LESSON 4 -APPLYING PASCAL'S PRINCIPLE

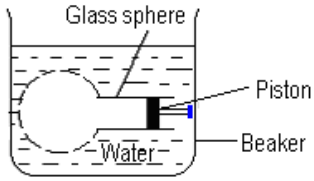
Introduction

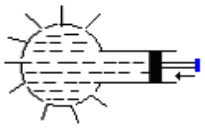
The molecules in a liquid are close and in contact with each other. As a result ,liquids are practically in compressible.

Pascal's Principle

Pascal's principle states that when pressure is applied to an enclosed fluid, the pressure will be transmitted equally throughout the whole enclosed fluid.

Eperiment to verify the Pascal's Principle





Jet of water

When the piston is pushed into the glass sphere the jet of water is shot out from the holes in the glass sphere with the same speed.
This is because the pressure acting on the water is transferred uniformly throughout the water.

Pascal's Principle in Mathematic Expression

$$\frac{\text{Output force}}{\text{Input force}} = \frac{\text{output piston area}}{\text{input piston area}}$$

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

Example 1

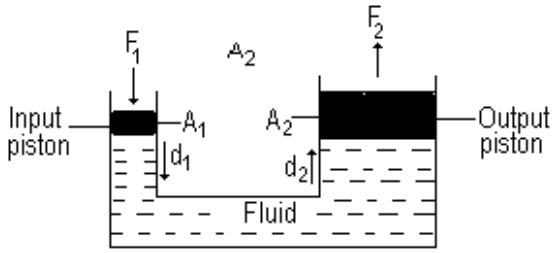
To produce a 2 500 N force over a 20 m^2 area of a hydraulic system, calculate the magnitude of the force that must be applied to a 50 cm^2 area.

Solution

Applications of Pascal's Principle

(1)Automoboile hydraulic lift

Automobile hydraulic lift is used to lift a vehicle in a workshop.
The system uses Pascal's Principle to produce a larger force to lift a heavy vehicle.



When incompressible fluid is moved through a hydraulic system, the volume through which the input system moved must be the same as the volume through which the output system,
Hence

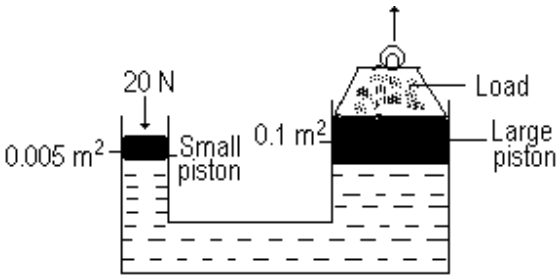
$$A_1d_1 = A_2d_2$$

Based on the Pascal's Principle,the pressure is transmitted throughout all points in the fluid and acts in all directions,

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

Example 2

The figure shows a basic hydraulic system has small and large pistons with cross-sectional area of 0.005 m^2 and 0.1 m^2 respectively. A force of 20 N is applied to the small piston.



Determine

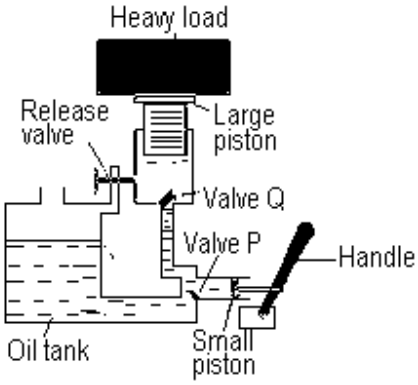
(a) The pressure transmitted in the hydraulic fluid.

(b) The mass of the load.

(c) If the small piston is pushed down at a depth a 0.04 m, what is the distance moved by the large piston.

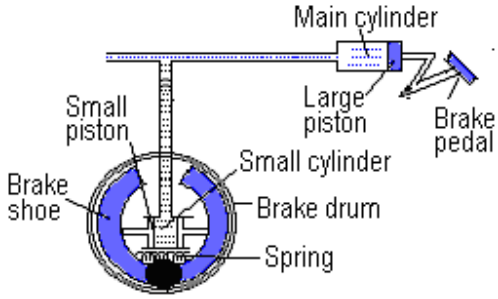
Solution

(2) Hidraulik Jack



When the handle is pulled, valve P is still closed and valve Q opens so the pressure can be sent to the larger piston. The large piston will rise.
While the small piston is pulled out, valve Q closes and valve P opens so that the oil in the tank enter into the hydraulic cylinder as a result of atmospheric pressure.
By moving the push-pull handle a number of times , the large piston can be raised carrying a heavy load.

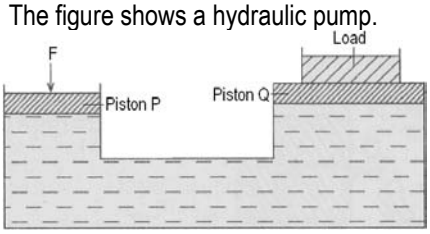
(3) Hidraulik Brake



A small force acting at the pedal can transmit a large force to all wheels simultaneously to stop the car.
It is because the pressure will be transferred through the pedal brake liquid to car's tyre .

