of the trolley was obtained and instantaneous velocity was determined. The experiment was repeated, now with masses on the trolley before recording data in the table.
distances were determined as shown in figure 3 below including time.



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8-10-09

Experiment 6: Newton's Second Law

Aim: To verify that when a constant force is applied to objects of different masses, the resulting acceleration is inversely proportional to the mass of the object.

Apparatus: Plane with pulley, metre rule, Scale pan, trolley, ticker timer, tape, masses.

m - hanging mass (100g/200g)

M_x - extra masses added to the trolley (0.5kg, 1kg)

M - Mass of the trolley

Theory

If T is the tension in the string and a is the acceleration then for the arrangement shown below, the equations of motion for the bodies are as follows (assuming negligible friction between the trolley and the plane)

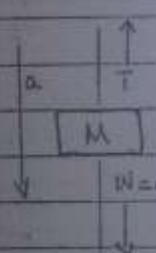


fig 2a

fig 2b

From fig 2a it follows from Newton's second law that: $Mg - T = ma$ (i)

From fig 2b, again it follows from the second law that: $T = (M + M_x)a$ (ii)

Adding equations (i) & (ii), T cancels and we get

$mg = (M_x + M + m)a$ (iii) Hence,

$$a = \frac{m}{M + M_x + m} g$$

The speed of sound in air is 332 m/s at 0°C

at 26°C ⇒ 15.6 m/s + 332 m/s

= 347.6 m/s

The difference between speeds ;

348.1 m/s − 347.6 m/s

Experiment error = 0.5 m/s

Experimental uncertainty = $\frac{\text{Experimental error}}{\text{Calculated value}} \times 100$

$= \frac{0.5}{348.1} \times 100$

Experimental uncertainty = 0.14 %

Method 2

V was also calculated using graphical method with the equation for the first resonance which as

$L_1 = (V/4F) - \Delta L$ (iv)

Diameter of the resonance tube = 4.22 cm

= 0.0422 m

(i) Slope = $\frac{y_2 - y_1}{x_2 - x_1}$ (3.5, 0.28) 2.0, 0.16

$= \frac{0.28 - 0.16}{3.5 - 2.0} = \frac{0.12}{1.5}$

= 0.08

(ii) The value of V from the graph

Slope = V/4

$0.08 = \cancel{x}\,\frac{V}{4}$ $V = 0.32 \times 10^3$ m/s

320 m/s

(iii) ΔL = 0.015 from the graph

$\Delta L = 0.3 \left(\frac{4.2}{100}\right)$

Which graph?

Method 1 :

Subtracting the equations for the first, second resonance is obtained by:

$$L_2 - L_1 = \lambda/2$$

Since $V = f\lambda$, we get $V = 2f(L_2 - L_1)$ (iii)

For each frequency L_1 and L_2 was determined. L_1 could be obtained for all frequencies, it was preferable to use frequencies above 400Hz for L_2 because it would have been difficult for to get the second resonance since the length required would have been more than the equipment's capacity.

The readings were tabulated as follows:

DATA COLLECTION

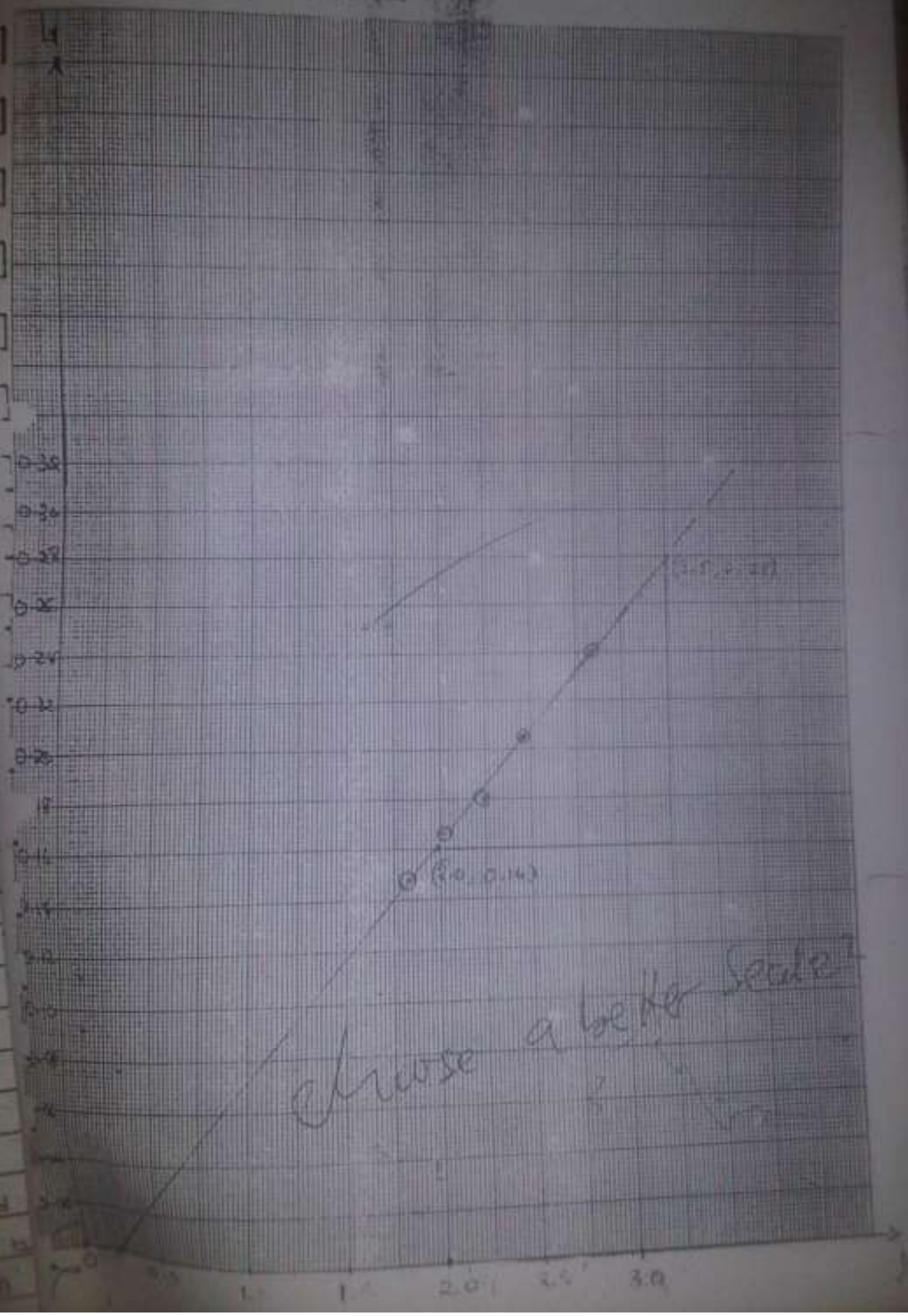
Freq. F Hz	1/f ×10⁻³ Sec	Measured length of air column: First resonance L_1 m	Second resonance L_2 m	$L_2 - L_1$ m	Speed V m/sec
360	2.78×10^{-6}	0.24	0.73	0.49	352.8
400	2.5×10^{-6}	0.218	0.66	0.442	353.6
440	2.27×10^{-6}	0.18	0.586	0.406	357.3
480	2.08×10^{-6}	0.17	0.535	0.365	350.4
520	1.92×10^{-6}	0.158	0.492	0.334	347.4
560	1.79×10^{-6}	0.15	0.442	0.292	327.04

Calculation of wavelength

$$L_2 - L_1 = \lambda/2$$

EXPERIMENT 10: SPEED OF SOUND IN AIR

A graph of L_1 versus $\frac{1}{f}$



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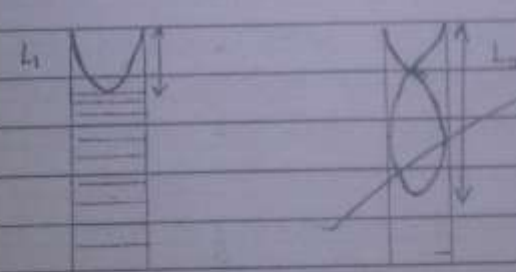
EXPERIMENT 10: VELOCITY OF SOUND IN AIR

AIM: To obtain a value for the velocity of sound in air using a resonance tube.

APPARATUS: Signal generator, resonance tube of about 50cm long, Large glass cylinder, meter rule to measure lengths, vernier callipers.

THEORY: Sound waves of variable (but known) frequency can be generated by a signal generator. When the output speaker for the generated sound is held a distance from the top of the inner tube, waves of frequency produced are propagated downwards and reflected at the water surface. The reflected waves travel up the air column and stationary waves can be set up in the air column in the inner tube. The air column is at rest at the surface of the water and this is a node (zero amplitude). For instance, the open end must be an anti-node (maximum amplitude). The antinodes are situated at a short distance ΔL outside of the top of the tube. This is called "end correction".



First resonance $L_1 + \Delta L = \lambda/4$

Second resonance $L_2 + \Delta L = 3\lambda/4$

We note that the velocity of sound v is related to the frequency f, and the wavelength λ through the relation $v = f\lambda$ (i)

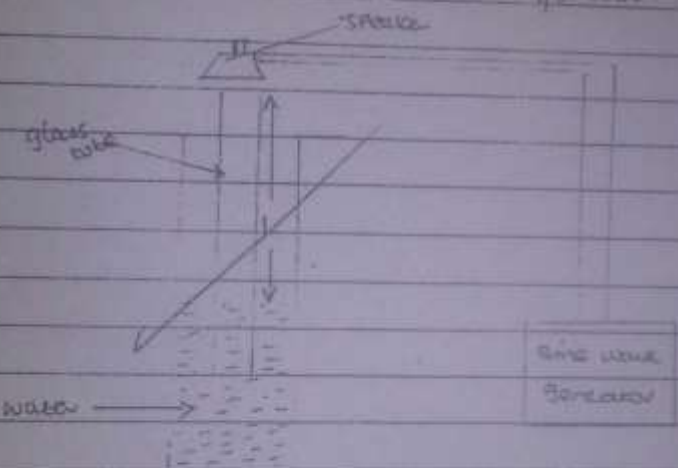
Further, the velocity v depends on the medium. In this experiment velocity of sound in air was measured at room temperature. For the n-th resonance we have the equation

$$L_n + \Delta L = (2n-1)\,\lambda/4 \qquad \text{(ii)}$$

Where $n = 1, 2, 3 \ldots$ corresponding to the first, second, third ... resonances.

PROCEDURE

The experiment was set as follows:



The inner tube was positioned in the water so that L is small then the signal generator was switched on and using the selector switches, sound waves of sufficient amplitude for any frequency whose value was displayed on the window were produced. First frequency was from 250Hz, increasing in steps of about 30Hz. This followed by holding the speaker face down about 2 cm from the open end of the tube and slowly increasing the length of air column until the first resonance was heard. This resonance gave the loudest sound compared to higher resonances. The first resonance length L_1 was measured and the air column

Discussion

From the expriment it was observed that the amount of heat losed by the pre heated water was equal to the heat gained by the water at room temperature since the calorimeter was acting as a closed system with no losses in energy. It was also observed that the latent heat of ice is the actual amount of heat needed to melt a given ice to liquid and the equation of conservation of heat (energy) was proven.

ΔQ_w = heat change of water at temp $\theta_1 = M_w C_w (\theta_1 - \theta_2)$

$\Rightarrow \cancel{20°} = 74\,(12.6 - 20)$

$= 74\,(1\,cal\,g^{-1}\,°C^{-1})\,(-7.4)$

$= \dfrac{\cancel{-547.6}}{\cancel{1000}}$

$= -\cancel{0.5476\,J/kg^{-1}\,°C^{-1}}$

$=$

$= 74\,\cancel{(1\,cal\,g^{-1}\,°C^{-1})\,265.6\,K}$

$= \dfrac{19\,654.J}{1000}$

$= \cancel{19.65}\,J/kg^{-1}\,K$

$\Delta Q_w \;\; 74g = 0.074\,kg$

$= 0.074\,kg\,(1\,cal\,g^{-1}\,°C^{-1})\,(265.6\,K)$

$= \underline{\underline{19.65\,J/kg^{-1}/K}}$

$\Delta Q_c = 0.072\,kg\,($

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EXPERIMENT 9: HEAT OF FUSION OF ICE

Aim: To use the law of conservation of energy as m[illegible] of measuring the latent heat of fusion of i[illegible]

APPARATUS: Copper calorimeter in lagging, water, D[illegible] thermometer, ice blocks.

THEORY: In a solid the molecules are held together more/less rigidly within a crystalline structure by [illegible] mutual attraction of atoms or molecules. For a solid to [illegible] ~~Shape~~ state, molecules must absorb energy so as to increase the separation between the molecules. When the molecul[illegible] gain enough energy to slide over one another and thus, solid turns into a free-flowing liquid.

