

Density, pressure, buoyancy and moving fluids

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train the five ideas of AP Physics 1 unit 8: density, pressure and depth, buoyancy, continuity and Bernoulli's equation. They begin with one-step calculations and finish with multi-part reasoning in the style of free-response questions. Use $g = 9.81 \text{ m/s}^2$, $\rho_{\text{water}} = 1000 \text{ kg/m}^3$ and $P_0 = 1.01 \times 10^5 \text{ Pa}$ unless told otherwise. Show every formula and write units with each final answer.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 8

Problem 1 Density of a metal block (easy)

Mei in Singapore measures an aluminium block with a mass of 0.54 kg and a volume of $2.0 \times 10^{-4} \text{ m}^3$.

1. State the SI unit of density.
2. Calculate the density of the block.
3. Convert your answer to g/cm^3 .

Problem 2 Drawing pin pressure (easy)

Wanjiru presses a drawing pin into a noticeboard with a force of 20 N. The tip has an area of $5.0 \times 10^{-7} \text{ m}^2$ and the head has an area of $1.0 \times 10^{-4} \text{ m}^2$.

1. Calculate the pressure under the tip.
2. Calculate the pressure on her thumb at the head.
3. Explain why the tip enters the board.

Problem 3 Tyre pressure (easy)

A tyre gauge in Lahore reads $2.20 \times 10^5 \text{ Pa}$. Take $P_0 = 1.01 \times 10^5 \text{ Pa}$.

1. Convert 250 kPa to pascals.
2. Calculate the absolute pressure inside the tyre.
3. State what the gauge actually measures.

Problem 4 Pressure in a water tank (easy)

A farm tank in Kenya holds fresh water 5.0 m deep and is open to the air.

1. Calculate the gauge pressure at the bottom.
2. Calculate the absolute pressure at the bottom.

Problem 5 Aquarium base (easy)

Emma's aquarium has a rectangular base of 0.60 m by 0.30 m and holds water 0.40 m deep.

1. Calculate the gauge pressure on the base.
2. Calculate the force of the water on the base.
3. Calculate the weight of the water and compare.

Problem 6 Fully submerged stone (easy)

Diego lowers a stone of volume $3.0 \times 10^{-4} \text{ m}^3$ fully into a bucket of fresh water.

1. Calculate the volume of water displaced.
2. Calculate the buoyant force on the stone.

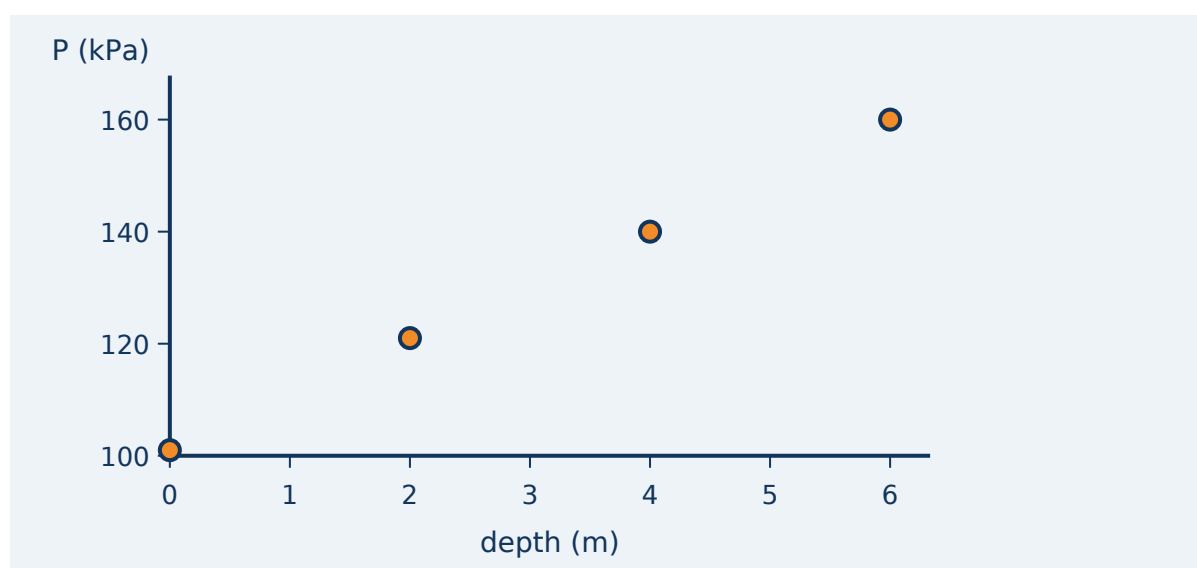
Problem 7 Flow rate in a pipe (medium)

