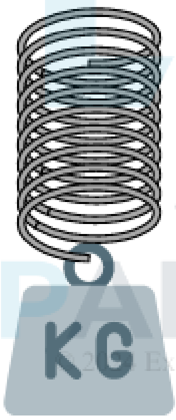
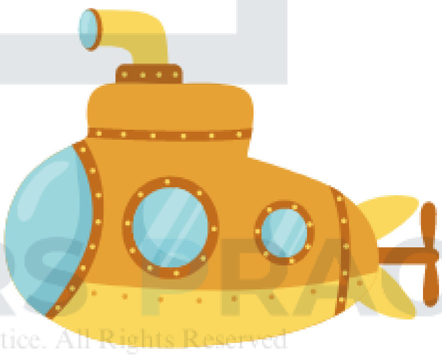
Chapter 5

Forces and matter



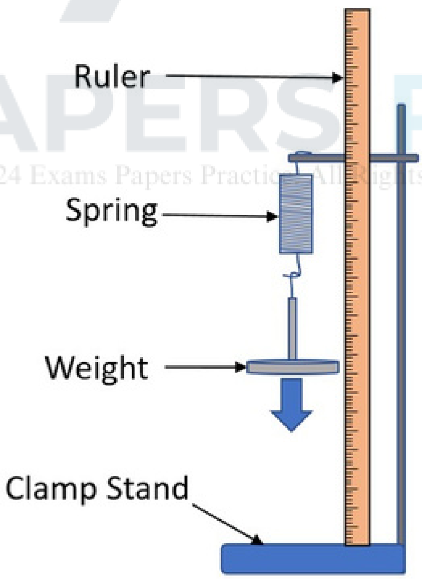


5.1 Forces acting on solids

1. Forces can change the size and shape of an object.
2. The list contains the various methods we can apply forces on an object:
   a. Stretch
   b. Squash
   c. Bend
   d. Twist
3. Certain materials, like foam rubber, regain their original shape after external forces are removed, whereas others, such as metals like gold, remain permanently deformed under the influence of forces.

5.2 Stretching springs

1. Springs are engineered to elongate significantly with minimal applied force, facilitating precise measurement of their length change.
2. The diagram below illustrates the process of conducting an experiment to study spring elongation.



3. Key terms
   a. Load – the force (usually weight) stretches an object (of a spring)
   b. Extension – the increased length of an object (for example, a spring) when a load (for example, weight) is attached to it

Worked Example 1 - Simulating the experiment:

The table provided below demonstrates how to utilize a three-column format for recording the outcomes of a spring stretching experiment.

Load / N	Length / cm	Extension / cm
0.0	10.0	
1.0	13.0	
2.0	16.0	
3.0	19.0	
4.0	25.0	
5.0	31.0	
6.0	37.0	

1. Populate the extension column.

2. When the load is increasing from 0N to 4N, how does the extension of the spring change?

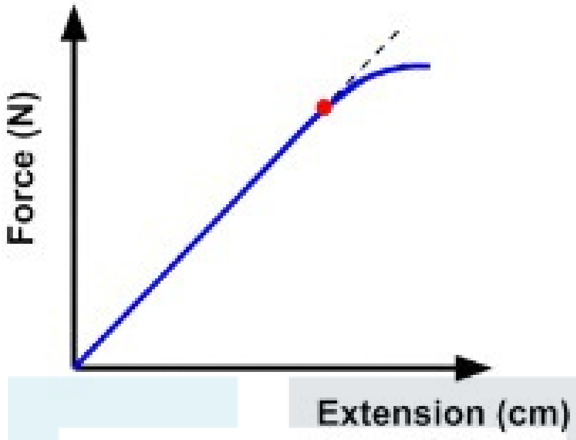
When the load is increased by 1N, the extension of the spring increased by 3 cm. Doubling the load doubles the extension.

3. Do you observe the same pattern when the load is increased to 4N. Why is that so?

No, the spring now extend even more when the load exceeds 4N. This happens when the load is so great that the spring has become permanently damaged. It will not return to its original shape.

4. Draw a load-extension graph to see how extension depends on the load.

5.3 The limit of proportionality and the spring constant

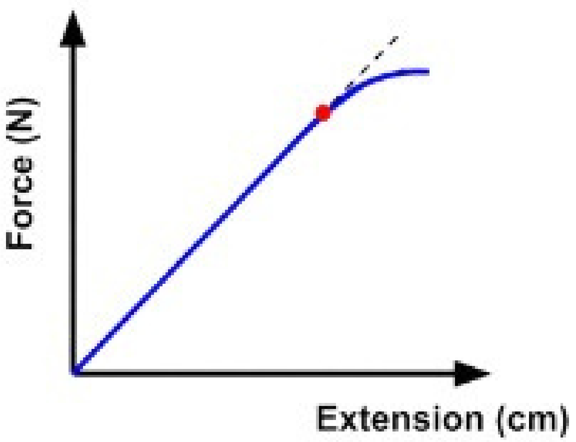


Analysis from the graph above:

1. Initially, the graph forms a straight line rising from the origin, indicating that the extension is directly **proportional** to the load.
2. At a specific point, the graph begins to curve and the slope of the line decreases. This point is known as the **limit of proportionality**.

Note on limit of proportionality:
Up to this limit, the extension on a spring is proportional to load.

3. Beyond the limit of proportionality, the extension is no longer directly proportional to the load, and the material experiences permanent deformation.



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5.3.1 Hooke's Law

1. Hooke's Law states that the force exerted by a spring is directly proportional to the extension or compression of the spring from its equilibrium position.
2. Equation for Hooke's Law:

$$F = kx$$

F = Force, k = spring constant ,x = extension

3. Spring constant – The measure of the stiffness of a spring.

The higher the spring constant of a spring, the harder it is to extend the spring.

