UNIT 7

PROPERTIES OF MATTER

Topic No.	Title	Page No.
7.1	**Kinetic Molecular Model of Matter** • Solid • Liquid • Gas • Plasma	246
7.2	**Density**	246
7.3	**Pressure**	251
7.4	**Atmospheric Pressure** • Measuring Atmospheric Pressure • Variations in Atmospheric Pressure	251
7.5	**Pressure in Liquids** • Pascal's Law • Applications of Pascal's Law	257
7.6	**Archimedes Principle** • Density of an Object	262
7.7	**Principle of Floatation** • Ships and Submarines	262
7.8	**Elasticity**	270
7.9	**Hook's Law** • Young Modulus	268
*	**Text Book Exercise** • Multiple Choice Questions • Exercise Questions • Numerical Problems	27
*	**Self-Test**	286

7.1 KINETIC MOLECULAR MODEL OF MATTER
7.2 DENSITY

LONG QUESTIONS

Q.1 Explain different states of matter on the basis of kinetic molecular theory. **(LHR 2013)**
(K.B+U.B+A.B)

Ans: Kinetic molecular model is used to explain the four states of matter – solid, liquid, gas and plasma.

(i) Solid:

Solids have **fixed shapes** and **volume**. Their molecules are held close together by **strong forces of attraction**. However, they vibrate about their mean positions but do not move from place to place.

Examples:

Examples of solids are stone, metal spoon, pencil etc.

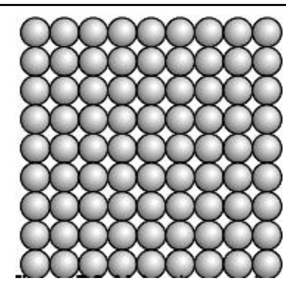

Figure: Molecules are Closely Packed in Solids

(ii) Liquids:

The distances between the molecules of a liquid are more than in solids. Thus, **attractive forces** between them are **weaker**. Like solids, molecules of a liquid also vibrate about their mean position but are not rigidly held with each other. Due to the weaker attractive forces, they can slide over one another. Thus, the liquids can flow. The volume of a certain amount of liquid remains the same but because it can flow hence; it attains the shape of a container to which it is put.

Examples:

Examples of liquids are milk, and liquid water etc.

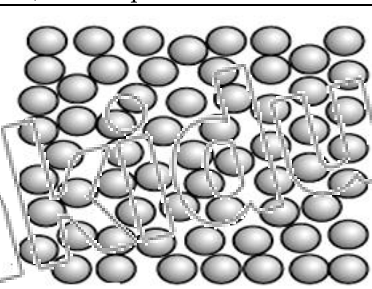

Figure: Molecules Are Loosely Packed In Liquids

(iii) Gases:

Gases such as air have **no fixed shape** or volume. They can be filled in any container of any shape. Their molecules have random motion and move with very high velocities. In gases, molecules are much farther apart than solids or liquids. Thus, gases are much lighter than solids and liquids. They can be **squeezed** into smaller volumes.

Examples:

Oxygen, Nitrogen and Carbon dioxide are examples of gases.

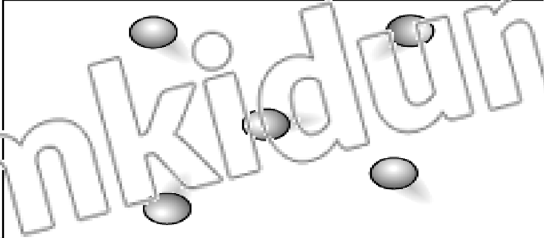

Figure: Molecules Are Much Farther Apart In Gases

Pressure of Gases:

The molecules of a gas are constantly striking the walls of a container. Thus, a gas exerts pressure on the walls of the container.

(iv) Plasma: **(LHR 2017)**

The kinetic energy of gas molecules goes on increasing if a gas is heated continuously. This causes the gas molecules move faster and faster. The collisions between atoms and molecules of the gas become so strong that they tear off the atoms. Atoms lose their electrons and become positive ions. This **ionic state** of **matter** is called plasma.

Plasma in Discharge Tubes:

Plasma is also formed in gas discharge tubes when electric current passes through these tubes.

Plasma – The Fourth State of Matter:

Plasma is also called the **fourth state** of **matter** in which **gas** occurs in its **ionic state**. Positive ions and electrons get separated in the presence of electric and magnetic field. Plasma also exists in neon and fluorescent tubes when they glow.

Universe Formation:

Most of the matter that fills the universe is in plasma state. In stars such as our sun, gases exist in their ionic state.

Plasma Good Conductor:

Plasma is highly conducting state of mater. It allows electric current to pass through it.

Brownian motion: evidence for moving particles: (Interesting information)

Smoke is made up of millions of tiny bits of ash or oil droplets. If you look at smoke through a microscope, you can see the bits of smoke glinting in the light. As they drift through the air, they wobble about in zing-zag paths. This effect is called Brownian motion, after the scientist Robert Brown who first noticed the wobbling, wandering motion of pollen grains in water; who first noticed the wobbling, wandering motion of pollen grains in water; in 1827.

The kinetic theory explains Brownian motion as follows. The bits of smoke are just big enough to be seen, but have so little mass that they are jostled about as thousands of particles (gas molecules) in the surrounding air bump into them at random.

7.1, 7.2 SHORT QUESTIONS

Q.1 What happens when we heat a gas? *(K.B)*

Ans: Given on Page # 247

Q.2 How can a liquid flow? *(K.B)*

Ans: Given on Page # 246

Q.3 What are the particles? *(K.B)*

Ans: Everything is made from about 100 simple substances called elements. An atom is the smallest possible amount of an element. In some materials, the 'moving particles' of the kinetic theory are atoms. However, in most materials, they are group of atoms called molecules. Below, each atom is shown as a coloured sphere. This is simplifies model (description) of an atom. Atoms have no colour or precise shape.

Q.4 Why does a gas exert pressure? *(K.B)*

Ans:

GASEOUS PRESSURE

Gaseous molecules have random motion and move with very high velocities. They collide with one another and with the walls of container hence they exert pressure.

Q.5 What is Kinetic molecular theory? Write down its postulates. *(K.B)* **(LHR 2013)**

Ans:

KINETIC MOLECULAR MODEL

Most of the properties of solids, liquids, and gases can be explained on the basis of the intermolecular forces that has been explained by Kinetic molecular model. Kinetic molecular model has some important features.

- Matter is made up of particles called molecules.
- The molecules remain in continuous motion. The motion of molecules could be linear, vibrational, or rotational.
- The molecules attract each other.

Q.6 What is plasma? *(K.B)* **(GRW 2013)**

Ans: Given on Page # 247

Q.7 Define density. Write its formula and unit? *(K.B+U.B+A.B)* **(LHR 2013, 2107)**

Ans:

DENSITY

Definition:

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

Formula:

$$\text{Density} = \frac{\text{mass of a substance}}{\text{volume of that substance}}$$

Unit:

SI unit of density is kilogramme per cubic meter (kg m^{-3}).

Density Equations:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Mass} = \text{Density} \times \text{Volume}$$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

Q.8 Find density of 5 litre of water. *(U.B)*

Solution:

Given Data:

As 1 litre of water = 1kg of water

So Mass of water = m =5 kg

Volume of water = V = 5 litre = 5×10^{-3} m^3

To Find:

Density of Water = d =?

Solution:

We know

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Putting values

$$\text{Density} = \frac{5}{5\times10^{-3}} = 1000\text{kgm}^{-3}$$

Results:

> **The density of water is 1000kgm^{-3}.**

Q.9 What do you know about density of the Earth's atmosphere? *(K.B)*

Ans:

DENSITY OF THE EARTH'S ATMOSPHERE

Earth's atmosphere extends upward about a few hundred kilometres with continuously decreasing density. Nearly half of its mass is between sea level and 10 km. Up to 30 km from sea level contains about 99% of the mass of the atmosphere. The air becomes thinner and thinner as we go up.

EXAMPLE 7.1

The mass of 200 cm3 of stone is 500 g. Find its density. (U.B+A.B)

Solution:

Given Data:

Mass of stone = m =500 g

Volume of water = V = 200 cm^3

To Find:

Density of stone = d = ?

Solution:

We know

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Putting values

$$\text{Density} = \frac{500}{200} = 2.5\text{gcm}^{-3}$$

Result:

> **Hence, the density of stone will be 200 gm^{-3}.**

7.1, 7.2 MULTIPLE CHOICE QUESTIONS

1. According to Kinetic Molecular theory, gases exert pressure on the walls of the container due to their: *(K.B)*

(A) Weight (B) Mass
(C) Collisions (D) All of above

2. The molecules of the matter are always remain in the state of: *(K.B)*

(A) Rest (B) Plasma
(C) Motion (D) Tension

3. The energy possessed by the molecules of the matter is due to its motion: *(K.B)*

(A) P.E. (B) K.E.
(C) Sound (D) None of above

4. When temperature of the matter increases, intermolecular forces : *(K.B)*

(A) Increases (B) Decreases
(C) Remains same (D) None of above

5. Molecules of which state of matter have strongest attractive for *(K.B)*

(A) Solid (B) Liquid
(C) Gasses (D) Plasma

6. How many states of matter are? *(K.B)*

(A) 2 (B) 3
(C) 4 (D) Many

7. Strongest attractive forces are in *(K.B)*

(A) Gases (B) Liquid
(C) Solid (D) Plasma

8. Weakest attractive forces are in *(K.B)*

(A) Solid (B) Liquid
(C) Gases (D) Plasma

9. Ionic state of matter is called *(K.B)* **(GRW 2013)**

(A) Gas (B) Plasma
(C) Liquid (D) None of these

10. Plasma is *(K.B)*

(A) Good conductor (B) Bad conductor
(C) Semi conductor (D) Non conductor

11. Unit of density *(K.B)* **(LHR 2013)**

(A) kg m^3 (B) kg m^{-2}
(C) kg m^{-3} (D) kg m^2

12. A solid object is: *(K.B)*

(A) Not elastic below the elastic limit (B) Elastic above the elastic limit
(C) Elastic below the elastic limit (D) None of above