The method of providing heat to a solid is by heating it. The energy absorbed by a solid results in an increase in the [illegible] of molecules. Thus, the molecular potential energy and not kin[illegible] energy increases, therefore, heat absorbed by the solid does [illegible] result in a temperature rise as a solid changes into a l[illegible]

The quantity of heat absorbed by each gram of a solid in ch[illegible] into a liquid is called the latent heat of fusion of the soli[illegible]

Let ΔQ_F = heat of fusion,

ΔQ_1 = heat change of the ice-water mixture

ΔQ_w = heat change of the warm water and

ΔQ_c = heat change of the calorimeter cup.

The heat change ΔQ is positive if heat is absorbed, negative if heat is lost. Therefore, conservation of energy leads to: heat lost = heat gained.

Hence $\Delta Q_F + \Delta Q_1 + \Delta Q_w + \Delta Q_c = 0$ (i) a[illegible]

C_w is specific heat of water = 4.18 J/g°C and C_c is the specific heat of the material of the calorimeter.

CONCLUSION

The experiment was successfully carried out and the law of parallelogram of forces was observed ~~because~~ hence proving Law of triangle forces and Lami's theorem.

DATA

A) Parallelogram of Forces

Zero error of the spring balance = 0.00N

Zero correction of the spring balance = 0.00N

Scale grams (10g) = ~~1cm = 10g = 0.001kg~~

= 1cm = 10g = 0.01 kg

NO	FORCES			LENGTH (Cm)			RESULT R' = OC.x	DIFFERENCE R-R'
	P	Q	R	P/x = OA	Q/x = OB	OC		
1	0.50N	0.50N	0.50N	5.00	5.00	6.00	0.3	0.2
2	0.70N	0.70N	0.50N	7.00	7.00	9.40	0.66	0.16
3	0.80N	0.80N	0.50N	8.00	8.00	5.70	0.416	0.08

R and R' were found to be within the limits of the experimental error, therefore R' is the resultant of P and Q, R is the equilibrant.

B LAW OF TRIANGLE FORCES

- O'a was taken to be equal to OA, ab parallel to OB, and bO' equal and parallel to OC

NO	FORCES			LENGTH (cm)			P/O'a	Q/ab	R/bO'
	P(N)	Q(N)	R(N)	O'a	ab	bO'			
1	0.50	0.50	0.5	5.00	5.00	6.00	0.10	0.10	0.10
2	0.70	0.70	0.5	7.00	7.00	9.40	0.10	0.10	0.08
3	0.80	0.80	0.5	8.00	8.00	5.3	0.10	0.10	0.[illegible]

RESULT :

It was found that $\frac{P}{O'A} = \frac{Q}{ab} = \frac{R}{bO'}$ within the limits of experimental error.

DISCUSSION

The torques were found based on the principle which states: for the body to be in equilibrium under the action of two or more forces, the vector sum of the forces must be zero and the sum of the torques about any point in the clockwise direction must be equal to the sum of the torques about the same point. ~~The~~ from the above ~~we used~~ the formula $T = f.d$ was used. However the mass of the rule was found by the formula $Mass(g) = \frac{M_1 X_1}{d}$ where

M_1 was ~~the distance of~~ Mass 1 and X_1 distance from the pivot to Mass 1 and d being the distance from the centre of gravity to the pivot. Discuss source of errors in the exp and how you can minimise them.

CONCLUSION

The experiment was a success though with difficulties NOT complete.

Mean ~~deviation~~ = Mean mass − least mass

$(\bar{x} - x) = 133.47$

Mean deviation $= |\Sigma| x_i - \bar{x}| = |\Sigma(m_i - \bar{m})$

$= \frac{(0.27)+(2.27)+(2.27)+(7.5)+(1.08)+(4.8)}{6}$

$= \frac{17.61}{6}$

$= 2.935$

Standard deviation $= \sqrt{\Sigma(x_i-\bar{x})^2 N-1}$

$= \cancel{\sqrt{(2.935)^2}}$

$= \sqrt{(17.61)^2/6-1}$

$= 3.592$

STEP 6

Reading on the spring balance

2.4 N

Mass = $\frac{force}{gravity}$

$= \frac{2.4N}{9.8}$

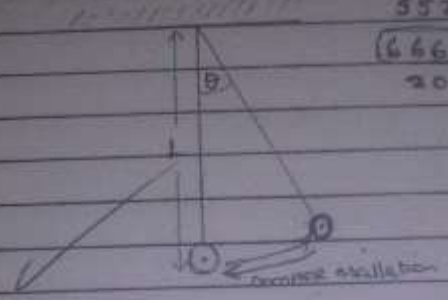
$= 0.24$ ~~grams~~ Kg

1g = 1000g

x = 0.24 Kg

Mass (g) = 240g − 120g = 120g

is assumed to be small. Equation (1) therefore predicts that period T, is independent of the amplitude of the oscillation.



55788744
(66666666)
20

60°
5 (18+4+4+8)

PROCEDURE

A : PERIOD AND LENGTH

L was made ~~a lagge~~ as large as possible. Then the pendulum was set into oscillations, with the amplitude being small (θ less than 5°), time t was measured for 20 complete oscillations. The measurements were then repeated. The observations were ~~as~~ for eleven repeated until ~~they gave~~ consistent values were found. The mean value of t was calculated and five values of L determined

B: PERIOD AND MASS

When the variation of period with length was investigated in part A, it was necessary to keep angular amplitude small and the mass constant throughout the experiment to prevent interfering with the investigation of period with length. To investigate the variation of the period with mass, length was kept constant with amplitude small aswell. Period L was determined and period T taken for three

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13TH August 2003

EXPERIMENT 4: SIMPLE PENDULUM

Aim

This experiment was aimed at investigating

i) the relationship between the length of a simple pendulum and its period of oscillation

ii) If the period of oscillation depends upon the mass of the bob, and

iii) If the period of oscillation depends upon the amplitude of the oscillation.

APPARATUS: Length of string, Masses to act as bobs, stop Vernier callipers, Stand and Clamp

THEORY

The simple pendulum consists of the pendulum consist into a size much smaller than the distance from the ma to the support and the supporting string is of light. The angular distance of the pendulum from the equilibri position is called Displacement and the maximum displ ment is called the amplitude of the oscillation (for s amplitudes (less than or equal to 5 degrees) the period (t for one complete oscillation) is given by $T = 2\pi\sqrt{(L/g)}$ (1) whe T is the period in seconds, L is the length in Metres and g the acceleration due to gravity in ms^{-2}. The three properties investigated in this experiment are:

1. The Period T is directly proportional to $\sqrt{L}$. Squaring bot (ii) were T^2 is proportional

$$T^2 = 4\pi^2\left(\frac{L}{g}\right)$$

2. Since the Mass of the bob does not appear in the equation equation (1) therefore predicts that period is independent of the ma the bob. Number gives eqns eg $T^2 = 4\pi^2(L/g)$

3. In the derivation of the equation, Amplitude of the oscill

Part B

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{100 - 50}{4 - 2}$$

$$= \frac{50}{2}$$

$$= \frac{25}{100}$$

Slope = 0.25

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{100 - 50}{4 - 2} = \frac{50}{1.99} = \frac{25}{100} = 0.25 = 0.36$$

$g = 4\pi^2 \times$ Slope of the graph

$$g = 4\pi^2 \times 0.25$$
$$= 9.869604401$$
$$= 9.87\ m/s^2$$

% error = Absolute error = 0.006

$$\%\ \text{error} = \frac{0.006}{9.87} \times 100$$

$$= 0.06\ \%$$

masses of the bob The procedure as in part A was followed

C PERIOD OF THE PENDULUM

The Mass of the bob and length of the pendulum was kept constant and period was measured for several widely different amplitudes.

DATA FOR PART A

LENGTH L	Time for 20 oscillation		Mean Time	Period T	T^2
cm	T_1 sec	T_2 sec	$t=(t_1+t_2)/2$ s	sec	sec^2
100	39.97	39.95	39.96	1.998	3.992
90	37.94	37.96	37.95	1.897	3.598
80	35.22	35.24	35.23	1.762	3.105
70	33.97	33.12	33.55	1.678	2.816
60	30.97	30.98	20.98	1.574	2.399
50	28.31	28.32	28.32	1.416	2.0015

Length at 100 cm

$$\text{Mean time} = \frac{39.97 + 39.95}{2}$$

$$= \underline{39.965}$$

$$\text{Time} = \frac{\text{Total time taken}}{\text{no of Complete oscillation}}$$

$$= \frac{39.96}{20}$$

$$= \underline{1.9985}$$

$$T^2 = (1.998)^2$$

$$= 3.99c$$

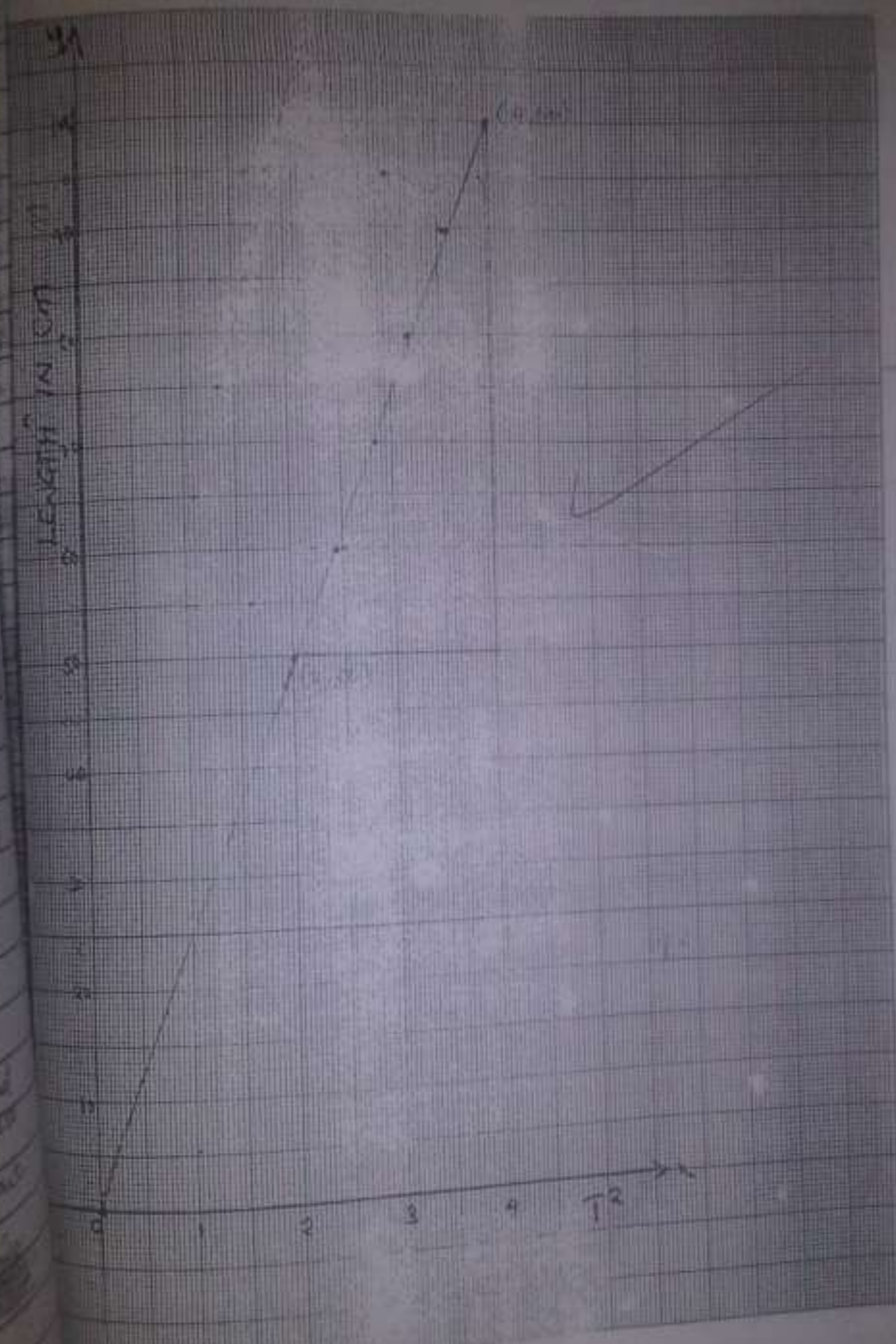
PART B

LENGTH IN cm	T_1 (s)	T_2 (s)	Mean Time	Period T	T^2	MASS
40	29.22	29.27	29.22	1.491	2.22	M_1
40	30.14	30.16	30.15	1.507	2.27	M_2
40	30.17	30.16	30.17	1.508	2.275	M_3

From the table, the period has a minimal variation

The Graph of L Against T^2

Scale
Length → 2 : 10 cm
T^2 → 2 : 1 second



9/10

27th AUGUST 2009

EXPERIMENT 5: HOOKE'S LAW AND VIBRATION

Aim
The aim of this experiment was to
- measure the extension produced in a spring for various loads and establish the relationship between the extension produced and the load. Hence calculating the spring constant.
- Measure the Period of oscillations for different loads and determine the spring constant and the value of g.

