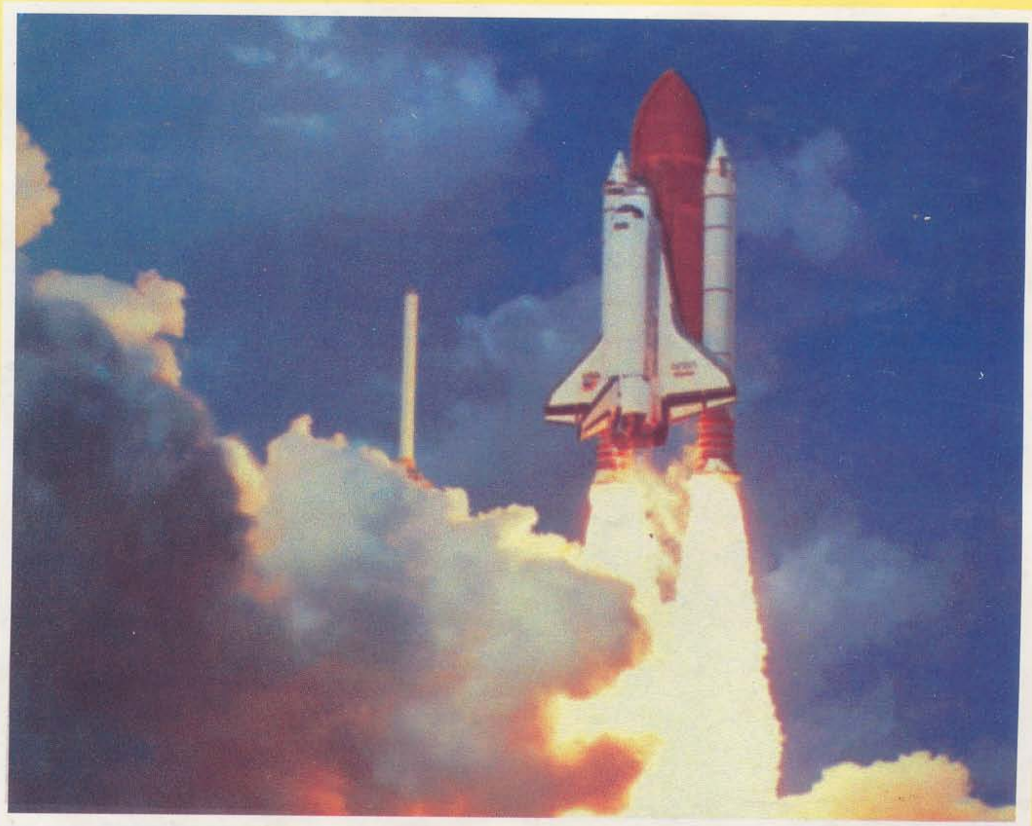
Includes > 800 MCQs

PHYSICS

PRACTICALS

F.Sc. (Part I)

Ross Nazir Ullah



Preface

This notebook has been compiled for F.Sc. Physics students. For helping them in their practicals in the Physics laboratory. Theory and lengthy procedures are intentionally excluded.

Observations and calculations must be completed in the laboratory and get signed by the teacher before the student leaves the laboratory.

I have entered the readings in the blank tables, ***just for guidelines***. It's a new idea! These readings are not perfect. Some of these are taken from a normal student's practical notebook. If you want to take good marks in the exams, you should take the readings by ***yourself.***

I have made major diagrams of the apparatus in two dimensions, so that the students can ***reproduce the figures easily***.

There is no shortage of Physics practical note books in the market. But this notebook presents a different approach. No claim of originality is laid, but some pioneer work should be appreciated. Brevity is the soul of everything. It is hoped that the teacher and taught will give the proper response for this work.

I have added new practicals in this manual, which are being introduced by the Education Department.

Useful suggestions will be appreciated to make this notebook more comprehensive and helpful.

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August 2002.

Ross Nazir Ullah

A person who has not made his great contribution to Science before the age of 30 will never do so. ___*Einstein*

Contents

Light

Heat

Objective Questions

Appendix

Method for plotting a graph

Step 1: Selecting independent and dependent variables

a) Find the values, which are changing independently. It will be your independent variable.

b) Find the values that depend upon the independent variable. It will be your dependent variable.

Step 2: Making the Scale

a) Take difference of highest and lowest values.

b) Divide that difference by 6 for X-axis. Make that calculated difference a round figure. Write it down as the Scale on top right corner of the graph paper.

c) Divide the difference by 8 for Y-axis. Make that calculated difference a round figure. Write it down as the Scale on top right corner.

Step 3: Writing numbers along the Axes

a) Take lowest reading and write its round figure on the origin O.

b) Write down the values along the X-axis and Y-axis below the bold lines (big squares) progressively. That is, after adding the big division's value in each next value.

Step 4: Plotting the points

a) Firstly divide big division's scale by 10, to get small division's (or squares) value. Make small division's scale for X- and Y-axis.

b) Take a point from X-values. Find its position along big divisions for its whole figure part .

c) Multiply this point's fractional part with small division's scale. Then locate the position of the point along X-axis.

d) Take corresponding Y-value point. Repeat the above steps (b) & (c).

e) Locate intersection of both values in the graph paper. Mark this point with a dot and encircle it.

f) Similarly plot all the points.

Step 5: Drawing the Curve

i) For straight line graph

a) Take a transparent ruler.

b) Put the ruler in such a way that maximum points are symmetrical or pass through it.

c) Finally draw the line which is called Curve.

ii) If it is not straight line graph, then draw a smooth free hand curve passing symmetrically through large number of points.

Step 6: Writing Graph Title

Finally write down in bold letters, 'Graph between (say) A and B' on top location, starting from left side of the sheet.

Please note: Method saves hours of wasted efforts.

Date...............

Plotting graphs.

Graph No. 1:

Natural Nos.	x	1	2	3	4	5	6	7	8	9	10
Squares	y	1	4	9	16	25	36	49	64	81	100

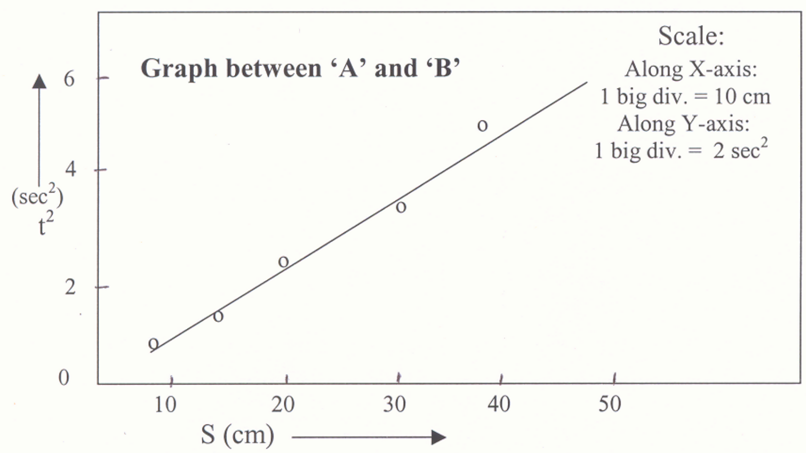
Graph No. 2:

Natural Nos.	x	1	2	3	4	5	6	7	8	9	10
Reciprocals	$1/x$	1	.5	.33	.25	.20	.17	.14	.13	.11	.1

Graph No. 3:

L	cm	71.3	81.3	91.3	101.3	111.3	121.3
T^2	sec^2	2.75	3.24	3.72	4.20	4.53	5.12

Typical graph:



Good start means that your half work is done!

Experiment A:

To plot a graph between:

i) Natural numbers and their squares.
ii) Natural numbers and their reciprocals,
iii) Given values of l and t^2

Materials:

Graph papers, lead pencil, rubber, sharpener, and transparent ruler.

Procedure:

1) *Draw the two axes with a sharp pencil, at right angles to each other taking a point O as origin at the left bottom corner of the graph paper.*
2) *Take independent variable (natural numbers) along X-axis and dependent (squares & reciprocals) along Y-axis.*
3) *Select suitable scales for both axes, so that all the graph paper would be covered.*
4) *Mark the scale on each axis, so that the value after every ten divisions is specified.*
5) *Start with a certain value represented along the X-axis and then locates the corresponding point along the Y-axis. Mark this point by a dot and encircle it. Similarly plot all points for different values of the two quantities.*
6) *Draw a smooth free hand curve passing symmetrically through large number of points. For straight line graph then draw with a transparent ruler so that maximum points pass through the line or symmetrical with it.*

Precautions:

1. A sharp pencil should be used.
2. Take along X-axis independent variable and along Y-axis dependent.
3. Small circles should be drawn around the plotted points.

Viva Voce:

Q.1 *What is a graph?*

Ans. A graph is a curve, which shows relation between an independent variable and its dependent variable.

Q.2 *What is variables?*

Ans. These are the quantities, which do not have fixed values.

Q.3 *What are independent and dependent variables?*

Ans. Independent variable is that which we vary independently and dependent variable is that which vary according to the variation depending upon independent variable.

Graph Illustration

Velocity time graph

V (m/s)	5.73	5.79	5.82	5.92	5.94
t(s)	0.66	0.76	0.86	0.95	1.05

(Read method for plotting a graph on page 7)

Step 1: taking t along X-axis & V along Y-axis

Step 2: big division

$t \rightarrow \frac{1.05 - 0.66}{6} = \frac{0.39}{6} \cong \frac{0.40}{6} \cong 0.07 \cong 0.1 \Rightarrow$ B.d = 0.1 & s.d = 0.01

small division

$V \rightarrow \frac{5.94 - 5.73}{8} = \frac{0.21}{8} \cong \frac{0.2}{8} \cong .03 \Rightarrow$ B.d = 0.03 & s.d = 0.003

Scale:
Along X-axis:
1 big div = 0.1 sec
Along Y-axis:
1 big div = 0.03 m/s

Step 4:

$t_1 \rightarrow 0.6 + 6x.01 = .66$ & $V_1 \rightarrow 5.73$

$t_2 \rightarrow 0.7 + 6x.01 = .76$ & $V_2 \rightarrow 5.79$

$t_3 \rightarrow 0.8 + 6x.01 = .86$ & $V_1 \rightarrow 5.82$

$t_4 \rightarrow 0.9 + 5x.01 = .95$ & $V_1 \rightarrow 5.91 + 4x.003 = 5.921 > 5.92$

$t_5 \rightarrow 1 + 5.5\ x.01 = 1.055 < 1.06$ & $V_1 \rightarrow 5.94$ a little lower point

5 & ½ s.d a little higher point

Evaluation

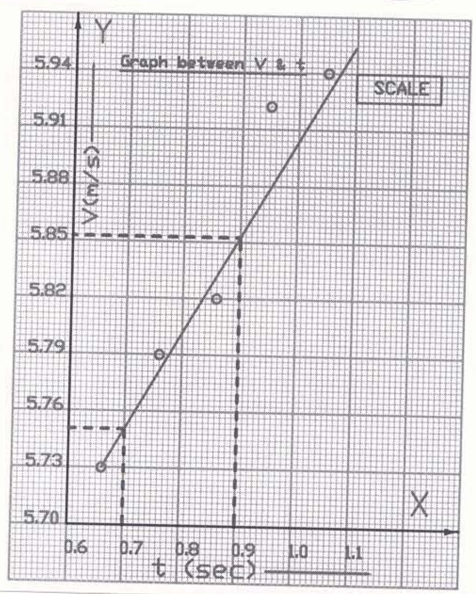
Finding :

average acceleration,

$a_{av} = \Delta V / \Delta t$

$= \frac{5.852 - 5.751}{0.9 - 0.7} = \frac{0.101}{0.2}$

$= 0.5\ cm/sec^2$



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Note: Do not depend upon these calculations, do your own calculations.

Natural numbers & their squares

N	1	2	3	4	5	6	7	8	9	10
N^2	1	45	9	16	25	36	49	64	81	100

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 2
Along Y-axis:
1 big div = 15

Step 1: taking N along X-axis & N^2 along Y-axis

Step 2:

$N \rightarrow \frac{10-1}{6} = \frac{9}{6} \cong 2 \Rightarrow$ B.d = 2 & s.d = 0.2

$N^2 \rightarrow \frac{100-1}{8} = \frac{99}{8} = 12.4 \cong 15 \Rightarrow$ B.d. = 15 & s.d. = 1.5

Step 4:

$N_1 \rightarrow 0 + 5x.2 = 1$ & $N_1^2 \rightarrow 0 + 2/3 \text{ x } 1.5 = 1$

$N_2 \rightarrow 2$ & $N_2^2 \rightarrow 0 + 3 \text{ x} 1.5\ 4.5 > 4$

$N_3 \rightarrow 2 + 5x.2 = 3$ & $N_3^2 \rightarrow 0 + 6\text{x } 1.5 = 9$

$N_4 \rightarrow 4$ & $N_4^2 \rightarrow 15 + 2/3 \text{ x} 1.5 = 16$

$N_5 \rightarrow 4 + 5 \text{ x}.2 = 5$ & $N_5^2 \rightarrow 15 + 7 \text{ x } 1.5 = 25.5 > 25$

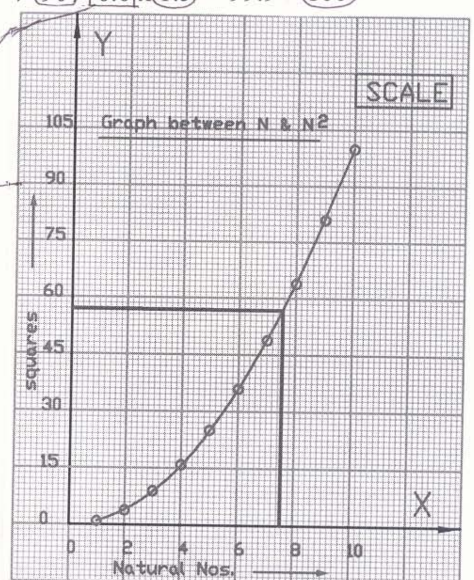
$N_6 \rightarrow 6$ & $N_6^2 \rightarrow 30 + 4\text{x } 1.5 = 36$

$N_7 \rightarrow 6 + 5 \text{ x}.2 = 7$ & $N_7^2 \rightarrow 45 + 3 \text{ x } 1.5 = 49.5 > 49$

$N_8 \rightarrow 8$ & $N_8^2 \rightarrow 60 + 3 \text{ x} 1.5 = 64.5 > 64$

$N_9 \rightarrow 8 + 5 \text{ x } .2 = 9$ & $N_9^2 \rightarrow 75 + 4\text{x } 1.5 = 81$

$N_{10} \rightarrow 10$ & $N_{10}^2 \rightarrow 90 + \boxed{6.6} \text{ x } 1.5 = 99.9 < 100$



How to find s.d. multiplier

$\frac{\text{Plot value} - \text{B.d. value}}{\text{s.d.}}$

$= \frac{100-90}{1.5} = \frac{10}{1.5} = 6.66$

Evaluation

Finding:

Value of $(7.5)^2$ from graph:

$N_{7.5} \rightarrow 57$

Value of $(7.5)^2$ from calculation:

$(7.5)^2 = 56.25$

The difference is 0.75

Your calculations and result should be better than this.

Natural Nos. & their reciprocals

N	1	2	3	4	5	6	7	8	9	10
1/N	1	0.50	0.33	0.25	0.20	0.17	0.14	0.13	0.11	0.10

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 2
Along Y-axis:
1 big div = 0.15

Step 1: taking N along X-axis & 1/N along Y-axis

Step 2:

$N \rightarrow \frac{10-1}{6} = \frac{9}{6} \cong 2 \Rightarrow$ B.d = 2 & s.d = 0.2

$N^2 \rightarrow \frac{1-0.1}{8} = \frac{0.9}{8} = .15 \Rightarrow$ B.d. = 0.15 & s.d. = 0.015

Step 4:

$N_1 \rightarrow 0 + 5x.2 = 1$ & $1/N_1 \rightarrow .9 + 7x.015 < 1$

$N_2 \rightarrow 2$ & $1/N_2 \rightarrow .45 + 3.5\ x.015 > .5$

$N_3 \rightarrow 2 + 5x.2 = 3$ & $1/N_3 \rightarrow .3 + 2x.015 = .33$

$N_4 \rightarrow 4$ & $1/N_4 \rightarrow .15 + 7x.015 < .25$

$N_5 \rightarrow 4 + 5\ x.2 = 5$ & $1/N_5 \rightarrow .15 + 3\ x\ .015 > .20$

$N_6 \rightarrow 6$ & $1/N_6 \rightarrow .15 + 1.5x.015 = .17$

$N_7 \rightarrow 6 + 5\ x.2 = 7$ & $1/N_7 \rightarrow 0 + 9\ x.015 < .135$

$N_8 \rightarrow 8$ & $1/N_8 \rightarrow 0 + 9\ x.015 > .135$

$N_9 \rightarrow 8 + 5\ x\ .2 = 9$ & $1/N_9 \rightarrow 0 + 7x.015 < .11$

$N_{10} \rightarrow 10$ & $1/N_{10} \rightarrow 0 + 7\ x\ .015 > .10$

Evaluation

Finding:

Value of (3.4) from graph:

$N_{3.4} \rightarrow (1/N) = 0.3$

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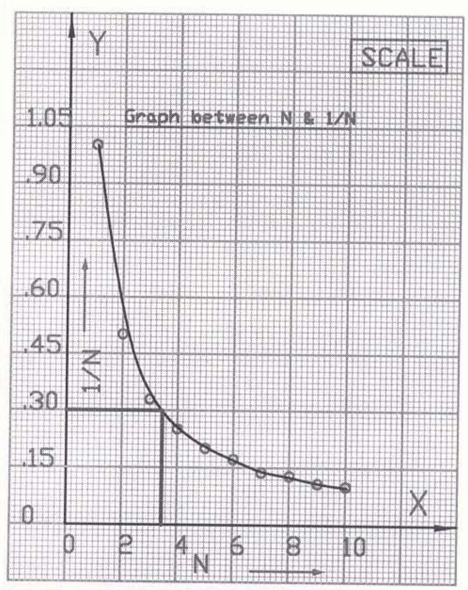


It is not must that you follow my method of manipulation, you may adopt your own.

Simple Pendulum graph

l (cm)	70	80	90	100	110
T^2 (s^2)	2.89	3.23	3.62	4.11	4.41

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 10 cm
Along Y-axis:
1 big div = 0.2 sec^2

Step 1: taking l along X-axis & T^2 along Y-axis

Step 2:

$l \rightarrow \frac{110-70}{6} = \frac{40}{6} \cong 7 \Rightarrow$ B.d = 10 & s.d = 1.0

$T^2 \rightarrow \frac{4.41-2.89}{8} = \frac{1.52}{8} \cong 0.2 \Rightarrow$ B.d. = 0.2 & s.d. = 0.02

Step 4:

$l_1 \rightarrow 70$ & $T_1^2 \rightarrow 2.8 + 4.5 \times .02 = 2.88$

$l_2 \rightarrow 80$ & $T_2^2 \rightarrow 3.2 + 1.5 \times .02 = 3.23$

$l_3 \rightarrow 90$ & $T_3^2 \rightarrow 3.6 + 1 \times .02 = 3.62$

$l_4 \rightarrow 100$ & $T_4^2 \rightarrow 4 + 5.5 \times .02 = 4.11$

$l_5 \rightarrow 110$ & $T_5^2 \rightarrow 4.4 + ½ \times .02 = 4.41$

Evaluation

Finding:

1) slope of the graph:

slope = tan CAB = BC/AB

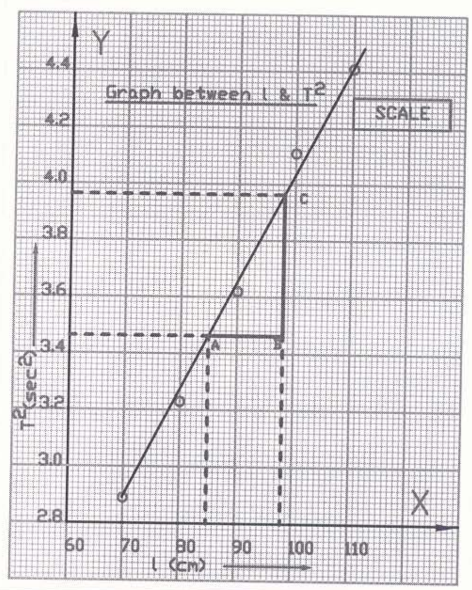
= 0.5 /13 = 3.8 sec^2 /cm

2) length of second's pendulum:

$T^2 = 4 \rightarrow l = 100$ cm

3) length corresponding to 1.9 sec:

$T_{1.9\ sec} \rightarrow T^2_{8.61} \rightarrow l = 90.5$ cm



We define slope of a line as tan θ, where θ is the inclination of a line.

Helical Spring graph

x (cm)	12.2	15.3	18.4	21.0	23.5
T^2 (s^2)	0.55	0.67	0.76	0.86	0.95

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 2 cm
Along Y-axis:
1 big div = 0.05 sec^2

Step 1: taking x along X-axis & T^2 along Y-axis

Step 2:

$$x \rightarrow \frac{23.5 - 12.2}{6} = \frac{11.3}{6} \cong 2 \Rightarrow \text{B.d} = 2 \ \&\ \text{s.d} = 0.2$$

$$T^2 \rightarrow \frac{0.95 - 0.55}{8} = \frac{0.4}{8} = .05 \Rightarrow \text{B.d.} = 0.05 \ \&\ \text{s.d.} = 0.005$$

Step 4:

$x_1 \rightarrow 12 + 1x.2 = 12.2$ & $T_1^2 \rightarrow .55$
$x_2 \rightarrow 14 + 6.5x.2 = 15.3$ & $T_2^2 \rightarrow .65 + 4x.005 = .67$
$x_3 \rightarrow 18 + 2x.2 = 18.4$ & $T_3^2 \rightarrow .75 + 2x.005 = .76$
$x_4 \rightarrow 20 + 5x.2 = 21$ & $T_4^2 \rightarrow .85 + 2x.005 = .86$
$x_5 \rightarrow 22 + 7.5\,x.2 = 23.5$ & $T_5^2 \rightarrow .95$

Evaluation

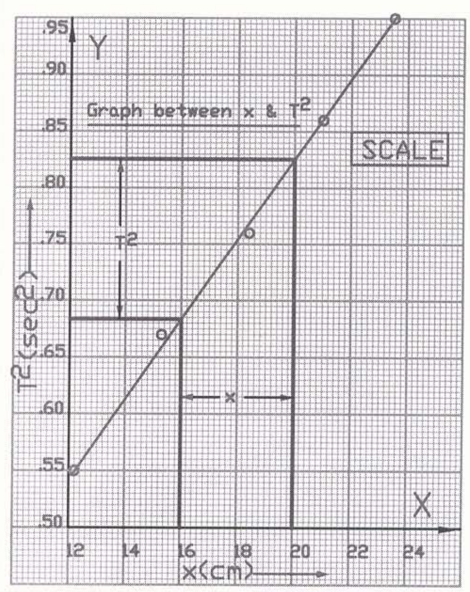
Finding:

'g' from graph :

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

$= 4\pi^2\,(4/0.14)$

$= 1126$ cm /sec^2



Not a good result. Sources of error might be in readings, or plotting the graph.

Law of length graph

From the following readings, verify law of length:

ν (Hz)	512	480	384	280
l (m)	0.12	0.129	0.16	0.23

For the verification of the law taking $1/l$;

ν (Hz)	512	480	384	280
$1/l$ (m^{-1})	8.33	7.75	6.25	4.35

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 40 Hz
Along Y-axis:
1 big div = 0.50 cm^{-1}

Step 1: taking ν along X-axis & $1/l$ along Y-axis

Step 2:

$$\nu \rightarrow \frac{512-280}{6} = 38.66 \cong 40 \Rightarrow B.d = 40 \text{ \& } s.d = 4$$

$$1/l \rightarrow \frac{8.33-4.35}{8} = 0.49 \cong 0.50 \Rightarrow B.d. = 0.50 \text{ \& } s.d. = 0.05$$

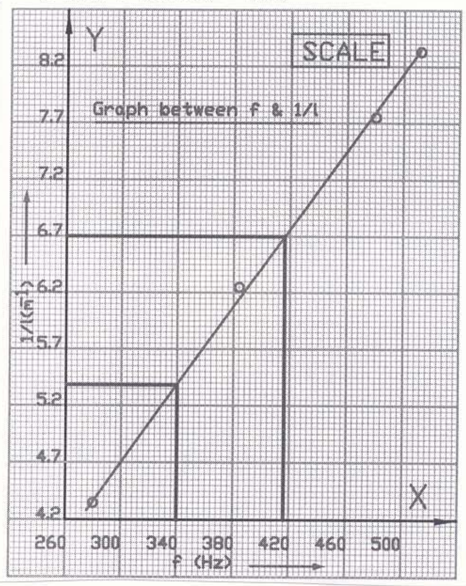
Step 4:

$\nu_1 \rightarrow 500 + 3 \times 4 = 512$ & $1/l_1 \rightarrow 8.20 + 2.6 \times .05 = 8.33$

$\nu_2 \rightarrow 460 + 5 \times 4 = 480$ & $1/l_2 \rightarrow 7.70 + 1 \times .05 = 7.75$

$\nu_3 \rightarrow 380 + 1 \times 4 = 384$ & $1/l_3 \rightarrow 6.20 + 1 \times .05 = 6.25$

$\nu_4 \rightarrow 260 + 5 \times 4 = 280$ & $1/l_4 \rightarrow 4.20 + 3 \times .05 = 4.35$



Evaluation

Finding:

1) Relation between ν & $1/l$:

Graph between ν & $1/l$ is a straight line

2) Finding slope of graph :

$$\frac{6.7-5.38}{420-340} = \frac{1.32}{80} = 0.0165$$

ν *& l graph will be decreasing straight line, showing inversely proportional to each other.*

Law of Tension graph

From the following readings, verify law of tension:

f (Hz)	518	480	384	350	300
T (N)	44.1	39.2	24.3	19.6	14.5

For the verification of the law taking $\sqrt{T}$;

f (Hz)	518	480	384	350	300
$\sqrt{T}$ ($\sqrt{N}$)	6.64	6.26	4.93	4.43	3.80

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 40 Hz
Along Y-axis:
1 big div = 0.4 $\sqrt{N}$

Step 1: taking f along X-axis & $\sqrt{T}$ along Y-axis

Step 2:

$f \rightarrow \frac{518 - 300}{6} = 36.33 \cong 40 \Rightarrow$ B.d = 40 & s.d = 4

$\sqrt{T} \rightarrow \frac{6.64 - 3.80}{8} = 0.355 \cong 0.4 \Rightarrow$ B.d. = 0.4 & s.d. = 0.04

Step 4:

$f_1 \rightarrow 500 + 4.5 \times 4 = 518$ & $\sqrt{T_1} \rightarrow 6.4 + 6 \times .04 = 6.64$

$f_2 \rightarrow 480$ & $\sqrt{T_2} \rightarrow 6 + 6.5 \times .04 = 6.26$

$f_3 \rightarrow 380 + 1 \times 4 = 384$ & $\sqrt{T_3} \rightarrow 4.8 + 3.25 \times .04 = 4.93$

$f_4 \rightarrow 340 + 2.5 \times 4 = 350$ & $\sqrt{T_4} \rightarrow 4.40 + 0.75 \times .04 = 4.43$

$f_5 \rightarrow 300$ & $\sqrt{T_5} \rightarrow 3.6 + 5 \times .04 = 3.80$

Evaluation

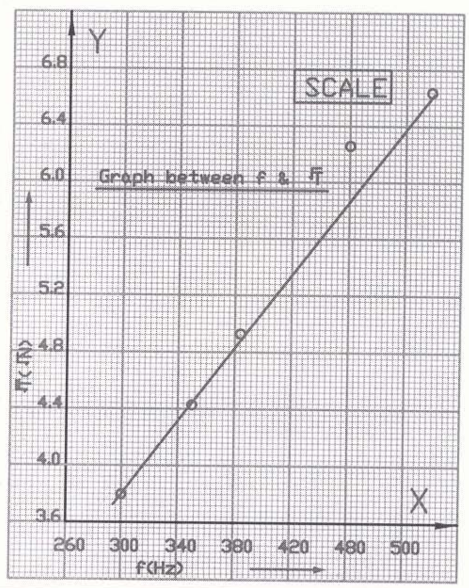
1) Verification of the law:

Since graph between

f & $\sqrt{T}$ is a straight line,

so $f \propto \sqrt{T}$,

which is Law of Tension.



Increasing straight line shows that both values are directly proportional to each other.

p-q graph

p (cm)	15.2	20.1	22.3	24.2	30.3	36.2
q (cm)	30.1	20.3	18.1	16.8	15.2	14.1

(Read method for plotting a graph on page 7)

Step 1: taking p along X-axis & q along Y-axis

Scale:
Along X-axis:
1 big div = 5 cm
Along Y-axis:
1 big div = 5 cm

Step 2:

p $\rightarrow \frac{36.2 - 15.2}{6} = 3.5 \cong 5 \Rightarrow$ B.d = 5 & s.d = 0.5

(making equal to x-scale)

q $\rightarrow \frac{30.1 - 14.1}{8} = 2 \cong 5 \Rightarrow$ B.d. = 5 & s.d. = 0.5

Step 4:

$p_1 \rightarrow 15 + ½ x .5 = 15.25 > 15.2$ & $q_1 \rightarrow 30 + 1/5 x .5 = 30.1$

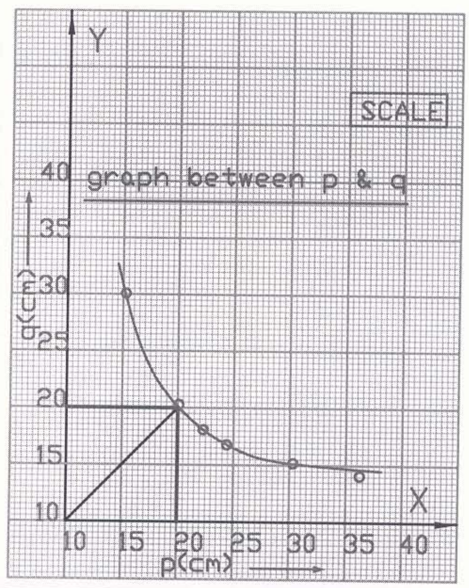
$p_2 \rightarrow 20 + 1/5 x .5 = 20.1$ & $q_2 \rightarrow 20 + .6 x .5 = 20.3$

$p_3 \rightarrow 20 + 4.6 x .5 = 22.3$ & $q_3 \rightarrow 15 + 6.2 x .5 = 18.1$

$p_4 \rightarrow 20 + 8.8 x .5 = 24.2$ & $q_4 \rightarrow 15 + 3.6 x .5 = 16.8$

$p_5 \rightarrow 30 + 0.6 x .5 = 30.3$ & $q_5 \rightarrow 15 + 0.4 x .5 = 15.2$

$p_6 \rightarrow 35 + 2.4 x .5 = 36.2$ & $q_6 \rightarrow 10 + 8.2 x .5 = 14.1$



Evaluation

Finding:

1) intercepts on x & y-axis:

intercepts on x-axis = 20 cm

& intercepts on y-axis = 20cm

2) focal length of the lens:

f = 20 /2 = 10 cm

We define x-intercept of a curve is the x-coordinate of the point of intersection of the curve with the x-axis. Similarly y-intercept is defined.

(p+q) & pq graph

(p+q) cm	50.00	48.00	49.20	51.00	54.20
pq (cm^2)	600.00	575.00	578.00	612.40	644.00

(Read method for plotting a graph on page 7)

Step 1: taking (p+q) along X-axis & pq along Y-axis

Step 2:

$(p+q) \rightarrow \dfrac{54.2 - 48.0}{6} = 1.03 \cong 1 \Rightarrow$ B.d = 1 & s.d = 0.1

$pq \rightarrow \dfrac{644.0 - 575}{8} = 8.6 \cong 10 \Rightarrow$ B.d. = 10 & s.d. = 1

Scale:
Along X-axis:
1 big div = 1 cm
Along Y-axis:
1 big div =10 cm^2

Step 4:

$(p+q)_1 \rightarrow 50$ & $pq_1 \rightarrow 600$

$(p+q)_2 \rightarrow 48$ & $pq_2 \rightarrow 570 + 5 \times 1 = 575$

$(p+q)_3 \rightarrow 49 + 2 \times .1 = 49.2$ & $pq_3 \rightarrow 570 + 8 \times 1 = 578$

$(p+q)_4 \rightarrow 51$ & $pq_4 \rightarrow 610 + 2.4 \times 1 = 612.4$

$(p+q)_5 \rightarrow 54 + 2 \times .1 = 54.2$ & $pq_5 \rightarrow 640 + 4 \times 1 = 644$

Evaluation

Finding:

1) slope of the graph:

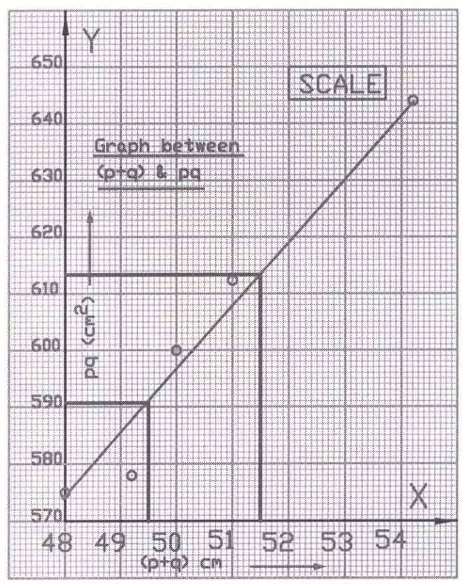
$$\text{slope} = \frac{614.25 - 590.75}{51.5 - 49.5}$$

$$= \frac{23.5}{2} = 11.75$$

2) focal length of the lens:

The focal length will be equal to the slope ,

= f = 11.75cm



Investigate the manipulations of how 'f' is equal to the slope in this graph.

