PHYSICS 510/3 PRACTICALS

MEASURING INSTRUMENTS

1. **Metre rule**
   Measures length in cm to $\mathbf{1}dp$
   e.g. 2.0 cm, 10.2 cm, 12.7 cm etc

2. **Vernier caliper**.
   Measures length in cm to 2dps
   eg 2.62cm, 6.67cm etc

3. **Micrometer screw gauge**
   Measures length in mm
   eg 0.34mm, 0.67mm etc

4. **Stop clock**
   Measures time in seconds (s) to $\mathbf{1}dp$
   e.g. $10.0s$ $25.5s$, $16.0s$ $17.5s$

5. **Stop watch**
   Measures time in seconds (s) to $\mathbf{2}dps$
   e.g $12.43s, 20.92s, 16.73$ etc

6. **Protractor**
   Measures angles in degrees (^{o}) to $\mathbf{0}dps$
   e.g. 10^0, 24^0, 29^0 etc.

7. **Ammeter**
   Measures current in amperes (A) to
   $\mathbf{2}\ dps$
   The last decimal value is
   0 $or\ an\ even\ number$.
   e.g $0.24A$, $1.40A$, $2.20A\ etc$

8. **Voltmeter**
   Measures $p.d$ in volts (V) to $\mathbf{2}\ dps$.
   The last decimal value is
   0 or $5.eg$ $0.45V$, $1.20V$, $4.50V$, $4.20V\ etc$

9. **Electronic beam balance.**
   Measures mass in grams (g) to
   $\mathbf{1}\ dp\ or\ \mathbf{2}dps$.
   e.g. $45.00g$, $158.00g\ or\ 40.0g$, $34.0g\ etc$

UNITS AND SYMBOLS

- Units are stated using the right symbols.
- Abbreviation of units is not used e.g. Unit for time is, (s) NOT sec
- Units named after Scientists are written with capital letters. e.g. watts (W), joule (J) ampere (A).
- Units must be written in brackets e.g. $m(kg)$, $t(s)$, $I(A)\ etc.$ **NOT** m/kg, t/s, I/A
- Units of derived quantities are written using Scientific notations e.g. ms^{-1} **NOT** m/s, kgm^{-3} **NOT** kg/m^3, Ω **NOT** V/A.
- $\boldsymbol{sin, cos, tan, log}$ do not have units.
- Values of $\boldsymbol{sin, cos, tan, log}$, are written to 3 dps.

e.g. $sin30^0 = 0.500$
$log2 = 0.301$ $cos30^0 = 0.866$

SIGNIFICANT FIGURES

1. All non - zero digits are significant. e.g.
   $1, 2, 3, 4, 5, 6, 7, 8, 9$
   $12.1\ has\ 3sfs$
   $2471\ has\ 4sfs$
   $1.2\ has\ 2sfs$

2. Zeros between non – Zero digits are Significant e.g.
   $10.1\ has\ 3sfs$
   $102\ has\ 3sfs$
   $100006\ has\ 5sfs$
   $2007\ has\ 4sfs$

3. Zeros to the left of the first non - Zero digits are not significant e.g.
   $0.12\ has\ 2sfs$
   $0.00006\ 1sfs$
   $0.0202\ has\ 3sfs$

4. Zeros at the end of a number and at the right of a $dp\ are\ significant$
   4.0 $has\ 2sfs$
   4.000 $has\ 4sfs$
   0.040 $has\ 2sf$s

5. Zeros at the end of a number without a dp in measured values and given values are significant
   e.g. $10^0\ has\ 2sfs$
   $40^0\ has\ 2sfs$
   $400g\ has\ 3sfs$

GENERAL GUIDELINES

Float:

A float is a constant or whole number which is not measured and therefore has an infinite number of decimal places (dps) and infinite number of significant (sfs). e.g $\pi,\ 2, 10, 20\ etc$

1. Division and multiplication with a float.

Significant figures of a measured value are to be used. e.g.

