Pressure with depth and upthrust

4.5.5.1.2 · Forces · revision notes

The pressure in a liquid increases with depth and with the density of the liquid. You need to use p = h ρ g (on the equations sheet), explain why pressure increases with depth, explain what causes upthrust, and describe what decides whether an object floats or sinks. This is Higher tier content, in GCSE Physics only, not in Combined Science.

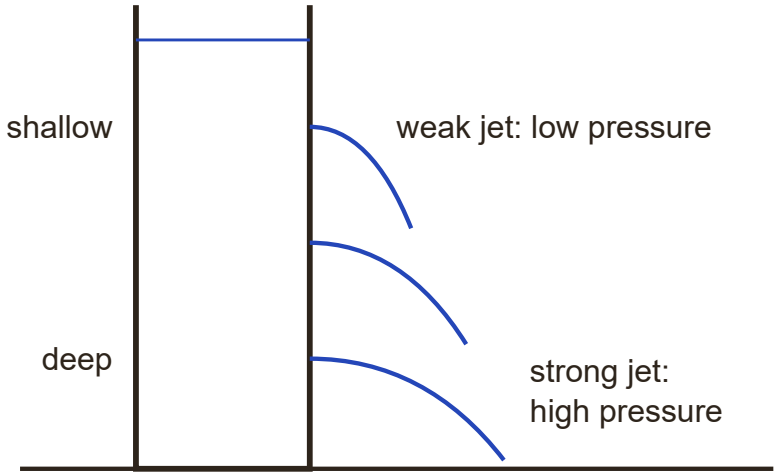
Key facts

- p = h ρ g (on the equations sheet)
- Deeper → greater weight of liquid above → greater pressure
- Upthrust = resultant upward force caused by the greater pressure on the bottom surface
- Less dense than the fluid → floats; denser than the fluid → sinks
- Units: p in Pa, h in m, ρ in kg/m^3, g in N/kg
- Denser liquid → greater pressure at the same depth
- Floats: upthrust = weight; sinks: weight > upthrust
- Density of water ≈ 1000 kg/m^3 (the value is usually given)

Notes

Pressure increases with depth

- The pressure at a point in a liquid depends on the height of the column of liquid above that point and on the density of the liquid.
- pressure = height of the column × density of the liquid × gravitational field strength: **p = h ρ g** (on the equations sheet).
- p in Pa, h in m, ρ (density) in kg/m^3, g in N/kg.
- The deeper the point, the greater the weight of liquid above it, so the greater the pressure.

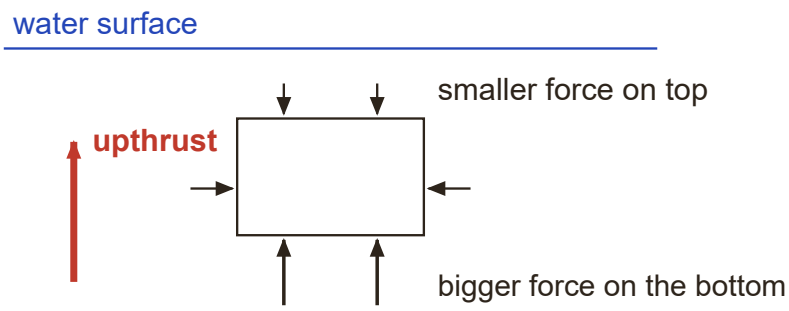


The deeper the hole, the greater the pressure, so the faster the water comes out.

- A denser liquid gives a greater pressure at the same depth.
- p = h ρ g gives the pressure due to the liquid only. The atmosphere pushes on the surface too, so the total pressure is greater. Grade 8+ only

Upthrust

- A partially or totally submerged object has a greater pressure on its bottom surface than on its top surface, because the bottom is deeper.
- This creates a resultant force upwards, called **upthrust**.

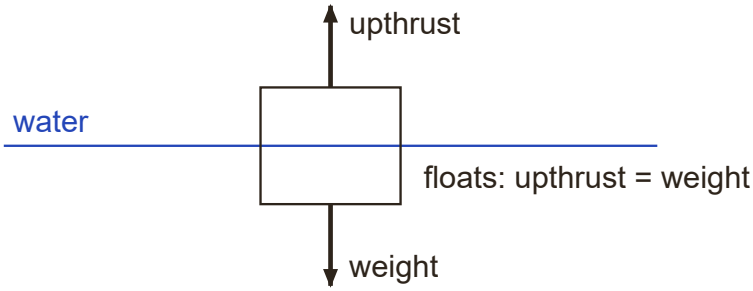


Pressure is greater on the deeper bottom face, so there is a resultant upward force: upthrust.

- Upthrust acts on objects in any fluid, liquid or gas.

Floating and sinking

- An object floats when the upthrust on it equals its weight, so the forces on it are balanced.



A floating object sinks in until the upthrust equals its weight.