1/p & 1/q graph

$1/p\ (cm^{-1})$	0	0.02	0.04	0.058	0.07	0.082
$1/q\ (cm^{-1})$	0.082	0.054	0.04	0.02	0.01	0.002

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 0.02 cm^{-1}
Along Y-axis:
1 big div = 0.01 cm^{-1}

Step 1: taking 1/p along X-axis & 1/q along Y-axis

Step 2:

$1/p \rightarrow \frac{0.082 - 0}{6} = 0.014 \cong 0.02 \Rightarrow$ B.d = 0.02 & s.d = 0.0.002

$1/q \rightarrow \frac{0.082 - 0.002}{8} = 0.01 \Rightarrow$ B.d. = 0.01 & s.d. = 0.001

Step 4:

$1/p_1 \rightarrow 0$ & $1/q_1 \rightarrow 0.08 + 2 \times .001 = 0.082$
$1/p_2 \rightarrow 0.02$ & $1/q_2 \rightarrow 0.05 + 4 \times .001 = 0.054$
$1/p_3 \rightarrow 0.04$ & $1/q_3 \rightarrow 0.04$
$1/p_4 \rightarrow 0.04 + 9 \times .002 = 0.058$ & $1/q_4 \rightarrow 0.02$
$1/p_5 \rightarrow 0.06 + 5 \times .002 = 0.07$ & $1/q_5 \rightarrow 0.01$
$1/p_6 \rightarrow 0.08 + 1 \times .002 = 0.082$ & $1/q_6 \rightarrow 0 + 2 \times .001 = 0.002$

Evaluation

Finding:

1) intercepts on x & y-axis:

intercepts on x-axis = 0.08 cm

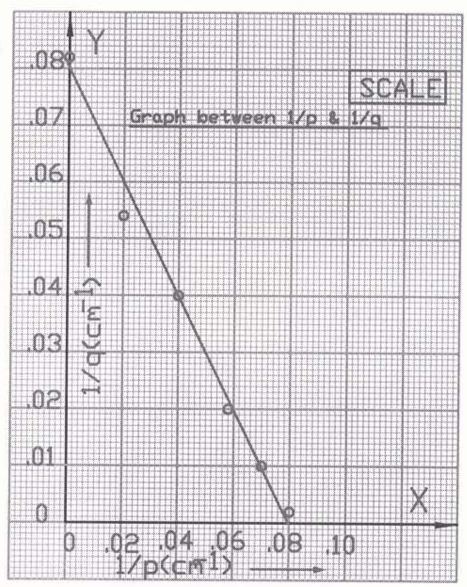
& intercepts on y-axis =0.08cm

2) focal length of the lens:

focal length of the lens is

reciprocal of either intercept

f = 1/ 0.08 = 12.5 cm



In the graph, what conclusion you make from the decreasing curve?

Young's Modulus graph

F (kg)	1	2	3	4	5
l (mm)	0.25	0.55	0.83	1.05	1.36

(Read method for plotting a graph on page 7)

Scale:
Along X-axis:
1 big div = 1 kg
Along Y-axis:
1 big div = 0.2 mm

Step 1: taking F along X-axis & l along Y-axis

Step 2:

$F \rightarrow \frac{5-1}{6} = \frac{4}{6} \cong .7 \cong 1 \Rightarrow$ B.d = 1 & s.d = 0.1

$l \rightarrow \frac{1.36-0.25}{8} = \frac{1.11}{8} = 0.14 \Rightarrow$ B.d. = 0.2 & s.d. = 0.02

Step 4:

$F_1 \rightarrow 1$ & $l_1 \rightarrow .2 + 2.5 \text{ x } .02 = .25$
$F_2 \rightarrow 2$ & $l_2 \rightarrow .4 + 7.5 \text{ x } .02 = 0.55$
$F_3 \rightarrow 3$ & $l_3 \rightarrow .8 + 1.5 \text{ x} .02 = 0.83$
$F_4 \rightarrow 4$ & $l_4 \rightarrow 1.0 + 2.5\text{x}.02 = 1.05$
$F_5 \rightarrow 5$ & $l_5 \rightarrow 1.2 + 8 \text{ x } .02 = 1.36$

Evaluation

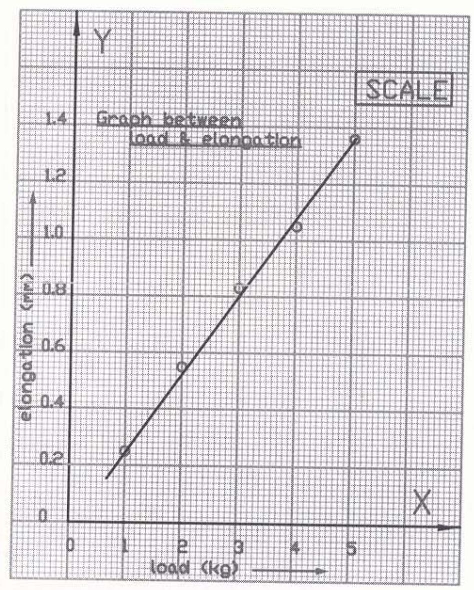
Finding:

1) Relation between F & l:

The curve of the graph shows,

that $F \propto l$,

which verify the relation for Young's modulus,



A normal student's value will not so perfect, due to neglecting the sources of error.

Graph Exercises

Draw the following graphs between the parameters and deduce the given requirements.

(1)

F(dynes)	50 x 980	100 x 980	150 x 980	200 x 980	250 x 980
x (cm)	2.9	5.8	8.4	11.3	14.8

i) What inference you draw from the graph?
ii) Determine the spring constant.

(2)

V(cm/sec)	3	5	7	9	11
KE(Joules)	22	75	165	295	489

i) Determine the slope of the graph.
ii) Find the value of KE, when velocity is 7.5 cm/sec.

(3)

v (cm s^{-1})	438	452	458	469	475	486
t (sec)	12	15	20	24	30	36

i) Find average acceleration at t = 10, 22 & 35 seconds.
ii) Which type of acceleration, the graph shows?

(4)

S (cm)	100	125	142	153	165
t (sec^2)	2.36	2.82	2.91	3.21	3.43

i) Find the average velocity at, t = 2.5, 2.8 & 3.0 seconds.
ii) The relation between S & t from the slope.

(5)

1/p(cm^{-1})	0.002	0.03	0.04	0.06	0.07
1/q(cm^{-1})	0.074	0.052	0.039	0.023	0.012

i) Determine focal length of the lens.
ii) Write down its units.

(6)

l (cm)	60	65	70	75	80	85
T^2 (sec^2)	2.10	2.58	2.62	3.15	3.65	3.82

i) What is the slope of the graph?
ii) Calculate length of second's pendulum.

(7)

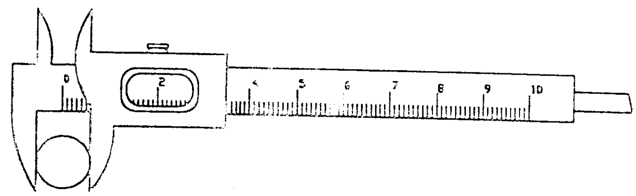
t °C	15	30	40	50	60	70
Surface tensionT(dynes/cm)	72.4	71.2	69.7	68.1	65.5	64.1

i) Show the relation between temperature and surface tension.
ii) Find surface tension at 53 °C.

You should be able to perform these exercises, if you made all previous 11 graphs

Date..........

Expt: Use of Vernier Calipers.

Vernier Calipers: 

Observations and Calculations:

Value of the smallest scale division = x = 0.1 cm
No. of divisions on the vernier scale = y = 10
Vernier constant (V.C.) = x/y = 0.1/10 = 0.01 cm
Zero error = i) ± zero , ii) ± zero , iii) ± zero
Mean zero error = nil
Zero correction = nil

No. of obs.	Quantity	Main scale reading	Vernier divisions coinciding	Fraction	Total reading
		x_1	N	Δx = n x V.C.	$x = x_1 + \Delta x$
		cm		cm	cm
1	Length	3.8	5	5 x .01= .05	3.85
2		3.9	1	1 x .01 =.01	3.91
3		3.8	4	4 x .01 =.04	3.84
1	Diameter	1.2	3	3 x .01 =.03	1.23
2		1.2	3	3 x .01 =.03	1.23
3		1.2	4	4 x .01 =.04	1.24

Mean length of cylinder = L = 11.6/3 = *3.86* cm
Mean diameter of cylinder = D = 3.69/3 = *1.23* cm
Radius of the cylinder R = D/2 = 0.62 cm
Volume of the cylinder = V = $\pi R^2 L$ = $\boxed{4.588\ cm^3}$

Note: The above-tabulated values are just for guideline. Take your own readings.

Find the Internal volume of glass beaker with the help of Vernier calipers. Cross check with 100 ml beaker.

Experiment No. 1:

To find the volume of a cylinder using Vernier calipers.

Apparatus:

Solid cylinder, Vernier calipers, and half meter rod.

Construction:

Vernier calipers consists of a steel bar of two scales. A fixed scale called main scale and a moveable scale called vernier scale. Usually vernier scale has 10 divisions equal to 9 small divisions of main scale. Lower jaws are for measuring the length or diameter and upper jaws are for measuring internal diameter. Backside strip is for measuring depth of an object.

Procedure:

1) *Find the vernier constant of the given vernier calipers.*
2) *Determine its zero error if any.*
3) *Place the cylinder length-wise between the two jaws. Read the main scale division just to the left of the zero of the vernier.*
4) *Locate the number of vernier divisions coinciding with any main scale division. Note these readings thrice.*
5) *Complete the table up to the last column.*
6) *In the same way find the diameter of the cylinder from different positions. Taking two reading at right angles on each position.*
7) *Calculate mean values of the length and the diameter and find the radius of the cylinder.*
8) *Find out the volume of the cylinder from the formula.*

Precautions:

1. Take at least three readings for each measurement.
2. The jaws of the vernier should not be pressed to hard.
3. Vernier divisions should be read clearly, may be with some magnifying glass.

Viva Voce:

Q.1 *What is vernier constant?*

Ans. It is the smallest measurement which a vernier can read.

Q.2 *What is a vernier?*

Ans. A device used to measure the fraction of smallest scale divisions up to tenth part of a centimeter.

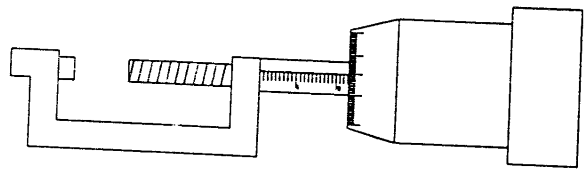
Q.3 *Who invented Vernier calipers?*

Ans. A French mathematician, Pierre Vernier invented it.

Date...........

Expt: Use of Screw gauge.

Screw gauge:



Observations and Calculations:

Pitch of the screw gauge = x = 1 mm
No. of divisions on circular scale = y = 100
Least count (L.C.) = x / y = 1/100 = 0.01 mm
Zero error = i) + .05, ii) +.07 , iii) + .06
Mean zero error = + .06
Zero correction (Z.C.) = - .06

No. of obs.	Quantity	Linear scale reading	Circular scale reading	Fraction	Diameter	
					Observed	Corrected
		R′	N	x = n x L.C.	R = R′ + x	R ± Z.C.
		mm		mm	mm	mm
1	Wire	1	59	59 x .01 =.59	1.59	1.53
2		1	63	63 x .01 = .63	1.63	1.57
3		1	58	58 x .01 = .58	1.58	1.52
1	Small sphere	3	87	87 x .01 = .87	3.87	3.81
2		4	11	11 x .01 = .11	4.11	4.05
3		3	92	92 x .01 = .92	3.92	3.86

a) Mean diameter = D = 4.62/3 = 1.54 mm
Radius r = D/2 = 1.54/2 = 0.77 mm
Area of cross-section of the wire = A = πr^2 = $\boxed{1.86\ mm^2}$

b) Mean diameter of small sphere = d = 11.72/3 = 3.91 mm
Radius = r = d/2 = 3.91/2 = 1.95 mm = .195 cm
Volume of small sphere = V = 4/3 πr^3 = $\boxed{0.031\ cm^3}$

Archimedes tomb was marked by the figure of a sphere inscribed in a cylinder.

Determine the diameter of a thinnest possible wire. [With screw gauge a measurement up to 0.01 mm is possible.]

Experiment No. 2:

To find area of cross-section of a wire and volume of a small sphere using micrometer screw gauge.

Apparatus:

Micrometer screw gauge, small sphere, fine wire, and half-meter rod.

Construction:

It consists of U-shaped metallic frame having one end fixed and the other end, moveable having a metal cylinder rod marked with a horizontal line over which a fixed scale is marked, called Main scale. A cap is fitted over cylinder, carries a moveable scale with 100 divisions around it, called circular scale.

Procedure:

1) *Find the pitch and least count of screw gauge.*
2) *Find the zero error, and determine the sign of zero correction.*
3) *Place the wire in the gap AB (see the fig.) and turn the screw till the wire is gently pressed. Note the reading of the linear as well as the circular scale in the table.*
4) *Complete the table up to last column. Take the readings from different places of the wire.*
5) *Calculate mean diameter of the wire.*
6) *Repeat the process for the given small sphere.*
7) *Calculate mean diameter of the sphere.*
8) *Find the radius and hence area of cross-section of the wire. Also the volume of the sphere by applying the formula.*

Precautions:

1. The screw should not be pressed too hard.
2. The screw should be turned in the same direction.
3. Take two readings at right angles at each point of the wire.

Viva Voce:

Q.1 *What is the least count of Screw gauge?*

Ans. The shortest distance which can be measured by it.

Q.2 *What is the 'pitch' of the screw gauge?*

Ans. It is the distance between the two successive threads of linear scale.

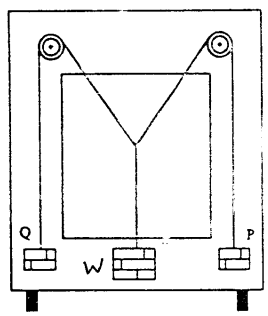
Q.3 *How screw gauge take linear readings from its circular movement?*

Ans. The forward (or backward) movement of the screw is directly proportional to linear movement of the head of the screw gauge.

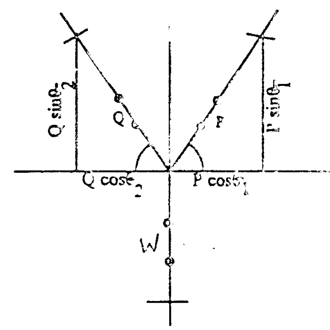
Date...........

Expt: Addition of vectors by Gravesand's apparatus.

The apparatus:



Geometrical work diagram :



Observations and Calculations:

No. of obs.	Forces		Angles		Vertical components		Unknown weight = W
	P	Q	θ_1	θ_2	P $\sin\theta_1$	Q $\sin\theta_2$	P $\sin\theta_1$ + Q $\sin\theta_2$
	gm-wt	gm-wt	θ °	θ °	gm-wt	gm-wt	gm-wt
1	30	30	49	48	22.65	22.29	44.94
2	40	35	48	25	29.72	14.79	44.51
3	35	40	27	46	15.88	28.77	44.65

Mean W = 44.73 gm-wt

Note: For the sake of convenience, we have taken gram-weight (gm-wt), a unit of force, as a laboratory unit of force. Instead to take grams and multiply with a factor 980 to get dynes.

1. Find out unknown weight by end-to-end and trigonometric method.
2. In Gravesand's apparatus, put known weights in the center (resultant position) and in one of the side. Calculate from vector addition one of the unknown side weight.

Experiment No. 3:

To find the unknown weight of a body by the method of vector addition of forces.

Apparatus:

Gravesand's apparatus, slotted weights with hangers, white paper sheet, drawing pins, mirror strip, set squares, Dee, thread, half meter rod.

Procedure:

1) Set the board vertical. Test pulleys for no friction.
2) Take three pieces of thread and knot them together. Attach one hanger to each of their free ends.
3) Load the hangers with suitable weights, and pass two of the hangers through the pulleys.
4) Attach unknown weight with middle thread.
5) Fix a sheet of paper on the board with drawing pins.
6) Mark two points for each thread, looking in such a direction that the thread and its image are coincident to each other.
7) Remove the paper. Join the points to produce three lines.
8) Note the weights. Repeat twice by taking different set of weights.
9) Choose a suitable scale. Do geometrical work as shown in fig. (6).
10) Complete all columns of the table, which includes taking rectangular components of vectors P and Q.

Precautions:

1. Pulleys should be frictionless.
2. Preferably heavy weights should be used.
3. The weights so chosen that the knot comes in the middle.

Sources of Error:

1. The weights might be touching the board.
2. The board might not be vertical and stable.
3. The thread might be of low quality.

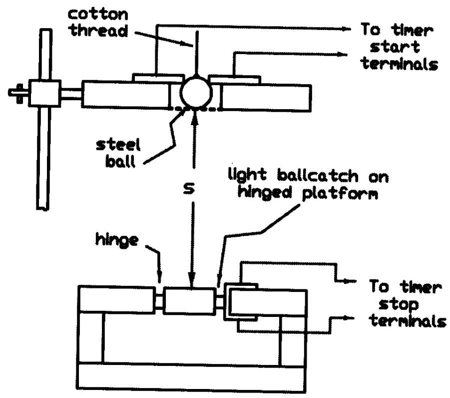
Viva Voce:

Q. 1: *What is 'Resultant force' ?*
Ans. It is a single force equivalent to the combined effect of all the forces.
Q. 2: *What happens to the components P_x and Q_x ?*
Ans. These components are equal and opposite and hence cancel each other.
Q. 3: *How is force represented on a diagram?*
Ans. A straight line represents force. The length of this line represents the magnitude of the force and its angle gives the direction of the force.

Date...........

Expt: 'g' by free fall method.

Free-fall Apparatus for ticker timer:



Observations and Calculations:

No. of obs.	Height fallen S	Time of fall T	t^2	$g = \frac{2S}{t^2}$
	cm	sec	sec^2	cm/sec^2
1	74.3	0.40	0.16	928.75
2	70.5	0.38	0.14	1007.14
3	65.1	0.36	0.13	1001.53
4	60.2	0.36	0.13	926.15
5	58.4	0.35	0.12	973.33

Mean 'g' = 967.38 cm/sec^2

Calculating g from the graph value of $((S/t^2)$

$g = 2\,S/t^2 = 978\ cm/sec^2$

Inference : The calculated value of g is a little different from actual value of g in this place of College laboratory (which we don't know exactly) due to experimental handling.

Note: Do not copy these values of the table, but take your own readings.
"Naqal Kay Leeay Uqal Chah heeay".

In this free fall experiment, plot graph between S & t. Analyze the graph by comparing it with the graph between S & t^2.

Experiment No. 4:

Determination of value of g by free fall method using an electronic timer/ticker timer.

Apparatus:

Millisecond timer or ticker timer, free-fall apparatus for electronic timer, metal ball, cotton thread, meter rod.

Theoretical Base:

In this case of free fall apparatus, we have

Initial velocity = $v_i = 0$, distance = S

time of free fall = t, a = g = ?

Using the equation

$$S = v_i t + \tfrac{1}{2} a t^2 = 0 \times t + \tfrac{1}{2} g t^2 = \tfrac{1}{2} g t^2$$

$$\text{or} \quad g = 2S / t^2$$

Procedure:

1) *Arrange the apparatus as shown in the figure.*
2) *Check the timer and other connections.*
3) *Hold the metal ball with a fine cotton thread in such a way that it completes the electric circuit between metal contact plates on the start switch.*
4) *Measure the height from the bottom of the ball down to the trapdoor.*
5) *Adjust the ticker timer tape (or the timer) for start reading.*
6) *Release the metal ball.*
7) *Note the time of free fall from the timer.*
8) *Repeat the experiment for 5 different values of height h.*
9) *Complete all the columns of the table.*
10) *Calculate mean 'g', and plot graph between S and t^2.*
11) *Find the value of 'g' from the graph.*

Precautions:

1. All the connections/contacts should be checked before start.
2. Reset the clock before releasing the ball.
3. Each time take difference of at least 5 cm in height.

Viva Voce:

Q.1 *Why is this method better than free fall method?*

Ans. Here we take time from electronic arrangement, instead mechanical way.

Q.2 *Is the value of 'g' constant?*

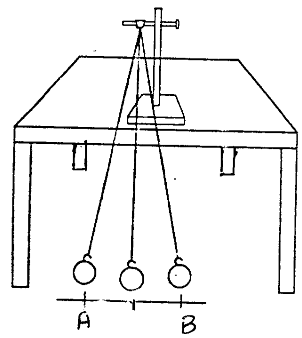
Ans. 'g' is constant at a given place but varies from place to place.

Q.3 What is the difference between 'g' and 'G'?

Ans. 'g' is acceleration due to gravity, and 'G' is gravitational constant.

Expt: Simple Pendulum relations.

Date...........



Observations and Calculations:

i) T is independent of amplitude,
for l and m constants.
Length of the simple pendulum = 100 cm
Mass of the pendulum = m

No. of obs.	Amplitude x	Time for 20 vibrations			Time period T = t / 20
		1	2	Mean t	
	cm	sec	sec	sec	sec
1	6	36.9	37.0	36.95	1.85
2	8	37.0	37.0	37.0	1.85
3	10	37.0	36.9	36.95	1.85

Inference: Since time period remains constant, it is independent of amplitude.

ii) T is independent of mass, for l and x constants.
Length of the pendulum = 100 cm
The amplitude = 6 cm

No. of obs.	Mass of the bob m	Time for 20 vibrations			Time period T = t / 20
		1	2	Mean T	
	gm	sec	sec	sec	sec
1	75	37.0	37.1	37.05	1.85
2	70	37.0	37.0	37.0	1.85
3	65	36.9	37.0	36.95	1.85

Inference: Since time period remains constant, it is independent of mass.

iii) $T \propto \sqrt{l}$, for m and x constant.
The radius of the bob = 0.8 cm

No. of obs.	Length of string including hook l_1	Total length $l = l +$ r	Time for 20 vibrations			Time period T = t / 20	$T / \sqrt{l}$
			1	2	Mean T		
	cm	cm	sec	sec	sec	sec	sec/ $\sqrt{\text{cm}}$
1	99.2	100	40	41	40.5	2.025	0.203
2	89.2	90	38.6	38.9	38.7	1.925	0.203
3	79.2	80	37.1	37.0	37.1	1.86	0.207

Inference: Since $T / \sqrt{l}$ is constant, $T \propto \sqrt{l}$.

The Laboratory equipments are your scientific toys to play with.

1. Find height of room (or a tower) by measuring T.
2. Find time period for different amplitudes for very long 'L'.

Experiment No. 5:

Verification of following relations of the simple pendulum:

i) Time period is independent of the amplitude.
ii) Time period is independent of its mass or density of the bob.
iii) Time period is directly proportional to the square root of its length.

Apparatus:

Three bobs of different sizes and masses, stopwatch, thread, split cork, iron stand, Vernier calipers.

Theoretical Base:

In the textbook we have calculated time period of simple pendulum as,

$$T = 2\pi \sqrt{l/g}$$

Squaring the above equation, we get

$$T^2 = 4\pi^2 (l/g) \quad \text{or} \quad g = 4\pi^2 (l/T^2)$$

Procedure:

1) *Measure diameter of the bob with Vernier caliper and calculate its diameter.*
2) *Take thread about 125 cm long. Attach one end of it to the bob and the other end through split cork with the clamp of iron stand.*
3) *Below the bob, mark line parallel to the table which should be 5 cm on either of the mean position.*
4) *Adjust apparatus so that position of bob should be minimum from the floor.*
5) *Measure the length of the thread including the hook.*
6) *Take time for 20 vibrations with a stopwatch twice.*
7) *Repeat four times more by shortening length of thread by 10 cm each time.*
8) *Complete all columns of the table (iii) and hence the inference.*
9) *Mark three points on the horizontal line at distances 3, 4 and 5 cm on either side of the mean position. Vibrate the bob for these different amplitudes.*
10) *Complete table (i) and hence the inference.*
11) *Take three bobs of different masses & complete table (ii) with inference.*

Precautions:

1. The thread should be held tight without slipping.
2. The bob should not spin.
3. The length of pendulum should be 70 cm to 120 cm.

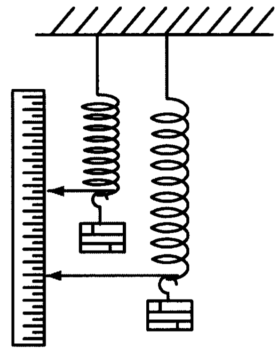
Viva Voce:

Q.1 *What is law of isochronism?*
Ans. For a pendulum when time period is independent of amplitude.
Q.2 *If earth stops rotating, will the T of a pendulum be effected?*
Ans. Yes, its time period will decrease.

Date...........

Exp: 'g' by mass-spring system.

Experimental arrangement:



Observations and Calculations:

Initial position of the pointer = 0.2 cm

No. of obs.	Mass suspended m	Extension x	Time for 20 vibrations 1	2	Mean	Time Period $T = t/20$	T^2	$g = \frac{4\pi^2}{T^2} x$
	gm	cm	sec	sec	sec	sec	sec	cm/sec^2
1	100	2.35	6.1	6.2	6.15	0.3075	0.095	975.57
2	150	3.25	7.2	7.3	7.25	0.362	0.131	978.42
3	200	4.10	8.3	8.2	8.25	0.413	0.170	951.15

Mean 'g' = 968.38 cm/sec^2

Actual value = 980 cm/sec^2

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{980 - 968.38}{980} \times 100 = 1.2\ \%$$

Note: The values in the table are not quite correct, certainly the student will take better than these values which are written just for guide line.

Verify oscillating mass spring system for <u>horizontal case</u>. Attach a body of mass 'm'. Find 'a' by oscillating mass spring system horizontally. $a = (4\pi^2 / T^2)x$
[$F = ma = kx \Rightarrow a = (k/m)x$ & $T = 2\pi \sqrt{m/k}$ or $k/m = 4\pi^2/T^2$]

Experiment No. 6:

To find the acceleration due to gravity by oscillating mass spring system.

Apparatus:

Helical spring apparatus, slotted weights with hanger.

Theoretical Base:

Consider a mass less spring of force constant 'k' in a uniform gravitational field.

We have: $F = kx$ & $F = mg \Rightarrow kx = mg$

or $m/k = x/g$ .....(1)

The time period for mass spring system is given as;

$T = 2\pi \sqrt{m/k}$ .....(2)

From equations (1) and (2) we get

$$T = 2\pi \sqrt{\frac{x}{g}} \quad \text{or} \quad g = \frac{4\pi^2}{T^2}x$$

Procedure:

1) *Arrange the helical spring apparatus.*
2) *Attach hanger with the spring and check its free movements.*
3) *Note initial position. Then add weights turn by turn and see the readings.*
4) *Fill the table for extensions by taking the difference between final reading and initial reading.*
5) *Take time for 20 vibrations twice.*
6) *Repeat twice and complete all the columns of the table.*

Precautions:

1. Increase the load in regular steps.
2. Pointer should not touch the scale.
3. The spring should move freely.

Viva Voce:

Q.1 *What is meant by for constant of a spring?*

Ans. Its equal to the ratio of force exerted on a spring to extension produced.

Q.2 *Define Hooke's Law.*

Ans. The applied force is directly proportional to the elongation produced within the elastic limits.

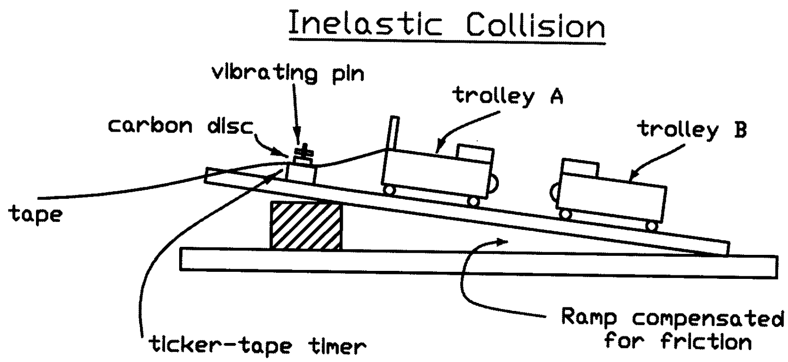
Q.3 *What is elastic limit?*

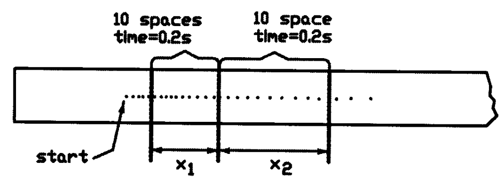
Ans. The limit beyond which the body do not obey Hooke's Law.

Expt: In-elastic collision.

Date...........

Experiment arrangement:





Observations and Calculations:

Frequency of the ticker timer , f = 50 dots/sec
Time interval of two consecutive dots = 1/50 = 0.02 sec
Mass of the trolley A , m_1 = 223 gm
Mass of the trolley B, m_2 = 221 gm

No. of obs.	Before collision				After collision				Difference between momenta
	distance	time	Velocity	Momentum	distance	time	Velocity	Momentum	
	x_1	t_1	$x_1 / t_1 = v_1$	$(m_1 v_1)$	x_2	t_2	$x_2 / t_2 = v_2$	$(m_1 + m_2)v_2$	
	cm	sec	cm/sec	gm-cm/sec	cm	sec	cm/sec	gm-cm/sec	gm-cm/s
1	*45*	*1.5*	*30*	*6690*	*15.2*	*0.98*	*15.5*	*6886.53*	*196.5*
2	*38*	*1.36*	*27.94*	*6230.88*	*10.3*	*0..74*	*13.92*	*6180.01*	*50.88*

Average difference = 123.69 gm-cm/sec

Inference: The difference of momenta is due to frictional forces.

The values in the table are typical values, your values will not be exactly same.

> **1. Verify the law with two table tennis balls for elastic collision.**
> **2. Repeat the experiment on the inclined plane after coating glue powerful enough to make them instantly stick together on contact. Analyze elastic and inelastic collisions.**

Experiment No. 7(a):

To study the laws of conservation of momentum by colliding trolleys and ticker timer for inelastic collisions.

Apparatus:

Runway, two trolleys, ticker timer, ticker tape, metre rod.

Using a Ticker Timer:

A ticker timer is connected to an A.C. mains having frequency 50 cycles/sec, which makes 50 ticks every second. A vibrating metal strip strikes a strip of paper tape through a carbon paper disc and so prints a dot on the tape 50 times a second. Time interval between two dots is 1/50 seconds or 0.02 sec, as shown in the figure.

Procedure:

1) Take the track (runway) with some slope to compensate friction.
2) Fit a pin to one trolley and a cork to the second trolley of equal mass.
3) Attach two end of ticker tape with first trolley and the ticker timer.
4) Place trolley B exactly opposite to trolley A at the middle of the track.
5) Give trolley A , a sharp push to run down the slope.
6) On colliding with trolley B, the pin is embedded in the cork and both move together.
7) From the tape find velocities of the trolleys before and after the collision.
8) Repeat the experiment twice and complete all columns of the table.

Precautions:

1. Use friction compensated track & negligible friction trolley wheels.
2. The trolleys should stick together after collision.
3. Sharp and instant push should be given to trolley A.

Viva Voce:

Q.1 *What is momentum?*
Ans. It is the product and mass and the velocity of a body.

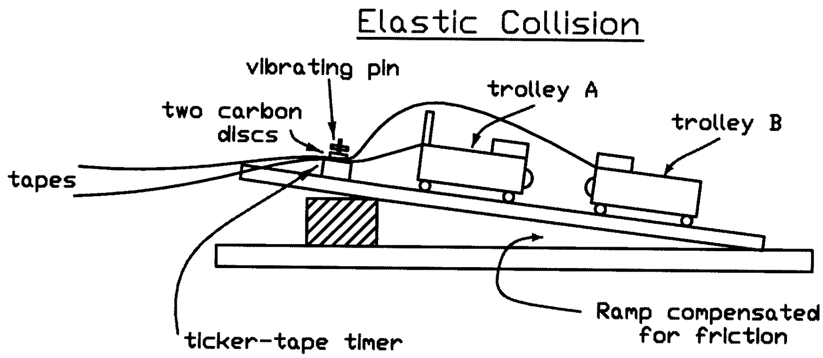
Q.2 *What is an inelastic collision?*
Ans. The collision in which total momentum is conserved but energy do not conserve before and after the collision.

Q.3 *What is the significance of momentum?*
Ans. Physically it gives the quantity of motion possessed by a body. It depends upon mass and velocity of the body.

Date...........

Expt: Elastic collision.

Experimental arrangement:



Observations and Calculations:

Frequency of the ticker timer , f = 50 dots/sec
Time interval of two consecutive dots = 1/50 = 0.02 sec
Mass of the trolley A , m_1 = 220 gm
Mass of the trolley B, m_2 = 225 gm

No. of obs.	Distance	Time	Velocity	Momentum
	x	t	x / t = v	m · v
	cm	sec	cm/sec	gm-cm/sec
	Trolley A before collision			
1	31.4	1.6	19.6	4317
2	28.5	1.14	25.0	5500
	Trolley A after collision			
1	-2.8	1.1	-2.5	-560
2	-3.1	1.47	2.11	-463.94
	Trolley B after collision			
1	17.5	0.86	20.3	4567.5
2	20.3	0.91	22.31	5019.23

1st attempt:

Total momentum before collision = 4317 + 0 = 4317 gm-cm/sec
Total momentum after collision = -560 + 4567.5 = 4007.5 gm-cm/sec
Difference = 309.5 gm-cm/sec

2nd attempt:

Total momentum before collision = 5500.0 + 0 = 5500.0 gm-cm/sec
Total momentum after collision = -463.94 + 5019.23 = 4555.29 gm-cm/sec
Difference = 944.71 gm-cm/sec

Inference: The difference of momenta is due to frictional forces.

