2025-26

Physics 9

Comprehensive Notes with Short Questions, Long Questions, MCQs, and Problems

Prepared By:

Muhammad Tayyab

Govt Christian High School Daska

Unit 6 Mechanical Properties of Matter

***1. What is a deforming force?**

*An external force applied on an object can change its **size or shape**. Such a force is known as a deforming force.*

**** 2. What is meant by elasticity?**

*An object is said to be **elastic**, if after removal of the **deforming force**, it **restores to its original size and shape**. This property of the material is known as **elasticity**.*

OR

Elasticity is the property of solids by which they come back to their original shape when deforming force ceases to act.

For example, an appropriate force applied to a spring can increase its length called **extension** or cause **compression** thus reducing its length. If this force is removed, the spring will restore its original size and shape.

Similarly, stretched **rubber strip** or band comes to its original shape and size on removing the applied force.

When a **tennis ball** is hit by a racket, the shapes of tennis ball and also racket strings are distorted or deformed. They regain their original shape after bouncing of the ball by the racket.

***3. What is elastic limit?**

*Most of the materials are **elastic up to a certain limit** known as **elastic limit**. Beyond the elastic limit, the change becomes **permanent**, and the object does **not regain its original shape or size** even after the removal of the **deforming force**.*

***4. What are inelastic materials?**

*Some materials such as **clay dough** or **plasticine** do not return to their original shape after the removal of the deforming force. They are known as inelastic materials.*

**** 5. State Hooke's Law and define spring constant.**

Within the elastic limit of a helical spring, the extension or compression in it is directly proportional to the applied force. This is known as Hooke's law.

If force F is applied on a spring to stretch or compress it, the extension or compression x has been found directly proportional to the applied force within the **elastic limit**. Thus,

$$F \propto x$$
$$F = kx$$
$$k = \frac{F}{x}$$

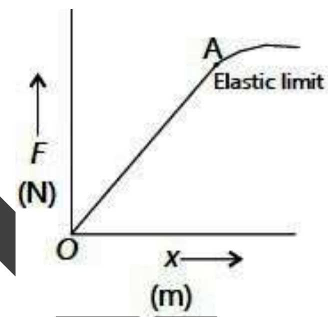
Here, k is the constant of proportionality and is known as the **spring constant**.

In fact, it is a measure of **stiffness of the spring**. The greater the value of spring constant, the greater will be the stiffness or strength of the spring. Its unit is Nm^{-1}.

Spring constant is defined as the ratio of applied force to the change in length of spring. Spring constant written as

$$k = \frac{F}{x}$$

**** 6. Describe the force-extension graph of a spring and explain what happens beyond the elastic limit.**



A graph of force against extension is a straight line passing through the origin. If the applied force or load exceeds the elastic limit of the spring, it is permanently deformed and its graph will **no longer remain linear**. The gradient or slope of the force-extension graph is a measure of **spring constant k**.

Hooke's law also holds when a force is applied to a straight thin wire or a rubber band within its elastic limit.

7. State the principle of Hooke's Law and describe its role in technology and engineering.

Hooke's law serves as the basic principle in a wide range of applications.

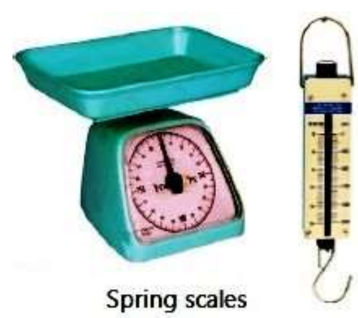
In the field of technology and engineering, springs in many devices rely on Hooke's law for their functions such as spring scales, balance wheel of the mechanical clocks, galvanometer, suspension systems in vehicles and motorbikes, door hinges, mattresses, material testing machines, etc.

However, Hooke's law applies within a specific range of forces.

Exceeding the range or limit results in permanent deformation and the spring no longer follows Hooke's law.

8. Describe three applications of Hooke's Law.

Spring scales: Spring scales use the extension or compression of a spring to determine the weight of objects. In a spring balance, the extension or elongation produced is a measure of the weight. In a compression balance, the spring is compressed by the load (force) and the compression produced is measured by means of a pointer moving over a scale. Weighing machines usually use this type of balance.



Spring scales

Balance wheel of mechanical clocks: The balance wheel in mechanical clocks uses spring to control the back and forth motion that regulates the speed of the hands of a clock.

Galvanometer: A galvanometer is a **current detecting device**. It makes use of a tiny spring called hair spring which provides electrical connections to the galvanometer coil and also restores the pointer back to zero position. The deflection of the pointer is proportional to the current flowing through it within the range.