APPARATUS
Spiral spring, Pointer, rigid stand and clamp, Meter rule, weights, scale pan and Stop watch.

THEORY
According to Hooke's law, extension caused by a load attached to a spiral spring is proportional to the weight of the load. This is given by the formula

$$E = \frac{mg}{K} \quad (1)$$

where E - Extension
M - Mass of the load
g - acceleration due to gravity
K - spring constant.

The method of using formular (1) to determine K is called the static method because measurements are performed in a static situation.
When a loaded spring is stretched beyond its equilibrium position and then released

DISCUSSION

The experiment was a success in that period was determined

CONCLUSION

From the experiment it was discovered that there was no change in the period of the pendu oscillation as it does not depend on the mass of the bob and the amplitude of the oscillation.

It was concluded that the period of the pendulum depended on the Length of the pendulum it starts vertical vibration. The period T of vibration is the time required to move from the upper end of the vibration to the lower end and back again. This is given by

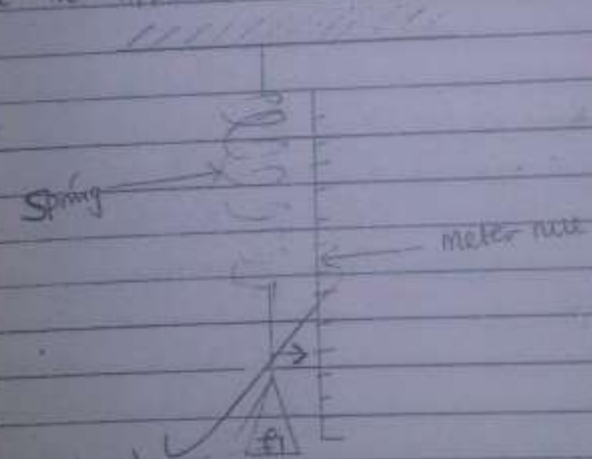
$$T = 2\pi\sqrt{\frac{(M+m+S/3)}{k}} \quad \text{or} \quad (ii)$$

$$T^2 = 4\pi^2\,(M+m+S/3)/k \quad \text{where}$$

M - Mass of applied load, m = Mass of scale pan and
S - Mass of the Spring
K is the same spring constant as in formular (i). A method of using formular (ii) to find the spring constant K is known as the Dynamical method because the motion of the mass is essential to the measurement.

PROCEDURE

~~Set the~~ The apparatus was set as below:



PART 1

Firstly the reading of the pointer was noted when no weight was added to the scale pan. The weights were put on the scale pan and the position of the pointer for each load was recorded. The load did not exceed the elastic limit of the spring.

Atleast 5 readings of the load were obtained and extension was obtained by taking the reading of the pointer with a certain load and subtracting the load with Zero load. Decreasing load was obtained by removing each of the weights Readings were recorded in a table.

PART 2

With the apparatus still in the Vertical position, the pin was removed from the scale pan, M load was added to the scale pan and it was set in vertical vibration by giving it a small additional downward displacement. Time taken for 20 vibrations was obtained twice and the measurements were repeated with different loads. Mass of the pan was also obtained and that of the spring and readings for 120, 140, 160, 180 and 200g were also taken and recorded in a table before plotting a graph of T^2 on the Y axis against $(M + m + s/3)$ on the X-axis to confirm the expectations from theory.

DATA ANALYSIS

PART 1

	POINTER READINGS		EXTENSION		MEAN EXTENSION (cm)
LOAD M (g)	INCREASING LOAD (cm)	DECREASING LOAD (cm)	INCREASING LOAD (cm)	DECREASING LOAD (cm)	
10	58.0	58.0	0.50	0.50	0.5
30	66.7	66.8	1.40	1.40	1.4
50	67.7	67.8	2.40	2.50	2.45
100	70.3	70.3	5.00	5.00	5.0
150	72.9	72.9	7.60	7.60	7.60

Readings for both increasing and decreasing load were taken to ensure accuracy of the measurements and to check weather the spring had been deformed by the load. The observations were that extension differed with the increase in mass.

Co-ordinates $\boxed{(80,4),\ (40,2)}$

$$\text{Gradient (slope)} = \frac{\Delta y}{\Delta x}$$

$$= \frac{4cm - 2cm}{80g - 40g}$$

$$= \frac{2cm}{40g}$$

$$= \underline{0.05\ cm/g}$$

Changing cm/g to m/kg was calculated as follows:

$$0.05\ \cancel{cm}/\cancel{g} \times \frac{1m}{100\cancel{cm}} \times \frac{1000\cancel{g}}{1\ kg}$$

$$= 0.05m \times 10\ kg$$

$$= 0.5\ m/kg$$

K was calculated as follows:

$$E = \frac{Mg}{K} \qquad K = \left(\frac{M}{E}\right)g$$

$$= \left(\frac{1\ kg}{0.5m}\right) \times 9.78\ m/s^2$$

$$= 2kg \times 9.78\ s^{2}$$

$$= \underline{19.56\ kg\ s^{-2}}$$

Part 2

Load M (g)	M+m+S/3 (g)	Time for 20 vibrations Set 1 (sec)	Set 2 (sec)	Mean time for 20 vibrations (sec)	Time for 1 vibration (sec)	T^2 (sec)^2
120	174.7	11.62	11.97	11.86	0.60	0.36
140	194.7	12.34	12.81	12.33	0.63	0.40
160	214.7	12.78	13.00	12.89	0.66	0.44
180	234.7	13.84	13.90	13.87	0.69	0.48
200	254.7	14.56	14.66	14.61	0.72	0.52

Mass of Spring (S) = 14.2g

Mass of scale pan (m) = 50g

Effective Mass of Spring, S/3 = 4.73 g

From the table it was noted that increasing the mass of the load increased the period T of the vibrations. The second column of M+m+S/3 was seen to differ by a constant value of 20g. The vibration period differed only by a constant margin of 0.4 seconds.

coordinates [(190, 0.4)]

Co-ordinates : (190, 0.4), (240, 0.5)

$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

$$= \frac{(0.5-0.4)(\text{sec})^2}{(240-190)\ g}$$

$$= \frac{0.1\ (\text{sec})^2}{50\ (g)}$$

$$= 0.002\ \text{sec}^2/g$$

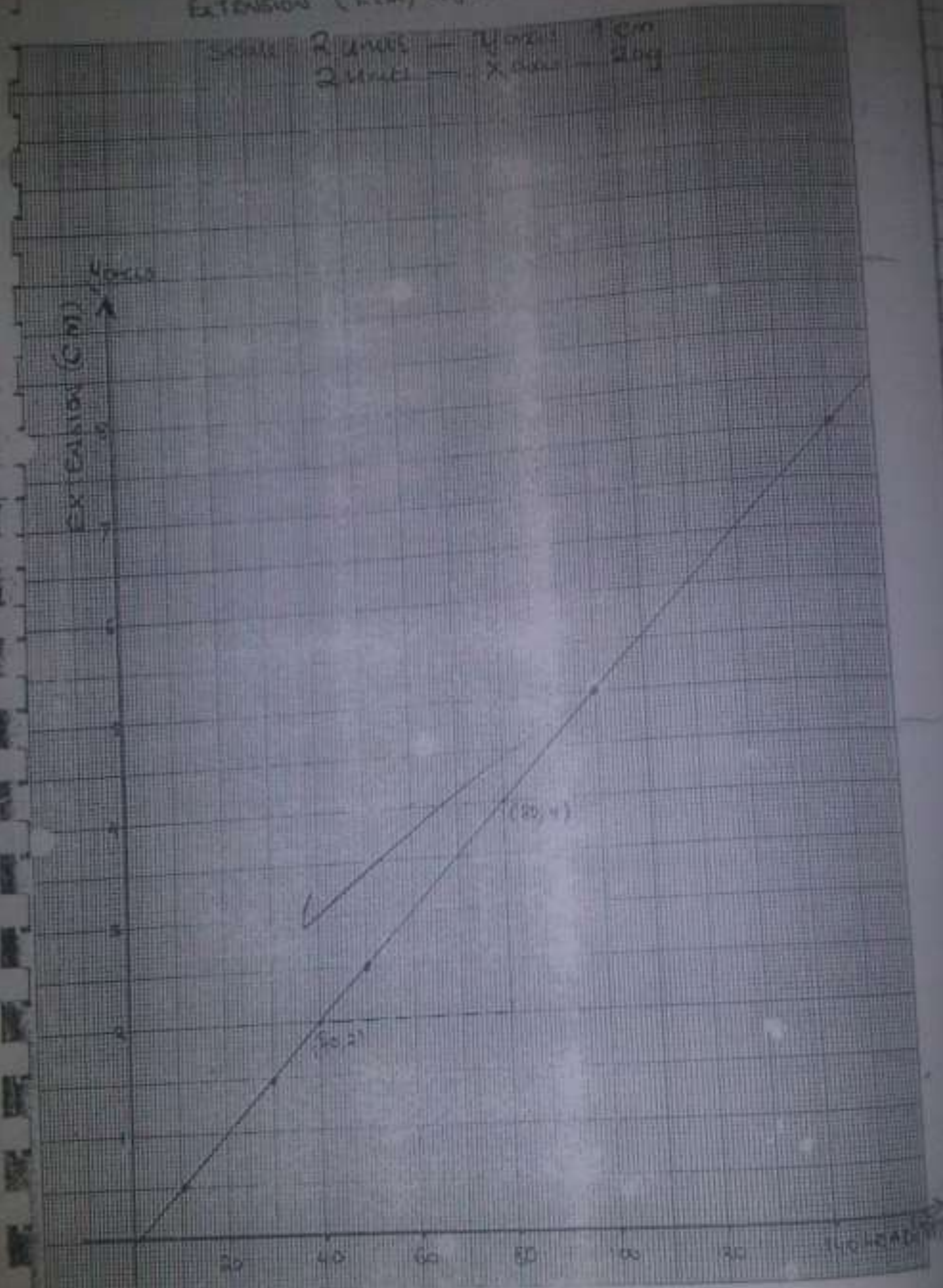
$$K = \left(\frac{m}{E}\right) g \qquad \frac{4\pi^2}{\text{slope}}\ N/m$$

$$\text{Slope} = \frac{y}{x} = \frac{4\pi^2}{K} \rightarrow K = $$

PART A

EXPERIMENT 3

EXTENSION (E cm) AGAINST LOAD (M) in Grams



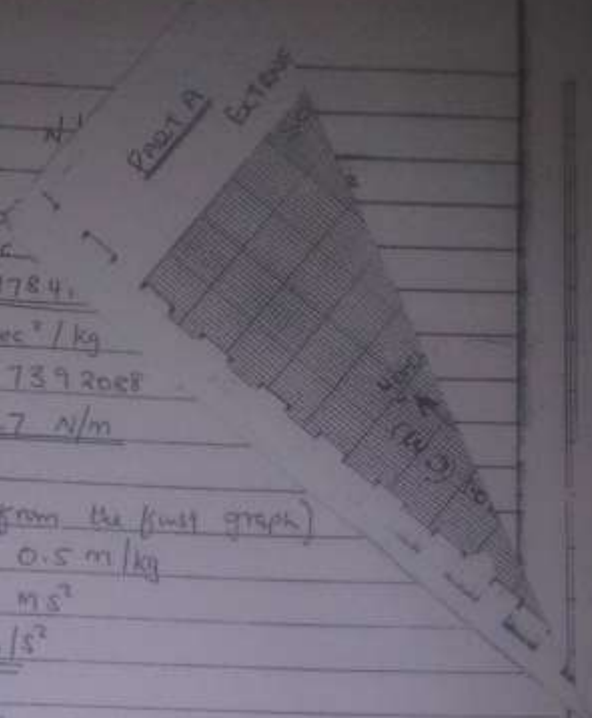
$$K = \frac{4\pi^2}{\text{Slope}} \quad N^{-1}$$

$$= \frac{4\pi^2}{2\ \text{sec}}$$

$$= \frac{39.4784}{2\ \text{sec}^2/\text{kg}}$$

$$= 19.7392088$$

$$= \underline{19.7\ N/m}$$



$g = Kx$ (Slope from the first graph)

$= 19.56 \times 0.5\ m/kg$

$= 9.78\ ms^{-2}$

$= \underline{9.8\ m/s^2}$

The values of K in parts (i) and (ii) where found to be almost the same with a difference of about 0.1 (19.7 - 19.6).