A person rarely succeeds at anything unless he has fun doing it.

Test this collision experiment by sending two trolleys towards each other with equal speeds along a horizontal runway.

Experiment No. 7(b):

To study the laws of conservation of momentum by colliding trolleys and ticker timer for elastic collisions.

Apparatus:

Runway, two trolleys, ticker timer, ticker tape, metre rod.

Theoretical Base:

According to the law of conservation of momentum;
Total momentum before collision = total momentum after collision

$$\text{or} \quad m_1 v_i + m_2 v_i = m_1 v_f + m_2 v_f$$
$$\text{or} \quad 0 = m_1 (-x_1 /t) + m_2 (x_2 /t)$$
$$\text{or} \quad - m_1 (x_1 /t) + m_2 (x_2 /t) = 0$$

Procedure:

1) Take the track (runway) with some slope to compensate friction.
2) Fix a metallic nose instead cork to one trolley and a tab to the second trolley of equal mass.
3) Pass the both tapes through the same ticker timer. Use two carbon discs to pass the two tapes.
4) Place trolley B exactly opposite to trolley A at the middle of the track.
5) Start the ticker timer and push trolley A gently to collide elastically with trolley B.
6) From the tapes find the velocity of each trolley before and after the collision.
7) Repeat the experiment and complete all columns of the table.

Precautions:

1. Use fresh carbon discs in the timer ticker.
2. Move first trolley gently to avoid inelastic collision.
4. Use small lengths of the tapes.

Viva Voce:

Q.1 *What is elastic collision?*
Ans. Collision in which laws of conservation of energy and momentum hold.

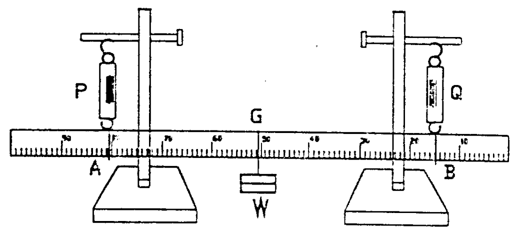
Q.2 *Why a slope is given to the track?*
Ans. This slope supply necessary force to compensate the frictional forces.

Q.3 *In this experiment, why first trolley is pushed gently?*
Ans. Is done to make elastic collision. If we push violently, it may move the second trolley and the collision may be inelastic.

Date...........

Expt: Condition of Eq. with suspended metre rod.

Experimental arrangement:



Observations and Calculations:

Position of center of gravity of meter rod = G = 50.1 cm

Weight of the meter rod = w = 40 gm-wt

No. of obs.	Forces			Moment arm			Torques about G			$\Sigma\tau$
	P	Q	F = W+w	AG	BG	CG	Counter Clockwise τ_1=P x AG	Counter clockwise τ_2=Q x BG	Clockwise τ_3=F x CG	$= \tau_1+\tau_2+\tau_3$
	gm-wt	gm-wt	gm-wt	cm	cm	cm	gm-wt-cm	gm-wt-cm	gm-wt-cm	gm-wt-cm
1	30	30	20+40	35.2	66.8	50.1	30 x 35.2 =1056	30 x 66.8 =2004	60 x 50.1 =3006	1056+2004-3006=54
2	35	35	30+40	25.4	71.2	50.1	35 x 25.4 =889	35 x 71.2 =2492	70 x 50.1 =3507	889+2492-3507=126
3	45	45	50+40	17.9	78.2	50.1	45 x 17.9 =805.5	45 x 78.2 =3519	90 x 50.1 =4509	806+3519-4509=184

Verification of 2nd condition:

Summation of all the torques is nearly equal to zero, so within the limits of experimental error, $\Sigma\tau = 0$

Put metre rod edge-wise on the wedge when you take its center of gravity.

Take a small rod of known weight. Hang it with a string. Hang one known weight on one side. Press from other side to make the rod horizontal. Apply 2nd condition of Eq. And find the pressing force.

Experiment No. 8:

Verify the second condition of equilibrium using a suspended meter rod.

Apparatus:

Two iron stands, two spring balances, weights, meter rod, wedge.

Theoretical Base:

There are two conditions of equilibrium.

The **1st condition of equilibrium** states that if a number of forces acting on a body, the sum of all the forces in x-direction is zero and the sum of all the forces in y-direction should also be equal to zero; i.e. $\Sigma F_x = 0$ & $\Sigma F_y = 0$

The **2nd condition of equilibrium** states that the sum of all the torques acting on a body is zero; i.e. $\Sigma \tau = 0$.

Procedure:

1) *Find the center of gravity G of the meter rod by using a wedge.*
2) *Hang two spring balances on iron stands and check their zero correction. Attach with them a meter rod with thread loops.*
3) *Read and note both the spring balances as weight of the meter rod.*
4) *Suspend a weight W at G with a loop on the meter rod.*
5) *Note positions and readings of the spring balances.*
6) *Repeat twice by changing the positions and weight.*
7) *Complete all columns of the first table, and complete second table with the help of first table.*

Precautions:

1. Meter rod should be placed edgewise in the thread loops.
2. Meter rod should be adjusted in horizontal position.
3. Read spring balances when the apparatus is stable.

Viva Voce:

Q.1 *What are like and unlike parallel forces?*

Ans. Like parallel forces are those forces, which act in the same, direction and their lines of action are parallel to each other.

Unlike parallel forces are those forces which act in opposite direction and their lines of action are parallel to each other.

Q.2 *Why the meter rod is balanced in edgewise position.*

Ans. So that it may act like a rigid body.

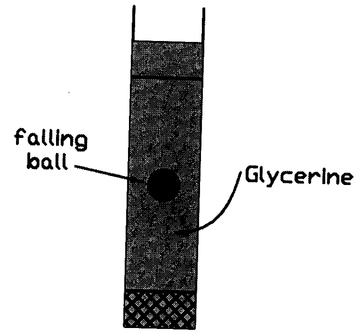
Q.3 *What are the necessary conditions for a body to be in complete equilibrium?*

Ans. It should have zero linear acceleration and zero angular acceleration.

Date...........

Expt: Coefficient of viscosity.

Experimental arrangement:



Observation and Calculations:

Diameter of the ball = i) 1.52 cm ii) 1.48 cm iii) 1.50 cm
Mean diameter = D = 1.50 cm
Radius = r = 0.75 cm = 0.0075 m
Density of glass ball = d = 1.36×10^3 kg/m^3
Density of glycerin = ρ = 1.23×10^3 kg/m^3, (at 20°)

No. of obs.	Distance of fall AB	Time taken T	Terminal velocity v	$\eta = \frac{2}{9}\frac{r^2 g(\rho - d)}{v}$
	m	sec	m/sec	N s/m^2
1	*0.14*	*0.78*	*0.18*	*0.776*
2	*0.14*	*0.82*	*0.17*	*0.821*
3	*0.14*	*0.74*	*0.19*	*0.720*

Mean η = 0.776 N s/m^2

There is no short cut to success. Just a ball has to pass through frictional force in the viscous liquid to reach the target!

1. Design a laboratory experiment to investigate how terminal velocity of the parachute depends upon the load, which it carries, and the diameter of the canopy.
2. Design an experiment to investigate how the depth of penetration varies with the speed of the pellet or small ball.

Experiment No. 9:

To study the fall of a body through a viscous medium and hence to deduce the coefficient of viscosity of the medium.

Apparatus:

Glass tube, glycerin, glass ball or steel ball, stop watch.

Theoretical Background:

[density = mass/volume or $\rho = m/V$ or $m = \rho \times V = \rho \times (4/3)\pi r^3$; & $F = mg$]
Resultant downward force on the ball = weight of ball – upward thrust
or $F = (4/3)\pi r^3 \rho g - (4/3)\pi r^3 d g = (4/3)\pi r^3 (\rho - d) g$
from Stokes Law, we have ; $F = 6\pi\eta rv$
so $6\pi\eta rv = (4/3)\pi r^3 (\rho - d) g$ or $\boxed{\eta = \dfrac{2}{9}\dfrac{r^2 g (\rho - d)}{v}}$

Procedure:

1) *Take the glass tube of about 5 cm in diameter and 50 cm in height.*
2) *Fill the tube with glycerin.*
3) *Fix one wire band at position A and the other at B, as shown in the figure.*
4) *Take small ball (having nearly 1 cm in diameter), find its diameter with vernier calipers. And fill the lines above the table.*
5) *Wet the ball with glycerin contained in a small dish.*
6) *Take a stop watch. Drop the wetted ball gently in the tube. Start the time when the ball crosses position A and stop timing when it crosses position B.*
7) *Measure the distance AB, and time t, find the terminal velocity.*
8) *Fill all columns of the table. Repeat twice.*
9) *Calculate coefficient of viscosity from the formula.*

Precautions:

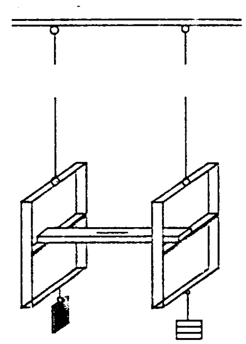
1. Wetted ball should be used for dropping to avoid formation of air bubbles.
2. Tube should be fitted with a secure bung at its lower end.
3. Handle the ball with tweezers and allowed to fall centrally down the tube.

Viva Voce:

Q.1 *Define viscosity of a fluid.*
Ans. Property of fluids by which they resist their flow due to internal friction.
Q.2 *What is coefficient of viscosity?*
Ans. Is is the constant of proportionality in the relation of frictional force F,
$$F = \eta A (dv/dr)$$
Q.3 *Define frictional force in case of fluids.*
Ans. The frictional force F, is proportional to the cross sectional area A, times the velocity gradient, dv/dr, (the velocity difference between two points divided by their distance apart).

Date...........

Expt: Young's Modulus for a wire.



Searle's apparatus with attachment:

Observation and Calculations:

Length of the wire $= L = 398$ cm

Diameter of the wire = d

i) .045 cm , ii) .055 cm,

iii) .065 cm, iv) .056 cm

Mean diameter $= d = 0.055$ cm

Radius $= d/2 = r = .0275$ cm

Area of cross-section of the wire $= a = \pi r^2 = .00238\ cm^2$

No. of obs.	Loads added on the hanger	Micrometer reading			Elongation for 1 kg l
		Load increasing	Load decreasing	Mean	
	Kg	mm	mm	mm	mm
1	0	1.21	1.22	1.215	—
2	1	2.11	2.15	2.13	0.915
3	2	2.88	2.90	2.89	0.76
4	3	3.71	3.78	3.745	0.855
5	4	4.49	4.49	4.49	0.75

Mean elongation $= l = 0.82$ mm

$= 0.082$ cm

Force $= Mg = 1 \times 1000 \times 980$ dynes

Young's modulus $= Y = MgL / al = \dfrac{980000 \times 398}{0.00238 \times .082} = 23 \times 10^{11}$ dynes / cm

Actual value $= 19 \times 10^{11}$ dynes/cm

Percentage error $= \dfrac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$

$= \dfrac{19 \times 10^{11} - 23 \times 10^{11}}{19 \times 10^{11}} \times 100 = 21\ \%$

Note: Its not a perfect result as 2-3 % error is allowed.

Select inflated big plastic ball. Make arrangement so that small weight can sit for a while on the ball. Find volume of the ball. Put some known weights on the ball. Estimate value of deformed volume. Calculate Bulk modulus.

$$B = \frac{\text{stress}}{\text{Strain}} = \frac{MgV}{\Delta V} = \frac{Mg(4/3\pi R^3)}{\{4/3\pi(\Delta R^3)}$$

Experiment No. 10:

To determine Young's Modulus of a wire by Searle's apparatus.

Apparatus:

Searle's apparatus, slotted weights with hangers, dead weight, screw guage, meter rod.

Theoretical Base:

We define elastic modulus , as the ratio of the stress on a body to the strain produced. And Young's modulus, Y , is the tensile or compressive stress. It is the force per unit cross sectional area divided by the fractional elongation of the sample. i.e. $Y = F/a \div l/L = F \times L / a \times l = MgL / \pi r^2 l$

Procedure:

1) *Suspend dead weight with reference wire and the hanger with experimental wire. Study to read micrometer reading.*
2) *For zero kilogram (only hanger) when bubble comes in the middle then note the reading.*
3) *Place turn by turn (all the given) 1 kg weights and note corresponding micrometer readings for load increasing and then for load decreasing.*
4) *Complete all columns of the table and the above and below line.*
5) *Calculate Young's modulus by applying the formula.*
6) *Note the actual value and from the formula calculate percentage error.*
7) *Plot a graph between load and elongation.*

Precautions:

1. The wires should be fixed tightly.
2. Load or unload the hanger gently.
3. The diameter should be measured from different places.

Sources of Error:

1. There might be kinks in the wire.
2. The wire might not be tightly griped from both ends.
4. The wire might be loaded beyond its elastic limits.

Viva Voce:

Q.1 *What is Young's modulus?*

Ans. It is the ratio of linear stress to longitudinal strain.

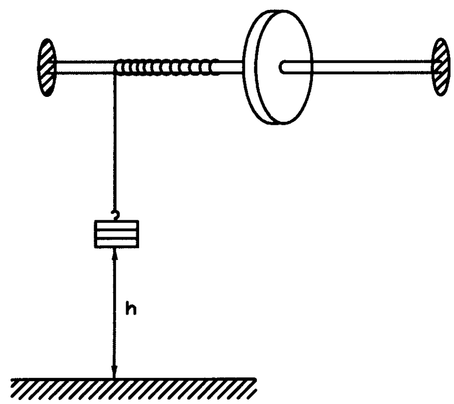
Q.2 *What do you mean by breaking stress?*

Ans. It's the load just sufficient to strain a wire beyond the elastic limit

Date:…………….

Expt: Moment of Inertia of a flywheel.

The Flywheel Apparatus:



Observations & Calculations:

Diameter of the axle = i) 3.1 cm ii) 3.0 cm iii) 2.9 cm
Mean diameter = 3.0 cm
Radius of the axle = r = 1.5 cm

No. of obs	Mass (hanger+ weights)	Height	String turns on the axle	Rotation of the wheel N			Time for N rotations t			$\omega = \frac{4\pi N}{t}$	$I = \frac{N}{N+n}\frac{m(2gh - r^2)}{\omega^2}$
	m	h	n	1	2	Mean	1	2	Mean		
	gm	cm					sec	sec	sec	rad/s	gm-cm^2
1	150	121	14	19	17	18	4.3	4.1	4.2	53.82	6718.41
2	160	121	14	22	23	22.5	4.5	4.6	4.55	62.11	5841.65
3	140	120	15	18	17	17.5	4.2	4.1	4.15	52.96	6151.95

Mean I = 6237.34 gm-cm^2

The person who makes no mistakes does not usually make anything.

Take values for different weights and corresponding number of rotations. Plot graph between them. Check for straight-line curve. [$\tau = I\,\alpha$ or $(r \times F) = I \times (\omega/t)$ or $F \propto \omega$, for other quantities const.]

Experiment No. 11:

To find the moment of inertia of a fly-wheel.

Apparatus:

Fly-wheel, slotted weights, thread, meter rod, stop watch., vernier calipers.

Theoretical Base:

We have; Loss of PE = gain in KE

or Loss of PE = KE_{mass} + rotational KE_{wheel} + energy used to overcome friction

or $mgh = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2 + (n/N) \frac{1}{2} I\omega^2$

or $2mgh = m(r\omega)^2 + I \omega^2 (1 + n/N)$ or $2mgh - m(r\omega)^2 = I \omega^2 (1 + n/N)$

or $I = \dfrac{2mgh - m(r\omega)^2}{\omega^2 (1 + n/N)}$ or $\boxed{I = \dfrac{N\, m}{N+n}\left(\dfrac{2gh}{\omega^2} - r^2\right)}$

Procedure:

1) *Check the wheel for least possible friction.*
2) *Measure the diameter of the axle from three different places.*
3) *Take the string. Make loops at its both ends for attaching one with the hanger and the other with peg of the axle.*
4) *Rotate the wheel and wrap the string on the axle.*
5) *Make a chalk mark on the wheel. Note the position of the lower surface of the weights carrying hanger.*
6) *Count the number of string turns wound on the axle.*
7) *Take a stopwatch and allow the mass to descend. As soon as the weight strike the ground, start the stopwatch. Count the number of revolutions N made by wheel before coming to rest. Take readings two times with same height and weights.*
8) *Repeat the experiment twice with different weights.*

Precautions:

1. There should be no over looping of the string on the axle.
2. Stop watch should be started just when the string is detached.
3. Measure the diameter of the axle along three mutually perpendicular axis.

Viva Voce:

Q.1 *What is moment of inertia?*

Ans. It is defined as the sum of the products of the mass and the square of the distance of different particles of the body from the axis of rotation.

Q.2 *Why flywheel has large mass in the middle?*

Ans. It is because to increase the number of rotations of the flywheel.

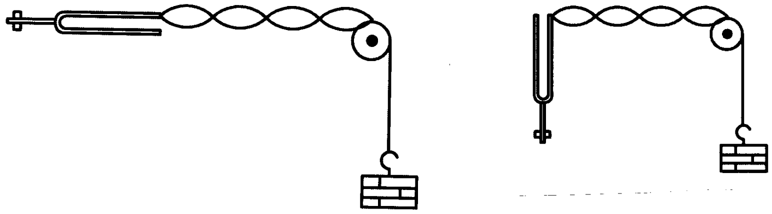
Q.3 *When the mass is allowed to fall, what happens to its potential energy?*

Ans. It partly changes into kinetic energy due to velocity gained by it and rotational energy.

Date..............

Expt: A.C. by Melde's App.

Some details of Melde's apparatus:



Observations and Calculations:

Length of the string = 500 cm

Mass of the string = 1.132 gm

Mass per unit length = m = 1.132 / 500 = 0.0022 gm

No. of obs.	No. of loops p	Distance between extreme nodes L cm	Length of each loop l = L/p cm	Total mass with hanger M gm	Tension T = Mg dynes	$\nu = 1/2l\,(\sqrt{T/m})$ hertz
1	4	97.5	24.37	60	58860	104.71
2	3	87.0	29.0	80	78480	101.61
3	3	96.0	32.0	100	98100	103.0

Mean ν = 103.1 hertz

For transverse mode arrangement:

Frequency = ν = 103.1 /2 = 51.5 hertz

Correct value of A.C. supply = 50 vib/sec or hertz

Percentage error = $\frac{50 - 51.5}{50}$ x 100 = 3 %

We never do anything well till we cease to think about the manner of doing it.

Investigate how resonant length 'l' of a vibrating wire depends on the mass per unit length 'm' of the wire.

Experiment No. 12:

Determination of frequency of A.C. by Melde's apparatus.

Apparatus:

Melde's apparatus, string, weights with hanger, A.C. mains

Functioning Tuning Fork:

Electrical circuit is made working through the screw, when its tip comes in contact with the prong of the tuning fork. The current then passes through the electromagnet. The prongs of the tuning fork are pulled to the iron core of the electromagnet. When the prongs are pulled over, the tip of the screw breaks contact at S. This breaks the circuit and the current stops, the magnetic field dies away and the prong fly back making contact with the tip of the screw again. This makes and break of the circuit, which is repeated over and over again, keeps the tuning fork vibrating with the frequency of A.C. supply.

Procedure:

1) *Set up the electrically driven tuning fork. Tie one end of the string with the hook provided on the prong of fork and the other end with the hanger.*
2) *Start the current in the electromagnet. Put some weights (say 50 grams) in the hanger. Adjust the distance of the pulley from the fork along with weights, such that well defined loops are formed on the string.*
3) *Measure the distance L between the extreme nodes. Also the number of nodes.*
4) *Change the weight in the hanger by some grams and adjust the distance of pulley to get well defined loops again.*
5) *Repeat the process twice. Complete all the columns of the table.*
6) *Calculate the frequency for the longitudinal or transverse mode of vibrations as the case may be.*

Precautions:

1. The hanger of the weights should be tight.
2. The string should be thin and fine.
3. Weights added in the hanger should be small.

Viva Voce:

Q.1 *What is the frequency of A.C. supply?*

Ans. It is 50 cycles per second.

Q.2 *What mode of vibrations are on the string?*

Ans. These are transverse stationary waves.

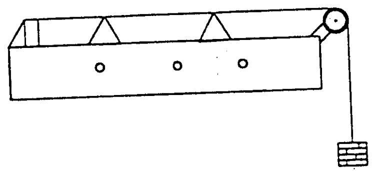
Q.3 *What are stationary waves?*

Ans. Waves apparently standing still resulting from two similar wave trains travelling in opposite directions.

Expt: Laws of Transverse vibrations with Sonometer

Date..............

Sonometer with experimental adjustments:



Observations and Calculations:

Stretching force including the hanger = 2.5 kg-wt

No. of obs.	Frequency	Resonant length			v x *l*
		1	2	Mean: *l*	
	hertz	m	m	m	hertz-m
1	512	0.09	0.091	0.09	46.08
2	480	0.097	0.095	0.096	46.08
3	384	0.12	0.122	0.121	46.47

Inference: *Since v x l is constant, the law of length is verified.*

Useful tip! Take the lowest frequency (say) 256 hertz first and start vibrating the string by moving one of the bridge very slowly and gently.

**Measure frequency of an unknown tuning fork using sonometer.
[Find resonant length '*l*' with known tuning fork. Find, const = fx*l*.
Determine resonant length of unknown fork keeping tension const.
find 'f' from; fx*l* = const]**

Experiment No. 13(a):

Investigation of the law of length of stretched strings by sonometer.

Apparatus:

Sonometer, three tuning forks of different frequencies, rubber pad, slotted weights with hanger, bridges, and meter rod.

Theoretical Background:

We have in case of transverse vibrations of string;

$$\nu = 1/2l\,(\sqrt{T/m})$$

The factors l, m & T are all variables, ν will vary as they are altered.

We have **Law of length** as; $\nu \propto 1/l$, when m and T are constant.

Procedure:

1) *Arrange the apparatus as shown in the diagram.*
2) *Put a load of one kg or 2 kg on the hanger. Place bridges very near to each other.*
3) *Put a light paper rider on the wire between the bridges.*
4) *Take the tuning fork having the lowest frequency (say 256). Vibrate it with a rubber pad.*
5) *Gently place the vibrating tuning fork on the board between the bridges. At the same time move slowly position of one of bridge, till the paper rider moves off.*
6) *Measure the length of the wire between the bridges for two good resonating positions when the paper rider moves off.*
7) *Repeat it with two more tuning forks, and complete all the columns of the table.*

Precautions:

1. The wire should have no kinks.
2. The edge of the bridges should be sharp.
3. The paper rider should be in the middle of vibrating segment.

Viva Voce:

Q.1 *What is law of length?*

Ans. $\nu \propto 1/l$ when T and m are constant: That is 'the frequency of transverse vibration of a stretched string is inversely proportional to its vibrating length' under a constant stretching force.

Q.2 *Why is it called sonometer?*

Ans. As it can measure the frequency of sound.

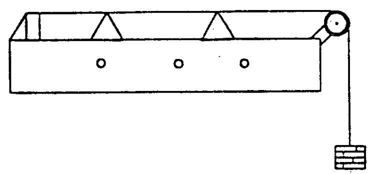
Q.3 *What is the function of holes in the sonometer?*

Ans. To make communication with the atmospheric air possible.

Date..............

Expt: Law of Tension with Sonometer

Sonometer with experimental arrangements:



Observations and Calculations:

Length of vibrating segment = 0.122 m

No. of obs.	Frequency Hertz	Total load 1st kg-wt	2nd kg-wt	Mean kg-wt	Tension $T = mg$ Newtons	$\sqrt{T}$	$v/\sqrt{T}$
1	512	1.5	1.51	1.5	14.7	3.83	133.7
2	480	1.25	1.26	1.25	12.25	3.5	137.1
3	384	0.89	0.90	0.89	8.72	2.95	130.2

Inference: *Since $v/\sqrt{T}$ is constant, the law of tension is verified.*

Useful tip! Take least frequency reading (of last experiment) with 1.5 kg load and add weights by 0.1 kg (100 grams) for higher frequency tuning forks.

In sonometer experiment, verify law of mass by taking wires of different materials. We have f = (1/2*l*)x($\sqrt{T/m}$), for constant tension & resonating length, $f \propto 1/\sqrt{m}$ or $\sqrt{m} \times f$ = const

Experiment No. 13(b):

Investigation of the law of tension of stretched strings by sonometer.

Apparatus:

Sonometer, three tuning forks of different frequencies, rubber pad, slotted fractional & kg-weights with hanger, bridges, and meter rod.

Theoretical Background:

From the formula;

$$\nu = 1/2l\,(\sqrt{T/m})$$

We have **Law of tension** as; $\nu \propto \sqrt{T}$, when l and m are constant.

Procedure:

1) *Stretch the wire over the sonometer with a load on hanger.*
2) *Find the resonating length for the lowest frequency and note it above the line of the table.*
3) *Increase the load in steps by 0.1 kg till the same length of the wire resonates with second tuning fork of higher frequency.*
4) *Take two observations for each tuning fork, and use total three tuning forks of different frequencies.*
5) *Complete all the columns of the table.*
6) *Plot a graph between T verses ν^2 by taking T along X-axis. It will be a straight line graph.*

Precautions:

1. The load of the hanger must be included.
2. The wire should not be loaded beyond the breaking stress.
3. Vibrating tuning fork should be placed very softly.

Viva Voce:

Q.1 *What is law of tension?*

Ans. $\nu \propto \sqrt{T}$ when l and m are constant: That is 'the frequency of transverse vibration of a stretch strings is directly proportional to the square root of its tension for a given length'.

Q.2 *What type of vibration is executed by sonometer wire?*

Ans. It executes transverse vibrations.

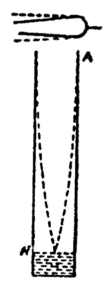
Q.3 *Why is sonometer sometimes called monochord?*

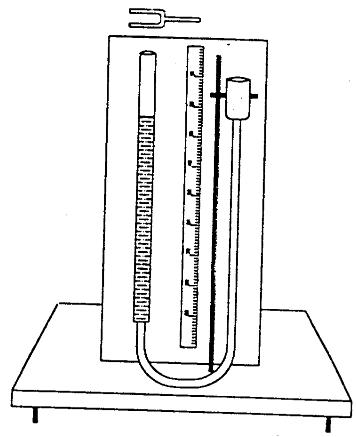
Ans. As it consists of a single wire.

Date..............

Expt: Velocity of sound by end correction.

Resonance tube apparatus with the position of tuning fork:





Observations and Calculations:

Internal diameter of the tube = i) 3.49 cm , ii) 3.42 cm , iii) 3.44 cm

Mean diameter = D = 3.44 cm

End correction = 0.3D = .3 x 3.44 = 1.03 cm

Room temperature = t = 31.5 °C

No. of obs.	Frequency	Resonance position			Length of resonating air column	$v_t = v\lambda$ $= v \times 4l$
	v	1	2	Mean: L	$l = L + 0.3D$	
	Hertz	cm	cm	cm	cm	cm/sec
1	512	15.2	15.3	15.25	16.503	33798.1
2	480	16.5	16.6	16.55	17.616	33823.3
3	384	21.0	20.9	20.95	21.970	33745.7

Mean v_t = 33789.03 cm/sec

Velocity of sound at 0 °C = $v_o = v_t - 61t$

or v_o = 33789.03 – (61 x 31.5) = 31867.53 cm/sec

Actual value = 33200 cm/sec

$$\text{Percentage error} = \frac{\text{Actual value} - \text{calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{33200 - 31867.5}{33200} \times 100 = 4.01\ \%$$

Note: When you take second tuning fork for finding resonance position, if its frequency is higher than previous one, lower the water level. And if the frequency of second tuning fork is less, then raise the water level for finding the resonance position.

Find the unknown frequency of a tuning fork. [Find ' l ', determine v_t from the formula, then calculate f = v_t /2l]

Experiment No. 14(a):

To determine the wave length of sound in air using stationary waves and to calculate the speed of sound by one resonance position and applying end correction.

Apparatus:

Resonance tube apparatus, three tuning forks of different frequencies, rubber pad, thermometer, vernier calipers, set squares and meter rod.

Procedure:

1) *Set the apparatus in vertical and stable position.*
2) *Bring the reservoir to the upper part of the stand, so that water rises to fall in the resonance tube.*
3) *Strike a tuning fork on the rubber pad, and very slowly lower the water level in the tube by lowering the reservoir or by loosing the pinchcock.*
4) *During vibrations, when a magnified sound is heard, note that position of the water level.*
5) *Lower the water level a little and then slowly rise. Again note the clear magnified sound as its second reading.*
6) *Repeat the above with two more tuning forks.*
7) *Complete all the columns of the table and the lines above the table.*
8) *From calculated and actual values find the percentage error.*

Precautions:

1. Lower meniscus of the water level should be read.
2. The vibrating prong should not touch the edge of the tube.
3. Strike the tuning fork gently against the rubber pad.

Sources of Error:

1. The tuning fork might not be held horizontally.
2. The vibrations of the tuning fork might not be stopped before revibrating it.
3. The exact position of resonance might not be located correctly.

Viva Voce:

Q.1 *What types of waves are produced in the tube?*

Ans. Longitudinal stationary waves are produced.

Q.2 *What is the effect of temperature upon the velocity of sound?*

Ans. It increases with increase of temperature.

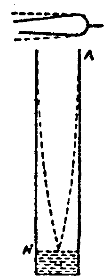
Q.3 *What is end correction?*

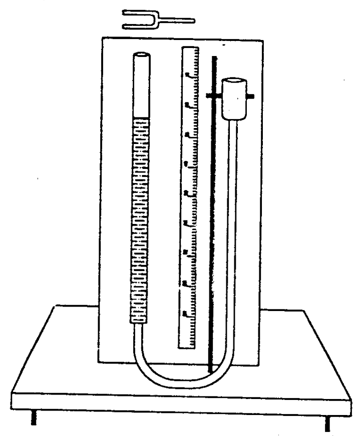
Ans. The antinode does not lie at the centre of open end but slightly above. This shift in the position of antinode is called end correction.

Date..............

Expt: Velocity of sound by two resonance positions.

Resonance tube apparatus with tuning fork position:





Observations and Calculations:

Room temperature = t = 31.5 °C

No. of obs.	Frequency ν	First position of resonance			Second position of resonance			Length $l = \lambda/2 = L_2 - L_1$	$V_t = 2\nu l$
		1	2	Mean : L_1	1	2	Mean : L_2		
	Hertz	cm	cm	cm	cm	cm	cm	cm	cm/sec
1	512	15.2	15.3	15.25	48.4	48.2	48.3	33.03	33825
2	480	16.5	16.6	16.55	51.6	51.8	51.7	35.19	33778
3	384	21.0	20.9	20.95	64.9	65.1	65.0	44.08	33850

Mean v_t = 33817.67 cm/sec

Velocity of sound at 0 °C = $v_o = v_t - 61t$ =

= 33817.67 – (61x31.5) = 31896.17 cm/sec

Actual value = 33200 cm/sec

Percentage error = $\frac{33200 - 31896}{33200}$ x 100 = 3.9 %

Useful tip! Take highest frequency reading of last experiment, lower the water level two time further, then check for second resonance position. This time the sound heard will be less.

Compare frequencies of two tuning forks. [$v_t = 2\nu l$ & $v_t = 2\nu' l'$ or $v_t / v_t = 1 = 2\nu l / 2\nu' l'$ or $\nu'/\nu = l / l'$]

Experiment No. 14(b):

To determine the wave length of sound in air using stationary waves and to calculate the speed of sound by using two resonance positions.

Apparatus:

Resonance tube apparatus, three tuning forks of different frequencies, rubber pad, thermometer, vernier calipers, set squares and meter rod.

Theoretical Background:

We have for 1st position of resonance; $l = \lambda/4$ or $l = l_1 + 0.3D$ .....(1)

For 2nd position, the length is, $l = \lambda/4 + \lambda/2 = 3\lambda/4 = l_2 + 0.3D$ ....(2)

From equations (1) & (2) we get

$$3\lambda/4 - \lambda/4 = l_2 + 0.3D - l_1 + 0.3D$$

$$\text{or} \quad \lambda = 2(l_2 - l_1)$$

so velocity of sound, v will be

$$v = \lambda\, \nu \qquad \text{or} \qquad \boxed{v_t = 2\,\nu(l_2 - l_1)}$$

Procedure:

1) *Adjust the apparatus for first resonance position with different three tuning forks.*
2) *Note the reading for First resonance position with different three tuning forks.*
3) *Lower the water level in the tube about three times the length of first resonance position.*
4) *Keeping the same vibrating tuning forks above the open end of the tube, after some lowering or rising the water level, again a magnified sound is heard. Note this resonance position.*
5) *Complete all the columns of the table and the lines above the table.*
6) *Repeat twice. From calculated and actual values find the percentage error.*

Precautions:

1. The apparatus should be made vertical.
2. During the experiment if temperature varies, take mean value.
3. The vibrations of the tuning fork should be stopped before re-vibrating it.

Viva Voce:

Q.1 *What is an echo?*

Ans. A reflected sound is called an echo.

Q.2 *What role does water play in resonance tube?*

Ans. It simply changes the length of air column.

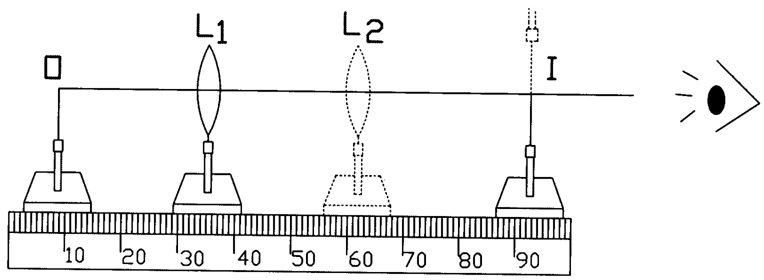
Q.3 *What is that which vibrates in the resonance tube?*

Ans. It is the air column.

