Chapter = 05

Forces and Matter

Q1)State and explain Hooke's law.

HOOKE'S LAW

Hooke's law states that:

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

EXPLANATION

Mathematically if 'F' is the applied force and 'x' is the displacement (extension) in the spring then the equation for Hooke's law may be written as:

$$F \propto x$$

or

$$F = kx$$

where k is spring constant (stiffness of spring).

Q2)Write two properties of spring

Properties of spring

1. Spring are useful in making balances. Hooke wanted to make a very sensitive and accurate weight machine or balance.
2. He also realized that a spiral spring could be used to control a clock or wrist watch.

Q3)Define pressure, give its formula and S.I unit.

Pressure

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

Formula

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

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

Unit

S.I unit is N/m^2

Q4)Discus the factors affecting pressure.

Factors affecting pressure

Pressure P is proportional to the depth, the deeper one dives into water, greater will be the pressure. Twice the depth means twice the pressure.

Similarly, pressure also depends upon the density of the material. If a material is five times denser than water, the pressure will be five times greater. At a depth h in a fluid of density ρ, the pressure p can be written as:

Pressure = depth **x** density **x** acceleration due to gravity

$$p = d\rho g$$

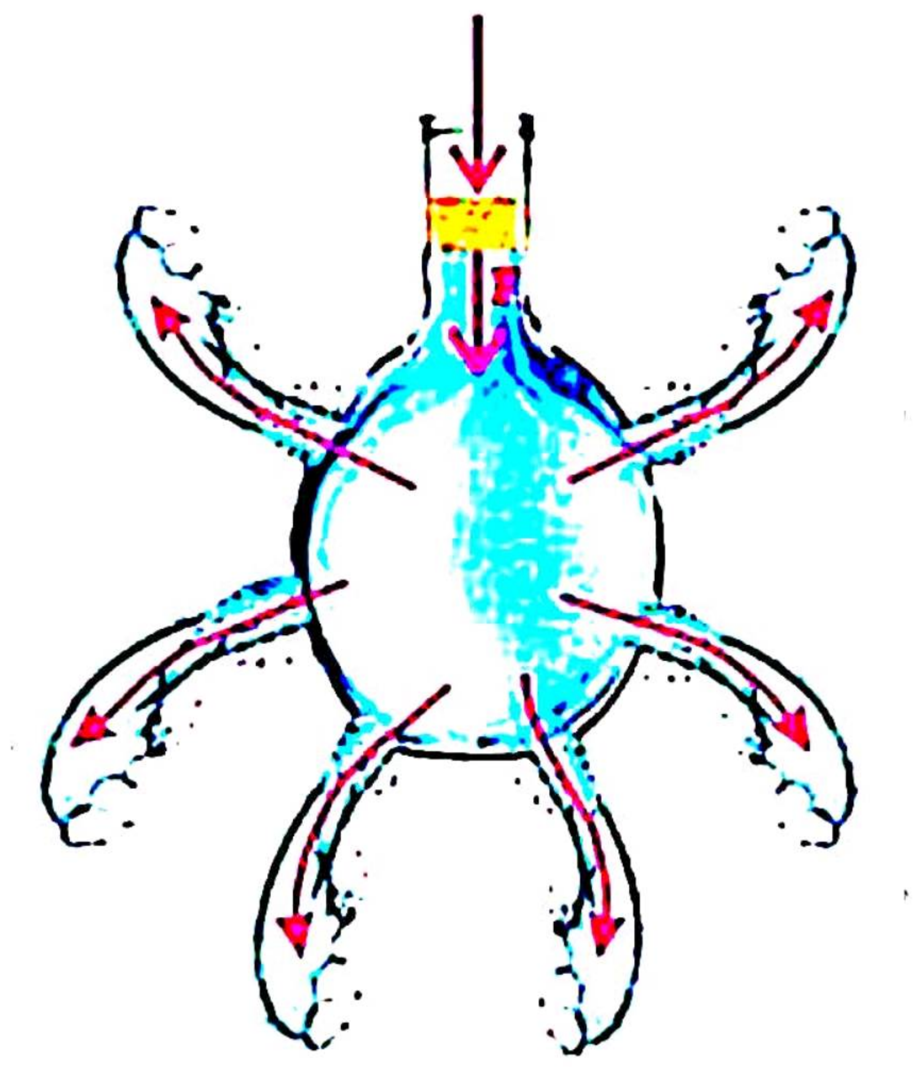
Q5)State Pascal's law. Explain with the help of an example