DISCUSSION

From the experiment it was clear that increasing the mass of the load increased the extension of the spring. It was also observed that increasing mass of load in scale pan increased the period of vibration. Errors could occur in future if the clamp and stand are not rigid

CONCLUSION

The experiment was successfully done in that extension produced for various loads were measured and the relationship between extension and load was carried out. The period of oscillation was also

DATA COLLECTION

M_x = 0.00 Kg.

t	S	Δ S	Δ t	v = Δs/Δt
sec.	mm	mm	sec	mm/s
0.1	40	18	0.04	450
0.2	91	23	0.04	575
0.3	168	28	0.04	700
0.4	230	33	0.04	825
0.5	315	38	0.04	950

Where are the tapes?

Mass = 0.5 Kg

t	S	Δ S	Δ t	V = Δs/Δt
Sec	mm	mm	sec	mm/s
0.1	49	22	0.04	~~550~~ 580
0.2	105	25	0.04	~~[illegible]~~ 625
0.3	169	28	0.04	~~700~~ 700
0.4	240	32	0.04	~~800~~ 800
0.5	320	33	0.04	~~875~~ 875

Mass = 1.0 kg

t	S	Δ S	Δ t	v = Δs/Δt
Sec	mm	mm	sec	m/s
0.1	40	12	0.04	~~275~~ 300
0.2	85	20	0.04	~~300~~ 500
0.3	138	22	0.04	~~375~~ 550,
0.4	185	24	0.04	~~400~~ 600
0.5	223	23	0.04	~~500~~ 625

Mass = 1.5 kg

t	S	Δs	Δt	$v = \Delta s / \Delta t$
Sec	mm	mm	sec	mm/s
0.1	25	11	0.04	~~122.5~~ 275
0.2	55	12	0.04	~~267.5~~ 300
0.3	88	15	0.04	~~422.5~~ 375
0.4	127	16	0.04	~~6000~~ 400
0.5	172	20	0.04	~~8000~~ 500

Data Summary

Mass of trolley = 724 g = 0.724 kg

Mass of the scale pan M_1 = 50g

Mass of the added weight in the scale pan

M_2 = 100g

Mass $m = M_1 + M_2$ = 50 g + 100g = 150 g = 0.15 kg

m_x	$(M + m_x + m)$	$(M + m_x + m)^{-1}$	Acceleration from
Kg	kg	Kg	graph (ms^{-2})
0	0.947	1.06	0.5
0.5	1.447	0.69	0.5
1.0	1.947	0.51	0.375
1.5	2.447	0.41	0.286

0.5 kg = m_x

$M + m_x + m$ = 0.747 kg + 0.5 kg + 0.15 kg

= 1.394 kg

$(M + m_x + m)^{-1} = \frac{1}{M + m_x + m}$

$= \frac{1}{1.394 \text{ kg}}$

= 0.73 kg

At $h = 70cm$

$$\bar{t} = \frac{0.375 + 0.365 + 0.376 + 0.383 + 0.381}{5}$$

$$= \frac{1.88}{5}$$

$\bar{t} = 0.376$ and $(\bar{t})^2 = 0.141376$

At $h = 60cm$

$$\bar{t} = 1.742/5$$

$$= 0.3485$$

$h =$ At $h = 10$

$t =$

At $h = 10cm$

$$\bar{t} = \frac{0.153 + 0.134 + 0.148 + 0.152 + 0.132}{5}$$

$$= 0.719/5$$

$$= 0.1438s$$

DISCUSSION

Calculation of diff

density calculation ??

CONCLUSION

introduction to some measuring instruments e.g. Vernier callipers, Micrometer screw gauge was a success in that reading was taken of different objects that were measured. The idea about uncertainty was also clear as experimental errors were calc... and this made significant figures which is very important in physics familiar

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EXPERIMENT 2 : GRAPHICAL AND ERROR ANALYSIS

3rd September 20[illegible]

Aim

Analysis of an object falling freely through several heights.

THEORY

For a body falling freely through a height h, the relationship $h = (1/2)gt^2$ is used. Here, t is the time taken for a body to fall through the height h. The following table gives the time of fall for several for several heights.

HEIGHTS (h cm)	TIME OF FALL (t seconds)	Σt sec	$\bar{t}$ sec	$(\bar{t})^2$ s^2
80	0.395, 0.412, 0.408, 0.395, 0.405	2.015	0.403	0.1624
70	0.375, 0.365, 0.376, 0.383, 0.381	1.88	0.376	0.141376
60	0.350, 0.348, 0.347, 0.352, 0.345	1.792	0.348	0.1213
50	0.321, 0.324, 0.315, 0.317, 0.325	1.602	0.3204	0.10266
40	0.281, 0.275, 0.286, 0.278, 0.283	1.403	0.2806	0.07874
30	0.251, 0.254, 0.245, 0.247, 0.250	1.247	0.2494	0.0622036
20	0.201, 0.198, 0.195, 0.208, 0.205	1.007	0.2014	0.0405 62
10	0.153, 0.134, 0.148, 0.152, 0.132	0.719	0.1438	0.02067844

Calculation for Mean

At h = 80 cm $\Sigma t = 2.015$

$$\bar{t} = \frac{0.395 + 0.412 + 0.408 + 0.395 + 0.405}{5}$$

$$= \underline{0.403}\ s$$

$$(\bar{t})^2 = (0.403)^2$$

$$= 0.162409 = \underline{0.1624}\ s$$

The result for best value of volume V was calculated using rule 4 of Significant figures where the final result is only taken to the same number of significant figures with the least number of significant figures. Therefore,

The best value of volume $V = 7.86\ cm^3$

b) Using the measuring cylinder D, the volume was measured and the following data was recorded

- Volume of water in the measuring cylinder before adding cylinder

$V_1 = 20.00\ cm^3$, Significant figures 4

- Volume of water plus cylinder D

$V_2 = 28.00\ cm^3$, Significant figures 4

- Therefore, volume of cylinder D :

$V_2 - V_1 = 28.00\ cm^3 - 20.00\ cm^3$

$= 8.00\ cm^3$, to 3 significant figures.

PART V : Using the micrometer atleast 6 measurements of thickness of the plate were taken and shown as follows

PLATE NO	THICKNESS OF THE PLATE	$\bar{x}$	$f(x - \bar{x})$	$(fx)^2$
1	3.50 mm	3.55 mm	-0.05 mm	0.0025 mm
2	3.74 mm	3.55 mm	-0.19 mm	0.0361 mm
3	3.76 mm	3.55 mm	-0.21 mm	0.0441 mm
4	3.32 mm	3.55 mm	-0.23 mm	0.0529 mm
5	3.54 mm	3.55 mm	-0.01 mm	0.0001 mm
6	3.42 mm	3.55 mm	-0.13 mm	0.0169 mm

Mean $(\bar{x}) = \frac{1}{N}\sum_{i=1}^{N} x_i$

$= \frac{3.56 + 3.76 + 3.76 + 3.52 + 3.54 + 3.42}{6}$

$(\bar{x}) = 3.55$ mm

Mean deviation $(\overline{\delta x}) = \sum |(x_i - \bar{x})| / N$

$= \frac{|0.03| + |-0.19| + |-0.21| + |0.13| + |0.01| + |0.13|}{6}$

$= \frac{0.82}{6}$

$\overline{\delta x} = 0.137$ mm

Standard deviation $(\sigma) = \sqrt{\sum (x_i - \bar{x})^2 / (N-1)}$

$= \sqrt{(0.82)^2 / 6-1}$

$= \sqrt{0.6724/5}$

$= 0.367$ mm

Standard Error $(\Delta x) = \sqrt{\sum (x_i - \bar{x})^2 / N(N-1)}$

$= \frac{\sigma}{\sqrt{N}}$

$= \frac{0.367}{\sqrt{6}}$

$= 0.149827$ mm

$\Delta x = 0.15$ mm

b) The vernier callipers were used the width W of the
Reading on the main scale = 28 mm
Reading on the vernier scale, number of divisions
Zero correction = 0.05 mm
$W = 28 + 0.05 \times 13 = 28.65$ mm
Thickness of the plate
c) To find thickness of the plate vernier callipers used
Reading on the main scale = 3 mm
Reading on the vernier scale, number of divisions
Zero correction = 0.05 m
$T = 3 + (6 \times 0.05) = 3.3$ mm
d) After thickness T was found using the vernier the micrometer was then used
Reading on the sleeve = 3 mm
Reading of the thimble, number of divisions = 28
Zero correction = 0.01 mm
$T = 3 + (28 \times 0.01) = 3.28 + 0.01 = 3.29$
0.01 was added to 3 mm because the zero correction was found to be 0.01 mm
c) results obtained under (a), b), c) and (d) the experimental error for each were given
a) $W = 28$ mm $\pm$ 0.1 mm
b) $W = 28.65$ mm $\pm$ 0.05 mm
c) $T = 3.3$ mm $\pm$ 0.05 mm
d) $T = 3.29$ mm $\pm$ 0.01 mm
PART III
Following the procedure in part II, the vernier callipers were used for the following observations
(i) Hollow Cylinder: This was marked as
External diameter of the cylinder = 25.8 mm

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EXPERIMENT 1: MEASUREMENTS AND

Aim

The experiment was aimed at introducing
- Introducing some measuring instrument callipers, and micrometer screw gauge
- giving an idea about uncertainties (experimental errors).
- Making significant figures familiar

APPARATUS

- Flat plate, hollow cylinder, blind-hole cylin Vernier callipers and micrometer screw ga

PROCEDURE

PART 1 :

A) THE METER RULE (MR) : The meter rule was
Each division on the meter rule =
Experimental error for the meter rule Δ

B) The vernier Callipers (VC): The vernier cal and the following were noted before ... Scale such that the zero of the vernier scale the 1cm mark of the main scale. At The number divisions which coincides with the main ... were also read.

