

Pressure in fluids upthrust and atmosphere

AQA GCSE Separate Physics 8463 only | Paper 2 with Paper 1 density skills | F/H pathways

Worked answers | Foundation 28 parts / 44 marks | Higher 29 parts / 48 marks

Specification points covered

4.5.5.1.1: fluid pressure, forces normal to surfaces and $p = F/A$

4.5.5.2: atmospheric pressure and its variation with altitude

4.3.1.1: density, mass, volume and unit conversions

Higher only 4.5.5.1.2: liquid pressure, depth, density, upthrust and floating

A reservoir team tests an inspection pod, its viewing windows and a flotation collar. Weather stations near the reservoir provide atmospheric data. Use each trial's stated conditions; these simplified checks do not establish the safety of a real pressure vessel.

Original PhysicsUK practice, not an official AQA resource. Foundation: pages 1–6, 28 parts/44 marks. Higher: pages 1–4 and 7–8, 29 parts/48 marks. Credit equivalent correct wording and sensible follow-through. The whole sheet is Separate Physics only; liquid pressure and upthrust are confined to Higher sections 6–7.

1 Preparing the pod

The team records the mass and external volume of the sealed pod and tests a low-density collar material. For density, use the volume of the object, including its sealed air space when finding its average density.

1(a) A fluid may be a liquid or what other state of matter? **[1 mark]**

Answer / mark points: A gas. [1] A solid is not a fluid in this model.

1(b) State the SI unit of pressure. Do not give the unit of force. **[1 mark]**

Answer / mark points: Pascal, Pa. [1] The newton, N, is the unit of force.

1(c) The sealed pod has mass 480 000 g and external volume 0.60 m^3 . Calculate its average density in kg m^{-3} . **[2 marks]**

Answer / mark points: Mass = 480 kg. [1]

Density = $480/0.60 = 800 \text{ kg m}^{-3}$. [1] Use the complete external volume, not just the wall material.

1(d) A collar-material sample occupies 40 litres and has density 250 kg m^{-3} . Calculate the sample's mass in kg. **[2 marks]**

Answer / mark points: 40 litres = 0.040 m^3 . [1]

$m = \rho V = 250 \times 0.040 = 10 \text{ kg}$. [1]

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



2 Testing the viewing window

Figure 1 shows the pod's rectangular viewing window. For these tests, the stated pressure is the uniform pressure difference across the window, so the net force magnitude is pressure difference $\times$ area.

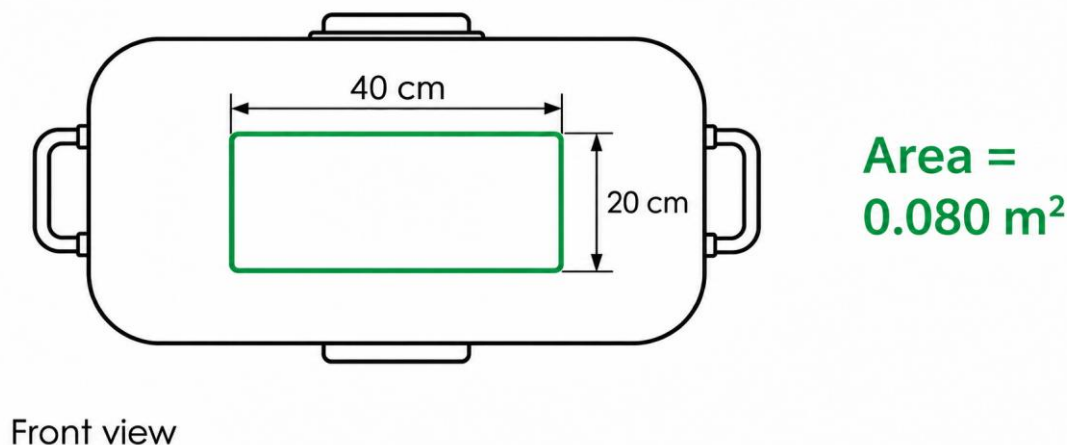


Figure 1

2(a) Use the window dimensions in Figure 1 to calculate its area in m². **[2 marks]**

Answer / mark points: 40 cm = 0.40 m and 20 cm = 0.20 m. [1 for both]
 $A = 0.40 \times 0.20 = 0.080 \text{ m}^2$. [1] Alternatively 800 cm²/10 000.

