Lab. 1. Density of a metal

Student name: ……………………………………………………………………….

HUST ID:…………………………………………TROY ID:…………………………

Group:……………………………………………..Time/date:…………………………

I. Purpose of the experiment

- Learn to use length and mass measuring tools.
- Learn how to analys experimental data, and treat measuring errors.

II. Theoretical basis

Volume of a ball: $V = \frac{\pi}{6} D^3$

Density of a substance is calculated from: $\rho = \frac{m}{V}$

where m is the mass and V is the volume of the object.

III. Experimental plan

3.1. Tools and Materials

- Screw gauge; Metal ball;

3.2. Lab Procedure

1. Use a Panmer (Scraw Gauge) to measure the diameter of a metal ball; mass of the ball will be given. Write the obtained results on table 1.
2. Calculate volume and density of the ball;

IV. Experimental results and analysis

Volume and Mass Density of Metal – A Metal Ball

a) Use a Panme (Screw Gauge) to measure the diameter of a metal ball; and use a balance to measure the mass of the ball. Write the obtained results on the following table .

	Tool error of the Screw Gauge: $\Delta D_{tool} =$………………………. Mass of the ball: $m =$………..±……… (g)	
No.	Diameter, D (mm)	ΔD (mm)
1		
2		
3		
4		
5		
	The everage $\overline{D}$=…………	$\overline{\Delta D}$=……………

b) Diameter

Absolute uncertainty

$$\Delta D = \overline{\Delta D} + \Delta D_{tool} = \ldots\ldots\ldots\ldots\ldots\ldots \pm \ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ldots \text{ (mm)}$$

Measuring results:

D = …………………±……..……. (mm)

c) Volume of the ball

$$V = \frac{\pi}{6} D^3 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (mm}^3\text{)} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \times 10^{-9} \text{ (m}^3\text{)}$$

+ Percentage uncertainty of volume V:

$$\delta_V = \frac{\Delta V}{V} = \frac{\Delta \pi}{\pi} + \frac{3\Delta D}{D} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ldots$$

+ absolute uncertainty volume V:

$$\Delta V = V \times \delta_V = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

d) Mass of the ball:

+ Mass:

m = ……………±….…….. (g)=……………… ±……………$\times 10^{-3}$ (kg)

e) Mass density of the ball:

$$\rho = \frac{m}{V} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (kg/m}^3\text{)}$$

Estimate the error:

+ Percentage uncertainty of density ρ:

$$\delta_\rho = \frac{\Delta \rho}{\rho} = \frac{\Delta V}{V} + \frac{\Delta m}{m} = \delta_V + \delta_m = \ldots\ldots\ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ldots$$

+ absolute uncertainty density ρ:

$$\Delta \rho = \rho \times \delta_\rho = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(kg/m}^3\text{)}$$

Writing final results:

The average value of g measured for the entire experiment is:

$$\overline{\rho} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \pm \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (kg/m}^3\text{)}$$

Lab. 2. Free fall

Student name: ………………………………………………………………….

HUST ID:………………………………………TROY ID:…………………………

Group:…………………………………………..Time/date:…………………………

I. Purpose of the experiment

+ Determine the value of free fall acceleration by experiment.

+ Practice skills in using vibrators and digital time meters to measure small periods of time thereby reinforcing basic operations of experiments and processing results with calculations and graphs.

+ Consolidate knowledge about free fall.

II. Theoretical basis

- Free fall is falling only under the influence of gravity.

- Characteristic:

+ Vertical direction, from top to bottom.

+ At a certain place on Earth and near the ground, all objects fall freely with the same acceleration g. ***(A contanst accelertation motion)***

- Formula to calculate free fall acceleration: $\boldsymbol{s = \frac{1}{2}.g.t^2}$

In which, s is distance traveled by a freely falling object (m). *t* is time that the object falls freely (s) between two points.

- Falling velocity at time *t*: $v = \frac{2s}{t}$

III. Experimental plan

3.1. Laboratory instruments

+ Digital timer.

+ Free fall acceleration measuring device.

+ Electromagnet N is installed on the top of the holder.

+ Optical sensor port Q is installed below, at a distance s ~ 0.60 m from N

3.2. Experimental process

+ Adjust the base screws and observe plumb bob D so that the two round holes of Q and N are coaxial.