Pascal Law

The pressure applied externally at any point of a liquid enclosed in a container is transmitted equally to all parts of the liquid in container.

Example

It can be demonstrated with the help of a water filled glass vessel having holes around its surface. When you apply force through the piston the water rushes out of the holes 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. In general, this law holds good for fluids both for liquids as well as gases



Q6)What is hydraulic machine? Write down the names of four machines that you have seen working on the principle of pascal's law

Hydraulic machine

The machine in which force is transmitted by liquids under pressure is known as hydraulic machine. By the application of relatively small force they produce greater force.

Examples

Hydraulic brakes

Car lifts

hydraulic

Jacks

Q7)Describe the construction and working of hydraulic press.

Hydraulic press

A hydraulic press is made of two pistons connected by a liquid-filled pipe

A force of magnitude F_1 is applied to a small piston of surface area A_1. The pressure is transmitted through an incompressible liquid to a larger piston of surface area A_2. Because the pressure must be the same on both sides.

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

Therefore, the force F_2 is greater than the force F_1 by a factor A_2/A_1.

By designing a hydraulic press with appropriate areas A_1 and A_2, a large output force can be applied by means of a small input force.

Each side of this equation is the work done by the force. Thus, the work done by F_1 on the input piston equals to the work done by F_2 on the output piston. Thus, the principle of conservation of energy applies in the hydraulic press.

Q8)Define density. Describe density in brief. Give it formula and unit.

Density

The term density of a substance is defined as mass of substance (m) per unit volume (V). It is denoted by Greek letter ρ (rho)

Density tells us how tightly matter is packed together.

Formula

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

Unit

Its S.I unit is kg/m^3

Numerical # 1

An elastic spring is 20cm long. When it is stretched by hanging some load its length increases to 60cm. Calculate its extension?

Data

x_1 = 20cm

x_2 = 60cm

x = ?

$x = x_2 - x_1$

x = 60 – 20

x = 40cm

Practice of Numerical # 1

An elastic spring is 40cm long. When it is stretched by hanging some load its length increases to 80cm. Calculate its extension?

Numerical # 2

A spring has spring constant $k = 30\ Nm^{-1}$. What load is required to produce an extension of 4 m?

Data

$K = 30\ Nm^{-1}$

$x = 4m$

$F = ?$

Solution

$F = Kx$

$F = 30 \times 4$

$F = 120\ N$

Practice of Numerical # 2

A spring has spring constant $k = 50\ Nm^{-1}$. What load is required to produce an extension of 5 m?

Numerical # 3

How much force is needed to pull a spring to a distance of 30cm, the spring constant is $15\ Nm^{-1}$?

Data

$x = 30cm = 30 \div 100 = 0.3\ m$

$K = 15\ Nm^{-1}$

$F = ?$

Solution

$F = Kx$

$F = 15 \times 0.3$

$F = 1.5\ N$

Practice of Numerical # 3

How much force is needed to pull a spring to a distance of 40cm, the spring constant is 16 Nm^{-1}?

Numerical # 4

Calculate the pressure at a depth of 3m in a swimming pool? (density of water = 1000kgm^{-3})

Data

d = 3m

ρ = 1000 kgm^{-3}

g = 9.8 ms^{-2}

P = ?

Solution

P = ρgd

P = 1000 x 9.8 x 3

P = 29400 N/m^2

Practice of Numerical # 4

Calculate the pressure at a depth of 6m in a swimming pool? (density of water = 1000kgm^{-3})

Numerical # 5

A boy is digging a hole with spade of edge 0.1 cm^2. Calculate the pressure when he is exerting the force of 1000N onto the spade.