2(b) The pressure difference across this window is 12 000 Pa. Calculate the net force magnitude on it. **[1 mark]**

Answer / mark points: $F = pA = 12\,000 \times 0.080 = 960 \text{ N}$. [1] Allow consistent follow-through from 2(a).

2(c) A separate window opening has area 300 cm². A net normal force of 600 N acts on it. Calculate the pressure difference across it in kPa. **[3 marks]**

Answer / mark points: 300 cm² = 0.030 m². [1]
 $p = 600/0.030 = 20\,000 \text{ Pa}$. [1]
 20 000 Pa = 20 kPa. [1]

2(d) Describe the direction of the force exerted by the fluid on a flat window, relative to the window's surface. **[1 mark]**

Answer / mark points: Normal/perpendicular/at right angles to the surface. [1] Not parallel to it.

2(e) The team doubles the window area without changing the pressure difference. State what happens to the pressure difference and to the net force. **[2 marks]**

Answer / mark points: Pressure difference stays the same. [1]
 Net force doubles because $F = pA$. [1] A larger force does not necessarily mean a larger pressure.



3 Reading the weather stations

Table 1 gives model atmospheric-pressure readings taken at the same time. The stations are near the reservoir but at different altitudes. Use the supplied values.

Table 1

Station	Altitude / m	Pressure / kPa
A	0	101
B	600	94
C	1200	87

3(a) What is the atmospheric pressure at station B? Include its unit. **[1 mark]**

Answer / mark points: 94 kPa. [1]

3(b) Calculate the decrease in atmospheric pressure from station A to station C in kPa. **[1 mark]**

Answer / mark points: $101 - 87 = 14$ kPa. [1]

3(c) Explain how air molecules produce pressure on a weather-station sensor. **[2 marks]**

Answer / mark points: Air molecules collide with the sensor surface. [1]
They exert a force on it; this force per unit area is pressure. [1] Molecules do not need to settle on it.

3(d) Explain why the atmospheric pressure is lower at station C than at station A. **[2 marks]**

Answer / mark points: There is less air above the higher station, so the weight of air above it is smaller. [1]
The air is less dense at the higher altitude. [1] Accept a coherent particle account of fewer collisions per area per second with the first point.

3(e) At station C, air pressure acts on one face of a flat 0.020 m^2 sensor panel. Calculate the force on THAT face. Do not calculate a net force on the whole panel. **[2 marks]**

Answer / mark points: $87 \text{ kPa} = 87\,000 \text{ Pa}$. [1]
 $F = 87\,000 \times 0.020 = 1740 \text{ N}$. [1] Pressure on the opposite face is not being subtracted in this task.

3(f) A trainee says, "There is no air at station C because its pressure is lower." Use the data and a model of the atmosphere to explain why this is wrong. **[2 marks]**

Answer / mark points: The pressure is still 87 kPa, not zero. [1]
Air remains above/around the station, but is less dense; the atmosphere has not ended there. [1]



4 Comparing pressure and force

Table 2 gives three independent tests of windows. The pressure difference is uniform across each opening. The net force magnitude on each window equals this difference multiplied by its area.

Table 2

Window	Pressure difference / Pa	Opening area / m ²
A	10 000	0.040
B	20 000	0.020
C	10 000	0.020

4(a) Calculate the net force magnitude on window A in Table 2. **[1 mark]**

Answer / mark points: $10\,000 \times 0.040 = 400\text{ N}$. [1]

4(b) Calculate the net force magnitude on window B in Table 2. **[1 mark]**

Answer / mark points: $20\,000 \times 0.020 = 400\text{ N}$. [1]

4(c) Calculate the net force magnitude on window C in Table 2. **[1 mark]**

Answer / mark points: $10\,000 \times 0.020 = 200\text{ N}$. [1]

4(d) A trainee claims that the window with the greatest pressure difference must have the greatest net force. Use windows A and B to evaluate the claim. **[2 marks]**

Answer / mark points: B has twice A's pressure difference but both have the same 400 N net force. [1]

B's area is half A's; force depends on both pressure difference and area. [1] The claim is false.