Number of main scale divisions =

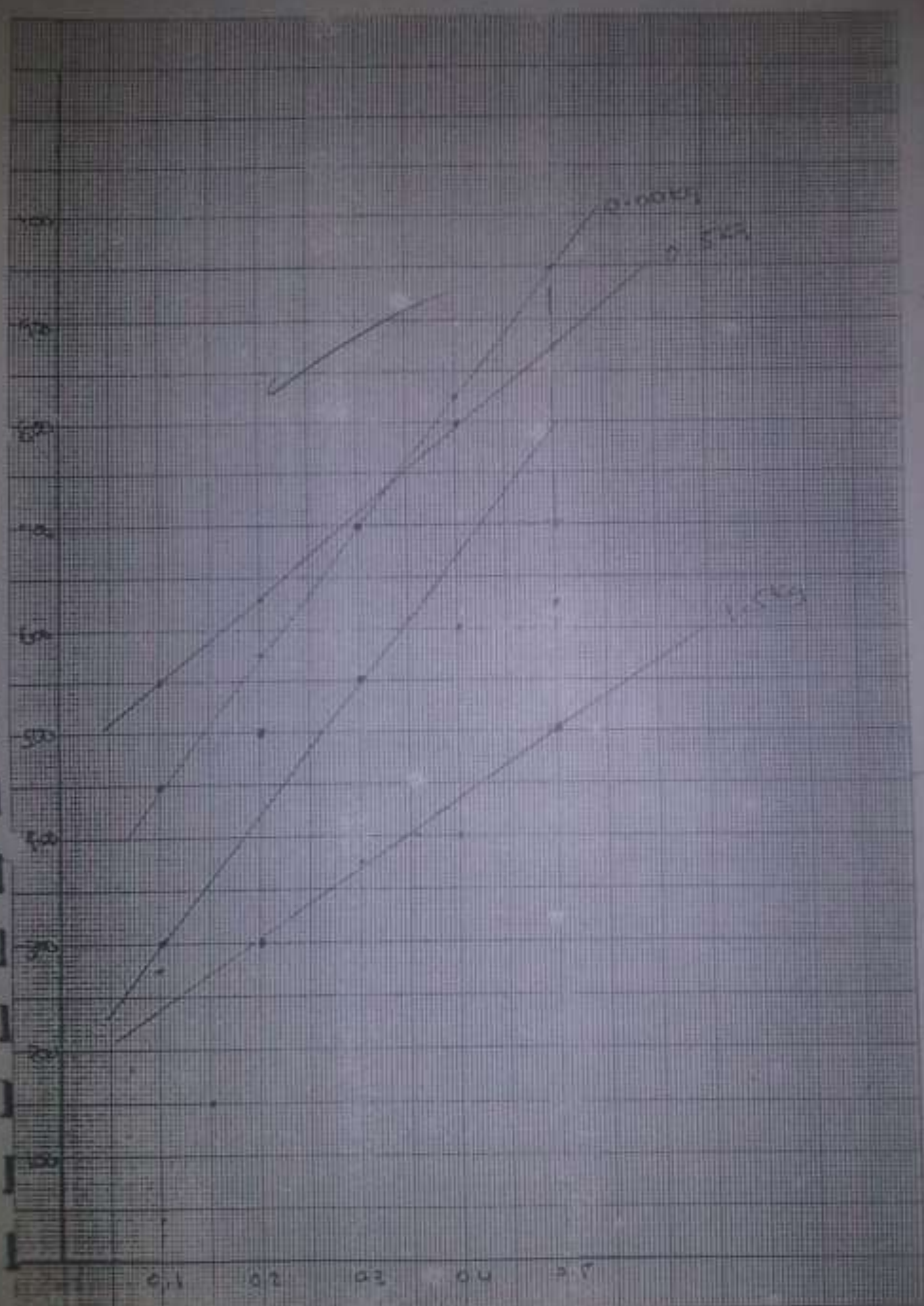
Number of vernier scale divisions =

There fore, each division on the vernier scale =

Least count of vernier callipers =

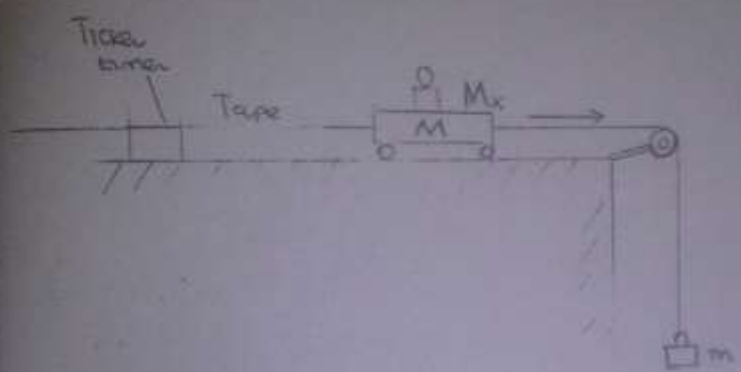
Velocity time graph

Scale x-axis
y-axis



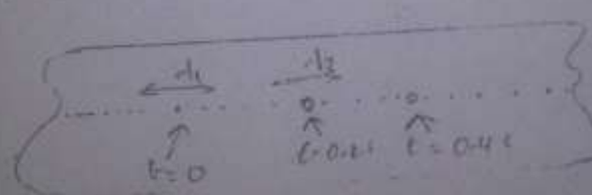
[illegible]paring equation (iii) with the usual [illegible]
Newton's second law, F = mass x accel[illegible]
[illegible] see that in the above statement, mg is
the applied force and the mass that
undergoes the acceleration is (Mx+M+m).

~~PROCEDURE~~ figure 1.



PROCEDURE

The procedure was followed and the experiment as arranged in figure 1 above. Masses of the trolley was obtained and instantaneous velocity was determined.
The experiment was repeated, now with masses on the trolley before recording data in the table.
distances were determined as shown in figure 3 below including time.



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8-10-09

Experiment 6: Newton's Second Law

Aim: To verify that when a constant force is applied to objects of different masses, the resulting acceleration is inversely proportionate to the mass of the object.

Apparatus: Plane with pulley, metre rule, scale pan, trolley, [illegible], tape, masses.

m - hanging mass (100g / 200g)

M_x - extra masses added to the trolley (0.5kg, 1 kg)

M - Mass of the trolley

Theory

If T is the tension in the string and a is the acceleration then for the arrangement shown below, the equations of motion for the bodies are as follows (assuming negligible friction between the trolley and the plane)

fig 2a

fig 2b

From fig. 2a it follows from Newton's second law that: $Mg - T = ma$ (i)

From fig. 2b, again it follows from the second law that: $T = (M + M_x)a$ (ii)

Adding equations (i) & (ii), T cancels and we get

$mg = (M_x + M + m)a$ (iii) Hence,

$$a = \frac{m}{M + M_x + m} g$$

The speed of sound in air is 332 m/s at 0°C

at 26°C ⇒ 15.6 m/s + 332 m/s

= 347.6 m/s

The difference between speeds ;

348.1 m/s − 347.6 m/s

Experiment error = 0.5 m/s

Experimental uncertainty = $\frac{\text{Experimental error}}{\text{Calculated value}} \times 100$

$= \frac{0.5}{348.1} \times 100$

Experimental uncertainty = 0.14 %

Method 2

V was also calculated using graphical method with the equation for the first resonance which as

$L_1 = (V/4f) - \Delta L$ (iv)

Diameter of the resonance tube = 4.22 cm

= 0.0422 m

(i) Slope = $\frac{y_2 - y_1}{x_2 - x_1}$ (3.5, 0.28) 2.0, 0.16

$= \frac{0.28 - 0.16}{3.5 - 2.0} = \frac{0.12}{1.5}$

= 0.08

(ii) The value of V from the graph

Slope = V/4

$0.08 = \frac{V}{4}$ V = 0.32×10^3 m/s

320 m/s

(iii) ΔL = 0.015 from the graph

ΔL = 0.3 ($\frac{4.2}{100}$)

Which graph?

Method 1 :

Subtracting the equations for the first, second resonances is obtained by :

$$L_2 - L_1 = \lambda/2$$

Since $V = f\lambda$, we get $V = 2f(L_2 - L_1)$ (iii)

For each frequency L_1 and L_2 was determined. L_1 could be obtained for all frequencies, it was preferable to use frequencies above 400Hz for L_2 because it would have been difficult for to get the second resonance since the length required would have been more than the equipment's capacity.

The readings were tabulated as follows:

DATA COLLECTION

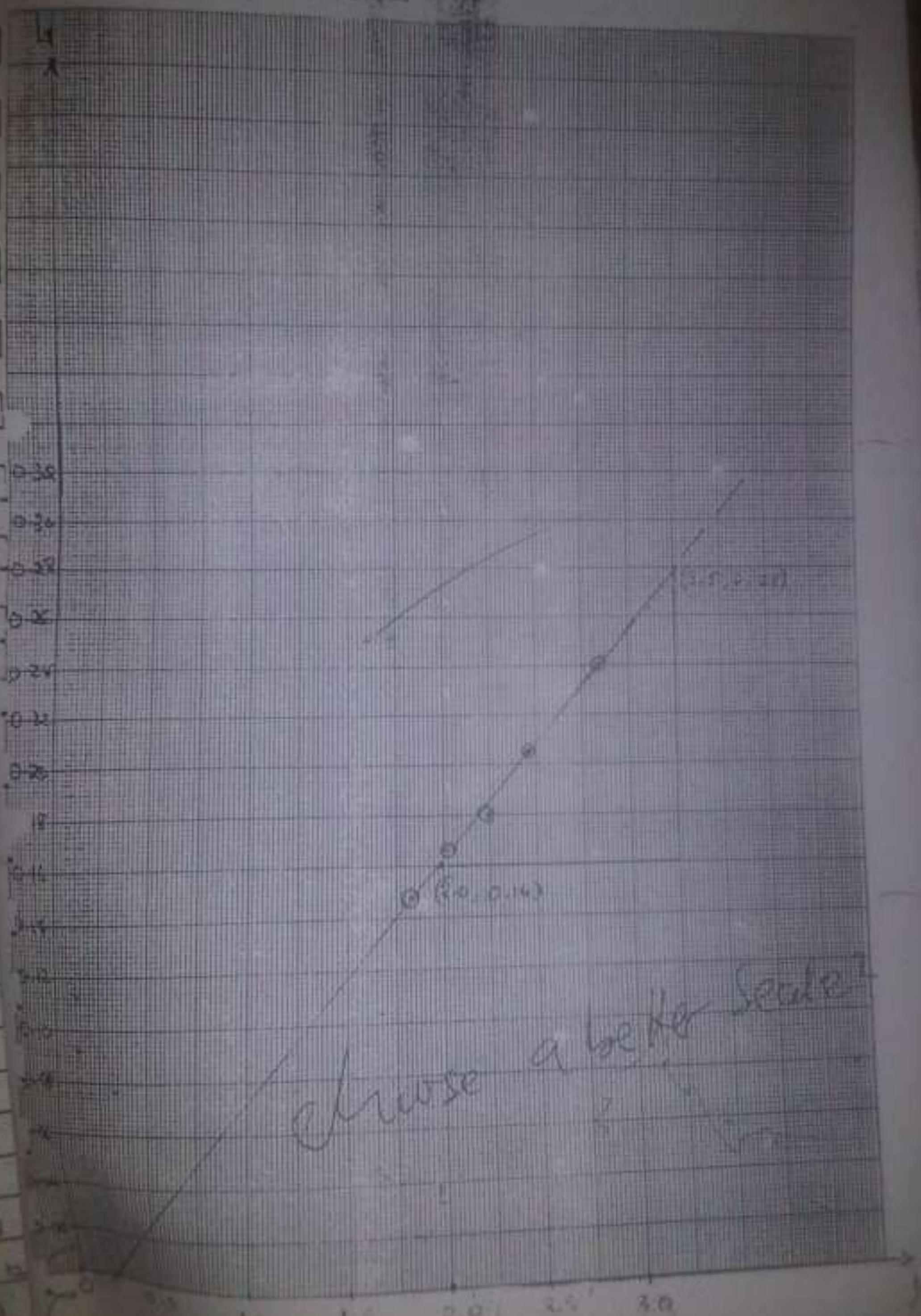
Freq. F Hz	$1/f \times 10^{-3}$ Sec	Measured length of air column: First resonance L_1 m	Second resonance L_2 m	$L_2 - L_1$ m	Speed V m/sec
360	2.78×10^{-6}	0.24	0.73	0.49	352.8
400	2.5×10^{-6}	0.218	0.66	0.442	353.6
440	2.27×10^{-6}	0.18	0.586	0.406	357.3
480	2.08×10^{-6}	0.17	0.535	0.365	350.4
520	1.92×10^{-6}	0.158	0.492	0.334	347.4
560	1.79×10^{-6}	0.15	0.442	0.292	327.04

Calculation of wavelength

$$L_2 - L_1 = \lambda/2$$

EXPERIMENT 10: SPEED OF SOUND IN AIR

A graph of L_1 versus $1/f$



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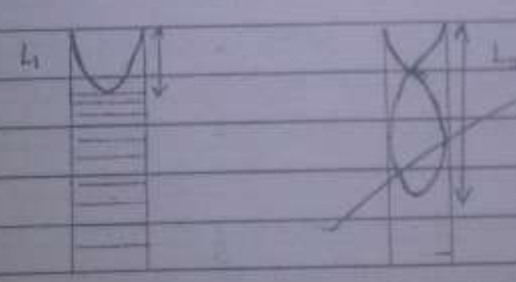
EXPERIMENT 10: VELOCITY OF SOUND IN AIR

AIM: To obtain a value for the velocity of sound in air using a resonance tube.

APPARATUS: Signal generator, resonance tube of about 60cm long, Large glass cylinder, metre rule to measure lengths, vernier callipers.

THEORY: Sound waves of variable (but known) frequency can be generated by a signal generator. When the output speaker for the generated sound is held a distance from the top of the inner tube, waves of frequency produced are propagated downwards and are reflected at the water surface. The reflected waves travel up the air column and stationary waves can be set up in the air column in the inner tube. The air column is at rest at the surface of the water and this is a node (zero amplitude). For instance, the open end must be an anti-node (maximum amplitude). The antinodes are situated at a short distance ΔL outside of the top of the tube. This is called "end correction".



First resonance Second resonance

$L_1 + \Delta L = \lambda/4$ $L_2 + \Delta L = 3\lambda/4$

We note that the velocity of sound v is related to the frequency f, and the wavelength λ through the relation $v = f\lambda$ (i)

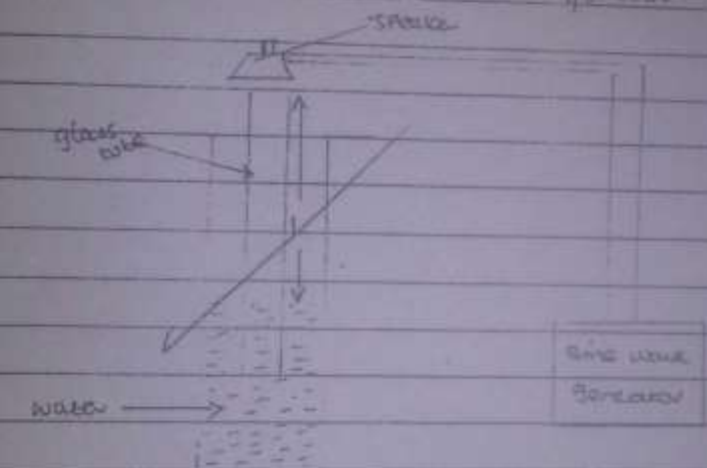
Further, the velocity v depends on the medium. In this experiment velocity of sound in air was measured at room temperature. For the n-th resonance we have the equation

$$L_n + \Delta L = (2n-1)\lambda/4 \qquad \text{(ii)}$$

Where $n = 1, 2, 3 \ldots$ corresponding to the first, second, third ... resonances.

