Yost, S.A.

General Physics I **Sect. 99**

Set 12 **Chapter 13**

Due Fri, Mar 26, 2004 at 17:00 *CAPA* ID 2376

Giancoli 13-6:

1. [1pt] If 5.00 l of antifreeze solution (specific gravity = 0.820) is added to 3.80 l of water to make a 8.80 l mixture what is the specific gravity of the mixture?

8.98×10^{-1} $[8.80 \times 10^{-1}, 9.16 \times 10^{-1}]$

The specific gravity of a substance is the ratio of its density to the density of water. If a volume $V_1 = 5.00\,l$ of antifreeze is added to a volume $V_2 = 3.80\,l$ of water, the density of the mixture is

$$\rho_{12} = (\rho_1 V_1 + \rho_2 V_2)/V_{12},$$

where $V_{12} = 8.80\,l$ is the volume of the mixture, ρ_2 is the density of water, and $\rho_1 = 0.820\ \rho_2$ is the density of the antifreeze. Dividing ρ_{12} by ρ_2 gives the specific gravity of the mixture,

$$(0.820 V_1 + V_2)/V_{12} = 0.898.$$

Giancoli 13-10:

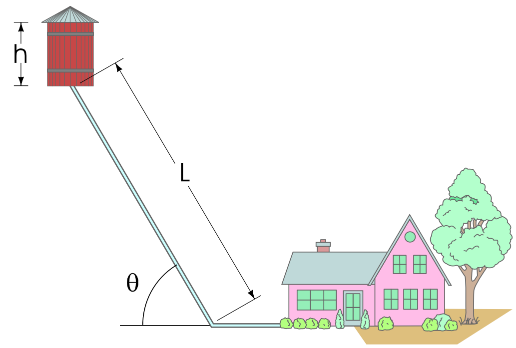
2. [1pt] The gauge pressure in each of the four tires of an automobile is 237 kPa. If each tire has a "footprint" of 212 cm^2, calculate the mass of the car.

2.05×10^3 $[2.01 \times 10^3, 2.09 \times 10^3]$ kg

We will assume the tires are inflated just enough to support the car. The gauge pressure is the additional pressure in the tires beyond atmospheric pressure, which is due to the weight of the car. If the mass of the car is m, then the force on each tire is $\frac{1}{4}mg$. The force on each tire is also equal to the gauge pressure times the area of the tire's "footprint", so $\frac{1}{4}mg = PA$, where $P = 2.37 \times 10^5\ N/m^2$, and $A = 2.12 \times 10^{-2}\ m^2$. Therefore, $m = 4PA/g = 2.05 \times 10^3\ kg$.

Giancoli 13-16:

3. [1pt] Determine the water gauge pressure at a house at the bottom of a hill fed by a full tank of water $h = 4.82\,m$ deep and connected to the house by a pipe that is $L = 120\,m$ long at an angle of $\theta = 64.7°$ from the horizontal (see figure below).



Neglect turbulence, and frictional and viscous effects.

1.11×10^6 $[1.09 \times 10^6, 1.13 \times 10^6]$ N/m^2

The gauge pressure at the house is $P = \rho g y$, where $\rho = 1000\ kg/m^3$ is the density of water, and $y = h + L \sin\theta = 113.3\,m$ is the height of the top of the water above the house. The gauge pressure is then $P = 1.11 \times 10^6\ Pa$.

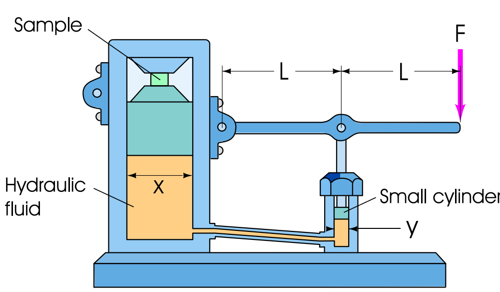
4. [1pt] How high would the water shoot if it came vertically out of a broken pipe in front of the house?

