

STRUCTURE QUESTIONS

1. Some students experimented to find out how a spring stretched when loads were added to it.

Table For load and extension

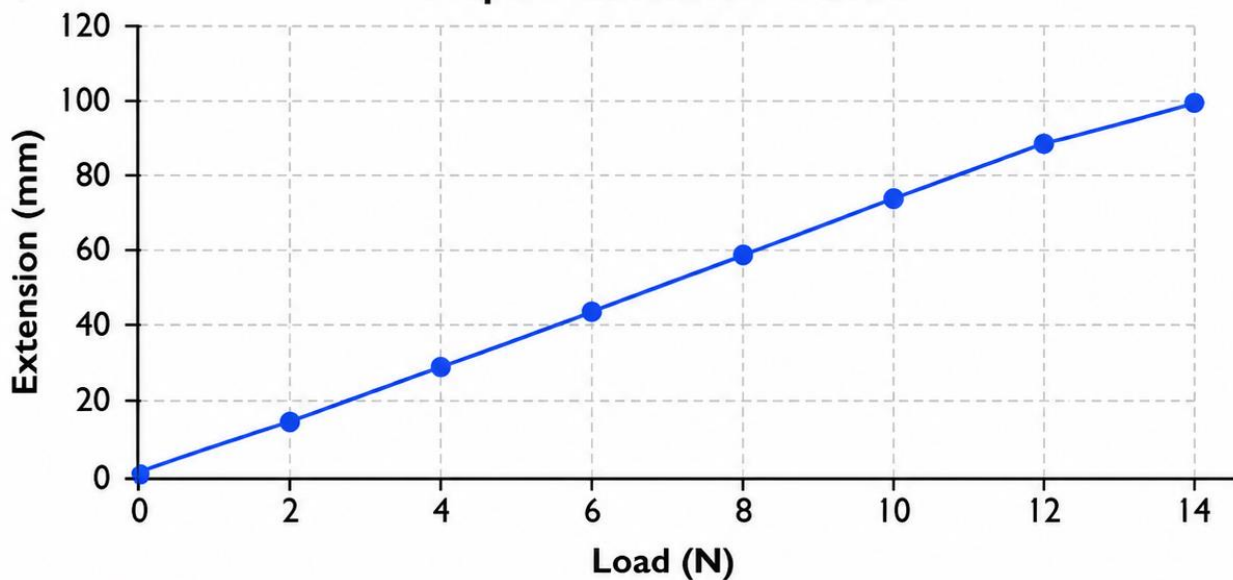
| | | | | | | | | |
|----------------|---|----|----|----|----|----|----|-----|
| Load (N) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
| Extension (mm) | 0 | 15 | 30 | 45 | 60 | 75 | 90 | 100 |

- Use these results to plot a graph. (Plot x = load, y = extension in spring).
- Use your graph to find
 - The extension when the load is 3 N;
 - The load which produces an extension of 40mm.

SOLUTION

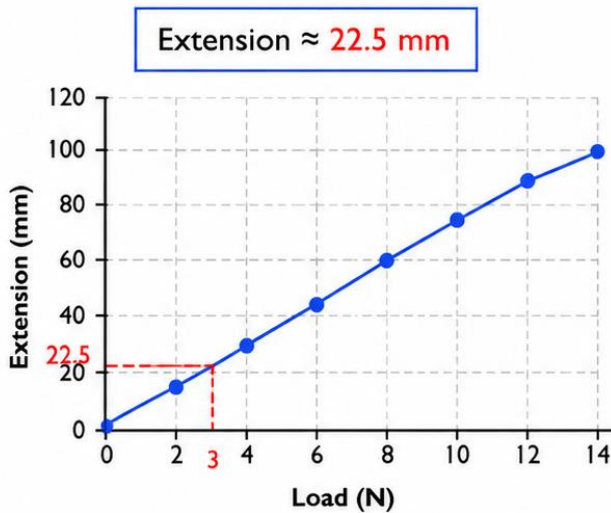
a)