***9. What is meant by density? What is its SI unit?**

Density of a substance is defined as its mass per unit volume.

$$Density = \frac{mass\ of\ sustance}{volume\ of\ that\ substantce}$$

$$\rho = \frac{m}{v}$$

SI unit of density is kilogram per cubic meter (kgm^{-3}). Othe unit also in use is gcm^{-3}.

10. How can the density of a substance be determined?
The density of a substance can be determined by measuring its **mass** and **volume**. The mass can be measured using a physical balance.

If the solid has a **regular shape**, its volume can be calculated by measuring its dimensions. For example, if the object is a **sphere**, its **diameter** is measured using a **Vernier Callipers**, and volume is calculated using the appropriate formula.

If the solid has an **irregular shape**, its volume is found using the displacement method. In this method, the object is gently dropped into a measuring cylinder containing water or any liquid in which it is **insoluble**. The **rise in liquid level** gives the **volume** of the object.

Once the mass and volume are known, density is calculated using the formula:

$$Density = \frac{mass}{volume}$$

***11. Define pressure and write its formula and unit.**

Pressure is defined as the force exerted normally on unit area of an object.

$$Pressure = \frac{Force}{Area}$$

$$P = \frac{F}{A}$$

Pressure is a scalar quantity. In **SI units**, the unit of pressure is Nm^{-2} also called pascal (Pa).

$$Nm^{-2} = 1\ Pa$$

12. How does pressure depend on area? Give daily life examples.
1. A **chopper's sharp blade** has a small area. When force is applied, pressure becomes high and it cuts easily.

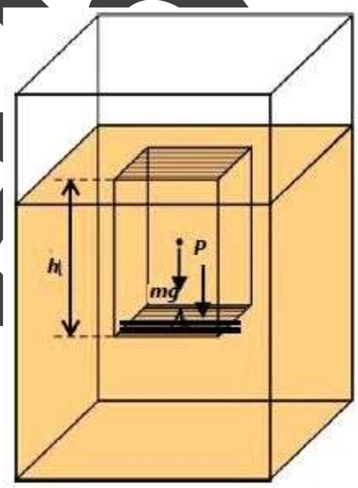
2. A **thumb pin** has a sharp end. The small contact area creates high pressure, so it easily pierces a wooden board.

3. On a **flat surface**, our weight is spread over a larger area, so pressure is low. On **pebbles**, smaller area increases pressure and causes pain.

4. Elephants have large feet. This increases contact area and reduces pressure, protecting their legs from damage.

**** 13. How is pressure at a depth in a liquid calculated?**
Liquids exert pressure in all directions, and this pressure increases with depth.

Consider a container filled with liquid as shown in figure. Take an area A located at a depth h in the liquid. The **force** acting on this area is due to the **weight** of the liquid column above it.



The **volume** of the liquid column is:

$$V = Ah$$

Let ρ be the **density** of the liquid. Then the **mass** of the liquid column is:

$$m = \rho V$$

$$m = \rho Ah \qquad \because V = Ah$$

The **force** on area A is:

$$F = weight$$

$$F = mg$$

$$F = \rho Ahg \qquad \because m = \rho Ah$$

So, the **pressure** at depth h is:

$$P = \frac{F}{A}$$

$$P = \frac{\rho Ahg}{A} \qquad \because F = \rho Ahg$$

$$P = \rho gh$$

This shows that pressure **depends on the depth and the density** of the liquid, and **increases with depth**.

Also, **pressure always acts perpendicular (normal) to a surface**. Any component of force parallel to the surface does not contribute to pressure. For example, if there is a hole in a container, the **liquid jets out at a right angle** to the surface before curving downward due to gravity.

***14. Define atmospheric pressure. How does it act and what is its value at sea level?**

The atmosphere exerts pressure on the surface of the Earth and on everything on the Earth. This pressure is called atmospheric pressure.

The Earth is surrounded by a layer of air called the **atmosphere**. Air is a mixture of gases whose **molecules are always in motion**. These molecules collide with each other and with objects, exerting a **force per unit area**, known as **atmospheric pressure**. Because of the random motion of air molecules, atmospheric pressure acts **equally in all directions**.

Atmospheric pressure extends up to a height of about $100\,kilometres$. The **density of air decreases continuously with altitude**.

15. Why don't we feel the enormous atmospheric pressure acting on our bodies?

We live at the bottom of the Earth's atmosphere which is a **fluid** that exerts pressure on our bodies. At **sea level**, the value of atmospheric pressure is about

$$1.013 \times 10^5\,Pa$$

This value is referred to as standard atmospheric pressure. It is an **enormous pressure** which can **crush anything**.

We do **not feel it** because practically all the bodies have air inside them. As atmospheric pressure acts in all directions, it balances the pressure inside.