TUTORIAL 3.4

1 The figure shows a hydraulic pump.



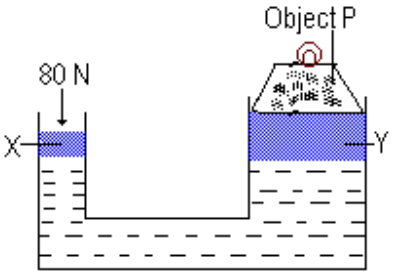
Which comparison is true?

A The force F is the same as the weight of the load
B The force F is greater than the weight of the load
C The pressure on piston P is the same as the pressure on piston Q
D The pressure on piston P is smaller than the pressure on piston Q

2 A force of 20N is applied to the input piston in a hydraulic jack. If the input piston area and output piston area are 0.02 m^2 and 0.1 m^2 respectively, what is the output force?

A 20 N **B** 50 N
C 100 N **D** 200 N
E 400 N

3 The figure shows a hydraulic system.



If the area of input piston and output piston are 0.03 m^2 and 0.90 m^2 respectively, what is the mass of object P.

A 3.2×10^2 kg **B** 2.4×10^2 kg
C 2.0×10^2 kg **D** 1.8×10^2 kg
E 1.2×10^2 kg

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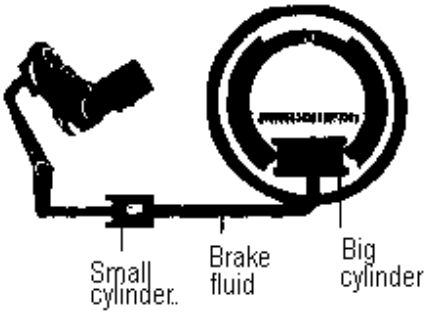
4 A hydraulic press has an input cylinder 8 cm in diameter and output cylinder 24 cm in diameter. If the input piston is moved through 10 cm , how far is the output piston moved?

A 0.11 cm **B** 0.30 cm
C 10.0 cm **D** 30.0 cm
E 90.0 cm

5 The figure shows a brake system of a car.



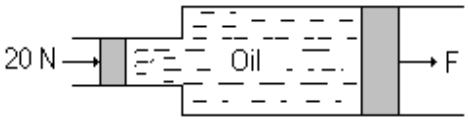
Which principle is used in this system?

A Pascal's principle
B Bernoulli's principle
C Archimedes' principle
D Principle of conservation of momentum

6 Which of the application is an application of Pascal's principle?

A Lift pump
B Filter pump
C Hydraulic pump

7 The figure shows a basic hydraulic system has a small and large pistons with cross sectional-areas 0.0005 m^2 and 0.0015 m^2 respectively. When a force of 20 N is applied to the small piston,it pushes down by 0.6 m.



Determine

(a) the pressure is applied on the small piston

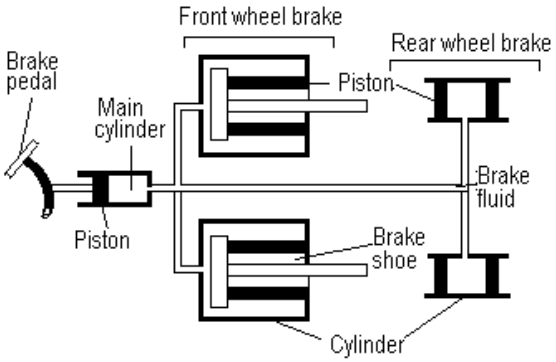
(b) the pressure is transmitted to the large piston

(c) the magnitude of the force ,F.

(d) the volume of oil transmitted .

(e) the distance moved by the large piston.

8 The figure shows the arrangement of the hydraulic brake system of a car.The cross-sectional area of the the main brake cylinder, the front brake cylinder and the rear brake cylinder are 5 x 10^{-4} m^2 , 6.0 x 10^{-4} m^2 and 5.5 x 10^{-4} m^2 respectively.



(a) The brake pedal is pressed with a constant force 15N.

(i) On the figure above indicate the direction of motions of the front brake cylinder and the rear brake cylinder.

(ii) State the relationship between the liquid pressure in the front brake cylinder and the rear brake cylinder.

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(iii) Calculate the pressure is exerted on each rear brake system.

(b) Explain why the front brake piston is applied a larger force than the rear brake piston.

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(c) Why is the brake system in the car is less effective air bubbles are present in the brake fluid. Give reasons for your answer.

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(d) Why is the cross-sectional area of the rear brake cylinder of the right wheel is the same as the cross-sectional area of the rear brake cylinder of the left wheel?

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