Date...........

Expt: Focal length of a convex lens by displacement.

Experimental arrangements for displacement method:



Observations and Calculations:

Approximate focal length = F = 10 cm
Length of knitting needle = l_1 = 30 cm
Distance between two needles = l_2 = 29.3 cm
Index correction for the needles = $l_1 - l_2$ = 0.7 cm

No. of obs.	Positions of: Object needle O	Image needle I	Lens L_1	Lens L_2	$d = L_2 - L_1$	Distance, l (between O & I): Observed l'	Corrected L	$f = (l^2 - d^2)/4l$
	cm	cm	cm	cm	cm	cm	cm	cm
1	17.9	68.8	50	36.8	13.2	50.9	50.2	11.8
2	19	68.9	50	40.5	9.5	49.9	49.2	12
3	20	69.4	50	45.8	4.2	49.4	48.7	12.2

Mean f = 12.0 cm

We are born with two eyes but one tongue, in order that we observe twice.

Discover inverted image on retina:
Take a card and make a hole in it with a pin. Hold the card close to your eye and look at a strong light through the pinhole. Place the pin between your eye and the card so that the head of the pin covers part of the pinhole. The shadow of the pin will appear upside down. [The eye acts merely like a window, when placed an object very close to the eye].

1. **Compare the difference of approximate focal length and calculated focal length for a thin convex lens and a thick convex lens.**
2. **Show there are two coaxial positions of a convex lens, which will give, on a fixed screen, a sharp image of a fixed object.**

Experiment No. 15:

To determine the focal length of a convex lens by displacement method.

Apparatus:

Convex lens, two needles, knitting needle, three uprights, set square and meter rod.

Theoretical Background:

The formula used for finding the focal length is;

$$f = (l^2 - d^2)/4l,$$

where l is the distance between object needle and image needle,
& d is distance between the displacement of lens

Procedure:

1) *Find the approximate focal length F.*
2) *Adjust the three uprights such that the distance between the two needles is about 4F, the lens being in middle. Distance p is little greater than F.*
3) *Remove the parallax. And note the positions L_1, O and I.*
4) *Without moving O, and I move the lens towards I and again remove the parallax. Note the position L_2.*
5) *Repeat the experiment twice by changing the distance between the needles.*
6) *Find the index correction for needles, by filling the lines above the table.*
7) *Complete all the columns of the table.*

Precautions:

1. Distance between the two needles should be greater than 4F.
2. For second observation parallax should be removed only by moving the lens.
3. For removing parallax look from a large distance to avoid strain on the eye.

Sources of Error:

1. The parallax might not be removed over the central portion of the lens.
2. The eye might be kept at distance less than 25 cm during removing parallax.
3. The needles might not be well illuminated.

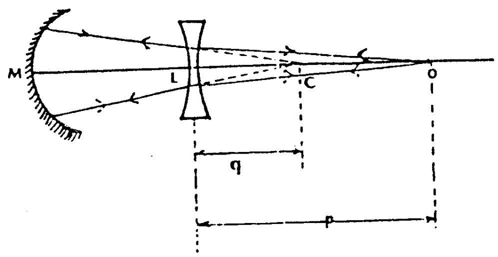
Viva Voce:

Q.1 *What is optical center of the lens?*
Ans. A point inside a lens, where is no deviation to a ray.
Q.2 *Why displacement method is better than the two needle methods?*
Ans. Here only one index correction is required.
Q.3 *What is the minimum distance between object and its real image for convex lens?*
Ans. It is exactly equal to four times the focal length of the lens.

Date..........

Expt: Focal length of concave lens by concave mirror.

Experimental Illustration:



Observations and Calculations:

Approximate focal length of concave mirror = F = 20 cm
Length of knitting needle = x = 30 cm
Distance between needle and mirror = y = 30.4 cm
Distance between needle and lens = z = 30.3 cm
Index correction for concave mirror = $x - y$ = - 0.4 cm
Index correction for concave lens = $x - z$ = - 0.3 cm
Position of the mirror = M = 10 cm

No. of obs.	Position of			Observed		Corrected		$f = \frac{p \times -q}{p+(-q)}$
	Needle at C	Lens L	Needle at O	p' OL	q' CL	p	Q	
	cm	cm	cm	cm	cm	cm	cm	cm
1	28.5	18.9	44.3	25.4	9.6	25.0	9.3	- 14.8
2	28.0	18.7	43.1	24.4	9.3	24.0	9.0	- 14.4
3	29.0	19.2	45.6	26.4	9.8	26.0	9.5	- 14.96

Mean f = -14.7 cm

Archimedes set the Roman fleet on fire by means of an arrangement of mirrors and lenses.

In this focal length of convex lens experiment, take a graph paper, graphically construct the ray diagram, measure p & q and find f.

Experiment No. 16(a):

To determine the focal length of a concave lens by using a concave mirror.

Apparatus:

Concave lens, concave mirror, three uprights, meter rod, knitting needle.

Theoretical Background:

A concave lens is a diverging lens. In this lens the rays diverge after passing through it. So looking the image is difficult. We use such device, which makes the rays converging, so that we can see the image. For looking the image, we can use concave mirror or convex lens to make the rays converging.

Procedure:

1) *Find the approximate focal length of the concave mirror.*
2) *Mount the mirror and the parallax needle on the uprights. Remove the parallax between the needle and its inverted image. Now the needle will be at C.*
3) *Place the concave lens between the mirror and object needle without changing the position of mirror. Now again remove the parallax.*
4) *Note the positions of object needle, lens and mirror after removing the parallax.*
5) *Repeat twice by changing the positions of the lens.*
6) *Measure the length of knitting needle and find index corrections for the mirror and the lens by filling the lines above the table.*
7) *Taking 'p' positive and 'q' negative, apply formula and calculate the focal length.*

Precautions:

1. The concave mirror should be of small focal length.
2. The mirror position should be kept same.
3. Parallax should be removed carefully.

Sources of Error:

1. The position of the mirror might be changed during the experiment.
2. Parallax might not be removed tip to tip.
3. Principal axis of the mirror might not be parallel to the optical surface.

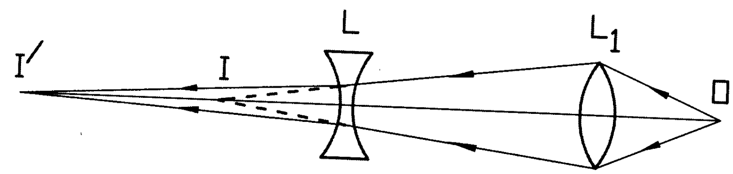
Viva Voce:

Q.1 *What is the nature of image formed by concave lens?*
Ans. It is virtual, erect and diminished in size.
Q.2 *How you define the power of a lens?*
Ans. It is the reciprocal of the focal length of a lens.
Q.3 *Why should the focal length of a concave mirror be short?*
Ans. To keep the combination of lens and mirror convergent over certain range.

Date..........

Expt: Focal length of concave lens by convex lens.

Experimental Illustration:



Observations and Calculations:

Approximate focal length of convex lens = F = 20 cm
Length of knitting needle = x = 30 cm
Distance between concave lens and image needle = y = 30.4 cm
Index correction for p = $x - y$ = - 0.3 cm
Index correction for q = $x - z$ = - 0.4 cm

No. of obs.	Position of Needle at O	Position of Convex lens L_1	Position of Concave lens L	Needle at I	Needle at I′	Observed p′ LI	Observed q′ LI′	Corrected p	Corrected q	$f = \frac{p\,x\,q}{p+(-q)}$
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
1	28.5	18.9	34.7	44.3	60.1	9.6	25.4	9.3	25.0	- 14.8
2	28.0	18.7	33.8	43.1	58.2	9.3	24.4	9.0	24.0	- 14.4
3	29.0	19.2	35.8	45.6	62.2	9.8	26.4	9.5	26.0	-14.96

Mean f = -14.7 cm

Take your own readings. Borrowed plumes are weak for flying.

1. Find focal length of a concave lens using a prism.
2. Take luminous object. Put screen instead of direct looking for image. Calculate focal length of concave lens.

Experiment No. 16(b):

To determine the focal length of a concave lens by using a convex lens.

Apparatus:

Concave lens, convex lens, three uprights, meter rod, knitting needle.

Procedure:

1) *Find the approximate focal length of the convex lens.*
2) *Place the object needle O beyond the focus of the convex lens.*
3) *On the other side of the lens, place the image needle beyond 2F.*
4) *Remove the parallax between the object needle and image needle. . Note the position I of the image needle.*
5) *Place concave lens between lens and image needle delicately.*
6) *Again remove the parallax to locate the new position I' and note it.*
8) *Find index correction for the image and object distances by filling the lines above the table. Fill all the columns of the table.*
9) *Calculate the mean focal length from the formula.*

Precautions:

1. Positions of O and I should remain unchanged when position of L is adjusted.
2. A concave lens of shorter focal length is preferred.
3. The aperture of the concave lens should be large.

Sources of Error:

1. The aperture of the concave lens might not be somewhat large.
2. The position of the uprights might not be read up to in millimeters.
3. The convex lens and the concave lens might not be formed a suitable combination to give undistorted inverted image.

Viva Voce:

Q.1 *What is the difference between convex lens and concave lens?*

Ans. Convex lens is thicker in the center and thinner at the edges, but concave lens is thinner in the center and thicker at the edges.

Q.2 *Why is parallax not removed over the whole aperture of the lens?*

Ans. The parallax is not removed over the whole aperture of the lens because of spherical aberration it is not possible.

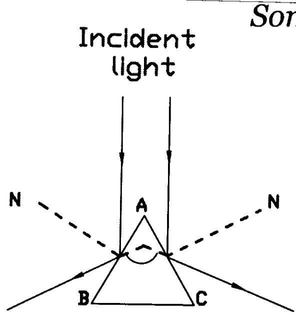
Q.3 *What type of image is formed by convex lens and concave lens?*

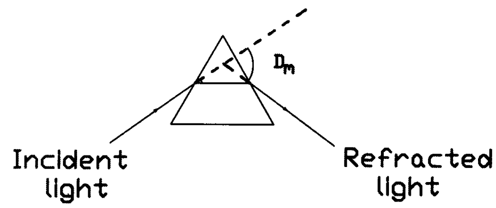
Ans. Convex lens forms a real image except object lies within its focal length, and concave lens always forms a virtual image.

Date...........

Expt: Refractive index of the material by spectrometer.

Some experimental details:





Observations and Calculations:

Least count of the spectrometer = 1.5 cm

Table for angle of the prism A:

No. of obs.	Telescope reading		Difference = 2A	Angle A
	Left	Right		
1	6°16′00″	66°15′30″	59°59′30″	29°59′45″
2	10°18′30″	70°19′00″	60°00′30″	30°00′15″
3	7°14′00″	67°14′30″	60°00′30″	30°00′15″

Mean angle of the prism A = 60° 00′ 05″ = 60°

Table for the angle of Minimum Deviation, D_m :

No. of obs.	Min. Deviation reading	Direct reading	Difference = D_m
1	70°11′30″	30°33′00″	39°38′30″
2	75°12′00″	35°14′30″	39°57′30″
3	73°11′30″	33°21′00″	39°50′30″

Mean D_m = 39° 48′ 30″
= 39.81°

$$\text{Index of refraction} = \frac{\sin (A + D_m) / 2}{\sin A/2} = \frac{\sin(60 + 39.81)/2}{\sin (60/2)} = 1.53$$

Your eyes open more in the dark than in the light!

Mount a metal stick nearly 5 m away. Put steam-producing water in between your eyes and the object. <u>Look that twinkling object</u>, looking like stars at night. It is due to refraction of light from heated layer of air.

Experiment No. 17(a):

To find the refractive index of the material of a prism using spectrometer.

Apparatus:

Spectrometer, glass prism and sodium light arrangement.

Procedure:

1) *Take the spectrometer in open window, focus the telescope for infinity, also focus the cross wires.*
2) *Place the spectrometer in front of sodium light. Adjust collimator.*
3) *Make the collimator and telescope in line. Adjust slit image.*
4) *Place the prism on the turntable so that edge 'A' towards collimator and light falls on both of the faces of the prism.*
5) *Move the telescope away. Adjust the image with naked eye so that you can look for clear and aligned image on both sides.*
6) *Turn the telescope. See and note the readings from both sides.*
7) *For angle of minimum deviation, place the prism on the table with its edge towards left so that light falls on its one of the face AB. Look for emergent rays through face AC.*
8) *Rotate the table so as the image moves in one direction, stops just as it appears to turn back. Note this reading.*
9) *Remove the prism. Bring the telescope in line with collimator. Note direct reading.*
10) *Complete the tables and calculate index of refraction.*

Precautions:

1. The slit should be narrow and fine.
2. Firstly the telescope should be set for infinity.
3. Do not touch the sides of the prism; instead handle it from the top or bottom of the prism.

Viva Voce:

Q.1 *Upon which factors the critical angle depends?*

Ans. It depends upon; i) the nature of the material of prism, and
ii) nature of the other medium.

Q.2 *What is angle of deviation and minimum deviation?*

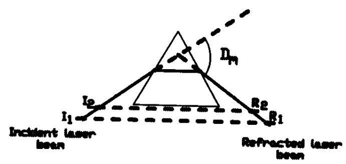
Ans. Angle of deviation is the angle between incident ray and emergent ray. When light passes symmetrically through the prism, its value is minimum.

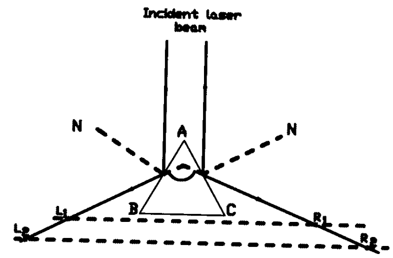
Q.3 *What is deviation of light?*

Ans. When light enters from one medium into another medium of different density, it changes its path, which is called deviation.

Date………..

Expt: Refractive index of the material by laser.





Observations and Calculations:

Table for angle of the prism A:

Laser pointer at				From geometry of the figure	Angle of prism
Left side		Right side			
L_1	L_2	R_1	R_2	2A	A
cm	cm	cm	cm	Degrees	Degrees
22.5	27.3	49.5	61.3	30.01	60.0

A = 60.0°

Table for the angle of Minimum Deviation, D_m :

Laser pointer at				From geometry of the figure
Incident light		Refracted light		
I_1	I_2	R_1	R_2	D_m
cm	cm	cm	cm	Degrees
42.4	37.3	77.1	65.2	39.5

$D_m = 39.5°$

$$\text{Index of refraction} = \frac{\sin (A + D_m)/2}{\sin A/2} = \frac{\sin(60 + 39.5)/2}{\sin (60/2)} = 1.52$$

Thoughtful question: How rainbow is formed in the sky after raining?

With a prism take different values of angle of incidence and angle of deviation. Plot a graph between them. Find angle of minimum deviation from the graph.

Experiment No. 17(b):

To find the refractive index of the material of a prism using a laser.

Apparatus:

Glass prism, laser source, half metre rod, protector.

Theoretical Base:

When a ray of light passes from rarer (air) medium to denser (glass prism) medium, it bends towards the normal. This is called refraction.

According to Snell's Law; refractive index = n = $\frac{\sin (A + D_m) / 2}{\sin A /2}$

where A = Angle of prism, D_m = Angle of minimum deviation

Procedure:

1) *Take the laser source and adjust its pointer.*
2) *Place the prism on the turntable so that edge 'A' towards the laser light such that the laser light falls on both of the faces of the prism.*
3) *Adjust the ray both sides, as shown in the figure.*
4) *Place the screen at the position L_1 R_1 and look for the refracted light spots. Note their positions.*
5) *Now place the screen at the position L_2 R_2 and look for the refracted light spots. Note their positions.*
6) *For angle of minimum deviation, place the prism on the table with its edge towards left so that laser light falls on its one of the face AB. Look for emergent rays through face AC.*
8) *Rotate table so as the ray moves in one direction, stops just as it appears to turn back. Note readings by placing a screen at the two positions I_1 R_1 and I_2 R_2.*
9) *Remove the prism. Do the geometrical work as in the figure.*
10) *Complete the table and calculate index of refraction.*

Precautions:

1. Do not look directly on the laser light.
2. Use sharp pointed laser light.
3. Clean sides of the prism before using it.

Viva Voce:

Q.1 *What acronym LASER stands for?*

Ans. Light Amplification by the Stimulated Emission of Radiation.

Q.2 *In lab why laser is preferable to sodium light?*

Ans. We can perform the experiment without having a dark room.

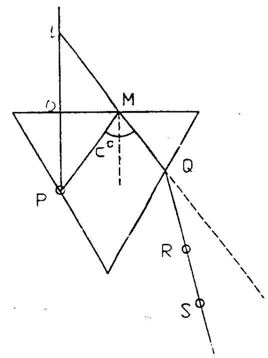
Q.3 *Do all holograms need laser light to give an image?*

Ans. No. Some holograms work using reflected daylight.

Date...........

Expt: Critical angle for glass using prism.

Geometrical work for finding critical angle with the prism:



Observations and Calculations:

No. of obs.	∠ PMQ degrees	Critical Angle = ½ ∠ PMQ degrees
1	81	40.5
2	79	39.5
3	80	40

Mean critical angle = C = 40°

Refractive index of glass = n = 1/sinC = 1/ sin40 = 1.5

Science knows only one commandment—contribute to Science.

1. **Determine the refractive index of glass slab using a traveling microscope.**
2. **Make such arrangements, to calculate refractive index of water.**

Experiment No. 18:

To find the refractive index of the material of a prism by critical angle method.

Apparatus:

Prism, pins, drawing board, paper sheet, set square, Dee, half-meter rod.

Procedure:

1) *Fix a sheet of paper on a drawing board. Place a prism with its base BC away. Draw its boundary ABC.*
2) *Remove the prism. Fix pin P in the middle of line AB.*
3) *Replace the prism on its boundary, such that the pin P just touches the face AB.*
4) *Look through the face AC with the eyes near C. Move the eyes towards A. fix pins at R and S in line with the image of P when it becomes just faint.*
5) *Remove the prism and the pins. Encircle the pin's points.*
6) *Draw a straight line through R and S up to Q.*
7) *From P draw PO perpendicular to BC and produce it to L to make PO = OL. Join L to Q, cutting BC at M.*
8) *Join PM and mark the path of the rays.*
9) *Measure the angle PMQ. Half of $\angle$ PMQ is the critical angle.*
10) *Calculate refractive index from the formula.*

Precautions:

1. The prism with clear faces should be used.
2. The pins should be vertical and well apart.
3. The pin P should touch the face of the prism.

Sources of Error:

1. The point where image of the pin disappears might not be located exactly during fixing of the pins.
2. Error due to thickness of the pins.
3. Error might be due to not fine geometrical work.

Viva Voce:

Q.1 *Why the pin P should touch the face of the prism?*

Ans. So that it may serve as an object lying in the glass.

Q.2 *Why OL is cut equal to OP?*

Ans. In this case, the image is at the same distance behind base BC as the object P is in front of it.

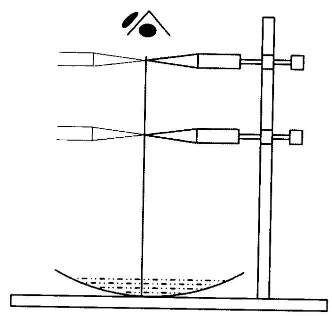
Q.3 *Does critical angle differ with colour of light?*

Ans. Yes. It is greater for red light and smaller for violet light.

Date...........

Expt: Refractive index of liquid by concave mirror.

Some experimental details:



Observations and Calculations:

Approximate focal length of the concave mirror = 25 cm

No. of obs.	Height of the needle above the liquid surface, after removing the parallax		$n = \frac{h_1}{h_2}$
	Without liquid, h_1	With liquid, h_2	
	cm	cm	
1	25.4	19.1	1.329
2	25.2	18.9	1.333
3	25.5	19.1	1.314

Mean refractive index of the liquid (water) = n = 1.325

Note: Mirror image is not up side down but it is left side right!

Differentiate between the images seen;
i) in the mirror, ii) on a screen through a lens,
iii) on a screen through a slide projector, iv) on a TV screen.
Try to shake hand with each of that image (if that is a man)!

Experiment No. 19:

To find the refractive index of a liquid, using a concave mirror.

Apparatus:

Concave mirror, tripod stand, needles, stand, plumb line & meter rod.

Theoretical Background:

In case of concave mirror, there is no parallax between the object and the image seen, as the rays strike the mirror normally and retraces its path back to form an inverted image just at the center of curvature.
When some liquid is put on the mirror, the ray no longer strikes normally due to refraction inside the liquid and no parallax position is disturbed. So we have to remove the parallax.
Formula is; refractive index of a liquid = n = real depth/ apparent depth

Procedure:

1) *Find the approximate focal length of the concave mirror.*
2) *Adjust the apparatus as shown in the figure.*
3) *Remove parallax between the needle and its image in such away that tip of the needle lies at the centre of curvature of the mirror.*
4) *Pour sufficient quantity of the liquid (water).*
5) *Measure vertical height from above the liquid surface to the tip of the needle with a plumb line.*
6) *Again remove the parallax, as the image seen through the liquid.*
7) *Measure the height as before.*
8) *Repeat twice. Calculate refractive index of the liquid.*

Precautions:

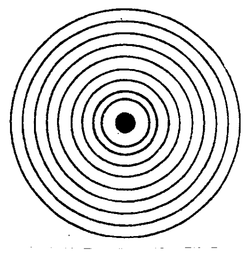
1. Mirror should be of large focal length.
2. The surface of the mirror should be cleansed with spirit.
3. To avoid distortion and high curvature, enough liquid should be used.

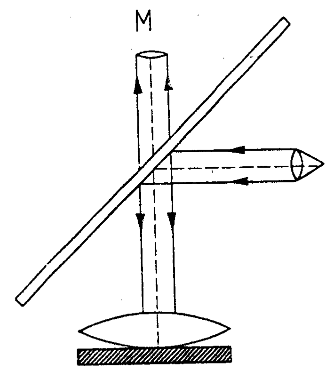
Viva Voce:

Q.1 *Why we use concave mirror of large radius of curvature?*
Ans. To adjust the approximation used in the formula.
Q.2 *Why we use* $n = CA/C'A$ *, instead the correct relation,* $n = CP/C'P$*?*
Ans. With large radius of curvature and small liquid depth, the ratio is nearly same; i.e. $CA/C'A = CP/C'P$
Q.3 *What is parallax method?*
Ans. The relative shift between object and image when eye is moved sideways.

Date...........

Expt: Wavelength of sodium light by Newton's rings.





Observations and Calculations:

Least count of spherometer = 0.01 mm
Mean distance between the two legs = l
Reading of spherometer on convex surface =
Reading of spherometer on plane surface =
Difference = h
Radius of curvature = R = $l^2/6h + h/2$ = 524 cm
Least count of the microscope = 0.005 cm
Eyepiece adjusted so that 100 scale division = 5 mm
∴ each division = x = .05 mm
eyepiece scale division = y

No. of obs.	Ring No.	Microscope reading		Diameter $y \times x$	Square of diameter	$\lambda = \dfrac{D_n^2 - D_m^2}{4(n-m)R}$
	N	Left	Right	mm	mm^2	(cm)
1	8^{th}	22	78	56x.05=2.8	7.84	$\dfrac{D_{10}^2 - D_8^2}{4(2)524} = 4222 \times 10^{-8}$
2	10^{th}	19	81	62x.05=3.1	9.61	$\dfrac{D_{12}^2 - D_{10}^2}{4(2)524} = 5128 \times 10^{-8}$
3	12^{th}	16	84	68x.05=3.4	11.56	$\dfrac{D_{14}^2 - D_{12}^2}{4(2)524} = 5081 \times 10^{-8}$
4	14^{th}	13	87	74x.05=3.7	13.69	

$$\text{Mean } \lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3} = 4810 \times 10^{-8} \text{ cm}$$

Actual value of $\lambda = 5896 \times 10^{-8}$ cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100 = \ldots\ldots \%$$

The rings are named after its discoverer, the great scientist once born in millenniums.

Put a prism at the curved surface of a Plano-convex lens. Throw monochromatic light on one side of the prism. Then look from other side broad and bright Newton's rings. Find λ of incident light as in the standard experiment.

Experiment No. 20:

To determine the wavelength of sodium light by Newton's rings.

Apparatus:

Newton's rings apparatus, sodium light, plane-convex lens, spherometer, traveling microscope, convex lens, and glass plate.

Theoretical Background:

The formula is; $$\lambda = \frac{D_n^2 - D_m^2}{4(n-m)R}$$

where D_n & D_m are the diameters of n^{th} & m^{th} rings seen through the microscope which are made by plano-convex lens

Procedure:

1) *Place plane-convex lens on the glass plate.*
2) *Adjust the beam of sodium light for 45° to focus on plane-convex lens.*
3) *Observe the concentric dark and bright rings through microscope.*
4) *Set the cross-wire at the end of (say) nth dark ring and note it.*
5) *Then read from the other end of diameter of the same ring.*
6) *Measure the diameters of twenty consecutive rings. Combine the first diameter with the eleventh, the second with twelfth, so on.*
7) *Find the radius of curvature R by filling the lines above table.*
8) *Complete all the columns of the table and the lines above the table.*

Precautions:

1. Allow the light to fall normally on the lens.
2. The surfaces of lens and glass plate should be cleansed with spirit.
3. Focus the microscope on the point of contact of lens and the plate.

Sources of Error:

1. The radius of curvature of the lens surface might not be measured exactly.
2. Light might not be incident on the lens normally.
3. Backslash error might be occurred during the screw movement.

Viva Voce:

Q.1 *What are Newton's rings?*

Ans. Circular rings produced by interference due to light reflected from an air film whose thickness increases uniformly.

Q.2 *What phenomenon do the Newton's rings illustrate?*

Ans. It illustrates the phenomenon of interference of light.

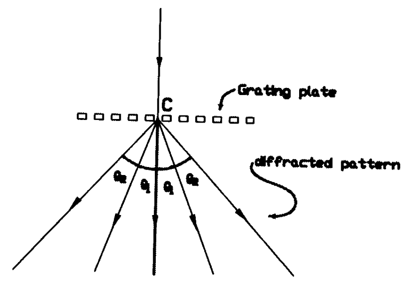
Q.3 *What type of fringes are obtained with white light?*

Ans. Coloured circular fringes.

Date...........

Expt: Wavelength of sodium light by diffraction grating.

Geometrical details of diffraction grating exp.



Observations and Calculations:

Least count of the spectrometer = 1.5 cm
No. of lines on the grating = n = 2400 line/inch
No. of lines per centimeter on the grating = n_l /2.54 = n
Grating element = d = 1/n = 2.54 /2400 = 1058 x 10^{-6}

No. of obs.	Order of spectrum	Telescope reading		Angle of diffraction			$\lambda = \frac{(a+b)\sin\theta}{n}$
		Right	Left				
	N	R	L	2θ = L - R	θ	Sin θ	cm
1	$I_{n=1}$	17°16'30"	23°51'00"	6°34'30"	3°17'15"	0.0573	6067 x 10^{-8}
2	$II_{n=2}$	13°55'30"	27°9'00"	13°13'30"	6°30'45"	0.1151	6091 x 10^{-8}

Mean λ = 6067 x 10^{-8} cm
Actual wavelength = 5890 x 10^{-8} cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{5890 - 6079}{5890} \times 100 = 3.2\ \%$$

Sometimes smaller things de-track straight paths, just like diffraction!

Take coarse gratings with a wide spacing. Look for 3rd order spectrum with sodium light. Find λ from the formula d sin θ = nλ. [No. of order possible depend on the width of the grating space. Sin θ cannot greater than 1, so maximum number of order possible cannot be greater than n, from nλ = d ·1, with wide spacing d, we can see 3rd or higher order.]

Experiment No. 21(a):

To determine the wavelength of sodium light by diffraction grating using spectrometer.

Apparatus:

Spectrometer, diffraction grating, sodium light arrangement.

Spectrometer:

A spectrometer consists of three major parts;

(1) Collimator: It is a tube with an adjustable slit at one end and a convex lens at the other. A screw can adjust the position of the slit.

(2) Telescope: It is an astronomical telescope with an eyepiece carrying a cross-section wire. It can be focused with a screw.

(3) Prism Table: It is a circular table of adjustable height and capable of rotation about a vertical axis.

Procedure:

1) *Take the spectrometer and focus for infinity,*
2) *Set the collimator for parallel rays. Make the telescope and collimator in line. Remove parallax between slit and cross-wire.*
3) *Make the image of the slit symmetrical with respect to cross-wire.*
4) *Mount the grating on its table and adjust it.*
5) *Move the telescope on extreme one side. Turn the table so that the grating becomes perpendicular to the collimator. Adjust the grating so that you can see first and second order spectrum from the naked eye.*
6) *Move the telescope for measuring firstly 1st order spectrum on both sides then for 2nd order spectrum. Note these readings.*
7) *Complete the lines above the table and all the columns of the table.*

Precautions:

1. The grating should be vertical.
2. The slit should be narrow.
3. When telescope is set for infinity, it should not be disturbed during expt.

Viva Voce:

Q.1 *What is a diffraction grating?*

Ans. It is a glass plate with several thousand equally spaced and parallel opaque lines ruled on it.

Q.2 *Why is the ruled surface of the grating away from the collimator?*

Ans. It is to avoid refraction after diffraction has taken place.

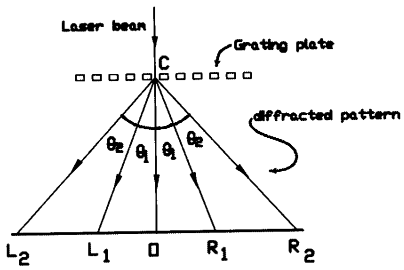
Q.3 *What is diffraction?*

Ans. It is bending of light around the edge of an opening or obstacle.

Date...........

Expt: Wavelength of laser light by diffraction grating.

Geometrical details of diffraction grating exp.



Observations and Calculations:

No. of lines on the grating = n = 2400 line/inch
No. of lines per centimeter on the grating = n_1 /2.54 = n
Grating element = d = 1/n = 2.54 /2400 = 1058 x 10^{-6}

No. of obs.	Order of spectrum	Distance			Angle of diffraction $\tan^{-1}$ OL / OC = θ_L & $\tan^{-1}$ OR / OC = θ_R				$\lambda = \frac{d \sin\theta}{n}$
		normal	Left	Right					
		OC	OL	OR	θ_L	θ_R	θ_{av}	sin θ_{av}	
	n	cm	cm	cm	degrees	degrees	degrees		cm
1	$I_{n=1}$	246.7	14.1	14.2	3.27°	3.29°	3.28°	0.057	6055 x 10^{-8}
2		257.3	16.5	16.4	3.67°	3.65°	3.66°	.064	6756 x 10^{-8}
1	$II_{n=2}$	243.2	28.0	27.9	6.57°	6.54°	6.56°	0.114	6041 x 10^{-8}
2		215.5	27.8	27.7	7.35°	7.32°	7.34°	0.128	6755 x 10^{-8}

Mean λ = 6402 x 10^{-8} cm
Actual wavelength = 6800 x 10^{-8} cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{(6800 - 6402)\ 10^{-8}}{6800 \times 10^{-8}} \times 100 = 5.8\ \%$$

Science is organized knowledge and wisdom is organized life.

Take a diffraction grating whose grating element is unknown. Pass laser light of known wavelength. Determine angle of diffraction. Calculate grating element: d = nλ /sinθ

Experiment No. 21(b):

To determine the wavelength of laser light by diffraction grating using a laser.

Apparatus:

Diffraction grating, laser source, metre rod, screen.

Theoretical Background:

A diffraction grating is a glass plate upon which are ruled a number of equally spaced lines. When light falls on it normally, the phenomenon of diffraction occurs. [The condition for diffraction is that, the opening (width of spacing) should be of the order of the wavelength of incident light.]

We define; grating element = d = $\dfrac{\text{Length of the grating}}{\text{No. of ruled lines on it}}$

Procedure:

1) *Take the laser source and adjust its pointer.*
2) *Mount the grating on its table and adjust the apparatus as in the figure.*
3) *Make transmitted ray symmetrical with respect to diffraction grating plate.*
4) *Turn the table so that the grating becomes perpendicular to the laser light.*
5) *Put a screen at a distance greater than 2 metres from the diffraction grating.*
6) *Adjust grating so that the rays of 1st & 2nd order spectrum can be seen on screen.*
7) *Look and note the readings on the screen for 1st and 2nd order spectrum.*
8) *Calculate the distances from the points taken and put them in the table.*
9) *Complete the lines above the table and all the columns of the table.*
10) *Calculate mean λ and % age error by comparing your value with actual value.*

Precautions:

1. Take large distance of measurement as compared to the angle.
2. Try to use measuring instrument of high resolving power.
3. The diffraction grating element should be comparable with the order of wavelength of laser light.

Viva Voce:

Q.1 *What is the difference between spectrometer reading and laser light reading?*

Ans. In spectrometer we <u>look through the telescope</u>, but in laser light <u>we look at the screen.</u>

Q.2 *Define laser light.*

Ans. A device which is able to produce a beam of radiation with unusual properties, generally the beam is, coherent monochromatic, parallel with high intensity.

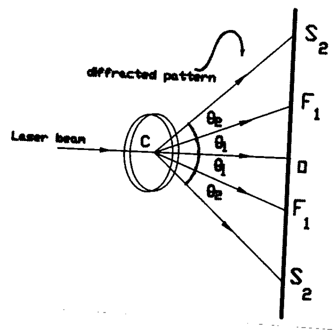
Q.3 *How lasers can be classified?*

Ans. There are three major kind: i) Solid laser, ii) Liquid laser & iii) Gas lasers.

Date...........

Expt: Diameter of a wire or hair using laser.

Geometrical details of diffraction grating exp.



