



Class: 9th

Subject: Physics

Chapter 6: Mechanical Properties of  
Matter

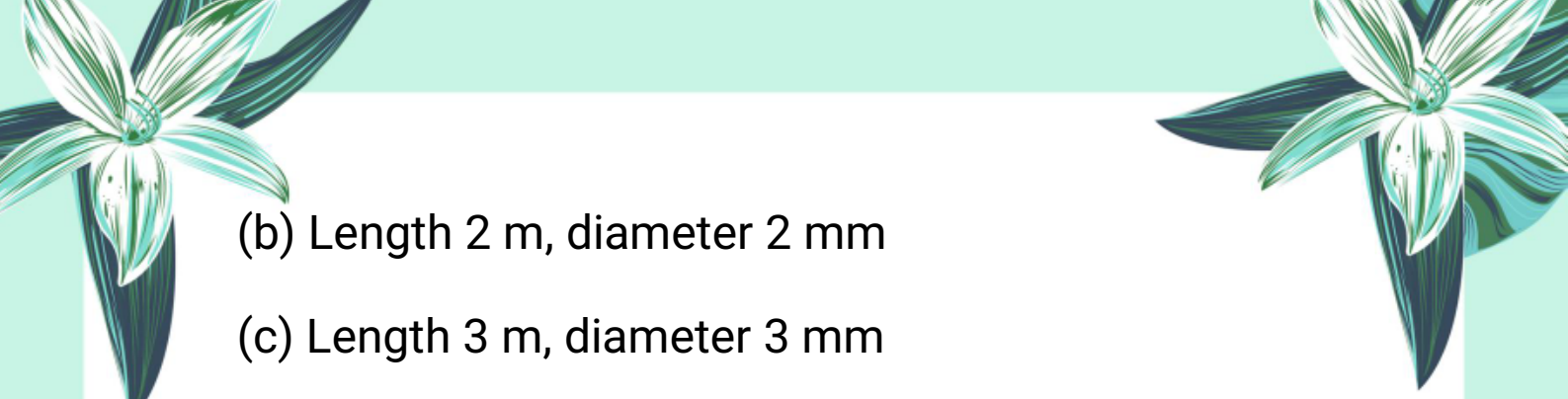
**A Exercise MCQs**


6.1 A wire is stretched by a weight  $w$ . If the diameter of the wire is reduced to half of its previous value, the extension will become:

- (a) One half
- (b) Double
- (c) One fourth
- (d) Four times

6.2 Four wires of the same material are stretched by the same load. Their dimensions are given below. Which of them will elongate most?


- (a) Length 1 m, diameter 1 mm

- 
- (b) Length 2 m, diameter 2 mm
  - (c) Length 3 m, diameter 3 mm
  - (d) Length 4 m, diameter 0.5 mm



**6.3 Two metal plates of area 2 and 3 square metres are placed in a liquid at the same depth. The ratio of pressures on the two plates is:**

- (a) 1:1
- (b)  $\sqrt{2}:\sqrt{3}$
- (c) 2:3
- (d) None of these

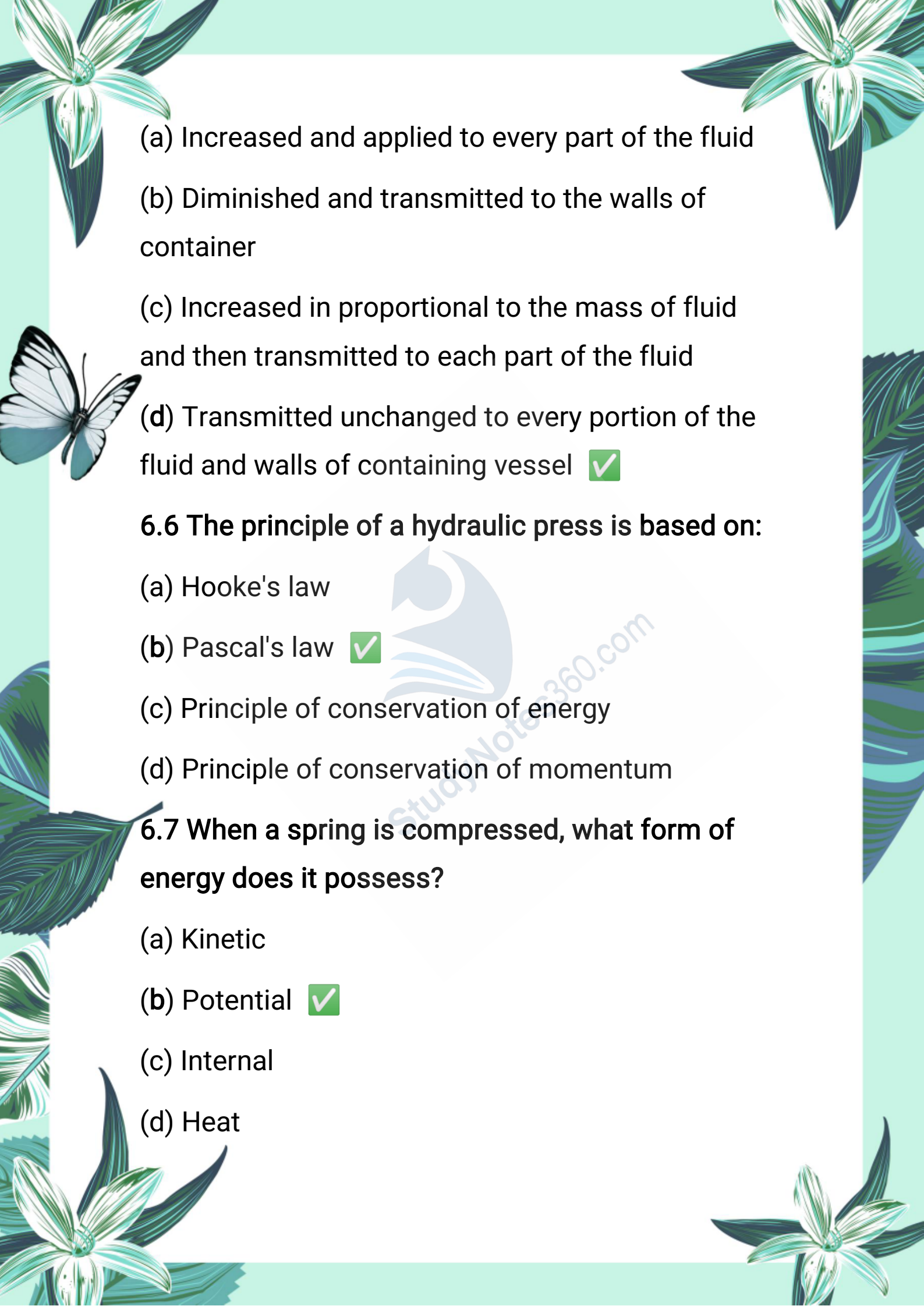


**6.4 The pressure at any point in a liquid is proportional to:**

- (a) Density of the liquid
- (b) Depth of the point below the surface of the liquid
- (c) Acceleration due to gravity
- (d) All of the above

**6.5 Pressure applied to an enclosed fluid is:**



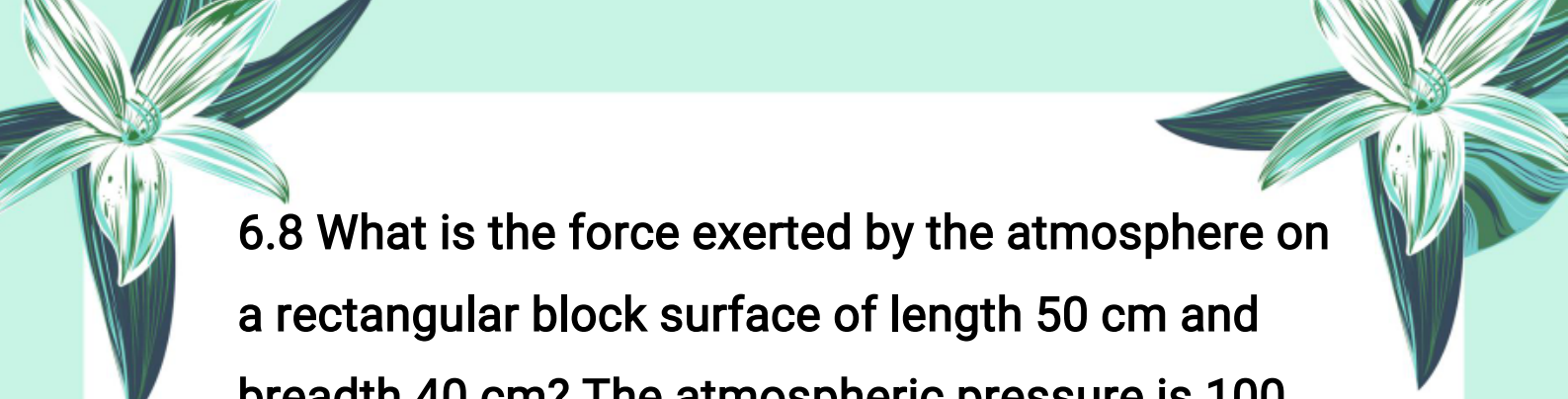
- 
- (a) Increased and applied to every part of the fluid
  - (b) Diminished and transmitted to the walls of container
  - (c) Increased in proportional to the mass of fluid and then transmitted to each part of the fluid
  - (d) Transmitted unchanged to every portion of the fluid and walls of containing vessel

**6.6 The principle of a hydraulic press is based on:**


- (a) Hooke's law
- (b) Pascal's law
- (c) Principle of conservation of energy
- (d) Principle of conservation of momentum

**6.7 When a spring is compressed, what form of energy does it possess?**

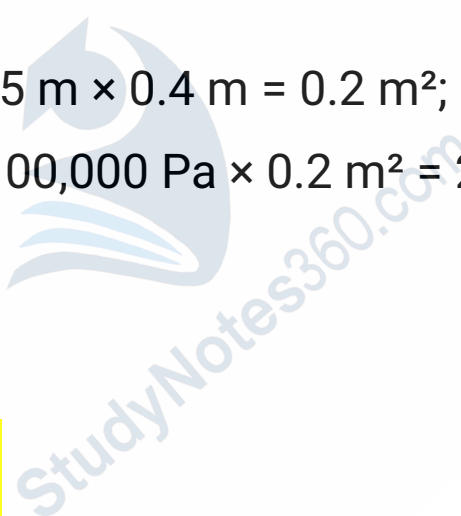
- (a) Kinetic
- (b) Potential
- (c) Internal
- (d) Heat



6.8 What is the force exerted by the atmosphere on a rectangular block surface of length 50 cm and breadth 40 cm? The atmospheric pressure is 100 kPa.

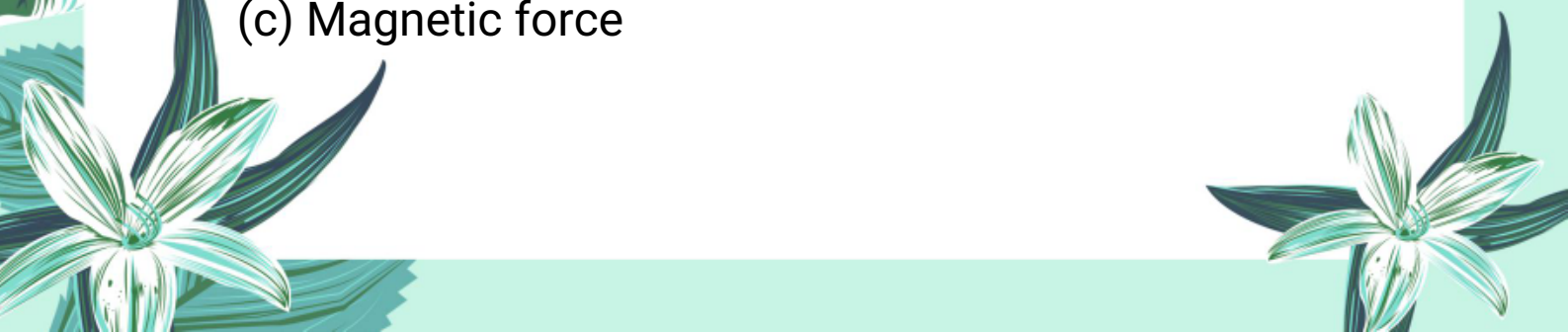
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- (a) 20 kN
  - (b) 100 kN
  - (c) 200 kN
  - (d) 500 kN

(Solution: Area = 0.5 m × 0.4 m = 0.2 m<sup>2</sup>; Force = Pressure × Area = 100,000 Pa × 0.2 m<sup>2</sup> = 20,000 N = 20 kN)



### Important MCQs:

1. What is the force called that changes the shape or size of an object?

- (a) Elastic force
  - (b) Deforming force
  - (c) Magnetic force
- 



(d) Gravitational force


**2. A material that returns to its original shape after the removal of deforming force is called:**

(a) Plastic

(b) Elastic

(c) Brittle

(d) Flexible



**3. The property of a material to regain its original shape and size is known as:**

(a) Plasticity

(b) Rigidity

(c) Elasticity

(d) Flexibility

**4. What is the elastic limit?**

(a) The point where elasticity becomes infinite

(b) The maximum force a material can bear before deforming permanently

(c) The limit beyond which mass increases





(d) The point at which a material melts

**5. Hooke's Law is valid:**

(a) After the breaking point

(b) Within the elastic limit



(c) In gaseous state only

(d) At high temperatures

**6. Hooke's Law is given by:**

(a)  $F = ma$

(b)  $F = mv^2$

(c)  $F = kx$

(d)  $F = \frac{1}{2} mv^2$

**7. In the formula  $F = kx$ , the constant 'k' is:**

(a) Acceleration

(b) Elastic limit

(c) Spring constant

(d) Mass

**8. The unit of spring constant is:**

(a) Nm



(b) N

(c)  $\text{Nm}^2$

(d)  $\text{Nm}^{-1}$

9. The force vs. extension graph for a spring following Hooke's Law is:

(a) A straight line through the origin

(b) A curve

(c) A horizontal line

(d) A zigzag line

10. Which device operates based on Hooke's Law?

(a) Thermometer

(b) Spring balance

(c) Hydrometer

(d) Barometer

11. What is the formula to calculate the density of a substance?

(a)  $\text{Density} = \text{Volume} / \text{Mass}$

(b)  $\text{Density} = \text{Mass} \times \text{Volume}$



(c) Density = Mass / Volume

(d) Density = Force / Area

12. What is the SI unit of density?



(a) g/cm<sup>3</sup>

(b) kg/m<sup>3</sup>

(c) N/m<sup>2</sup>

(d) kg/cm<sup>2</sup>

13. If two substances have equal volume, the one with higher mass will have:

(a) Lower density

(b) Equal density

(c) Higher density

(d) Zero density

14. Which of the following has the greatest density?

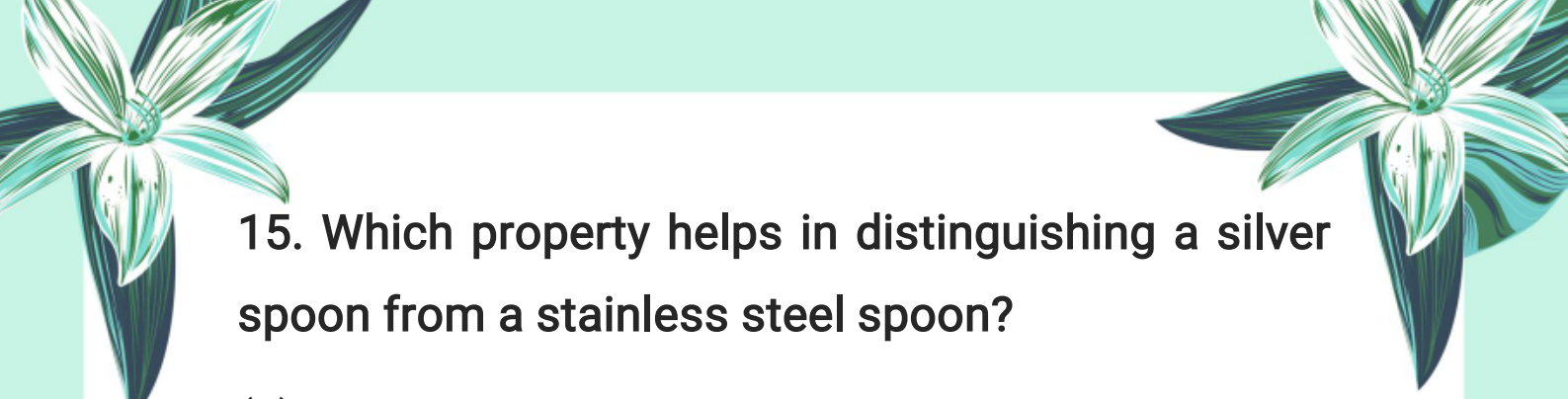
(a) Air

(b) Water

(c) Iron


(d) Wood





15. Which property helps in distinguishing a silver spoon from a stainless steel spoon?

- (a) Shape
- (b) Temperature
- (c) Density
- (d) Elasticity



16. Which tool is used to measure the volume of a regularly shaped solid?

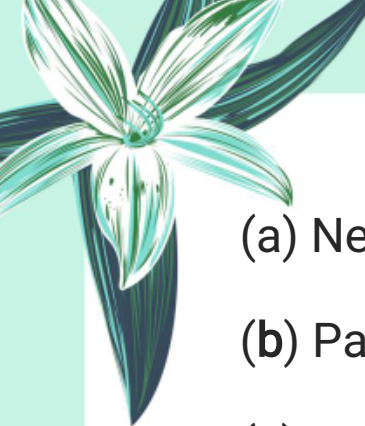


- (a) Thermometer
- (b) Vernier calipers
- (c) Barometer
- (d) Stopwatch

17. What is the definition of pressure?

- (a) Force per unit mass
- (b) Force per unit time
- (c) Force per unit area
- (d) Mass per unit area