**** 16. What is the evidence of atmospheric pressure? Explain using the tin can experiment.**

We can observe the force of the atmospheric pressure if we **remove the inside air from a vessel** as shown in the following activity.

Boil some water in a tin can. When it is full of steam, remove it from the burner and close its mouth by an **air-tight cork**. Then pour cold water over it. The **can crumples**.

Why does the tin crumple?

The tin crumples because the steam inside cools down and condenses, creating **low pressure**. The higher atmospheric pressure outside pushes on the can and crushes it.

17. What is the variation of atmospheric pressure with height?

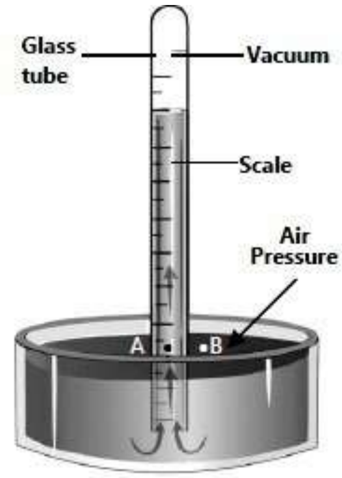
As gases in the atmosphere are fluids, atmospheric pressure is **maximum at sea level** and **decreases with height**.

According to the formula $P = \rho g h$, pressure depends on depth. At $\mathbf{5\ km}$ height, the pressure drops to $\mathbf{55\ kPa}$, and at $\mathbf{30\ km}$, it drops to $\mathbf{1\ kPa}$.

Thus, lower atmospheric pressure means greater altitude.

**** 18. How is atmospheric pressure measured using a barometer?**

*Atmospheric pressure is usually measured by the height of mercury column which it can support. Instruments which measure the atmospheric pressure are called **barometers**.*



A simple mercury barometer consists of a glass tube about one metre long that is closed at one end. It is filled with mercury and inverted vertically in a dish of mercury. A metre scale is placed by the side of the tube to measure the height of mercury column. The space in the glass tube over the top of the mercury is completely empty. The pressure is almost zero.

The pressure **P**, at point **A** in the mercury column is the same as at point **B** at the surface of mercury in the dish because both points are at the same level. This is equal to the atmospheric pressure $P = \rho g h$ acting at the surface of mercury.

If $P = 1.013 \times 10^5\,Pa$ at sea level and $\rho = 13.6 \times 10^3\,kgm^{-3}$ for mercury, the height of mercury column is $760\,mm$.

Using this instrument, atmospheric pressure at any altitude can be measured in terms of height of mercury column.

19. Can we use water in place of mercury to construct a barometer? Explain why.

No, we cannot use water in place of mercury in a barometer because water is much less dense. Since mercury is 13.6 times denser, a water barometer would need to be over **10 meters tall** to measure the same air pressure. This makes it **impractical** to use.

20. How does atmospheric pressure vary and how is it used in weather forecasting?

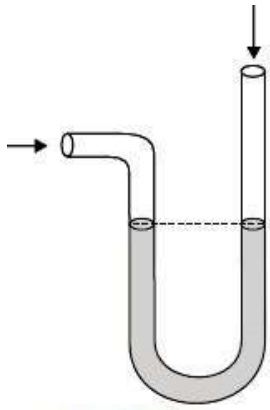
The **atmospheric pressure** does not always remain uniform but fluctuates. By observing these variations, meteorologists can forecast weather conditions.

Atmospheric pressure depends on the **density of air**. At high altitudes, where the air is less dense, atmospheric pressure decreases. Similarly, an increase in the quantity of water vapour also reduces air density. Therefore, atmospheric pressure is lower in cloudy regions.

Weathercasters use this information to predict rainfall. A **fall in pressure** often indicates that rain clouds are approaching and rain is likely to follow.

**** 21. What is a simple manometer and how does it indicate pressure?**

A **simple manometer** consists of a U-shaped glass tube containing mercury. Initially, the atmospheric pressure at both open ends is the same, so the mercury level in both arms remains equal.

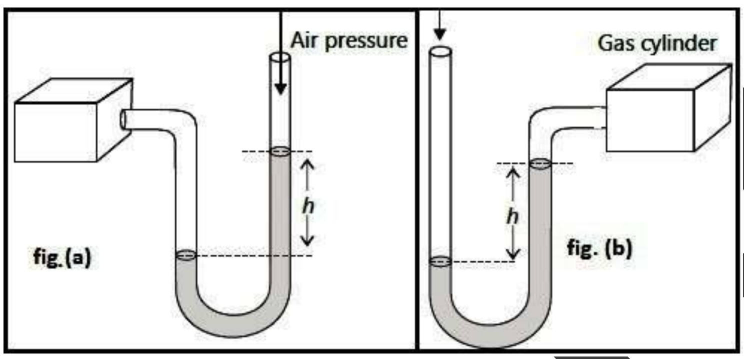


manometer

If a gas cylinder is connected to the short arm while keeping the long arm open:

(i) If the mercury level in the **short arm is lower** than in the long arm (Fig. a), the unknown pressure is more than atmospheric pressure.