13. What is density of air? *(K.B)*

(A) 920 kg m^{-3} (B) 1000 kg m^{-3}
(C) 1.3 kg m^{-3} (D) 2700 kg m^{-3}

14. What is density of ice? *(K.B)*

(A) 920 kg m^{-3} (B) 1000 kg m^{-3}
(C) 1.3 kg m^{-3} (D) 2700 kg m^{-3}

15. **What is density of water? *(K.B)***
(A) 920 kg m^{-3} (B) 1000 kg m^{-3}
(C) 1.3 kg m^{-3} (D) 2700 kg m^{-3}

16. **What is density of Aluminum? *(K.B)***
(A) 920 kg m^{-3} (B) 1000 kg m^{-3}
(C) 1.3 kg m^{-3} (D) 2700 kg m^{-3}

17. **What is density of iron? *(K.B)***
(A) 7900 kg m^{-3} (B) 13600 kg m^{-3}
(C) 19300 kg m^{-3} (D) 8900 kg m^{-3}

18. **What is density of Copper? *(K.B)***
(A) 7900 kg m^{-3} (B) 13600 kg m^{-3}
(C) 19300 kg m^{-3} (D) 8900 kg m^{-3}

19. **What is density of Aluminum? *(K.B)***
(A) 7900 kg m^{-3} (B) 13600 kg m^{-3}
(C) 19300 kg m^{-3} (D) 8900 kg m^{-3}

20. **What is density of Gold? *(K.B)***
(A) 2700 kg m^{-3} (B) 13600 kg m^{-3}
(C) 19300 kg m^{-3} (D) 8900 kg m^{-3}

21. **$1m^3$ = *(K.B+U.B)*** **(Useful information Pg. # 147)**
(A) 10 Litre (B) 100 Litre
(C) 1000 Litre (D) 0.1 Litre

22. **$1cm^3$ = *(K.B+U.B)*** **(Useful information Pg. # 147)**
(A) 10^{-6} m^3 (B) 10^{-3} m^3
(C) 1 m^3 (D) 0.1 m^3

23. **1 Litre = *(K.B+U.B)*** **(Useful information Pg. # 147, LHR 2017)**
(A) 10^{-6} m^3 (B) 10^{-3} m^3
(C) 1 m^3 (D) 0.1 m^3

24. **1000 kgm^{-3} =** **(Useful information Pg. # 147)**
(A) 10^{-6} gcm^{-3} (B) 10^{-3} gcm^{-3}
(C) 1 gcm^{-3} (D) 0.1 gcm^{-3}

7.3 PRESSURE
7.4 ATMOSPHERIC PRESSURE

LONG QUESTIONS

Q.1 **What is atmospheric pressure? And explain atmospheric pressure with the help of an experiment.**

OR **Show that atmosphere exert pressure. *(K.B+U.B+A.B)*** **(Ex. 7.7)**

Ans: **ATMOSPHERIC PRESSURE**

Definition:

"The **earth** is **surrounded** by a **cover of air** is called atmosphere."

Atmosphere extends to a few hundred kilometers above sea level. Just as certain sea creatures live at the bottom of ocean, we live at the bottom of a huge ocean of air.

Atmospheric Pressure Decreases With Height:

Air is the mixture of gases. The density of air in the atmosphere is not uniform. It decreases continuously as we go up due to this reason atmospheric pressure decreases with height. The atmospheric pressure at sea level is greater as compared to hilly areas.

Atmospheric Pressure Acts in All Directions:

Atmospheric pressure acts in all directions.

Examples:

- Soap bubbles expand till the pressure of air in them is equal to the atmospheric pressure. Soap bubbles so formed have spherical shapes because the atmospheric pressure acts on a bubble equally in all directions.

Figure: The Air Pressure Inside The Bubble is Equal To The Atmospheric Pressure

- A balloon expands as we fill air into it. The balloon will expand in all directions it is because of the fact that atmospheric pressure acts in all directions equally as shown in the figure.

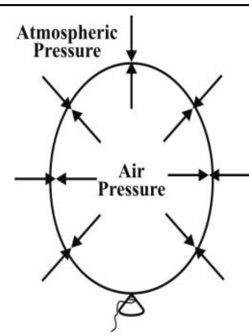

Figure: Air Pressure Inside The Balloon is Equal To The Atmospheric Pressure.

Experiment:

The fact that atmosphere exerts pressure can be explained by simple experiment.

- Take an empty tin can with a lid.
- Open its cap and put some water in it. Place it over flame.
- Wait till water begins to boil and the steam expels the air out of the can
- Remove it from the flame.
- Close the can firmly by its cap.
- Now place the can under tape water as shown in the figure:

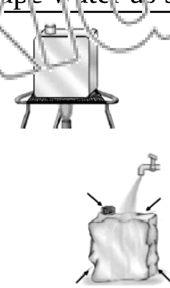

Figure: Crushing Can Experiment

Observations:

The can will squeeze due to atmospheric pressure.

Reasons:

When the can is cooled by tap water, the steam in it condenses. As the steam changes into water, it leaves an empty space behind it. This lowers the pressure inside the can as compared to the atmospheric pressure outside the can. This will cause that can to collapse from all directions. This experiment shows that atmosphere exerts pressure in all directions.

Q.2 Which device is used to measure the atmospheric pressure? Explain the measurement of atmospheric pressure by using barometer. ***(K.B+U.B+A.B)***

Ans: **MEASUREMENT OF ATMOSPHERIC PRESSURE**

Introduction:

At sea level, the atmospheric pressure is about **101,300 Pa** or **101,300 Nm^{-2}.** The instruments that measure atmospheric pressure are called **barometers**. One of the simple barometers is a **mercury barometer**. Its construction and working is given below:

Construction:

It consists of a glass tube **1m long** closed at one end. After filling it with mercury, it is inverted in a mercury trough. Mercury in the tube descends and stops at a certain height as shown in the figure:

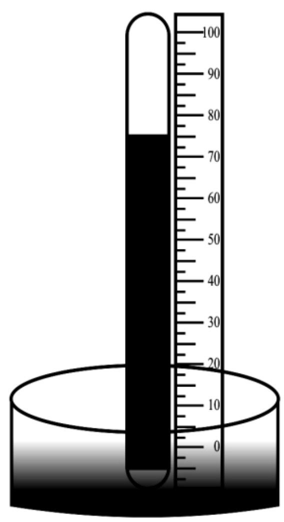

Figure: A Mercury Barometer

Working:

The column of mercury held in the tube exerts pressure at its base. At sea level the height of mercury column above the mercury in the trough is found to be about 76 cm. Pressure exerted by 76 cm of mercury column is nearly 101,300 Nm^{-2} equal to atmospheric pressure. It is common to express atmospheric pressure in terms of the height of mercury column. As the atmospheric pressure at a place does not remains constant, hence, the height of mercury column also varies with atmospheric pressure.

Mercury in Barometer Instead of Water:

Mercury is **13.6** times denser than water. Atmospheric pressure can hold vertical column of water about 13.6 times the height of mercury column at a place. Thus, at sea level, vertical height of water column would be 0.76 m x 13.6 = 10.34 m. Thus, a glass tube more than 10 m long is required to make a water barometer that is difficult to handle and manage practically. So water is not suitable for constructing barometer.

Q.3 Write a note on variation in atmospheric pressure. ***(K.B+U.B)***

Ans:

VARIATION IN ATMOSPHERIC PRESSURE

The atmospheric pressure decreases as we go up due to decrease in the density of the air. The atmospheric pressure on mountains is lower than at sea level. At a height of about **30 km**, the atmospheric pressure becomes only **7 mm** of mercury which is approximately **1000 Pa**. It would become zero at an altitude where there is no air. Thus we can determine the altitude of a place by knowing the atmospheric pressure at that place.

Effect of Weather on Atmospheric Pressure:

Atmospheric pressure may also indicate a change in the weather as:

- On a hot day, air above the Earth becomes hot and expands. This causes a fall of atmospheric pressure in that region.
- During cold chilly nights, air above the Earth cools down. This causes an increase in atmospheric pressure.

Expected Weather Changes Due to Variation of Atmospheric Pressure:

The changes in atmospheric pressure at a certain place indicate the expected changes in the weather conditions at that place.

Decrease in Atmospheric Pressure:

- A gradual and average drop in atmospheric pressure means a low pressure in a neighboring locality.
- Minor but rapid fall in atmospheric pressure indicates a windy and showery condition in the nearby region.
- A decrease in atmospheric pressure accompanied by breeze and rain.
- A sudden fall in atmospheric pressure often followed by a storm, rain and typhoon to occur in few hours' time.

Increase in Atmospheric Pressure:

- An increasing atmospheric pressure with a decline later on predicts an intense weather conditions.
- A gradual large increase in the atmospheric pressure indicates a long spell of pleasant weather.
- A rapid increase in atmospheric pressure means that it will soon be followed by a decrease in the atmospheric pressure indicating poor weather ahead.

7.3, 7.4 SHORT QUESTIONS

Q.1 Define the term pressure write its formula and unit. ***(K.B+U.B)*** **(GRW 2014)**

Ans:

PRESSURE

Definition:

"The **force acting** normally **per unit area** on the surface of a body is called pressure.**"**

Formula:

$$P = \frac{\text{Force}}{\text{Area}}$$

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

Quantity:

Pressure is a scalar and derived quantity.

Unit:

In SI units, the unit of pressure is N m^{-2} also called Pascal (Pa). Thus, 1N m^{-2} = 1Pa

Q.2 Write factors effecting pressure: *(K.B)*

Ans: **FACTORS EFFECTING PRESSURE**

As we know

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

Above relation shows that two factors effect pressure:

- **Force:**
Pressure is directly proportional to force. Greater the force on the surface greater will be the pressure on that surface.
- **Area:**
Pressure is inversely proportional to area. Greater the Area of the surface smaller will be the pressure on that surface.