Graph of Extension vs Load

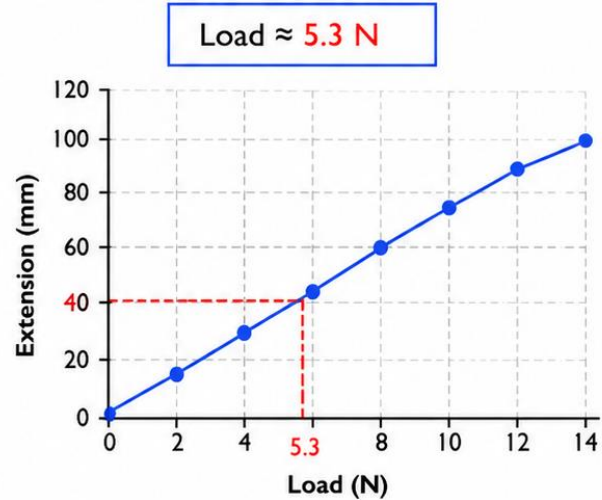


b) Using the graph:

i) The extension when the load is 3 N;



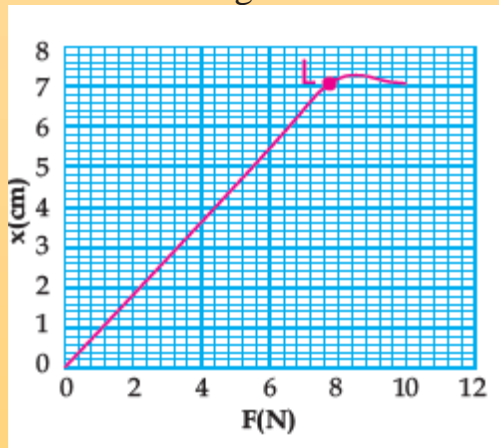
ii) The load which produces an extension of 40 mm.



The extension when the load is 3 N is 22.5 mm
The load which produces an extension of 40mm. = 5.3 N

2 The variation in extension x of the force F for a spring is shown in Fig . The point L on the graph is the elastic limit of the spring.

a) Describe the meaning of elastic limit.



b) Calculate the force in extending the spring to its elastic limit 'L'

SOLUTIONS

a)

Elastic Limit

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

In simpler terms:

If you stretch, compress, or bend a material **below this limit** , it will **return to its original shape** when the force is removed.

If you go **beyond this limit** , the material will be **permanently deformed** , even after removing the force.

b) Calculate the force in extending the spring to its elastic limit 'L'

Extension = 7 cm

Hooke's Law

3. State Hooke's law.

STATEMENT

Within the elastic limit, the displacement produced in the spring is directly proportional to the force applied.

4. Calculate the spring constant for a spring which extends by a distance of 3.5cm when a load of 14N is hung from its end.