A pipe has a cross-sectional area of $4.0 \times 10^{-4} \text{ m}^2$. Water flows through it at 1.5 m/s.

1. Calculate the volume flow rate in m^3/s .
2. Calculate the volume that passes in one minute, in litres.

Problem 8 Pressure against depth graph (medium)

Kofi records the absolute pressure at different depths in a water tank (graph shown).



Measured pressure at four depths in a tank of water.

1. Find the gradient using the points at 0 m and 6 m.
2. Use it to estimate the fluid density.
3. Predict the pressure at 8 m.

Problem 9 Float or sink (medium)

Three solid blocks of the same size are released in fresh water. Their densities are 500, 1000 and 1200 kg/m^3 .

1. Predict what each block does.

2. Calculate the fraction of the 500 kg/m^3 block that is under water.
3. Explain why the 1000 kg/m^3 block can stay at any depth.

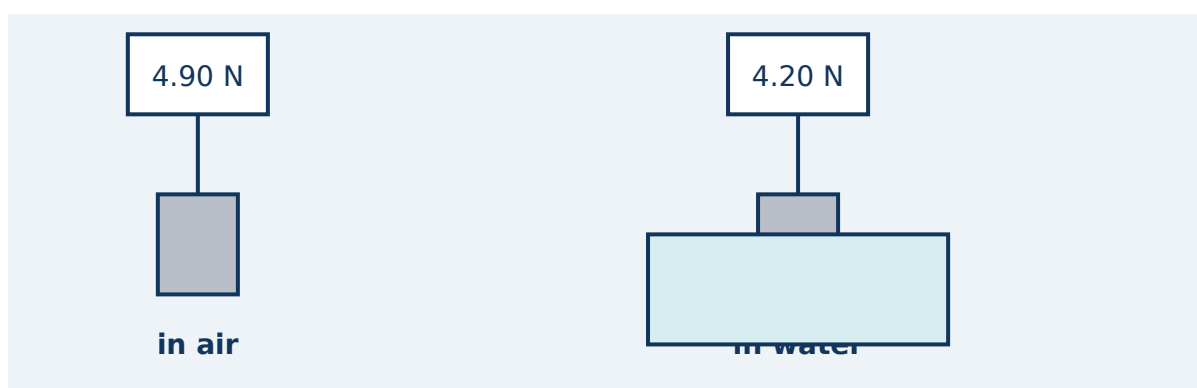
Problem 10 Iceberg (medium)

An iceberg of density 917 kg/m^3 floats in seawater of density 1025 kg/m^3 off Greenland.

1. Calculate the fraction of the iceberg that is below the surface.
2. State the fraction above the surface.

Problem 11 Weight in air and in water (medium)

A metal sample hangs from a scale (shown). It reads 4.90 N in air and 4.20 N fully submerged in water.



The reading drops when the sample is lowered into water.

