

GREENHILL ACADEMY- SECONDARY

S5 HOLIDAY WORK

PHYSICS

Attempt **all** items.

Item1

A group of Senior Five students at a village school wants to build a simple **water clock** to keep time during outdoor activities. They plan to use a container with a small hole at the bottom so that water can drip out slowly. To measure time, they observe how long it takes for water to drain from the container.

They want to determine how the **time taken (t)** for water to completely drain depends on the **height (h)** of the water column in the container, the **diameter (d)** of the hole, and the **acceleration due to gravity (g)**. They don't know the exact mathematical formula, but they believe **dimensional analysis** can help them estimate the relationship.

Task:

As part of your holiday work, help the group by completing the following tasks:

1. **Define** the term *dimensions of a physical quantity* and explain the usefulness of **dimensional analysis** in solving real-life physics problems.
2. **State** the dimensions of the following quantities:
 - Time, t
 - Height, h
 - Diameter, d
 - Acceleration due to gravity, g
3. **Assume** that the time, t taken for the water to drain out depends on the height, h , the diameter d , and acceleration due to gravity g . Use **dimensional analysis** to derive a possible expression of the time, t :
4. a) What does your result suggest about the effect of increasing the water height or the hole's diameter on the time taken?
b) Would a deeper container drain faster or slower? Why?
5. a) Suggest one way you could test this relationship in your school or at home using simple materials.
b) Identify **two other situations** in everyday life or technology where dimensional analysis could help estimate or derive useful relationships between variables.

Item 2

While carrying out experiments using a gold leaf electroscope a student of Physics charged a metal spheres (held in insulating handle) by friction. When the sphere was lowered into a metal can connected to a neutral gold leaf electroscope, the following observation: -

- i. there was a divergence gold leaf
- ii. the gold leaf fell back when sphere was removed from the metal can
- iii. when the sphere touched the inside of the metal can the divergence of the gold leaf was the same as before
- iv. the gold leaf remained in a divergent state on removing the metal sphere after contact with the inner surface.

The sphere was charged again and was brought close to a neutral sphere of mass 20g suspended with a silk thread, the student observed that the suspended sphere was attracted to the charged sphere and after being in contact it was repelled away. This puzzled the student.

Task: Using your knowledge of electrostatics

- (a) Explain how the metal sphere acquired charge by friction.
- (b) Help the student to understand each of the observations (i) to (iv) above.
- (c) Explain how the suspended sphere was first attracted and later on repelled after touching the charged sphere
- (d) Determine the magnitude of charge on either sphere; if the suspended sphere rested in equilibrium with the thread at an angle of 30° to the vertical and at a distance of separation of 12 cm.

Hint:

Acceleration due to gravity $g = 9.81 \text{ ms}^{-2}$

The permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$

The constant $\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}\text{m}$

Item 3

An old man who wanted to shave his beard went to a barber's saloon and was asked to sit in a chair placed at a distance of 2.0m facing a plane mirror. Another plane mirror was placed 6.0m at the back wall directly facing the first mirror. When the old man looked in the plane mirror he could see two images, one of his face and another image of the back of his head and wondered why the images were not one but separated from each other. According to the old man the images seen were real but the barber told him that the images were virtual.

Task: Using your knowledge of reflection of light, help the old man to

- (a) understand how the two images were formed.
- (b) determine the distance separating the two images seen in the mirror.
- (c) understand how the position of the image could be determined in a scientific investigation.
- (d) distinguish between real and virtual images.

END