Hanoi University of Science and Technology **GENERAL PHYSICS**

(PHYS2520)

Fabculty of Engineering Physics

TROY IT Program Lecturer: Asso. Prof. Dr. Nguyen Hoang Thoan

Lab. 1. Density of a metal or solid material

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: $V = \frac{\pi}{6}D^3$

Volume of a solid cylinder: $V = \frac{\pi}{4}D^2H$

Volume of a hollow cylinder: $V = \frac{\pi}{4}(D^2 - d^2)H$

where D is the outside diameter; d is the inner diameter, and H the height.

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; Vernier caliper;
- Metal ball; solid/hollow cylinder;

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;
3. Use a vernier caliper to measure the diameter of a **hollow** cylinder and a **solid** cylinder; and use a balance to measure the mass of them. Write the obtained results on table 2, and Table 3.
4. Calculate volume and density of the cylinders

IV. Experimental results and analysis

4.1. 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 table 1.

Table 1.

	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

$\Delta D = \overline{\Delta D} + \Delta D_{tool} =$ ………………±……………...=……………… (mm)

Measuring results:

$D =$ …………………±……….……. (mm)

c) Volume of the ball

$V = \frac{\pi}{6} D^3 =$……………………….. (mm^3)=…………………………×10^{-9} (m^3)

+ Percentage uncertainty of volume V:

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

+ absolute uncertainty volume V:

$\Delta V = V \times \delta_V =$..=..

d) Mass of the ball:

+ Mass:

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

e) Mass density of the ball:

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

Estimate the error:

+ Percentage uncertainty of density ρ:

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

+ absolute uncertainty density ρ:

$\Delta\rho = \rho \times \delta_\rho = \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots = \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$ (kg/m^3)

Writing final results:

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

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

4.2. Volume and Mass Density of a solid cylinder

a) Use a vernier caliper to measure the diameter and the height of a solid cylinder; and use a balance to measure the mass of the cylinder. Write the obtained results on table 2.

Table 2.

	Tool error of the Vernier Caliper: $\Delta D_{tool} = \Delta H_{tool}$.......................... Mass of the solid cylinder: m =..............±........... (g)			
No.	Diameter, D (mm)	ΔD (mm)	Height, H (mm)	ΔH (mm)
1				
2				
3				
4				
5				
	$\overline{D}$=...........	$\overline{\Delta D}$=.........	$\overline{H}$=...........	$\overline{\Delta H}$=.........

b) Diameter and height

Absolute uncertainty of diameter and height

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

$\Delta H = \overline{\Delta H} + \Delta H_{tool} = \dots\dots\dots\dots \pm \dots\dots\dots\dots = \dots\dots\dots\dots$ (mm)

Measuring results:

D = …………………±……….……. (mm)

H = …………………±……….……. (mm)

c) Volume of the solid cylinder

$V = \frac{\pi}{4} D^2 H =$……………………….. (mm^3)=……………………….×10^{-9} (m^3)

+ Percentage uncertainty of volume V:

$\delta_V = \frac{\Delta V}{V} = \frac{\Delta \pi}{\pi} + \frac{2\Delta D}{D} + \frac{\Delta H}{H}$ =……………………………………………….=…………………………

+ absolute uncertainty volume V:

$\Delta V = V \times \delta_V =$……………………………………=……………………………………×10^{-9} (m^3)

+ Volume: V = ……………………±………………………… 10^{-9} (m^3)

d) Mass of the solid cylinder:

+ Mass:

m = ……………±…..……… (g)=……………… ±……………×10^{-3} (kg)

d) Mass density of the solid cylinder:

$\rho = \frac{m}{V} =$ ……………………….. (kg/m^3)

Estimate the error of density:

+ Percentage uncertainty of density ρ:

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

+ absolute uncertainty density ρ:

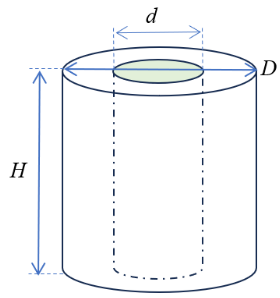
$\Delta\rho = \rho \times \delta_\rho =$……………………………=……………………….(kg/m^3)

Writing final results:

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

$\overline{\rho} =$……………………….±……………………….. (kg/m^3)

4.3. Volume and Mass Density of a hollow cylinder



a) Use a vernier caliper to measure the diameter and the height of a solid cylinder; and use a balance to measure the mass of the cylinder. Write the obtained results on table 3.