1.13×10^2 $[1.11 \times 10^2, 1.16 \times 10^2]$ m

The water would shoot to a height where its gravitational potential energy is equal to the gravitational potential energy at the top of the tank, so it would shoot to the height of the top of the tank, $y = 113\,m$, neglecting viscosity, turbulence, and air resistance.

Giancoli 13-20:

5. [1pt] A hydraulic press for compacting powdered samples has a large cylinder which is $x = 11.5\,cm$ in diameter, and a small cylinder with a diameter of $y = 1.86\,cm$ (see figure below).



A lever is attached to the small cylinder as shown. The sample which is placed on the large cylinder, has an area of $3.88\,cm^2$. What is the pressure on the sample if $F = 309\,N$ is applied to the lever?

6.09×10^7 $[5.97 \times 10^7, 6.21 \times 10^7]$ N/m^2

The pressure $P_2 = F_2 A_2$ on the large cylinder must equal the pressure $P_1 = F_1 A_1$ on the small one. Since the area of each cylinder is proportional to its diameter, this implies that

$$F_2 = F_1\ A_1/A_2 = F_1(\text{x}/\text{y})^2 = 38.2 F_1.$$

The pressure on the sample is $P = F_2/A$, where $A = 3.88 \times 10^{-4}\ m^2$ is the area of the sample. Balance of torques about the lever pivot shows that $2LF = LF_1$, or that $F_1 = 2F$, where $F = 309\,N$ is the force on the end of the handle. Therefore,

$$P = 38.2 \times 2F/A = 6.09 \times 10^7\,N/m^2.$$

Giancoli 13-34:

6. [1pt] A scuba diver is diving off the shores of the Cayman Islands. The diver and her gear displace a volume of $66.9\,l$ and have a total mass of $65.3\,kg$. What is the buoyant force on the diver?

6.72×10^2 [6.59×10^2,6.85×10^2] N

The bouyant force is equal to the weight of the water displaced by the diver and her gear, which is $F = \rho V g$, where $\rho = 1.025 \times 10^3\,kg/m^3$ is the density of sea water, and $V = 6.7 \times 10^{-2}\,m^3$ is the volume of the diver ($1\,l = 1 \times 10^{-3}\ m^3$). This gives $F = 672\,N$.

7. [1pt] What is the net force?

3.21×10^1 [3.14×10^1,3.27×10^1] N

The net force on the diver is the buoyant force minus her weight, including the equipment, or $672\,N$ - $mg = 32\,N$.

Giancoli 13-40:

8. [1pt] A $3.13\,kg$ piece of wood (SG = 0.500)) floats on water. What minimum mass of copper, hung from it by a string, will cause it to sink?

3.53 [3.46,3.60] kg

The wood and copper together will have neutral buoyancy when the specific gravity of the combination is equal to 1. If $m_1 = 3.13\,kg$ is the mass of the wood and $\rho_1 = 0.500$ is its specific gravity (the density in units of the density of water), and m_2 is the unknown mass of the copper, which has specific gravity $\rho_2 = 8.90$, then the specific gravity of the combination is the total mass divided by the total volume, or

$$1 = \rho_{12} = \frac{m_1 + m_2}{m_1/\rho_1 + m_2/\rho_2} = \frac{\rho_1\rho_2(m_1 + m_2)}{\rho_2 m_1 + \rho_1 m_2}. \quad (1)$$

Then the mass of copper needed is

$$m_2 = m_1 \left(\frac{1/\rho_1 - 1}{1 - 1/\rho_2} \right) = 3.53\,kg. \quad (2)$$

Giancoli 13-46:

9. [1pt] A $3/8\,in.$ (inside) diameter garden hose is used to fill a round swimming pool $8.32\,m$ in diameter. How many days will it take to fill the pool to a depth of $1.27\,m$ if water issues from the hose at a speed of $0.356\,m/s$? Do not enter units.