- A floating object sinks into the liquid until enough of it is submerged for the upthrust to equal its weight.
- If the object's weight is greater than the upthrust even when it is completely submerged, it sinks.
- An object that is less dense than the liquid floats. An object that is denser than the liquid sinks.
- A steel ship floats because its average density, including the air inside the hull, is less than the density of water.

How to answer each type of question

Calculate the pressure due to a liquid

2 marks | Grade 6

1. Check h is in m and ρ in kg/m^3.
2. Substitute into p = h ρ g.
3. Give the answer in Pa.

Example. A swimming pool is 2.5 m deep.
density of water = 1000 kg/m^3; gravitational field strength = 9.8 N/kg
Calculate the pressure due to the water at the bottom of the pool.

Model answer.

p = 2.5 × 1000 × 9.8 (1)
p = 24 500 Pa (1)

Explain why pressure increases with depth

2 to 3 marks | Grade 6

1. State that pressure increases with depth.
2. Give the reason: a greater height (weight) of liquid above.
3. Apply it to the situation in the question.

Example. The wall of a dam is much thicker at the bottom than at the top.
Explain why.

Model answer.

The pressure in the water increases with depth (1)
because there is a greater height (weight) of water above (1)
so the force on the bottom of the wall is greater and the wall needs to be stronger there (1).

Explain upthrust and floating

3 to 4 marks | Grade 7

1. Compare the pressures on the bottom and top surfaces.
2. Name the resultant upward force: upthrust.
3. Compare upthrust with weight to explain floating or sinking.

Example. A wooden block floats in water.
Explain why there is an upward force on the block and why the block floats.

Model answer.

The pressure on the bottom surface of the block is greater than the pressure on its top surface (1).
This gives a resultant upward force called upthrust (1).
The block sinks into the water until the upthrust equals its weight (1)
so the forces on it are balanced and it floats (1).

Pressure difference between two depths

3 marks | Grade 8

1. Find the difference in depth.
2. Use it as h in p = h ρ g.
3. Give the answer to a sensible number of significant figures.

Example. A diver swims down from a depth of 4.0 m to a depth of 19.0 m in sea water.
density of sea water = 1030 kg/m^3; gravitational field strength = 9.8 N/kg
Calculate the increase in pressure on the diver.

Model answer.

difference in depth = 19.0 − 4.0 = 15.0 m (1)
Δp = 15.0 × 1030 × 9.8 (1)
Δp = 151 410 Pa ≈ 151 000 Pa (1)

Predict floating or sinking from density

3 marks | Grade 8

1. Calculate the density of the object: ρ = m ÷ V.
2. Compare it with the density of the liquid.
3. State whether it floats or sinks.

Example. An object has a mass of 0.60 kg and a volume of 0.00050 m^3. The density of water is 1000 kg/m^3.
Will the object float or sink in water? Explain your answer.

Model answer.

density = 0.60 ÷ 0.00050 = 1200 kg/m^3 (1)
This is greater than the density of water (1)
so the object sinks (1).

Don't lose marks

- Using the depth of the whole container instead of the depth of the point below the surface.
- Using a density in g/cm^3 (e.g. 1.0) instead of kg/m^3 (1000).
- Saying upthrust is caused by 'the water pushing up' without explaining that the pressure on the bottom surface is greater than on the top.
- Thinking heavy objects always sink. A steel ship floats because its average density is less than that of water.
- Saying the pressure depends on the shape or width of the container. It depends only on the depth, the density and g.

More tips

Memory tricks

- p = h ρ g: read it as 'height, rho, g'. All three make the pressure bigger.
- Sense check: every 10 m of water adds about 100 000 Pa (10 × 1000 × 9.8 = 98 000 Pa).
- Upthrust in five words: the bottom pushes harder than the top.
- Density test: object's density below the liquid's → floats; above → sinks.

Exam technique

- p = h ρ g is on the equations sheet, but you must know what each symbol means and its unit.
- For upthrust questions, use the key phrase 'greater pressure on the bottom surface than on the top surface'.
- For floating questions, compare the forces (upthrust and weight) or the densities, and say which is bigger.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 5

State that liquid pressure increases with depth

The deeper a point is below the surface, the greater the pressure there.

Grade 6

Calculate liquid pressure with p = hρg

For example, 3.0 m × 1000 kg/m^3 × 9.8 N/kg = 29 400 Pa.

Grade 6

Explain why pressure increases with depth

At a greater depth there is a greater height, and so a greater weight, of liquid above that point.

Grade 7

Explain what causes upthrust

The pressure on the bottom surface of a submerged object is greater than on its top surface, giving a resultant upward force.

Grade 7

Explain floating and sinking using forces

An object floats when the upthrust equals its weight; it sinks if its weight is greater than the upthrust when fully submerged.

Grade 8

Use density to predict floating or sinking

An object less dense than the liquid floats; an object denser than the liquid sinks.

Grade 8

Calculate the pressure difference between two depths

Pressure difference = difference in depth × ρ × g.

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.