PROCEDURE

The experiment was set as follows:



The inner tube was positioned in the water so that L is small then the signal generator was switched on and using the selector switches, sound waves of sufficient amplitude for any frequency whose value was displayed on the window were produced. First frequency was from 250Hz, increasing in steps of about 30Hz. This followed by holding the speaker face down about 2 cm from the open end of the tube and slowly increasing the length of air column until the first resonance was heard. This resonance gave the loudest sound compared to higher resonances. The first resonance length L_1 was measured and the air column

Discussion

From the experiment it was observed that the amount of heat losed by the pre heated water was equal to the heat gained by the water at room temperature since the calorimeter was acting as a closed system with no losses in energy. It was also observed that the latent heat of ice is the actual amount of heat needed to melt a given ice to liquid and the equation of conservation of heat (energy) was proven.

ΔQ_w = heat change of water at temp $\theta_1 = M_w C_w (\theta_1 - \theta)$

$\Rightarrow \cancel{20^\circ} = 74\,(12.6 - 20)$

$= 74\,(1\,\mathrm{cal}\,g^{-1}\,{}^\circ C^{-1})(-7.4)$

$= \dfrac{-547.6}{\cancel{1000}}$

$= -\cancel{0.5476\ J/kg^{-1}\,{}^\circ C^{-1}}$

$=$

$= 74\,\cancel{(1\,\mathrm{cal}\,g^{-1}\,{}^\circ C^{-1})} \times 265.6\,K$

$= \dfrac{19\,654.\,J}{1000}$

$= \cancel{19.65\ J/kg^{-1}\,K}$

$\Delta Q_w \quad 74g = 0.074\,kg$

$= 0.074\,kg\,(1\,\mathrm{cal}\,g^{-1}\,{}^\circ C^{-1})(265.6\,K)$

$= 19.65\ J/kg^{-1}/K$

$\Delta Q_c = 0.072\,kg\,($

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EXPERIMENT 9 : HEAT OF FUSION OF ICE

Aim : To use the law of conservation of energy as means of measuring the Latent heat of fusion of ice.

APPARATUS : Copper Calorimeter in lagging, water, 0 to 50°C thermometer, Ice blocks.

THEORY : In a solid the molecules are held together more/less rigidly within a crystalline structure by the mutual attraction of atoms or molecules. For a solid to [illegible] Shape state, Molecules must absorb energy so as to increase the separation between the molecules. When the Molecules gain enough energy to slide over one another and thus, Solid turns into a free-flowing liquid.

The Method of providing heat to a solid is by heating it. The energy absorbed by a solid results in an increase in the separation of Molecules. Thus, the Molecular potential energy and not kinetic energy increases, therefore, heat absorbed by the solid does not result in a temperature rise as a solid changes into a liquid.

The quantity of heat absorbed by each gram of a solid in changing into a liquid is called the latent heat of fusion of the solid.

Let ΔQ_F = heat of fusion,

ΔQ_1 = heat change of the ice-water mixture

ΔQ_w = heat change of the warm water and

ΔQ_c = heat change of the Calorimeter cup.

The heat change ΔQ is positive if heat is absorbed, negative if heat is lost. Therefore, Conservation of energy leads to : heat lost = heat gained.

Hence $\Delta Q_F + \Delta Q_1 + \Delta Q_w + \Delta Q_c = 0$ (i) and

C_w is Specific heat of water = 4.18 J/g°C and C_c is the Specific heat of the Material of the Calorimeter.

CONCLUSION

The experiment was successfully carried out and the law of parallelogram of forces was observed ~~hence~~ hence proving law of triangle forces and Lami's theorem.

DATA

A) Parallelogram of Forces

Zero error of the spring balance = 0.00N

Zero correction of the spring balance = 0.00N

Scale grams (10g) = ~~1cm = 10g = 0.001kg~~

= 1cm = 10g = 0.01 kg

A

NO	FORCES			LENGTH (Cm)			RESULT RESULTANT R' = OC.X	DIFFERENCE R-R'
	P	Q	R	P/X = OA	Q/X = OB	OC		
1	0.50N	0.50N	0.50N	5.00	5.00	6.00	0.3	0.2
2	0.70N	0.70N	0.50N	7.00	7.00	9.40	0.66	0.16
3	0.80N	0.80N	0.50N	8.00	8.00	5.70	0.416	0.08

R and R' were found to be within the limits of the experimental error, therefore R' is the resultant of P and Q, R is the equilibrant.

B LAW OF TRIANGLE FORCES

- O'a was taken to be equal to OA, ab parallel to OB, and bO' equal and parallel to OC

NO	FORCES			LENGTH (Cm)			$\frac{P}{O'a}$	$\frac{Q}{ab}$	$\frac{R}{bO'}$
	P(N)	Q(N)	R(N)	O'a	ab	bO'			
1	0.50	0.50	0.5	5.00	5.00	6.00	0.10	0.10	0.10
2	0.70	0.70	0.5	7.00	7.00	9.40	0.10	0.10	0.08
3	0.80	0.80	0.5	8.00	8.00	5.3	0.10	0.10	0.09

RESULT :

It was found that $\frac{P}{O'A} = \frac{Q}{ab} = \frac{R}{bO'}$ within the limits of experimental error.

DISCUSSION

The torques were found based on the principle which states: for the body to be in equilibrium under the action of two or more forces, the vector sum of the forces must be zero and the sum of the torques about any point in the clockwise direction must be equal to the sum of the torques about the same point. ~~The~~ from the above ~~we used~~ the formula $T = f.d$ was used. However the mass of the rule was found by the formula $Mass(g) = \frac{M_1 X_1}{d}$ where

M_1 was ~~the distance of~~ Mass 1 and X_1 distance from the pivot to Mass 1 and d being the distance from the centre of gravity to the pivot. Discuss source of errors in the expt and how you can minimise them.

CONCLUSION

The experiment was a success though with difficulties NOT complete.

Mean ~~deviation~~ = Mean mass − least mass

$(\bar{x} - x) = 133.27$

Mean deviation $= \left| \sum |x_i - \bar{x}| = |\sum (m_i - \bar{m})\right.$

$= \dfrac{(0.27) + (2.27) + (2.27) + (7.5) + (1.08) + (4.3 m)}{6}$

$= \dfrac{17.61}{6}$

$= 2.935$

Standard deviation $= \sqrt{\sum (x_i - \bar{x})^2 / N-1}$

$= \cancel{\sqrt{(2.935)^2}}$

$= \sqrt{(17.61)^2 / 6-1}$

$= 3.592$

STEP 6

Reading on the spring balance

2.4 N

Mass $= \dfrac{\text{force}}{\text{gravity}}$

$= \dfrac{2.4N}{9.8}$

$=$ 0.24 ~~grams~~ Kg

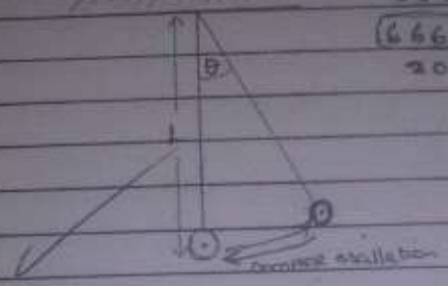
1g = 1000g

x = 0.24 Kg

Mass (g) = 240g − 120g = 120g

Messy ...

is assumed to be small. Equation (1) therefore predicts that period T, is independent of the amplitude of the oscillation.



5578874 4
66666666
20

60%
5 [illegible]

PROCEDURE

A : PERIOD AND LENGTH

L was made ~~alarge~~ as large as possible. Then the pendulum was set into oscillations, with the amplitude being small (θ less than 5°), time, t was measured for 20 complete oscillations. The measurements were then repeated. The observations were [illegible] repeated until ~~they gave~~ consistent values were found. The mean value of t was calculated [illegible] five values of L determined

B: PERIOD AND MASS

When the variation of period with length was investigated in Part A, it was necessary to keep angular amplitude small and the mass constant throughout the experiment to prevent interfering with the investigation of period with length. To investigate the variation of the period with mass, length was kept constant with amplitude small as well. [illegible] L was determined and period T taken for [illegible]

8/10

13TH August 2003

EXPERIMENT 4: SIMPLE PENDULUM

Aim

This experiment was aimed at investigating
i) the relationship between the length of a simple pendulum and its period of oscillation
ii) If the period of oscillation depends upon the mass of the bob, and
iii) If the period of oscillation depends upon the amplitude of the oscillation.

APPARATUS: Length of string, Masses to act as bobs, Stop Vernier callipers, Stand and clamp

THEORY

The simple pendulum consists of the pendulum concent into a size much smaller than the distance from the ma to the support and the supporting string is of light. The angular distance of the pendulum from the equilibri position is called Displacement and the maximum displ ment is called the amplitude of the oscillation. For s amplitudes (less than or equal to 5 degrees) the period (t for one complete oscillation) is given by $T = 2\pi\sqrt{(L/g)}$ (1) whe T is the period in seconds, L is the length in Metres and g the acceleration due to gravity in ms^{-2}. The three properties investigated in this experiment are:

1. The Period T is directly proportional to $\sqrt{L}$. Squaring bo (ii) were T^2 is proportional
$$T^2 = 4\pi^2\left(\frac{L}{g}\right)$$
2. Since the Mass of the bob does not appear in the equation, equation (1) therefore predicts that period is independent of the mass of the bob. Number yields eqns eg $T^2 = 4\pi^2(L/g)$
3. In the derivation of the equation, Amplitude of the oscillati

Part B

Slope $= \dfrac{y_2 - y_1}{x_2 - x_1}$

$= \dfrac{100 - 50}{4 - 2}$

$= \dfrac{50}{2}$

$= 25/100$

Slope $= 0.25$

$g = 4\pi^2 \times$ Slope of the graph

$g = 4\pi^2 \times 0.25$

$= 9.869604401$

$= 9.87\ m/s^2$

% error = Absolute error = 0.006

% error $= \dfrac{0.006}{9.87} \times 100$

$= 0.06\ \%$

Slope $= \dfrac{y_2 - y_1}{x_2 - x_1}$

$= \dfrac{100 - 50}{4 - 2}$

$= \dfrac{54}{1.99}$

$= \dfrac{25}{100}$

$= 0.25$

$= 0.36$

Absolute error =

masses of the bob. The procedure as in part A was followed.

C PERIOD OF THE PENDULUM

The mass of the bob and length of the pendulum was kept constant and period was measured for several widely different amplitudes.

DATA FOR PART A

LENGTH L	Time for 20 oscillations		Mean Time	Period T	T^2
cm	T_1 sec	T_2 sec	$t=(t_1+t_2)/2$ s	sec	sec^2
100	39.97	39.95	39.96	1.998	3.992
90	37.94	37.96	37.95	1.897	3.592
80	35.22	35.24	35.23	1.762	3.105
70	33.97	33.12	33.55	1.678	2.816
60	30.97	30.98	30.98	1.574	2.399
50	28.31	28.32	28.32	1.416	2.0015

Length at 100 cm

$$\text{Mean time} = \frac{39.97 + 39.95}{2}$$

$$= 39.965$$

$$\text{Time} = \frac{\text{Total time taken}}{\text{no of complete oscillation}}$$