Observations and Calculations:

Wave length of laser light = λ = 6800 x 10^{-8} cm

No. of obs.	Order of spectrum	Distance			Angle of diffraction $\tan^{-1}$ OF / OC = θ_1 & $\tan^{-1}$ OS / OC = θ_2				$d = \frac{n\lambda}{\sin\theta}$
		normal	First	Second					
		OC	OF	OF	θ_1	θ_1	θ_{av}	$\sin\theta_{av}$	
	n	cm	cm	cm	degrees	degrees	degrees		cm
1	$I_{n=1}$	230	3.1	3.1	0.77°	0.77°	0.77°	.0134	.0049
2		255	3.4	3.4	0.76	0.76	0.76	.0133	.0051
1	$II_{n=2}$	OC	OS	OS	θ_2	θ_2	θ_{av}	$\sin\theta_{av}$	.0050
		230	6.3	6.3	1.57°	1.57°	1.57°	.0274	
2		255	7.0	7.1	1.57	1.59	1.58	.0276	.0049

Mean d = = .004975 = 4975 x 10^{-6} cm

These readings are just for guideline; take your readings more precisely.

Construct a hole or slide wire whose width is such that through which diffraction of laser light is possible. Find λ for 1^{st} order spectrum.

Experiment No. 22:

To measure the diameter of a wire or hair using laser.

Apparatus:

Laser source, wire slide, stand, screen, metre rod.

Theoretical Background:

We measure large diameter (say of some hole) with metre rod or with a vernier calipers. Smaller one (of the order of millimeter), with a micrometer screw gauge. And for smaller than that, we use traveling microscope. When a diameter is comparable with the wavelength of light, we observe the phenomenon of diffraction. Then we can calculate the diameter, from the diffraction properties, by taking positions of 1^{st} or 2^{nd} order spectrum.

Procedure:

1) *Take the laser source and adjust its pointer.*
2) *Mount the wire slide on its table and adjust the apparatus as in the figure.*
3) *Make transmitted ray symmetrical with respect to wire slide.*
4) *Turn the table so that the wire slide becomes perpendicular to the laser light.*
5) *Adjust the wire grating so that the rays of first and second order spectrum can be seen on the screen.*
6) *Note the readings by looking the spots of first order and second order spectrum on the screen. And calculate the distances.*
7) *Complete all the columns of the table. And calculate mean diameter.*

Precautions:

1. The screen upon which laser light falls should be vertical.
2. Take reading of the spot of laser light from the center of the spot.
3. The laser light should be handle in such a way that horizontal beam should fall on the screen.

Viva Voce:

Q.1 *Why we should take long distances for measurement in case of laser light experiments?*

Ans. Because resolving power of the spots on the screen is less than the telescope readings.

Q.2 *What is laser principle?*

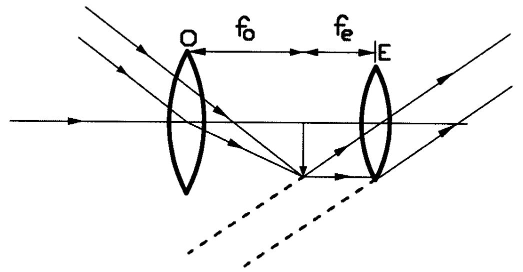
Ans. The light is produced in a process in which de-excitation of an atom is caused by incident photon with the emission of a second photon of the same energy, coherent with original photon.

Q.3 *How many wavelengths are contained in laser light?*

Ans. The laser light is monochromatic light.

Date...........

Expt: Setting up a telescope.



Observations and Calculations:

Approximate focal length objective $= F_o = 20$ cm

Approximate focal length eyepiece = $F_e = 10$ cm

Length of knitting needle = $l_1 = 30$ cm

Distance between two needles = $l_2 = 29.3$ cm

Index correction for the needles = $l_1 - l_2 = 0.7$ cm

No. of obs.	Positions of				$d = L_2 - L_1$	Distance, l (between O & I)		$f = (l^2 - d^2)/4l$
	Object needle	Image needle	Lens			Observed	Corrected	
	O	I	L_1	L_2		l'	l	
	cm	cm	cm	cm	cm	cm	cm	cm
Eye-piece	17.9	68.8	50	36.8	13.2	50.9	50.2	11.8
	19	68.9	50	40.5	9.5	49.9	49.2	12
	20	69.4	50	45.8	4.2	49.4	48.7	12.2
Obje-ctive	12	88.3	76	68.3	7.7	76.3	77.0	19.1
	6	79.3	72	61.2	10.8	73.3	74.0	18.1
	18	92.2	73	64.4	8.6	74.2	74.9	18.5

Mean focal lengths : $f_o = 18.6$ cm & $f_e = 12.0$ cm

Magnifying power of the telescope = $f_o / f_e = 1.55$

Length of the telescope = $f_o + f_e = 30.6$ cm

Galileo made his last astronomical discovery about moon from the telescope he made, before he was sentenced and got blind.

1. Make a telescope with three lenses so that an erect image can be seen (Terrestrial telescope).

2. Find magnifying power of a convex lens. Mount a ruler vertically. Place your eye 25cm apart. Place the convex lens close to your eye. Hold a second ruler behind the lens. Looking at the two rulers simultaneously, compare these scales.

[If 1 cm have same visual angle as 2cm, then magnification is 2]

Experiment No. 23:

Setting up a telescope and determination of its magnifying power and length.

Apparatus:

Two convex lenses, uprights, metre rod, parallax needles, knitting needle.

Theoretical Background:

A simple astronomical telescope consists of two convex lenses; an objective (of large focal length) and an eyepiece (of short focal length). The objective forms a real and inverted image of a far distant object. The eyepiece is adjusted so that the image formed should be at its focus. The eyepiece behaves as a magnifying glass, the image can be seen by placing the eye close to get final image at the least distance of distinct vision.

The magnifying power is, $M = \frac{f_o}{f_e} = \frac{\text{focal length of the objective}}{\text{focal length of the eyepiece}}$

Procedure:

1) *Select two lenses having one with short and other with long focal length.*
2) *Find approximate focal lengths of both lenses and fill lines above the table.*
3) *Find the correct focal lengths of objective lens (longer focal length), and the eyepiece lens (shorter focal length) and fill the tables.*
4) *Mount the objective and eyepiece on the lens holders and adjust their heights. Place an object needle far away (> $2f_o$) from the objective.*
5) *Place the parallax needle just beyond the focus f_o . Remove the parallax.*
6) *Place the eyepiece such that distance between needle and eyepiece is equal to f_e .*
7) *Adjust position of the eyepiece to get a clear image of the object needle tip.*
8) *Remove the object needle. Now adjust both lenses for the focus at infinity.*
9) *Measure the distance L between the objective and the eyepiece.*
10) *Calculate magnifying power of the telescope from the formula.*

Precautions:

1. The focal length of objective should be larger than the eyepiece.
2. The optical centers of both lenses should be along the same line.
3. The eye should be kept close to the eyepiece.

Viva Voce:

Q.1 *What is a telescope?*

Ans. An instrument for looking distant objects.

Q.2 *What is a magnifying glass?*

Ans. A convex lens of small focal length behaves as a simple microscope.

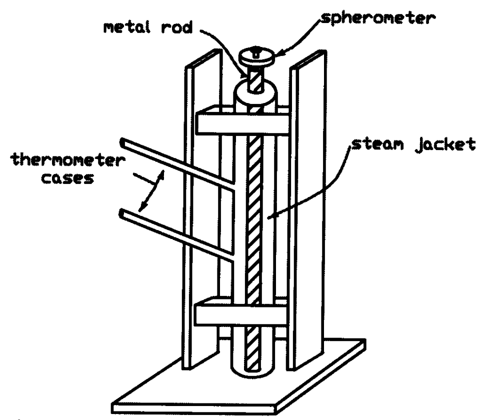
Q.3 *Define magnifying power of a telescope.*

Ans. Ratio of angle subtended by image at the eye as seen through the telescope to the angle of the object at the unaided eye, both lying at infinity.

Date...........

Expt: Linear expansion by Pullinger's App.

Pullinger's App:



Observations and Calculations:

Initial length of the rod = L = 100 cm
Initial temperature of the rod = t_1 = 32 °C
Final temperature of the rod = t_2 = 98 °C
Rise in temperature = $t_2 - t_1 = t$ = 66 °C
Pitch of the spherometer = 0.5 mm
No. of divisions of the circular scale = 100
Least count of the spherometer = 0.005 mm

Table for Spheromaeter:

No. of obs.	Initial reading (with cold water)	Final reading (when steam is passed)	Increase in length (Expansion)
	mm	mm	mm
1	1.45	1.56	0.11
2	1.25	1.37	0.12
3	1.35	1.47	0.12

Mean expansion = Δl = 0.1166 mm

Coefficient of linear expansion:

$$\alpha = \frac{\Delta l}{L \times \Delta t} = \frac{0.1166}{100 \times 66} = 17.66 \times 10^{-6} \ ^{\circ}C^{-1}$$

Correct value (for brass) = $19 \times 10^{-6}\ ^{\circ}C^{-1}$

Percentage error = 7.02 %

Every man's task is his life preserver.

Make a thermocouple (two metals joined together) and compare its bending for different temperatures.

Experiment No. 24:

To find the coefficient of linear expansion of the material of a rod by Pullinger's apparatus.

Apparatus:

Pullinger's apparatus, spherometer, two thermometers, boiler, rubber tubing, meter scale.

Theoretical Background:

We have: $\alpha = \Delta L / (L_o \times \Delta t)$,

where L_o = Length of rod, Δt = change in temperature,

ΔL = change in length of rod & α = coefficient of linear expansion.

Procedure:

1) *Measure the length of the rod and replace it in the frame.*
2) *Insert two thermometers into the two side tubes.*
3) *Pass the cold water through the tube jacket and note the initial thermometer readings. Take their mean value.*
4) *Place the spherometer on the glass plate with its central leg just touching the top end of the rod. Note the reading.*
5) *Pass steam through the tube. When temperature becomes steady, note final spherometer reading and the temperature. Repeat twice.*
6) *Complete the table and the lines. Calculate coefficient of linear expansion.*

Precautions:

1. The thermometer bulb should just touch the rod.
2. Temperature should be noted when it becomes steady.
3. Measurements should be made accurately.

Sources of Error:

1. The loss of heat due to radiation and convection cannot be avoided.
2. The temperature of the rod will be not be exactly same near the upper end.
3. Less time of heating might not be able to produce constant temperature throughout the rod.

Viva Voce:

Q.1 *What is coefficient of linear expansion?*

Ans. It is increase in unit length, when heated through 1 ^oC.

Q.2 *Why should the rod be supported on a heavy iron base?*

Ans. To ensure that the rod will expand upwards only.

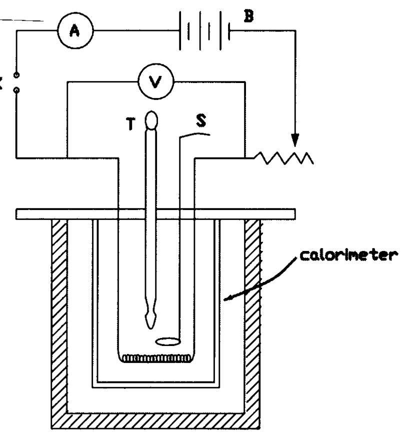
Q.3 *Is co-efficient of linear expansion same for all metals?*

Ans. No. It is different for different metals.

Date...........

Expt: 'J' by electrical method.

Joule's calorimeter:



Observations and Calculations:

Specific heat of copper calorimeter = c_1 = 0.095 cal/gm °C
Mass of calorimeter + stirrer = m_1 = 80 gm
Mass of calorimeter + stirrer + water = m_2 = 125 gm
Mass of water = $m_2 - m_1$ = m = 45 gm
Specific heat of water = c = 1.0 cal/gm °C
Initial temperature of water = T_1 = 29 °C
Final temperature of water = T_2 =34.5 °C
Rise in temperature = $\Delta T = T_2 - T_1$ = 5.5 °C
Current from ammeter = I = 1.0 amp
Voltage from voltmeter = V = 5.3 volts
Time for which current flows = t = 4 min = 240 sec

Mechanical equivalent of heat = $J = \dfrac{V I t}{(mc + m_1 c_1)\,\Delta T} = = \dfrac{5.3 x 1 x 240}{(45x1 + 80x0.095)\ 5.5}$

= 4.397 joules/cal
= 4.3×10^7 ergs/cal

Actual value = 4.2×10^7 ergs/cal

Percentage error = 4.7 %

Hello! Best of luck in your practical exams.

Calculate 'J' for A.C. voltage by taking an immersion rod.

Experiment No. 25:

To measure the mechanical equivalent of heat by electrical method.

Apparatus:

Joule's calorimeter, ammeter, voltmeter, thermometer, key, rheostat, stop clock, balance, weight box, battery, sand paper, connecting wires.

Theoretical Background:

We have: $J = W/Q$, where J is mechanical equivalent of heat,

Q = amount of heat gained by calorimeter and the liquid,

& $W = P \times t = V I t$ = electrical energy supplied in Joules.

Procedure:

1) *Weigh the calorimeter with stirrer.*
2) *Fill the calorimeter with water so that the resistance coil can easily immersed in it. Weigh again.*
3) *Make connections according to circuit diagram without battery with open key.*
4) *Insert a thermometer in the calorimeter. Note initial temperature.*
5) *First circuit to be checked by the teacher, then attaches the battery.*
6) *Close the key and at the same time start stop clock.*
7) *Check and note for smooth current and voltage.*
9) *Wait till the temperature rises 4 or 5 °C then stop the current and the stop clock.*
10) *Record all readings & calculate mechanical equivalent of heat 'J' from formula.*

Precautions:

1. A constant current should pass with adjustment of rheostat.
2. Coil should be covered completely with water.
3. Voltage applied should not exceed 10 volts to avoid electrolysis.

Sources of Error:

1. Radiation of heat cannot be avoided in this experiment.
2. Corrections might not be applied for ammeter and voltmeter readings.
3. The liquid might not be stirred uniformly during the experiment.

Viva Voce:

Q.1 *What is meant by J ?*

Ans. It is mechanical work done to produce one calorie of heat.

Q.2 *What type of heating coil should be used?*

Ans. Constantan, Manganin or Eureka wire.

Q.3 *What is Joules law in electricity?*

Ans. When a current flows in a conductor, heat produced in it is directly proportional to square of current and time for which current passes.

> 800 Objectives Questions

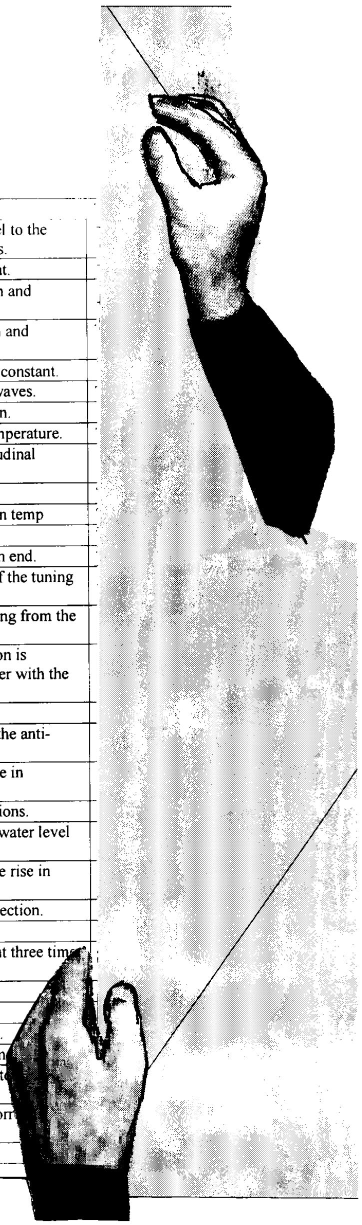
Types:

Type 1: Fill in the blanks
Type 2: Tick the correct Answer
Type 3: True and False Statements
Type 4: Short Ans. to Questions

Selection includes papers
from different Boards.

For best results:

***Cover the answers** and first think out answer.*
It doesn't matter, that may be wrong!
Afterwards uncover the paper
and look out the correct answer.



105

553	Sound waves are electromagnetic waves.
554	Waves in which the particles of the medium vibrate parallel to the direction of motion of waves are called longitudinal waves.
555	For waves along a string f ∝ 1/*l* if tension remains constant.
556	For the waves along a string f ∝ 1/√m provided the length and tension remain constant.
557	For the waves along a string f ∝ 1/√T provided the length and tension remain constant.
558	For waves along a string f ∝ √T provided length remains constant.
559	The waves produced in air column of tube are transverse waves.
560	The shift in the position of antinode is called end correction.
561	Velocity of sound decreases by 61 cm/s for 1 °C rise in temperature.
562	The waves produced in the air column of a tube are longitudinal stationary waves.
563	The velocity of sound increases with increase in pressure.
564	Velocity of sound increases by 6 cm/s for every 1 °C rise in temp
565	The open end of resonance tube behaves as node.
566	Vibrating tuning fork should be kept along the tube at open end.
567	At the position of resonance even the feeblest vibrations of the tuning fork produce sufficient loudness.
568	At resonance a sound of maximum loudness is heard coming from the resonance tube.
569	The length of resonating column for first resonance position is measured from open end of tube to lower meniscus of water with the help of setsquares.
570	Tuning fork should be struck with rubber briskly.
571	The top end of the resonance tube is the exact position of the anti-node of the stationary wave.
572	The velocity of sound decreases by 61 cm/sec for 1 °C rise in temperature.
573	End correction is not applied in using two resonance positions.
574	The length of resonating column is measured once, while water level is falling, secondly while water level is rising.
575	The speed of sound increases by 61 cm/sec for each degree rise in temperature of the medium..
576	The shift in the position of the anti-node is called end correction.
577	Resonance tube is used to find the wavelength.
578	The second resonance position should be expected at about three tim the length of the first resonance position.
579	The speed of sound in air at 0 °C is about 930 m/s.
580	The distance between two consecutive troughs is λ/4.
581	The open end of a resonance tube behaves as an anti-node.
582	The velocity of sound is affected by the density of medium
583	In resonance tube apparatus end correction is applied due t defect of tube.
584	Two resonance position method is more better than end corr method.
585	Sound waves are transverse waves

FILL IN THE BLANKS

MECHANICS

1	Graph between L and T is a ________	straight line
2	An instrument that can measure with an accuracy of one-hundredth of a millimeter is called a________	micrometer screw gauge
3	In vernier calipers scales are a)_____ , b) ________	vernier scale,main scale
4	Pitch is distance moved by circular scale in ______	one complete rotation
5	Smallest length measured by vernier calipers is ___	0.1mm
6	The zero error of a vernier calipers is positive when vernier scale lies on the ______________	right of the main scale zero
7	The instrument that can measure with an accuracy of 0.01 mm is called a___________.	micrometer screw gauge
8	Vernier constant = value of______division on main scale / _____no. of div. on vernier scale	smallest, total
9	The smallest length measured by micrometer screw gauge is ________	0.01mm
10	When the circular cap of the screw gauge is turned through one complete rotation the linear distance is called __________	pitch of the screw gauge
11	Least count of screw gauge is ___________	$\frac{\text{pitch of the screw}}{\text{No. of div. on circular scale}}$
12	An instrument which can measure the smallest length accurately, is called _________	Vernier calipers
13	Volume of cylinder of area A and length l is _____	$\pi A^2 \times l/4$
14	The volume of test tube is given as V = ________	$\pi r^2 l + 2/3\, \pi r^3$
15	Diameter of wire is 2 mm and its area of cross section is _____mm^2	3.14
16	A body which does not yield to a force, how large it may be, is called a ________.	rigid body
17	Surface area of a cylinder of length l and radius r is given by ______	$2\pi rl$
18	The components of a vector perpendicular to each other are called ___________	rectangular components
19	The name of the apparatus used to find the resultant of two vectors ____________	Gravesands apparatus
20	Two methods to add the vectors are a)_______ b) ______	a) graphical method, b) trigonometric method
21	Splitting of a single vector into its components is called __________	resolution of a vector
22	The rectangular components of a vector are _________to each other.	perpendicular
23	A single vector which has the same effect as the combined effect of all vectors is called ________	resultant vector
24	Parallel forces acting in same direction are_______	like parallel forces
25	Forces which are parallel to each other but act in opposite directions are called ____________	Unlike parallel forces
26	Two equal, parallel and unlike forces having different lines of action form a ________	couple

27	The product of force &moment arm is called _____	torque
28	The method of vector addition by their rectangular components is used to determine the ______vector.	resultant
29	A pair of equal unlike parallel forces acting on a body is called a _______.	couple
30	In S.I. unit the unit of force is ________	Newton
31	Torque is a ________ quantity.	vector
32	In SI units, the unit of torque is ___________	Newton-meter
33	Anticlockwise torque is taken as __________	positive
34	Clockwise torque is taken as _________	negative
35	A body is said to be in rotational equilibrium if algebraic sum of all the ______acting on it is zero.	torques
36	$\Sigma F = 0$, this condition deprives the body from __________	Second condition of equilibrium
37	When a body is at rest its equilibrium is called ___	Static equilibrium
38	When a body has uniform velocity, its equilibrium is called __________	dynamic equilibrium
39	Relation between time period and frequency is ___	$T = 1 / f$
40	Relation between real depth and apparent depth is __________	real depth /apparent depth
41	In SI units the value of 'g' is ________	$9.8\ m / S^2$
42	The weight of a body traveling upward in a sputnik with an acceleration equal to 'g' becomes ______of its actual weight.	twice
43	Simple pendulum time period is independent of __	mass
44	Time period is the time in which number of vibrations completed is _______	one.
45	Frequency is umber of vibrations completed in____	a unit time
46	A point where amplitude is minimum is called____.	Mean point
47	Position where amplitude is maximum is _______.	extreme position
48	Length of second's pendulum 0.995 m and its frequency _______	0.5 Hz.
49	The thread used in simple pendulum must be _____	fine
50	Formula for value of 'g' in free fall method is ____	$g = 32S / T^2$
51	Second's pendulum is that whose frequency is ____	0.5 Hz.
52	The time period of second's pendulum_______.	2 sec
53	A pendulum which completes its one vibration in two seconds is called ___________	second's pendulum
54	Time period of simple pendulum at the earth's center of is ________	infinity
55	Second's pendulum completes one vibration in ___	2 sec.
56	Formula for value of 'g' by simple pendulum____	$g = 4\pi^2 l / T^2$
57	What is the unit of stress ________	N / m^2
58	Within elastic limits stress is proportional______	to Strain
59	The spring constant K = _______	F / x
60	Elastic potential energy = _________	$\frac{1}{2} kx^2$
61	The limit after which an elastic body does not obey Hooke's law is called __________	elastic limit.
62	With the rise of temp. surface tension of water _____	decreases

WAVES & SOUND

63	Velocity of sound in air increases with increase___	in temperature
64	Velocity of sound in air for 1 ^{o}C rise of temperature increases by ______m/s.	0.61
65	The speed of wave v = ______	$f\lambda$
66	Formula for velocity of sound at room temperature applying end correction is, v_t = ________	$4f(l_1 + 0.3D)$
67	Velocity of sound in air at 0^o C is ______ m/sec	330
68	Velocity of sound at 0 C, $V_o = V_t -$ _______	61 t
69	The velocity of sound in a medium having elasticity E and density ρ is given by, V = _______	$\sqrt{E/\rho}$
70	Distance between two consecutive nodes is ______	$\lambda / 2$
71	Distance between two consecutive antinodes is ___	$\lambda / 2$
72	Velocity of sound at room temperature , V_t = _____	$V_o + 61$ t
73	Velocity of sound in air is ________of its pressure.	independent
74	The velocity of sound in a medium varies directly as the _______of the elasticity of the medium.	square root
75	Distance between two consecutive crusts called___	wavelength
76	Distance between two consecutive troughs is ____	wavelength
77	In _______waves, the particles of the medium vibrate at right angles to the direction of waves.	transverse
78	Distance between two successive troughs is_____	wavelength
79	The product of frequency and wavelength determines the _______of a wave.	velocity
80	In _________waves, the particles of the medium vibrate along the direction of waves.	longitudinal
81	When frequency increases, wavelength_______.	decreases
82	With the decrease of frequency the wavelength_____	increase
83	In sonometer _________waves are set up.	Stationary
84	The upper portion of the vibrating medium from the mean position is called_______.	crest
85	The particles of medium vibrate perpendicular to the propagation of wave in ________waves.	stationary
86	In resonance tube apparatus, we get sound due to the phenomenon of_____________	interference and resonance
87	The end correction applied in a resonance tube having internal diameter D cm is _______cm.	0.3D
88	In resonance tube app, the open end acts as ______	An antinode
89	Frequency of a vibrating body is reciprocal of______	its time period
90	The end correction to be applied in a resonance tube having internal diameter 3.5 cm is _____cm.	1.05
91	The marked increase in the amplitude of a vibrating body occurs due to ________	resonance
92	Type of vibrations set up in sonometer wire ______	Is forced vibrations
93	For a vibrating string, law of length is; $f \propto$ ______	$1 / l$
94	For a vibrating string, law of mass is; $f \propto$ _______	$\sqrt{1} / m$
95	For a vibrating string, law of tension is; $f \propto$ _______	$\sqrt{T}$
96	Types of waves produced in resonance tube are_____	longitudinal stationary

97	In law of length, f & l satisfy the condition, ______= constant	f x l
98	Distance between an antinode and node is _____	$\lambda / 4$
99	On loading tuning fork with wax its frequency____	decreases
100	Distance covered by the wave during the time of one vibration is ________	called wavelength
101	Antinode is point where amplitude is _____and strain is_______.	Maximum, minimum
102	The lower portion of vibrating medium from mean position is called________	trough
103	The points in a vibrating column where amplitude is zero but the strain is maximum are called ______	nodes.
104	Beats are produced due to______ of sound waves.	interference
105	In ripple tank when light falls on water waves, the crest acts as_______	convex lens
106	The points in a vibrating column where amplitude is maximum but strain is minimum are called ____	anti-nodes
107	Beats are produced due to ______of sound waves.	interference
108	Distance between two successive nodes in standing waves is equal to _______	$\lambda / 2$
109	The vibrations in which particles of medium vibrate parallel to the direction of wave are called_______.	longitudinal waves
110	The vibrations in which particles of the medium vibrate at right angle to the direction of wave are called_________.	transverse waves
111	If 'l' is the length of a stretched string which vibrates in one loop, then l = ________	$\lambda / 2$
112	Sound waves are (longitudinal/transverse) _______	longitudinal
113	Sound waves are _____(compress ional/transverse)	compress ional
114	Resonance tube apparatus is used to determine___.	velocity of sound
115	Sound reflected from an object is called _______.	Echo
116	________waves are longitudinal waves.	Sound
117	Water waves are________ in nature.	transverse

LIGHT

118	Focal length of a convex lens is equal to _____of its radius of curvature.	Half
119	The distance separating the principal focus and the optical center of a lens is called the__________.	focal length
120	The diameter of a lens is called its __________.	aperture
121	A point inside a lens through which rays of light can pass undeviated is called _________of lens.	optical center
122	For light incident at critical angle in water, the corresponding angle of refraction in air is ______.	90^{o}
123	Refractive index in terms of critical angle; μ = ____	1 / sin C
124	Light is a form of______	energy
125	A _____lens is thinner at center & thicker at edges.	concave
126	Refractive index in terms of A and D_m is given ___	$\mu = \frac{\sin (A + D_m/2)}{\sin A/2}$

127	Parts of spectrometer are, a)___, b)___, c) _______	Turntable, collimator, telescope
128	The ratio of the sine of angle of incidence to the sine of angle of refraction is called __________	refractive index
129	Critical angle is determined by relation sin C =___	$1/\mu$
130	________lens is used as objective in microscope.	Convex
131	Image is formed by the lens by phenomenon of___.	refraction
132	Angular magnification = _________	θ_I / θ_o
133	In a compound microscope the focal length of objective is _______than the eye piece.	smaller
134	Microscope consists of two lenses called ___and__	Objective, eyepiece
135	The type of lens which diverges a parallel beam of light is called a__________.	concave lens
136	Focal length of concave lens is taken as_________	negative
137	For all positions of the object, the image formed by a ________is virtual.	concave lens
138	The reciprocal of the focal length of a lens in meters is called__________	power of lens
139	Name the two defects of lenses, i)_____ii)_____	spherical aberration, chromatic aberration
140	If an object is placed within its focal length of a convex lens, the image formed will be _________	virtual and erect
141	Unit of power in SI units is _________	Dioptre
142	The power of concave lens is (positive/ negative)___	negative
143	The power of lens of focal length ___is one dioptre	1 m
144	_______of lens is reciprocal of focal length in m.	Power
145	A ray through _____of a lens emerges undeviated.	optical center
146	Light of single wavelength is called _________	monochromatic light
147	When light travels from rarer to denser medium, it bends_________ the normal.	towards
148	At minimum deviation the ray passes through the prism ________to its base.	parallel
149	Sodium light is the nearest approach to_____light.	monochromatic
150	Incidence angle for light in denser medium for which angle of refraction in rarer medium is 90° is called__	critical angle
151	Total internal reflection occurs only when light travels from a ______medium to a ______medium.	Denser, rarer
152	The apparent separation between two objects caused by the motion of the eye is called________	parallax
153	The difference between actual distance & observed distance of a needle from a lens is called______	index correction
154	Light consisting of seven colours is called _______	white light(sunlight)
155	Light of single wavelength is called ________light.	monochromatic
156	Sun light consists of_____________	seven colours
157	Light containing two wavelengths is called ______	dichromatic light
158	When sun light passes through a prism it suffers____	dispersion.
159	Bending of light from small obstacles is called_____	diffraction of light
160	Whether light waves are longitudinal/transverse_____	transverse.
161	The index of refraction have (units /no units)_______	no unit

HEAT

162	Thermometer is developed by ___________	Fahrenheit
163	The unit of specific heat is ___________	J /kg-K
164	Units of thermal conductivity in S.I. units are_____	J/m-S-^{o}C
165	S.I. units of heat is_________	Joule
166	Unit of coefficient of linear expansion is________	$^{o}C^{-1}$
167	In the Pullinger's Apparatus, length of rod is measured by__________	spherometer
168	A gas which strictly obeys the gas laws is known as__________	Ideal gas
169	Heat is a form of______which flows from higher to lower temperature.	Energy
170	Heat is transferred from molecule to molecule without leaving their mean position in_______	conduction
171	The heat energy involved in a change of state is called_________	Latent heat
172	Amount of heat required to raise the temperature of 1 kg of the substance through 1 ^{o}K is called ______	Specific heat
173	The specific heat of a substance depends on_______of the substance.	nature
174	If different liquids are allowed to cool under the similar conditions, then their rate of cooling will be_________	Equal
175	The method of mixture for finding the specific heat based on _________	Law of heat exchange
176	Increase in length of a body when heated is______	Linear thermal expansion
177	Boiling point of the water increases with_________in the pressure.	Increase
178	Newton's law of cooling is used in lab for finding specific heat of_______	Liquid
179	In Newton's law of cooling expt., rate of fall of temperatures of two liquids will be_____	Different
180	Newton's law of cooling is applicable only to_____	Liquids
181	In drawing cooling curves for water and kerosene, curve for the kerosene would be______than water.	Steeper
182	Mechanical equivalent of heat = __________	4.2 J
183	Specific heat of water is __________	4200J/kg-^{o}K
184	When current is passed in conductor, electrical energy converts into________	Heat energy
185	Amount of work required to produce one calorie of heat is called________	Mechanical equivalent of heat

TICK THE CORRECT ANSWER

MECHANICS

186	The x-component of 100 √3 N force acting at 30° with x-axis is:- a) 100N, b) 125√3 N, c) 150 N	**(c)**
187	The pitch of screw of a micrometer screw gauge is 0.5 mm and it has 50 divisions on its circular scale. The least count of the instrument is:- a) 0.01 mm, b) 0.05 mm, c) 0.5 mm	**(a)**
188	The smallest length a Vernier Calipers can measure is:- a) 1 mm, b) 0.1 mm, c) 0.01 mm	**(b)**
189	Diameter of a steel ball is measured by screw gauge, which one is correct; a) 1.92 mm, b) 1.9 mm, c)1.92 cm	**(a)**
190	In S.I. units torque is expressed in:- a) kg- m/s, b) N-m, c) dyne-cm	**(b)**
191	The base units of the SI system include those of; a) length, m, b) mass, kg, c) electric current, A	**(c)**
192	Which pair includes a scalar quantity and a vector quantity? a) potential energy & work, b) kinetic energy & momentum, c) weight & force	**(b)**
193	A mass accelerates uniformly when the resultant force acting on it; a) increases uniformly with time, b) is zero, c) is constant but not zero	**(c)**
194	When a force of 4 N acts on a body of mass 2 kg for 2 seconds, what is the rate of change of momentum? a) 4 kg m s^{-2} , b) 2 kg m^{-1} s^{-2} , c) 8 kg m^{-1} s^{-1}	**(a)**
195	The rate of change of momentum of a body falling freely under gravity is equal to its; a) weight, b) impulse, c) power	**(a)**
196	On the ground the gravitational force on a satellite is W. What is the gravitational force on the satellite when at a height R/ 50, R is radius of earth; a) 0.96 W, b) 1.00 W, c) 0.98 W	**(a)**
197	The uncertainty in *l* is 4% and that of T is 1%, using the formula of simple pendulum for finding '*g*', calculated value will be; a) 6%, b) 5%, c) 2%	**(a)**
198	Which quantity has different units from the other two? a) Young's modulus x area, b) rate of change of momentum, c) density x volume x velocity,	**(c)**
199	Both Newton and dyne are units of force where 1 Newton is equal to:- a) 10^2 dynes, b) 10^3 dynes, c) 10^5 dynes	**(c)**
200	Volume of a wire of radius r and length *l*, having uniform cross-section, is given by:- a) $\pi r^2 l$, b) 4/3 πr^3 , c) $4\pi r^2 l$	**(a)**
201	Torque is also called:- a) Couple, b) Moment of force, c) Moment of inertia	**(b)**
202	Rate of change of momentum is equal to:- a) work, b) force, c) impulse	**(b)**
203	Unit of work is:- a) Joule, b) watt, c) calorie	**(a)**
204	Greatest uncertainty in calculating Young's modulus leads from; a) measurement of length, b) measurement of diameter, c) measurement of extension	**(c)**