18. The SI unit of pressure is:



- 
- 
- 
- (a) Newton
  - (b) Pascal
  - (c) Bar
  - (d) Kilogram

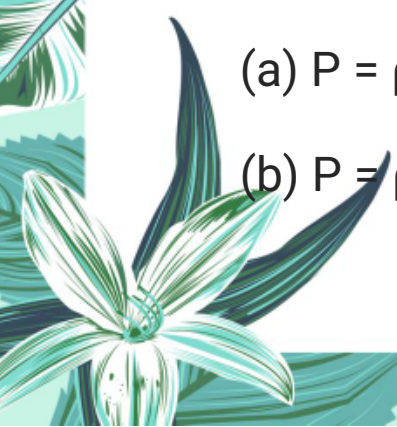

**19. Why is a chopper's blade made sharp?**

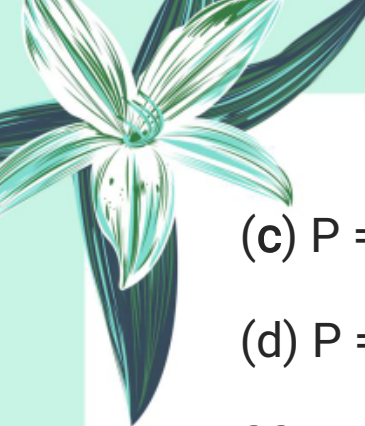
- (a) To reduce weight
- (b) To look good
- (c) To increase area
- (d) To increase pressure on a small area

**20. An elephant's feet are broad and flat to:**

- (a) Run faster
- (b) Look large
- (c) Reduce pressure on the ground
- (d) Increase body temperature

**21. What is the formula for pressure in a liquid at depth h?**

- (a)  $P = \rho/h$
  - (b)  $P = \rho g/h$
- 
- 



(c)  $P = \rho gh$

(d)  $P = h/\rho g$

**22. In which direction does pressure in a liquid act?**

(a) Only downwards



(b) Only upwards

(c) Only sideways

(d) In all directions

**23. What is the value of standard atmospheric pressure at sea level?**

(a)  $1.013 \times 10^3 \text{ Pa}$

(b)  $1.013 \times 10^4 \text{ Pa}$

(c)  $1.013 \times 10^5 \text{ Pa}$


(d)  $1.013 \times 10^6 \text{ Pa}$

**24. Why don't we feel the atmospheric pressure on our body?**

(a) It only acts upwards

(b) Our skin is insensitive

(c) The air inside our body balances it





(d) Atmospheric pressure is very low


**25. What is the name of the instrument used to measure atmospheric pressure?**

(a) Thermometer

(b) Hydrometer

(c) Barometer

(d) Manometer



**26. In a simple mercury barometer, the space above the mercury column is:**

(a) Filled with air

(b) Filled with water vapours

(c) Completely empty

(d) Filled with mercury vapours

**27. Why is mercury preferred over water in barometers?**

(a) Mercury is cheaper

(b) Mercury is denser

(c) Mercury is colourless





(d) Mercury evaporates quickly


**28. The unit used to express standard atmospheric pressure is:**

(a) 1000 Pa

(b) 1 Pa

(c)  $1.013 \times 10^5$  Pa

(d) 76 Pa



**29. In a manometer, if the mercury level is higher in the arm connected to the gas, the gas pressure is:**

(a) Equal to atmospheric pressure

(b) Greater than atmospheric pressure

(c) Less than atmospheric pressure

(d) Equal to zero

**30. Pascal's Law states that pressure applied to an enclosed fluid is:**

(a) Transmitted unequally in all directions

(b) Absorbed by the fluid

(c) Lost in friction



(d) Transmitted equally to all parts

**31. Hydraulic systems work effectively because liquids are:**

(a) Compressible

(b) Dense

(c) Incompressible

(d) Light in weight

**32. In a hydraulic press, the output force is greater than the input force because:**

(a) Output area is smaller

(b) Pressure is reduced

(c) Input force is very large

(d) Output piston has a larger area

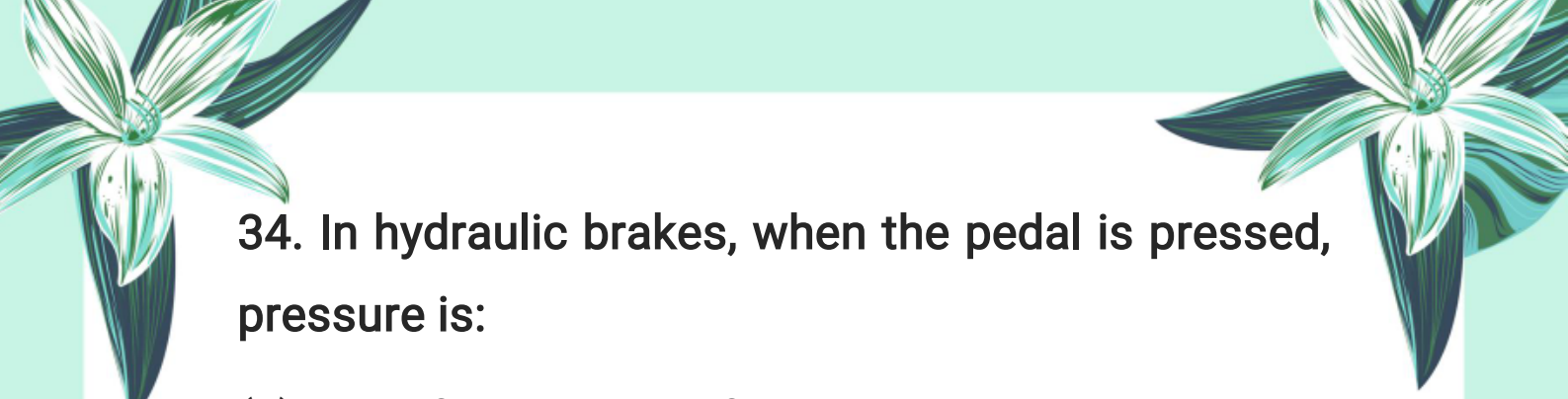
**33. The hydraulic press is an example of a:**

(a) Pressure reducer


(b) Temperature sensor

(c) Force multiplier

(d) Vacuum system



34. In hydraulic brakes, when the pedal is pressed, pressure is:

- (a) Transferred only to front wheels
  - (b) Lost in the brake oil
  - (c) Transmitted equally to all wheels
  - (d) Reduced due to friction
- 

## B Exercise Short Questions

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

**Answer:**

Heavy animals like elephants have large feet to distribute their weight over a larger area, which reduces pressure on the ground. According to the formula:


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

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


**Answer:**



Animals like deer have small feet to increase the pressure they exert on the ground. This higher pressure provides a better grip, which helps them in running fast and making quick movements without slipping.

**6.3. Why is it painful to walk barefooted on pebbles?**

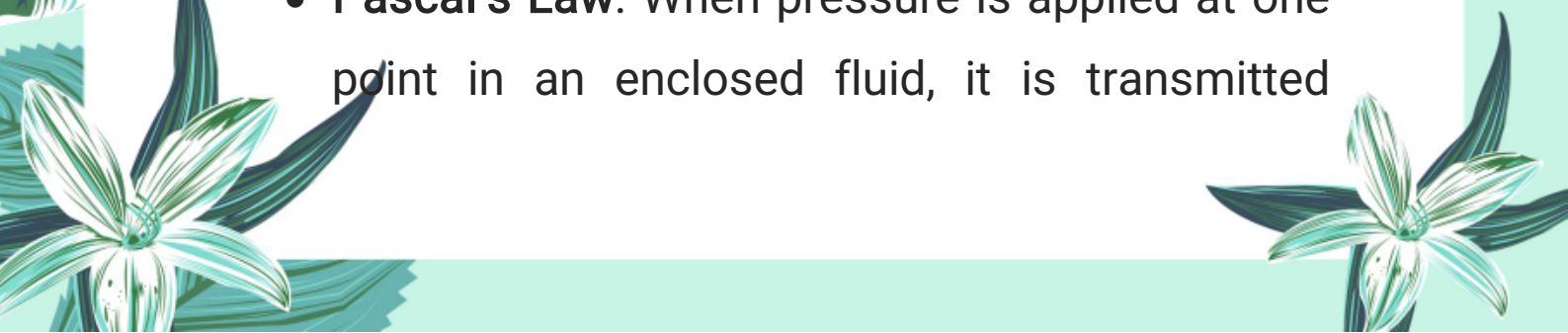
**Answer:**



Pebbles have small surface areas, so when we walk barefoot on them, the pressure (Force/Area) on our feet increases. This high pressure is focused on small spots of our skin, causing pain and discomfort.

**6.4. State Pascal's law. Give an application of Pascal's law.**

**Answer:**

- **Pascal's Law:** When pressure is applied at one point in an enclosed fluid, it is transmitted
- 



equally in all directions without any loss.

- **Application:** Hydraulic press and hydraulic brakes in vehicles work on Pascal's Law.

### 6.5. What do you mean by elasticity of a solid?



**Answer:**

Elasticity is the property of a solid body by which it returns to its original shape and size after the removal of the external force that caused deformation.

### 6.6. What is Hooke's law? Does an object remain elastic beyond the elastic limit? Give reason.

**Answer:**

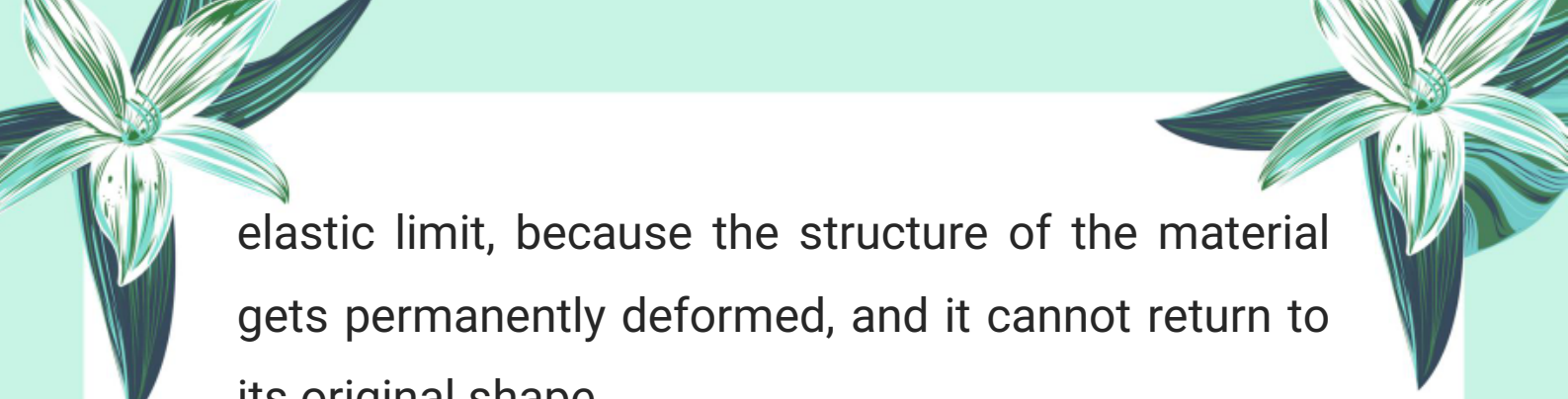
**Hooke's Law:** The extension in an elastic object is directly proportional to the applied force, provided the elastic limit is not exceeded.

**Mathematically:**

$$F \propto x$$

**No,** an object does not remain elastic beyond its







elastic limit, because the structure of the material gets permanently deformed, and it cannot return to its original shape.

### 6.7. Distinguish between force and pressure.

**Answer:**

- 
- **Force:** It is a push or pull that changes the state of motion of a body. Its SI unit is newton (N).
  - **Pressure:** It is the force acting per unit area. Its SI unit is pascal (Pa).

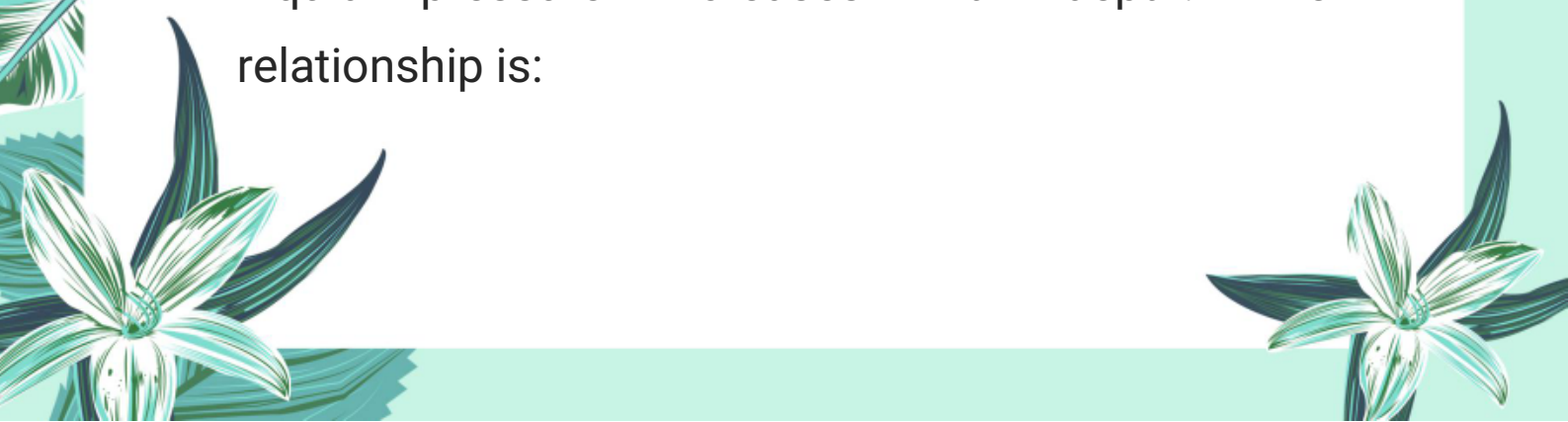
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$



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### 6.8. What is the relationship between liquid pressure and the depth of the liquid?

**Answer:**

Liquid pressure increases with depth. The relationship is:




$$P = \rho gh$$

- $P$  = pressure
  - $\rho$  = density of liquid
  - $g$  = gravitational acceleration
  - $h$  = depth of the liquid
- 

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

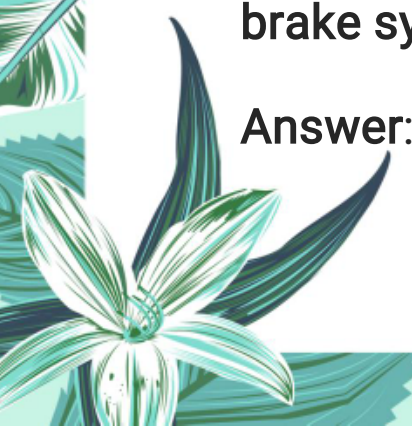
**Answer:**

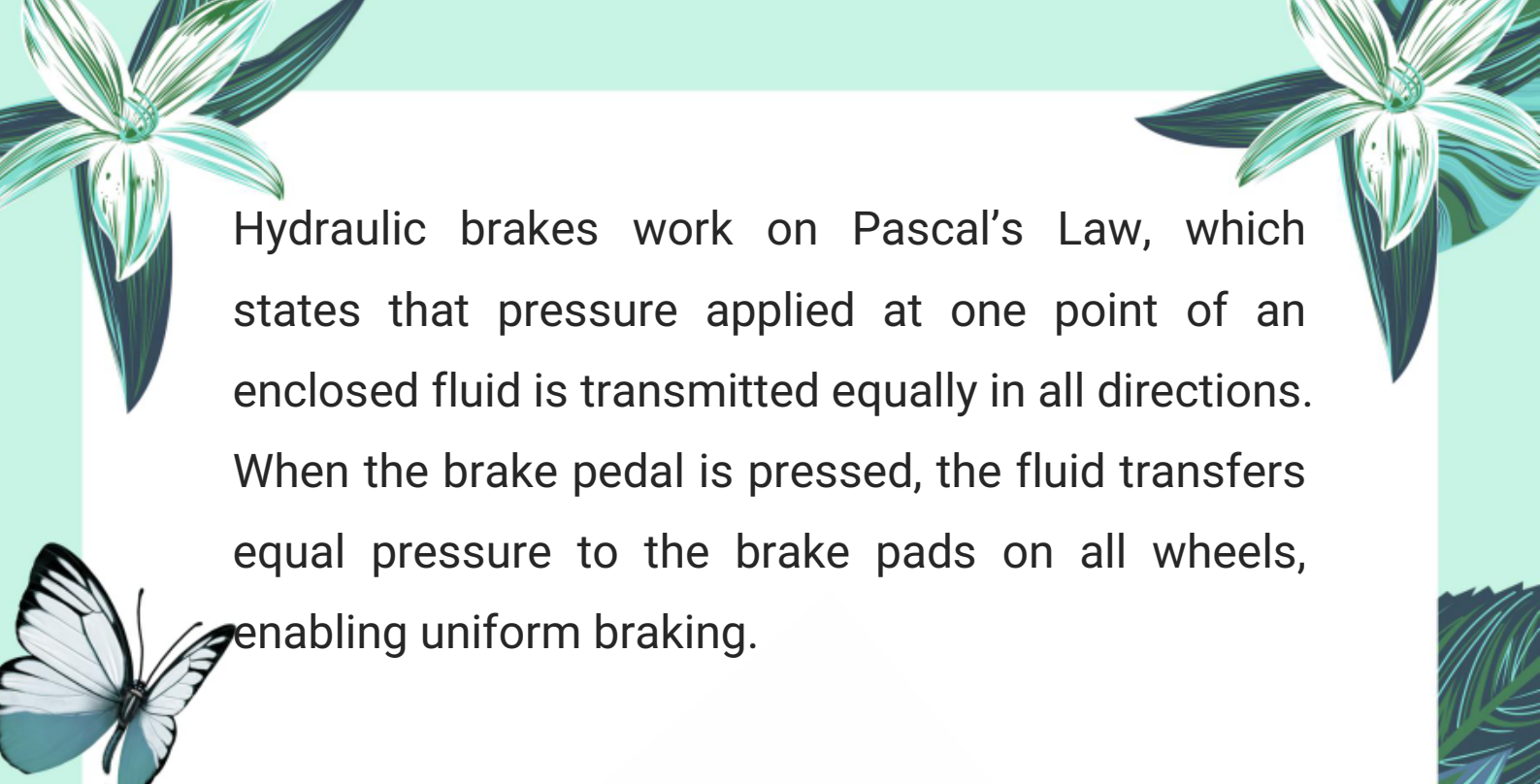
The atmospheric pressure is measured by the height of mercury column in a barometer. The height of mercury in the tube balances the atmospheric pressure acting on the mercury in the dish. The pressure is calculated using:

$$P = \rho gh$$

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

**Answer:**





Hydraulic brakes work on Pascal's Law, which states that pressure applied at one point of an enclosed fluid is transmitted equally in all directions. When the brake pedal is pressed, the fluid transfers equal pressure to the brake pads on all wheels, enabling uniform braking.