Formula for spring constant:

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

Worked Example 2:

A cable has a spring constant, k, of 15 N/m. What weight is required to cause a stretch of 1.8 m?

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Worked Example 3:

A rubber band needs a force of 10 N to stretch it by 8.0 cm. What force will extend it by 15 cm?

5.4 Pressure

1. We encounter pressure in the following situations:
   a. Submersion underwater results in pressure due to the **weight of water** above pressing down on any submerged object. Deeper depths lead to increased water pressure.
   b. On Earth's surface, we experience **atmospheric pressure** (approximately 101,325 Pa).
2. Water exerts significantly higher pressure compared to air because water is much **denser** than air.
3. Pressure arises from the impact of molecules **colliding** with every surface they encounter.

5.4.1 Calculating Pressure

1. Pressure is the force per unit area applied perpendicular to the surface of an object or substance.
2. Equation of pressure:

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

3. Units:
   a. N/m2
   b. (SI unit for pressure) Pascal = 1 N/m2

Worked Example 4:

Which exerts greater pressure: a force of 300 N acting on 0.5 m^2, or the same force acting on 1.0 m^2 ?

Worked Example 5:

What pressure is exerted by an elephant weigh 60000 N acting on 1.2 m^2?

5.4.2 Pressure under water/liquid

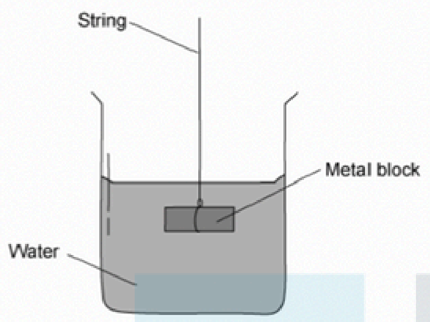
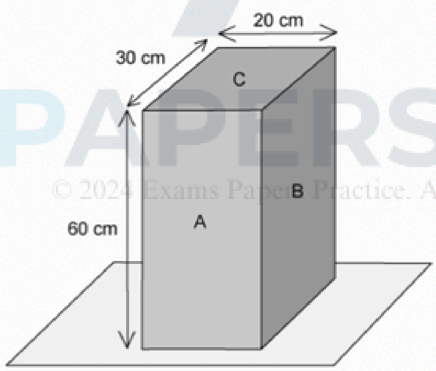
1. We have seen that the deeper one dives into water, the greater the pressure.
2. Pressure under liquid depends on:
   a. **Depth** (we use the letter h, for height)
   b. **Density** (we use the letter p)
3. Equation:

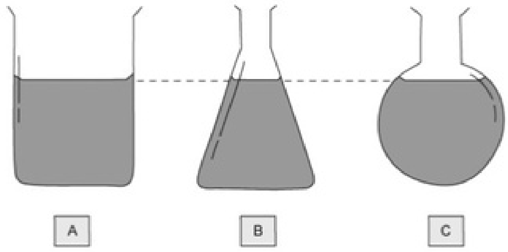
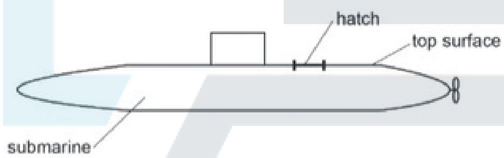
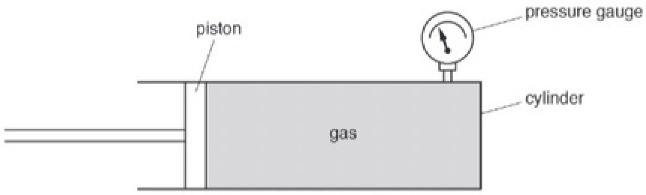
$$p = \varrho g h$$

Worked Example 6:

Determine the pressure at the base of a lake that is 3.0 meters in depth. How does this pressure compare with atmospheric pressure, which is 101, 325 Pa? (Density of water is 1000 kg/m3).

Past Year Questions

No	Questions
1	A small metal block is suspended under the surface of a beaker of water by a string. The metal block experiences a pressure exerted by the liquid.  What would increase the pressure exerted on the metal block? **A** increasing the surface area of the stone **B** using a liquid with a lower density **C** increasing the mass of the metal block **D** lowering the metal block deeper into the liquid
2	A wooden block rests on a table.  On which surface should the block be laid to produce the largest pressure on the table? **A** A. **B** B **C** C **D** Any side, they will all produce the same pressure

3	Three beakers of water are placed on a table. The depth of water in each container is the same.  In which container does the water exert the greatest pressure on the base of the container? **A** A **B** B **C** C **D** None, the pressure is the same in all three.
4	**1** The diagram shows a submarine. The submarine is fully submerged in the sea.  The density of sea water is 1020 kg/m^3. The atmospheric pressure is 100 kPa and the total pressure on the top surface of the submarine is 500 kPa. Calculate the depth of the top surface of the submarine below the surface of the sea. depth = ... [3]
5	The diagram shows a gas contained in a cylinder enclosed by a piston.  Describe, in terms of momentum of the molecules, how a pressure is exerted on the walls of the cylinder. .... [3]

Answer	Marks
P = ρgh in any form (1) (h =) 400 × 10^3 / (1020 × 10) (1) (h =) 39 m (1)	3

Answer	Marks
they / molecules collide with walls (1) change of momentum causes force (to be exerted on walls) (1) pressure = force / area (so pressure is exerted on walls) (1)	3