WAVES & SOUND

205	The distance between two consecutive nodes or anti-nodes in terms of wavelength is:- a) λ, b) 2λ, c) $\lambda/2$	(c)
206	The frequency of fundamental note of vibration of a stretched string is:- a) $f = 2l\sqrt{T/m}$, b) $f = (1/2l)\sqrt{m/T}$, c) $f = (1/2l)\sqrt{T/m}$	(c)
207	The frequency f and stretching force T in case of vibrating segment of a stretched string satisfy the condition:- a) $f/\sqrt{T}$ = const., b) $\sqrt{f} \times T$ = const. c) $f \times \sqrt{T}$ = const.	(a)
208	The time period of a simple pendulum depends upon:- a) Amplitude of vibration, b) Mass of the bob, c) Length	(c)
209	When temperature of air increases the velocity of sound:- a) increases, b) decreases, c) remain constant	(a)
210	For every 1° C rise in the temperature of air the velocity of sound increases by __________ m/s. a) 0.31, b) 0.61, c) 0.91	(b)
211	The length of the simple pendulum is directly proportional to the square of its_________ a) Amplitude, b) Mass, c) Time period	(c)
212	Due to increase in air pressure, the velocity of sound will _________ a) Increase, b) Decrease, c) Remain un-affected	(c)
213	______waves are longitudinal waves:- a) Water waves, b) Sound waves, c) Waves in a stretched string	(b)
214	For transverse waves set up in a stretched string, the law of mass is:- a) $f \propto m$, b) $f \propto 1/m$, c) $f \propto 1/\sqrt{m}$	(c)
215	Time period of a simple pendulum is independent of its:- a) amplitude, b) material of bob, c) Both the above	(c)
216	Time period of a simple pendulum is directly proportional to:- a) $\sqrt{g}$, b) $\sqrt{l}$, c) $\sqrt{1/l}$	(b)
217	In a simple pendulum experiment the graph between L and T^2 is:- a) curve, b) straight line, c) exponential	(b)
218	The velocity of sound in air at 0 °C in cm/s is given by:- a) $V_o = V_t + 61t$, b) $V_o = V_t - 61t$, c) $V_t = V_o - 61t$	(b)
219	The time period of a mechanical oscillator is given by:- a) $T = 2\pi\sqrt{x/k}$, b) $T = 2\pi\sqrt{m/g}$, c) $T = 2\pi\sqrt{m/k}$	(c)
220	Crests and troughs are formed in:- a) longitudinal waves, b) transverse waves, c) stationary waves	(b)
221	Wavelength is given by:- a) $\lambda = fv$, b) $\lambda = v/f$, c) $\lambda = f/v$	(b)
222	Change in velocity of sound depends upon:- a) volume, b) pressure, c) temperature	(c)
223	A particle performs simple harmonic motion of amplitude 0.020 m and frequency 2.5 Hz. What is its maximum speed? a) 0.314 m s^{-1}, b) 0.157 m s^{-1}, c) 0.125 m s^{-1}	(a)
224	The acceleration of free fall on the moon is $1/6^{th}$ that of Earth. What will be T on Moon of a simple pendulum whose value on Earth is 1 s; a) $1/\sqrt{6}$ s, b) 1/ 6 s, c) $\sqrt{6}$ s	(a)
225	A body performing SHM has x = 30 sin 50 t, t is in sec. The frequency is ; a) 20 Hz, b) 8.0 Hz, c) 0.13 Hz	(b)
226	A body moves with SHM and makes a complete oscillations in one second. The angular frequency is; a) 2 n rad s^{-1}, b) 2π n rad s^{-1}, c) $2\pi/$ n rad s^{-1}	(b)

227	A stretched wire with clamped ends has a fundamental frequency of 1000 Hz. What will be the new fundamental frequency if tension in wire is increased by 2 % ? a) 1010 Hz, b) 1040 Hz, c) 1020 Hz	(a)
228	A resonance tube is filled with water. A small sound source of constant frequency is held a little above the open upper end and water is run out from lower end. A number of resonance positions are detected. The first of these occurs when the water surface is 7 cm below the top of the tube and another occurs at 39 cm. At which of the following distances should resonance also be detected? a) 15 cm, b) 31 cm, c) 23 cm	(c)
229	A wire is stretched over two supports, a distance 4x apart. Three paper riders rest on the wire. When the wire is made to vibrate at a particular frequency, the middle rider stays on, but the others fall off the wire. What is λ produced on wire? a) 2x, b) 3x, c) 4x	(c)
230	In a resonance tube, first two resonances occur when the air column lengths are 0.14 m and 0.46 m. What is λ of sound waves? a) 0.56 m, b) 0.60 m, c) 0.64 m	(c)

LIGHT

231	A lens having one side plane and the other side convex is called a:- a) Plano-convex lens, b) concave lens, c) convex lens	(a)
232	A _______ of short focal length acts as an objective in a compound microscope:- a) concave mirror, b) convex mirror, c) convex lens	(c)
233	If the critical angle for a refracting medium is 42^{o} , its refractive index is:- a) 1.36, b) 1.49, c) 1.66	(b)
234	The power of a lens of focal length 50 cm is:- a) 1 diopter, b) 2 diopter, c) 2.5 diopter	(b)
235	When a single convex lens is placed close to eye, then it acts as:- a) telescope, b) compound microscope, c) simple microscope	(c)
236	Image of distant object as seen through astronomical telescope is:- a) real and inverted, b) virtual and inverted, c) real and erect	(b)
237	If f is the focal length of a lens, then:- a) 1/f = powers, 1/f = dioptre, c) 1/ $\sqrt{f}$ = power	(a)
238	A concave mirror is used to form an image of the Sun on a white screen. If the lower half of the mirror were covered with an opaque card, the effect on the image on the screen would be; a) to prevent the image from being focused, b) to make upper half of the image disappear, c) to make the image less bright than before,	(c)
239	A single converging lens is held close to the eye for use as a magnifying glass. For maximum magnifying power, the lens must be positioned so that; a) the image is in the focal plane of the lens, b) the image is at the near point of the eye, c) the object is just beyond the principal focus of the lens	(b)
240	Having monochromatic red light each of duration 2.5 n S. the number of wavelengths in each pulse is; a) 10^{4}, b) 10^{6}, c) 10^{3}	(b)
241	Monochromatic light falls on a diffraction grating. If θ is angle for 2^{nd} order spectrum, then $\sin\theta$ will be; a) $2\lambda/d$, b) λ/d, c) $2d/\lambda$	(a)

242	In a spectrometer experiment, monochromatic light falls on a diffraction grating having 4.5 x 10^5 lines per meter. The 2^{nd} order line is seen at an angle 30^o with normal. The λ is; a) 589 nm, b) 556 nm, c) 430 nm	**(b)**
243	Light having wavelength λ is incident normally on a diffraction grating for which fringe spacing is equal to 3λ. What will be sine of the angle between 2^{nd} order maximum and the normal; a) 3/2, b) 2/3, c) 1/3	**(b)**
244	Which effect provides direct experimental evidence that light is a transverse, rather than a longitudinal, wave motion? a) light can be diffracted, b) light can be polarized, c) coherent light waves can made to interfere	**(b)**
245	A diffraction grating has a spacing of 16 x 10^{-6} m. a beam of light is incident normally on the grating. The first order maximum makes an angle of 20^o with the undeviated beam. What is λ for incident light? a) 270 nm, b) 550 nm, 270 nm	**(b)**
246	Light of wavelength 600 nm falls on a pair of slits, forming fringes 3.0 nm apart on a screen. What is fringe spacing when λ = 300 nm is used and slit separation is halved. a) 1.5 nm, b) 6.0 nm, c) 3.0 nm	**(c)**
247	A microscope and a telescope each consist of two converging lenses. In which one of the following ways is the telescope similar to the microscope when both are in normal adjustment? a) each produces an intermediate image which is magnified and inverted, b) in each the final image is inverted and virtual, c) each has a long focal length objective lens.	**(b)**

HEAT

248	What is the SI unit for thermal conductivity? a) $Wm^{-1}\ K^{-1}$, b) $Wm^{-2}\ K^{-1}$, c) $Wm^{-1}\ K^{-2}$	**(a)**
249	What are the dimensions of thermal conductivity? a) $M\ L\ T^{-2}\ \theta^{-1}$, b) $M\ L^{-1}\ T^{-2}\ \theta^{-1}$, c) $M\ L\ T^{-1}\ \theta^{-1}$,	**(c)**
250	What are the base units of specific heat capacity? a) $m^2\ s^{-2}\ K^{-1}$, a) $m^2\ s^{-1}\ K^{-1}$, a) $m\ s^{-2}\ K^{-1}$	**(a)**
251	Which quantity must be the same for two bodies if they are to be in thermal equilibrium? a) temperature, b) internal energy, c) mass	**(a)**
252	The thermal conductivity of copper decreases significantly as the temperature is increased. This is because, at higher temperatures; a) lattice vibrations travel more slowly, b) ionic forces between copper atoms decrease, c) the rate of collision between conduction electrons and copper atoms increases	**(c)**
253	Thermal conduction in metals differs from thermal conduction in insulators. The reason for this is that, in metals, heat can be transported by; a) lattice vibrations, b) electrons, c) positive ions	**(b)**

TRUE/FALSE STATEMENTS

MECHANICS

254	The positive zero error is always added in observed reading.	True/False ✓
255	If zero error is positive then the zero correction is also positive.	True/False ✓
256	The negative zero error is subtracted from observed reading.	True/False ✓
257	Measurement of smaller distances involves large %age of error.	True/False ✓
258	Name of person who invented vernier calipers is Archimedes.	True/False ✓
259	Vernier calipers is called so as it was invented by Vernier.	✓ True/False
260	In vernier calipers 10 vernier divisions are equivalent to 9 main scale divisions. If the main scale is graduated in 0.1 inch, the vernier constant becomes 0.01 inch.	✓ True/False
261	25 vernier divisions are found to be equal to 24 main scale divisions. 1 inch is divided into 20 such main scale divisions. The least count of the vernier is 0.02 inch.	✓ True/False
261	The vernier calipers is based on the principle that the graduation of main scale and vernier scale are identical.	True/False ✓
263	The least count of a vernier calipers is one millimeter.	True/False ✓
264	The graduations of the main scale are identical with the graduations of vernier scale.	True/False ✓
265	In general (n - 1) divisions of vernier scale cover a length equal to n division of main scale	True/False ✓
266	If n vernier divisions are equivalent to (n – 1) main scale divisions, the vernier constant is nth part of a main scale division.	✓ True/False
267	Vernier calipers is used to measure accurately a length of 10^{-1} mm.	✓ True/False
268	For measurement of external diameter of a pipe, lower jaws of vernier calipers are used.	✓ True/False
269	The movable jaw of the vernier calipers carriers a sliding strip along the back of the main scale. This strip is used to measure the depth of a hollow body.	✓ True/False
270	There is no difference between accurate and precise measurements.	True/False ✓
271	Spherometer is a modification of screw gauge.	True/False ✓
272	Spherometer works on same principle as , micrometer screw gauge.	✓ True/False
273	The error introduced on reversing the direction of rotation of screw is called back lash error.	✓ True/False
274	Spherometer is a device to measure thickness of thin plates and radii of curvature of spherical surfaces.	✓ True/False
275	One vernier division is equal to 1 mm.	True/False ✓
276	Vernier calipers have zero error, if zero of main scale does not coincides with zero of vernier scale, when lower jaws are in contact.	✓ True/False
277	When the jaws of the vernier calipers are placed in contact and the vernier zero is in advance of the main scale zero, then the instrumental error is positive.	✓ True/False
278	When the jaws of the vernier calipers are placed in contact and the vernier zero is behind that of the main scale , then the instrumental error is negative.	✓ True/False
279	When jaws of the vernier calipers are placed in contact and the vernier zero exactly coincides with the main scale zero, there is zero error.	True/False ✓
280	If No. of divisions on vernier scale is 50 then, least count is 0.02 mm.	✓ True/False

281	The backlash error is avoided if the screw, before taking any reading is always turned in the same direction.	✓ True/False
282	Least count of a screw gauge is one thousandth of a centimeter.	✓ True/False
283	The vernier scale of micrometer screw gauge is linear.	True/False ✓
284	If the zero error is negative then the zero correction is positive.	✓ True/False
285	The pitch of a screw gauge is equal to its least count.	True/False ✓
286	For each complete turn, the screw advances through a fixed distance called the pitch of screw gauge.	✓ True/False
287	The formula for the capacity of a test tube is πr^2 (h – r/3)	True/False ✓
288	$M L^2 T^2$ I think this quantity is a force.	True/False ✓
289	One cent is equal to 10^{-2}	True/False ✓
290	One deca is equal to 10^{-2}	True/False ✓
291	One atto is equal to 10^{-16}	True/False ✓
292	The least count of vernier calipers is one centimeter.	True/False ✓
293	One femto is equal to 10^{-5}	True/False ✓
294	One hector is equal to 10^2	✓ True/False
295	One nano is equal to 10^9	True/False ✓
296	One micro is equal to 10^6	True/False ✓
297	One pico is equal to 10^{+12}	True/False ✓
298	One mega is equal to 10^{-6}	True/False ✓
299	One centi is equal to 10^{-3}	True/False ✓
300	One kilo is equal to 10^{-3}	True/False ✓
301	One giga is equal to 10^{-9}	True/False ✓
302	One femto is equal to 10^{15}	True/False ✓
303	The vernier constant of a vernier calipers is $1/10^{th}$ a millimeter.	✓ True/False
304	A meter rod is more rigid breadth-wise.	True/False ✓
305	If zero error is negative then the zero correction is also negative.	True/False ✓
306	If zero of circular scale advances beyond zero of pitch scale, the zero error is negative.	✓ True/False
307	If the zero error is positive then the zero correction is negative.	✓ True/False
308	The least count of a vernier calipers is one hundredth of a centimeter	✓ True/False
309	The difference between one main scale division and one vernier scale division is called vernier constant of vernier calipers.	✓ True/False
310	The minimum reading on the main scale of a screw gauge is one mm .	✓ True/False
311	Vernier calipers is said to have positive error if zero of vernier is right of zero of main scale, when lower jaws are in contact.	✓ True/False
312	A meter rod is more rigid edge-wise.	✓ True/False
313	Screw gauge is used to fined length.	True/False ✓
314	Vernier calipers is used to find length.	✓ True/False
315	Vernier calipers is used to find force.	True/False ✓
316	Least count of a scale is zero.	True/False ✓
317	Upper pair of jaws are used to measure external diameter of cylinder.	True/False ✓
318	In Gravesand's apparatus preferably heavy weights are suspended	✓ True/False
319	The volume of a solid cylinder is given by $\pi^2 R l$	True/False ✓
320	Capacity of test tube is determined by the formula $\pi^2 r^2$ (h – r/3)	True/False ✓
321	The oil should be applied to the pulleys of Gravesand's apparatus to minimize the friction.	✓ True/False

322	To make impressions of forces in Gravesand's apparatus, we only need a pencil.	True/False ✔
323	On paper sheet representative lines on suitable scale are drawn.	✔ True/False
324	Resultant vector is determined by simple addition of vectors.	✔ True/False
325	Momentum is a scalar quantity.	True/False ✔
326	The total momentum of an isolated system of bodies remains constant. This is statement of law of conservation of momentum.	✔ True/False
327	In inelastic collision of bodies, kinetic energy of system is conserved.	True/False ✔
328	The volume of a solid cylinder is $4\pi^3 r^3$	True/False ✔
329	Independent variable is taken along X-axis	✔ True/False
330	Independent variable is taken along Y-axis	True/False ✔
331	Dependent variable is taken along X-axis	True/False ✔
332	Dependent variable is taken along Y-axis	✔ True/False
333	In Gravesand's apparatus the force of friction is main source of error.	✔ True/False
334	Process of replacing one vector by two or more vectors is called subtraction of vectors.	True/False ✔
335	In the verification of conditions of equilibrium for parallel forces, meter rod should not be placed edge-wise in thread loop.	True/False ✔
336	Two given parallel forces will either be like or unlike.	✔ True/False
337	Two parallel forces acting in opposite directions are called unlike parallel forces.	✔ True/False
338	The resultant of two unlike parallel forces is a force whose line of action is in the direction of greater force.	✔ True/False
339	The resultant of two like parallel forces is a force whose line of action is in the direction of either forces.	✔ True/False
340	The resultant of parallel forces can be found by the law of parallelogram of forces.	True/False ✔
341	The resultant of parallel forces is found by applying the principle of moments.	✔ True/False
342	To maintain a body in equilibrium under the action of parallel forces at least three forces parallel to each other must act on the body.	✔ True/False
343	Forces having different lines of action are called unlike parallel forces.	True/False ✔
344	The Gravesand's board need not be vertical.	True/False ✔
345	Weight-thread system should be given a little jerk before marking position of threads.	✔ True/False
346	The anti-clockwise torques is taken as negative.	True/False ✔
347	Sum of all the torques acting on a body is zero, is statement of second condition of equilibrium.	✔ True/False
348	Unlike parallel forces have any line of action.	✔ True/False
349	In the verification of conditions of equilibrium for parallel forces, the meter rod should be placed edge-wise in thread loop.	✔ True/False
350	The vector sum of all forces acting on a body must be zero, is statement of first condition of equilibrium.	✔ True/False
351	A body is in dynamic equilibrium, if it has some acceleration.	True/False ✔
352	Torque is product of magnitude of force and moment arm.	✔ True/False
353	Torque on a body produces linear acceleration in it.	True/False ✔
354	Torque produces angular acceleration in a body.	✔ True/False
355	A body satisfying first condition of equilibrium cannot be in motion.	True/False ✔

356	Perpendicular distance from line of action of force to the axis of rotation is called moment arm.	✓ True/False
357	A meter rod is more rigid breadth-wise.	True/False ✓
358	Conditions of equilibrium are two.	✓ True/False
359	The spring balances should be read after slightly disturbing them.	✓ True/False
360	A meter rod is more rigid edge-wise.	✓ True/False
361	The resultant of parallel forces is found by applying the principle of moments.	✓ True/False
362	A body satisfying first condition of equilibrium, will have zero acceleration.	✓ True/False
363	Moment-arm is a vector quantity.	✓ True/False
364	A body satisfying first condition of equilibrium, will be in complete equilibrium.	True/False ✓
365	A body satisfying first condition of equilibrium, may have angular acceleration.	✓ True/False
366	A body satisfying first condition of equilibrium, will have zero angular acceleration, if all forces acting have same line of action.	✓ True/False
367	Head to tail rule is used in addition of vectors.	✓ True/False
368	The point of application of resultant of like parallel forces acting on a body is a fixed point in a body.	True/False ✓
369	Clockwise torques should be taken as negative.	✓ True/False
270	The resultant of two like parallel forces P and Q is P – Q.	True/False ✓
371	The spring constant depends upon the value of g.	True/False ✓
372	Unit of centre of gravity is N.	True/False ✓
373	Unit of mass is N.	True/False ✓
374	Weight is a scalar quantity.	True/False ✓
375	Weight is a vector quantity.	✓ True/False
376	Spring balance measures weight.	True/False ✓
377	Head to tail rule is used in addition of vectors.	✓ True/False
378	There are three rectangular components of a vector.	True/False ✓
379	Unit of amplitude is second.	True/False ✓
380	NxS is unit of energy.	True/False ✓
381	Unit of time period is m.	True/False ✓
382	Moment arm is a vector quantity.	True/False ✓
383	N x m is a unit of velocity.	True/False ✓
384	m/s is the unit of velocity.	✓ True/False
385	Unit of spring constant is N / m.	True/False ✓
386	Unit of frequency is N/S.	True/False ✓
387	Unit of time period is meter.	True/False ✓
388	Unit of spring constant is N x m.	True/False ✓
389	SI unit of Young's modulus are N-m.	True/False ✓
390	Dynes/cm^2 is the unit of force.	True/False ✓
391	Head to tail rule is used to find resultant vector.	✓ True/False
391	A body, which does not yield a force however large, called rigid body.	✓ True/False
393	Graph between natural nos. & their reciprocals is not a straight line.	✓ True/False
394	Graph between natural numbers and their squares is not a straight line.	True/False ✓
395	Two forces acting in the same direction are called parallel forces.	✓ True/False

396	Two equal and anti-parallel forces having same line of action forms a couple.	True/False ✓
397	For a body to be in stable equilibrium, the center of gravity should be as low as possible.	✓ True/False
398	A second's pendulum has a time period slightly greater than 2 secs..	True/False ✓
399	Bob of a simple pendulum should be kept near the floor of laboratory.	✓ True/False
400	Length of simple pendulum includes the diameter of the bob.	True/False ✓
401	Simple pendulum is used to find mass.	True/False ✓
402	In calculation for time period of a simple pendulum a minimum of ten vibrations should be recorded.	✓ True/False
403	All pendulums of same length will have the same time period.	✓ True/False
404	The bob of simple pendulum oscillates in elliptical path.	True/False ✓
405	Second pendulum will beat(vibrate)for 24x60x60 times in a day	True/False ✓
406	In the calculation of time period of a simple pendulum a minimum of ten vibrations should be recorded.	True/False ✓
407	The diameter of bob should be measured without using the vernier scale i.e. correct to a millimeter only.	True/False ✓
408	Vibrations should be counted starting from 0.	✓ True/False
409	Vibrations should be counted starting from 1.	True/False ✓
410	For a body to be in stable equilibrium the center of gravity should be as low as possible.	✓ True/False
411	In simple pendulum experiment, the use of silk thread is preferable.	True/False ✓
412	All pendulums of same length will have the same time period.	✓ True/False
413	In a simple pendulum the use of fine thread is preferred.	✓ True/False
414	The bob is displaced from mean position through a small angle, not more than 5^{o} .	✓ True/False
415	Draw two mutually perpendicular lines on the floor with chalk and the bob be just over the point of intersection.	✓ True/False
416	The time period of a simple pendulum does not depend upon the mass of the bob.	✓ True/False
417	In measuring the length of a simple pendulum the vertical diameter in different directions should be used in calculations.	✓ True/False
418	An ideal simple pendulum is a heavy point mass suspended by a weightless, inextensible thread.	✓ True/False
419	The bob of pendulum must vibrate in a single plane.	✓ True/False
420	In the simple pendulum experiment the motion of the pendulum should be perpendicular to the cut of cork.	True/False ✓
421	The cut of the cork between which the thread is clamped should be along the plane of vibration of pendulum.	True/False ✓
422	The value of 'g' will be greater at Murree than Lahore.	True/False ✓
423	The length of simple pendulum should be changed by equal intervals of 5 cm.	True/False ✓
424	The amplitude of a simple pendulum should be large.	True/False ✓
425	Time period is not related with frequency.	True/False ✓
426	Simple pendulum is used to find 'G'.	True/False ✓
427	Simple pendulum is used to find mass.	True/False ✓
428	Free fall method is used to find 'G'.	True/False ✓
429	Time period of second's pendulum is 4 seconds.	True/False ✓

430	Free-fall method is used to find gravitational constant.	True/False ✓
431	Simple pendulum is used to find 'g'.	✓ True/False
432	Free fall method is used to find 'g'.	✓ True/False
433	The bar of free-fall apparatus may not vibrate freely, as it does not affect the result.	True/False ✓
434	In free-fall apparatus the most suitable position of sliding weight is the upper end of the bar.	True/False ✓
435	In free-fall apparatus, the time for free fall is equal to time for one complete vibration of bar.	True/False ✓
436	The value of g_{moon} is greater than $g_{earth.}$	True/False ✓
437	Center of gravity is a point inside or outside a body through which weight of the body acts.	✓ True/False
438	Time period of a simple pendulum depends upon the mass of the bob.	True/False ✓
439	Approximate angle of swing of wooden bar of free fall apparatus should be less than 30^o .	True/False ✓
440	Time period of simple pendulum is independent of its amplitude.	✓ True/False
441	Time period of a simple pendulum will not remain the same at Karachi and at the top of Mount Everest.	✓ True/False
442	Time period of simple pendulum is independent of its length.	True/False ✓
443	Time period of a simple pendulum increases when the mass of the bob increased.	True/False ✓
444	In a simple pendulum experiment the amplitude of simple pendulum should be kept small.	✓ True/False
445	The simple pendulum used in laboratories is the ideal pendulum.	True/False ✓
446	A second's pendulum completes its one vibration in one second.	True/False ✓
447	A pendulum, which completes one vibration in two seconds, is called second's pendulum.	✓ True/False
448	Changing length of a simple pendulum will change the value of 'g'.	✓ True/False
449	The time period of a simple pendulum varies directly to its length.	✓ True/False
450	If the string of a simple pendulum is not very light we have to take into consideration its moment of inertia.	✓ True/False
451	Period of simple pendulum depends on mass and material of the bob.	True/False ✓
452	The equivalent length of the pendulum is means the length from the center of gravity of the bob to the point of suspension.	✓ True/False
453	In the study of the changes in potential energy of the body, hanger is used as dead weight.	✓ True/False
454	In the free fall apparatus, the change in the position of sliding weight does not affect the time period of bar.	True/False ✓
455	To increase inertia of the bar of free-fall apparatus, a mass is attached at the lower end of the bar.	✓ True/False
456	The value of g by free-fall is inversely proportional to square of time-period of the bar, thus the time-period of the bar must be determined accurately.	✓ True/False
457	Before performing experiment, the free-fall apparatus is set vertically with the help of plumb line and leveling screws at the base.	✓ True/False
458	The height h through which the mass m is lifted to give gravitational P.E. must to half of the extension due to the load mg.	✓ True/False
459	The pulleys of free-fall apparatus may not be frictionless, as they do not affect the result.	True/False ✓

460	To study the changes in potential energy of a body the spring along with hanger are one body.	✓ True/False
461	On a loaded spring an upward force is applied at the lower end to compress it. The change in gravitational potential energy of the spring is equal to the work done in this compression.	✓ True/False
462	The graph between load and extension is not a straight line.	True/False ✓
463	The work done in compressing or stretching the elastic spring is elastic potential energy of the spring.	✓ True/False
464	The elastic potential energy of a spring is proportional to x^2 where x is the amplitude of vibration.	True/False ✓
465	If a spring is made stiffer, then with the same suspended mass it will oscillate less rapidly.	True/False ✓
466	Beyond elastic limit, the body regains it's original shape after removal of stress.	True/False ✓
467	After reaching elastic limit, the body starts obeying Hooke's law.	True/False ✓
468	We have two spring constants $k_1 = 4$ and $k_2 = 2$, I think k_2 is a hard spring.	✓ True/False
469	In the free fall apparatus the most suitable position of the sliding weight is the lower end bar.	✓ True/False
470	P.E. = "mgh" is the equation for elastic P. E.	True/False ✓
471	The sun has to do a lot of work daily to rotate the earth around it.	True/False ✓
472	Inelastic collision is that in which K.E. is conserved but momentum does not remain conserve.	✓ True/False
473	The surface tension of water can be found by capillary tube method, the surface tension of mercury can also be found by this method.	✓ True/False
474	In a capillary tube, the meniscus of mercury is concave.	True/False ✓
475	The capillary tube may have non-uniform bore.	True/False ✓
476	A steel needle can float at stationary water in a glass.	✓ True/False
477	The needle used in experiment of surface tension gives the level of water surface.	✓ True/False
478	The capillary tube should be broken at the level of meniscus for measuring its internal diameter.	✓ True/False
479	Surface tension is defined as a force, not as a force / unit length.	True/False ✓
480	There should be no parallax between the horizontal cross-wire and image of lower meniscus of water in capillary.	✓ True/False
481	The meniscus of water level in a capillary tube is plane.	True/False ✓
482	The meniscus of water level in a capillary tube appears convex through the microscope.	✓ True/False
483	While performing experiment, the upper end of capillary may be closed with wax.	True/False ✓
484	The best capillaries for work on surface tension are those having circular cross-section.	✓ True/False
485	In the free fall apparatus, the time for free fall is equal to time for one complete vibration of bar.	True/False ✓
486	The meniscus of water level in a capillary tube is concave.	✓ True/False
487	Surface tension is defined as force per unit area.	✓ True/False
488	Spring balances should be read after slightly disturbing them.	✓ True/False
489	To get rid of contaminations the capillary tubes are washed by caustic soda and nitric acid.	✓ True/False

490	In the free fall apparatus the most suitable position of the sliding weight is the upper end bar.	True/False ✓
491	In the study of changes in potential energy, elastic potential energy cannot be equal to gravitational potential energy.	True/False ✓
492	For a body, within elastic limits, the ratio of stress to strain is constant, called its modulus of elasticity.	✓ True/False
493	If the force needed to stretch an object is proportional to the elongation, the object obeys Hooke's law.	✓ True/False
494	The spring constant K depends on the value of g.	True/False ✓
495	The spring constant may be defined as the force required to produce unit extension.	✓ True/False
496	The ratio of longitudinal stress to strain is called Young's modulus.	✓ True/False
497	The value of Young's modulus changes by using a thicker wire of same material.	✓ True/False
498	With the increase in temperature of a metal wire its Young's modulus will increase.	True/False ✓
499	S.I. units of Young's modulus are N-m.	True/False ✓
500	Load or unload the hanger gently.	✓ True/False
501	The wires may be loaded up to its breaking stress.	True/False ✓
502	The wire should not be loaded beyond one third of its breaking stress.	✓ True/False
503	A fixed weight is attached to one end and a hanger to the other end of Searle's apparatus to keep wires free from kinks & bend.	✓ True/False
504	The two wires used in Searle's apparatus may be made of different materials, but should have same size.	True/False ✓
505	The change in length per unit length is called longitudinal strain.	✓ True/False
506	The elongation per unit length is called longitudinal stress.	True/False ✓
507	The two wires used in Searle's apparatus should have same size and made of same material.	✓ True/False
508	Force required to double the length of wire of unit area of cross section is numerically equal to Young's modulus.	True/False ✓
509	Unit of elastic potential energy is N.	True/False ✓
510	If a material is easy to stretch, it has a small Young's modulus.	True/False ✓

WAVES & SOUND

511	The waves along sonometer wire are stationary waves.	✓ True/False
512	Ripple tank is a simple tray with transparent bottom.	✓ True/False
513	Waves produced have same time-period are called periodic waves.	✓ True/False
514	Bright and dark fringes are seen on the screen of ripple tank, as crest behave like convex lenses and troughs behave like concave lenses.	✓ True/False
515	When water filled in tray is not disturbed and is illuminated with bulb, will make alternate bright and dark bands.	True/False ✓
516	Depth of water in ripple tank should be uniform.	✓ True/False
517	Distance between two nodes is equal to wavelength of waves.	True/False ✓
518	Crest is the lowest point below the mean position attained by particles of medium through which waves are passing.	True/False ✓
519	Trough is the highest point above the mean position attained by particles of medium through which waves are passing.	True/False ✓

520	Sound waves are compress ional waves.	✓ True/False
521	The velocity of sound increase with increase of pressure.	✓ True/False
522	Velocity of sound in cold water is greater than the hot water.	True/False ✓
523	Transverse waves do not occur in a gas.	✓ True/False
524	The velocity of sound in cold water is greater than the hot water.	True/False ✓
525	The velocity of sound decreases with increase in density of medium.	✓ True/False
526	The tuning fork should be struck against some hard surface.	True/False ✓
527	A sonometer may be used to compare frequencies of two nodes.	True/False ✓
528	Vibrating tuning fork should be held horizontal above open end	✓ True/False
529	In sonometer apparatus, tuning fork should be held near the vibrating wire.	True/False ✓
530	In sonometer apparatus, tuning fork should be placed on the wooden apparatus near the vibrating wire.	✓ True/False
531	In sonometer apparatus, tuning fork should be placed near the bridges.	True/False ✓
532	The open end of resonance tube acts as anti-node.	✓ True/False
533	At the resonant length of a sonometer wire nodes are formed at the ends of length.	✓ True/False
534	At the resonant length of a sonometer wire anti-nodes are formed at the ends of length.	True/False ✓
535	We use wooden box in sonometer to get louder sound.	✓ True/False
536	Vibrations of the tuning fork should be stopped before revibrating it.	✓ True/False
537	The vibrations of the tuning fork may or may not stop before revibrating it.	True/False ✓
538	The waves produced along a sonometer wire are longitudinal waves.	True/False ✓
539	At resonance the paper rider on the wire is observed to remain stationary on the wire.	True/False ✓
540	When the vibrating fork is placed on the sonometer, its vibrations are communicated to the wood of the sonometer box and then to the wire attached.	✓ True/False
541	The wire on the sonometer vibrates only slightly when its natural frequency is not the same as that of the vibrating tuning fork.	✓ True/False
542	When a vibrating tuning fork is held in contact with laboratory table, the sound emitted by the fork dies away immediately.	True/False ✓
543	A sonometer may be used to compare frequencies of two notes.	✓ True/False
544	The function of the hollow box is to increase the loudness of the tone emitted by the wire or any other vibrating source placed in contact with the board.	✓ True/False
545	The wire of a sonometer vibrates with max. amplitude when its natural frequency is a little different from that of the vibrating tuning fork.	True/False ✓
546	The sonometer wire executes transverse vibrations.	✓ True/False
547	Only longitudinal waves can pass through stretched string of sonometer.	True/False ✓
548	The vibrations set in a sonometer wire are forced vibrations.	✓ True/False
549	To verify law of tension, the weight of hanger should not be included to calculate the tension in the wire.	True/False ✓
550	Law of length for a stretched string is verified when $f \times l$ = constant.	✓ True/False
551	Stationary waves are produced on a vibrating string.	✓ True/False
552	Distance between two successive crests is $\lambda/2$	✓ True/False