### Important short questions:

1. What is a deforming force?

Answer:

A deforming force is an external force applied to an object that changes its shape or size.

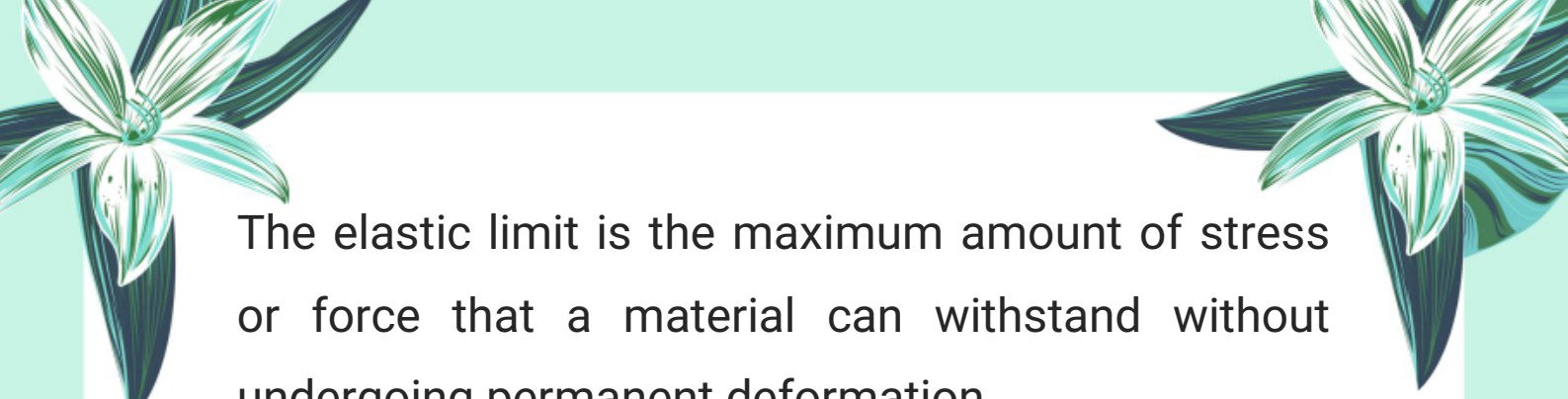
2. Define elasticity.

Answer:

Elasticity is the property of a material by which it returns to its original shape and size after the deforming force is removed.

3. What is the elastic limit?


Answer:



The elastic limit is the maximum amount of stress or force that a material can withstand without undergoing permanent deformation.

#### 4. State Hooke's Law.

**Answer:**



Hooke's Law states that within the elastic limit, the extension or compression of a spring is directly proportional to the applied force.

Mathematically,  $F = kx$ , where  $F$  is force,  $x$  is extension, and  $k$  is the spring constant.

#### 5. What is the spring constant?

**Answer:**

The spring constant is a measure of the stiffness of a spring. A larger means a stiffer spring. Its unit is Newton per meter (N/m).

#### 6. What happens if the force applied on a spring exceeds its elastic limit?





**Answer:**

If the force exceeds the elastic limit, the spring undergoes permanent deformation and does not return to its original length.

**7. How is a spring scale used to measure weight?**



**Answer:**

A spring scale measures weight by the amount of extension or compression of a spring, which is proportional to the force (weight) applied.

**8. What is the role of the balance wheel in mechanical clocks?**

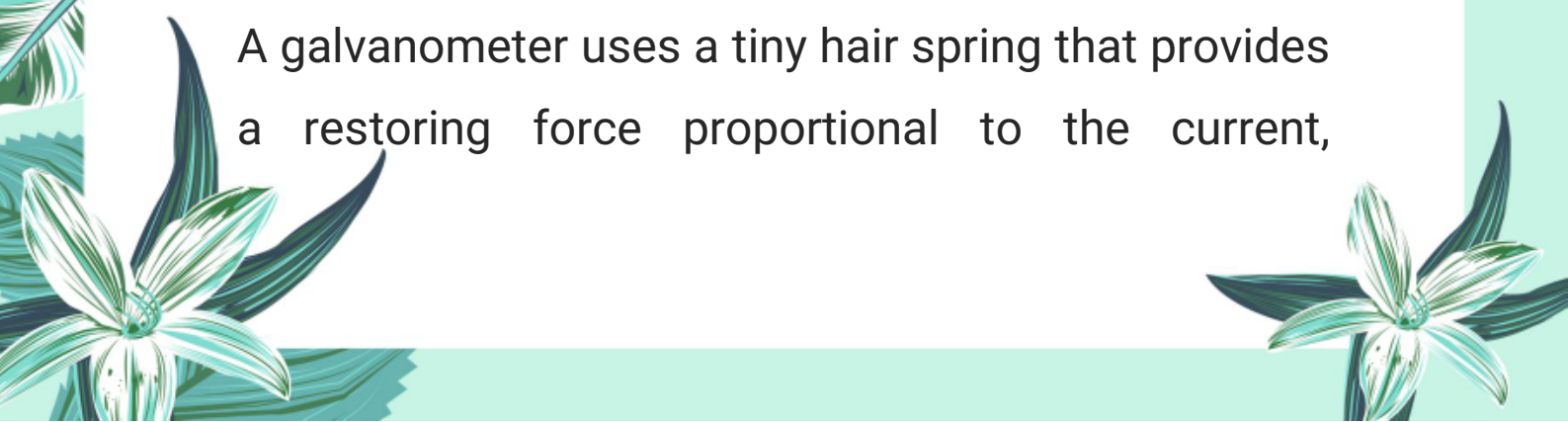
**Answer:**

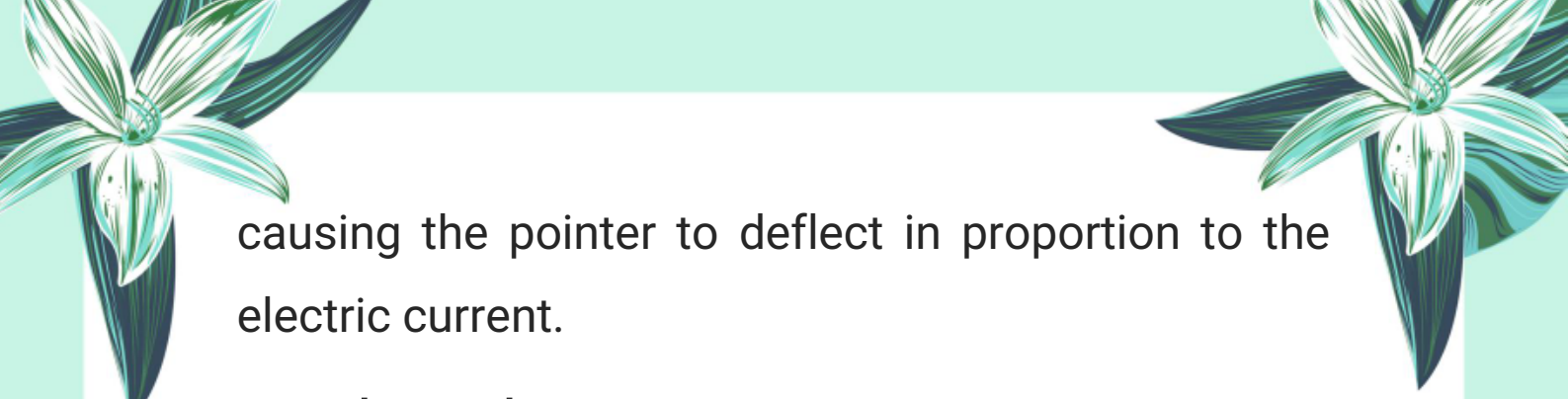
The balance wheel controls the back-and-forth motion regulated by a spring, which helps maintain the accurate speed of the clock's hands.

**9. How does a galvanometer use Hooke's Law?**

**Answer:**

A galvanometer uses a tiny hair spring that provides a restoring force proportional to the current,






causing the pointer to deflect in proportion to the electric current.

### 10. What is density?

Density is the mass of a substance per unit volume.

Mathematically,


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

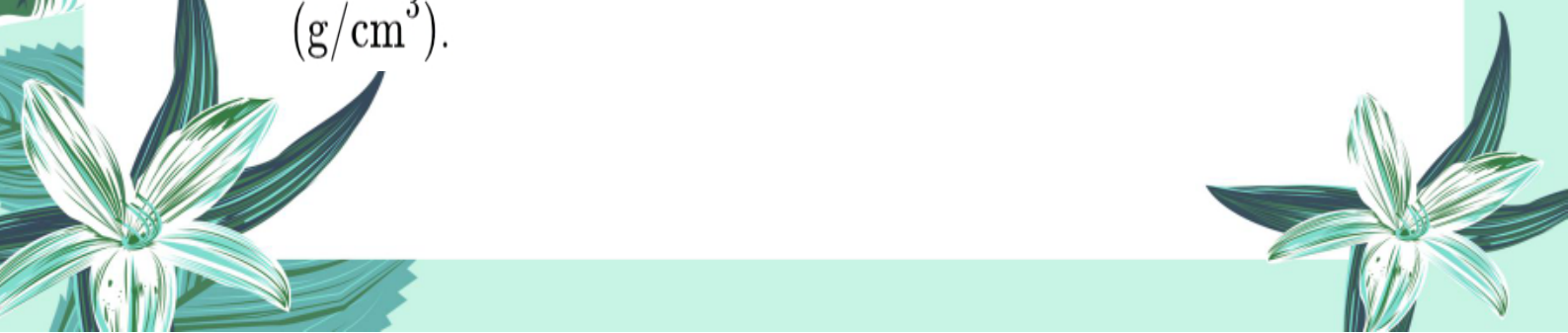
### 11. Why does iron weigh more than wood for the same volume?

Because iron's molecules are heavier and more densely packed than wood's molecules, giving iron a higher density.

### 12. What are the SI units of density?

**Answer:**


The SI unit of density is kilogram per cubic meter ( $\text{kg}/\text{m}^3$ ). Another common unit is gram per cubic centimeter ( $\text{g}/\text{cm}^3$ ).





**13. How can the volume of a regular solid be measured?**

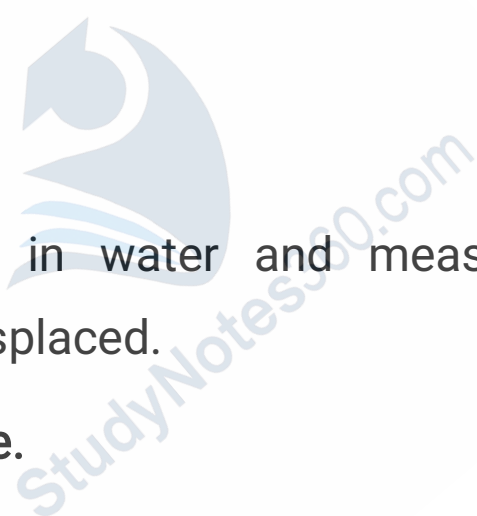
**Answer:**



By measuring its dimensions (length, breadth, height) and using the appropriate geometric formula (e.g., volume of a cube = length × breadth × height).

**14. How can the volume of an irregular solid be measured?**

**Answer:**



By submerging it in water and measuring the volume of water displaced.

**15. Define pressure.**

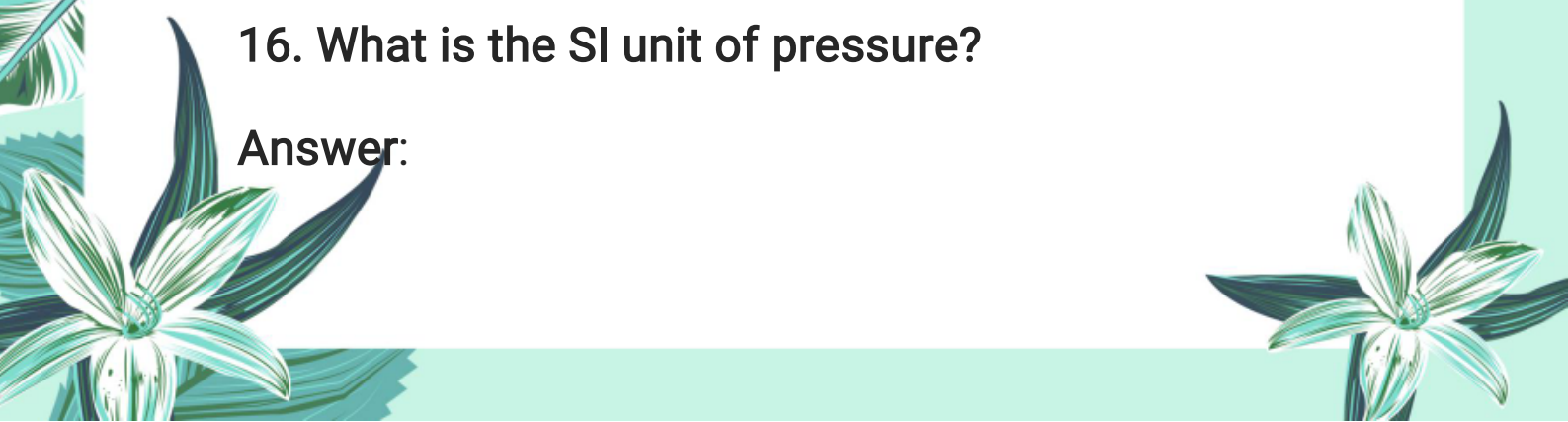
**Answer:**

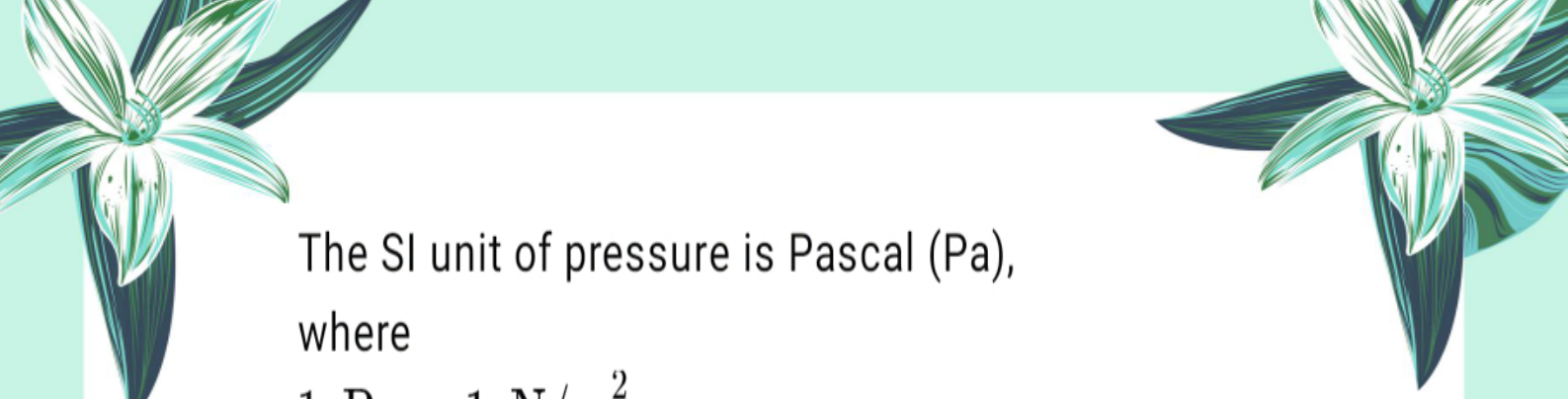
Pressure is the force exerted normally (perpendicularly) on a unit area of a surface.

$$P = F/A$$

**16. What is the SI unit of pressure?**

**Answer:**





The SI unit of pressure is Pascal (Pa),

where

$$1, \text{Pa} = 1, \text{N/m}^2.$$



**17. How does pressure vary with contact area for a constant force?**

**Answer:**

Pressure increases as contact area decreases, and pressure decreases as contact area increases.

**18. Why are blades of knives and pins made very sharp?**

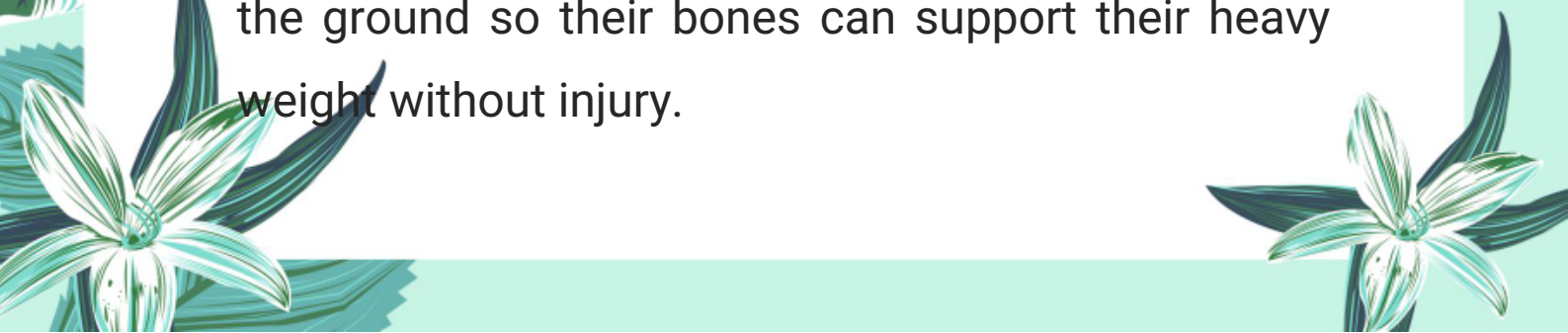
**Answer:**

Because a small contact area increases pressure for the same force, making cutting or piercing easier.

**19. Why do elephants have large flat feet?**

**Answer:**


To increase the contact area, reducing pressure on the ground so their bones can support their heavy weight without injury.





20. Define pressure in liquids and explain how it varies with depth.

**Answer:**



Pressure in liquids is the force exerted per unit area by the liquid on the surface. It increases with depth because the weight of the liquid above increases.

The formula is  $P = \rho gh$ , where  $\rho$  is the density,  $g$  is gravity, and  $h$  is depth.