$$= \frac{39.96}{20}$$

$$= 1.9985$$

$$T^2 = (1.998)^2$$

$$= 3.99c$$

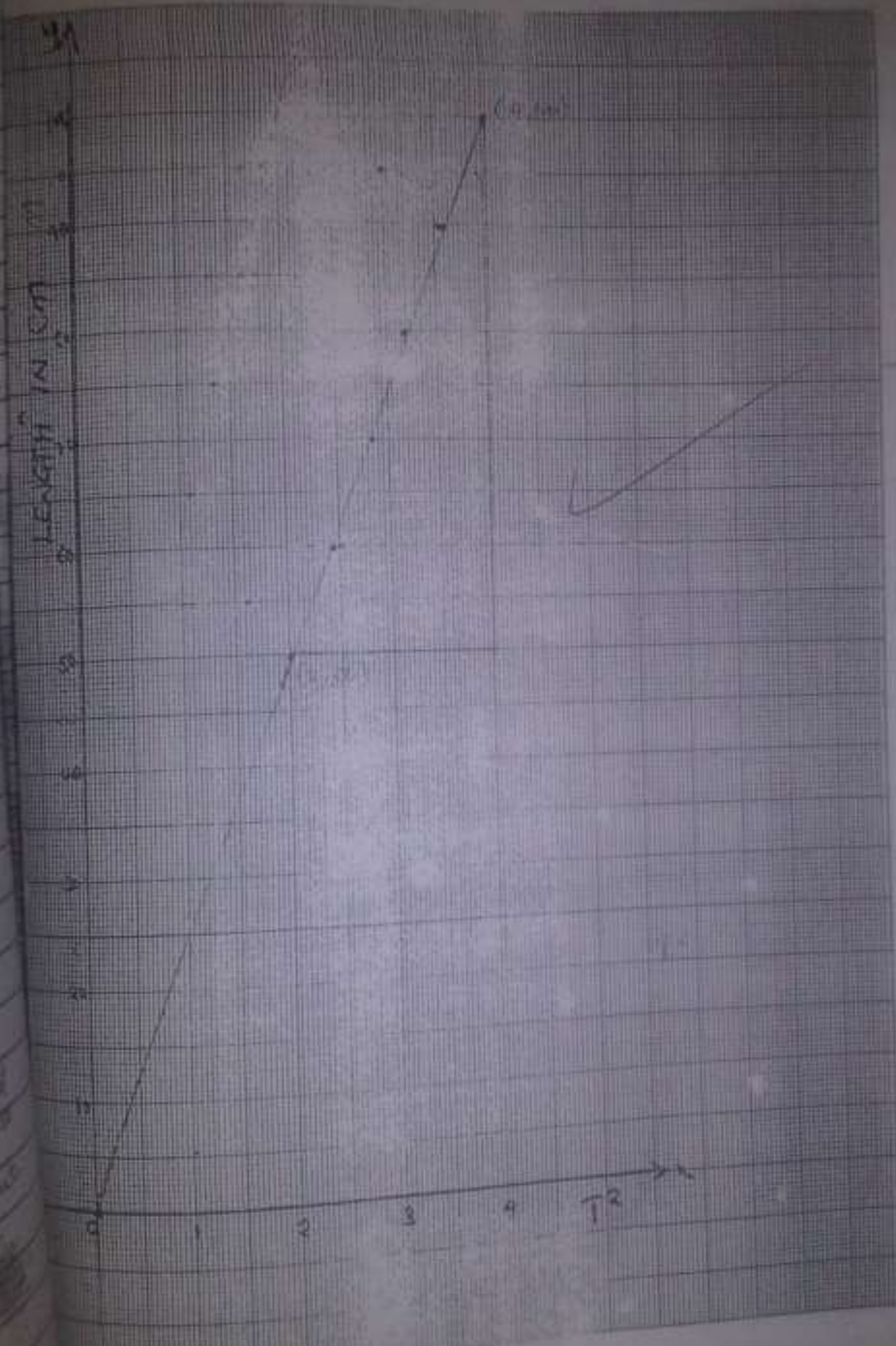
PART B

LENGTH IN CM	T_1 (s)	T_2 (s)	Mean Time	Period T	T^2	MASS
40	29.22	29.27	29.22	1.491	2.22	M_1
40	30.14	30.16	30.15	1.507	2.27	M_2
40	36.17	30.16	30.17	1.508	2.275	M_3

From the table, the period has a minimal variation

The Graph of L Against T^2

Scale
Length → 2 : 10 cm
T^2 → 2 : 1 second



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27th AUGUST 2023

EXPERIMENT 5: HOOKE'S LAW AND VIBRATION

Aim

The aim of this experiment was to

- measure the extension produced in a spring for various loads and establish the relationship between the extension produced and the load. Hence calculating the spring constant.
- Measure the period of oscillations for different loads and determine the spring constant and the value of g.

APPARATUS

Spiral spring, pointer, rigid stand and clamp, Meter rule, weights, scale pan and Stop watch.

THEORY

According to Hooke's law, extension caused by a load attached to a spiral spring is proportional to the weight of the load. This is given by the formular

$$E = \frac{mg}{K} \quad (1)$$

where E - extension
M - mass of the load
g - acceleration due to gravity
K - spring constant.

The method of using formular (1) to determine K is called the static method because measurements are performed in a static situation.

When a loaded spring is stretched beyond its equilibrium position and then released

DISCUSSION

The experiment was a success in that period was determined

CONCLUSION

From the experiment it was discovered that there was no change in the period of the pendu oscillation as it does not depend on the mass of the bob and the amplitude of the oscillation.

It was concluded that the period of the pendulum depended on the Length of the pendulum it starts vertical vibration. The period T of vibration is the time required to move from the upper end of the vibration to the lower end and back again. This is given by

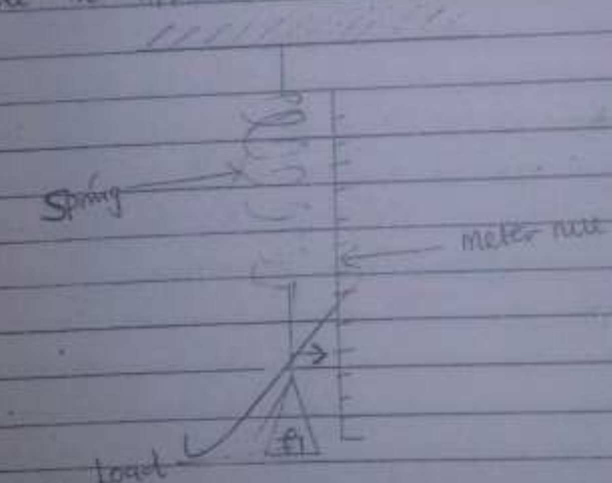
$$T = 2\pi\sqrt{\frac{(M+m+S/3)}{K}} \quad \text{or} \quad \text{(ii)}$$

$$T^2 = 4\pi^2 (M+m+S/3)/K \quad \text{where}$$

M - Mass of applied load, m = Mass of scale pan and
S - Mass of the Spring
K is the same spring constant as in formular (i). A method of using formular (ii) to find the spring constant K is known as the Dynamical method because the motion of the mass is essential to the measurement.

PROCEDURE

~~Set the~~ The apparatus was set as below:



PART 1

Firstly the reading of the pointer was noted when no weight was added to the scale pan. The weights were put on the scale pan and the position of the pointer for each load was recorded. The load did not exceed the elastic limit of the spring.

Atleast 5 readings of the load were obtained and extension was obtained by taking the reading of the pointer with a certain load and subtracting the load with zero load. Decreasing load was obtained by removing each of the weights. Readings were recorded in a table.

PART 2

With the apparatus still in the vertical position, the pin was removed from the scale pan, M load was added to the scale pan and it was set in vertical vibration by giving it a small additional downward displacement. Time taken for 20 vibrations was obtained twice and the measurements were repeated with different loads. Mass of the pan was also obtained and [illegible] the spring and readings for 120, 140, 160, 180 and 200g were also taken and recorded in a table before plotting a graph of T^2 on the Y-axis against $(M + m + s/3)$ on the X-axis to confirm the expectations from theory.

DATA ANALYSIS

PART 1

	POINTER READINGS		EXTENSION		[illegible] (cm)
LOAD M (g)	INCREASING LOAD (cm)	DECREASING LOAD (cm)	INCREASING LOAD (cm)	DECREASING LOAD (cm)	
10	58.0	58.0	0.50	0.50	0.5
30	66.7	66.8	1.40	1.40	1.4
50	67.7	67.8	2.40	2.50	2.45
100	70.3	70.3	5.00	5.00	5.0
150	72.9	72.9	7.60	7.60	7.60

Readings for both increasing and decreasing load were taken to ensure accuracy of the measurements and to check weather the spring had been deformed by the load. The observations were that extension differed with the increase in mass.

Co-ordinates [(80,4), (40,2)]

$$\text{Gradient (Slope)} = \frac{\Delta y}{\Delta x}$$

$$= \frac{4cm - 2cm}{80g - 40g}$$

$$= \frac{2cm}{40g}$$

$$= \underline{0.05\ cm/g}$$

Changing cm/g to m/kg was calculated as follows:

$$0.05\ cm/g \times \frac{1m}{100cm} \times \frac{1000g}{1kg}$$

$$= 0.05m \times 10\ kg$$

$$= 0.5\ m/kg$$

K was calculated as follows:

$$E = \frac{Mg}{K} \qquad K = \left(\frac{M}{E}\right)g$$

$$= \left(\frac{1kg}{0.5m}\right) \times 9.78\ m/s^2$$

$$= 2kg \times 9.78\ s^{-2}$$

$$= \underline{19.56\ kg\ s^{-2}}$$

PART 2

Load M (g)	M+m+S/3 (g)	Time for 20 vibrations Set 1 (sec)	Set 2 (sec)	Mean time for 20 vibrations (sec)	Time for 1 vibration (sec)	T^2 (sec)^2
120	174.7	11.62	11.97	11.86 / 0.68	0.60	0.36
140	194.7	12.34	12.81	12.33 / 0.63	0.63	0.40
160	214.7	12.78	13.00	12.89 / 0.66	0.66	0.44
180	234.7	13.84	13.90	13.87 / 0.69	0.69	0.48
200	254.7	14.56	14.66	14.61 / 0.72	0.72	0.52

Mass of Spring (s) = 14.2g

Mass of Scale pan (m) = 50g

Effective Mass of Spring, S/3 = 4.73 g

From the table it was noted that increasing the mass of the Load increased the period T of the vibrations. The second column of M+m+S/3 was seen to differ by a constant value of 20g. The vibration period differed only by a constant margin of 0.4 seconds.

Coordinates [(190, 0.4)]

Co-ordinates : (190, 0.4), (240, 0.5)

$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

$$= \frac{(0.5-0.4)(\text{sec})^2}{(240-190)\ g}$$

$$= \frac{0.1(\text{sec})^2}{50(g)}$$

$$= 0.002\ \text{sec}^2/g$$

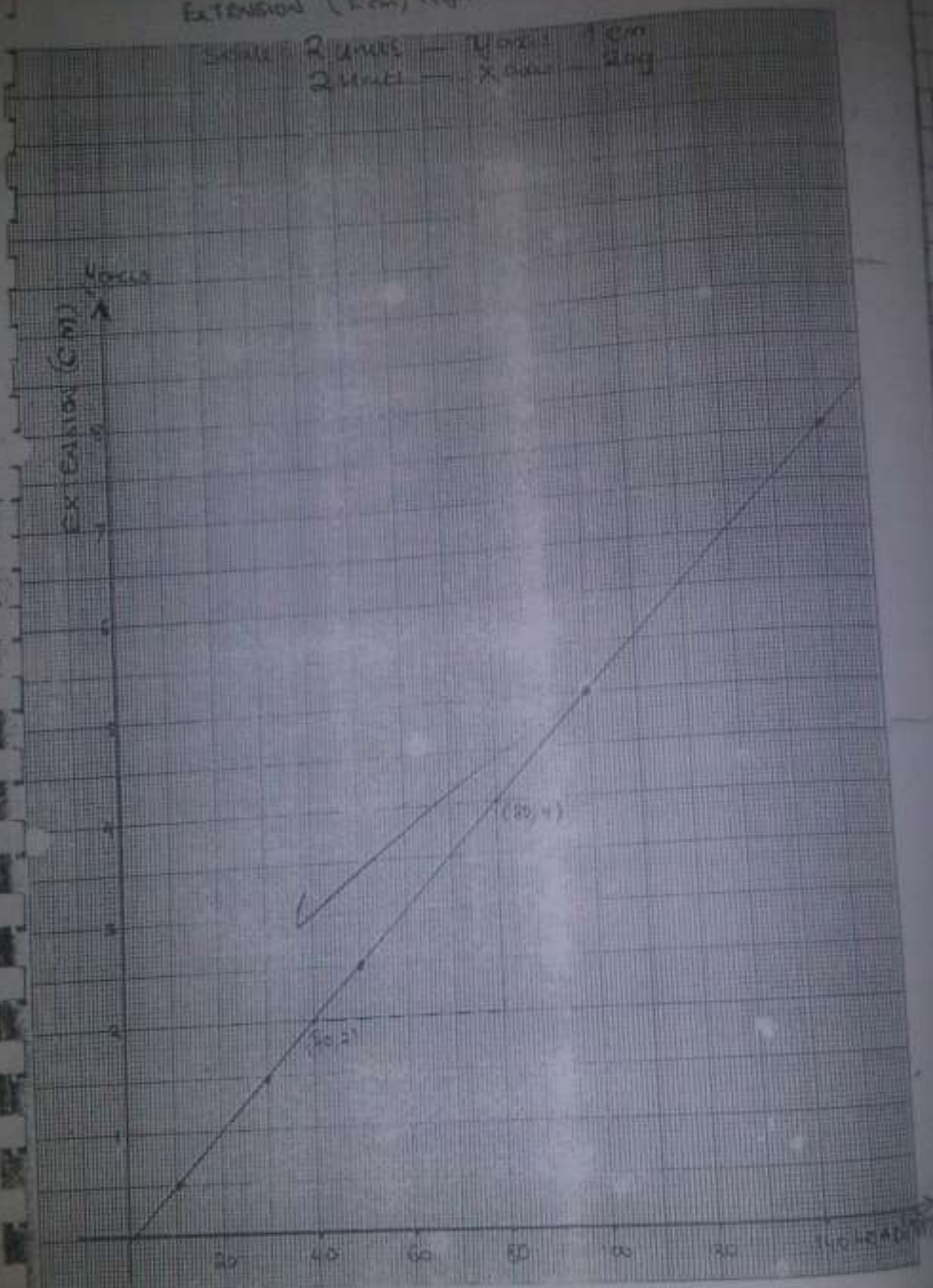
$K = (m/e)\,g$ $\quad \frac{4\pi^2}{K} \rightarrow K = \frac{4\pi^2}{\text{slope}}$ N/m

