BID: Hydrostatic pressure

The Big Idea

When you are below a layer of fluid (gas or liquid), the weight of all the fluid above you pushes down on you creating pressure over your surface area.

More details

An incompressible fluid is one where the density is pretty much the same throughout the column of fluid above you. In other words, the fluid at the bottom doesn't get compressed and become more dense due to the weight of all the fluid above it pushing down. Most liquids can be treated this way for our purposes. If the fluid meets these conditions, then the pressure can be found using the formula: $P = \rho gh$

How to recognize it

Most problems are going to ask for the pressure on an object or the force on an object at a given depth of liquid. Often the problem will be combined with a buoyant force or apparent weight problem for the same object. See the help sheet on buoyant force/apparent weight for that part of the problem.

How to tackle it

If the problem asks for the pressure at a given depth, just plug and chug using the formula above. If they ask for force on an object at a certain depth, you need to multiply the pressure times the surface area of the object. Often the problem will also require you to determine the surface area as well. (A common shape for problems is a sphere: $A_{sphere} = 4\pi r^2$)

Pitfalls to watch for

1) If problem is under water, fresh or seawater? (Slightly different densities)
2) If the problem asks for "absolute" or "total" pressure, then you need to add atmospheric pressure to total. Also, remember if you have hollow object like a sub, then there is 1 atm from inside pushing out.
3) Be EXTRA careful as to whether the problem asks for "pressure" or "force". (Use P=F/A to convert)

Example problem

A solid gold coin that is 5 cm in diameter and 2.5 mm thick is lying on the bottom of the ocean at a depth of 5,250 m. a) What is the force on the coin? b) What is the buoyant force on the coin?

Solution:

a) $P = \rho gh = 1025 \text{ kg/m}^3 \cdot 9.8 \text{ m/s}^2 \cdot 5250 \text{ m} = 52{,}736{,}250 \text{ Pa}$

$A = 2\pi r \cdot h + 2 \cdot (\pi r^2) = 2\pi \cdot 0.025 \text{ m} \cdot 0.0025 \text{ m} + 2\pi \cdot (0.025 \text{ m})^2 = 4.32\text{x}10^{-3} \text{ m}^2$

$F = P \cdot A = 52{,}736{,}250 \text{ Pa} \cdot 4.32\text{x}10^{-3} \text{ m}^2 =$ $\boxed{228{,}000 \text{ N or } 2.28 \text{ kN}}$

b) "Buoyant force/apparent weight" help sheet gives more info on how to do this type of problem.

$F_b = \rho Vg = \rho \cdot \pi r^2 h \cdot g = 1025 \text{ kg/m}^3 \cdot \pi \cdot (0.025 \text{ m})^2 \cdot 0.0025 \text{ m} \cdot 9.8 \text{ m/s}^2 =$ $\boxed{0.0493 \text{ N}}$