553	Sound waves are electromagnetic waves.	True/False ✓
554	Waves in which the particles of the medium vibrate parallel to the direction of motion of waves are called longitudinal waves.	✓ True/False
555	For waves along a string $f \propto 1/l$ if tension remains constant.	✓ True/False
556	For the waves along a string $f \propto 1/\sqrt{m}$ provided the length and tension remain constant.	✓ True/False
557	For the waves along a string $f \propto 1/\sqrt{T}$ provided the length and tension remain constant.	True/False ✓
558	For waves along a string $f \propto \sqrt{T}$ provided length remains constant.	✓ True/False
559	The waves produced in air column of tube are transverse waves.	True/False ✓
560	The shift in the position of antinode is called end correction.	✓ True/False
561	Velocity of sound decreases by 61 cm/s for 1 °C rise in temperature.	True/False ✓
562	The waves produced in the air column of a tube are longitudinal stationary waves.	✓ True/False
563	The velocity of sound increases with increase in pressure.	True/False ✓
564	Velocity of sound increases by 6 cm/s for every 1 °C rise in temp	True/False ✓
565	The open end of resonance tube behaves as node.	True/False ✓
566	Vibrating tuning fork should be kept along the tube at open end.	True/False ✓
567	At the position of resonance even the feeblest vibrations of the tuning fork produce sufficient loudness.	✓ True/False
568	At resonance a sound of maximum loudness is heard coming from the resonance tube.	✓ True/False
569	The length of resonating column for first resonance position is measured from open end of tube to lower meniscus of water with the help of setsquares.	✓ True/False
570	Tuning fork should be struck with rubber briskly.	✓ True/False
571	The top end of the resonance tube is the exact position of the anti-node of the stationary wave.	True/False ✓
572	The velocity of sound decreases by 61 cm/sec for 1 °C rise in temperature.	True/False ✓
573	End correction is not applied in using two resonance positions.	✓ True/False
574	The length of resonating column is measured once, while water level is falling, secondly while water level is rising.	✓ True/False
575	The speed of sound increases by 61 cm/sec for each degree rise in temperature of the medium..	✓ True/False
576	The shift in the position of the anti-node is called end correction.	✓ True/False
577	Resonance tube is used to find the wavelength.	True/False ✓
578	The second resonance position should be expected at about three times the length of the first resonance position.	✓ True/False
579	The speed of sound in air at 0 °C is about 930 m/s.	True/False ✓
580	The distance between two consecutive troughs is $\lambda/4$.	True/False ✓
581	The open end of a resonance tube behaves as an anti-node.	✓ True/False
582	The velocity of sound is affected by the density of medium.	✓ True/False
583	In resonance tube apparatus end correction is applied due to some defect of tube.	True/False ✓
584	Two resonance position method is more better than end correction method.	✓ True/False
585	Sound waves are transverse waves	True/False ✓

586	Index of correction has no unit.	True/False ✓
587	End correction is applied in using two resonance position.	True/False ✓
588	Unit of wavelength is m.	✓ True/False
589	Sound waves are compress ional waves.	✓ True/False
590	Resonance is produced in a convex lens.	True/False ✓
591	In standing waves distance between two anti-nodes $= \lambda/2$	✓ True/False
592	The distance between a node and an anti-node is $\lambda/4$.	✓ True/False
593	Sound waves are longitudinal waves.	✓ True/False
594	Nodes are formed at the open end.	True/False ✓
595	Speed of sound increases with increase in temp. of the medium (air).	✓ True/False
596	The string in Melde's experiment must be stretched without kinks and bends	✓ True/False
597	Mass per unit length of string in Melde's experiment should be calculated accurately.	✓ True/False
598	Beats are produced due to diffraction of waves.	True/False ✓
599	When resonance occurs the string of Melde's apparatus vibrates with maximum amplitude.	✓ True/False
600	Distance between two successive node or anti-nodes is $\lambda/4$.	True/False ✓
601	Velocity of sound in air decreases with increase in temperature.	True/False ✓

LIGHT

602	A ray passing from denser to rarer medium bends away from normal.	✓ True/False
603	Light travels with different velocities in two media.	✓ True/False
604	The diameter of a lens is called aperture.	✓ True/False
605	The radius of curvature of plano-convex lens is measured by micro-meter screw gauge.	True/False ✓
606	A convex lens always behaves as a converging lens.	True/False ✓
607	Optical center does not lie on principal axis.	True/False ✓
608	A ray passing from rarer to denser medium bends towards the normal.	✓ True/False
609	Light should fall on the lens normally.	✓ True/False
610	Light is deviated more at edges of a lens than at the central portion.	✓ True/False
611	A converging lens has real focus but a diverging lens has a virtual focus.	✓ True/False
612	Convex lens is a magnifying glass.	✓ True/False
613	Images formed by a convex mirror can be received on a screen.	True/False ✓
614	Thickness of a diverging lens is minimum at the center.	✓ True/False
615	In order to get real image, the object must be placed away from focal point.	✓ True/False
616	If a screen is placed at the position of a real image, the image is visible on the screen.	✓ True/False
617	An object is placed at a distance of $f/2$ from a convex lens. The image will be virtual and half in size.	True/False ✓
618	For all positions of object, the convex lens makes real image.	True/False ✓
619	A virtual image can be seen on a screen.	True/False ✓
620	Monochromatic light has seven colours.	True/False ✓
621	The unit of index of refraction is cm.	True/False ✓
622	The image formed with a glass slab is virtual.	True/False ✓

623	The eyepiece convex lens should have larger aperture and focal length as compared to objective.	✓ True/False
624	The length of upright should be adjusted such that the optical centers of both objective and eyepiece lenses must be co-linear.	✓ True/False
625	The image of an object placed far away from a converging lens is focused behind the lens at infinity.	True/False ✓
626	The critical angle remains same for all colours.	True/False ✓
627	For total internal reflection the angle of incidence should be greater than the critical angle.	✓ True/False
628	A virtual image is not visible to the eye.	True/False ✓
629	The critical angle of a given prism remain same for all colours.	True/False ✓
630	The two pins should be fixed at a distance more than five cm where image of the pin fixed on the boundary of the prism, just disappears.	✓ True/False
631	The directions of rays should be given by putting arrowheads.	✓ True/False
632	Refractive index of the transparent slab (glass) is the ratio of real thickness to apparent thickness.	✓ True/False
633	In finding refractive index of liquid, the concave mirror should be properly polished.	✓ True/False
634	In the parallax method the graph between p+q and pq is not a straight line.	True/False ✓
635	In parallax method the graph between 1/p and 1/q is a straight line.	✓ True/False
636	The apparent change in the relative position of two objects due to change in the position of the observer, is called parallax.	✓ True/False
637	The positive error is always added in the observed readings.	True/False ✓
638	Laws of reflections are not valid in total internal reflection.	True/False ✓
639	The critical angle for red light is smaller than the violet light.	True/False ✓
640	The index correction is a type of zero error.	✓ True/False
641	The ray passing from a denser to rarer medium bends towards the normal.	True/False ✓
642	Angle of refraction can never be greater than 90^o.	✓ True/False
643	For glass critical angle lies between 36^o to 42^o.	✓ True/False
644	The critical angle for red light is greater than the violet light.	✓ True/False
645	Unit of wavelength is N x m.	True/False ✓
646	Power of a lens is 1/f.	✓ True/False
647	Unit of focal length is m/s.	True/False ✓
648	Convex lens is thinner at the center.	True/False ✓
649	In determining focal length of concave lens using convex lens, the convex lens should be placed nearer to concave lens.	✓ True/False
650	Convex mirror should be placed such that its principal axis should be vertical.	True/False ✓
651	Concave lens must be placed between center of curvature of concave mirror.	✓ True/False
652	Concave mirror must have shorter focal length and concave lens should have larger aperture.	True/False ✓
653	Total internal reflection occurs when the incident angle in the denser medium becomes equal to the critical angle.	True/False ✓
654	The enough quantity of a liquid should be poured in the concave mirror.	✓ True/False

655	For total internal reflection the angle of incidence should be less than the critical angle.	True/False ✔
656	In p-q graph we take equal lengths for units along two axis	✔ True/False
657	Glass prism is used to find refractive index.	✔ True/False
658	The thickness of diverging lens is minimum at the center.	✔ True/False
659	Unit of focal length is N x m.	True/False ✔
660	Index of refraction has no unit.	✔ True/False
661	Glass prism is used to find critical angle.	✔ True/False
662	The phenomenon of change of path of light, while entering from one transparent medium to another is called polarization.	True/False ✔
663	Light changes its path while it enters from one transparent medium to another.	✔ True/False
664	The bending of light on entering into a second medium is called diffraction of light.	True/False ✔
665	Sun light (white light) is monochromatic.	True/False ✔
666	The image formed by a concave lens is always virtual.	✔ True/False
667	Sodium light is nearest approach to monochromatic light.	✔ True/False
668	Focal length of lens is equal to the radius of curvature.	True/False ✔
669	The graph between p and q for a convex lens will be curve.	✔ True/False
670	The light of single frequency is not known as a monochromatic light.	True/False ✔
671	With vertical crosswire, coincide one side (left or right) of the image of slit, for all readings of the experiment.	✔ True/False
672	Light is composed of seven colours.	✔ True/False
673	Keep eye very near to the eyepiece to see the magnified image.	✔ True/False
674	The telescope is focused for infinity by removing parallax between vertical crosswire and a distant object.	✔ True/False
675	Focus the telescope and collimator for parallel rays of light.	✔ True/False
676	The cross-wires of telescope should be made distinctly visible, with the help of eyepiece adjustment.	✔ True/False
677	Cross wires of telescope should be focused for infinity.	✔ True/False
678	A microscope is an instrument used to see distant objects.	True/False ✔
679	A spectrometer is used to study the refractive index.	True/False ✔
680	Grating should be placed such that the side of the ruling of grating should be opposite to the collimator.	✔ True/False
681	A narrow slit should be used.	✔ True/False
682	It makes no difference, if the turntable is not leveled.	True/False ✔
683	A telescope is used to see near objects.	True/False ✔
684	The graph of (p+q) and pq is a parabola.	True/False ✔
685	If path difference between two light beams is $(n + \frac{1}{2})\lambda$ we get bright fringes.	True/False ✔
686	The indices of refraction of glass for component colours of white light are different.	True/False ✔
687	A plano-convex lens of shorter focal length is usually used in Newton's rings experiment.	True/False ✔
688	Focus eyepiece of traveling microscope to see cross-wire distinctly.	✔ True/False
689	Index refraction is real distance minus observed distance.	✔ True/False
690	Refractive index depends on the colour of light.	✔ True/False

HEAT

691	It is better to wear a black dress on a hot day.	True/False ✓
692	Heat is a such form of energy which cannot be converted into mechanical energy.	True/False ✓
693	Newton's law of cooling does not hold for large temperature difference	✓ True/False
694	The law of cooling is used in laboratory for finding specific heat of gases.	True/False ✓
695	Mercury is usually preferred in the thermometer due to its large heat capacity.	True/False ✓
696	The volume of a gas sample is proportional to its absolute temperature.	✓ True/False
697	Law of cooling is applicable to liquids only.	✓ True/False
698	Thermometry is a branch of physics dealing with measurement of temperature.	✓ True/False
699	When different liquids are cooled under same conditions, rate of cooling is equal	✓ True/False
700	The cooling curve of liquid A is steeper than that of liquid B. It indicates that the rate of fall of temp of A is greater than that of B.	✓ True/False
701	In Searl's apparatus for thermal conductivity, rate of flow of water should be fast and uniform.	True/False ✓
702	Searl's apparatus is suitable for determining the thermal conductivity of a metal bar.	✓ True/False
703	The specific heat of water in Joules is 420 J/kg- ^{o}C	True/False ✓
704	A gas that does not obey gas laws is called an ideal gas.	True/False ✓
705	Absolute zero may be regarded as that temperature at which molecular motion in a gas could be minimum possible.	✓ True/False
706	The relation between Joule and calorie is given by; 1 cal = 7.2 J	True/False ✓
707	The absolute zero, lowest possible temperature which is equal to –373 ^{o}C	True/False ✓
708	The thermal conductivity of metals decreases with increase of temperature	✓ True/False
709	The thermal conductivities of all the metals have same value.	True/False ✓
710	There electro-chemical equivalent is denoted by J.	True/False ✓
711	The value of mechanical equivalent of heat is 4.2 Joules/cal.	✓ True/False
712	The value of 'J' in S.I. system is 4.2×10^{7} ergs/cal.	True/False ✓
713	Coefficient of linear expansion is same as coefficient of volume expansion.	True/False ✓
714	In Pullinger's experiment , the spherometer screw should not be placed sideways to measure the diameter of the rod.	✓ True/False
715	In Pullinger's experiment , time of 2 minutes is sufficient for taking the reading.	True/False ✓
716	In Pullinger's experiment, the temperature of the rod will be exactly same as that of the projecting end.	True/False ✓
717	In Joule's calorimeter there is no heat loss due to radiation.	True/False ✓

SHORT ANSWERS TO QUESTIONS

Write brief answers of each question in the space provided.

MECHANICS

718	***Define zero error.***	When zeros of both scales, main (or linear) scale and vernier(or circular) scales do not coincide, the instrument have zero error.
719	***What is zero correction?***	Add or subtract zero error to get actual reading.
720	***Define Vernier constant or least count.***	It is the smallest measurement which a vernier can read.
721	***What is Vernier?***	A device used to measure the fraction of smallest scale division up to tenth part of a centimeter.
722	***Who invented Vernier calipers?***	A French mathematician, Pierre Vernier invented it.
723	***How zero error of vernier calipers determined?***	Taking the reading of vernier calipers when the jaws of vernier calipers are closed.
724	***For a vernier calipers, when is the zero error negative?***	If vernier zero is to the left of the main scale zero, the zero error is negative.
725	***The 20 divisions on the vernier scale coincide with 19 main scale divisions. What is the vernier constant of the vernier if the least main scale division is 1 mm.***	Vernier constant = 1/20 = 0.05 mm
726	***What is meant by the pitch of the screw?***	A linear distance through which one complete rotation is given to the circular cap.
727	***A screw is turned clockwise. Will it move inwards or outwards?***	When a screw is turned clockwise, it will move inward.
728	***What is the reading power of a screw gauge?***	It is one hundredth of a millimeter ; 1/100 mm
729	***What is least count of an instrument?***	The smallest reading which can be measured by an instrument.
730	***What is reading power of vernier calipers?***	It is one tenth of a millimeter; 1/10 mm
731	***The diameter of a wire as measured by a screw gauge is 0.22 mm. What is its area of cross-section?***	Area = $\pi r^2 = (22/7)x(0.22/2) = 0.038 \text{ mm}^2$
732	***The diameter of a small spherical ball as measured by a screw gauge is 1.24 cm. Calculate its volume.***	Volume = $4/3 \text{ x } \pi r^3 = 4/3 \text{ x } 22/7 \text{ x } (1.24/2)^3$ $= 0.998 \text{ cm}^3$
733	***What do you understand by resolution of vector?***	The splitting of a single vector into two or more component vectors.
734	***Define resultant vector.***	A single vector which has the same effect as the combined effect by two or more vectors.

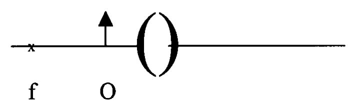
735	***You want to unscrew a nut. Will you turn it clockwise or anti-clockwise?***	Anti-clockwise would be turned.
736	***What do you mean by moment arm?***	It is the perpendicular distance from the line of action of force to the axis of rotation.
737	***Define couple.***	Two equal, parallel and unlike forces having different lines of action makes a couple.
738	***In what type of collision between two bodies only momentum is conserved.***	In-elastic collision. Only momentum is conserved, not kinetic energy.
739	***What are like and Unlike parallel forces?***	Like parallel forces :Two parallel forces acting in the same direction. Unlike parallel forces: Two parallel forces acting in opposite directions.
740	***Define torque and give its unit.***	The product of force and its moment arm. Its unit is Newton-meter.
741	***What does 'T' represent in the formula $g = 32xS/T^2$***	'T' is the time period taken by the vibrating wooden bar.
742	***What is an ideal simple pendulum?***	A heavy small bob attached with weightless and inextensible thread suspended from frictionless support.
743	***Define equilibrium.***	When a body remains at rest or moves with uniform velocity.
744	***A force of 10 N makes an angle of 30^o with X-axis. What are its rectangular components?***	$F = 10$ N, $\theta = 30^o$ $F_x = F \cos 30^o = 10 \times .86 = 8.6$ N $F_y = F \sin 30^o = 10 \times ½ = 5$ N
745	***What is difference between gravity and gravitation?***	Gravity is the force with which the earth attracts the bodies towards its center. Gravitation is the force of attraction between different bodies in the Universe.
746	***Define Hooke's law.***	Within elastic limits stress is proportional to strain.
747	***Define elastic limit.***	The limit beyond which a body does not obey Hooke's law.
748	***What two types of energies are interchanged in case of mass suspended by a helical spring?***	Mechanical potential energy and gravitational potential enrgy.
749	***What is spring constant? Give its unit.***	The ratio of the force exerted on a spring to the extension produced by it. Unit is Newton/meter
750	***Why do we take one fourth of the time period (1/4) of the wooden bar as the time of free fall in free-fall experiment.***	Because time of free fall of the ball is equal to ¼ of complete vibration of oscillating wooden bar.
751	***Why is free fall method so called?***	Here the bob fall freely, when we note the time.
752	***What is the value of 'g' at the center of the earth?***	It is zero at the center of the earth.

753	***What is the value of 'g' at an altitude of one radius of earth?***	It will be (¼)x g
754	***Define second's pendulum.***	A pendulum whose time period is 2 seconds.
755	***Why the amplitude of a simple pendulum should be kept small?***	When we made the expression for time period of simple pendulum, we put $\sin\theta = \theta$, which is good for small θ only.
756	***What is the center of gravity of a body?***	A point at which the weight of the body acts.
757	***A satellite moves at constant speed in a circular orbit about earth. What about its mom. And kinetic energy?***	Its momentum will change and the kinetic energy will be constant.
758	***What is cohesive and adhesive forces?***	The molecular force of attraction between same substance is cohesive force and force between different substances is called adhesive force.
759	***How does surface tension vary with temperature?***	It decreases with rise in temperature.
760	***Define surface tension. Give its units.***	The force per unit length along an imaginary line drawn on the surface of a liquid. Unit is Newton/meter; N/m
761	***What is the effect of density of a liquid on its surface tension?***	Surface tension increases with increase of density.
762	***What is isolated system?***	Bodies having definite boundary and can interact each other without interaction of external forces.

WAVES & SOUND

763	***Write a relation between frequency and time period.***	$f = 1/T$, where f is frequency, and T is time period.
764	***Why does paper rider fly off at a certain fixed length of the wire of sonometer?***	At resonant length, nodes (point of minimum displacement) are formed at the ends, and anti-nodes—point of maximum displacement, are formed in the middle, where the paper rider is placed.
765	***Are sound waves transverse waves?***	No. the sound waves are longitudinal waves.
766	***What is the role of water in resonance tube apparatus?***	For reflection of sound waves from a denser medium the water is used.
767	***Define node and anti-node.***	Nodes are those points where particles of the medium do not vibrate, and anti-nodes are those points where particles of the medium vibrate with maximum amplitude.
768	***How does time period vary with length of pendulum?***	Time period is proportional to square root of the length.
769	***What is the effect of mass on 'T' of simple pendulum?***	Time period does not depend upon mass of the pendulum.

LIGHT

770	***What is monochromatic light?***	Light having single colour or wavelength.
771	***What is an optical center of a lens?***	A point in the lens through which the ray does not suffer any deviation.
772	***Define parallax.***	The apparent shift of two objects(object & its image) caused by the motion of eye.
773	***What is the difference between real and virtual images?***	Real image can be obtained on the screen, but virtual image cannot be taken on the screen.
774	***What is the nature of an image formed by a convex lens when the object is placed between its focus and optical center.***	It will be virtual, magnified and erect on the same side.
775	***What is the nature and size of the image formed by a plane mirror.***	Virtual, equal size, and along the same side
776	***Where will you place the object in front of a convex lens in order to get its magnified virtual image. Sketch the ray diagram.***	Object will be between f and optical center. 
777	***Can you obtain the approx. focal length of a concave lens. Justify you answer.***	No. we cannot take approximate focal length, because the rays diverge after transmission.
778	***What do you mean by removing parallax?***	Removal of apparent change in the relative positions of two objects due to change in position of the observer.
779	***What is meant by index correction?***	The difference between actual distance seen between object and image uprights and taken by arrow marks on the foot of two uprights.
780	***What is the practical unit of power of a lens?***	Dioptre is the practical unit.
781	***Define power of a lens.***	The reciprocal of a focal length.
782	***Find power for f = 0.5 m .***	Power of lens = 1/f = 1/0.5 m = 2 dioptre
783	***When light passes through prism, then what do you mean by angle of deviation?***	The angle between incident ray and emergent ray is called angle of deviation.
784	***What is refraction?***	Deviation of light while entering from one medium to another.
785	***Find critical angle for glass if its refractive index is 1.5.***	$\mu =$ 1/SinC or $C = \sin^{-1} \mu = \sin^{-1} (1/1.5)$ or angle $C = \sin^{-1} (.66) = 42^{o}$
786	***Define critical angle.***	The angle of incidence in denser medium for which the angle of refraction in rarer medium is 90^{o}
787	***What is the relation between critical angle and refractive index?***	$\mu = \frac{1}{\sin C}$

788	***What formula would you use to determine the refractive index by finding the real depth and apparent depth of an object lying at the bottom of denser medium?***	The formula is: Refractive index = $\frac{\text{real depth}}{\text{Apparent depth}}$
789	***What is Snell's law?***	The ratio of the sine of angle of incidence to the sine of the angle of refraction is constant for two media.
790	***Write down the formula for magnifying power of a compound microscope.***	$M = L/f_o (1 + d/f_e)$, where f_o = objective focal length f_e = eyepiece focal length
791	***What are the conditions for total internal reflection?***	i) the ray of light should travel from denser to rarer medium. ii) the angle of incidence should be greater than the critical angle.
792	***What is diffraction grating?***	A glass plate on which very large number of equidistant parallel line are ruled for studying spectrum of light.
793	***What is grating element?***	(a + b) is the grating element, where a = width of spacing, b = no. of ruled lines
794	***What is the function of collimator in a spectrometer?***	Used to make narrow slit for making clear and well defined image.
795	***What is resolving power of a telescope.***	Ssmallest angular separation which two points, very close to each other, on an object must have in order that one point can be distinguished from its neighbouring point in the image.
796	***What is magnifying power of an astronomical telescope.***	The ratio between focal lengths of objective and eyepiece.
797	***What LASER stands for?***	Light Amplification by Stimulated Emission of Radiation
798	***What is solid laser?***	Here a fluorescent crystal, is used as light amplifying substance.
799	***What is liquid laser?***	These lasers make use of a dye dissolved in methanol or a similar liquid.
800	***What is metastable state?***	The existence of temporary stable state in the atoms of some substances.

HEAT

801	***Is method of cooling applicable to solids?***	No. As solids cannot be maintained for uniform temperature in all the body.
802	***What is S.I. unit of heat?***	The unit of heat is Joule in S.I. units.
803	***What is meant by heat?***	Total kinetic energy of all the molecules of the substance.
804	***What is practical use of Newton's law of cooling.***	To find specific of liquid accurately.
805	***What is absolute zero?***	Lowest possible temperature equal to $-273\ ^{o}C$
806	***What is Newton's law of cooling?***	The rate of cooling is directly proportional to the difference of temperature between body and surrounding for small difference.
807	***What is pressure coefficient of air at constant volume?***	The value of pressure coefficient is 1/273 per ^{o}C
808	***Upon which factors thermal conductivity depends?***	It depends upon the material and the units used.
809	***What is the symbol of Mechanical Equivalent of Heat? Define it.***	Symbol is J. It is the amount of work required to produce one calorie of heat.
810	***What happens to electrical energy when a current passes through a conductor?***	The electrical energy is converted into heat energy due to resistance in the conductor.
811	***Relate coeff of linear expansion & coeff of volume expansion.***	$\beta = 3\alpha$
812	***Which law hold for large temperature difference?***	Stefan's law. It states that the loss of heat by radiation is directly proportional to the fourth power of the absolute temperature.
813	***What are the limitations of Newton's law of cooling?***	It is valid only for liquids and valid for small temperature difference.
814	***What is the effect of temperature on thermal conductivity?***	It decreases as the temperature increases.
815	***Can Joule's calorimeter experiment be performed on A.C.?***	Yes, a transformer before use should step down the voltage.

In education, the life of mind proceeds gradually from scientific experiment to intellectual theories, to spiritual feelings and then to God.

______Khalil Gibran

APPENDICES

Paper VI		Time Allowed 2 Hrs
Physics – Practical	(Part-I)	Max. Marks: 25

NOTE:

(i) Attempt one question from section I as allotted by the examiner.
(ii) Mark one question from section II and one from section III. Perform one experiment as allotted by the examiner out of the marked questions.

SECTION – I

Q. No. 1 Draw a graph between p and q for a convex lens from the given data.

p:	24cm	26cm	28cm	30cm	32cm
q:	33cm	29.3cm	27.2cm	24cm	23cm

Find out focal length of the lens from the graph. 5

Q. No. 2 Draw a graph between t and x for a moving body from the given data:

t:	14sec	15sec	16sec	17sec	18sec
x:	33m	45m	67m	93m	115m

Find out average velocity of the body from the graph. 5

SECTION – II

Q. No. 3 Find the value of g by free fall method. 10

Q. No. 4 Verify second condition of equilibrium by wedge method. 10

SECTION – III

Q. No. 5 Find velocity of sound at 0 ^{o}C, by applying end correction. 10

Q. No. 6 Determine focal length of a convex lens by parallax method. 10

Q. No. 7 Viva Voce 02

Q. No. 8 Note – Book 03

Q. No. 9 Part – II, Objective is on separate sheet. 5

Tables of Constants & Useful Data

$\pi = 3.14$; $\sqrt{\pi} = 1.773$; $\pi^2 = 9.87$
Sphere's surface area = $4\pi R^2$
Circumference of a circle = $2\pi R$

Area of cross-section = πR^2
Volume of a sphere = $4/3\ \pi R^3$
Volume of a cylinder = $\pi R^2 \times l$

Value of g at different places	
Peshawar	970.3 cm/sec^2
Rawalpindi	973.2 cm/sec^2
Lahore	979.0 cm/sec^2
Multan	979.4 cm/sec^2
North pole	983.2 cm/sec^2

Substance	Critical Angle	μ
Crown glass	41°	1.52
Flint glass	37°	1.67
Water	48.5°	1.33
Glycerin	44.5°	1.47
Diamond	24°	2.42
Air	nil	1.00

Elastic constants for wire		
Material	Breaking stress kgm/mm^2	Young's modulus dynes/cm^2
Aluminum	20 to 25	7.2 to 7.5 x 10^{11}
Brass	30 to 90	8 to 10.5 x 10^{11}
Copper	40 to 45	10 to 13 x 10^{11}
Iron	40 to 55	19 to 20 x 10^{11}

Surface Tension	
Substance	Surface tension
Water	72.3 dynes/cm
Kerosene oil	26.3 dynes/cm
Turpentine oil	27.3 dynes/cm
Paraffin oil	26.4 dynes/cm
Alcohol	22 dynes/cm
Mercury	465 dynes/cm

Specific Heat for Solids and Liquids					
Solid	Kcal / kg °C	J / Kg °C	Liquid	Kcal / kg °C	J / Kg °C
Aluminum	0.212	903.0	water	1.000	4200.0
Brass	0.088	369.6	Glycerin	0.58	2226.0
Copper	0.094	387.7	Kerosene oil	0.53	2226.0
Glass	0.19	798.0	Castor oil	0.508	2133.6
Iron	0.119	499.8	Olive oil	0.47	1974.0

Coefficients of Linear Expansion (°C^{-1})			
Aluminum	0.000023	Silver	0.000019
Brass	0.000019	Iron	0.000011
Copper	0.000017	Platinum	0.000009
Glass	0.000008	Ice	0.000051

Coefficients of Viscosity					
Water	.01793 at 0 °C	.01142at 15 °C	.01006at 20 °C	.00902at 50 °C	.00012at100 °C
Air	.00017at 0 °C	.00018at 15 °C	Mercury	.016 at 20 °C	.00532at100 °C
Ether	.00234at 20 °C	.000097at100 °C	Alcohol	.0119at 20 °C	.00011at100 °C

Wavelength of light: Sodium (yellow) = 5896 A.U. = 5.9 x 10^{-7} m
Laser (red) = 6800 A.U. = 6.8 x 10^{-7} m

Velocity of Sound in: Air at 0 °C = 331.3 m/sec; Increase for 1 °C = 61 cm/sec
Water at 15 °C = 1450 m/sec, Copper at 20 °C = 3560 m/sec, Steel = 5000 m/sec

Conversion Factors

1 inch = 2.54 cm = 0.0255 meter, 1 meter = 100 cm = 39.37 inch
1 Newton = 10^5 dynes, 1 calorie = 4.18 joules, 1 Joule = 10^7 erg = 0.239 calorie
1 litre = 1000 c.c., 180 = π radians, 1 radian = 57.3°, 1 mile = 1.61 km

Natural Trigonometric Functions

Angle	Sine	Cosine	Tangent	Angle	Sine	Cosine	Tangent
1°	.018	.999	.018	46°	.719	.695	1.036
2°	.035	.999	.035	47°	.731	.682	1.072
3°	.052	.999	.052	48°	.743	.669	1.111
4°	.070	.998	.070	49°	.755	.656	1.150
5°	.087	.996	.087	50°	.766	.643	1.192
6°	.105	.995	.105	51°	.777	.629	1.235
7°	.122	.993	.123	52°	.788	.616	1.280
8°	.139	.990	.141	53°	.799	.602	1.327
9°	.156	.988	.158	54°	.809	.588	1.376
10°	.174	.985	.176	55°	.819	.574	1.428
11°	.191	.982	.194	56°	.829	.559	1.483
12°	.208	.978	.213	57°	.839	.545	1.540
13°	.225	.974	.231	58°	.848	.530	1.600
14°	.242	.970	.249	59°	.857	.515	1.664
15°	.259	.966	.268	60°	.866	.500	1.732
16°	.276	.961	.287	61°	.875	.485	1.804
17°	.292	.956	.306	62°	.883	.469	1.881
18°	.309	.951	.325	63°	.891	.454	1.963
19°	.326	.946	.344	64°	.899	.438	2.030
20°	.342	.940	.364	65°	.906	.423	2.145
21°	.358	.933	.384	66°	.914	.407	2.246
22°	.375	.927	.404	67°	.921	.391	2.356
23°	.391	.921	.425	68°	.927	.375	2.475
24°	.407	.914	.445	69°	.934	.358	2.655
25°	.432	.906	.466	70°	.940	.342	2.748
26°	.438	.899	.488	71°	.946	.326	2.904
27°	.454	.891	.510	72°	.951	.309	3.078
28°	.469	.883	.525	73°	.956	.292	3.271
29°	.485	.875	.554	74°	.961	.276	3.487
30°	.500	.866	.577	75°	.966	.259	3.732
31°	.515	.857	.601	76°	.970	.242	4.011
32°	.530	.848	.625	77°	.974	.225	4.331
33°	.545	.839	.649	78°	.978	.208	4.705
34°	.559	.829	.675	79°	.982	.191	5.145
35°	.574	.819	.700	80°	.986	.174	5.671
36°	.588	.809	.727	81°	.988	.156	6.314
37°	.602	.799	.754	82°	.990	.139	7.115
38°	.616	.788	.781	83°	.993	.122	8.144
39°	.629	.777	.810	84°	.995	.106	9.514
40°	.643	.766	.839	85°	.996	.087	11.43
41°	.656	.755	.869	86°	.998	.070	14.30
42°	.669	.743	.900	87°	.999	.062	19.80
43°	.682	.731	.933	88°	.999	.030	28.64
44°	.695	.719	.966	89°	.999	.018	57.29
45°	.707	.707	1.000	90°	1.000	.000	∞

An example of calculating sines or tangents of <u>intermediate angles</u>: To find sin 57.8 ; sin 57 is .839 and sin 58 is .848. the difference is .009 for 10 and .0009 for 1 of a degree. Therefore sin 57.8 is .839 + .0072 = .846 .

The readings of a normal student in the lab

Experiment No. 1:

To find the volume of a cylinder using Vernier calipers.

Observations and Calculations:

Value of the smallest scale division = x = 0.1 cm
No. of divisions on the vernier scale = y = 10
Vernier constant (V.C.) = x/y = 0.1/10 = 0.01 cm
Zero error = i) ± zero , ii) ± zero , iii) ± zero
Mean zero error = nil ; Zero correction = nil

No of ob.	Quantity	Main scale reading	Vernier divisions coinciding	Fraction	Total reading
		x_1	N	Δx = n x V.C.	$x = x_1 + \Delta x$
		cm		cm	cm
1	**Length**	3.8	5	5 x .01= .05	3.85
2		3.9	1	1 x .01 =.01	3.91
3		3.8	4	4 x .01 =.04	3.84
1	Diameter	1.2	3	3 x .01 =.03	1.23
2		1.2	3	3 x .01 =.03	1.23
3		1.2	4	4 x .01 =.04	1.24

Mean length of cylinder = L = 11.6/3 = 3.86 cm
Mean diameter of cylinder = D = 3.69/3 = 1.23 cm
Radius of the cylinder R = D/2 = 0.62 cm
Volume of the cylinder = V = $\pi R^2 L$ = $\boxed{4.588\ cm^3}$

Experiment No. 2:

To find area of cross-section of a wire and volume of a small sphere using micrometer screw gauge.

