Exp.1: Basics of Measurements

- Units and unit conversion introduced
- Dimensions and masses of several objects are measured and density of objects are calculated
Exp.1: Basics of Measurements

• Because solely magnitude is not enough for definition, units are used to define property of a given quantity.
• Historically many nations produced their unit system for standardization. With globalization and interaction between countries got tighter, need for a global standard for units is emerged. With this purpose International System of Unit is formed.
Exp.1: Basics of Measurements

- There are seven basic SI units:
  - **Meter (m)** for length
  - **Kilogram (kg)** for mass
  - **Second (s)** for time
  - **Ampere (A)** for current
  - **Kelvin (K)** for temperature
  - **Candela (cd)** for luminosity
  - **Mole (mol)** for amount of substance
Exp.1: Basics of Measurements

• **Prefix**es are used to express multiple and sub-multiple of units.

• Most commonly used prefixes are:
  - Peta (P): $10^{15}$
  - Tera (T): $10^{12}$
  - Giga (G): $10^9$
  - Mega (M): $10^6$
  - Kilo (k): $10^3$
  - Hekto (h): $10^2$
  - Deca (da): $10^1$

  **Multiples**
  - Deci (d): $10^{-1}$
  - Canti (c): $10^{-2}$
  - Mili (m): $10^{-3}$
  - Micro (μ): $10^{-6}$
  - Nano (n): $10^{-9}$
  - Pico (p): $10^{-12}$
  - Femto (f): $10^{-15}$

  **Sub-multiples**
Exp.1: Basics of Measurements

- Beside SI basic units, there are **derived units** formed by multiples of basic units like:
  - Newton = kg×m×s⁻²
  - Joule = kg×m²×s⁻²
  - Coulomb = s×A

...etc
Exp.1: Basics of Measurements

• Unit conversion is made as follows:

While $aX$ is unit to be converted to $bY$

$$aX = aX \times \frac{10^m X}{1 \ aX} \times \frac{Y}{X} \times \frac{10^n bY}{1 \ Y}$$

$a$ and $b$ are prefixes of given units in $m$th and $n$th power of 10 respectively
cf. is conversion factor between units X and Y
Exp.1: Basics of Measurements

**Example:** Convert 10 kdyn to μN. 1 dyne = 10^{-5} N

\[
10 \text{ kdyn} = 10 \text{ kdyn} \times \frac{10^3 \text{ dyn}}{1 \text{ kdyn}} \times 10^{-5} \frac{N}{\text{ dyn}} \times \frac{10^6 \mu N}{1 N}
\]

\[
10 \text{ kdyn} = 10 \times 10^3 \times 10^{-5} \times 10^6 \mu N = 10^5 \mu N
\]
Exp.1: Basics of Measurements

Performing Experiment

• We will find density of given objects using equation 
  \[ \rho = \frac{m}{V} \]
  here \( \rho \) is density, \( m \) is mass and \( V \) is volume.

• In order to find volume, we will measure dimensions of objects using a **Vernier Caliper**
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Measuring with Vernier Caliper
The main scale contributes the main number and one decimal place to the reading.
The vernier scale contributes the second decimal place to the reading.
Some vernier calipers (for instance ours) have an upper scale to perform measurements in inches. But we will not use them.
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Measuring with Vernier Caliper
Check out the image below. We will just use a two steps method to get the measurement from this:
To obtain the main scale reading: In the image, 0.5 cm is to the immediate left of the zero on the vernier scale. Hence, the main scale reading is 0.5 cm
To obtain the vernier scale reading: look closely for an alignment of the scale lines of the main scale and vernier scale. In the image above, the aligned line correspond to 4. Hence, the vernier scale reading is 0.04 cm.
In order to obtain the final measurement, we will add the main scale reading and vernier scale reading together. This will give 0.54 cm.
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Measuring with Vernier Caliper
Exercise: Please try to find the measured values from the image given below.

Answer: 1.12cm
Exp.1: Basics of Measurements

Measuring with Vernier Caliper
Exercise: Please try to find the measured values from the image given below.

Answer: 2.88cm
Exp.1: Basics of Measurements

Measuring the Mass
Measure the mass of objects using mechanical balance

Note:
Mechanical balance’s actually measures the weight, however it’s scale converted in order to measure the mass.
Exp.1: Basics of Measurements

Performing Experiment
Measure dimensions of three objects supplied and calculate their volume. After that measure objects’ masses by using balances.

Object1: Pac Man

\[
V_{\text{pacman}} = V_{\text{Total}} - V_{\text{missing piece}}
\]

\[
= h \times \pi \times r^2 \times \frac{360^\circ - 30^\circ}{360^\circ}
\]

\[
V_{\text{pacman}} = h \times \pi \times \left(\frac{d}{2}\right)^2 \times \frac{360^\circ - 30^\circ}{360^\circ}
\]
Exp.1: Basics of Measurements

Performing Experiment
Measure dimensions of three objects supplied and calculate their volume. After that measure objects’ masses by using balances.

Object2: Hollow Cylinder

\[ V_{\text{HollowCylinder}} = V_{\text{Total}} - V_{\text{Hollow}} \]
\[ = h \times \pi \times r^2_{\text{out}} - h \times \pi \times r^2_{\text{in}} \]
\[ = h \times \pi \times (r^2_{\text{out}} - r^2_{\text{in}}) \]
\[ V_{\text{HollowCylinder}} = h \times \pi \times \left( \left( \frac{d_{\text{out}}}{2} \right)^2 - \left( \frac{d_{\text{in}}}{2} \right)^2 \right) \]
Exp.1: Basics of Measurements

Performing Experiment
Measure dimensions of three objects supplied and calculate their volume. After that measure objects’ masses by using balances.

\[ V_{\text{scrapmetal}} = V_{\text{Total}} - V_{\text{gap}} = (a + b) \times c \times t - \frac{3\sqrt{3}}{8} \times d \times t \]