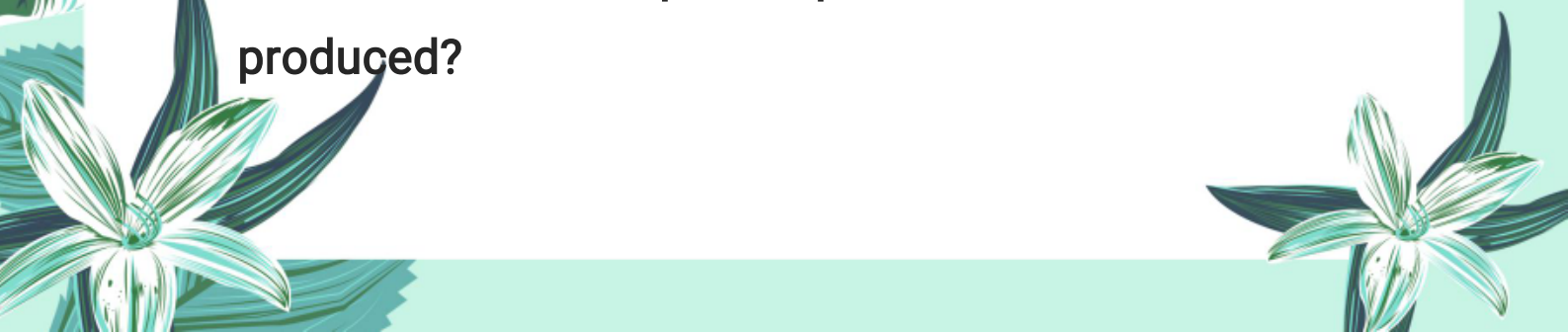
21. Derive the formula for pressure exerted by a liquid at depth .

**Answer:**

Consider a liquid column with base area  $A$  and height  $h$ .

- Volume  $V = A \times h$
  - Mass  $m = \rho V = \rho Ah$
  - Weight  $W = mg = \rho g Ah$
- Pressure  $P = \frac{\text{Force}}{\text{Area}} = \frac{W}{A} = \rho gh.$


22. What is atmospheric pressure and how is it produced?





**Answer:**

Atmospheric pressure is the pressure exerted by the weight of air molecules in the atmosphere. It is produced due to constant collisions of air molecules with objects and surfaces.



**23. State the value of standard atmospheric pressure and its unit.**

**Answer:**

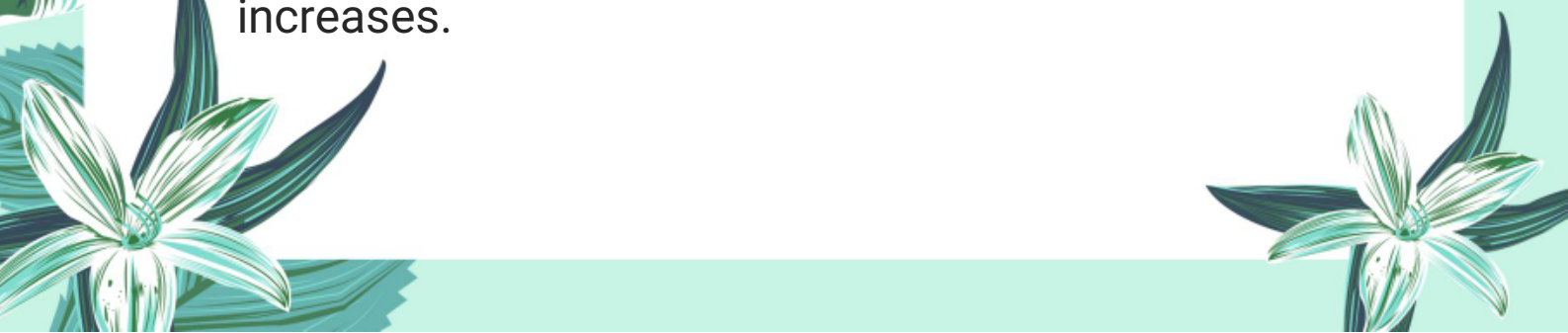
Standard atmospheric pressure at sea level is  $1.013 \times 10^5$  pascals (Pa), which is equivalent to 760 mm of mercury (Hg).

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**24. Why does atmospheric pressure decrease with altitude?**

**Answer:**


Because the density of air decreases with height, reducing the weight of the air column above, hence atmospheric pressure decreases as altitude increases.





**25. Describe the construction and working of a mercury barometer.**

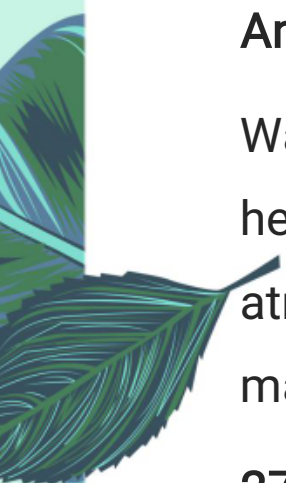
**Answer:**



A mercury barometer consists of a glass tube filled with mercury and inverted in a mercury-filled dish. Atmospheric pressure pushes mercury in the dish up the tube. The height of mercury column indicates atmospheric pressure.

**26. Why can't water be used instead of mercury in a barometer?**

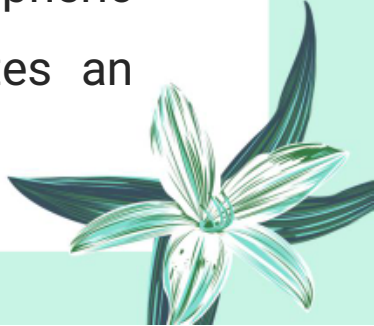
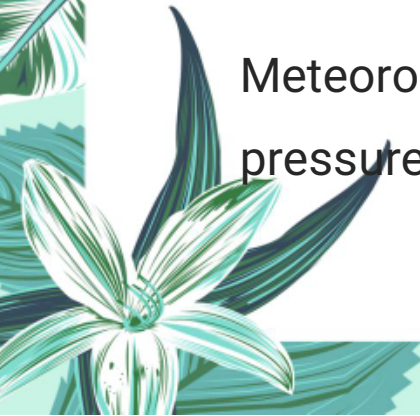
**Answer:**



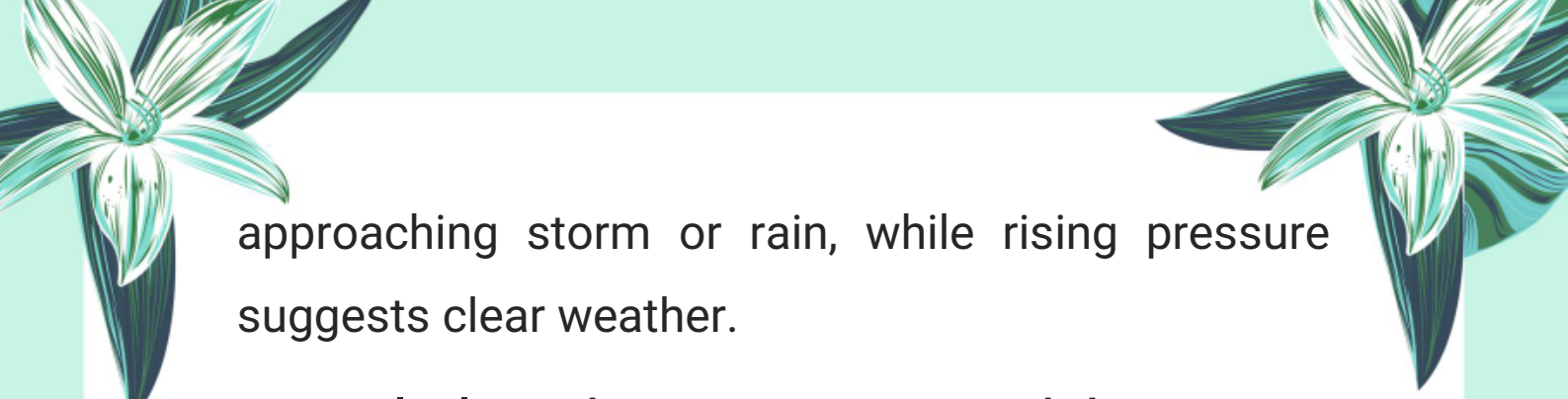
Water has much lower density than mercury, so the height of water column required to balance atmospheric pressure would be about 13.6 meters, making it impractical.

**27. Explain how atmospheric pressure helps in weather forecasting.**

**Answer:**




Meteorologists monitor changes in atmospheric pressure; a falling pressure usually indicates an



approaching storm or rain, while rising pressure suggests clear weather.

28. Calculate the pressure exerted by a 5 m column of water. (Density of water , )

Answer:


$$\rho = 1000, kg/m^3, g = 9.8, m/s^2)$$

**Answer:**

Using  $P = \rho gh$ ,

$$P = 1000 \times 9.8 \times 5 = 49000, Pa \text{ or } 49 \text{ kPa.}$$

29. Explain why atmospheric pressure acts equally in all directions.

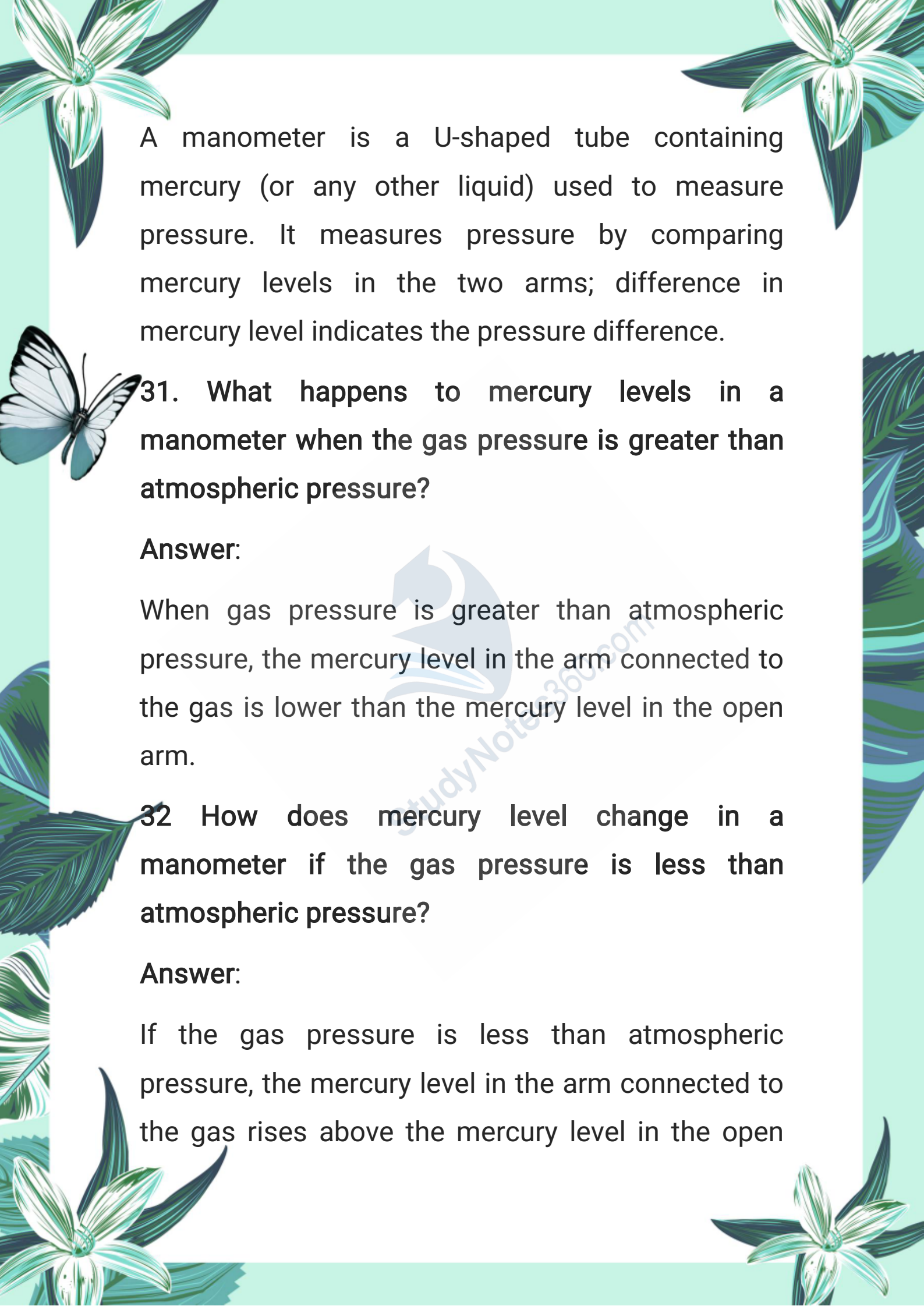
Answer:

Because air molecules move randomly in all directions and collide with surfaces uniformly, atmospheric pressure is exerted equally in every direction.

30. What is a manometer and how does it measure pressure?

Answer:



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A manometer is a U-shaped tube containing mercury (or any other liquid) used to measure pressure. It measures pressure by comparing mercury levels in the two arms; difference in mercury level indicates the pressure difference.

**31. What happens to mercury levels in a manometer when the gas pressure is greater than atmospheric pressure?**

**Answer:**

When gas pressure is greater than atmospheric pressure, the mercury level in the arm connected to the gas is lower than the mercury level in the open arm.

**32 How does mercury level change in a manometer if the gas pressure is less than atmospheric pressure?**

**Answer:**


If the gas pressure is less than atmospheric pressure, the mercury level in the arm connected to the gas rises above the mercury level in the open



arm.

**33. State Pascal's law.**


**Answer:**



Pascal's law states that when pressure is applied at any point in an enclosed incompressible fluid, it is transmitted equally and undiminished in all directions throughout the fluid.

**34. Explain with an example how Pascal's law is demonstrated in everyday life.**


**Answer:**




When inflating a motorbike tyre, air pressure applied at the valve is transmitted equally inside the tyre, causing uniform inflation all around.

**35. Why are liquids used in hydraulic systems?**

**Answer:**



Liquids are used because they are incompressible and transmit pressure equally in all directions without loss of energy, allowing them to move heavy loads efficiently.



**36. What is the principle behind the hydraulic press?**

**Answer:**

The hydraulic press works on Pascal's law. A small force applied on a small piston creates pressure transmitted equally to a larger piston, producing a larger force capable of lifting heavy objects.

**37. Write the formula relating forces and areas in a hydraulic system and explain the terms.**

**Answer:**

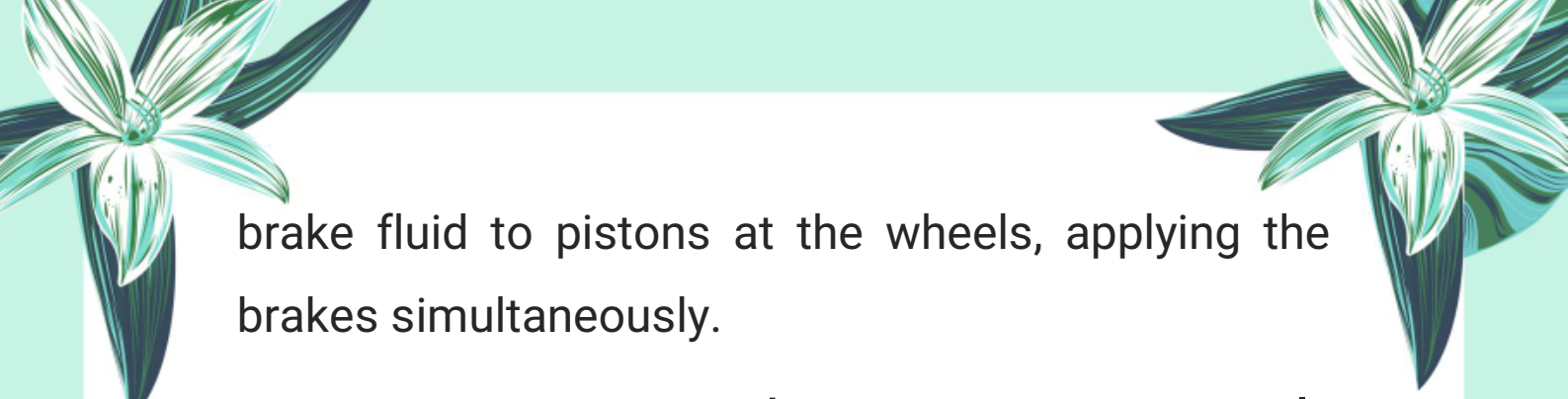
$$F_2 = \frac{A_2}{A_1} F_1$$

Where  $F_1$  = force on small piston,  $A_1$  = area of small piston,  $F_2$  = force on large piston, and  $A_2$  = area of large piston.  
This shows force multiplication.

**38. How do hydraulic brakes in vehicles use Pascal's law?**

**Answer:**


When the brake pedal pushes the master cylinder piston, pressure is transmitted equally through the



brake fluid to pistons at the wheels, applying the brakes simultaneously.

39. In a manometer, why is mercury commonly used instead of water?

Answer:



Mercury is used because it has a high density, which allows a shorter column to measure pressure differences accurately, unlike water which requires a much taller column.

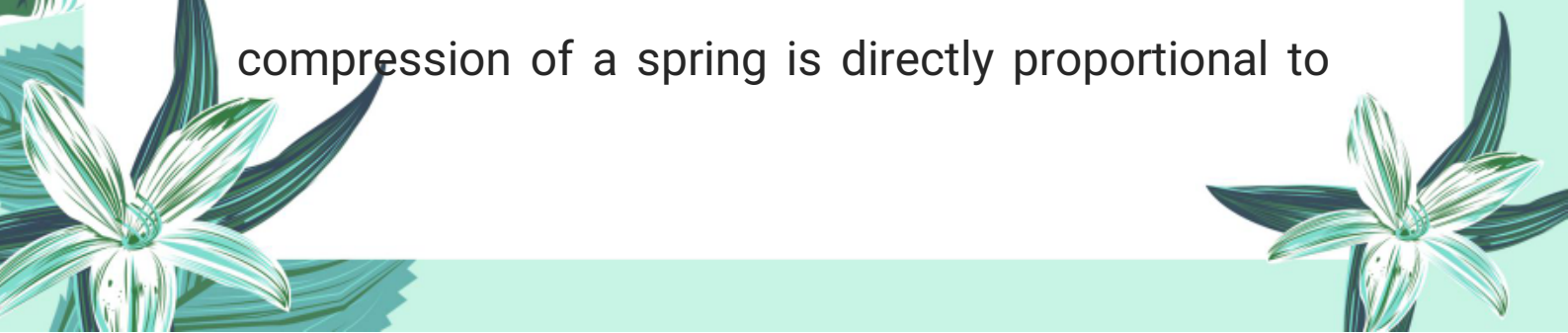
### Important Long Questions :

✨ Q1. What is Hooke's Law? Explain it mathematically and define the spring constant.