$\text{Slope} = y/x = \frac{4\pi^2}{K}$

PART A

EXPERIMENT 5

EXTENSION (E cm) AGAINST LOAD (m) in Grams



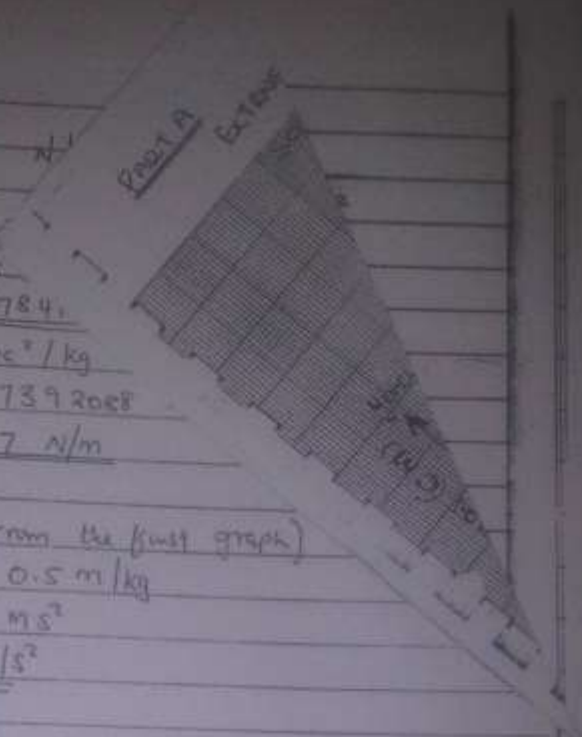
$$K = \frac{4\pi^2}{\text{slope}}$$

$$= \frac{4\pi^2}{2\ \text{sec}}$$

$$= \frac{39.4784}{2\ \text{sec}^2/\text{kg}}$$

$$= 19.7392088$$

$$= \underline{19.7\ \text{N/m}}$$



$g = Kx$ (Slope from the first graph)

$$= 19.56 \times 0.5\ \text{m/kg}$$

$$= 9.78\ \text{ms}^{-2}$$

$$= \underline{9.8\ \text{m/s}^2}$$

The values of K in parts (i) and (ii) where found to be almost the same with a difference of about 0.1 (19.7 − 19.6).

DISCUSSION

From the experiment it was clear that increasing the mass of the load increased the extension of the spring. It was also observed that increasing mass of load in scale pan increased the period of vibration. Errors could occur in future if the clamp and stand are not rigid

CONCLUSION

The experiment was successfully done in that extension produced for various loads were measured and the relationship between extension and load was carried out. The period of oscillation was also

DATA COLLECTION

Mx = 0.00 Kg.

t	S	ΔS	Δt	$v = \Delta s/\Delta t$
Sec	mm	mm	Sec	mm/s
0.1	40	18	0.04	450
0.2	91	23	0.04	575
0.3	168	28	0.04	700
0.4	230	33	0.04	825
0.5	315	38	0.04	950

Where are the tapes?

Mass = 0.5 Kg

t	S	ΔS	Δt	$V = \Delta s/\Delta t$
Sec	mm	mm	Sec	mm/s
0.1	49	22	0.04	~~550~~ 580
0.2	105	25	0.04	~~625~~ 625
0.3	169	28	0.04	~~700~~ 700
0.4	240	32	0.04	~~800~~ 800
0.5	320	33	0.04	~~875~~ 875

Mass = 1.0 kg

t	S	ΔS	Δt	$v = \Delta s/\Delta t$
Sec	mm	mm	Sec	m/s
0.1	40	12	0.04	~~275~~ 300
0.2	85	20	0.04	~~300~~ 500
0.3	138	22	0.04	~~375~~ 550
0.4	185	24	0.04	~~400~~ 600
0.5	223	23	0.04	~~500~~ 625

Mass = 1.5 Kg

t	S	Δs	Δt	$v = \Delta s / \Delta t$
Sec	mm	mm	sec	mm/s
0.1	25	11	0.04	~~1225~~ 275
0.2	55	12	0.04	~~267.5~~ 300
0.3	88	15	0.04	~~422.5~~ 375
0.4	127	16	0.04	~~6000~~ 400
0.5	172	20	0.04	~~8000~~ 500

Data Summary

Mass of trolley = 724 g = 0.724 kg

Mass of the scale pan M_1 = 50g

Mass of the added weight in the scale pan M_2 = 100g

Mass $m = M_1 + M_2$ = 50 g + 100g = 150 g = 0.15 kg

Mx Kg	(M + mx + m) kg	$(M + mx + m)^{-1}$ Kg	Acceleration from graph (ms^{-2})
0	0.947	1.06	0.5
0.5	1.447	0.69	0.5
1.0	1.947	0.51	0.375
1.5	2.447	0.41	0.285

0.5 Kg = m_x

$M + m_x + m$ = 0.7~~24~~ kg + 0.5 kg + 0.15 kg

= 1.~~3~~94 kg

$(M + M_x + m)^{-1} = \frac{1}{M + M_x + m}$

$= \frac{1}{1.394 \text{ kg}}$

= 0.~~7~~3 kg

At $h = 70cm$

$$\bar{t} = \frac{0.375 + 0.365 + 0.376 + 0.383 + 0.381}{5}$$

$$= \frac{1.88}{5}$$

$$\bar{t} = 0.376 \quad \text{and } (\bar{t})^2 = 0.141376$$

At $h = 60cm$

$$\bar{t} = 1.742/5 \qquad h = \text{ At } h = 10$$

$$= 0.3484 \qquad t =$$

At $h = 10cm$

$$\bar{t} = \frac{0.153 + 0.134 + 0.148 + 0.152 + 0.132}{5}$$

$$= 0.719/5$$

$$= 0.14385$$

DISCUSSION

Calculation of diff

density calculation ??

CONCLUSION

introduction to some measuring instruments e.g. Vernier callipers, Micrometer screw gauge was a suc[illegible] in that reading was taken of different objects that were measured. The idea about uncertain[illegible] was also clear as experimental errors were calc[illegible] and this made significant figures which [illegible] very important in physics familiar

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EXPERIMENT 2: GRAPHICAL AND ERROR ANALYSIS — 3rd September 20[illegible]

Aim

Analysis of an object falling freely through several heights.

THEORY

For a body falling freely through a height h, the relationship $h = (1/2)gt^2$ is used. Here, t is the time taken for a body to fall through the height h. The following table gives the time of fall for several for several heights.

HEIGHTS (h cm)	TIME OF FALL (t seconds)	Σt sec	$\bar{t}$ sec	$(\bar{t})^2$ s^2
80	0.395, 0.412, 0.408, 0.395, 0.405	2.015	0.403	0.1624
70	0.375, 0.365, 0.376, 0.383, 0.381	1.88	0.376	0.141376
60	0.350, 0.348, 0.347, 0.352, 0.345	1.742	0.348	0.1213
50	0.321, 0.324, 0.315, 0.317, 0.325	1.602	0.3204	0.10266
40	0.281, 0.275, 0.286, 0.278, 0.283	1.403	0.2806	0.07874
30	0.251, 0.254, 0.245, 0.247, 0.250	1.247	0.2494	0.06220036
20	0.201, 0.198, 0.195, 0.208, 0.205	1.007	0.2014	0.040562
10	0.153, 0.134, 0.148, 0.152, 0.132	0.719	0.1438	0.02067844

Calculation for Mean

At h = 80 cm $\quad \Sigma t = 2.015$

$$\bar{t} = \frac{0.395 + 0.412 + 0.408 + 0.395 + 0.405}{5}$$

$$= \underline{0.403\ s}$$

$$(\bar{t})^2 = (0.403)^2$$

$$= 0.162409 = \underline{0.1624\ s}$$

The result for best value of volume V was calculated using rule 4 of significant figures where the final result is only taken to the same number of significant figures with the least number of significant figures. Therefore,

The best value of volume $V = \underline{7.86\ cm^3}$

b) Using the measuring cylinder D, the volume was measured and the following data was recorded

- Volume of water in the measuring cylinder before adding cylinder

$\underline{V_1 = 20.00\ cm^3}$, Significant figures $\underline{4}$

- Volume of water plus cylinder D

$\underline{V_2 = 28.00\ cm^3}$, Significant figures $\underline{4}$

- Therefore, volume of cylinder D :

$V_2 - V_1 = 28.00\ cm^3 - 20.00\ cm^3$

$= \underline{8.00\ cm^3}$, to 3 significant figures.

PART V : Using the micrometer atleast 6 measurements of thickness of the plate were taken and shown as follows

PLATE NO	THICKNESS OF THE PLATE	$\bar{x}$	$f(x - \bar{x})$	$(fx)^2$
1	3.50 mm	3.55 mm	-0.05 mm	0.0025 mm
2	3.74 mm	3.55 mm	-0.19 mm	0.0361 mm
3	3.76 mm	3.55 mm	-0.21 mm	0.0441 mm
4	3.32 mm	3.55 mm	-0.23 mm	0.0529 mm
5	3.54 mm	3.55 mm	-0.01 mm	0.0001 mm
6	3.42 mm	3.55 mm	-0.13 mm	0.0169 mm

Mean $(\bar{x}) = \frac{1}{N}\sum_{i=1}^{N} x_i$

$= \frac{3.50 + 3.76 + 3.76 + 3.52 + 3.54 + 3.42}{6}$

$(\bar{x}) = 3.55\ mm$

Mean deviation $(\overline{\delta x}) = \sum |(x_i - \bar{x})| / N$

$= \frac{|0.05| + |-0.19| + |-0.21| + |0.03| + |0.01| + |0.13|}{6}$

$= \frac{0.82}{6}$

$\overline{\delta x} = 0.137\ mm$

Standard deviation $(\sigma) = \sqrt{\sum (x_i - \bar{x})^2 / (N-1)}$

$= \sqrt{(0.82)^2 / 6-1}$

$= \sqrt{0.6724/5}$

$= 0.367\ mm$

Standard Error $(\Delta x) = \sqrt{\sum (x_i - \bar{x})^2 / N(N-1)}$

$= \frac{\sigma}{\sqrt{N}}$

$= \frac{0.367}{\sqrt{6}}$

$= 0.149827\ mm$

$\Delta x = 0.15\ mm$

b) The vernier callipers were used the width W of the

Reading on the main scale = 28 mm

Reading on the Vernier Scale, number of divisions

Zero correction = 0.05 mm

$W = 28 + 0.05 \times 13 = 28.65$ mm

Thickness of the plate

c) To find thickness of the plate vernier callipers used

Reading on the main scale = 3 mm

Reading on the vernier Scale, number of divisions

Zero correction = 0.05 m

$T = 3 + (6 \times 0.05) = 3.3$ mm

d) After thickness T was found using the Vernier the micrometer was then used

Reading on the sleeve = 3 mm

Reading of the thimble, number of divisions = 28

Zero correction = 0.01 mm

$T = 3 + (28 \times 0.01) = 3.28 + 0.01 = 3.29$

0.01 was added to 3 mm because the zero error was found to be 0.01 mm

c) results obtained under (a), b), c) and (d) the experimental error for each were given

a) W = 28 mm ± 0.1 mm

b) W = 28.65 mm ± 0.05 mm

c) T = 3.3 mm ± 0.05 mm

d) T = 3.29 mm ± 0.01 mm

PART III

Following the procedure in part II, the vernier callipers were used for the following observations

(i) Hollow Cylinder: This was marked as

External diameter of the cylinder = 25.8 mm

iii) Internal diameter of the cylinder = 25.1mm ± 0.05mm

ii) Blind hole cylinder : This was marked C

External diameter of the cylinder = 12.7 mm ± 0.05mm

Depth of the hole in the cylinder = M.S = 32mm

V.S = 15mm Reading = 32 + 15x0.05 = 32.75 mm ± 0.05mm

b) Using the micrometer the following were found

Blind hole cylinder C

External diameter of the cylinder = Sleeve reading = 12.5mm, Thimble scale reading = 16.0mm

Reading = 12.5 + 16 x 0.01 = 12.66 mm ± 0.01 mm

PART IV : COMPARISON OF TWO MEASURED VALUES USING SIGNIFICANT FIGURES

Solid cylinder D had its length L and diameter D measured using the vernier calliper. The number of significant figures were indicated as follows

L = 2.83 cm ± 0.005 cm (3 significant figures

D = 1.88 cm ± 0.005 cm (3 significant figures

The volume of the cylinder was given by

$V = \pi r^2 L$ where

r = radius of the round surface, and

L = height of the cylinder

The best value of the volume V ~~and~~ was calculated and using the rule of significant figures this is how volume was calculated

$V = \pi r^2 L = \pi (1.88 cm)^2 \times 2.83 cm$

$= \cancel{\pi \left(\frac{0.8836}{2}\right) \times 2.83 cm}$

$= \cancel{7.8558} cm^3$

$= 7.86 cm^3$