

Density, pressure, buoyancy and moving fluids

AP Physics 1 (algebra-based) · Worksheet answers

Check each answer against your own working. Marks in AP-style grading go to the correct law, a clean substitution and a final value with the right unit, so compare your method as well as your number.

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

Problem 1 Density of a metal block

1. kg/m^3 .
2. $\rho = m/V = 0.54 / 2.0 \times 10^{-4} = \mathbf{2.7 \times 10^3 \text{ kg/m}^3}$.
3. $1 \text{ g/cm}^3 = 1000 \text{ kg/m}^3$, so the density is $\mathbf{2.7 \text{ g/cm}^3}$.

Problem 2 Drawing pin pressure

1. $P = F/A = 20 / 5.0 \times 10^{-7} = \mathbf{4.0 \times 10^7 \text{ Pa}}$.
2. $P = 20 / 1.0 \times 10^{-4} = \mathbf{2.0 \times 10^5 \text{ Pa}}$.
3. The same force acts over a tiny area at the tip, so the pressure is 200 times larger and exceeds what the board can withstand.

Problem 3 Tyre pressure

1. $250 \text{ kPa} = \mathbf{2.5 \times 10^5 \text{ Pa}}$.
2. $P = P_0 + P_{\text{gauge}} = 1.01 \times 10^5 + 2.20 \times 10^5 = \mathbf{3.21 \times 10^5 \text{ Pa}}$.
3. It reads gauge pressure: the pressure above atmospheric pressure.

Problem 4 Pressure in a water tank

1. $P_{\text{gauge}} = \rho gh = 1000 \times 9.81 \times 5.0 = \mathbf{4.9 \times 10^4 \text{ Pa}}$.
2. $P = 1.01 \times 10^5 + 0.49 \times 10^5 = \mathbf{1.50 \times 10^5 \text{ Pa}}$.

Problem 5 Aquarium base

1. $P = \rho gh = 1000 \times 9.81 \times 0.40 = \mathbf{3.9 \times 10^3 \text{ Pa}}$.
2. $A = 0.60 \times 0.30 = 0.18 \text{ m}^2$, $F = PA = 3924 \times 0.18 = \mathbf{7.1 \times 10^2 \text{ N}}$.
3. $W = \rho Vg = 1000 \times (0.18 \times 0.40) \times 9.81 = 706 \text{ N}$, equal to the force on the base because the sides are vertical.

Problem 6 Fully submerged stone

1. A fully submerged object displaces its own volume: $\mathbf{3.0 \times 10^{-4} \text{ m}^3}$.

2. $F_b = \rho Vg = 1000 \times 3.0 \times 10^{-4} \times 9.81 = \mathbf{2.9\ N}$.

Problem 7 Flow rate in a pipe

1. $Q = Av = 4.0 \times 10^{-4} \times 1.5 = \mathbf{6.0 \times 10^{-4}\ m^3/s}$.

2. $V = Qt = 6.0 \times 10^{-4} \times 60 = 0.036\ m^3 = \mathbf{36\ L}$.

Problem 8 Pressure against depth graph

1. Gradient = $(160 - 101) / 6 = \mathbf{9.8\ kPa/m}$.

2. The gradient is ρg , so $\rho = 9.8 \times 10^3 / 9.81 = \mathbf{1.0 \times 10^3\ kg/m^3}$, which is water.

3. $P = 101 + 9.8 \times 8 = \mathbf{1.8 \times 10^2\ kPa}$ (179 kPa).

Problem 9 Float or sink

1. $500\ kg/m^3$ floats, $1000\ kg/m^3$ is neutrally buoyant, $1200\ kg/m^3$ sinks.

2. Fraction = $\rho_{\text{object}} / \rho_{\text{fluid}} = 500/1000 = \mathbf{0.50}$.

3. Its weight equals the buoyant force when fully submerged, wherever it is, so the net force is zero at any depth.

Problem 10 Iceberg

1. Fraction = $917 / 1025 = \mathbf{0.89}$.

2. Above the surface: $1 - 0.89 = \mathbf{0.11}$, about 11 %.

Problem 11 Weight in air and in water

1. $F_b = 4.90 - 4.20 = \mathbf{0.70\ N}$.

2. $V = F_b / (\rho g) = 0.70 / (1000 \times 9.81) = \mathbf{7.1 \times 10^{-5}\ m^3}$.