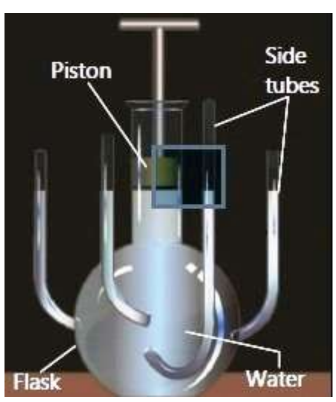
(ii) If the mercury level in the **short arm is higher** than in the long arm (Fig. b), the unknown pressure is less than atmospheric pressure.



**** 22. What is Pascal's Law? State its advantages and applications.**

When pressure is applied at one point in an enclosed fluid, it is transmitted equally to all parts of the fluid without loss.

To understand this in liquids, take water in a flask with a piston and side tubes at different positions. On pressing the piston, the water level in all side tubes rises equally.



Advantages of hydraulic systems based on Pascal's Law:

(i) Liquids do not absorb any of the supplied energy.

(ii) They can move heavy loads and produce great forces due to their incompressibility.

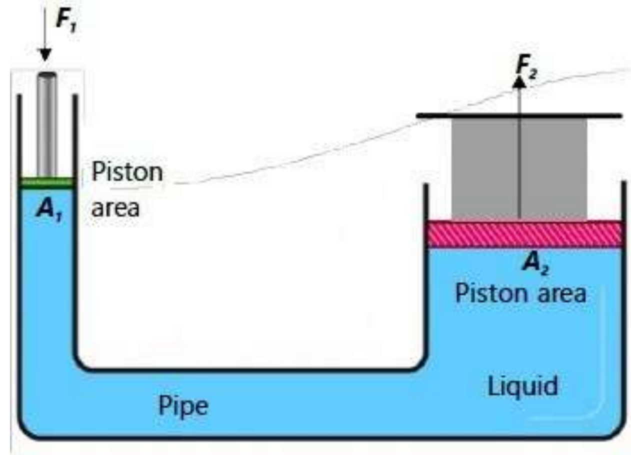
Applications of hydraulic systems:

(1) Hydraulic press

(2) Car lift at service stations

(3) Hydraulic brakes in vehicles

**** 23. How does a hydraulic press work as a force multiplier? Explain using Pascal's law.**



Consider a specially designed container with two cylinders connected by a pipe as shown in figure. The smaller cylinder has a cross-sectional area A_1 and the larger cylinder has area A_2. Both are filled with an incompressible liquid.

When a force F_1 is applied on the small piston, it creates pressure

$$P = \frac{F_1}{A_1}$$

This pressure is transmitted equally to the larger piston due to Pascal's Law. Hence, a force F_2 acts on the larger piston and is given by:

$$F_2 = P \times A_2$$

Putting the value of P,

$$F_2 = \left(\frac{F_1}{A_1}\right) \times A_2$$

$$F_2 = F_1 \times \left(\frac{A_2}{A_1}\right)$$

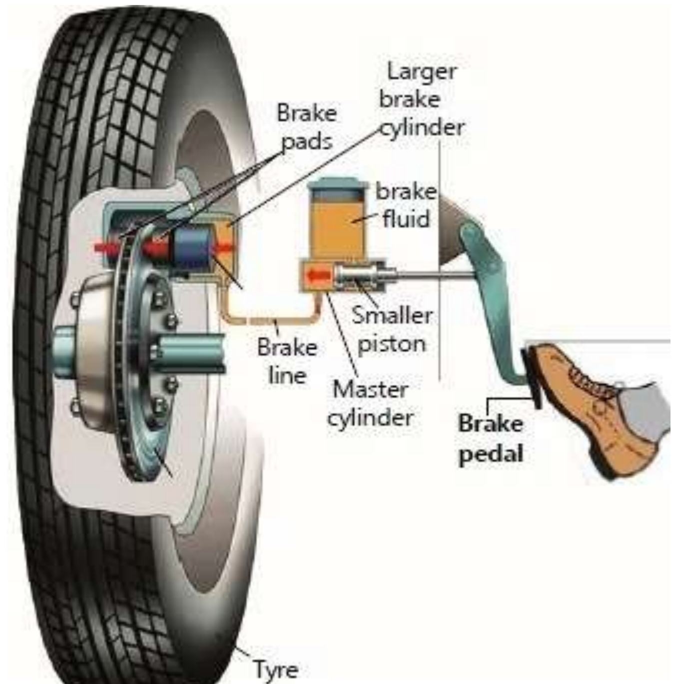
Since $A_2 > A_1$, therefore $F_2 > F_1$. This means a **small force** applied on the small piston results in a **large force** on the larger piston. Such a system is called a **force multiplier**.