4(e) In another test, uniform pressures are 120 000 Pa outside and 100 000 Pa inside a 0.020 m² window. Calculate the magnitude and direction of the net force on the window. **[2 marks]**

Answer / mark points: Pressure difference = $120\,000 - 100\,000 = 20\,000\text{ Pa}$. [1]

Net force = $20\,000 \times 0.020 = 400\text{ N}$, inwards/towards the inside. [1 for magnitude and direction] Not 2400 N.



5 Foundation replacement section

Foundation: complete both pages of section 5 after sections 1–4, then stop. Higher pupils skip section 5. These are new pod-window and weather-station tests; no depth-pressure or floating equation is needed.

5(a) A new window has area 400 cm^2 . Convert this area to m^2 . **[1 mark]**

Answer / mark points: $400/10\,000 = 0.040 \text{ m}^2$. [1] Divide area by 10 000, not 100.

5(b) The net normal force on that 400 cm^2 window is 1200 N. Calculate the pressure difference in kPa. **[2 marks]**

Answer / mark points: $p = 1200/0.040 = 30\,000 \text{ Pa}$. [1]
 $30\,000 \text{ Pa} = 30 \text{ kPa}$. [1] Allow correct follow-through from 5(a).

5(c) A test rig must produce a 900 N net force with a pressure difference of $15\,000 \text{ Pa}$. Calculate the required window area in m^2 . **[1 mark]**

Answer / mark points: $A = F/p = 900/15\,000 = 0.060 \text{ m}^2$. [1]

5(d) For a 900 N net force, choose an opening of area 0.040 m^2 or 0.060 m^2 so that the pressure difference is no more than $18\,000 \text{ Pa}$. Justify your choice with a calculation. **[2 marks]**

Answer / mark points: Choose 0.060 m^2 : $p = 900/0.060 = 15\,000 \text{ Pa}$. [1]
 $15\,000$ is below $18\,000 \text{ Pa}$; the 0.040 m^2 option needs $22\,500 \text{ Pa}$, above the limit. [1] This only checks the stated test condition.

5(e) Air pressure of $94\,000 \text{ Pa}$ acts on one face of a 0.050 m^2 weather-station panel. Calculate the force on that face. **[1 mark]**

Answer / mark points: $F = 94\,000 \times 0.050 = 4700 \text{ N}$. [1] This is one-face force, not the net force when air also acts on the other side.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



5 Foundation replacement section continued

Foundation only. Complete the remaining weather-station and casing checks, then stop.

5(f) The team moves a weather sensor from the valley to a much higher site. Explain the expected change in atmospheric pressure, assuming ordinary atmospheric conditions. **[2 marks]**

Answer / mark points: Pressure decreases. [1]

There is less air above it, hence a smaller weight of air above; accept less dense air/fewer collisions per area per second as the linked explanation. [1]

5(g) A sealed sensor casing has mass 4.8 kg and external volume 6000 cm³. Use 1 m³ = 1 000 000 cm³ to calculate its average density in kg m⁻³. **[2 marks]**

Answer / mark points: 6000 cm³ = 0.0060 m³. [1]

Density = 4.8/0.0060 = 800 kg m⁻³. [1] Do not use the area-conversion factor.

5(h) A trainee draws the pressure force along a flat window's surface. State how its direction should be corrected. **[1 mark]**

Answer / mark points: The arrow must point at right angles/normal to the window surface, not along it. [1]

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



6 Higher only liquid pressure

Higher only: complete sections 6–7 INSTEAD of section 5. Figure 2 shows a DIFFERENT test pod. Its circular window has area 0.080 m^2 and centre depth 3.0 m . Use water density 1000 kg m^{-3} , $g = 9.8 \text{ N kg}^{-1}$ and $p = h\rho g$. Treat the liquid pressure at the centre as the mean over the window.

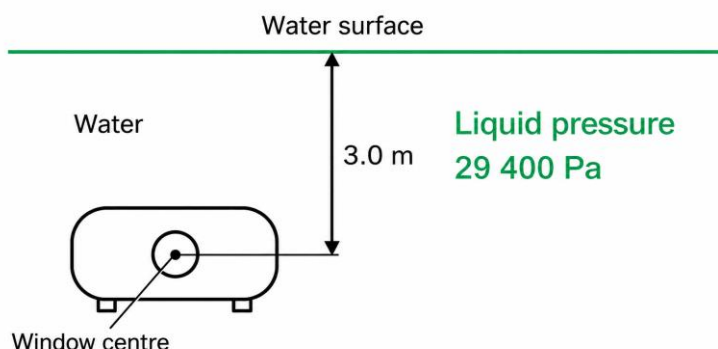


Figure 2

6(a) Calculate the pressure due to the WATER ALONE at the centre of the window in Figure 2. **[1 mark]**

Answer / mark points: $p = h\rho g = 3.0 \times 1000 \times 9.8 = 29\,400 \text{ Pa}$. [1] Depth is vertical below the free surface, not distance to the tank bed.