◆ Hooke's Law – Definition:

Hooke's Law describes the behavior of a spring or elastic object when a force is applied to stretch or compress it.

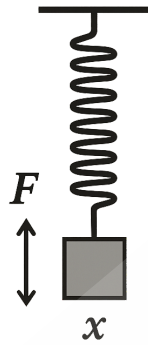
> "Hooke's Law states that the extension or compression of a spring is directly proportional to



the force applied on it, provided that the elastic limit is not exceeded."

**What is Hooke's Law?**

$$F = kx$$



$k$  is the spring constant.

◆ **Mathematical Form of Hooke's Law:**

Let:

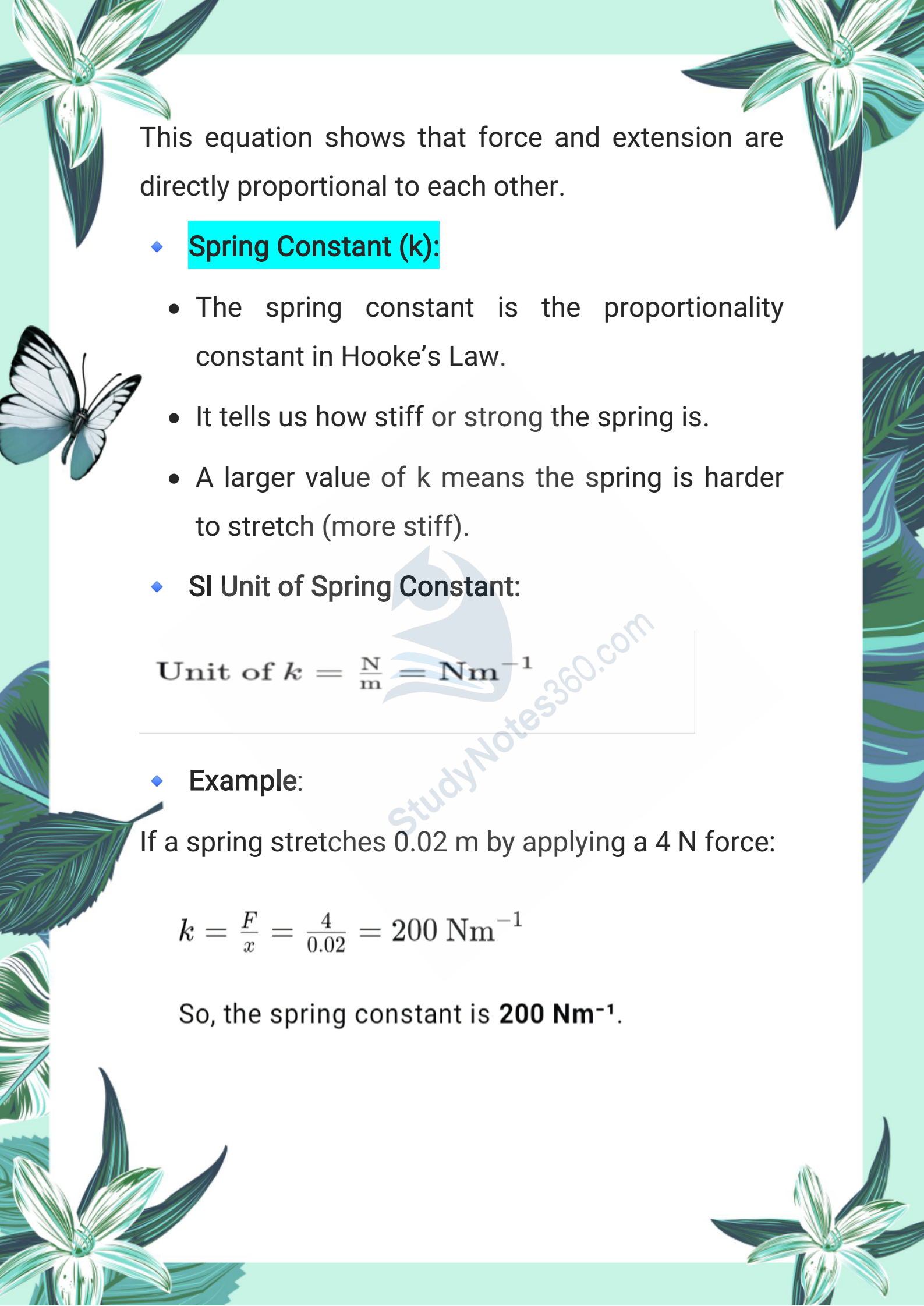
- $F$  = applied force
- $x$  = extension or compression
- $k$  = spring constant

Then,

$$F = kx$$

Or,

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



This equation shows that force and extension are directly proportional to each other.

◆ **Spring Constant (k):**

- The spring constant is the proportionality constant in Hooke's Law.
- It tells us how stiff or strong the spring is.
- A larger value of  $k$  means the spring is harder to stretch (more stiff).

◆ **SI Unit of Spring Constant:**

$$\text{Unit of } k = \frac{\text{N}}{\text{m}} = \text{Nm}^{-1}$$

◆ **Example:**

If a spring stretches 0.02 m by applying a 4 N force:

$$k = \frac{F}{x} = \frac{4}{0.02} = 200 \text{ Nm}^{-1}$$

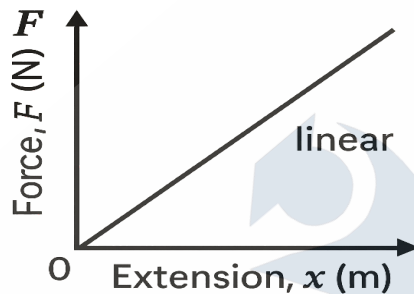
So, the spring constant is **200 Nm<sup>-1</sup>**.

☀ Q2. Explain the relationship between force and extension according to Hooke's Law. What is the significance of the force-extension graph?

- ◆ Relationship Between Force and Extension:

### Force vs. Extension

According to Hooke's Law, the force  $F$  applied to a spring is proportional to the extension  $x$ .



The force-extension graph is a straight line through the origin.

According to Hooke's Law:

$$F \propto x$$

- This means when you apply more force, the extension increases proportionally, as long as the elastic limit is not exceeded.
- If you double the force, the extension will also double.

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### ◆ Force-Extension Graph:

- The graph of force ( $F$ ) vs. extension ( $x$ ) is a straight line through the origin  $(0,0)$  within the elastic limit.
- This line represents a linear relationship, showing direct proportionality.



Slope of the line = Spring Constant ( $k$ )

### ◆ Significance of the Graph:

1. Linearity shows that Hooke's Law holds.
2. Gradient (slope) tells us the stiffness of the spring.
3. Beyond the elastic limit, the graph bends (nonlinear), showing permanent deformation.

✨ Q3. What is the elastic limit? What happens if the force applied on a spring exceeds its elastic limit?

### ◆ Elastic Limit – Definition:

> "The elastic limit is the maximum force that can be applied to an elastic object (like a spring) without



causing permanent deformation."

- Within this limit, the object returns to its original shape after the force is removed.
- Beyond this limit, the object is permanently deformed.



◆ **What Happens Beyond the Elastic Limit?**

1. The object no longer obeys Hooke's Law.
2. The extension increases rapidly with force.
3. The object may be damaged or broken.
4. The force-extension graph becomes non-linear.


◆ **Example:**

If you keep adding weights to a spring:

Initially, the extension is proportional.

After a certain point (elastic limit), the spring stretches more than expected and does not return to its original length.

✨ **Q4. Discuss the applications of Hooke's Law and describe three important devices that use this**



law.

### ◆ General Applications of Hooke's Law:

Hooke's Law is widely used in science, technology, and engineering wherever springs or elastic materials are involved.



### Devices That Use Hooke's Law:

#### 1. Spring Scales (Spring Balance):

- Used to measure weight (force).
- Based on extension of the spring when an object is hung.
- The more the object weighs, the more the spring stretches.



**Example:** Weighing machines in shops.

#### 2. Balance Wheel in Clocks:


- In mechanical clocks, a spring controls the oscillating motion of the balance wheel.
- Hooke's Law helps keep the motion regular and maintains accurate time.



Used in old watches and wall clocks.


### 3. Galvanometer:

- A device to detect small electric currents.
- A hair spring inside provides restoring force.
- As current passes, the needle deflects, and the spring obeys Hooke's Law to return it to zero.

 Used in physics labs and measuring instruments.

#### ◆ Other Uses:

- Car suspension systems (shock absorbers)
- Door hinges and mattresses
- Material testing machines

 **Q5. Define density. Derive the formula for density and explain its SI unit.**

**Definition:**

**Definition of Density:**

Density is a physical property of matter that tells how closely packed the mass is in a given volume of a substance. In simpler words, it shows how



heavy or light an object is for its size.

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

### Formula of Density:

Let:

Mass of an object =  $m$

Volume of the object =  $V$

Then, the formula for density ( $\rho$ ) is:

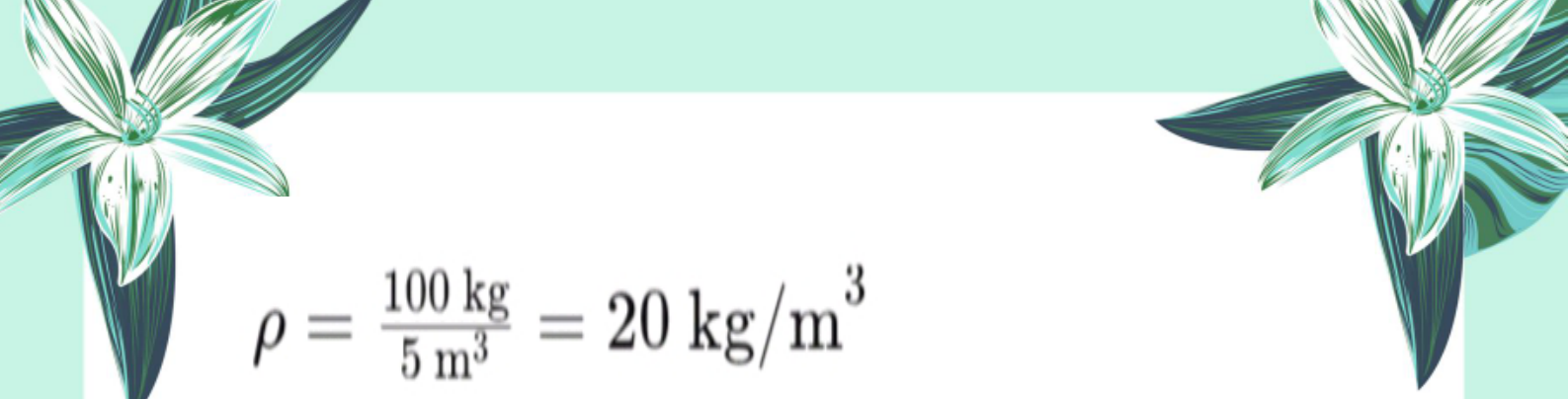
$$\text{Density}(\rho) = \frac{\text{Mass}(m)}{\text{Volume}(V)}$$

This formula helps us calculate how much mass is contained in a specific amount of space (volume).

### Derivation of the Formula:

Suppose a body has:

- Mass = 100 kg
- Volume = 5 m<sup>3</sup>
- Using the formula:


$$\rho = \frac{100 \text{ kg}}{5 \text{ m}^3} = 20 \text{ kg/m}^3$$

---

So, the density of the body is  $20 \text{ kg/m}^3$ .



### SI Unit of Density:

The SI unit of:

- Mass = kilogram (kg)
- Volume = cubic metre ( $\text{m}^3$ )

Thus, the SI unit of density is:

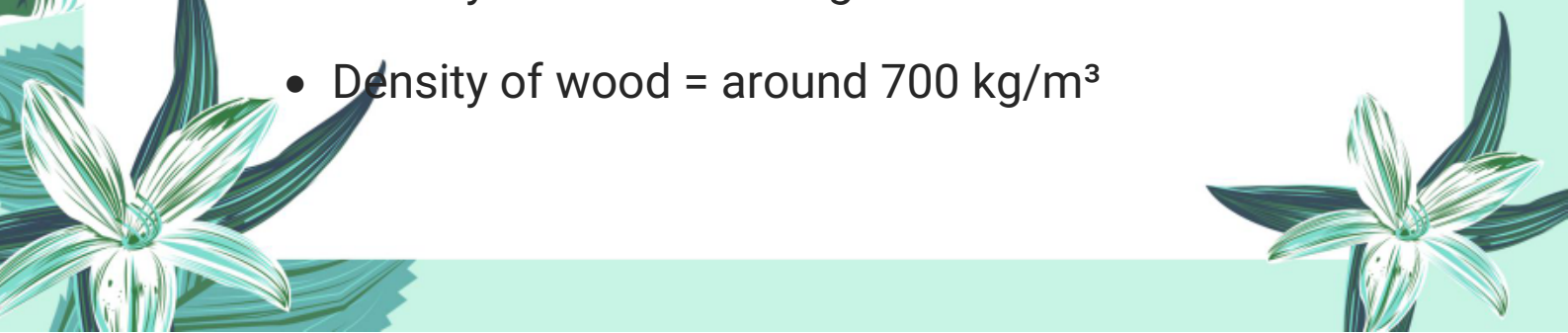
$\text{Kg/m}^3$

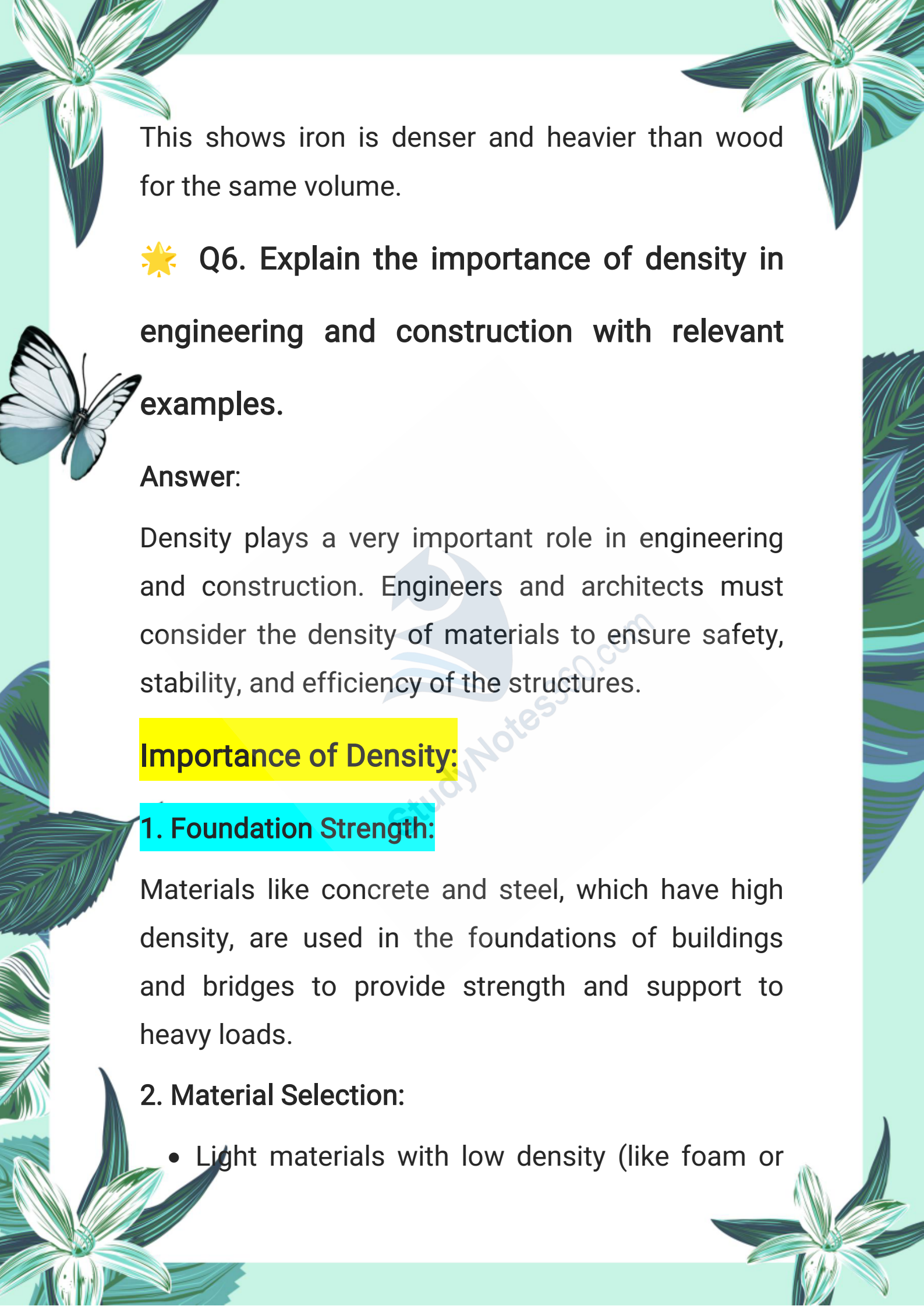
### Other Units of Density:

- **In labs:**  $\text{g/cm}^3$ , where  $1 \text{ g/cm}^3 = 1000 \text{ kg/m}^3$
- **In liquids:**  $\text{g/mL}$  (used commonly in chemistry and biology)



### Examples:

- Density of water =  $1000 \text{ kg/m}^3$  or  $1 \text{ g/cm}^3$
  - Density of iron =  $7800 \text{ kg/m}^3$
  - Density of wood = around  $700 \text{ kg/m}^3$
- 

This shows iron is denser and heavier than wood for the same volume.

This page features decorative illustrations of white flowers with green leaves in the corners and a white butterfly on the left side. A faint watermark of a bird is visible in the background.

☀️ **Q6. Explain the importance of density in engineering and construction with relevant examples.**

**Answer:**

Density plays a very important role in engineering and construction. Engineers and architects must consider the density of materials to ensure safety, stability, and efficiency of the structures.


### **Importance of Density:**

#### **1. Foundation Strength:**

Materials like concrete and steel, which have high density, are used in the foundations of buildings and bridges to provide strength and support to heavy loads.