Example:

Press a pencil from its ends between the palms. The palm pressing the tip feels much more pain than the palm pressing its blunt end. We can push a drawing pin into a wooden board by pressing it by our thumb. It is because the force we apply on the drawing pin is confined just at a very small area under its sharp tip. A drawing pin with a blunt tip would be very difficult to push into the board due to the large area of its tip. In these examples, we find that the effectiveness of a small force is increased if the effective area of the force is reduced. The area of the tip of pencil or that of the nail is very small and hence increases the effectiveness of the force. The quantity that depends upon the force and increases with decrease in the area on which force is acting is called pressure.

Effect of area on pressure is shown in figure below:

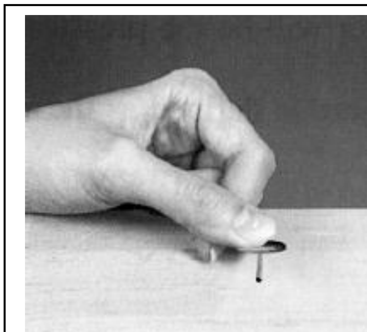

Figure: **A Drawing Pin With Sharp Tip Enters Easily When Pressed On A Wooden Table**

Q.3 Write working of vacuum cleaner. *(K.B)* **(Do you know Pg. # 150)**

Ans: **VACUUM CLEANER**

The fan in a vacuum cleaner lowers air pressure in its bucket. The atmospheric air rushes into it carrying dust and dirt with it through its intake port. The dust and dirt particles are blocked by the filter while air escapes out as shown in the figure:

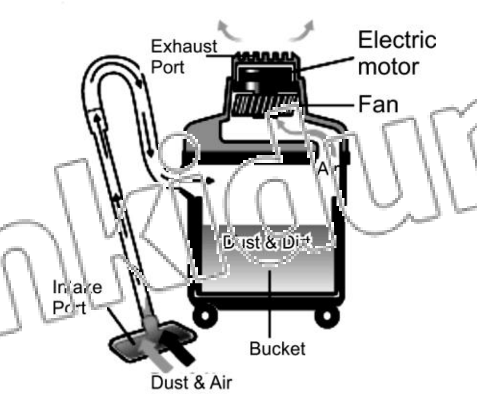

Figure: **Construction of Air Cleaner**

Q.4 How do we suck juice with the help of a straw? *(K.B+A.B)*

Ans: **SUCKING A LIQUID WITH STRAW**

When air is sucked through straw with its other end dipped in a liquid, the air pressure in the straw decreases. This causes the atmospheric pressure to push the liquid up the straw as shown in the figure:

Figure: **Sucking a Liquid with Straw**

7.3, 7.4 MULTIPLE CHOICE QUESTIONS

1. **The force exerted perpendicularly on unit area of an object is called: *(K.B)***
   (A) Strain (B) Constant
   (C) Pressure (D) Work
2. **The unit of pressure is: *(K.B)***
   (A) Nm^{-2} (B) Nm^{-1}
   (C) Pa (D) Both A & C
3. **Pressure depends upon: *(K.B)***
   (A) Density (B) Depth
   (C) Temperature (D) Both A & B
4. **The law about pressure on the object is presented by: *(K.B)***
   (A) Joule (B) Pascal
   (C) Newton (D) Galileo

5. When temperature of the gas increases, gas pressure: *(K.B)*
(A) Increases (B) Decreases
(C) Remains same (D) None of above

6. If quantity of the gas is increased in the container then gas pressure: *(K.B+U.B)*
(A) Increases (B) Decreases
(C) Remains same (D) None of above

7. Pressure depend upon: *(K.B)* **(LHR 2013)**
(A) Force (B) Area
(C) Length (D) Both A&B

8. The instrument used to measure atmospheric pressure *(K.B)*
(A) Colorimeter (B) Hypsometer
(C) Barometer (D) None of these

9. At sea level atmospheric pressure is: *(K.B)* **(LHR 2017)**
(A) 10107 Pa (B) 10300 Pa
(C) 101300 Pa (D) 10107 Pa

7.5 PRESSURE IN LIQUIDS

LONG QUESTIONS

Q.1 Derive an expression for Pressure in liquids. *(K.B+U.B+A.B)*

Ans:

PRESSURE IN LIQUIDS

Liquids exert pressure. The pressure of a liquid acts in all directions. If we take pressure sensor (a device that measures pressure) inside a liquid, then the pressure of the liquid varies with the depth of sensor.

Mathematical Derivation:

Consider a surface area **A** in a liquid at a depth **h** as shown in figure.

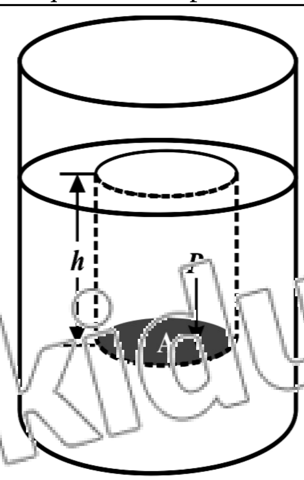

Figure: Pressure Of The Liquid At A Depth h

The length of the cylinder of liquid over this surface will **be h**. The force acting on this surface will be the **weight** w of the liquid above this surface.

If ρ is the **density** of the liquid and m is **mass** of the liquid above the surface, then

Mass of the liquid = m = volume x density

$= m = (A \times h) \times \rho$

Force acting on area A $= F = w = mg$

$= A\, h\, \rho\, g$

As pressure $= P = F/A$

So $= \frac{Ah\rho g}{A}$

Therefore, Liquid pressure at depth h $= P = \rho\, g\, h$

The above equation gives the pressure at a depth h in a liquid of density ρ. It show that its pressure in a liquid increases with depth.

Conclusion:

Pressure of the liquid increases with:

- Increase in depth of the liquid **(h)**
- Increase in the density of the liquid **(ρ)**
- Increases in the value of gravitational acceleration **(g)**

Q.2 State and explain Pascal's law. *(K.B)* **(GRW 2014,2017, LHR 2017, RWP 2017)**

Ans: **PASCAL'S LAW**

Introduction:

An external force applied on the surface of a liquid increases the liquid pressure at the surface of the liquid. This increase in liquid pressure is transmitted equally in all direction and to the walls of the container in which it is filled this result is called Pascal's law.

Statement:

According to Pascal's law:

"Pressure applied at any point of a **liquid enclosed** in a container, is **transmitted** without **loss** to all other parts of the liquid.**"**

Explanation:

Pascal's law can be demonstrated with the help of a glass vessel having holes all over its surface as shown in figure.

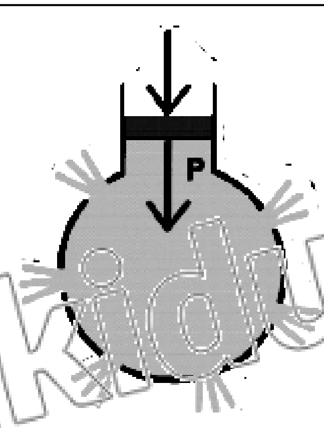

Figure: Demonstrating Pascal's Law

Fill the glass vessel with water. Push the piston. The water rushes out of the holes in the vessel with the same pressure. The force applied on the piston exerts pressure on water. This pressure is transmitted equally throughout the liquid in all directions.

Applications of Pascal's Law:

In general, Pascal's law holds good for fluids both for liquids as well as gases. Pascal's law finds numerous applications in our daily life such as automobiles, hydraulic brake system, hydraulic jack, hydraulic press and other hydraulic machine.

Q.3 What is hydraulic press? Write its construction and working. *(K.B+U.B+A.B)*
(GRW 2014,2017)

Ans: **HYDRAULIC PRESS**

Introduction:
Hydraulic press is a machine that works on Pascal's law. It is used to compress heavy cotton bales for ease in transportation and storing.

Construction:
It consists of two cylinders of different cross sectional areas which are fitted with pistons of cross – sectional area **a** and **A** as shown in the figure:

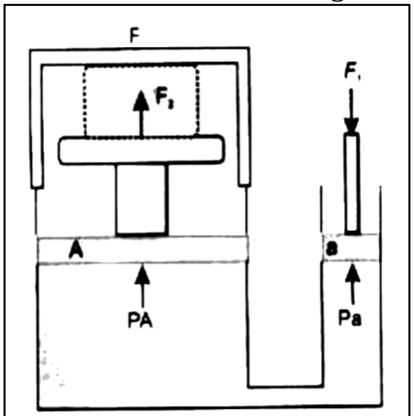

Figure: A Hydraulic Press

Working:
The object is to be compressed is placed over the piston of large cross – sectional area **A**. The Force $\mathbf{F_1}$ is applied on the piston of small cross – sectional area **a.** The pressure **P** produced by small piston is transmitted equally through the liquid and acts on the on the large piston and a force $\mathbf{F_2}$ acts on **A** which is much larger than $\mathbf{F_1}$.

Mathematical Form:
Pressure on piston of small area a is given by,

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

By applying Pascal's law, the pressure on the larger piston of area A will be same as on the small piston.

$$P = \frac{F_2}{A}$$

By comparing the above equations, we have

$$\frac{F_2}{A} = \frac{F_1}{a}$$

Force Multiplier:

$$\therefore \quad F_2 = F_1 \times \frac{A}{a}$$

Since the ratio $\frac{A}{a}$ is greater than **1**, hence the force $\mathbf{F_2}$ acts on the larger piston is greater than the force $\mathbf{F_1}$ on the smaller piston. Hydraulic systems working in this way are known as force multipliers.

