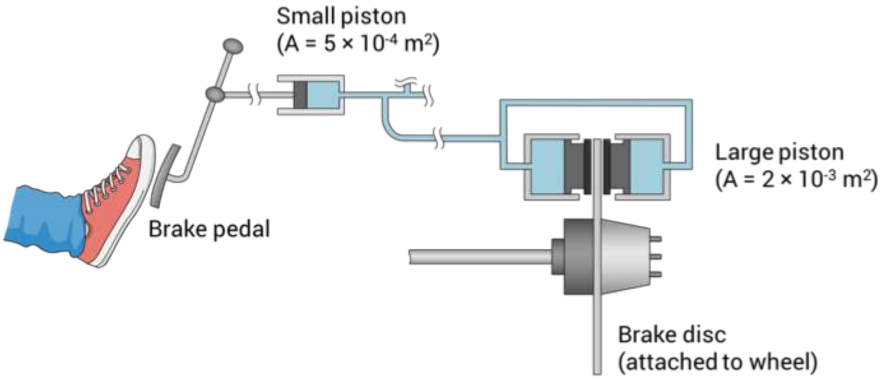
0	1

The braking systems of cars and many other vehicles rely on the fact that the pressure exerted by a force can be transmitted through a fluid. The below diagram shows a typical car braking system.



When the brake pedal is pushed, the pressure exerted on the small piston next to it (the *master cylinder*) is transferred to the large pistons at all four wheels. For clarity, just one of these four pistons is shown above. At each wheel, the action of the large piston causes the calipers (brake pads) to be pushed towards the brake disc. The friction between the calipers and brake disc is what causes the vehicle to slow down.

0 1 . 1

The driver in the above diagram applies a force of 20 N to the brake pedal. Calculate the pressure which this will exert on the fluid inside the small piston. Include an appropriate unit with your answer.

p = F ÷ A = 20 ÷ (5 × 10^{-4}) = **40,000 Pa**
(Equivalent to 40,000 N/m^2 or 40 kPa or 40 kN/m^2)

0 1 . 2

Calculate the braking force which is produced at each wheel.

F = p A = 40,000 × (2 × 10^{-3}) = **80 N**

0	2

A holidaymaker takes a scuba diving class. They are told that the pressure acting on them will double when they dive to a depth of 10 m.

0 2 . 1

If the (atmospheric) pressure at the surface is 100 kPa, estimate the density of the seawater in which they are diving. Take g = 9.8 N/kg.

Change in pressure from surface to 10 m depth, p = 200 – 100 = 100 kPa
p = h ρ g
100,000 = 10 × ρ × 9.8
100,000 = 98 ρ
ρ = 100,000 ÷ 98 = **1020 kg/m^3** (to nearest whole number)

02.2 The following day, they go skydiving from an altitude of 5 km. Before jumping out of the plane with their parachute, they glance at the barometer, and notice that the air pressure is 55 kPa. Explain why the air pressure at this altitude is lower than the pressure at the surface.

Air pressure is caused by collisions between air particles and a surface [1]. As height increases, density of air decreases [1], so air particles collide into surfaces and other air particles less frequently [1]. This leads to a decrease in air pressure.

03 As shown in **Figure 1** below, an ice cube is held beneath the surface of a beaker of water by applying a downwards force on it.

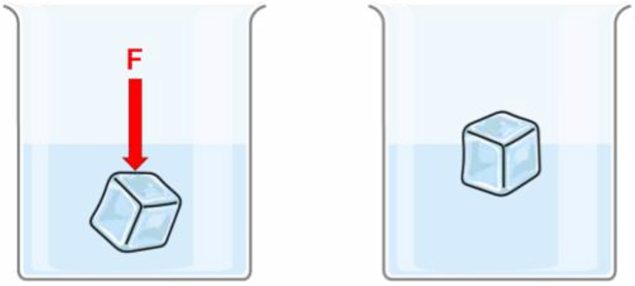


Figure 1: ice cube held beneath surface of water

Figure 2: after ice cube is released

03.1 The ice cube weighs 0.23 N and the upthrust acting on it has a magnitude of 0.25 N. Determine the magnitude of force F.

In equilibrium, total downwards force = total upwards force on ice cube
F + W = U (force + weight = upthrust)
F = U – W = 0.25 – 0.23 = **0.02 N**

03.2 Determine the volume of the ice cube. The density of water is 1 g/cm^3 and the value of g is 9.8 N/kg.

Upthrust = weight of water displaced by ice cube = 0.25 N
Mass of water displaced = W ÷ g = 0.25 ÷ 9.8 = 0.0255 kg = 25.5 g
Volume of water displaced, V = m ÷ ρ = 25.5 ÷ 1 = 25.5 cm^3
Volume of ice cube = volume of water displaced = **25.5 cm^3**

03.3 When the force is removed, the ice cube floats to the surface and comes to rest as shown in Figure 2. Explain why this happens in terms of the forces involved.

Any THREE points.

When F is removed (from submerged ice cube), U > W [1]. This means that there is a net (resultant) upwards force acting on the ice cube [1] which will cause it to accelerate upwards [1]. As it moves out of the water, U will decrease (the weight of water displaced will decrease) [1]. When it has come to rest, U = W [1].