If $t = 14.2s$ and n=20

$T = \frac{t}{20}$

$= \frac{14.2\ (\ 3sfs)}{20\ (float)}$

$= 0.71\ (\ cal\ )$

$= 0.710s\ (3sfs)$

If $I = 2.46A, then$

$\frac{1}{I} = \frac{1}{2.46\ (\ 3sfs)}$

$= 0.406504065\ (cal)$

$= 0.407A^{-1}\ (3sfs)$

2. Addition and subtraction with a float

Decimal values of a measured value are to used.e.g. If $x = 14.2cm\ then\ 10 + x\ is\ caluculated\ as;$

$$10 + x = 10 + 14.2(\ 1dp)$$

$$= 24.2\ (cal)$$

$$= 24.2\ cm\ (1dp)$$

3. Addition and subtraction with another measured value

Decimal places of a value with the least number of decimal places are to be used e.g. e.g $If\ x = 12.6cm\ and\ y = 20.24cm, then$,

$$x + y = 12.6(1dp) + 20.24(2dps)$$

$$= 32.84\ (cal)$$

$$= 32.8\ (1dp)$$

4. Division and multiplication with another measured value.

Significant figures of the value with the least number of significant figures are to be used.

e.g.

$$5.21(3sfs) \times 4.6\ (2sfs) = 23.966\ (cal)$$

$$= 24(2sfs)$$

$$\frac{0.0463(3sfs)}{2.8\ (2sfs)} = 0.016535714(cal)$$

$$= 0.017\ (2sfs)$$

RECORDING MEASUREMENTS

1. Single measurements:

(a). **To be measured once.**
These are recorded once outside the table of values

- mass of the metre rule
- $e.m.f$ of the cell
- Focal length etc.
- Centre of gravity
- Room temperature

Note; take note of dictating questions e.g. recording in $metres$

(b). To be recorded three times

- Width/Breadth
- Diameter
- Thickness
- Length eg of a glass block

Take note of the degree of accuracy of the instruments used.
Show the working when getting the average.
Values should be recorded in a logical way eg for thickness, t

$t_1 = 6.67cm$
$t_2 = 6.67cm$
$t_3 = 6.67cm$

Then;

$t = \frac{6.67+6.67+6.67}{3}$, $\boldsymbol{t = 6.67cm}$

OR

$t_1(cm)$	$t_2(cm)$	$t_3(cm)$
6.67	6.67	6.67

2. **Repeated measurements**.

Take note of changing quantities e.g. extension, angles, current, voltage etc.

These are recorded in the main table of values

RECORDING IN THE MAIN TABLE OF RESULTS

The main table of results should be columnar
Each column should have a heading with units written in brackets
Take note of units which are names of people.
The table should be self-explanatory.
The main table of results has only values of changing quantities. These are categorized as;

1. Given values
2. Measured values
3. Calculated values

GIVEN VALUES

- These are provided in the procedures
- They are recorded in the first column
- They are recorded as they are provided in their order in the question.

MEASURED VALUES

- They are determined using an instrument
- They are recorded to the degree of accuracy of the instrument.

CALCULATED VALUES

- They are obtained using a formula
- The equations are not included in the table of values

CALCULATED VALUES

- Obtained using a formula
- Equations are not included in the table of values

FILLING TABLE OF RESULTS

A table of results should be

(a) Columnar
(b) Closed

A table must be filled using a pen

Examples

(a) Modal table

Given values	Measured values	Calculated (addition or subtraction)	Division and multiplication	Log, sin, cos, and tan
Appear are they are given	Accuracy of the instrument	dps of the number with smallest number of dps is to be used	First entry use sfs and maintain same dps	All values written to 3 dps

Note

Uniformity in the table of values is based on dps

$\boldsymbol{R}(\Omega)$	$\boldsymbol{I}(\boldsymbol{A})$	$\frac{\mathbf{1}}{\boldsymbol{I}}(\boldsymbol{A^{-1}})$
1	1.50	0.667
2	0.75	1.333
3	0.50	2.000
4	0.30	3.333
5	0.25	4.000

Largest value of $\boldsymbol{I}(\mathbf{1.50})$ gives the number of sfs for the first entry in $\frac{\mathbf{1}}{\boldsymbol{I}}$

$$I = 1.50\ (3\ sfs)$$

$$\frac{1}{I} = \frac{1}{1.50\ (3\ sfs)} = 0.666666666666\ (cal)$$

$$= 0.667(3\ sfs)$$

$i(^0)$	$x(cm)$	$y(cm)$	$\frac{x}{y}$	$\sin i$
10	1.0	6.6	0.15	0.174
20	1.5	6.7	0.22	0.342
30	2.4	7.0	0.34	0.500
40	3.2	7.4	0.43	0.643
50	3.8	7.6	0.50	0.766
60	4.6	8.0	0.58	0.866
			2 dps	3 dps