+ Place the falling object V (metal pillar) attached to the electromagnet N.

+ Press the switch button R to let the cylinder fall, and at the same time start the meter.

+ Read the falling time results on the clock.

+ Repeat the operation with other distances, for example of 0.200; 0.300; 0.400; 0.500; 0.600 m.

3.3. Record data

+ Read the time measurements t corresponding to different distances s and create an appropriate data table.

+ Data processing.

- Calculate values for data table.
- Draw a graph of v versus t and s versus t^2.
- Comment on the obtained graphs.

IV. Experimental results

Table 2.1.

No.	Distance s (m)	Falling time t (s)			Average time $\bar{t}$ (s)	Δt (s)	t^2 (s^2)	g (m/s^2)	Δg (m/s^2)	v (m/s)
		No. 1	No. 2	No. 3						
1										
2										
3										
4										
5										

4.1. Graph

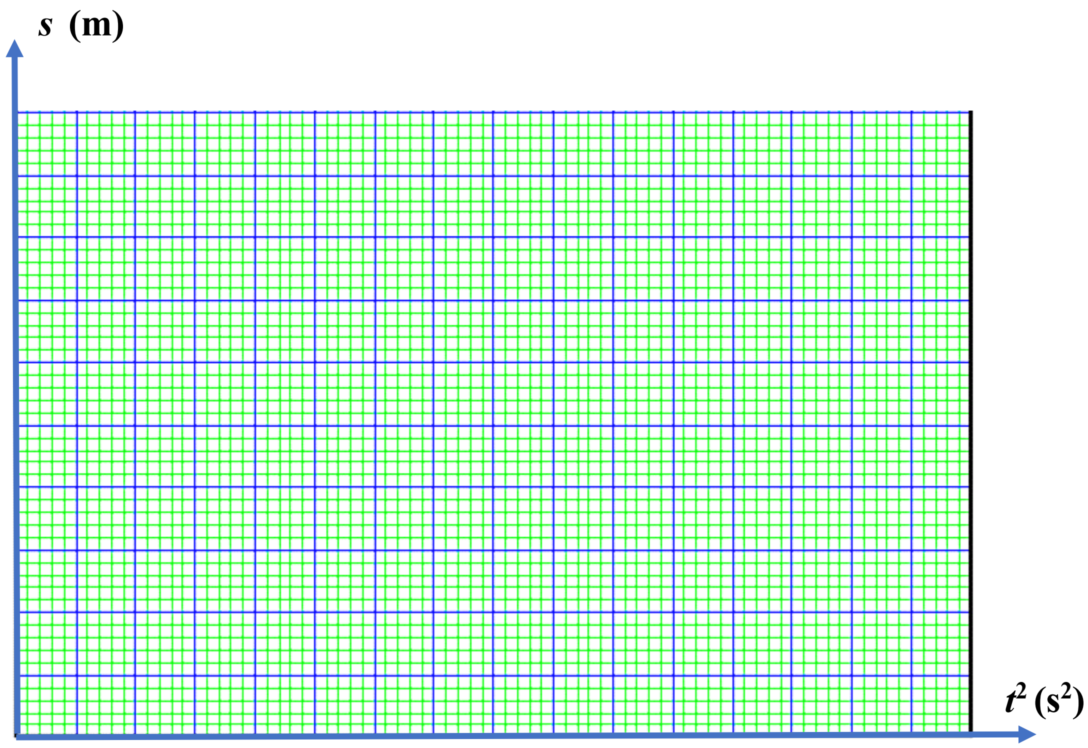
a) Based on the results in the Table 2.1, choose the appropriate scale on the vertical and horizontal axes to draw the graph $\boldsymbol{s = s(t^2)}$.

Draw the straight line of best fit.

Determine the gradient of this line. gradient = ...