#### **2. Material Selection:**

- Light materials with low density (like foam or

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plastic) are used where weight reduction is needed.


- Heavy and strong materials with high density (like iron, concrete) are used where durability and strength are needed.

### 3. Bridge and Road Construction:

Engineers calculate the density of materials like asphalt, cement, and steel to design roads and bridges that can carry specific loads without collapsing.

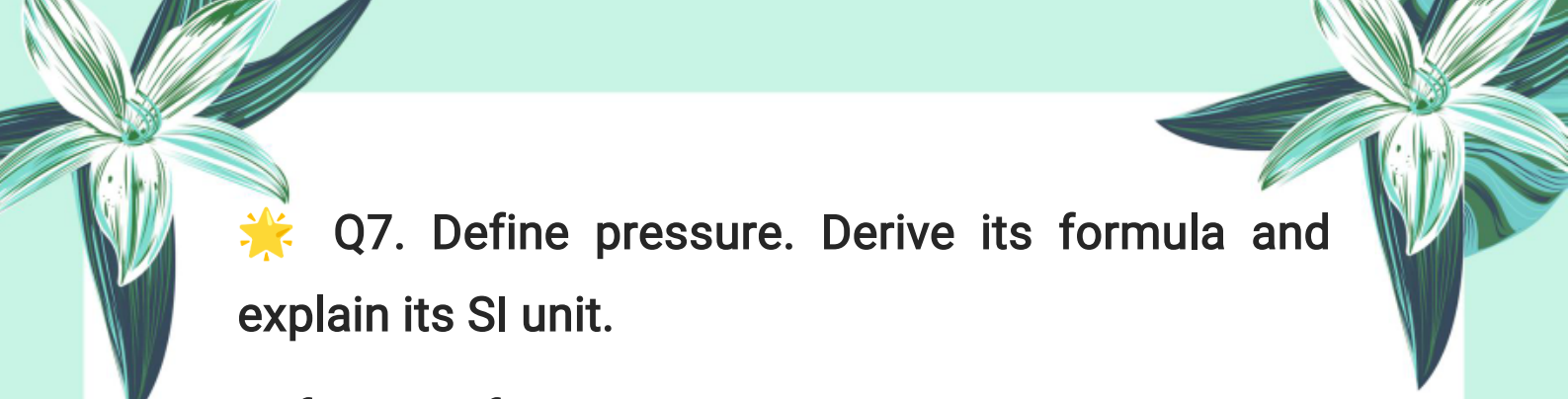
### 4. Buoyancy and Safety:

- In water-related structures, knowing density is important to ensure whether an object will float or sink.

 **For example,** ships are designed to have average density less than that of water so they float.


### 5. Cost and Transport Consideration:

Heavier materials with more density cost more to transport, so density also affects logistics and budgeting in construction.



☀ Q7. Define pressure. Derive its formula and explain its SI unit.

### Definition of Pressure:



Pressure is defined as the force exerted perpendicularly on a unit area of a surface. It tells us how concentrated or spread out a force is over a given area.

> Pressure = Force acting normally / Area on which the force acts

### Derivation of Formula:

Let:

= Force acting normally (i.e., perpendicular) on a surface

= Area of contact

Then pressure is given by the formula:

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

---

### SI Unit of Pressure:

In SI units:



- Force is measured in newtons (N)
- Area is measured in square meters (m<sup>2</sup>)

So, the SI unit of pressure is:

$$\text{SI Unit of Pressure} = \frac{\text{N}}{\text{m}^2} = \text{Pascal (Pa)}$$

### Definition of Pascal:

**1 Pascal (Pa)** is the pressure exerted when a force of **1 newton** is applied normally over an area of **1 square meter**.

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

☀️ Q8. Explain with examples how pressure depends on the area of contact.

**Concept:**

From the formula:


$$P = F/A$$

We can see that pressure is inversely proportional to the area – when force is constant, decreasing the contact area increases the pressure, and increasing the contact area decreases the pressure.



Examples:

### 1. Chopper Blade:

- The edge of the chopper is made very sharp, which means the contact area is very small.
  - When force is applied on the handle, pressure becomes very high at the edge, allowing it to cut easily.
- 

### 2. Thumb Pin:

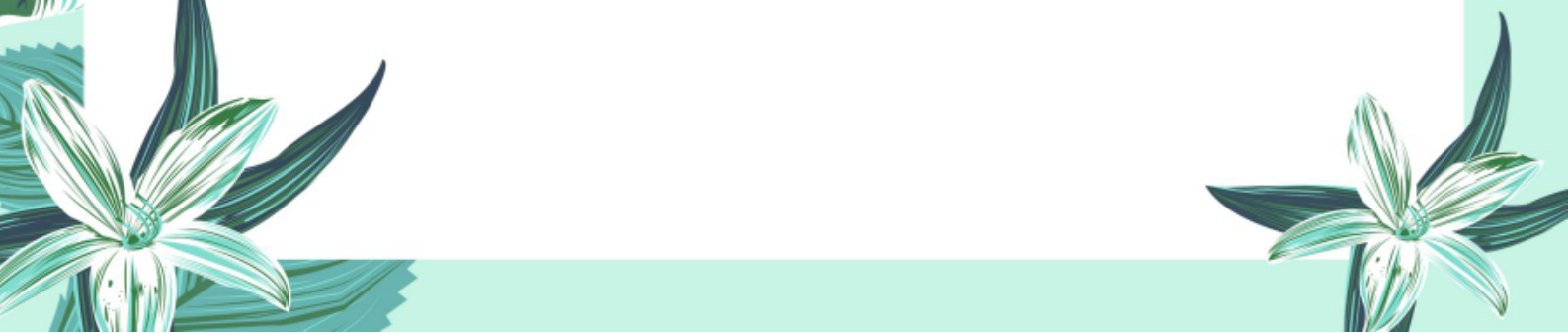
- The tip of the pin is sharp, so area is tiny.
- Even a small force produces large pressure, making it easy to pierce wood or paper.

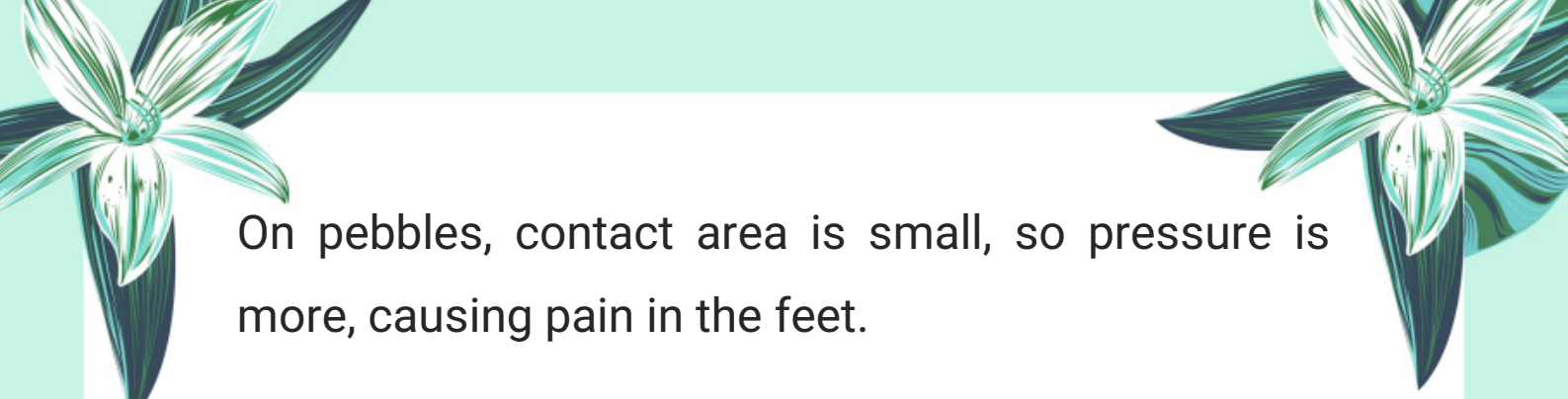
### 3. Knife Edge vs. Blunt Surface:

A sharp knife cuts better than a blunt one because the sharp edge concentrates force over a small area, increasing pressure.

### 4. Walking on Pebbles:

When walking on flat ground, the area of foot contact is large, so pressure is less.





On pebbles, contact area is small, so pressure is more, causing pain in the feet.

☀️ Q9. Discuss the importance of pressure in daily life with four examples.



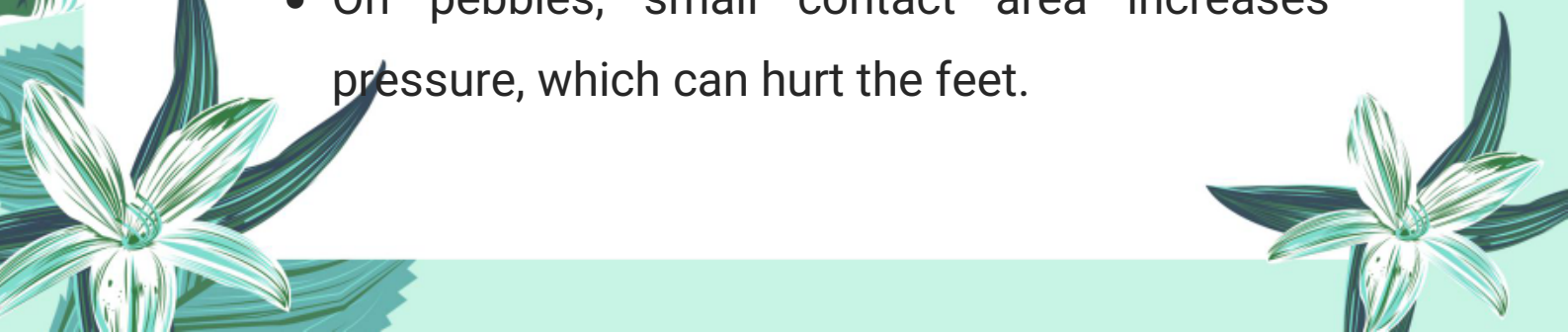
### 1. Chopper Blade:

- The cutting edge is thin and sharp.
- This small area increases pressure, making it easy to cut vegetables or meat.

### 2. Thumb Pin:

- The sharp end has a very small area.
- Even small force results in high pressure, helping it pierce hard surfaces like wood or walls.

### 3. Walking on Ground vs. Pebbles:

- On flat ground, body weight is spread over a large area, so pressure is less and walking is comfortable.
  - On pebbles, small contact area increases pressure, which can hurt the feet.
- 

#### 4. Elephant's Feet:

- Despite being heavy animals, elephants have large, wide feet.
- This large contact area reduces the pressure on the ground and prevents their bones from getting damaged.

#### Other Relevant Examples:

- **Syringes:** The needle has a very sharp tip, which increases pressure and allows it to easily pierce the skin.
- **Snowshoes:** They increase the surface area of the foot, helping a person walk on snow without sinking, because pressure is reduced.

☀️ **Q10. Define pressure. Derive its formula and explain its SI unit.**

#### Definition:

Pressure is defined as the force exerted normally (perpendicularly) on a unit area of a



surface.

It tells us how much force is acting per unit area and is used to describe how concentrated or spread out a force is over a surface.



### Mathematical Formula:

If a force  $F$  acts normally on a surface of area  $A$ , then the pressure  $P$  is given by:

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

---

This shows that:

- Pressure increases if force increases.
- Pressure decreases if area increases.

SI Unit of Pressure:

- Force (F) is measured in newtons (N).
- 

- Area (A) is measured in square meters ( $\text{m}^2$ ).

So the unit of pressure is:

$$\text{SI Unit of Pressure} = \frac{\text{N}}{\text{m}^2} = \text{Pascal (Pa)}$$

### Definition of Pascal:

**1 Pascal (Pa)** is the pressure exerted when a force of **1 newton** is applied normally over an area of **1 square meter**.

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

## C Constructed Response

6.1. A spring having spring constant  $k$  hangs vertically from a fixed point. A load of weight  $L$ , when hung from the spring, causes an extension  $x$ , the elastic limit of the spring is not exceeded.

Some identical springs, each with spring constant

The page is decorated with various illustrations: a large white flower with green leaves in the top left and bottom left corners, a white butterfly with black markings on the left side, and a large green leaf on the right side. The background is a light green color.

$k$ , are arranged as shown below:

For each arrangement, complete the table by determining:

- (i) the total extension in terms of  $x$ .
- (ii) the spring constant in terms of  $k$ .

Answer:

This problem explores how identical springs behave when arranged in **series** or **parallel**, and how their effective spring constant and extension change.

### Concepts to Understand

1. Hooke's Law states that force  $F$  applied to a spring is proportional to its extension  $x$  :


$$F = kx$$

where  $k$  is the spring constant of the



spring.

## 2. Series Arrangement:



When two springs are connected end-to-end, the total extension is **greater because** the force is distributed across both springs.

- The effective spring constant  $k_{\text{eff}}$  is given by:

$$\frac{1}{k_{\text{eff}}} = \frac{1}{k} + \frac{1}{k}$$

which simplifies to:

$$k_{\text{eff}} = \frac{k}{2}$$

- Since the force is the same in both springs, the total extension is:

$$x_{\text{total}} = 2x$$

## 3. Parallel Arrangement:

When two springs are connected side-by-side,



the total extension is smaller because each spring shares the load.

- The effective spring constant is:

$$k_{\text{eff}} = k + k = 2k$$

- Since the force is split between the two springs, the total extension is:

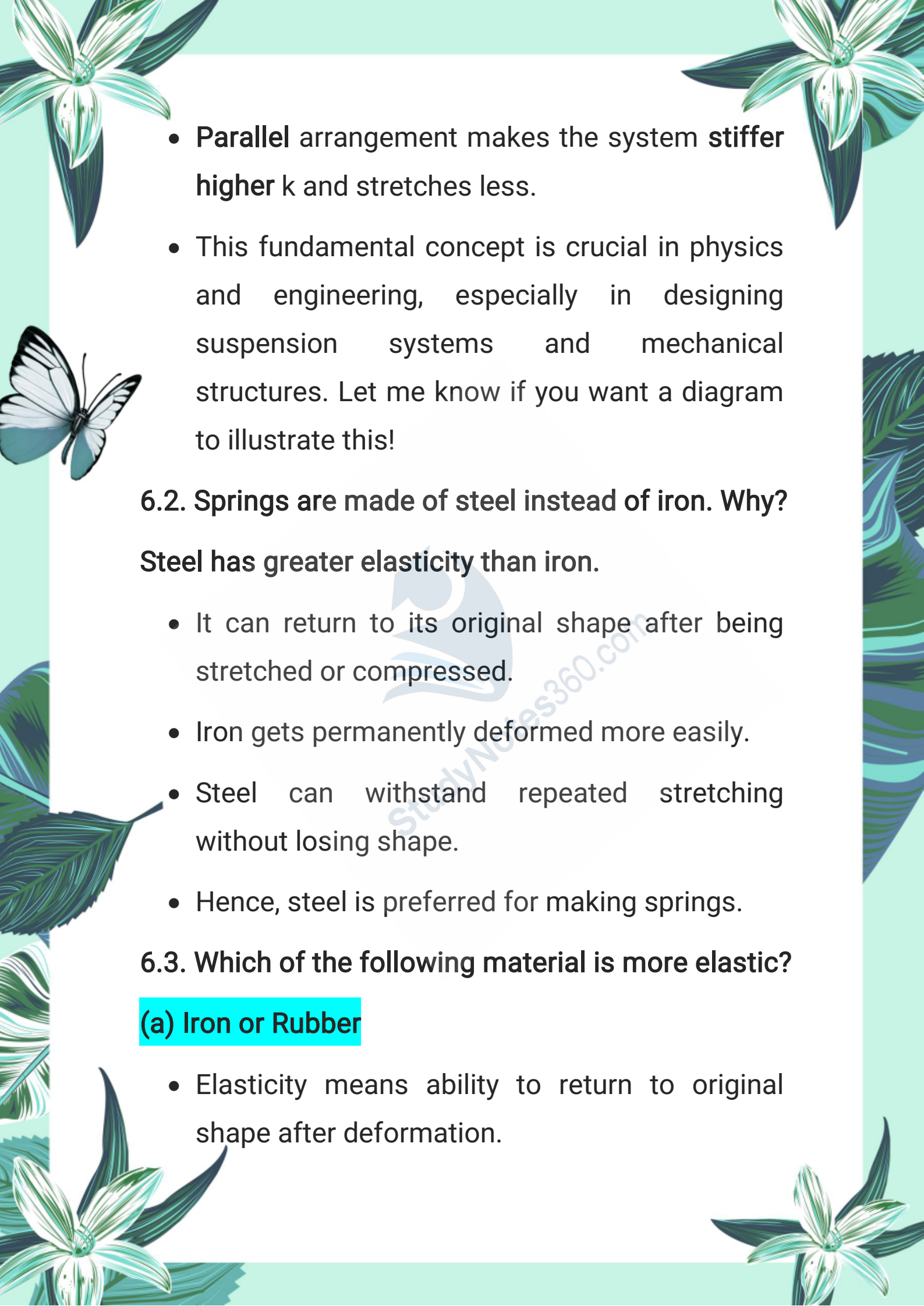
$$x_{\text{total}} = \frac{x}{2}$$

### Table of Results :

Arrangement	Total Extension	Effective Spring Constant
<b>Series</b> (Two springs in a row)		
<b>Parallel</b> (Two springs side by side)		

### Conclusion:

- Series arrangement makes the system softer lower  $k$  and stretches more.

- 
- The page is decorated with various illustrations: a white butterfly with black markings on its wings is on the left side. There are several green and white flowers with long, narrow leaves, some in the top corners and some at the bottom. The background is a light green color with a subtle pattern of leaves and flowers.
- **Parallel** arrangement makes the system **stiffer** **higher**  $k$  and stretches less.
  - This fundamental concept is crucial in physics and engineering, especially in designing suspension systems and mechanical structures. Let me know if you want a diagram to illustrate this!

## 6.2. Springs are made of steel instead of iron. Why?

**Steel has greater elasticity than iron.**

- It can return to its original shape after being stretched or compressed.
- Iron gets permanently deformed more easily.
- Steel can withstand repeated stretching without losing shape.
- Hence, steel is preferred for making springs.

## 6.3. Which of the following material is more elastic?

### (a) Iron or Rubber

- Elasticity means ability to return to original shape after deformation.