Observations and Calculations:

Pitch of the screw gauge = x = 1 mm
No. of divisions on circular scale = y = 100
Least count (L.C.) = x / y = 1/100 = 0.01 mm
Zero error = i) + .05, ii) +.07 , iii) + .06
Mean zero error = + .06 ; Zero correction (Z.C.) = - .06

No. of obs.	Quantity	Linear scale reading	Circular scale reading	Fraction	Diameter Observed	Diameter Corrected
		R′	N	x = n x L.C.	R = R′ + x	R ± Z.C.
		mm		mm	mm	mm
1	*Wire*	1	59	59x.01=0.59	1.59	1.53
2		1	63	63x.01=0.63	1.63	1.57
3		1	58	58x.01=0.58	1.58	1.52
1	Small sphere	3	87	87x.01=0.87	3.87	3.81
2		4	11	11x.01=0.11	4.11	4.05
3		3	92	92x.01=0.92	3.92	3.86

a) Mean diameter = D = 4.62/3 = 1.54 mm
Radius r = D/2 = 1.54/2 = 0.77 mm
Area of cross-section of the wire = A = πr^2 = $\boxed{1.86\ mm^2}$

b) Mean diameter of small sphere = d = 11.72/3 = 3.91 mm
Radius = r = d/2 = 3.91/2 = 1.95 mm = .195 cm
Volume of small sphere = V = $4/3\ \pi r^3$ = $\boxed{0.031\ cm^3}$

Experiment No. 3:

To find the unknown weight of a body by the method of vector addition of forces.

Observations and Calculations:

No. of obs.	Forces		Angles		Vertical components		Unknown weight = W
	P	Q	θ_1	θ_2	P $\sin\theta_1$	Q $\sin\theta_2$	P $\sin\theta_1$ + Q $\sin\theta_2$
	gm-wt	Gm-wt	θ^o	θ^o	gm-wt	Gm-wt	gm-wt
1	30	30	49	48	22.65	22.29	44.94
2	40	35	48	25	29.72	14.79	44.51
3	35	40	27	46	15.88	28.77	44.65

Mean W = 44.73 gm-wt

Experiment No. 4:

Determination of value of g by free fall method using an electronic timer/ticker timer.

Observations and Calculations:

No. of obs.	Height fallen S	Time of fall T	t^2	g = $\frac{2S}{t^2}$
	cm	sec	sec^2	cm/sec^2
1	74.3	0.40	0.16	928.75
2	70.5	0.38	0.14	1007.14
3	65.1	0.36	0.13	1001.53
4	60.2	0.36	0.13	926.15
5	58.4	0.35	0.12	973.33

Mean 'g' = 967.38 cm / sec^2

Calculating g from the graph value of ((S / t^2)

$$g = 2S/t^2 = 978 \text{ cm / sec}^2$$

Inference : *The calculated value of g is a little different from actual value of g in this place of College laboratory (which we don't know exactly) due to experimental handling.*

Experiment No. 5:

Verification of following relations of the simple pendulum:

i) Time period is independent of the amplitude.

ii) Time period is independent of its mass or density of the bob.

iii) Time period is directly proportional to the square root of its length.

Observations and Calculations:

i) T is independent of amplitude,
for l and m constants.

Length of the simple pendulum = 100 cm

Mass of the pendulum = m

No. of obs.	Amplitude X	Time for 20 vibrations			Time period T = t / 20
		1	2	Mean T	
	cm	sec	sec	sec	sec
1	*6*	*36.9*	*37.0*	*36.95*	*1.85*
2	*8*	*37.0*	*37.0*	*37.0*	*1.85*
3	*10*	*37.0*	*36.9*	*36.95*	*1.85*

Inference: *Since time period remains constant, it is independent of amplitude.*

ii) T is independent of mass, for l and x constants.

Length of the pendulum = 100 cm

The amplitude = 6 cm

No. of obs.	Mass of the bob m	Time for 20 vibrations			Time period T = t / 20
		1	2	Mean T	
	gm	sec	sec	sec	sec
1	*75*	*37.0*	*37.1*	*37.05*	*1.85*
2	*70*	*37.0*	*37.0*	*37.0*	*1.85*
3	*65*	*36.9*	*37.0*	*36.95*	*1.85*

Inference: *Since time period remains constant, it is independent of mass.*

iii) $T \propto \sqrt{l}$, for m and x constant.

The radius of the bob = 0.8 cm

No. of obs.	Length of string including hook l_1	Total length $l = l + r$	Time for 20 vibrations			Time period T = t / 20	$T / \sqrt{l}$
			1	2	Mean T		
	cm	cm	sec	sec	sec	sec	sec/ √cm
1	*99.2*	*100*	*40*	*41*	*40.5*	*2.025*	*0.203*
2	*89.2*	*90*	*38.6*	*38.9*	*38.7*	*1.925*	*0.203*
3	*79.2*	*80*	*37.1*	*37.0*	*37.1*	*1.86*	*0.207*

Inference: Since $T / \sqrt{l}$ is constant, $T \propto \sqrt{l}$.

Experiment No. 6:

To find the acceleration due to gravity by oscillating mass spring system.

Observations and Calculations:

Initial position of the pointer = 0.2 cm

No. of obs.	Mass suspended M	Extension	Time for 20 vibrations			Time Period	T^2	$g = \frac{4\pi^2}{T^2} x$
		x	1	2	Mean	$T = t/20$		
	gm	cm	sec	sec	sec	sec	sec	cm/sec^2
1	*100*	*2.35*	*6.1*	*6.2*	*6.15*	*0.3075*	*0.095*	*975.57*
2	*150*	*3.25*	*7.2*	*7.3*	*7.25*	*0.362*	*0.131*	*978.42*
3	*200*	*4.10*	*8.3*	*8.2*	*8.25*	*0.413*	*0.170*	*951.15*

Mean 'g' = 968.38 cm/sec^2

Actual value = 980 cm/sec^2

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{980 - 968.38}{980} \times 100 = 1.2\ \%$$

Experiment No. 7(a):

To study the laws of conservation of momentum by colliding trolleys and ticker timer for inelastic collisions.

Observations and Calculations:

Frequency of the ticker timer , f = 50 dots/sec

Time interval of two consecutive dots = 1/50 = 0.02 sec

Mass of the trolley A , m_1 = 223 gm

Mass of the trolley B, m_2 = 221 gm

No. of obs.	Before collision				After collision				Difference between momenta
	distance	Time	Velocity	Momentum	distance	time	Velocity	Momentum	
	x_1	t_1	$x_1 / t_1 = v_1$	$(m_1 v_1)$	x_2	t_2	$x_2 / t_2 = v_2$	$(m_1 + m_2)v_2$	
	cm	sec	cm/sec	gm-cm/sec	cm	sec	cm/sec	gm-cm/sec	gm-cm/s
1	*45*	*1.5*	*30*	*6690*	*15.2*	*0.98*	*15.5*	*6886.53*	*196.5*
2	*38*	*1.36*	*27.94*	*6230.88*	*10.3*	*0..74*	*13.92*	*6180.01*	*50.88*

Average difference = 123.69 gm-cm/sec

Inference: *The difference of momenta is due to frictional forces.*

Experiment No. 7(b):

To study the laws of conservation of momentum by colliding trolleys and ticker timer for elastic collisions.

Observations and Calculations:

Frequency of the ticker timer , f = 50 dots/sec
Time interval of two consecutive dots = 1/50 = 0.02 sec
Mass of the trolley A , m_1 = 220 gm
Mass of the trolley B, m_2 = 225 gm

No. of obs.	Distance	Time	Velocity	Momentum
	x	t	*X* / t = v	m · v
	cm	sec	cm/sec	gm-cm/sec
	Trolley A before collision			
1	*31.4*	*1.6*	*19.6*	*4317*
2	*28.5*	*1.14*	*25.0*	*5500*
	Trolley A after collision			
1	*-2.8*	*1.1*	*-2.5*	*-560*
2	*-3.1*	*1.47*	*2.11*	*-463.94*
	Trolley B after collision			
1	*17.5*	*0.86*	*20.3*	*4567.5*
2	*20.3*	*0.91*	*22.31*	*5019.23*

1st attempt:

Total momentum before collision = 4317 + 0 = 4317 gm-cm/sec
Total momentum after collision = -560 + 4567.5 = 4007.5 gm-cm/sec
Difference = 309.5 gm-cm/sec

2nd attempt:

Total momentum before collision = 5500.0 + 0 = 5500.0 gm-cm/sec
Total momentum after collision = -463.94 + 5019.23 = 4555.29 gm-cm/sec
Difference = 944.71 gm-cm/sec
Inference: The difference of momenta is due to frictional forces.

Experiment No. 8:

Verify the second condition of equilibrium using a suspended meter rod.

Observations and Calculations:

Position of center of gravity of meter rod = G = 50.1 cm
Weight of the meter rod = *w* = 40 gm-wt
Axis of rotation = One end of meter rod = C = 0 .00 cm

No. of obs.	Forces			Moment arm			Torques about G			$\Sigma\tau = \tau_1+\tau_2+\tau_3$
	P	Q	F = W+w	CA	CB	CG	Counter Clockwise τ_1=P x AG	Counter clockwise τ_2=Q x BG	Clockwise τ_3=F x CG	
	gm-wt	gm-wt	gm-wt	cm	cm	cm	gm-wt-cm	gm-wt-cm	gm-wt-cm	gm-wt-cm
1	*30*	*30*	*20+40*	*35.2*	*66.8*	*50.1*	*30 x 35.2 =1056*	*30 x 66.8 =2004*	*60 x 50.1 =3006*	*1056+2004-3006=54*
2	*35*	*35*	*30+40*	*25.4*	*71.2*	*50.1*	*35 x 25.4 =889*	*35 x 71.2 =2492*	*70 x 50.1 =3507*	*889+2492-3507=126*
3	*45*	*45*	*50+40*	*17.9*	*78.2*	*50.1*	*45 x 17.9 =805.5*	*45 x 78.2 =3519*	*90 x 50.1 =4509*	*806+3519-4509=184*

Verification of 2nd condition:

Summation of all the torques is nearly equal to zero, so within the limits of experimental error, $\Sigma\tau = 0$

Experiment No. 9:

To study the fall of a body through a viscous medium and hence to deduce the coefficient of viscosity of the medium.

Observation and Calculations:

Diameter of the ball = i) 1.52 cm ii) 1.48 cm iii) 1.50 cm
Mean diameter = D = 1.50 cm
Radius = r = 0.75 cm = 0.0075 m
Density of glass ball = d = 1.36 x 10^3 kg/m^3
Density of glycerin = ρ = 1.23 x 10^3 kg/m^3, (at 20^o)

No. of obs.	Distance of fall AB	Time taken T	Terminal velocity v	$\eta = \frac{2}{9}\frac{r^2 g(\rho - d)}{v}$
	m	sec	m/sec	N s/m^2
1	*0.14*	*0.78*	*0.18*	*0.776*
2	*0.14*	*0.82*	*0.17*	*0.821*
3	*0.14*	*0.74*	*0.19*	*0.720*

Mean η = 0.776 N s/m^2

Experiment No. 10:

To determine Young's Modulus of a wire by Searle's apparatus.

Observation and Calculations:

Length of the wire = L = 398 cm
Diameter of the wire = d
i) .045 cm , ii) .055 cm,
iii) .065 cm, iv) .056 cm
Mean diameter = d = 0.055 cm
Radius = d/2 = r = .0275 cm
Area of cross-section of the wire = a = πr^2 = .00238 cm^2

No. of obs.	Loads added on the hanger	Micrometer reading			Elongation for 1 kg l
		Load increasing	Load decreasing	Mean	
	Kg	mm	mm	mm	mm
1	*0*	*1.21*	*1.22*	*1.215*	—
2	*1*	*2.11*	*2.15*	*2.13*	*0.915*
3	*2*	*2.88*	*2.90*	*2.89*	*0.76*
4	*3*	*3.71*	*3.78*	*3.745*	*0.855*
5	*4*	*4.49*	*4.49*	*4.49*	*0.75*

Mean elongation = l = 0.82 mm
= 0.082 cm

Force = Mg = 1 x 1000 x 980 dynes

Young's modulus = Y = MgL / al = $\frac{980000 \times 398}{0.00238 \times .082}$ = 23 x 10^{11} dynes / cm

Actual value = 19 x 10^{11} dynes/cm

Percentage error = $\frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$

$= \frac{19 \times 10^{11} - 23 \times 10^{11}}{19 \times 10^{11}} \times 100$ = 21 %

Experiment No. 11:

To find the moment of inertia of a fly-wheel.

Observations & Calculations:

Diameter of the axle = i) 3.1 cm ii) 3.0 cm iii) 2.9 cm
Mean diameter = 3.0 cm

Radius of the axle = r = 1.5 cm

No. of obs	Mass (hanger+ weights)	Height	String turns on the axle	Rotation of the wheel N			Time for N rotations t			$\omega = \frac{4\pi N}{t}$	$I = \frac{N}{N+n} \frac{m(2gh - r^2)}{\omega^2}$
	m	h	n	1	2	Mean	1	2	Mean		
	gm	cm					sec	sec	sec	rad/s	gm-cm^2
1	150	121	14	19	17	18	4.3	4.1	4.2	53.82	6718.41
2	160	121	14	22	23	22.5	4.5	4.6	4.55	62.11	5841.65
3	140	120	15	18	17	17.5	4.2	4.1	4.15	52.96	6151.95

Mean I = 6237.34 gm-cm^2

Experiment No. 12:

Determination of frequency of A.C. by Melde's apparatus.

Observations and Calculations:

Length of the string = 500 cm
Mass of the string = 1.132 gm
Mass per unit length = m = 1.132 / 500 = 0.0022 gm

No. of obs.	No. of loops	Distance between extreme nodes	Length of each loop	Total mass with hanger	Tension	$\nu = 1/2l\,(\sqrt{T/m})$
	P	L	l = L/p	M	T = Mg	
		cm	cm	gm	dynes	hertz
1	*4*	*97.5*	*24.37*	*60*	*58860*	*104.71*
2	*3*	*87.0*	*29.0*	*80*	*78480*	*101.61*
3	*3*	*96.0*	*32.0*	*100*	*98100*	*103.0*

Mean ν = 103.1 hertz

For transverse mode arrangement:

Frequency = ν = 103.1 /2 = 51.5 hertz

Correct value of A.C. supply = 50 vib/sec or hertz

Percentage error = $\frac{50 - 51.5}{50} \times 100 = 3\ \%$

Experiment No. 13(a):

Investigation of the law of length of stretched strings by sonometer.

Observations and Calculations:

Stretching force including the hanger = 2.5 kg-wt

No. of obs.	Frequency	Resonant length			$\nu \times l$
		1	2	Mean: l	
	Hertz	m	m	m	hertz-m
1	*512*	*0.09*	*0.091*	*0.09*	*46.08*
2	*480*	*0.097*	*0.095*	*0.096*	*46.08*
3	*384*	*0.12*	*0.122*	*0.121*	*46.47*

Inference: *Since $\nu \times l$ is constant, the law of length is verified.*

Experiment No. 13(b):

Investigation of the law of tension of stretched strings by sonometer.

Observations and Calculations:

Length of vibrating segment = 0.122 m

No. of obs.	Frequency	Total load			Tension	$\sqrt{T}$	$\nu / \sqrt{T}$
		1st	2nd	Mean	$T = mg$		
	Hertz	kg-wt	kg-wt	kg-wt	Newtons		
1	*512*	*1.5*	*1.51*	*1.5*	*14.7*	*3.83*	*133.7*
2	*480*	*1.25*	*1.26*	*1.25*	*12.25*	*3.5*	*137.1*
3	*384*	*0.89*	*0.90*	*0.89*	*8.72*	*2.95*	*130.2*

Inference: *Since $\nu / \sqrt{T}$ is constant, the law of tension is verified.*

Experiment No. 14(a):

To determine the wave length of sound in air using stationary waves and to calculate the speed of sound by one resonance position and applying end correction.

Observations and Calculations:

Internal diameter of the tube = i) 3.49 cm , ii) 3.42 cm , iii) 3.44 cm

Mean diameter = D = 3.44 cm

End correction = 0.3D = .3 x 3.44 = 1.03 cm

Room temperature = t = 31.5 ^{o}C

No. of obs.	Frequency	Resonance position			Length of resonating air column	$v_t = \nu\lambda = \nu \times 4l$
	ν	1	2	Mean: L	$l = L + 0.3D$	
	Hertz	cm	cm	cm	cm	cm/sec
1	*512*	*15.2*	*15.3*	*15.25*	*16.503*	*33798.1*
2	*480*	*16.5*	*16.6*	*16.55*	*17.616*	*33823.3*
3	*384*	*21.0*	*20.9*	*20.95*	*21.970*	*33745.7*

Mean v_t = 33789.03 cm/sec

Velocity of sound at 0 ^{o}C = $v_o = v_t - 61t$

or v_o = 33789.03 – (61 x 31.5) = 31867.53 cm/sec

Actual value = 33200 cm/sec

$$\text{Percentage error} = \frac{\text{Actual value} - \text{calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{33200 - 31867.5}{33200} \times 100 = 4.01\ \%$$

Experiment No. 14(b):

To determine the wave length of sound in air and to calculate the speed of sound by using resonance positions in stationary waves for both ends open.

Observations and Calculations:

Room temperature = t = 31.5 ^oC

Internal diameters of the tubes ;

1^{st} end = D_1 = i) 2.41 cm , ii) 2.39 cm , iii) 2.40 cm

Mean diameter = D_1 = 2.40 cm

2^{nd} end = D_2 = i) 2.34 cm , ii) 2.35 cm , iii) 2.36 cm

Mean diameter = D_2 = 2.35 cm

End correction = $0.3D_1 + 0.3\,D_2 = .3\,(D_1+D_2) = .3D =$ 1.43 cm

.No .of obs	Frequency	Resonance length			Corrected length	$\lambda = 2l$	$v_t = f\lambda = 2f\,l$
	F	1	2	Mean: L	$l = L + 0.3D$		
	Hertz	cm	cm	cm	cm		cm/sec
1	*512*	*31.62*	*31.60*	*31.61*	*33.03*	*66.06*	*33825*
2	*480*	*33.77*	*33.73*	*33.75*	*35.19*	*70.37*	*33778*
3	*384*	*42.65*	*42.63*	*42.64*	*44.07*	*88.15*	*33850*

Inference: *Frequency and wavelength are inversely proportional to each other*.

Mean v_t = 33817.67 cm/sec

Velocity of sound at 0 ^oC = $v_o = v_t - 61t$ =

= 33817.67 – (61x31.5) = 31896.17 cm/sec

Actual value = 33200 cm/sec

$$\text{Percentage error} = \frac{33200 - 31896}{33200} \times 100 = 3.9\ \%$$

Experiment No. 15:

To determine the focal length of a convex lens by displacement method.

Observations and Calculations:

Approximate focal length = F = 10 cm

Length of knitting needle = l_1 = 30 cm

Distance between two needles = l_2 = 29.3 cm

Index correction for the needles = $l_1 - l_2$ = 0.7 cm

No. of obs.	Positions of				$d = L_2 - L_1$	Distance, l (between O & I)		$f = (l^2 - d^2)/4l$
	Object needle	Image needle	Lens			Observed	Corrected	
	O	I	L_1	L_2		l'	L	
	cm	cm	cm	cm	cm	cm	cm	cm
1	*17.9*	*68.8*	*50*	*36.8*	*13.2*	*50.9*	*50.2*	*11.8*
2	*19*	*68.9*	*50*	*40.5*	*9.5*	*49.9*	*49.2*	*12*
3	*20*	*69.4*	*50*	*45.8*	*4.2*	*49.4*	*48.7*	*12.2*

Mean f = 12.0 cm

Experiment No. 16(a):

To determine the focal length of a concave lens by using a concave mirror.

Observations and Calculations:

Approximate focal length of concave mirror = F = 20 cm
Length of knitting needle = x = 30 cm
Distance between needle and mirror = y = 30.4 cm
Distance between needle and lens = z = 30.3 cm
Index correction for concave mirror = $x - y$ = - 0.4 cm
Index correction for concave lens = $x - z$ = - 0.3 cm
Position of the mirror = M = 10 cm

No. of obs.	Position of			Observed		Corrected		$f = \frac{p\ x{-}q}{p+(-q)}$
	Needle at C	Lens L	Needle at O	p′ OL	q′ CL	p	Q	
	cm	cm	cm	cm	cm	cm	cm	cm
1	*28.5*	*18.9*	*44.3*	*25.4*	*9.6*	*25.0*	*9.3*	*- 14.8*
2	*28.0*	*18.7*	*43.1*	*24.4*	*9.3*	*24.0*	*9.0*	*- 14.4*
3	*29.0*	*19.2*	*45.6*	*26.4*	*9.8*	*26.0*	*9.5*	*- 14.96*

Mean f = -14.7 cm

Experiment No. 16(b):

To determine the focal length of a concave lens by using a convex lens.

Observations and Calculations:

Approximate focal length of convex lens = F = 20 cm
Length of knitting needle = x = 30 cm
Distance between concave lens and image needle = y = 30.4 cm
Index correction for p = $x - y$ = - 0.3 cm
Index correction for q = $x - z$ = - 0.4 cm

No. of obs.	Position of					Observed		Corrected		$f = \frac{p\ x{-}q}{p+(-q)}$
	Needle at O	Convex lens L_1	Concave lens L	Needle at I	I′	p′ LI	q′ LI′	p	q	
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
1	*28.5*	*18.9*	*34.7*	*44.3*	*60.1*	*9.6*	*25.4*	*9.3*	*25.0*	*- 14.8*
2	*28.0*	*18.7*	*33.8*	*43.1*	*58.2*	*9.3*	*24.4*	*9.0*	*24.0*	*- 14.4*
3	*29.0*	*19.2*	*35.8*	*45.6*	*62.2*	*9.8*	*26.4*	*9.5*	*26.0*	*-14.96*

Mean f = -14.7 cm

Experiment No. 17(a):

To find the refractive index of the material of a prism using spectrometer.

Observations and Calculations:

Least count of the spectrometer = 1.5 cm

Table for angle of the prism A:

No. of obs.	Telescope reading		Difference = 2A	Angle A
	Left	Right		
1	*6°16′00″*	*66°15′30″*	*59°59′30″*	*29°59′45″*
2	*10°18′30″*	*70°19′00″*	*60°00′30″*	*30°00′15″*
3	*7°14′00″*	*67°14′30″*	*60°00′30″*	*30°00′15″*

Mean angle of the prism A = 60° 00′ 05″ = 60°

Table for the angle of Minimum Deviation, D_m :

No. of obs.	Min. Deviation reading	Direct reading	Difference = D_m
1	*70°11′30″*	*30°33′00″*	*39°38′30″*
2	*75°12′00″*	*35°14′30″*	*39°57′30″*
3	*73°11′30″*	*33°21′00″*	*39°50′30″*

Mean D_m = 39° 48′ 30″ = 39.81°

$$\text{Index of refraction} = \frac{\sin (A + D_m) / 2}{\sin A / 2} = \frac{\sin(60 + 39.81) / 2}{\sin (60 / 2)} = 1.53$$

Experiment No. 17(b):

To find the refractive index of the material of a prism using a laser.

Observations and Calculations:

Table for angle of the prism A:

Laser pointer at				From geometry of the figure	Angle of prism
Left side		Right side			
L_1	L_2	R_1	R_2	2A	A
cm	cm	cm	cm	Degrees	Degrees
22.5	*27.3*	*49.5*	*61.3*	*30.01*	*60.0*

A = 60.0°

Table for the angle of Minimum Deviation, D_m :

Laser pointer at				From geometry of the figure
Incident light		Refracted light		
I_1	I_2	R_1	R_2	D_m
cm	cm	Cm	cm	degrees
42.4	*37.3*	*77.1*	*65.2*	*39.5*

D_m = 39.5°

$$\text{Index of refraction} = \frac{\sin (A + D_m) / 2}{\sin A / 2} = \frac{\sin(60 + 39.5) / 2}{\sin (60 / 2)} = 1.52$$

Experiment No. 18:

To find the refractive index of the material of a prism by critical angle method.

Observations and Calculations:

No. of obs.	∠ PMQ	Critical Angle = ½ ∠ PMQ
	degrees	degrees
1	81	40.5
2	79	39.5
3	80	40

Mean critical angle = C = 40^{o}

Refractive index of glass = n = 1/sinC = 1/ sin40 = 1.5

Experiment No. 19:

To find the refractive index of a liquid, using a concave mirror.

Observations and Calculations:

Approximate focal length of the concave mirror = 25 cm

No. of obs.	Height of the needle above the liquid surface, after removing the parallax		$n = \frac{h_1}{h_2}$
	Without liquid, h_1	With liquid, h_2	
	cm	cm	
1	25.4	19.1	1.329
2	25.2	18.9	1.333
3	25.5	19.1	1.314

Mean refractive index of the liquid (water) = n = 1.325

Experiment No. 20:

To determine the wavelength of sodium light by Newton's rings.

Observations and Calculations:

Least count of spherometer = 0.01 mm
Mean distance between the two legs = l
Reading of spherometer on convex surface =
Reading of spherometer on plane surface =
Difference = h
Radius of curvature = R = l^2 /6h + h /2 = 524 cm
Least count of the microscope = 0.005 cm
Eyepiece adjusted so that 100 scale division = 5 mm
∴ each division = x = .05 mm
eyepiece scale division = y

No. of obs.	Ring No.	Microscope reading		Diameter $y \times x$	Square of diameter	$\lambda = \frac{D_n^2 - D_m^2}{4(n-m)R}$
	N	Left	Right	mm	mm^2	(cm)
1	8^{th}	22	78	56x.05=2.8	7.84	$\frac{D_{10}^2 - D_8^2}{4(2)524} = 4222 \times 10^{-8}$
2	10^{th}	19	81	62x.05=3.1	9.61	$\frac{D_{12}^2 - D_{10}^2}{4(2)524} = 5128 \times 10^{-8}$
3	12^{th}	16	84	68x.05=3.4	11.56	$\frac{D_{14}^2 - D_{12}^2}{4(2)524} = 5081 \times 10^{-8}$
4	14^{th}	13	87	74x.05=3.7	13.69	

$$\text{Mean } \lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3} = 4810 \times 10^{-8} \text{ cm}$$

Actual value of $\lambda = 5896 \times 10^{-8}$ cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100 = \ldots\ldots \%$$

Experiment No. 21(a):

To determine the wavelength of sodium light by diffraction grating using spectrometer.

Observations and Calculations:

Least count of the spectrometer = 1.5 cm
No. of lines on the grating = n = 2400 line/inch
No. of lines per centimeter on the grating = n_1 /2.54 = n
Grating element = d = 1/n = 2.54 /2400 = 1058 x 10^{-6}

No. of obs.	Order of spectrum	Telescope reading		*Angle of diffraction*			$\lambda = \frac{(a+b)\sin\theta}{n}$
		Right	Left				
	N	R	L	2θ = L - R	θ	Sin θ	cm
1	$I_{n=1}$	17°16′30″	23°51′00″	6°34′30″	3°17′15″	0.0573	6067×10^{-8}
2	$II_{n=2}$	13°55′30″	27°9′00″	13°13′30″	6°30′45″	0.1151	6091×10^{-8}

Mean $\lambda = 6067 \times 10^{-8}$ cm
Actual wavelength = 5890×10^{-8} cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{5890 - 6079}{5890} \times 100 = 3.2\ \%$$

Experiment No. 21(b):

To determine the wavelength of laser light by diffraction grating using a laser.

Observations and Calculations:

No. of lines on the grating = n = 2400 line/inch
No. of lines per centimeter on the grating = n_1 /2.54 = n
Grating element = d = 1/n = 2.54 /2400 = 1058 x 10^{-6}

No. of obs.	Order of spectrum	Distance normal	Distance Left	Distance Right	Angle of diffraction $\tan^{-1} OL / OC = \theta_L$ & $\tan^{-1} OR / OC = \theta_R$				$\lambda = \frac{d \sin\theta}{n}$
		OC	OL	OR	θ_L	θ_R	θ_{av}	$\sin \theta_{av}$	
	N	cm	cm	cm	degrees	degrees	degrees		cm
1	$I_{n=1}$	246.7	14.1	14.2	3.27°	3.29°	3.28°	0.057	6055 x 10^{-8}
2		257.3	16.5	16.4	3.67°	3.65°	3.66°	.064	6756 x 10^{-8}
1	$II_{n=2}$	243.2	28.0	27.9	6.57°	6.54°	6.56°	0.114	6041 x 10^{-8}
2		215.5	27.8	27.7	7.35°	7.32°	7.34°	0.128	6755 x 10^{-8}

Mean λ = 6402 x 10^{-8} cm
Actual wavelength = 6800 x 10^{-8} cm

$$\text{Percentage error} = \frac{\text{Actual value} - \text{Calculated value}}{\text{Actual value}} \times 100$$

$$= \frac{(6800 - 6402)\,10^{-8}}{6800 \times 10^{-8}} \times 100 = 5.8\ \%$$

Experiment No. 22:

To measure the diameter of a wire or hair using laser.

Observations and Calculations:

Wave length of laser light = λ = 6800 x 10^{-8} cm

No. of obs.	Order of spectrum	Distance normal	Distance First	Distance Second	Angle of diffraction $\tan^{-1} OF / OC = \theta_1$ & $\tan^{-1} OS / OC = \theta_2$				$d = \frac{n\lambda}{\sin\theta}$
		OC	OF	OF	θ_1	θ_1	θ_{av}	$\sin \theta_{av}$	
	N	cm	cm	cm	degrees	degrees	degrees		cm
1	$I_{n=1}$	230	3.1	3.1	0.77°	0.77°	0.77°	.0134	.0049
2		255	3.4	3.4	0.76	0.76	0.76	.0133	.0051
1	$II_{n=2}$	OC	OS	OS	θ_2	θ_2	θ_{av}	$\sin \theta_{av}$	.0050
		230	6.3	6.3	1.57°	1.57°	1.57°	.0274	
2		255	7.0	7.1	1.57	1.59	1.58	.0276	.0049

Mean d = = .004975 = 4975 x 10^{-6} cm

Experiment No. 23:

Setting up a telescope and determination of its magnifying power and length.

Observations and Calculations:

Approximate focal length objective = F_o = 20 cm
Approximate focal length eyepiece = F_e = 10 cm
Length of knitting needle = l_1 = 30 cm
Distance between two needles = l_2 = 29.3 cm
Index correction for the needles = $l_1 - l_2$ = 0.7 cm

No. of obs.	Positions of Object needle	Image needle	Lens		$D = L_2 - L_1$	Distance, l (between O & I) Observed	Corrected	$f = (l^2 - d^2)/4l$
	O	I	L_1	L_2		l'	L	
	cm	cm	cm	cm	cm	cm	cm	cm
Eye-piece	*17.9*	*68.8*	*50*	*36.8*	*13.2*	*50.9*	*50.2*	*11.8*
	19	*68.9*	*50*	*40.5*	*9.5*	*49.9*	*49.2*	*12*
	20	*69.4*	*50*	*45.8*	*4.2*	*49.4*	*48.7*	*12.2*
Obje-ctive	*12*	*88.3*	*76*	*68.3*	*7.7*	*76.3*	*77.0*	*19.1*
	6	*79.3*	*72*	*61.2*	*10.8*	*73.3*	*74.0*	*18.1*
	18	*92.2*	*73*	*64.4*	*8.6*	*74.2*	*74.9*	*18.5*

Mean focal lengths : f_o = 18.6 cm & f_e = 12.0 cm
Magnifying power of the telescope = f_o / f_e = 1.55
Length of the telescope = $f_o + f_e$ = 30.6 cm

Experiment No. 24:

To find the coefficient of linear expansion of the material of a rod by Pullinger's apparatus.

Observations and Calculations:

Initial length of the rod = L = 100 cm
Initial temperature of the rod = t_1 = 32 ^oC
Final temperature of the rod = t_2 = 98 ^oC
Rise in temperature = $t_2 - t_1 = t$ = 66 ^oC
Pitch of the spherometer = 0.5 mm
No. of divisions of the circular scale = 100
Least count of the spherometer = 0.005 mm

Table for Spheromaeter:

No. of obs.	Initial reading (with cold water)	Final reading (when steam is passed)	Increase in length (Expansion)
	mm	mm	mm
1	1.45	1.56	0.11
2	1.25	1.37	0.12
3	1.35	1.47	0.12

Mean expansion = Δl = 0.1166 mm

Coefficient of linear expansion:

$$\alpha = \frac{\Delta l}{L \times \Delta t} = \frac{0.1166}{100 \times 66} = 17.66 \times 10^{-6}\ {}^oC^{-1}$$

Correct value (for brass) = $19 \times 10^{-6}\ {}^oC^{-1}$
Percentage error = 7.02 %

Experiment No. 25:

To measure the mechanical equivalent of heat by electrical method.

Observations and Calculations:

Specific heat of copper calorimeter = c_1 = 0.095 cal/gm ^oC
Mass of calorimeter + stirrer = m_1 = 80 gm
Mass of calorimeter + stirrer + water = m_2 = 125 gm
Mass of water = $m_2 - m_1$ = m = 45 gm
Specific heat of water = c = 1.0 cal/gm ^oC
Initial temperature of water = T_1 = 29 ^oC
Final temperature of water = T_2 =34.5 ^oC
Rise in temperature = $\Delta T = T_2 - T_1$ = 5.5 ^oC
Current from ammeter = I = 1.0 amp
Voltage from voltmeter = V = 5.3 volts
Time for which current flows = t = 4 min = 240 sec

Mechanical equivalent of heat = $J = \dfrac{V\,I\,t}{(mc + m_1 c_1)\,\Delta T} = \dfrac{5.3 \times 1 \times 240}{(45 \times 1 + 80 \times 0.095)\,5.5}$

= 4.397 joules/cal
= 4.3×10^7 ergs/cal

Actual value = 4.2×10^7 ergs/cal
Percentage error = 4.7 %