$$\frac{x}{y} = 0.15151515$$

$$= 0.22388$$

$$= 0.34286$$

$$= 0.43243$$

$$= 0.5$$

$$= 0.575\ (4.6 \div 8.0)$$

$$(2\ sfs)\quad (2\ sfs)$$

t = time for oscillations

$\boldsymbol{l}(\boldsymbol{m})$	$\boldsymbol{t}(\boldsymbol{s})$	$\boldsymbol{T}(\boldsymbol{s})$	$\boldsymbol{T^2}(\boldsymbol{s^2})$
0.900	37.0	1.85	3.42
0.800	36.0	1.80	3.24
0.700	34.5	1.73	2.99
0.600	32.0	1.60	2.56
0.500	29.5	1.48	2.19
0.400	26.0	1.30	1.69
0.300	23.0	1.15	1.32

$T = \frac{t}{n}$

$= \frac{37.0\ (3\ sfs)}{20}$

$= 1.85\ (3sfs)$

$T^2 = T \times T$

$= 1.85(3sfs) \times 1.85(3sfs)$

$= 3.42(3sfs)$

$u(cm)$	$v(cm$	$\frac{v}{u}$	$\frac{1}{u}(cm^{-1})$	$\frac{1}{v}(cm^{-1})$	$(u+v)(cm)$
15.0	30.0	2.00	0.0667	0.0333	45.0
20.0	20.0	1.00	0.0500	0.0500	40.0
25.0	16.7	0.67	0.0400	0.0599	31.7
30.0	15.0	0.50	0.0300	0.0667	45.0
35.0	14.0	0.40	0.0286	0.0714	50.0
40.0	13.3	0.33	0.0250	0.0752	53.3
		2dps	4dps	4dps	1dp

$\frac{v}{u} = \frac{30.0(3sfs)}{15.0(3sfs)}$	$\frac{1}{u} = \frac{1}{40.0(3sfs)}$	$\frac{1}{v} = \frac{1}{30.0(3sfs)}$
2	$= 0.0250(3sfs)$	$= 0.0333(3sfs)$
1		
0.668		
0.5		
0.4		
0.3325		

Largest Quotient

Note

For any change of units, the constant is regarded a float and the rule of significant figures is followed

$i(^0)$	$r(^o)$	$x(cm)$	$\sin i$	$\cos r$	$xcos\ r\ (cm)$
10	8	1.0	0.174	0.990	1.0
20	12	1.4	0.342	0.978	1.4
30	18	2.2	0.500	0.951	2.1
40	25	3.1	0.643	0.906	2.8
50	29	3.5	0.766	0.875	3.1
60	32	4.2	0.866	0.848	3.6

Largest product

$x\cos r = 0.99$

1.3692

2.0922

2.8086

3.0625

3.5616 $(4.2(2sfs) \times 0.848(3sfs)$

$= 3.6\ (2sfs)$

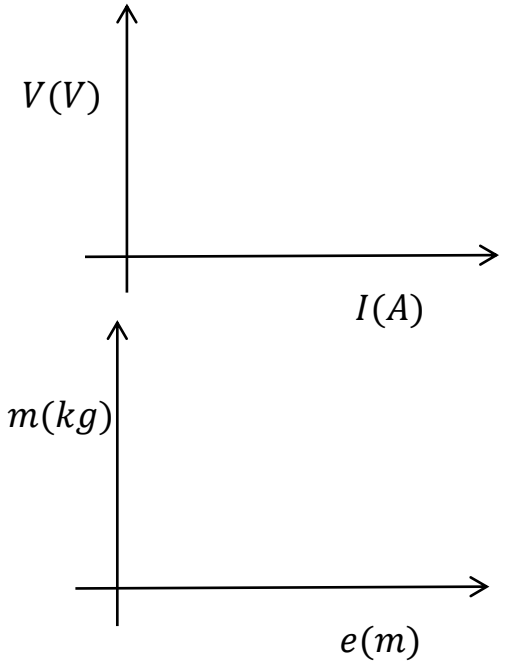
PLOTTING GRAPHS

(a) Title

- Clearly written at the **top** of the graph in one line
- Units **should not** be included in the title
- Example
  - **A graph of *V* against *I***
  - **A graph of T^2 against *L***

(b) Axes

- Drawn perpendicular to each other with arrows
- Axes must be clearly labeled with quantities with units



(c) Scale

- Scale must be uniform

- It should be at least 50% of the graph paper provided
- Should be suitable and convenient

A convenient scale is a multiple or a sub multiple of $\mathbf{1, 2, 2.5}$ ***and*** $\mathbf{5}$

e.g.