Table 3.

	Tool error of the Vernier Caliper: $\Delta D_{tool} = \Delta d_{tool} = \Delta H_{tool}$…………………………					
	Mass of the solid cylinder: $m =$……………..…±………… (g)					
No.	Outer Diameter D (mm)	ΔD (mm)	Inner Diameter d (mm)	Δd (mm)	Height H (mm)	ΔH (mm)
1						
2						
3						
4						
5						
	$\overline{D}$=………	$\overline{\Delta D}$=………	$\overline{d}$=………	$\overline{\Delta d}$=………	$\overline{H}$=………	$\overline{\Delta H}$=………

b) Outer/inner diameters and height

Absolute uncertainty of diameter and height

$$\Delta D = \overline{\Delta D} + \Delta D_{tool} = \text{………………±……………..=………………} \text{ (mm)}$$

$$\Delta H = \overline{\Delta H} + \Delta H_{tool} = \text{………………±……………..=………………} \text{ (mm)}$$

Measuring results:

D = …………………±……………… (mm)

H = …………………±……………… (mm)

c) Volume of the hollow cylinder

$$V = \frac{\pi}{4}(D^2 - d^2)H = \text{…………………………………………………………………}$$

=………………………..(mm³)=……………………….×10^{-9} (m^3)

\+ Percentage uncertainty of volume V:

$$\delta_V = \frac{\Delta V}{V} = \frac{\Delta \pi}{\pi} + 2\frac{D.\Delta D + d.\Delta d}{D^2 - d^2} + \frac{\Delta h}{h} = \text{……………………………………………………………}$$

δ_V=..............................

+ absolute uncertainty volume V:

$\Delta V = V \times \delta_V =$...=..

d) Mass of the hollow cylinder:

+ Mass:

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

e) Mass density of the hollow cylinder:

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

Estimate the error of density:

+ Percentage uncertainty of density ρ:

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

+ Absolute uncertainty density ρ:

$\Delta\rho = \rho \times \delta_\rho =$………………………………=………………………………(kg/m^3)

Writing final results:

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

$\overline{\rho} =$………………………±……………………….. (kg/m^3)

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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 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

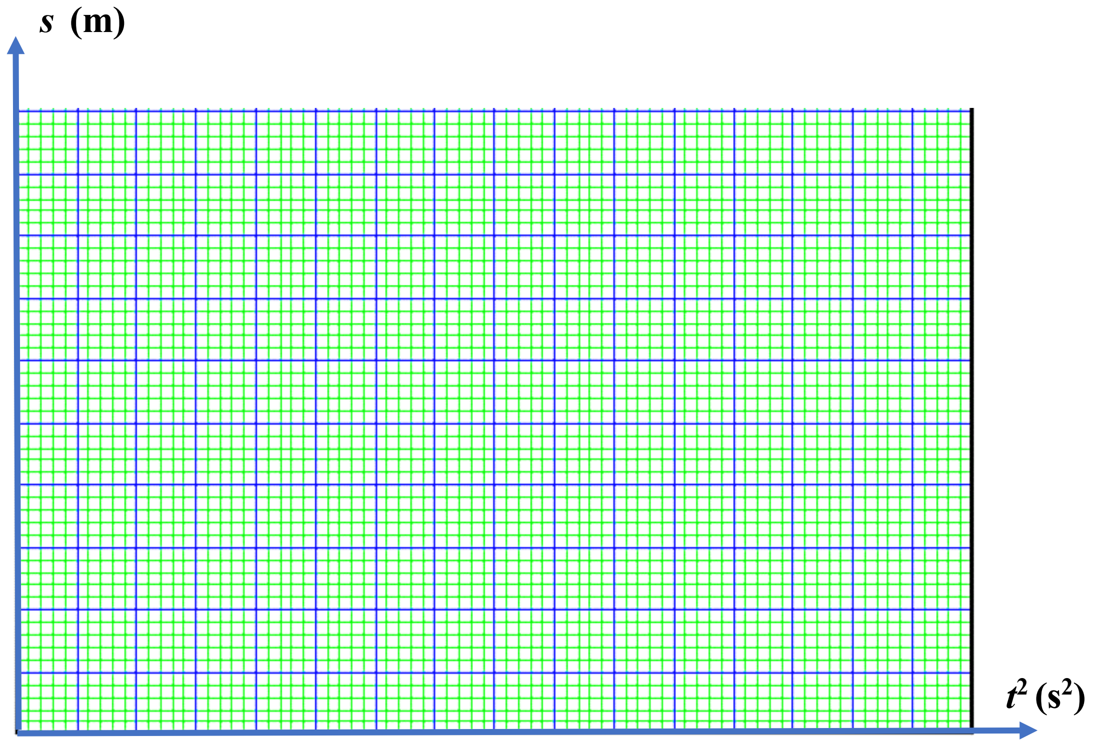
a) Based on the results in the Table 1, choose the appropriate scale on the vertical and horizontal axes to draw the graph $\boldsymbol{s = s(t^2)}$.