Q.4 Explain the braking system of the vehicles. ***(K.B)***

Ans:

BRAKING SYSTEM OF VEHICLES

The brakes of cars, buses etc. work on the principle of Pascal's law. In such a type of brakes, when brake pedal is pushed, it exerts pressure on the master cylinder, which increases the liquid pressure in the cylinder. The liquid pressure is transmitted equally through the liquid in the metal pipes to all the pistons of other cylinders. Due to the increase pressure of the liquid pressure, the pistons in the cylinder mover outwards pressing the brakes pad with brake drums. The force of friction between frictions the brake pads and the brake drum stops the wheels as shown in the figure:

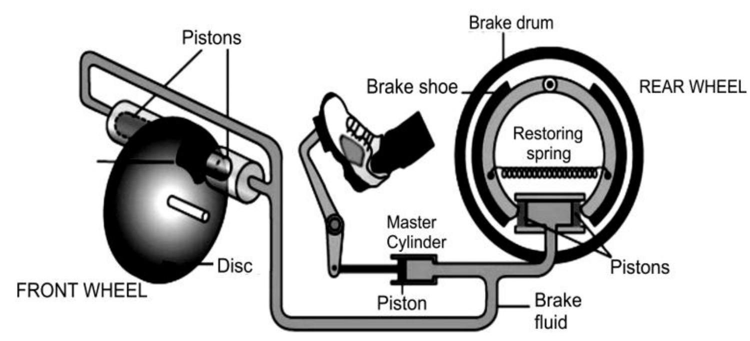

Figure: **A Hydraulic Brake of A Car**

7.5 SHORT QUESTIONS

Q.1 On what factors pressure of the liquids depends? ***(K.B)***

Ans: **Given on Page #257**

Q.2 How is a syringe filled with a liquid? ***(K.B)***

Ans:

FILLING A SYRINGE

The piston of the syringe is pulled out. This lowers the pressure in the cylinder. The liquid from the bottle enters into the piston through the needle as shown in figure:

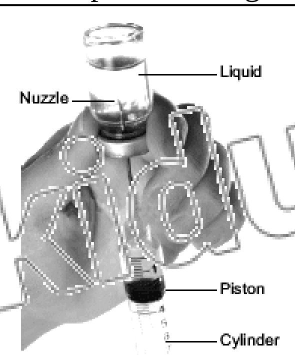

Figure: **Filling A Syringe**

Q.3 Write some applications of Pascal's law. ***(A.B)***

Ans: **APPLICATIONS OF PASCAL'S LAW**

In general, Pascal's law holds good for fluids both for liquids as well as gases. Pascal's law finds numerous applications in our daily life such as automobiles, hydraulic brake system, hydraulic jack, hydraulic press and other hydraulic machine.

Q.4 Why hydraulic press is called as force multiplier? ***(K.B)***

Ans: **FORCE MULTIPLIER**

We know working equation of hydraulic press

$$\frac{F_1}{a} = \frac{F_2}{A}$$

So
$$F_2 = F_1 \times \frac{A}{a}$$

Since the ratio $\frac{A}{a}$ is greater than **1**, hence the force $\mathbf{F_2}$ acts on the larger piston is greater than the force $\mathbf{F_1}$ on the smaller piston. Hydraulic systems working in this way are known as force multipliers.

EXAMLE 7.2 *(U.B)*

In a hydraulic press, a force of 100 N is applied on the piston of a pump of cross-sectional area 0.01 m^2. Find the force that compresses a cotton bale placed on larger piston of cross-sectional area 1 m^2.

Solution:

Given Data:

Force applied on the piston of the pump = F_1 = 100N
Cross sectional area of small piston = a = 0.01 m^2
Cross sectional area of large piston = A = 1 m^2

To Find:

Force that compresses cotton = F_2 = ?

Calculations:

We know working equation of hydraulic press

$$\frac{F_1}{a} = \frac{F_2}{A}$$

So
$$F_2 = F_1 \times \frac{A}{a}$$

Putting values

$$F_2 = (100)\frac{1}{0.01} = 10000\text{N}$$

Result:

Hence, the hydraulic press will compress the bale with a force of 10000N.

7.5 MULTIPLE CHOICE QUESTIONS

1. **If a body is at a depth of 'h' from the liquid surface of density 'ρ', then the pressure 'P' on that body is:** ***(K.B)***
   (A) P = w/t (B) P = ρgV
   (C) P = ρgh (D) P = F/a
2. **Hydraulic press is based on:** ***(K.B)*** **(GRW 2014)**
   (A) Joule's law (B) Pascal law
   (C) Newton's law (D) Young's Modulus

3. If pressure is exerted on a liquid, liquid transmits it: ***(K.B)***
(A) Variably (B) Equally
(C) In all directions (D) Both B & C

4. Hydraulic brake works on the principle of: ***(K.B)*** **(GRW 2014)**
(A) Hydraulic press (B) Pascal law
(C) Joule's law (D) Both A & B

7.6 ARCHIMEDES PRINCIPLE
7.7 PRINCIPLE OF FLOATATION

LONG QUESTIONS

Q.1 State and explain Archimedes Principle. ***(K.B+U.B+A.B)*** **(GRW 2015)**

Ans: **ARCHIMEDES PRINCIPLE**

Introduction:
More than two thousand years ago, the Greek scientist, Archimedes noticed the upthrust force of the liquid.

Upthrust Force:
There is an upward force which acts on an object kept inside a liquid. As a result an apparent loss of weight is observed in the object. This upward force acting on the object is called the up thrust of the liquid.

Statement:
According to Archimedes principle
"When object is **totally** or **partially immersed** in a liquid, an **upthrust** act on it equal to the **weight** of the liquid it displaces.**"**

Explanation:
Consider a solid cylinder of cross – sectional area **A** and height h immersed in a liquid as shown in figure:

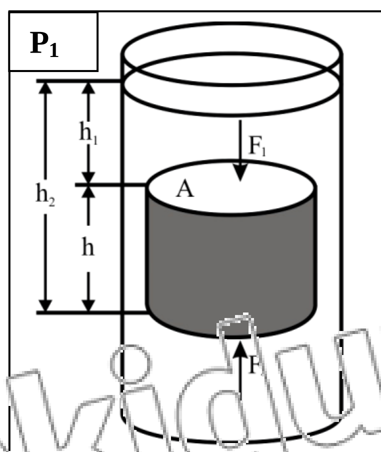

Figure 7.18: Upthrust on a body immersed in a liquid is equal to the weight of the liquid displaced

Let **h_1** and **h_2** be the depth of the top and bottom surfaces of the cylinder respectively from the surface of the liquid.
Then

$$h_2 - h_1 = h$$

If P_1 and P_2 are the liquid pressures at the depth h_1 and h_2 respectively and ρ is its density, then

$P_1 = \rho g h_1$
$P_2 = \rho g h_2$

Let the force F_1 is exerted at the cylinder top by the liquid due to pressure P_1 and the force F_2 is exerted at the bottom of the cylinder by the liquid due to P_2

So $F_1 = P_1A = \rho g h_1 A$
$F_2 = P_2A = \rho g h_2 A$

F_1 and F_2 are acting on the opposite faces of the cylinder. Therefore, the net force F will be $F_2 - F_1$ in the direction of F_2. The net force F on the cylinder is called the upthrust of the liquid.

Therefore,

$$F_2 - F_1 = \rho g h_2 A - \rho g h_1 A$$
$$= \rho g A (h_2 - h_1)$$

or upthrust of liquid $= \rho g Ah$

or $= \rho g V$

Here **Ah** is the volume **V** of the cylinder and equal to the volume of the liquid displaced by the cylinder. Therefore**, ρ g V** is the weight of the liquid displaced

We know $m = \rho V$

So upthrust of liquid = mg = w

Conclusion:

> **The above equation shows that an upthrust acts on the body immersed in a liquid and is equal to the weight of liquid displaced, which is Archimedes principle.**

Interesting Story about Archimedes and the crown :(Interesting information)

Archimedes, a Greek mathematician, lived in Syracuse (now in Sicily) around 250 BCE. He made important discoveries about levers and liquids, but is probably best remembered for his clever solution to a problem set him by the king of Syracuse.

The king had given his goldsmith some gold to make a crown. But when the crown was delivered, the king was suspicious. Perhaps the goldsmith had stolen some of the gold and mixed in cheaper silver instead. The king asked Archimedes to test the crown. Archimedes knew that the crown was the correct mass. He also knew that silver was less dense than gold. So a crown with silver in it would have a greater volume than one day, so the story goes, Archimedes noticed the rise in water level. Here was the answer! He was so excited that he leapt from his bath and ran naked through the streets, shouting "Eureka!" which means "I have found it!"

Later, Archimedes put the crown in a container of water and measured the rise in level. Then he did the same with an equal mass of pure gold. The rise in level was different. So the crown could not have been pure gold.

Q.2 How density of an object can be found by Archimedes principle? ***(K.B+U.B+A.B)***

Ans:

<u>DENSITY OF AN OBJECT</u>

Archimedes principle is also helpful to determine the density of an object.

The **ratio** in the **weights** of a body with an equal volume of the liquid is the same as in their **densities**

Let Density of the object $= D$

Density of the liquid $= \rho$

Weight of the object $= w_1$

Weight of equal volume of liquid $= w = w_1 - w_2$

Here w_2 is the weight of solid in liquid. According to Archimedes principle, w_2 is less than its actual weight w_1 by an amount w.

$$\frac{D}{\rho} = \frac{w_1}{w}$$

$$D = \frac{w_1}{w} = \rho$$

$$D = \frac{w_1}{w_1 - w_2}\rho$$

Thus, finding the weight of the solid in air $\mathbf{w_1}$ and its weight in water $\mathbf{w_2}$, we can calculate the density of the solid by using above equation and following procedure as shown in the fig:

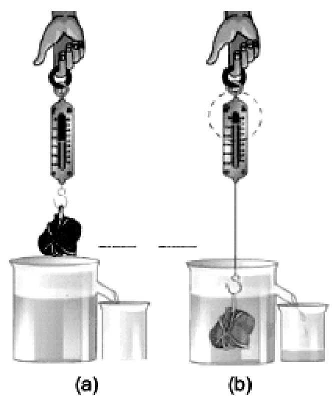

Figure: (a) **Weighing Solid in Air**
(b) **Weighing Solid in Water And Measuring Water displaced By the Solid**

Q.3 Explain the Principle of Floatation. ***(K.B)***

Ans:

PRINCIPLE OF FLOATATION

Introduction:

An object sinks if its weight is greater than the up thrust force acting on it. An object floats if its weight is equal or less than the up thrust. When an object floats in a fluid, the up thrust acting on it is equal to the weight of the object. In case of floating object, the object may be partially immersed. The up thrust is always equal to the weight of the fluid displaced by the object. This is principle of floatation.