6(b) The liquid-only pressure increases to 58.8 kPa in the same water. Calculate the new vertical depth of the window centre. **[2 marks]**

Answer / mark points: $58.8 \text{ kPa} = 58\,800 \text{ Pa}$. [1]
 $h = p/(\rho g) = 58\,800/(1000 \times 9.8) = 6.0 \text{ m}$. [1] The centre is twice as deep.

6(c) Return to the 3.0 m depth. Atmospheric pressure on the water surface is $101\,000 \text{ Pa}$. Calculate the total pressure outside the window. **[1 mark]**

Answer / mark points: $101\,000 + 29\,400 = 130\,400 \text{ Pa}$. [1] The hydrostatic value alone is not the total pressure.

6(d) At that 3.0 m depth the inside pressure is $101\,000 \text{ Pa}$. Calculate the net force on the 0.080 m^2 window and state its direction. **[2 marks]**

Answer / mark points: Difference = $130\,400 - 101\,000 = 29\,400 \text{ Pa}$. [1]
 $F = 29\,400 \times 0.080 = 2352 \text{ N}$, inwards. [1 for magnitude and direction] Accept 2350 N . Do not multiply the total outside pressure by area for the net load.

6(e) A laboratory repeats the 3.0 m test using a liquid of density 1250 kg m^{-3} . Calculate its liquid-only pressure and explain why it is greater than in water. **[2 marks]**

Answer / mark points: $p = 3.0 \times 1250 \times 9.8 = 36\,750 \text{ Pa}$. [1]
 At the same depth, a denser liquid has greater mass/weight of liquid above a given area, giving greater pressure. [1] The pod's density is not used.



7 Higher only the flotation trial

Higher only. In a separate tank test, a sealed rectangular collar has horizontal top and bottom faces, each of area 0.20 m^2 . The water pressure is 9800 Pa at the top and $14\,700 \text{ Pa}$ at the bottom. Horizontal forces from the water cancel. These are pressures due to the water alone; atmospheric contributions cancel between the two faces.

7(a) Use the given top and bottom pressures to calculate the resultant vertical force exerted by the water on the collar. Include its direction. **[2 marks]**

Answer / mark points: Pressure difference = $14\,700 - 9800 = 4900 \text{ Pa}$. [1]
Upward resultant = $4900 \times 0.20 = 980 \text{ N}$. [1 for magnitude and direction] Alternatively bottom force 2940 N up minus top force 1960 N down.

7(b) Explain why the water exerts an upthrust on the collar. Refer to depth, pressure and force direction. **[2 marks]**

Answer / mark points: The bottom face is deeper, so water pressure is greater there than at the top. [1]
Pressure gives upward force on the bottom and downward force on the top; with equal areas the upward force is greater, giving an upward resultant/upthrust. [1]

7(c) The collar's weight is 1176 N . It is released from rest, fully submerged, with no support force. Calculate the initial resultant vertical force and state whether it initially moves up or down. **[2 marks]**

Answer / mark points: $1176 - 980 = 196 \text{ N}$ downwards. [1]
It initially moves/sinks down because weight is greater than upthrust. [1] Initially drag is zero. Do not state that no upward force acts.

7(d) The collar is replaced by a larger sealed collar of the SAME weight. The replacement floats at rest, partly submerged. State its upthrust and explain why increasing the external volume can make floating possible. **[2 marks]**

Answer / mark points: Upthrust = weight = 1176 N . [1]
The larger external volume allows more water to be displaced, so sufficient upthrust can be produced before the collar is fully submerged. [1] Its average density is lower at the same mass. Floating does not mean zero weight.

Review and improve

Check units before substitution. Pressure is force per unit area, not force. For a net window load, compare both sides. Higher: use vertical depth, liquid density and an upward pressure resultant. Timing is estimated and untrials.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