Draw the straight line of best fit.

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

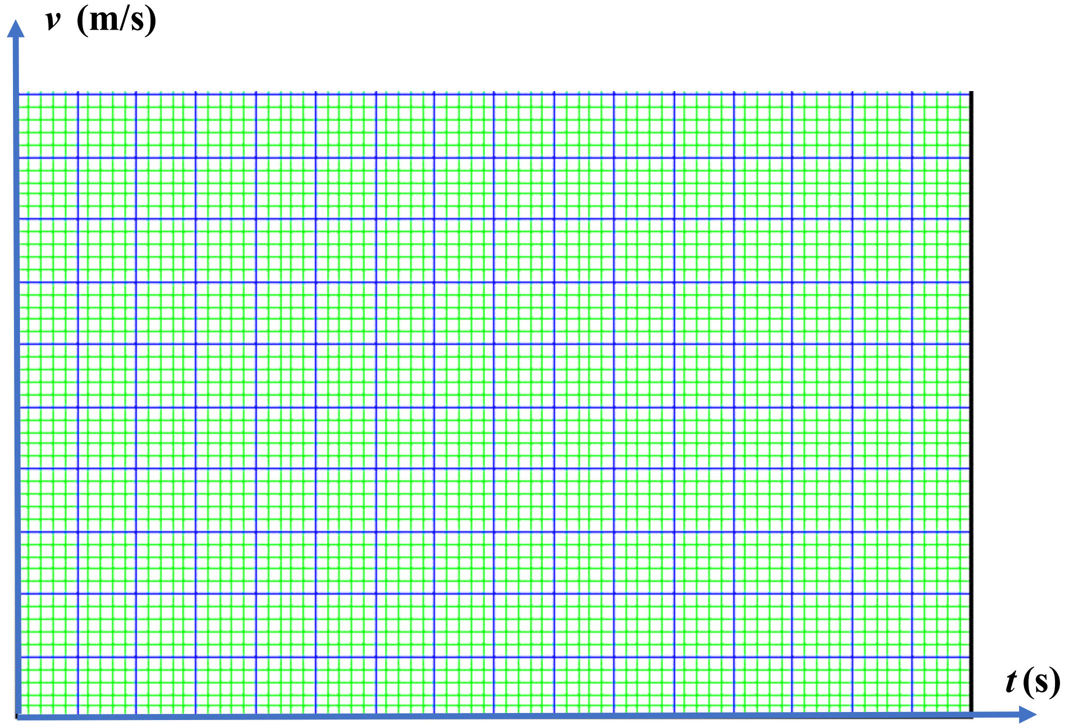
Because we have: $s = \frac{1}{2}.g.t^2 = s(t^2)$. So: $the\ gradient = \frac{1}{2}.g$.

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



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

Draw the graph $v = v(t)$ 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: $\Delta s = 2\Delta s_{d.cụ} =$…………………(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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