Statement:

According to principle of floatation:

"A **floating object** displaces a **fluid** having weight **equal** to weight of the object.**"**

Applications:

Archimedes principle is applicable on liquids as well as gases. We find numerous applications of this principle in daily life.

Understanding of Floating Objects:

A wooden block floats on water. It is because the weight of an equal volume of water is greater than the weight of the block. According to the principle of floatation, a body floats if it displaces water equal to the weight of the body when it is partially or completely immersed in water.

Design of Ships and Boats:

Ships and boats are designed on the same principle of floatation. They carry passengers and goods over water. It would sink in water if its weight including the weight of its passengers and goods becomes greater than the upthrust of water.

Working of Submarines:

A submarine can travel over as well as under water. It also works on the principle of floatation. It floats over water when the weight of the water equal to its volume is greater than its weight. Under this condition, it is similar to a ship and remains partially above water level. It has a system of tanks which can be filled with and emptied from sea water. When these tanks are filled with sea water, the weight of the submarine increases. As soon as its weight becomes greater than the upthrust, it dives into water and remains under water. To come up on the surface, the tanks are emptied from sea water.

7.6, 7.7 SHORT QUESTIONS

Q.1 State Archimedes principle. ***(K.B)***

Ans: Given on Page #262

Q.2 Define Upthrust. **(GRW 2017)**

Ans: **UPTHRUST**

Definition:

"There is an upward force which acts on an object kept inside a liquid. As a result an apparent loss of weight is observed in the object. This upward force acting on the object is called the up thrust of the liquid.**"**

Upthrust of the liquid is also called as **"Buoyant force"**

Example:

An air filled balloon immediately shoots up to the surface when released under water. The same would happen if a piece of wood is released under water all of this is because of upthrust of the liquid acting on bodies.

Q.3 State Principle of floatation. ***(K.B)***

Ans: Given on Page # 264

Q.4 Why does a heavy wooden log float on water while a needle sinks?

Ans: **A NEEDLE SINKS**

A wooden block floats on water. It is because the weight of an equal volume of water is greater than the weight of the block. According to the principle of floatation, a body floats if it displaces water equal to the weight of the body when it is partially or completely immersed in water while a needle sinks because upthrust force acting on it is less than its weight.

EXAMPLE 7.3

A wooden cube of sides 10 cm each has been dipped completely in water. Calculate the upthurst of water acting on it. ***(U.B+A.B)***

Solution:

Given Data:

Length of a side = L = 10cm = 0.1m

Volume of wooden cube = V = $L^3 = (0.1)^3 = 1\times10^{-3}\ m^3$

Density of water = ρ = 1000kgm^{-3}

To Find:

Upthrust of water = F = ?

Calculations:

We know

$$\text{Upthrust} = \rho g V$$

Putting values

Upthrust = (1000)(10)(1×10^{-3})
= 10N

Result:

Hence, the upthurst of water acting on the wooden cube will be 10 N.

EXAMPLE 7.4

The weight of a metal spoon in air is 0.48 N. Its weight in water is 0.42 N. Find its density. *(U.B+A.B)*

Solution:

Given Data:

Weight of the metal spoon in air = W_1 = 0.48 N
Weight of the metal spoon in water = W_2 = 0.42 N
Density of water = ρ = 1000kgm^{-3}

To Find:

Density of spoon = D =?

Calculations:

We know

$$\frac{D}{\rho}=\frac{w_1}{w}$$

$$D=\frac{w_1}{w}\rho$$

$$D=\frac{w_1}{w_1-w_2}\rho$$

Putting values

$$D=\frac{0.48}{0.48-0.42}1000=8000\text{kgm}^{-3}$$

Results:

Hence, the density of the material of the spoon will be 8000 kgm^{-3}.

EXAMPLE 7.5

An empty meteorological balloon weighs 80 N. It is filled with 10 cubic metres of hydrogen. How much maximum contents the balloon can lift besides its own weight? The density of hydrogen is 0.09 kgm-3and the density of air is 1.3 kgm^{-3}. *(U.B+A.B)*

Solution:

Given Data:

Weight of the balloon = w = 80 N
Volume of hydrogen = V = 10m^3
Density of hydrogen = ρ_1 = 0.09 kgm^{-3}
Density of air = ρ_2 = 1.3kgm^{-3}

To Find:

Weight of hydrogen = w_1 =?
Weight of contents = w_2 =?

Calculations:

First we find upthrust of air

F = weight of air displaced

Upthrust = $\rho_2 \; g \; V$

Putting values

Upthrust = (1.3)(10)(10) = 130N

Now we find weight of hydrogen

$w_1 = \rho_1 \; g \; V$

Putting values =

$w_1 = (0.09)(10)(10)$

$w_1 = 9N$

Total weight lifted equal to upthrust = $w + w_1 + w_2$

$130 = 80N + 9N + w_2$

Hence

$w_2 = 41N$

Result:

Hence, the maximum weight of 41 N can be lifted by the balloon in addition to its own weight.

EXAMPLE 7.6

A barge, 40 metre long and 8 metre broad, whose sides are vertical, floats partially loaded in water. If 125000 N of cargo is added, how many metres will it sink? *(U.B+A.B)*

Solution:

Given Data:

Area of barge = A = 40 m × 8 m = $320m^2$

Additional load to carry = w = 125000N

To Find:

Depth to which barge will sink = h =?

Calculations:

We know

Increased upthrust F of water must be equal to the additional load. Hence

Upthrust= F = w = $\rho \; g \; V$

$$V = \frac{w}{\rho g}$$

Putting values

$$V = \frac{125000}{(1000)(10)} = 12.5 \text{ m}^3$$

We know

$$V = Ah$$

Hence $$h = \frac{V}{A}$$

Putting values

$$h = \frac{12.5}{320} = 0.4\text{m or 4cm}$$

Result:

Hence, the barge will sink 4 cm in water on adding 125000 N cargo.

MULTIPLE CHOICE QUESTIONS

Q.1 Which law or principle tells about the floating and sinking of objects: *(K.B)*
(A) Pascal's law (B) Newton's law
(C) Archimedes principle (D) None of them

Q.2 Due to pressure difference on an object, an upward force acts on the object known as: *(K.B)*
(A) Weight (B) Buoyant force
(C) Stress (D) All of above

Q.3 Buoyant force is equal to: *(K.B)*
(A) Volume of displaced liquid (B) Density displaced liquid
(C) Weight displaced liquid (D) All of above

Q.4 The object will float on the liquid surface when: *(U.B)*
(A) W > F (B) W < F
(C) W = F (D) None of above

Q.5 The object will sink in the liquid surface when: *(U.B)*
(A) W > F (B) W < F
(C) W = F (D) None of above

Q.6 Submarine works on the principle of: *(K.B)*
(A) Pascal's law (B) Newton's law
(C) Archimedes principle (D) None of them

7.8 ELASTICITY

7.9 HOOKE'S LAW

LONG QUESTIONS

Q.1 State and explain the Hooke's Law. *(K.B+U.B+A.B)* **(BWP, 2017)**

Ans: **HOOKE'S LAW**

Introduction:

It has been observed that deformation in length, volume or shape of a body depends upon the stress acting on the body. The mathematical relationship between stress and strain was first of all formulated by Hooke in the form of a law.

Statement:

According to Hook's law:

"The **strain** produced in a body by the **stress applied** to it is **directly proportional** to the **stress** within the **elastic limit** of the body.**"**

Mathematical Formula:

Stress α strain

Stress = constant x strain

Or $\frac{\text{Stress}}{\text{Strain}}$ = constant

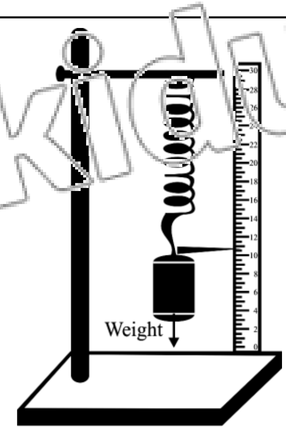

Figure: **Extension in The Spring Depends Upon the Load**

Applications:

Hooke's law is applicable to all kinds of deformation and all types of matter i.e. solids, liquids or gases within certain limit. This limit tells the maximum stress that can be safely applied on a body without causing permanent deformation in its length, volume or shape.

Elastic Limit:

It is a **maximum value of elasticity** within which a body **recovers** to **original length**, **volume** or **shape** after deforming force is removed. This value of elasticity is called the **elastic limit**.

When a stress crosses this limit, called the elastic limit, a body is permanently deformed and is unable to restore its original state after the stress is removed as shown in the figure:

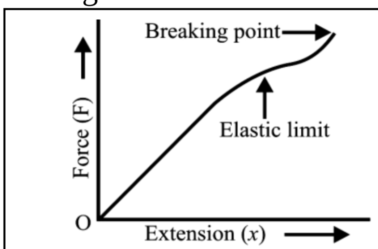

Figure: **Graph Between Force And Extension**

Q.2 Define Young's Modulus and derive its mathematical formula. **(LHR 2015, GRW 2017)** ***(K.B+U.B+A.B)***

Ans: **YOUNG'S MODULUS**

Definition:

"The **ratio of stress to tensile strain** is called Young's Modulus."