- Iron is more elastic because it regains its shape more perfectly.
- Rubber stretches more but does not return completely to its original shape.

### (b) Air or Water

- Elasticity in fluids is related to compressibility.
- Water is more elastic because it is less compressible.
- Air compresses easily, hence less elastic than water.

6.4. How does water pressure 1m below surface of pool compare to lake?

Water pressure depends on:

Depth (h)

Density of water ( $\rho$ )

Acceleration due to gravity (g)

At same depth (1 metre), pressure is:

$$P = \rho gh$$

Total size or volume of water does not affect



pressure at a point.

6.5. What happens to pressure in all parts of confined liquid if increased in one part? Daily life example?



**Based on Pascal's Law:**

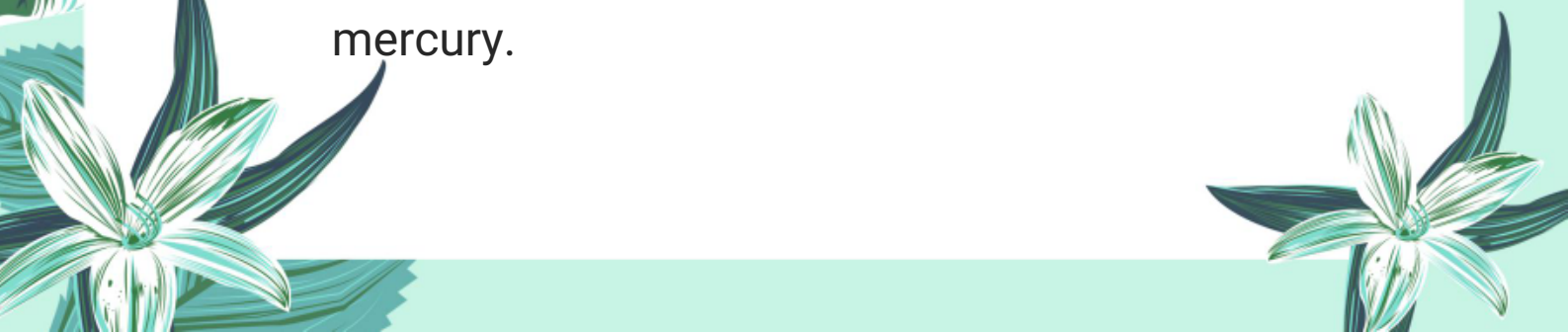
- Pressure applied at one point is transmitted equally in all directions.
- Every part of the liquid feels same pressure increase.

Daily Life Example:

**Hydraulic brakes in cars:**

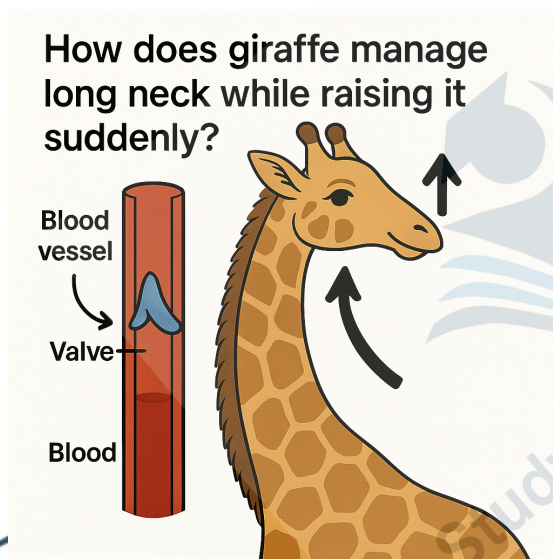
- Pressure applied on brake pedal is transmitted through brake fluid.
- Equal pressure activates brake pads at all wheels.

6.6. If air remains trapped in vacuum space of barometer, how is mercury level affected?

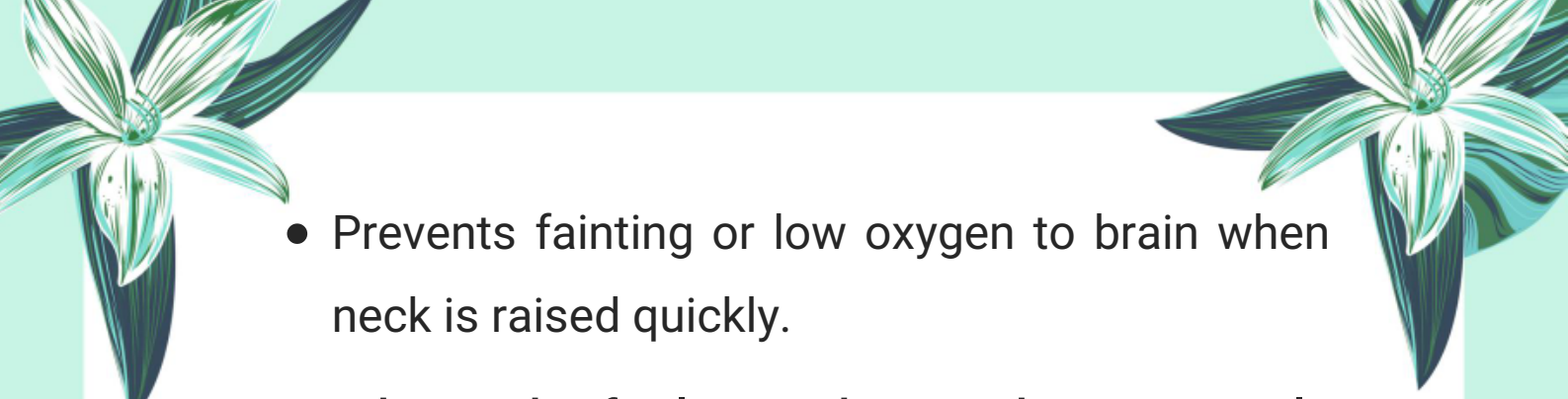
- Trapped air will exert extra pressure on mercury.
- 

- This reduces the net effect of atmospheric pressure.
- As a result, height of mercury column decreases.
- Inaccurate atmospheric pressure is recorded.

### 6.7. How does giraffe manage long neck while raising it suddenly?



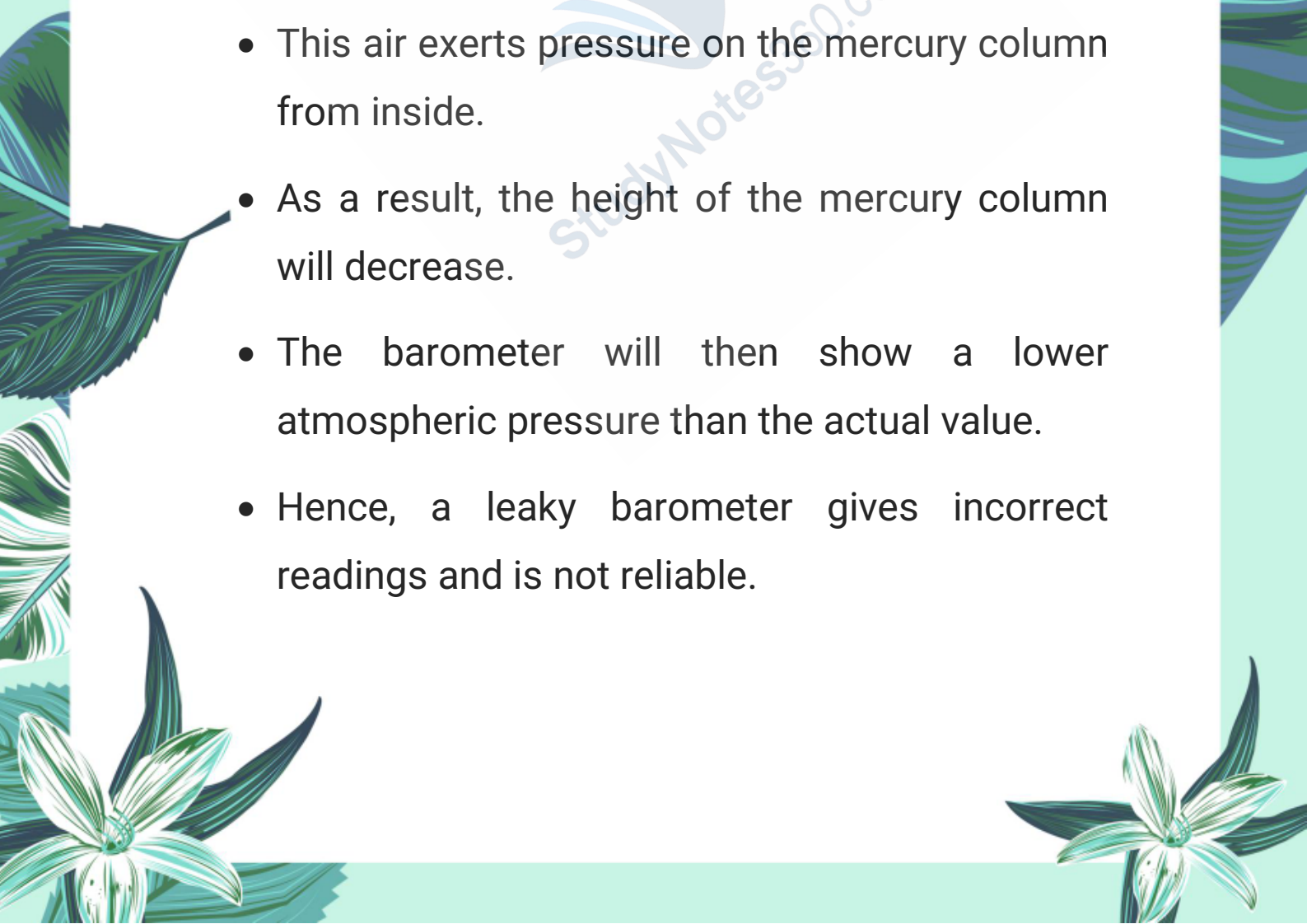
- Giraffe has valves in neck veins to prevent blood backflow.
- It also has a strong heart to pump blood to the brain.
- These adaptations maintain stable blood pressure.

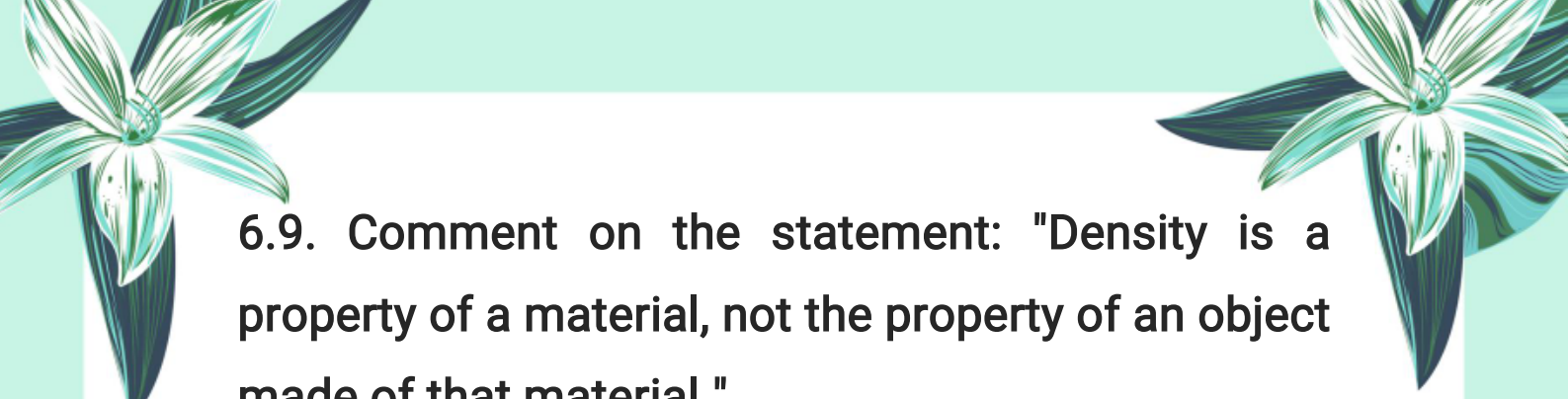
- 
- Prevents fainting or low oxygen to brain when neck is raised quickly.

6.8. The end of glass tube used in a simple barometer is not properly sealed, some leak is present. What will be its effect?




Answer:

- In a simple mercury barometer, the top of the tube must be a vacuum (no air).
  - If there is a leak, air will enter the tube and mix with the vacuum.
  - This air exerts pressure on the mercury column from inside.
  - As a result, the height of the mercury column will decrease.
  - The barometer will then show a lower atmospheric pressure than the actual value.
  - Hence, a leaky barometer gives incorrect readings and is not reliable.
- 



**6.9. Comment on the statement: "Density is a property of a material, not the property of an object made of that material."**

**Answer:**



Density = Mass / Volume  $\Rightarrow$  It tells how tightly particles are packed.

Density depends on the material's composition, not the shape or size of the object.

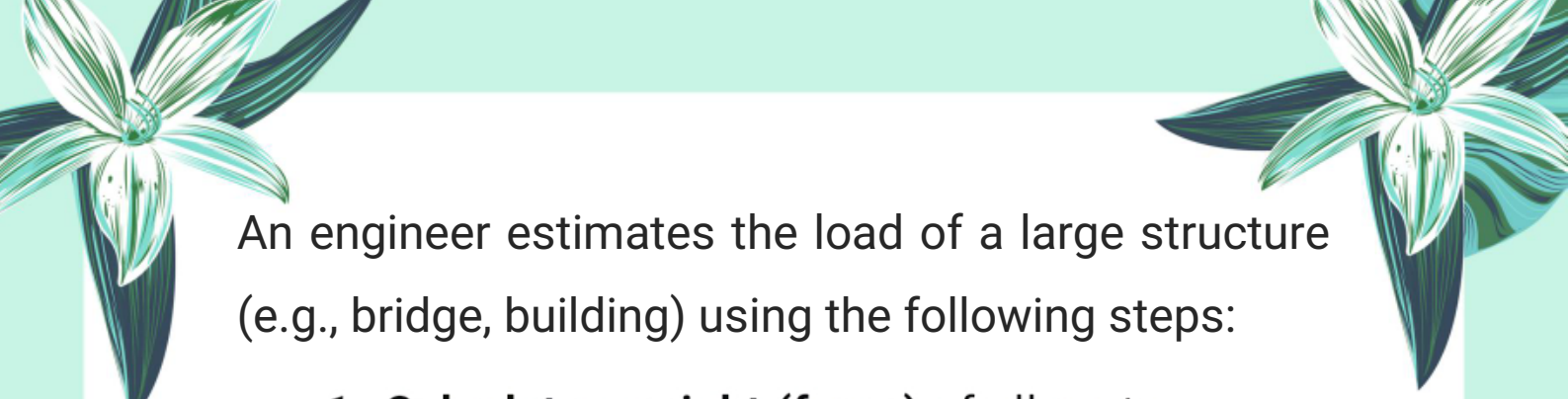
**For example:**

- A small piece of iron and a big block of iron have same density, because both are made of iron.
- An iron block and a rubber ball of same size have different densities, because they are made of different materials.
- Therefore, density is a characteristic property of a substance, not of the object.

**6.10. How is the load of a large structure estimated by an engineer?**


**Answer:**





An engineer estimates the load of a large structure (e.g., bridge, building) using the following steps:

1. **Calculates weight (force)** of all parts using:

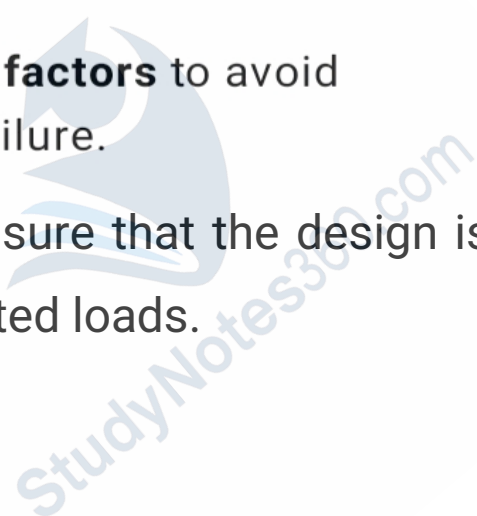

$$\text{Weight} = \text{Mass} \times g$$

3. **Calculates pressure** using:

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

5. Uses **safety factors** to avoid structural failure.

✓ This helps to ensure that the design is safe and stable under expected loads.



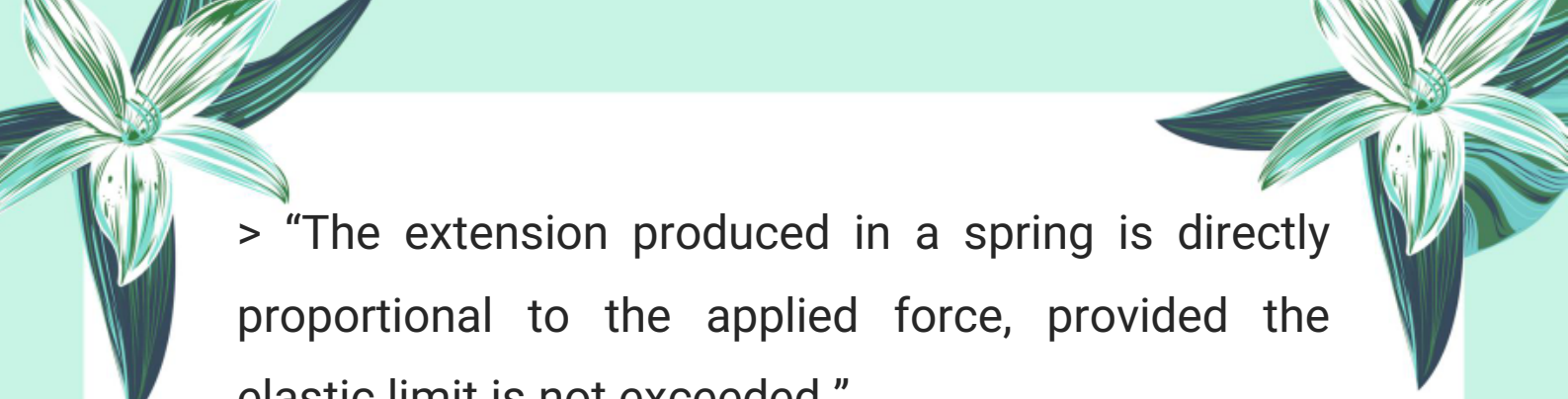
## **D Comprehensive Questions**

6.1. What is Hooke's Law? Give three applications of this law.

### **Hooke's Law:**


Hooke's Law states that:





> “The extension produced in a spring is directly proportional to the applied force, provided the elastic limit is not exceeded.”