Data

A = 0.1 cm^2 = 0.1 ÷ 10000 = 0.00001 m^2

F = 1000 N

P = ?

Solution

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

P = 1000/0.00001

P = 100000000 N/m^2

Practice of Numerical # 5

A boy is digging a hole with spade of edge 0.2 cm^2. Calculate the pressure when he is exerting the force of 3000N onto the spade.

Numerical # 6

A wooden block of dimensions 0.5m×0.6m×1.0m kept on the ground has a mass of 200kg. Calculate the maximum pressure acting on the ground.

Data

dimensions = 0.5m×0.6m×1.0m

l = 0.5 m

b = 0.6 m

h = 1 m

m = 200 kg

g = 9.8 ms^{-2}

P = ?

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

A = l x b

A = 0.5 x 0.6

A = 0.3 m^2

W = mg

W = 200 x 9.8

W = 1960 N

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

$P = \frac{1960}{0.3}$

P = 6533.33 N/m^2

Practice of Numerical # 6

A wooden block of dimensions 0.4m×0.7m×1.2m kept on the ground has a mass of 150kg. Calculate the maximum pressure acting on the ground.

Numerical # 7

If the density of sea water is 1150 kgm^{-3}, calculate the pressure on a body of 50m below the surface of sea?

Data

ρ = 1150 kgm^{-3}

d = 50m

g = 9.8 ms^{-2}

P = ?

P = ρgd

P = 1150 x 9.8x 50

P = 563500 N/m^2

Practice of Numerical # 7

If the density of sea water is 1950 kgm^{-3}, calculate the pressure on a body of 40m below the surface of sea?

Numerical # 8

In a hydraulic lift system, what must be the surface area of a piston. If a pressure of 300 kpa is used to provide an upward force of 2000 N?

Data

P = 300 kpa = 300 x 1000 = 300000 pa

F = 2000 N

A = ?

Solution

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

A = $\frac{2000}{300000}$

A = 0.00667 m^2

Practice of Numerical # 8

In a hydraulic lift system, what must be the surface area of a piston. If a pressure of 250 kpa is used to provide an upward force of 3000 N?

Numerical # 9

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

Data

F_1 = 100 N

A_1 = 0.01m^2

A_2 = 1m^2

F_2 = ?

Solution

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

$\frac{100}{0.01} = \frac{F_2}{1}$

F_2 = 10000 N

Practice of Numerical # 9

In a hydraulic press, a force of 150 N is applied on the pump of cross-sectional area $0.02m^2$. Find the force that compresses a cotton bale placed on larger piston of cross-sectional area $1.5m^2$.

Numerical # 10

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.

Data

x = 3.5 cm = 3.5 ÷ 100 = 0.035 m

F = 14N

K = ?

Solution

F = Kx

14 = K x 0.035

$K = \frac{14}{0.035}$

K = 400 N/m

Practice of Numerical # 10

Calculate the spring constant for a spring which extends by a distance of 2.5cm when a load of 20N is hung from its end.

Numerical # 11

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.

Data

F = 20N

A_1 (head of thumbtack) = 1 cm^2

A_2 (tip of the thumbtack) = 0.01 cm^2

P_1 = ?

P_2 = ?

Solution

P = F/A

P = 20/1

P = 20 N/cm^2

P = F/A

P = 20/0.01

P = 2000 N/cm^2

Practice of Numerical # 11

A boy is pressing a thumbtack into a piece of wood with a force of 30 N. The surface area of head of thumbtack is $2cm^2$ and the cross-section area of the tip of the thumbtack is $0.02cm^2$. 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.