A **hydraulic press** works on this principle. The object to be compressed (like a cotton bale) is placed on the larger piston. A force F_1 is applied on the smaller piston. The pressure generated lifts the larger piston and compresses the object.

This principle is also used at **service stations to lift cars** for washing.

24. How do hydraulic brakes work? Explain using Pascal's law.

Hydraulic brakes of some vehicles work on **Pascal's law**. In this system:



- A **master cylinder** with a small cross-sectional area is connected to a brake pedal.
- It is joined through pipes to larger **cylinders with pistons** attached to the wheels.
- The system is **filled with oil**.

When the brake pedal is pressed, the piston in the master cylinder applies pressure to the liquid. According to Pascal's law, this pressure is **transmitted equally** to all the larger pistons in the wheel cylinders.

This causes the larger pistons to move outward, pressing the brake pads against **brake discs or drums**. The resulting **friction** slows down the vehicle.

When the **pedal is released**, **springs pull back** the brake pads and the wheels move freely again.

**** 25. Distinguish between force and pressure.**

Force	Pressure
Force is a push or pull acting on an object.	Pressure is the force applied per unit area.
It is measured in newtons (N).	It is measured in pascals (Pa).
Formula: $F = ma$	Formula: $P = \frac{F}{A}$

**** 26. What is the relationship between liquid pressure and the depth of the liquid?**

Liquid pressure increases with depth**.** The relationship is given by the formula:

$$P = \rho g h$$

This means that the deeper you go in a liquid, the greater the pressure becomes.

**** 27. What is the basic principle to measure the atmospheric pressure by a simple mercury barometer?**

The basic principle is that atmospheric pressure is equal to the pressure exerted by the mercury column in the barometer. This is expressed as:

$$P = \rho g h$$

At sea level, this height is about $760\,mm$, which corresponds to a standard atmospheric pressure of $1.013 \times 10^5\,Pa$.

****. 28. State the basic principle used in the hydraulic brake system of the automobiles.**

The hydraulic brake system works on Pascal's law, which states:

When pressure is applied at one point in an enclosed fluid, it is transmitted equally to all parts of the fluid without loss.

This principle allows a small force applied at the brake pedal to create a larger force at the brake pads, slowing down the vehicle.

**** 29. Why do heavy animals like an elephant have a large area of the foot?**

Heavy animals like elephants have **thick legs and large flat feet** so that due to large contact area, pressure becomes less, otherwise, their bones would not tolerate the pressure.

**** 30. Why is it painful to walk bare footed on pebbles?**

When we walk on pebbles, the contact area of our foot with the ground becomes **small**, so the pressure due to our weight becomes **very high**, and it becomes painful.

On a flat surface, the reaction force is spread over a larger area, so the pressure is low and **not painful**.

**** 31. Why animals like deer who run fast have a small area of the foot?**

Animals like deer who run fast have a **small area of the foot** so that the pressure on the ground becomes high, which gives them a **stronger grip** and helps them to **run quickly** without slipping.

Important Formulas

- **Density** $Density = \frac{Mass}{Volume} \quad \Rightarrow \rho = \frac{m}{V}$
- **Pressure** $P = \frac{F}{A}$
- **Spring constant** $k = \frac{F}{x}$
- **Equation of Hydraulic Press** $\frac{F_1}{A_1} = \frac{F_2}{A_2}$
- **Volume** $V = L \times B \times H$
- **Pressure at a depth** $P = \rho g h$

6.1. A spring is stretched $20\ mm$ by a load of $40\ N$. Calculate the value of spring constant. If an object cause an extension of $16\ mm$, what will be its $weight$?

Given Data

$$Extension\ in\ spring = x_1 = 20\ mm$$
$$x_1 = 20 \times 10^{-3}\ m$$
$$x_1 = 0.02\ m$$
$$Force\ applied = F_1 = 40\ N$$
$$New\ extension = x_2 = 16\ mm$$
$$x_2 = 16 \times 10^{-3}\ m$$
$$x_1 = 0.016\ m$$

To Find

$$Spring\ constant = k = ?$$
$$Weight\ for\ extension\ of\ 16\ mm = F_2 = ?$$

Solution

By using formula of spring constant $k = \frac{F}{x}$

$$k = \frac{F_1}{x_1}$$
$$k = \frac{40}{0.02}$$
$$\boldsymbol{k = 2000\ Nm^{-1}}$$