SOLUTIONS

$$F = k x$$

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

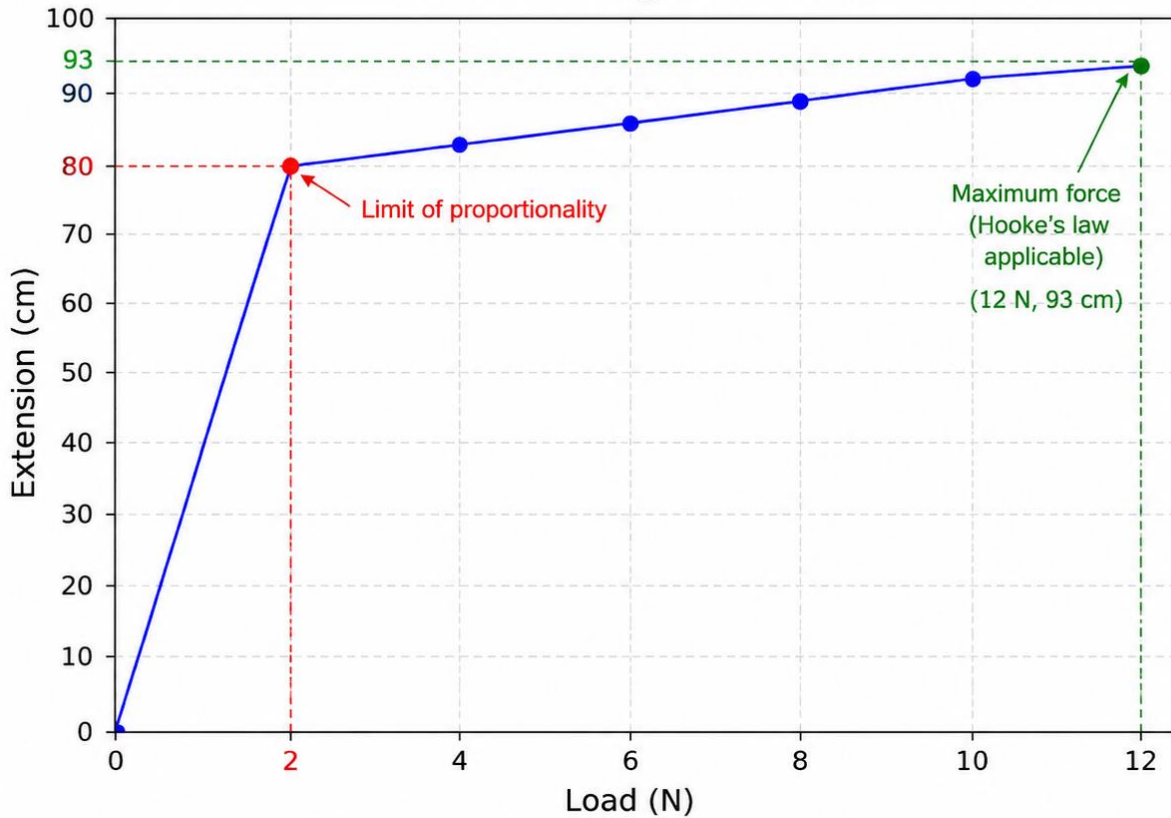
$$k = \frac{14}{3.5} = 4 \text{ N/m}$$

5. Table shows the results of an experiment to stretch a spring

| Load (N) | Extension (cm) |
|----------|----------------|
| 0.0 | 0.0 |
| 2.0 | 80.0 |
| 4.0 | 83.0 |
| 6.0 | 86.0 |
| 8.0 | 89.0 |
| 10.0 | 92.0 |
| 12.0 | 93.0 |

- Use the result to plot an extension against load graph.
- On the graph mark the limit of proportionality and state the value of the load at this point.
- Calculate the spring constant k .
- Show maximum force at which Hooke's law is applicable.

Extension against Load



b) Limit of proportionality

The load at the limit of proportionality is **2 N**.

c) Spring constant k

Within the proportional limit (0 to 2 N), Hooke's law applies. The gradient gives k .
 $k = F / x = 2 \text{ N} / 80 \text{ cm} = 2 / 0.80 \text{ m}$
 $k = 2.5 \text{ N m}^{-1}$

d) Maximum force at which Hooke's law is applicable

From the graph, the maximum force is **12 N** (extension = 93 cm).

PRESSURE

6. a) Define the term pressure.
 b) Write down the S.I unit of pressure.

ANS:

PRESSURE

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

FORMULA

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

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

UNIT OF PRESSURE:

The unit of pressure is Newton per metre square (N/m^2 or Nm^{-2})

$$1 \text{ Nm}^{-2} = 1 \text{ Pascal}$$

Pascal is also the unit of pressure. It is represented by "Pa"

7. Why does pressure increase as you dig deeper;
Explain in detail.

ANS:

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

FORMULA

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

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

1. Deeper means more weight above Imagine digging into soil. At a shallow depth, only a small amount of soil is above that point. But at a greater depth, there is a much larger thickness of soil above. The deeper point must support the weight of all the soil above it. So the force increases, and therefore the pressure increases.
2. In liquids, pressure increases with depth for a liquid, the pressure at a depth is given by:

$$P = \rho g h$$

This shows that pressure is directly proportional to depth. If you go twice as deep, the pressure due to the liquid roughly doubles.