100, 200, 250, 500

10, 20, 25, 50

1, 2, 2.5, 5

0.1, 0.2, 0.25, 0.5

0.01, 0.02, 0.025, 0.05

0.001, 0.002, 0.0025, 0.005

Obtain the scale of one small division on each axis

(d) Starting values

- A graph should have starting values on all axes
- Starting values should be multiples of the scale used on that axis
- Using a calculator (***press*** **0** then ***press*** $=$ then ***press*** $+$ ***button*** then ***scale)*** then continuously **press** $=$ until a value just less than the smallest value in the column is obtained

(e) Intercept

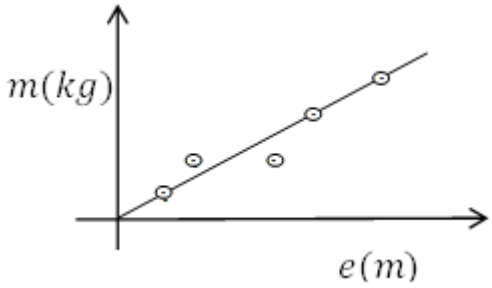
- Is a value of a quantity for which another quantity is zero
- For a vertical intercept, the horizontal axis must start from zero
- For a horizontal intercept, the vertical axis must start from zero
- Written to same dps as on the axis

(f) Plotting

- While plotting we use the number of small divisions.

(g) Line of best fit

- Moves in the trend of plotted points
- Passes in most of the plotted points leaving almost equal number of points on either side if any



(h) Slope

- Draw a right angled triangle which covers all plotted points on the graph. ***Don't use dotted lines***
- Values are read and transferred directly from the axes
- Units of the slope are derived from the axes
- E.g.
  - A graph of T^2 against m

Units of the slope $= \frac{units\ of\ T^2\ (s^2)}{units\ of\ m\ (kg)}$

$= s^2kg^{-1}$ (***But not*** $\mathbf{kg^{-1}s^2}$)

(i) Calculations

- **We** follow rules of dps and sfs in all calculation

Exercises

Instructions

Complete the following tables and plot the corresponding graphs

1.

Let $t =$ time for 20 oscillations

$h(m)$	$t(s)$
0.100	44.5
0.200	43.0
0.300	41.0
0.400	39.0
0.500	36.5
0.600	34.5

(a) Complete the table including values of T and T^2

(b) Plot a graph of T^2 against l

$l(cm)$	$V(V)$
10.0	1.40
20.0	1.25
30.0	1.10
40.0	1.00
50.0	0.90
60.0	0.85
70.0	0.75
80.0	0.70

(a) Plot a graph of V against l
(b) Find the intercept V_0 on the $V-$ axis

2.

$l(m)$	$t(s)$
0.900	37.0
0.800	36.0
0.700	34.5
0.600	32.0
0.500	29.5
0.400	26.0
0.300	23.0

$t =$ time for 20 oscilations
(a) Complete the table including values of T and T^2
(b) Plot a graph of T^2 against h
(c) Find the slope, S of the graph
(d) Calculate the value of acceleration due to gravity, g, from $g = -\frac{4\pi^2}{S}$

(take $\pi = 3.14$)

3.

$i(^0)$	$x(cm)$	$y(cm)$
10	1.0	6.6
20	1.5	6.7
30	2.4	7.0
40	3.2	7.4
50	3.8	7.6
60	4.6	8.0

(a) Complete the table including values of $\frac{x}{y}$ and $\sin i$, $\cos i$
(b) Plot a graph of $\sin i$ against of $\frac{x}{y}$
(c) Find the slope, n of the graph

(a) Complete the table including values of $\frac{1}{I}$, $\frac{V}{I}$ and IV

(b) Plot a graph of $\frac{1}{I}$ $against$ $\frac{V}{I}$

$x(m)$	$I(A)$	$V(V)$
0.200	0.64	1.65
0.300	0.56	1.90
0.400	0.44	2.05
0.500	0.34	2.10
0.600	0.26	2.25

4.

$i(^0)$	$r(^0)$
17	27
23	39
28	48
32	57
36	69
41	77

(a) Plot a graph of $cos^2 i$ against $sin^2 r$

(b) Determine the slope S of the graph

(c) Calculate n from the expression

$$n = \left(-\frac{1}{S}\right)^{\frac{1}{2}}$$