As $k = \frac{F}{x} \Longrightarrow F = kx$, so

$$F_2 = kx_2$$
$$F_2 = (2000)(0.016)$$
$$\boldsymbol{F_2 = 32\ N}$$

6.2. The mass of 5 litres of milk is 4.5 kg. Find its density in SI units.

Given Data

$$Mass\ of\ milk = m = 4.5\ kg$$
$$Volume\ of\ milk = V = 5\ litres$$
$$V = 5 \times 10^{-3}\ m^3$$

To Find

$$Density = \rho = ?$$

Solution

By using formula of density

$$Density = \frac{Mass}{Volume}$$
$$\rho = \frac{m}{V}$$
$$\rho = \frac{4.5}{5 \times 10^{-3}}$$
$$\boldsymbol{\rho = 900\ kgm^{-3}}$$

Note: *A volume of* $1000\ litres$ *is the same as* $1\ cubic\ meter$ *of space.*

$$1000\ litres = 1\ m \times 1\ m \times 1\ m$$
$$1000\ litres = 1\ m^3$$
$$1\ litres = \frac{1}{1000}\ m^3$$
$$1\ litres = \frac{1}{10^3}\ m^3$$
$$1\ litres = 10^{-3} m^3$$

6.3. When a solid of mass $60\ g$ is lowered into a measuring cylinder, the level of water rises from $40\ cm^3$ to $44\ cm^3$. Calculate the density of the solid.

Given Data

$$Mass\ of\ solid = m = 60\ g$$
$$m = \frac{60}{1000}\ kg$$
$$m = 0.06\ kg$$
$$Initial\ volume\ of\ water = V_1 = 40\ cm^3$$
$$Final\ volume\ of\ water = V_2 = 44\ cm^3$$
$$Volume\ of\ solid = V = V_2 - V_1$$
$$V = 44 - 40$$
$$V = 4\ cm^3$$
$$V = 4\ (10^{-2})^3 m^3$$
$$V = 4 \times 10^{-6}\ m^3$$

To Find

$$Density = \rho = ?$$

Solution

By using formula of density

$$Density = \frac{Mass}{Volume}$$
$$\rho = \frac{m}{V}$$
$$\rho = \frac{0.06}{4 \times 10^{-6}}$$
$$\boldsymbol{\rho = 15000\ kgm^{-3}}$$
$$\boldsymbol{\rho = 15 \times 10^3\ kgm^{-3}}$$

6.4. A block of density $8 \times 10^3\ kgm^{-3}$ has a volume $60\ cm^3$. Find its mass.

Given Data

$$Density = \rho = 8 \times 10^3\ kgm^{-3}$$
$$Volume = V = 60\ cm^3$$
$$V = 60\ (10^{-2})^3 m^3$$
$$V = 60 \times 10^{-6}\ m^3$$

To Find

$$Mass\ of\ the\ block = m = ?$$

Solution

By using formula of density

$$\rho = \frac{m}{V}$$
$$m = \rho V$$
$$m = (8 \times 10^3)(60 \times 10^{-6})$$
$$\boldsymbol{m = 0.48\ kg}$$

6.5. A brick measures $5\ cm \times 10\ cm \times 20\ cm$. If its mass is $5\ kg$, calculate the maximum and minimum pressure which the brick can exert on a horizontal surface.

Given Data

$$Dimensions\ of\ the\ brick = V = 5\ cm \times 10\ cm \times 20\ cm$$
$$Mass\ of\ the\ brick = m = 5\ kg$$
$$Minimum\ area = A_{min} = 5\ cm \times 10\ cm$$
$$A_{min} = 50\ cm^2$$

$$A_{min} = 50\ (10^{-2})^2 m^2$$
$$A_{min} = 50\ \times 10^{-4}\ m^2$$
$$Maximum\ area = A_{max} = 10\ cm \times 20\ cm$$
$$A_{max} = 200\ cm^2$$
$$A_{max} = 200\ (10^{-2})^2 m^2$$
$$A_{max} = 200\ \times 10^{-4}\ m^2$$

To Find

$$Minimum\ pressure = P_{min} = ?$$
$$Maximum\ pressure = P_{max} = ?$$

Solution

As we know that force is equal to weight of brick, so

$$F = w$$
$$F = mg$$
$$F = (5)(10)$$
$$F = 50\ N$$

For minimum pressure, by using formula of pressure $P = \frac{F}{A}$

$$P_{min} = \frac{F}{A_{max}}$$
$$P_{min} = \frac{50}{200\ \times 10^{-4}}$$
$$P_{min} = 2500\ Nm^{-2}$$
$$\boldsymbol{P_{min} = 2.5 \times 10^3\ Nm^{-2}} \quad (\boldsymbol{Pa})$$

For maximum pressure, by using formula of pressure $P = \frac{F}{A}$

$$P_{max} = \frac{F}{A_{min}}$$
$$P_{max} = \frac{50}{50\ \times 10^{-4}}$$
$$P_{max} = 10000\ Nm^{-2}$$
$$\boldsymbol{P_{max} = 1.0 \times 10^4\ Nm^{-2}} \quad (\boldsymbol{Pa})$$

Note: Pressure is *minimum* when the area is ***maximum***, and pressure is *maximum* when the area is ***minimum***.