1. Calculate the buoyant force.
2. Calculate the volume of the sample.
3. Calculate its density.

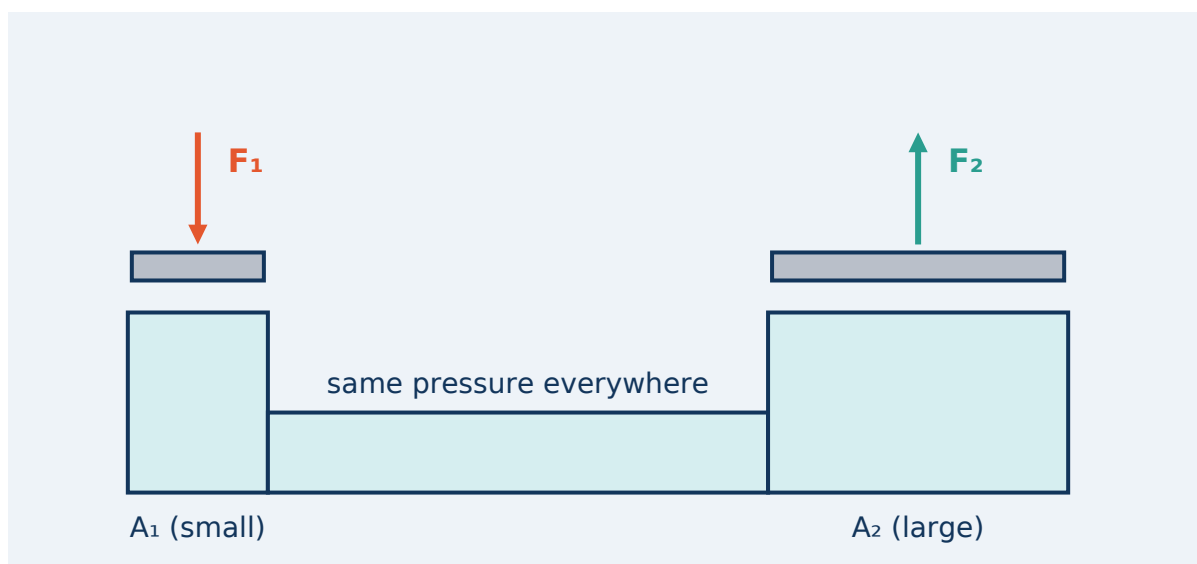
Problem 12 Garden hose nozzle (medium)

Bilal's garden hose has a diameter of 1.8 cm . Water travels at 1.2 m/s inside it and leaves through a nozzle of diameter 0.60 cm .

1. Calculate the exit speed.
2. Calculate the flow rate in litres per minute.

Problem 13 Hydraulic car lift (medium)

A garage lift (shown) has a small piston of area $4.0 \times 10^{-3} \text{ m}^2$ and a large piston of area 0.16 m^2 . A force of 150 N pushes on the small piston.



A force on the small piston creates a pressure that acts on the large piston.

1. Calculate the pressure in the fluid.
2. Calculate the force on the large piston.
3. The small piston moves 0.80 m. Calculate how far the large piston rises.

Problem 14 Pressure drop in a fast section (medium)

Water at 1.0 m/s and pressure 2.40×10^5 Pa flows along a horizontal pipe that narrows so that the speed becomes 5.0 m/s.

1. Calculate the new pressure.
2. State by how many pascals the pressure drops.

Problem 15 Roof in a strong wind (medium)

Wind of 20 m/s blows over a flat tin roof of area 8.0 m^2 and mass 150 kg in Nairobi. The air under the roof is still. Use $\rho_{\text{air}} = 1.2 \text{ kg/m}^3$.

1. Calculate the pressure difference across the roof.
2. Calculate the net upward force from the air.
3. Decide whether the roof lifts if it is not fixed.

Problem 16 Jet from a tank (hard)

A wide open tank of fresh water has a small hole 3.2 m below the surface and 1.0 m above the ground.

1. Use Bernoulli's equation to find the exit speed of the jet.
2. Calculate the time for water to fall to the ground.
3. Calculate the horizontal distance reached.