Or

"The ratio of stress and strain is a constant within the elastic limit, this constant is called the Young's Modulus."

Unit:

SI unit of Young's Modulus is Newton per square meter ($N\ m^{-2}$)

Mathematical Form:

Consider a long bar of length **Lo** and cross – sectional area **A**. Let an external force **F** equal to weight **w** stretches it such that the stretched length becomes **L**.
Mathematically,
Young's modulus = Y = Stress/Tensile strain
Let ΔL be the change in length of the rod, then

$$\Delta L = L - L_o$$

Since $\text{Stress} = \dfrac{\text{Force}}{\text{Area}} = F/A$

And $\text{Tensile Strain} = \dfrac{L - L_o}{L_o} = \Delta L/L_o$

As Young's modulus = Y = Stress/Tensile strain

So $$Y = \frac{F}{A} \times \frac{L_o}{\Delta L}$$

Therefore, $$Y = \frac{F \times L_o}{A \times \Delta L}$$

Examples:
Young's Modulus of some common materials is as follows:
- Diamond 1120×10^9 Nm^2
- Glass 60×10^9 Nm^2
- Lead 16×10^9 Nm^2

7.8,7.9 SHORT QUESTIONS

Q.1 Define Elasticity. (K.B) **(LHR 2017)**

Ans:

ELASTICITY

The property of a body to **restore** its **original size** and **shape** as the **deforming force** ceases to act is called elasticity.

Example:
When we stretch a rubber with a small force and then release that force the rubber attains it original size and shape due to elasticity.

Q.2 Define deforming force. (K.B) **(GRW 2017)**

Ans:

DEFORMING FORCE

Definition:
"The **applied force** that changes **shape**, **length** or **volume** of a substance is called the deforming force**"**

Unit:
Being a force its unit is newton (N)

Example:
A pictorial concept of deforming force and elasticity is given below

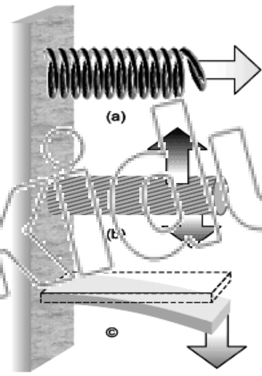

Figure: (a) A Spring is Stretched By a force
(b) A Rod is Twisted by the Torque Produced by A Couple
(c) A Strip is Bent by a Force.

Q.3 What is stress? *(K.B)* **(LHR 2016,GRW 2017)**

Ans:

STRESS

Definition:

"The **deforming force** acting on **unit area** at the surface of a body is called stress.**"**

Mathematical Form:

If a force F is applied on an area A of an object, the stress is) mathematically defined as:

$$\text{Stress} = \frac{F}{A}$$

Unit:

In System International, the unit of stress is Nm^{-2}.

Q.4 What is strain? (K.B)

Ans:

STRAIN

Definition:

"A stress can produce a change in shape, length or volume of an object. A **comparison** of **change** caused by the **stress** with the **original length**, **volume** or **shape** is called the strain.**"**

Tensile Strain:

If a stress produces a change in length of an object then the strain is called tensile strain. Therefore,

$$\text{Tensile Strain} = \frac{\text{Change in Length}}{\text{Original Length}}$$

Unit:

As the strain is a ratio between two similar quantities so it has no unit.

EXAMPLE 7.7

A steel wire 1 m long and cross sectional area 5×10^{-5} m^2 is stretched through 1mm by a force of 10000 N. Find Young modulus of the wire. (U.B+A.B)

Solution:

Given Data:

Initial length of steel wire = L_o = 1 m

Cross sectional area of the steel wire = A = $5\times10^{-5}\,m^2$

Extension or change in length = ΔL = 1mm = 0.001m

Force producing extension = F = 10000N

To Find:

Young modulus of the wire = Y =?

Calculations:

As we know

$$Y=\frac{FL_o}{A\Delta L}$$

Putting the values

$$Y=\frac{10000\times 1}{5\times 10^{-5}}=2\times 10^{11}\,Nm^{-2}$$

Result:

Hence, the Young modulus of steel will be 2 x 10^{11}Nm^{2}.

7.8,7.9 MULTIPLE CHOICE QUESTIONS

1. The force that acts on unit area of an object and thus changes its shape or size: ***(K.B)***

(A) Stress (B) Strain
(C) Yong's Modulus (D) Elastic limit

2. In system international, the unit of stress is: ***(K.B)***

(A) Nm^{-2} (B) Nm^{-1}
(C) Nm (D) None of above

3. The ratio of change in length to the original length is: ***(K.B)***

(A) Stress (B) Tensile strain
(C) Young's Modulus (D) Elastic limit

4. When stress is increased, the strain also goes on: ***(K.B+U.B)*** **(LHR 2016)**

(A) Decreasing (B) Increasing
(C) Constant (D) All of above

5. The law about stress and strain is presented by: ***(K.B)***

(A) Hook (B) Newton
(C) Joule (D) Archimedes

6. According to Hooke's law, within the elastic limit stress and strain has proportion: ***(K.B)***

(A) Inverse (B) Direct
(C) Same (D) None of above

7. The ratio of stress and tensile strain is: ***(K.B)***

(A) Variable (B) Pascal's Law
(C) Non-uniform (D) None of above

8. The unit of Young's modulus is: ***(K.B)***

(A) Nm^{-2} (B) Nm^{-1}
(C) Nm (D) None of above

9. What is young modulus of Aluminum? ***(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times 10^{9}\,Nm^{-2}$ (B) $110\times 10^{9}\,Nm^{-2}$
(C) $190\times 10^{9}\,Nm^{-2}$ (D) $200\times 10^{9}\,Nm^{-2}$

10. **What is young modulus of bone? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $0.02\times10^9\,Nm^{-2}$ (B) $110\times10^9\,Nm^{-2}$
(C) $190\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

11. **What is young modulus of brass? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $91\times10^9\,Nm^{-2}$
(C) $190\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

12. **What is young modulus of nickel? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $110\times10^9\,Nm^{-2}$
(C) $200\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

13. **What is young modulus of Rubber? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $110\times10^9\,Nm^{-2}$
(C) $190\times10^9\,Nm^{-2}$ (D) $0.0007\times10^9\,Nm^{-2}$

14. **What is young modulus of Tungsten? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $110\times10^9\,Nm^{-2}$
(C) $400\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

15. **What is young modulus of wood (Parallel gain)? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $10\times10^9\,Nm^{-2}$
(C) $190\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

16. **What is young modulus of wood (Parallel gain)? *(K.B)*** **(Table 7.2 Pg. # 162)**

(A) $70\times10^9\,Nm^{-2}$ (B) $110\times10^9\,Nm^{-2}$
(C) $1\times10^9\,Nm^{-2}$ (D) $200\times10^9\,Nm^{-2}$

MCQ'S ANSWER KEY (TOPIC WISE)

7.1 KINETIC MOLECULAR MODEL OF MATTER

7.2 DENSITY

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	B	A	B	C	C	B	A	C	C
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
C	A	B	D	A	D	A	C	C	A	B	C

7.3 PRESSURE

7.4 ATMOSPHERIC PRESSURE

1	2	3	4	5	6	7	8	9
C	D	D	B	A	A	D	C	B

7.5 PRESSURE IN LIQUIDS

1	2	3	4
C	B	D	B

7.6 ARCHIMEDES PRINCIPLE

7.7 PRINCIPLE OF FLOATATION

1	2	3	4	5	6
C	B	A	C	A	C

7.8 ELASTICITY

7.9 HOOKE'S LAW

1	2	3	4	5	6	7	8	9	10	11	12
A	A	B	B	A	B	D	A	A	A	B	C

13	14	15	16
D	C	B	C

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

7.1 Encircle the correct answer from the given choices.

i. In which of the following state, molecules do not leave their position: **(LHR 2015, 2016)** ***(K.B)***

(a) solid (b) liquid
(c) gas (d) plasma

ii. Which of the substances is the lightest one? *(K.B)* **(LHR 2016)**

(a) copper (b) mercury
(c) aluminum (d) lead

iii. SI unit of pressure is Pascal, which is equal to? *(U.B+K.B)*

(a) 10^{-4} Nm^{-2} (b) 1 Nm^{-2}
(c) 10^{2} Nm^{-2} (d) 10^{3} Nm^{-2}

iv. What should be the approximate length of a glass tube to construct a water barometer? *(K.B)*

(a) 0.5 m (b) 1 m
(c) 2.5 m (d) 11 m

v. According to Archimedes, upthrust is equal to: *(K.B)* **(LHR 2014, GRW 2015, 2016)**

(a) weight of displace body (b) volume of displaced body
(c) mass of displaced liquid (d) none of these

vi. The density of a substance can be found with the help of: *(K.B)*

(a) Pascal's law (b) Hooke's law
(c) Archimedes principle (d) Principle of floatation

vii. According to Hooke's law: *(K.B)*

(a) stress x strain = constant (b) stress/strain = constant
(c) strain/stress = constant (d) stress = strain

ANSWER KEY

i	ii	iii	iv	v	vi	vii
a	c	b	d	d	c	c

7.2 How kinetic molecular model is helpful in differentiating various states of matter? ***(K.B+U.B+A.B)***

Ans: See Q. 1 Long Question TOPIC 7.1 Given on Page #246

_7.3_ Does there exist a fourth state of matter? What is that? _(K.B)_

Ans: Given on Page # 246

7.4 What is meant by a density? What is its SI unit? _(K.B+A.B)_

Ans: Given on Page # 248

7.5 Can we use a hydrometer to measure the density of milk? _(K.B+A.B)_

Ans:

HYDROMETER

Yes, we can use Hydrometer to measure density of milk. Hydrometer is a glass tube with a scale marked on its stem and heavy weight in the bottom. It is partially immersed in a fluid, the density of which is to be measured. One type of hydrometer is used to measure the concentration of acid in a battery. It is called acid meter.