6.6. What will be the height of the column in barometer at sea level if mercury is replaced by water of density $\boldsymbol{1000\ kgm^{-3}}$, where density of mercury is $\boldsymbol{13.6 \times 10^3\ kgm^{-3}}$.

Given Data

$$Density\ of\ water = \rho_1 = 1000\ kgm^{-3}$$
$$Density\ of\ mercury = \rho_2 = 13.6 \times 10^3\ kgm^{-3}$$
$$height\ of\ mercury\ column = h_2 = 0.76\ m$$

To Find

$$Height\ of\ water\ column = h_1 = ?$$

Solution

Since the pressure at sea level remains the same, we equate the pressures for mercury and water columns. So

$$P_{water} = P_{mercury}$$
$$\rho_1 g h_1 = \rho_2 g h_2 \qquad \because P = \rho g h$$
$$h_1 = \frac{\rho_2 g h_2}{\rho_1 g}$$
$$h_1 = \frac{\rho_2 h_2}{\rho_1}$$
$$h_1 = \frac{(13.6 \times 10^3)(0.76)}{1000}$$
$$\boldsymbol{h_1 = 10.34\ m}$$

6.7. Suppose in the hydraulic brake system of a car, the force exerted normally on its piston of cross-sectional area of $\boldsymbol{5\ cm^2}$ is $\boldsymbol{500\ N}$. What will be the pressure transferred to the brake oil? What will be the force on the second piston of area of cross-section $\boldsymbol{20\ cm^2}$?

Given Data

$$Area\ of\ first\ piston = A_1 = 5\ cm^2$$
$$A_1 = 5\ (10^{-2})^2 m^2$$
$$A_1 = 5\ \times 10^{-4}\ m^2$$
$$Force\ on\ first\ piston = F_1 = 500\ N$$
$$Area\ of\ second\ piston = A_2 = 20\ cm^2$$
$$A_2 = 20\ (10^{-2})^2 m^2$$
$$A_2 = 20\ \times 10^{-4}\ m^2$$

To Find

$$Pressure\ transferred\ to\ brake\ oil = P_1 = ?$$
$$Force\ on\ second\ piston = F_2 = ?$$

Solution

By using formula of pressure $P = \frac{F}{A}$

$$P_1 = \frac{F_1}{A_1}$$
$$P_1 = \frac{500}{5\ \times 10^{-4}}$$
$$P_1 = 1000000$$
$$\boldsymbol{P_1 = 1.0 \times 10^6\ Nm^{-2}} \quad (\boldsymbol{Pa})$$

By using equation of hydraulic press

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$
$$F_2 = \frac{F_1 A_2}{A_1}$$
$$F_2 = \frac{(500)(20\ \times 10^{-4})}{5\ \times 10^{-4}}$$
$$\boldsymbol{F_2 = 2000\ N}$$

6.8. Find the water pressure on a deep-sea diver at a depth of $\boldsymbol{10\ m}$, where the density of sea water is $\boldsymbol{1030\ kgm^{-3}}$.

Given Data

$$Depth\ of\ water = h = 10\ m$$
$$Density\ of\ sea\ water = \rho = 1030\ kgm^{-3}$$
$$Gravitational\ acceleration\ = g = 10\ ms^{-2}$$

To Find

$$Pressure\ at\ depth\ h = P = ?$$

Solution

By using formula of pressure at a depth

$$P = \rho g h$$
$$P = (1030)(10)(10)$$
$$P = 103000\ Nm^{-2}$$
$$\boldsymbol{P = 1.03 \times 10^5\ Nm^{-2}} \quad (\boldsymbol{Pa})$$

6.9. The area of cross-section of the small and large pistons of a hydraulic press is respectively $\boldsymbol{10\ cm^2}$ and $\boldsymbol{100\ cm^2}$. What force should be exerted on the small piston in order to lift a car of weight $\boldsymbol{4000\ N}$?