Problem 17 Venturi flow meter (hard)

A horizontal pipe has a wide section of area $2.0 \times 10^{-3} \text{ m}^2$ and a narrow section of area $5.0 \times 10^{-4} \text{ m}^2$. The pressure difference between the sections is 1.5×10^4 Pa for water.

1. Write v_2 in terms of v_1 .
2. Use Bernoulli's equation to find v_1 .
3. Calculate the volume flow rate.

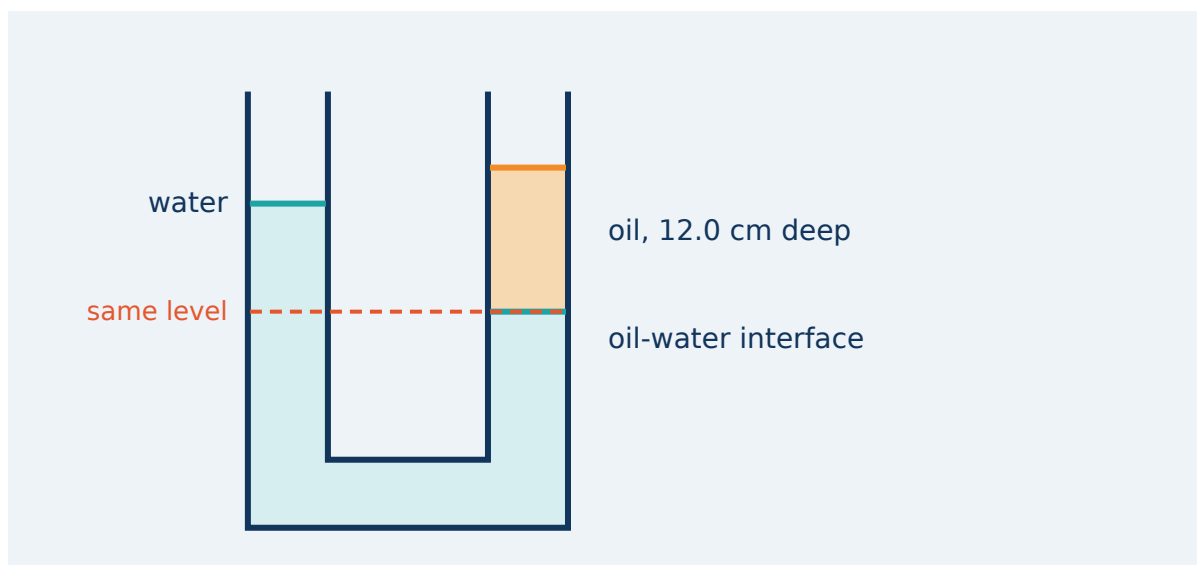
Problem 18 Ball held under water (hard)

A ball of mass 0.50 kg and volume $2.0 \times 10^{-3} \text{ m}^3$ is held fully under water by a string tied to the bottom of a pool.

1. Calculate the buoyant force.
2. Draw a free-body diagram in words and calculate the tension.
3. The string is cut. Calculate the initial acceleration, ignoring drag.

Problem 19 Oil in a U-tube (hard)

Water fills a U-tube (shown). Oil of density 800 kg/m^3 is poured into the right arm until it is 12.0 cm deep.



Water in the left arm balances water plus oil in the right arm.

1. State which two points have equal pressure.
2. Calculate the height of the water in the left arm above the interface.
3. Calculate how far the oil surface is above the left water surface.

Problem 20 Loaded barge (hard)

A flat-bottomed barge is 6.0 m long and 2.0 m wide, has a mass of 3000 kg and sides 0.80 m high. It floats in river water.

1. Calculate how deep the empty barge sits.
2. Calculate the depth after loading 2400 kg of sand.
3. Calculate the largest load it can carry before water reaches the top of the sides.
4. Calculate the depth of the loaded barge (5400 kg in total) if it moves into seawater of density 1025 kg/m^3 .