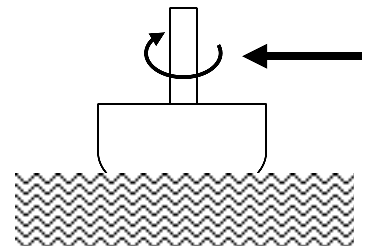
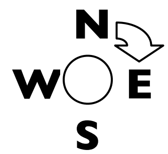
Name______________________________Pd________

Archimedes, Pascal, & Bernoulli: Three Really Dense Guys

1. A ship is constructed that has a mast that rotates due to a motor. There are no sails and there are no engine or propellers. The wind is from the north. If the mast rotates clockwise (as seen from above), in which direction will the ship move? Explain why. If the ship's mast were to rotate in the opposite direction, which way would the ship move? (This really does work, and a ship was built that used this method for "emergency" propulsion!)





Since the velocity of the wind will be faster on the East side of the mast and slower on the West side of the mast, that means there will be low pressure on the East side and the ship will be slowly accelerated to the EAST.

2. An irregularly shaped rock has an average density of 8 g/cm^3 and a weight in air of 90 N. When the rock is suspended in water and fully submerged, what will be the tension in the supporting wire?

$W = 10 \cdot m$, so $m = 9$ kg $\quad \rho = 8000$ kg/m^3 $\quad V = m/\rho = 9/8000 = 0.001125$ m^3

Force diagram $F_T + F_B = F_W$ (ups=downs), so $F_T = F_W - F_B$ $\quad F_T = 90 - (8000)(10)(.001125) = 90 - 11.2 = 78.8$ N

3. __A__ "Change in pressure exerted at any point in a confined fluid is transmitted undiminished in all directions to all points in the fluid" is a statement of… A. Pascal's Principle B. Archimedes' Principle C. Bernoulli's Principle D. First Law of Thermo

4. A bracelet that appears to be gold is suspended from a spring scale that reads 50 g in air and 46 g when the bracelet is submerged in water. The density of pure gold is 19 g/cm^3. Is the bracelet pure gold? If it is an alloy, is it mixed with something of greater or lesser density than gold?

$F_B = 0.5 - 0.46 = 0.04$ N

$F_B = \rho g V = 1000(10)V = 0.04$

So $V = 4 \cdot 10^{-6}$ m^3

$\rho = m/V = 0.05/4 \cdot 10^{-6} = 12500$ kg/m^3

So, it is an alloy of gold that was mixed with something less dense.

5. A block of oak has a density of $7.2 \cdot 10^2$ kg/m^3, and will thus float when placed in water. What percentage of the block will be above the waterline?

By Archimedes: $W_{\text{Fluid displaced}} = W_{\text{Object}}$ and weight = m·g, so $m_{\text{Fluid displaced}} = m_{\text{Object}}$ using $\rho V = m$, we get

$\rho_{\text{Fluid}} V_{\text{Submerged}} = \rho_{\text{Object}} V_{\text{Total}}$ Percent is defined as part of the total, so solve for $V_{\text{Submerged}} / V_{\text{Total}}$

That means the % submerged is $\rho_{\text{Object}} / \rho_{\text{Fluid}}$! % submerged is 720/1000 or 72%, so

% above surface = 28%

6. Water flows through a hose of radius 6 mm at a rate of 2.5 m/s. What should the radius of the nozzle be to make the water leave at 10 m/s? About how long would it take to fill a 34 liter bucket?

$J_{\text{hose}} = J_{\text{water}}$ $\quad A_1 v_1 = A_2 v_2$

$\pi(.006)^2(2.5) = \pi(r)^2(10)$ [π cancels out]

$r = 0.003$ m **or** 3 mm

$J = 0.00028$ m^3/s $= V/t$

$0.00028 = 0.034 / t$

$t = 121$ s **or** about 2 mins

7. A boat strikes an underwater rock and opens a pencil-sized crack 7 mm wide and 150 mm long in its hull, 65 cm below the waterline. If the crew takes 5 minutes to locate and plug the crack, how much water will they have to pump out of the hold? How much does that water weigh? $P_1 + \rho g h_1 + {}^1/_2 \rho v_1^2 = P_2 + \rho g h_2 + {}^1/_2 \rho v_2^2$ If the "1" side of the equation is outside the ship…

P_1 is just the $\rho g h$ value at the depth of the crack. h_1 and h_2 are the same (the water entering the crack flows straight in), v_1 will be 0 if the boat is stopped after the damage, P_2 will be zero since there's no water in the ship initially. We're left with $P_1 = {}^1/_2 \rho v_2^2$ And plugging in gives us a speed of 3.61 m/s

$V/t = A \cdot v$, so $V = A \cdot t \cdot v = 0.00105(300)(3.61) = 1.14$ m^3.