3. $m = 4.90 / 9.81 = 0.500\ kg$, so $\rho = 0.500 / 7.14 \times 10^{-5} = \mathbf{7.0 \times 10^3\ kg/m^3}$.

Problem 12 Garden hose nozzle

1. $A_1/A_2 = (1.8/0.60)^2 = 9$, so $v_2 = 9 \times 1.2 = \mathbf{11\ m/s}$ (10.8 m/s).

2. $Q = \pi(0.0090)^2 \times 1.2 = 3.05 \times 10^{-4}\ m^3/s = \mathbf{18\ L/min}$.

Problem 13 Hydraulic car lift

1. $P = 150 / 4.0 \times 10^{-3} = \mathbf{3.75 \times 10^4\ Pa}$.

2. $F_2 = PA_2 = 3.75 \times 10^4 \times 0.16 = \mathbf{6.0 \times 10^3\ N}$.

3. Equal volumes: $4.0 \times 10^{-3} \times 0.80 = 0.16 \times d$, so $d = \mathbf{0.020\ m}$. The work in (120 J) equals the work out.

Problem 14 Pressure drop in a fast section

- $P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2) = 2.40 \times 10^5 + 500 \times (1.0 - 25) = \mathbf{2.28 \times 10^5 \text{ Pa}}$.
- The drop is $\mathbf{1.2 \times 10^4 \text{ Pa}}$.

Problem 15 Roof in a strong wind

- $\Delta P = \frac{1}{2}\rho v^2 = 0.5 \times 1.2 \times 20^2 = \mathbf{240 \text{ Pa}}$.
- $F = \Delta P \times A = 240 \times 8.0 = \mathbf{1.9 \times 10^3 \text{ N}}$ upward.
- $W = 150 \times 9.81 = 1.47 \times 10^3 \text{ N}$. Since 1920 N is more than 1472 N, the net force is about $4.5 \times 10^2 \text{ N}$ upward and **the roof lifts**.

Problem 16 Jet from a tank

- P and the tank-top speed are negligible compared with the exit: $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 3.2} = \mathbf{7.9 \text{ m/s}}$.
- $t = \sqrt{2 \times 1.0 / 9.81} = \mathbf{0.45 \text{ s}}$.
- $x = vt = 7.92 \times 0.4515 = \mathbf{3.6 \text{ m}}$.

Problem 17 Venturi flow meter

- $A_1 v_1 = A_2 v_2$ gives $v_2 = 4v_1$.
- $\Delta P = \frac{1}{2}\rho(v_2^2 - v_1^2) = 500 \times 15 v_1^2 = 7500 v_1^2$, so $v_1^2 = 2.0$ and $v_1 = \mathbf{1.4 \text{ m/s}}$.
- $Q = A_1 v_1 = 2.0 \times 10^{-3} \times 1.414 = \mathbf{2.8 \times 10^{-3} \text{ m}^3/\text{s}}$.

Problem 18 Ball held under water

- $F_b = 1000 \times 2.0 \times 10^{-3} \times 9.81 = \mathbf{19.6 \text{ N}}$.
- Forces: B up, weight and tension down. $W = 0.50 \times 9.81 = 4.9 \text{ N}$, so $T = 19.62 - 4.91 = \mathbf{14.7 \text{ N}}$.
- $a = (B - W)/m = 14.7 / 0.50 = \mathbf{29 \text{ m/s}^2}$ upward.

Problem 19 Oil in a U-tube

- Points at the same level in the same connected water: the oil-water interface in the right arm and the point at that level in the left arm.
- $\rho_w g h = \rho_o g (0.120)$ so $h = 800 \times 0.120 / 1000 = \mathbf{0.096 \text{ m}}$.
- $12.0 - 9.6 = \mathbf{2.4 \text{ cm}}$.

Problem 20 Loaded barge

- $V = m/\rho = 3.0 \text{ m}^3$; area = 12 m^2 , so depth = $\mathbf{0.25 \text{ m}}$.
- Total 5400 kg: $V = 5.4 \text{ m}^3$, depth = $5.4 / 12 = \mathbf{0.45 \text{ m}}$.
- Maximum displaced mass = $1000 \times 12 \times 0.80 = 9600 \text{ kg}$, so the load is $9600 - 3000 = \mathbf{6.6 \times 10^3 \text{ kg}}$.

4. Depth = $5400 / (1025 \times 12) = \mathbf{0.44\ m}$, slightly higher in the water.