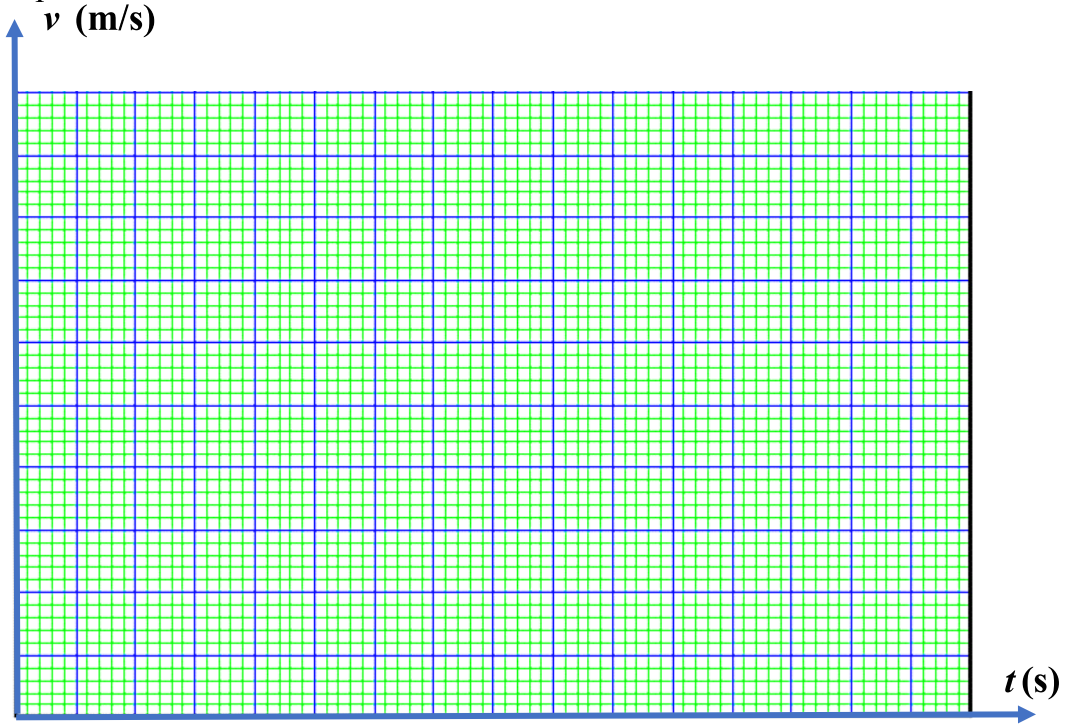
Because we have: $\boldsymbol{s = \frac{1}{2}.g.t^2 = s(t^2)}$. So: $the\ gradient = \boldsymbol{\frac{1}{2}.g}$.

Then, g =2×gradient=……………………………….(m/s^2)



b) Determine value of velocity when it's passing through

Draw the graph $\boldsymbol{v} = \boldsymbol{v}(\boldsymbol{t})$ based on the data in the table, to once again verify the properties of free fall motion.



- Draw a straight line best fit to the experimental data, then give a conclusion about the dependence of velocity v on time t.

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4.2. Determine errors and average values

a) The average value of g and error Δg after 3 measurements (at the same distance) are determined as follows:

+ avergae value of g : $\overline{g} = \frac{2s}{(\overline{t})^2}$

+ Percentage uncertainty of g : $\delta_g = \frac{\Delta g}{g} = \frac{\Delta s}{s} + \frac{2\Delta t}{t}$

+ where: $\Delta s = 2\Delta s_{tool} =$…………………(m)

+ error (absolute uncertainty): $\Delta g = \overline{g} \times \delta_g$

Then write coresponding results in Table 1.

b) The average value of *g* measured for the **entire experiment** is:

$\overline{g} = \frac{g_1+g_2+\cdots+g_n}{n} =$…………………………………………..=………….. (m/s²)

The average value of Δg measured for the entire experiment is:

$\overline{\Delta g} = \frac{\Delta g_1+\Delta g_2+\cdots+\Delta g_n}{n} =$……………………………………………=…………..(m/s²)

The results of the free fall acceleration measurement are:

$g = \overline{g} \pm \overline{\Delta g} =$………………..±……………………. (m/s²)

Compare the obtained value with g-value obtained in section 4.1.(a).

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Lab. 3. Interference patterns

Student name: ……………………………………………………………………..

HUST ID:………………………………………TROY ID:…………………………

Group:…………………………………………..Time/date:…………………………

I. Purpose of the experiment

In this experiment, you will investigate the interference patterns produced by overlaid grids.