8. A boy is pressing a thumbtack into a piece of wood with a force of 20 N. The surface area of head of thumbtack is 1cm^2 and the cross-section area of the tip of the thumbtack is 0.01cm^2 . Calculate

- a) The pressure exerted by boy's thumb on the head of thumbtack.
b) The pressure of the tip of the thumbtack on the wood.
c) What conclusion can be drawn from answers of part (a) and (b)?

ANS:

- a) Pressure exerted by the boy's thumb on the head of the thumbtack

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

$$P = \frac{20}{1}$$

$$P = 20\text{ N/cm}^2$$

- b) Pressure of the tip of the thumbtack on the wood

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

$$P = \frac{20}{0.01}$$

$$P = 2000\text{ N/cm}^2$$

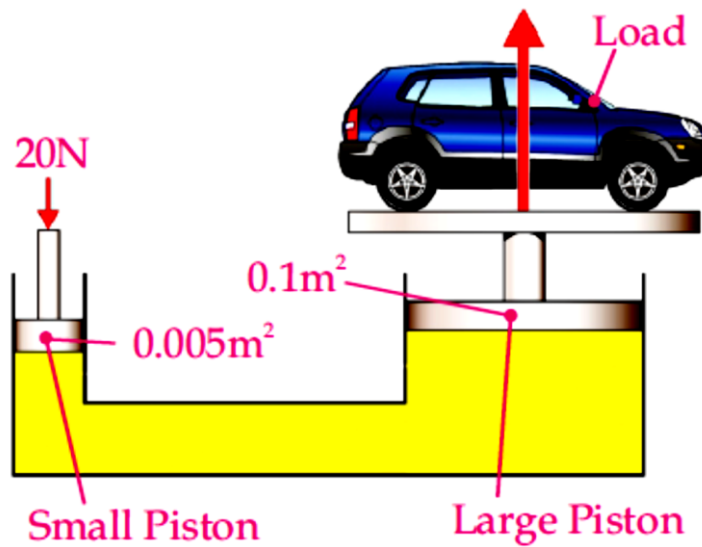
The pressure at the tip is much greater than the pressure at the head.

$$P = \frac{2000}{20} = 100$$

So the pressure at the tip is **100 times greater** than the pressure on the head.

9. The Fig 5.15 shows a basic hydraulic system that has small and large pistons of cross section area of 0.005 m^2 and 0.1 m^2 respectively. A force of 20N is applied to small piston. Calculate

- The pressure transmitted into hydraulic fluid.
- The force at large piston.
- Discuss the distance travelled by small and large pistons.



ANS:

DATA

$$A_1 = 0.005 \text{ m}^2$$

$$A_2 = 0.1 \text{ m}^2$$

$$F_1 = 20 \text{ N}$$

$$F_2 = ?$$

SOLUTIONS

a)

$$P_1 = \frac{F_1}{A_1}$$

$$P_1 = \frac{20}{0.005}$$

$$P_1 = 4000 \text{ Pa}$$

$$P_2 = P_1$$

$$\frac{F_2}{0.1} = 4000$$

$$F_2 = 4000 \times 0.1$$

$$F_2 = 400 \text{ N}$$

Distance travelled by small and large pistons

In a hydraulic system, the volume of fluid displaced by the small piston is equal to the volume of fluid moved at the large piston.

$$A_s d_s = A_L d_L$$

$$0.005 d_s = 0.1 d_L$$

$$\frac{0.005}{0.1} d_s = d_L$$

$$0.05 d_s = d_L$$

$$\frac{1}{20} d_s = d_L$$

This means the large piston moves only **one-twentieth** of the distance moved by the small piston.

Or

The small piston moves 20 times farther than the large piston.