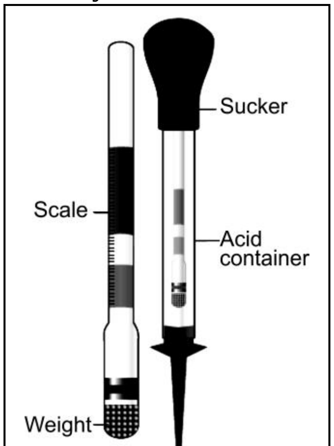

Figure: A Hydrometer

7.6 Define the term pressure. _(K.B)_

Ans: Given on Page #254

7.7 Show that atmosphere exert pressure. _(K.B)_

Ans: Long question #1 TOPIC 7.3 Given on Page #251

7.8 It is easy to remove air from a balloon but it is very difficult to remove air from a glass bottle. Why? _(K.B)_

Ans:

REMOVAL OF AIR

Because the atmospheric pressure acts more easily on balloon as compared to glass bottle, so emptying air is easier from balloon than glass bottle.

7.9 What is barometer? _(K.B+A.B)_

Ans:

BAROMETER

The instrument used to measure atmospheric pressure is called barometer. One of the simple barometers is mercury barometer. It consists of a glass tube 1m long closed at one end as shown in the figure:

Figure: A Mercury Barometer

7.10 Why water is not suitable to be used in a barometer? *(K.B+U.B)*

Ans: **WATER IS NOT SUITABLE**

Mercury is 13.6 times denser than water. Atmospheric pressure can hold vertical column of water about 13.6 times the height of mercury column at a place. Thus, at sea level, vertical height of water column would be 0.76 m x 13.6 = 10.34 m. Thus, a glass tube more than 10 m long is required to make a water barometer that is difficult to handle practically.

7.11 What makes a sucker pressed on a smooth wall sticks to it? *(K.B+U.B)*

Ans: **SUCKER PRESSED ON A WALL**

When a sucker is pressed on a smooth surface, the air pressure below it becomes very small (due to the displaced air) as compared to the air pressure above it. Therefore, it sticks with the smooth surface as shown in the figure:

Figure: **Pressed Sucker**

7.12 Why does the atmospheric pressure vary with height? *(K.B)*

Ans: **VARIATION IN ATMOSPHERIC PRESSURE**

As we go high in the atmosphere, the density of the air becomes low. Due to this reason, atmospheric pressure decreases as we go high.

7.13 What does it mean when the atmospheric pressure at place fall suddenly? *(K.B)*

Ans: **SUDDEN FALL OF ATMOSPHERIC PRESSURE**

A sudden fall in atmospheric pressure means there will be a storm, rain and typhoon to occur in coming few hours.

7.14 What changes are expected in weather if the barometer reading shows a sudden increase? *(K.B)*

Ans: **SUDDEN INCREASE IN READING**

A sudden increase in atmospheric pressure means that it will soon followed by a decrease in the atmospheric pressure indicating poor weather ahead.

7.15 State Pascal's law. *(K.B)*

Ans: Given on Page #258

7.16 Explain the working of hydraulic press. *(U.B+A.B)*

Ans: Given on Page #259

7.17 What is meant by elasticity? *(K.B)*

Ans: Given on Page #270

7.18 State Archimedes principle? *(K.B+A.B)*

Ans: Given on Page #262

7.19 What is up thrust? Explain the principle of floatation. *(K.B+A.B)*

Ans: Given on Page #262

7.20 Explain how a submarine moves up the water surface and down into water. *(K.B+U.B)*

Ans: Given on Page #264

7.21 Why does a piece of stone sink in water but a ship with huge weights floats? *(K.B)*

Ans: **A STONE SINKS**

The upthrust force on stone is much smaller than its weight because weight of the water displaced under stone is very small. While the ships are designed in such a way weight of the water displaced by them is greater than their weight. So upthrust force in case of ships is greater than their weights. So ships float on the surface of water.

7.22 What is Hooke's law? What is meant by elastic limit? *(K.B+A.B+U.B)*

Ans: Given on Page #268

7.23 Take a rubber band. Construct a balance of your own using a rubber band. Check its accuracy by weighing various objects. *(K.B+U.B)*

Ans: **CONSTRUCTING A BALANCE**

Take a rubber band hang it with a hook. Then pointer is attached at the lower end of it with scale in front of pointer. Different known weights are suspended one by one at the lower end of the rubber band. Mark the pointer positions for each known weight. It is called calibration of scale for weight measurements. This makes a balance for weight measurement as shown in the figure:

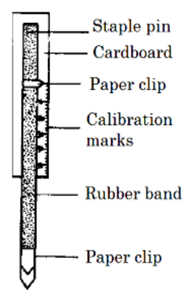

Figure: **A Balance From Rubber Band**

NUMERICAL PROBLEMS *(U.B+A.B)*

7.1 A wooden block measuring 40 cm x 10cm x 5 cm has a mass of 850 g. find the density of the wood.

Solution:

Given Data:

Volume of wooden block = v = 40 cm x 10 cm x 5 cm = 2000 cm^3 = 2 x 10^{-3} m^3

Mass of wooden block = m = 850 g = 0.85 kg

To Find:

Density of wooden block = d =?

Calculations:

As we know that

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

By putting the values, we have

$$\text{Density} = \frac{0.85}{2\times10^{-3}}$$

Density = 0.425 x 10^3 kg m^{-3} OR

Density = 425 kg m^{-3}

Result:

Hence, the density of wooden block will be 425 kgm^{-3}.

7.2 How much would be the volume of the ice formed by freezing 1 litre of water? (LHR 2014)

Solution:

Given Data:

Volume of water = V_1 = 1 litre
1 litre of water = 1kg
Mass of water = 1kg
Density of water = 1000 kgm^{-3}

To Find:

Volume of ice on freezing = V_2 = ?

Calculations:

Since density of ice is 0.92 times of the liquid water therefore,
Density of ice = 1000 × 0.92
= 920 kgm^{-3}

$$\text{Volume of ice} = \frac{\text{mass}}{\text{Density}}$$

$$\text{Volume of ice} = \frac{1000}{920}$$

= 1.09 litre

Result:

Hence, the volume of ice will be 1.09 litre.

7.3 (i) Calculate the volume of the following objects.

(i) An iron sphere of mass 5 kg, the density of iron is 8200 kgm^{-3}.
(ii) 200 g of lead shot having density 11300 kgm^{-3}.
(iii) A gold bar of mass 0.2 kg. the density of gold is 19300 kgm^{-3}.

(i) An iron sphere of mass 5 kg, the density of iron is 8200 kgm^{-3}.

Solution:

Given Data:
Mass of iron sphere = m = 5 kg
Density of iron = d = 8200 kgm^{-3}

To Find:
Volume of iron sphere = V = ?

Calculations:
As we know that

$$Density = \frac{\text{Mass}}{\text{Volume}}$$

$$Volume = \frac{\text{Mass}}{\text{Density}}$$

By putting the values, we have

$$Volume = \frac{5}{8200}$$

Volume = 0.00069 m^3
OR
Volume = 6.9×10^{-4} m^3

Volume of iron sphere = 6.9×10^{-4} m^3

(ii) **200 g of lead shot having density 11300 kgm^{-3}.** **(LHR 2013)**

Solution:

Given Data:

Mass of lead shot = m = 200 g = 0.2 kg
Density of lead = d = 11300 kgm^{-3}

To Find:

Volume of lead shot = v = ?

Calculations:

As we know that

$$Density = \frac{\text{Mass}}{\text{Volume}}$$

$$Volume = \frac{\text{Mass}}{\text{Density}}$$

By putting the values, we have

$$Volume = \frac{0.2}{11300}$$

Volume = 0.000017699 m^3
OR Volume = 1.77×10^{-5} m^3

Volume of lead shot = 1.77×10^{-5}

(iii) **A gold bar of mass 0.2 kg. The density of gold is 19300 kgm^{-3}.** **(LHR 2016)**

<u>Solution</u>:

<u>Given Data</u>:

Mass of gold bar = m = 0.2 kg
Density of gold = d = 19300 kgm^{-3}

<u>To Find</u>:

Volume of gold bar = v =?

<u>Calculations</u>:

As we know that

$$Density = \frac{\text{Mass}}{\text{Volume}}$$

$$Volume = \frac{\text{Mass}}{\text{Density}}$$

By putting the values, we have

$$\text{Volume} = \frac{0.2}{19300}$$

Volume = 0.00001036 m^3
OR Volume = 1.04×10^{-5} m^3

Volume of gold bar = 1.04×10^{-5}

<u>Result</u>:

Hence,
The volume of iron sphere will be 6.9×10^{-4} m^3
The volume of lead shot will be 1.77×10^{-5} m^3
The volume of gold bar will be 1.04×10^{-5} m^3

7.4 The density of air is 1.3 kgm^{-3}. Find the mass of air in a room measuring 8 m x 5 m x 4 m. **(GRW 2016)**

Solution:

Given Data:

Density of air = d = 1.3 kgm^{-3}
Volume of air = v = 8 m x 5 m x 4 m = 160 m^3

To Find:

Mass of air = m = ?

Calculations:

As we know that

$$Density = \frac{\text{Mass}}{\text{Volume}}$$

So

Mass = density x volume

By putting the values, we have

Mass = 1.3 x 160

Mass = 208 kg

Result:

Hence, the mass of air will be 208kg

7.5 A student passes her palm by her thumb with a force of 75 N. How much would be the pressure under her thumb having contact area 1.5 cm^2?

Solution:

Given Data:

Force exerted by student = F = 75 N
Contact area = A = 1.5 cm^2 = 1.5 x 10^{-4} m^2

To Find:

Pressure under the thumb = P = ?

Calculations:

As we know that

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

By putting the values, we have

$$P = \frac{75}{1.5\times10^{-4}}$$

P = 50 x 10^4 Nm^{-2}
P = 5 x 10^5 Nm^{-2}

Result:

Hence, the pressure under the thumb will be 5 × 10^5 Nm^{-2}.