Numerical # 12

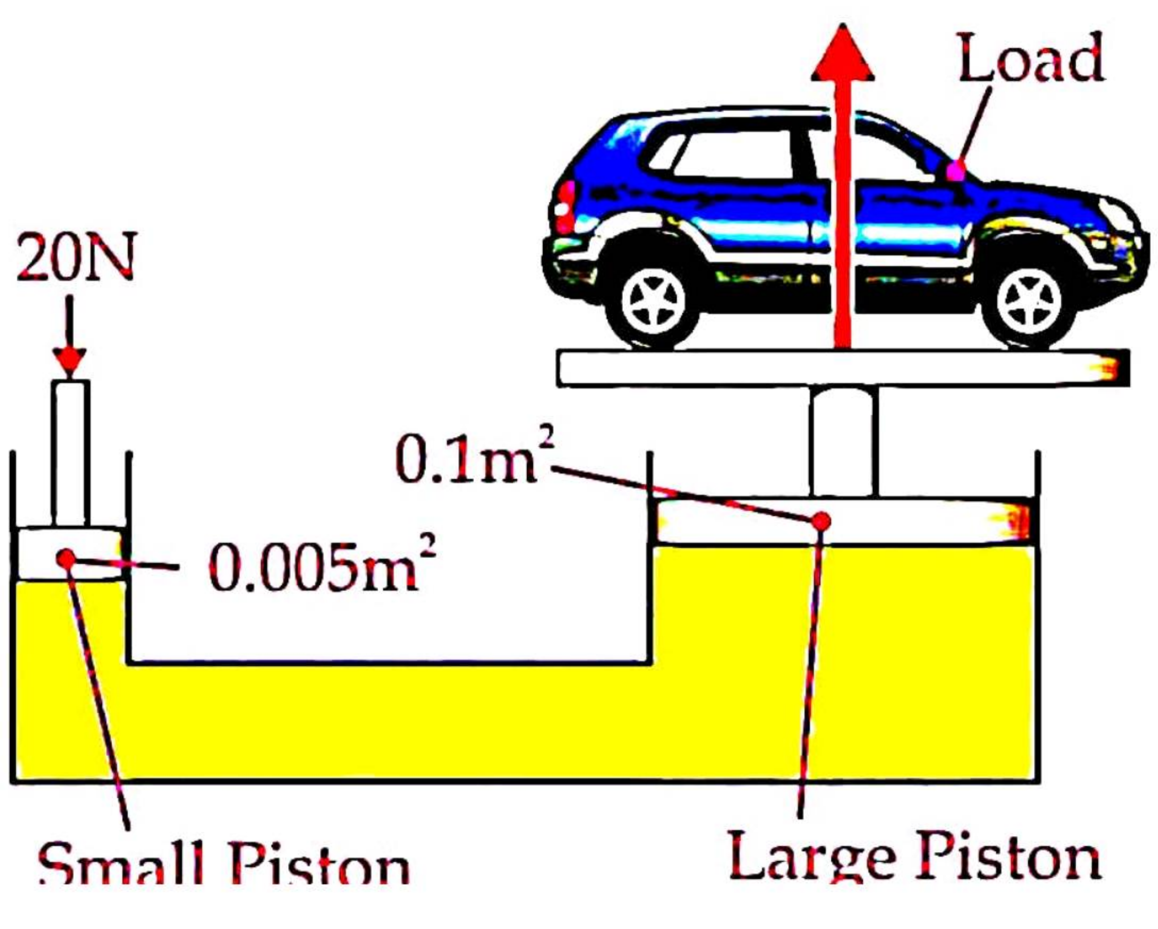
The Fig shows a basic hydraulic system that has small and large pistons of cross section area of 0.005 m^2 and 0.1 m^2 respectively. A force of 20N is applied to small piston. Calculate a) The pressure transmitted into hydraulic fluid. b) The force at large piston.

Data

F_1 = 20 N

$A_1 = 0.005m^2$

$A_2 = 0.1m^2$



$F_2 = ?$

Solution

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

$$\frac{20}{0.005} = \frac{F_2}{0.1}$$

$F_2 = 4000 \times 0.1$

$F_2 = 400$ N