II. Experimental plan

2.1. Tools and Materials

- Grid A and Grid B (on transparent films)
- Protractor or angular scale
- Ruler (mm scale)
- Calculator

2.2. Lab Procedure and Report

(a) Grid A is the grid of parallel, equally spaced lines shown in Fig.3.1.

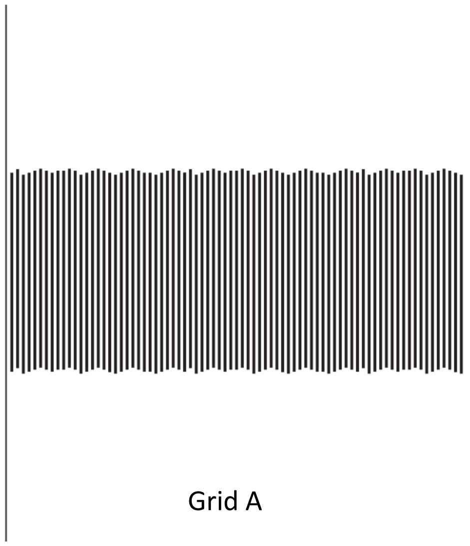

Fig. 3.1.

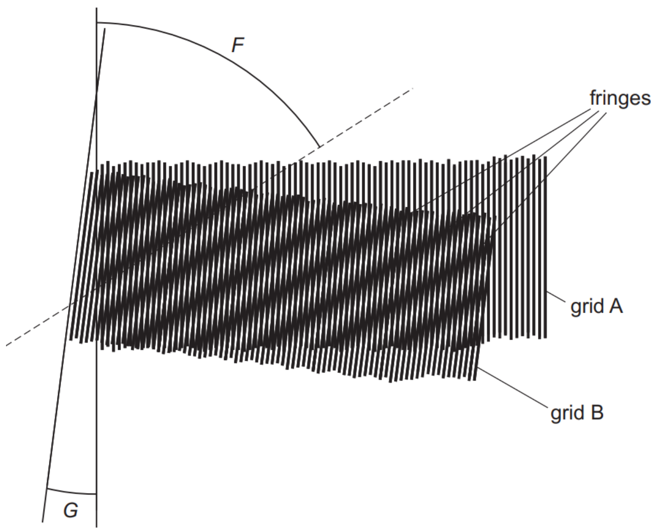

Fig.3.2.

Take measurements to determine the average spacing s_A between the centres of the lines on grid A.

s_A = ...mm

(b) You have been provided with a second grid (labelled grid B) printed on a transparent sheet.

● Place grid B on top of grid A, as shown in Fig.3.1.

● Turn grid B so that there is a small angle *G* between the grids. A pattern of fringes will be produced, as shown in the example in Fig.3.2

● **Do not take measurements from Fig.3.2.**

Measure and record your value of G from Fig. 1.1.

G = ... °

● The fringes make an angle F with grid A, as shown in Fig.3.2. Measure and record your value of F from Fig. 1.1.

F = ... °

(c) Rotate grid B and repeat (b) until you have six sets of values of G and F.

Use values of G in the range 0° to 20°.

Record your results in a table. Include values of sin$F$ and sin(F–G) in your table.

No.	Angle G (°)	Angle F (°)	F – G (°)	sin$F$	sin(F–G)
1					
2					
3					
4					
5					
6					

(d) (i) Plot a graph of sin(F–G) on the y-axis against sin$F$ on the x-axis.

(ii) Draw the straight line of best fit.

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

(e) It is suggested that the quantities F and G are related by the equation

$$\boldsymbol{sin(F - G) = psin\, F + \ q}$$

where p and q are constants. Use your answers in **(d)(iii)** to determine the values of p and q.

p = ...

q = ...

(f) The constant p is related to the spacing of the lines of grids A and B by $\boldsymbol{p} = \frac{s_B}{s_A}$ where $\boldsymbol{s_B}$ is the line spacing of grid B. Use your values of p and $\boldsymbol{s_A}$ to calculate $\boldsymbol{s_B}$.

$\boldsymbol{s_B}$ = ...mm [1]