**Mathematically:**


$$F = kx$$

- F = Force applied
- k = Extension
- x = Spring constant (stiffness of spring)

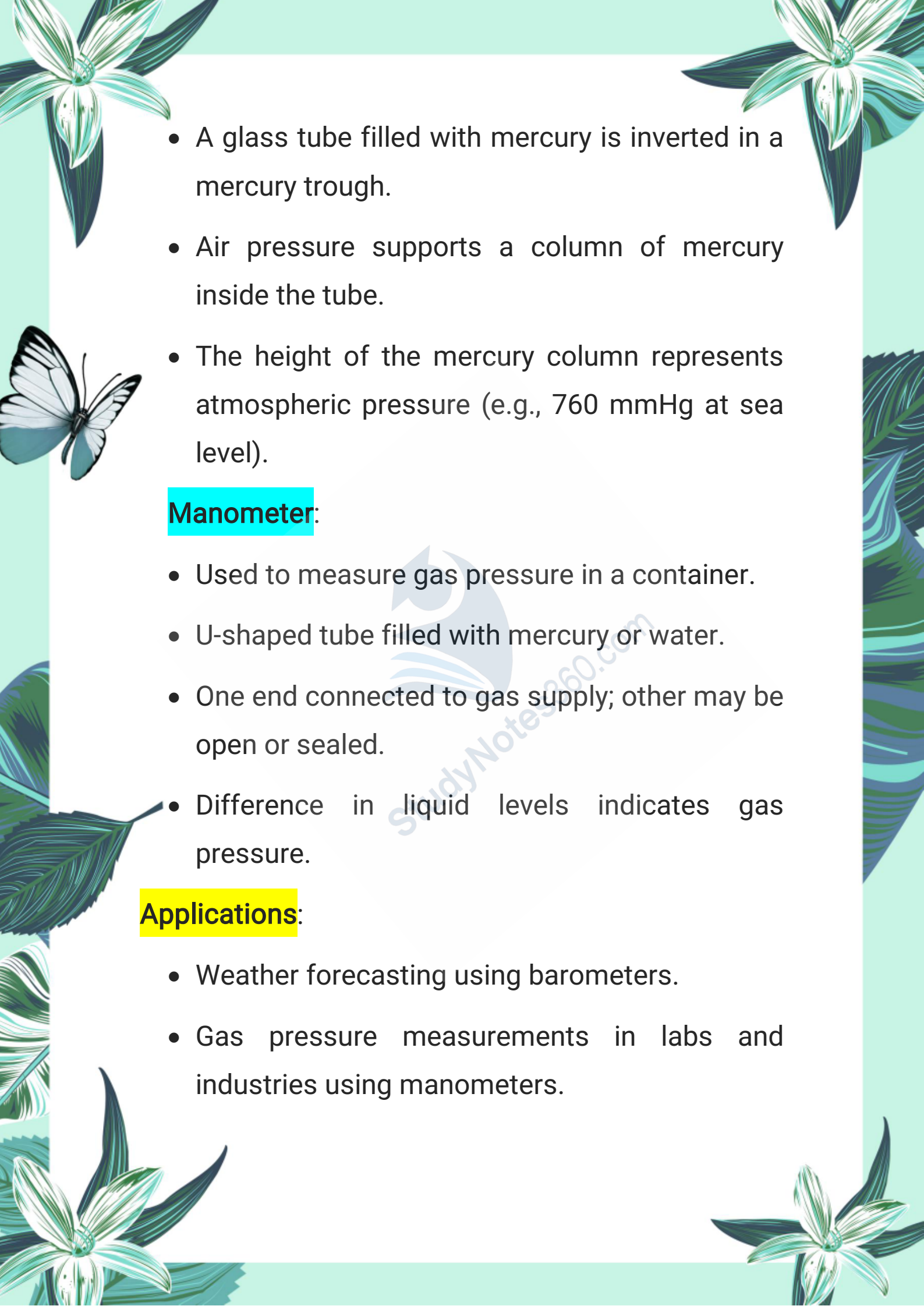
### **Three Applications of Hooke's Law:**

1. Spring balance – Used to measure weight based on spring extension.
2. Mechanical watches – Spiral springs use Hooke's Law for timekeeping.
3. Vehicle suspension system – Springs absorb shocks using elastic behavior.

**6.2. Describe the working and applications of a simple mercury barometer and a manometer.**

### **Mercury Barometer:**

- Used to measure atmospheric pressure.
- 

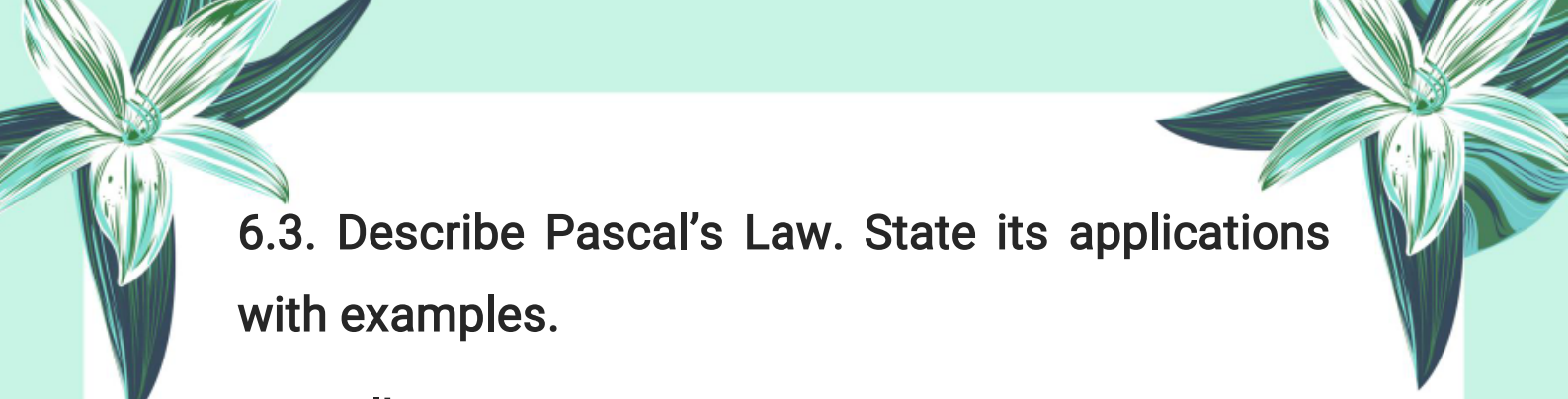
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- A glass tube filled with mercury is inverted in a mercury trough.
  - Air pressure supports a column of mercury inside the tube.
  - The height of the mercury column represents atmospheric pressure (e.g., 760 mmHg at sea level).

### **Manometer:**

- Used to measure gas pressure in a container.
- U-shaped tube filled with mercury or water.
- One end connected to gas supply; other may be open or sealed.
- Difference in liquid levels indicates gas pressure.

### **Applications:**


- Weather forecasting using barometers.
- Gas pressure measurements in labs and industries using manometers.



6.3. Describe Pascal's Law. State its applications with examples.

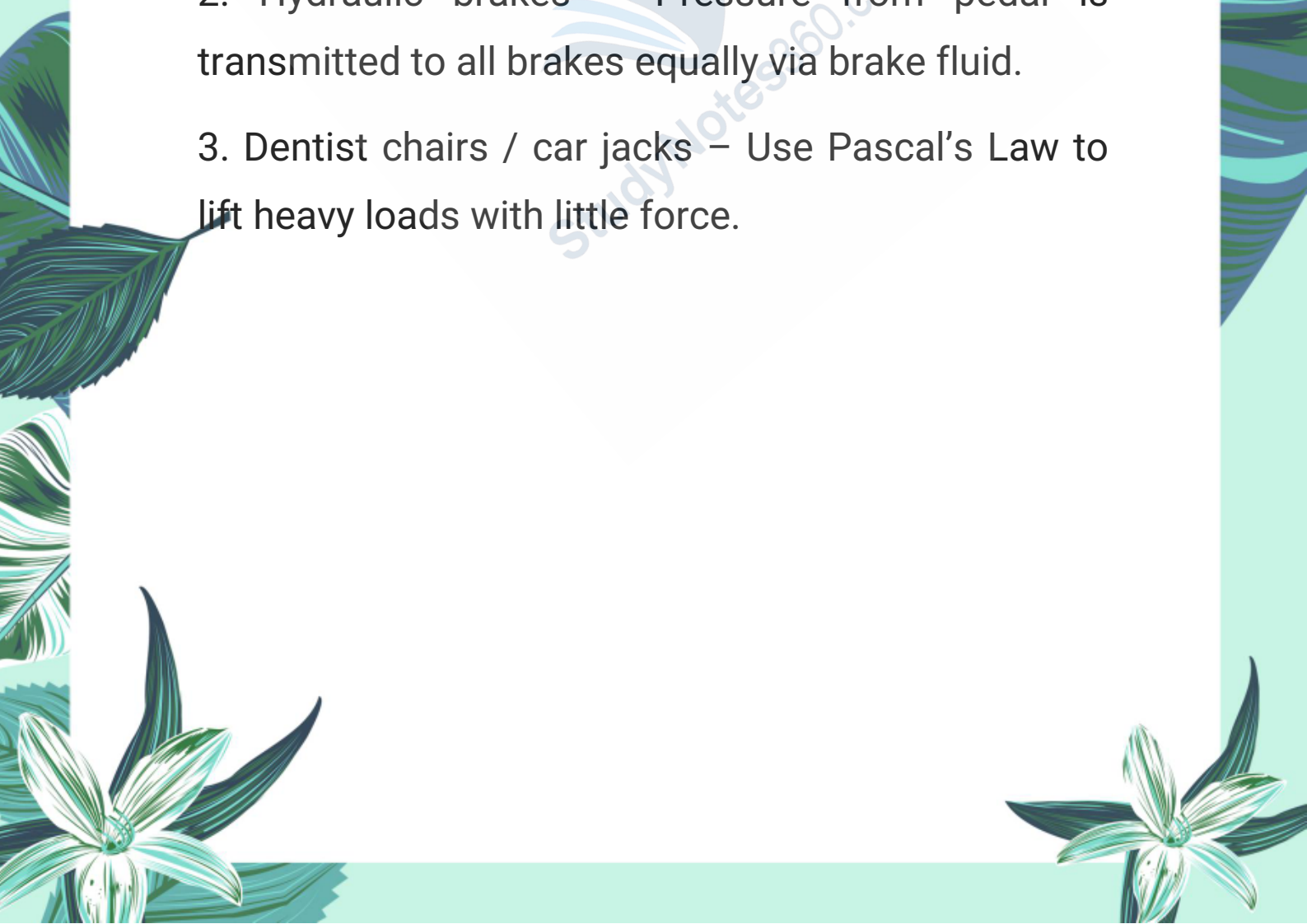
**Pascal's Law:**

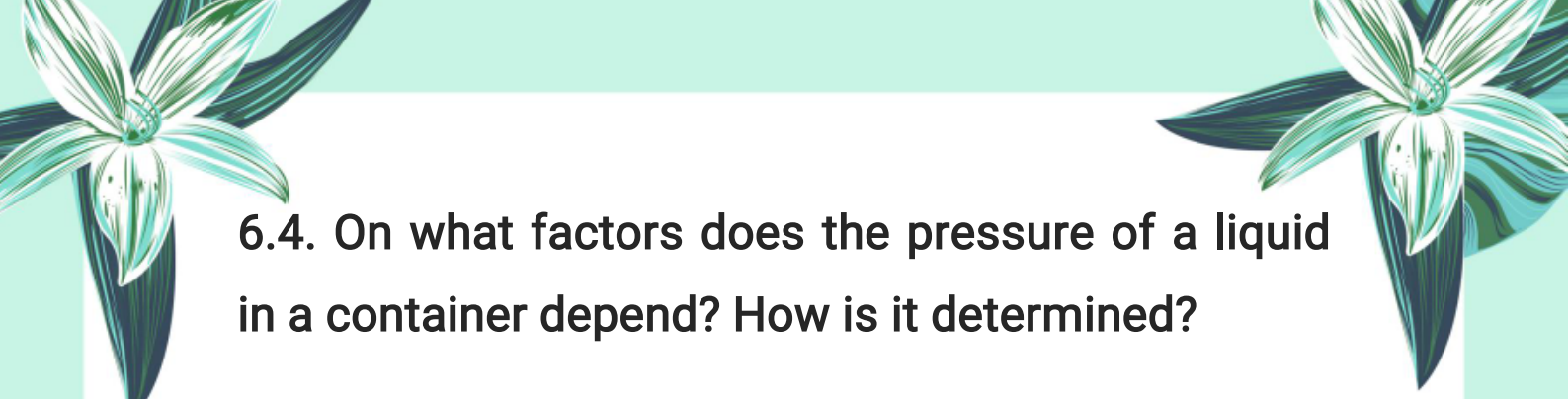
States that:



> "When pressure is applied to a confined liquid, it is transmitted equally in all directions."


**Applications:**

1. Hydraulic press – Small force applied on small piston creates a large force on large piston.
  2. Hydraulic brakes – Pressure from pedal is transmitted to all brakes equally via brake fluid.
  3. Dentist chairs / car jacks – Use Pascal's Law to lift heavy loads with little force.
- 




6.4. On what factors does the pressure of a liquid in a container depend? How is it determined?

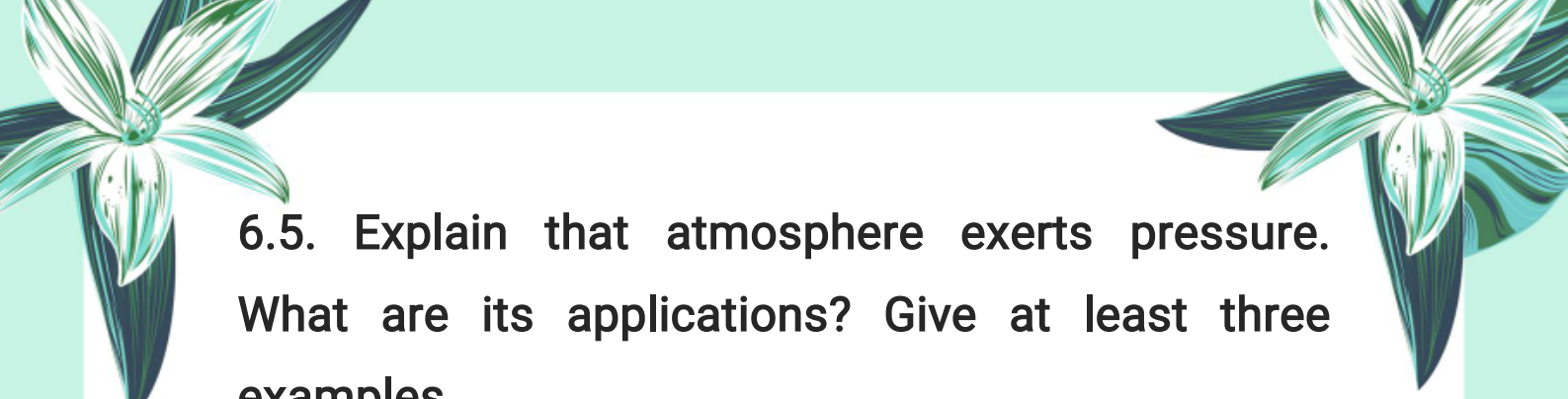
### Factors affecting liquid pressure:

- 
1. **Depth (h)** – Pressure increases with depth.
  2. **Density ( $\rho$ )** of the liquid – Denser liquids exert more pressure.
  3. **Gravitational acceleration (g)** – On Earth,  $g \approx 9.8, m/s^2$

Formula for Pressure:


$$P = \rho gh$$

- $P$  = Pressure
  - $\rho$  = Density
  - $g$  = Acceleration due to gravity
  - $h$  = Depth
- 


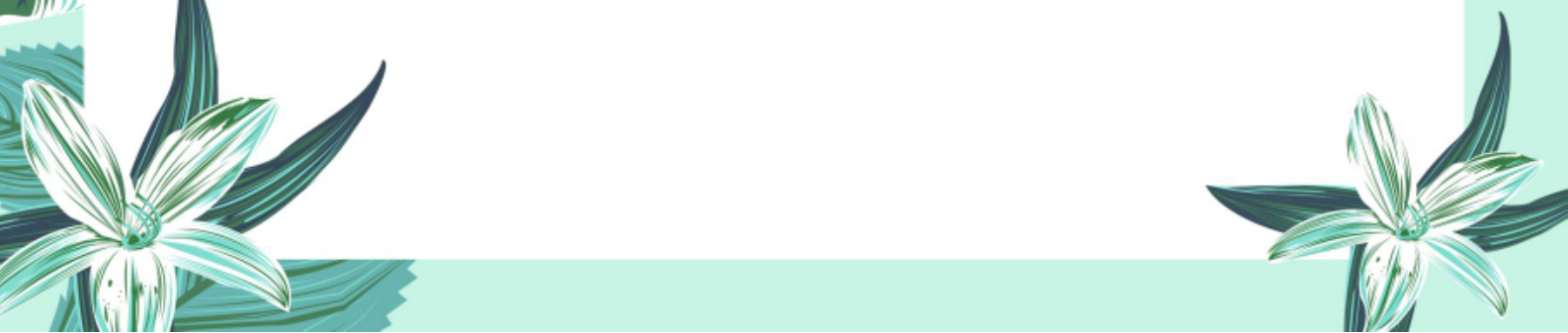


6.5. Explain that atmosphere exerts pressure. What are its applications? Give at least three examples.

### Atmospheric Pressure:

- 
- The weight of the air column above us exerts pressure on everything on Earth.
  - Demonstrated by barometer (e.g., mercury barometer showing 760 mmHg at sea level).

### Applications / Examples:

- 
1. **Syringe** – Pulling the plunger reduces internal pressure; atmospheric pressure pushes liquid in.
  2. **Vacuum pump** – Removes air by creating pressure difference.
  3. **Drinking with straw** – Sucking reduces pressure inside the straw; atmospheric pressure pushes the drink up.
- 



## **Note:**

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

**Author: Muhammad Asghar**

**Purpose:** To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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