7.6 The head of the pin is a square of side 10 mm. find the pressure on it due to a force of 20 N. **(GRW 2014)**

Solution:

Given Data:

Force applied = F = 20 N
Side of head of pin = L = 10 mm = 10 x 10^{-3} m

Area of head of pin = A = L x L = 10×10^{-3} m x 10×10^{-3} m
= 100×10^{-6} m^2 = 1×10^{-4} m^2

To Find:

Pressure exerted by head of pin = P = ?

Calculations:

As we know that

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

By putting the values, we have

$$P = \frac{20}{1\times10^{-4}}$$

P = 20×10^{4} Nm^{-2}

P = 2×10^{5} Nm-2

Result:

Hence, the pressure exerted by head of pin will be 2×10^{5} Nm^{-2}.

7.7 A uniform rectangular block of wood 20 cm x 7.5 cm x 7.5 cm and of mass 1000 g stands on a horizontal surface with its longest edge vertical. Find

(i) The pressure exerted by the block on the surface

(ii) Density of the wood

Solution:

Given Data:

Mass of wooden block = m = 1000 g = 1 kg

Volume of wooden block = V = 20 cm x 7.5 cm x 7.5 cm = 0.001125 m^3 or 1.125×10^{-3}

Area of wooden block = A = 7.5 cm x 7.5 cm = 0.005625 m^2 or 5.625×10^{-3} m^2

To Find:

(i) The pressure exerted by the block on the surface = P =?

Density of wood = d =?

Calculations:

As we know that

V = L x W x H

By putting the values, we have

V = 20 cm x 7.5 cm x 7.5 cm = 1125 cm^3 = 0.001125 m^3

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

By putting the values, we have

$$\text{Density} = \frac{1}{0.001125}$$

Density = 888.89 kgm^{-3} = 889 kgm^{-3}

Density of wood = 889kgm^{-3}

As we know that

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

By putting the values, we have

$$P = \frac{10}{0.005625}$$

$P = 1778\ Nm^{-2}$

The pressure exerted by the block on the surface = 1778 Nm^{-2}

Result:

Hence, the pressure exerted by the block on the surface will be 1778 Nm^{-2} and density of wood will be 889 kgm^{-3}.

7.8 A cube of glass of 5 cm side and mass 306g, has a cavity inside it. If the density of the glass is 2.55 gcm^{-3}. Find the volume of the cavity.

Solution:

Given Data:

Length of side of glass cube = L = 5 cm

Volume of glass cube = v = $L^3 = (5\ cm)^3 = 125\ cm^3$

$= 125 \times 10^{-6}\ m^3 = 1.25 \times 10^{-4}\ m^3$

Mass of cube = m = 306 g = 0.306 kg = 3.06×10^{-1} kg

Density of glass = d = 2.25 gcm^{-3} = $2.55 \times 10^3 kg\ m^{-3}$

To Find:

Volume of cavity inside the glass cube = V =?

Calculations:

Volume without cavity = $1.25 \times 10^{-4}\ m^3$

Volume with cavity = mass/density

$= (3.06 \times 10^{-1})/(2.55 \times 10^3)$

$= 1.20 \times 10^{-4}\ m^3$

Volume of cavity = volume without cavity – volume with cavity

$= 1.25 \times 10^{-4}\ m^3 - 1.20 \times 10^{-4}\ m^3$

$= 0.05 \times 10^{-4}\ m^3$

$= 5 \times 10^{-6}\ m^3$ or $5\ cm^3$

Result:

Hence, the volume of cavity inside the glass cube will be 5 cm^3.

7.9 An object has weight 18 N in air. Its weight is found to be 11.4 N when immersed in water. Calculate its density. Can you guess the material of the object? (GRW 2014)

Solution:

Given Data:

Weight of object in air = w_1 = 18 N

Weight of object in water = w_2 = 11.4 N

Density of water = ρ_w = 1000 kgm^{-3}

Gravitational acceleration = g = 10 ms^{-2}

Weight of equal volume of water = w = $w_1 - w_2$ = 18 N – 11.4 N = 6.6 N

To Find:

Density of material = D_m =?

Name of material =?

Calculations:

As we know that

$$\frac{D}{\rho} = \frac{w_1}{w}$$

By putting the value, we have

$$\frac{D}{1000} = \frac{18}{6.6}$$

$$D = \frac{18000}{6.6}$$

$$D = 2727\ \text{Kgm}^{-3}$$

Result:

Hence, the density of material is 2727 Kgm⁻3. As we know that density of aluminum is approximately equal to the density calculated above. So, the material will be aluminum.

7.10 A solid block of wood of density 0.6 gcm^{-3} weighs 3.06 N in air. Determine:

(i) Volume of the block

(ii) The volume of block immersed when placed freely in a liquid of density 0.9 gcm^{-3}.

Solution:

Given Data:

Density of wooden block = $d = 0.6$ gcm^{-3}

Weight of the wooden block = $w = 3.06$ N

Density of liquid = $d_l = 0.9$ gcm^{-3}

To Find:

Volume of the wooden block = V_1 =?

Volume of block when immersed in liquid = V_2 =?

Calculations:

As we know that

Volume = mass/ densit

$V_1 = 0.306/(0.6 \times 10^3) = 0.51 \times 10^{-3}\ m^3$ or $510 cm^3$

Volume of the wooden block = 510 cm^3

As we also know that

Upward thrust = weight of the liquid displaced

Weight= 10 x volume x density

3.06 = 10 x volume x 0.9×10^3

Volume = $3.06/(9 \times 10^3)$

$V_2 = 0.00034\ m^3$ or $340\ cm^3$

Volume of block when immersed in liquid 340 cm^3

Result:

Hence, the volume of the wooden block will be 510 cm3 and the volume of block when immersed in liquid will be 34 cm^3.

7.11 The diameter of the piston of hydraulic press is 30 cm. How much force is required to lift a car weighing 20000 N on its piston, if the diameter of the piston of the pump is 3 cm.
(GRW 2016)

Solution:

Given Data:

Diameter of the piston of hydraulic press = D = 30 cm = 0.3 m

Diameter of the piston of pump = d = 3 cm = 0.03 m

Weight of the car lifted by hydraulic press = w = F_2 = 20000 N

To Find:

Force applied on piston of pump = F_1 =?

$\text{Area of piston} = A = 2\pi R^2 = 2\times3.14\times(0.15)^2$

$A = 0.1413\text{m}^2$

$\text{Weight of car} = w = F_2 = 20000\text{N}$

$\text{Diameter of piston} = d = 3\text{cm}$

$\text{Radius of the piston} = r = \frac{d}{2} = 1.5\text{cm} = 0.015\text{m}$

Calculations: $\text{Area of the piston} = a = 2\pi r^2 = 2\times3.14\times(0.015)^2$

$a = 1.1413\times10^{-3}\text{m}^2$

$\text{Force} = F_1 = ?$

$$\frac{F_1}{a} = \frac{F_2}{A}$$

$$F_1 = 20000\times\frac{1.413\times10^{-3}}{0.1413}$$

$F_1 = 200\text{N}$

Result:

Hence, the force applied on the piston of pump will be 200 N.

7.12 A steel wire of cross-sectional area 2 x 10^{-5} m^2 is stretched through 2 mm by a force of 4000 N. Find the young's modulus of the wire. The length of the wire is 2m.

Solution:

Given Data:

Length of the wire = L_o = 2 m

Area of steel wire = A = 2 x 10^{-5} m^2

Increase in length of wire = ΔL = 2 mm = 2 x 10^{-3} m

Force applied = F = 4000 N

To Find:

Young's modulus of wire = Y =?

Calculations:

As we know that

$$Y = \frac{F \times L}{A \times \Delta L}$$

By putting the values, we have

$$Y = \frac{4000 \times 2}{2 \times 10^{-5} \times 2 \times 10^{-3}}$$

$$Y = \frac{2000}{10^{-5} \times 10^{-3}}$$

$Y = 2000 \times 10^{8}\ Nm^{-2} = 2 \times 10^{3} \times 10^{8}\ Nm^{-2}$

$Y = 2 \times 10^{11}\ Nm^{-2}$

Result:

Hence, the Young's modulus of wire will be $2 \times 10^{11}\ Nm^{-2}$

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. At sea level, the atmospheric pressure is about:

(A) 101320 Pa (B) 101300 N
(C) 101300 Pa (D) 1000 Pa

2. Young's modulus of steel in Nm^{-2} is:

(A) 70 (B) 110
(C) 200 (D) 400

3. Unit of strain is:

(A) Nm (B) Nm^2
(C) Nm^{-2} (D) No Unit

4. 1 litre is equal to:

(A) $10^{-3}\,m^3$ (B) $10^{-6}\,m^3$
(C) $10^3\,m^3$ (D) $10^2\,m^3$

5. Young modulus is equal to:

(A) $\frac{FLo}{A\Delta L}$ (B) ρgh
(C) Weight of displaced water (D) F/A

6. If baro meter reading suddenly falls it means:

(A) Pleasant weather ahead (B) Poor weather ahead
(C) Stormy ahead (D) Rainy weather ahead

Q.2 Give short answers to following questions. **(5×2=10)**

i. Why water is not suitable for use, in place of mercury in barometer?
ii. The weight of metal spoon in air is 0.48N its weight in water is 0.42 N; Find its density and also name the type of metal.
iii. Show elastic limit by drawing a graph between force and extension.
iv. Why does a needle sink while a large wooden log floats?
v. Why do we feel greater pressure under the ocean as compared to fresh water of same depth?

Q.3 Answer the following questions in detail. **(4+5=9)**

a) What do you mean by pressure of liquids? Also prove that P= ρgh.
b) What would be the volume of ice formed by freezing 1 litre of water?

Note:
Parents or guardians can conduct this test in their supervision in order to check the skill of students.