Given Data

$$Area\ of\ small\ piston = A_1 = 10\ cm^2$$
$$A_1 = 10\ (10^{-2})^2 m^2$$
$$A_1 = 10 \times 10^{-4}\ m^2$$
$$Area\ of\ large\ piston = A_2 = 100\ cm^2$$
$$A_2 = 100\ (10^{-2})^2 m^2$$

$$A_2 = 100 \times 10^{-4}\, m^2$$
$$Weight\ to\ be\ lifted = F_2 = 4000\ N$$

To Find

$$Force\ on\ small\ piston = F_1 = ?$$

Solution

By using equation of hydraulic press

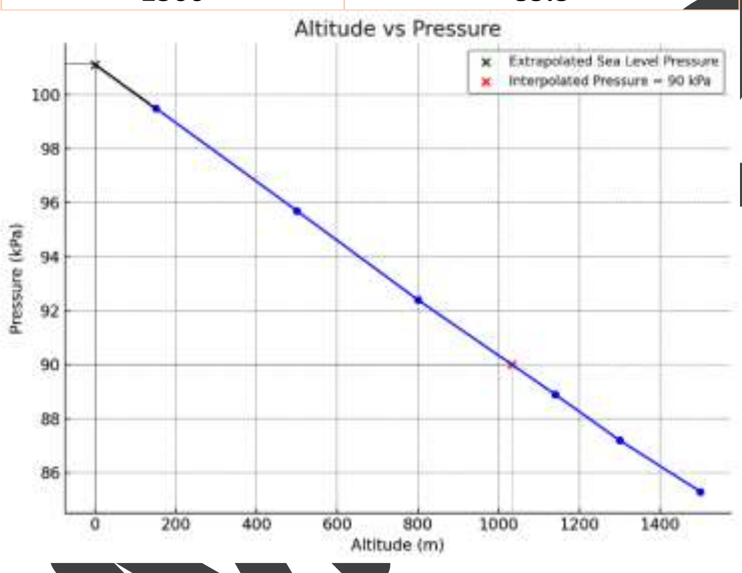
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$
$$F_1 = \frac{F_2 A_1}{A_2}$$
$$F_1 = \frac{(4000)(10 \times 10^{-4})}{100 \times 10^{-4}}$$
$$\boldsymbol{F_1 = 400\ N}$$

6.10. In a hot air balloon, the following data was recorded. Draw a graph between the altitude and pressure and find out:

(a) What would the air pressure have been at sea level?

(b) At what height the air pressure would have been 90 kPa?

Altitude (m)	Pressure (kPa)
150	99.5
500	95.7
800	92.4
1140	88.9
1300	87.2
1500	85.3



From the graph:

(a) At sea level ($0\ m$), the extrapolated air pressure is approximately $101.1\ kPa$.

(b) When the air pressure is $90\ kPa$, the interpolated altitude is approximately $1033\ m$.

6.11. If the pressure in a hydraulic press is increased by an additional $10\ Ncm^{-2}$, how much extra load will the output platform support if its cross-sectional area is $50\ cm^2$?

Given Data

$$Pressure\ increase = P = 10\ Ncm^{-2}$$
$$Cross-sectional\ area = A = 50\ cm^2$$

To Find

$$Extra\ load\ (Force)\ supported = F = ?$$

Solution

By using formula of pressure

$$P = \frac{F}{A}$$
$$F = PA$$
$$F = (10\ Ncm^{-2})(50\ cm^2)$$
$$\boldsymbol{F = 500\ N}$$

6.12. The force exerted normally on the hydraulic brake system of a car, with its piston of cross-sectional area $5\ cm^2$ is $500\ N$. What will be the:

(a) pressure transferred to the brake oil?

(b) force on the brake piston of area of cross section $20\ cm^2$? $[Same\ as\ 6.7]$

Given Data

$$Area\ of\ small\ piston = A_1 = 5\ cm^2$$
$$A_1 = 5\,(10^{-2})^2 m^2$$
$$A_1 = 5 \times 10^{-4}\ m^2$$
$$Force\ on\ small\ piston = F_1 = 500\ N$$
$$Area\ of\ large\ piston = A_2 = 20\ cm^2$$
$$A_2 = 20\,(10^{-2})^2 m^2$$
$$A_2 = 20 \times 10^{-4}\ m^2$$

To Find

$$Pressure\ transferred\ to\ brake\ oil = P_1 = ?$$
$$Force\ on\ the\ large\ piston = F_2 = ?$$

Solution

By using formula of pressure $P = \frac{F}{A}$

$$P_1 = \frac{F_1}{A_1}$$
$$P_1 = \frac{500}{5 \times 10^{-4}}$$
$$P_1 = 1000000$$
$$\boldsymbol{P_1 = 1.0 \times 10^6\ Nm^{-2}} \qquad \boldsymbol{(Pa)}$$

By using equation of hydraulic press

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$
$$F_2 = \frac{F_1 A_2}{A_1}$$
$$F_2 = \frac{(500)(20 \times 10^{-4})}{5 \times 10^{-4}}$$
$$\boldsymbol{F_2 = 2000\ N}$$