3.15×10^1 [3.09×10^1,3.21×10^1]

The volume rate of flow is $Av = \frac{1}{4}\pi {D_1}^2 v$ where $D_1 = 3/8\,in.$ $= 9.52 \times 10^{-3}\,m$ is the interior diameter of the hose ($1\,in. = 2.54\,cm$). The length of time it takes to fill the pool will be the volume of the pool divided by the volume rate of flow. The volume of the pool is $V = \frac{1}{4}\pi {D_2}^2 h$, where $D_2 = 8.32\,m$ is the pool's diameter and $h = 1.27\,m$ is its depth. Then $V = 8.30\,m^3$, and the time to fill the pool is $V/(Av) = 2.72 \times 10^6\,s$. There are 86,400 seconds in a day, so it will take 31.5 days to fill the pool.

Giancoli 13-50:

10. [1pt] If wind blows at $22.9\,m/s$ over your house, what is the net force on the roof if its area is $232\,m^2$?

7.85×10^4 [7.69×10^4,8.00×10^4] N

Apply Bernoulli's Principle to the air above the roof and below the roof. The height is the same in both cases, and the speed of the air is zero inside the house, so Bernoulli's Principle states that

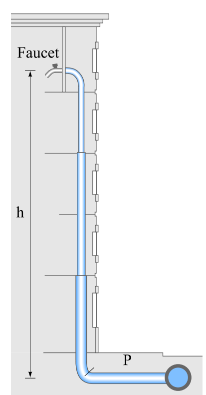
$$P_2 + \tfrac{1}{2}\rho v^2 = P_1,$$

where P_1 and P_2 are the pressures below and above the roof, respectively, $\rho = 1.29\ kg/m^3$ is the density of air, and v is the wind speed. The net force on the roof is the pressure difference P_1 - P_2 times the area $A = 232\,m^2$ of the roof:

$$F = \tfrac{1}{2}\rho v^2 A = 7.85 \times 10^4\,N.$$

Giancoli 13-54:

11. [1pt] Water at a gauge pressure of $P = 3.96\ atm$ at street level flows into an office building at a speed of $0.556\,m/s$ through a pipe $4.91\,cm$ in diameter. The pipes taper down to $2.30\,cm$ in diameter by the top floor, $h = 19.7\,m$ above (see figure below).



Calculate the flow velocity and the gauge pressure in such a pipe on the top floor. Assume no branch pipes and ignore viscosity.

2.53 [2.48,2.58] m/s

2.02 [1.98,2.06] atm

The flow velocity at the top floor is determined by the continuity equation. The volume rates of flow at the bottom and top must be equal: $A_1 v_1 = A_2 v_2$, where point 1 is at street level and point 2 is on the top floor. Since the areas of the pipes are proportional to the diameters, $v_2 = v_1(d_1/d_2)^2 = 2.53\,m/s$ at

the top floor.
The gauge pressure at the top floor is given by the Bernoulli equation:

$$P_2 + \rho g h + \frac{1}{2}\rho {v_2}^2 = P_1 + \frac{1}{2}\rho {v_1}^2.$$

The gauge pressure at the entrance to the building is $P_1 = 3.96\, N/m^2$, and the density of water is $\rho = 1000\ \ kg/m^3$. Using the velocity v_2 found in the first part of the problem, the gauge pressure at the top floor is found to be

$$P_2 = P_1 + \rho\big[h + \frac{1}{2}({v_1}^2 - {v_2}^2)\big] = 2.05 \times 10^5\, N/m^2.$$

In terms of atmospheres, $P_2 = 2.02\, atm$.

Giancoli 13-92:

12. [1pt] The drinking fountain outside your classroom shoots water about $14.5\, cm$ up in the air from a nozzle of diameter $0.618\, cm$. The pump at the base of the unit ($1.09\, m$ below the nozzle) pushes water into a $1.23\, cm$ diameter supply pipe that goes up to the nozzle. What gauge pressure does the pump have to provide? Ignore the viscosity; your answer will therefore be an underestimate.

1.20×10^4 [1.18×10^4,1.23×10^4] N/m^2

First, apply Bernoulli's equation to point 1 at the pump and point 2 at the nozzle. The pressure just outside the nozzle is atmospheric, so the gauge pressure there is zero, and Bernoulli's equation gives

$$P_1 + \frac{1}{2}\rho {v_1}^2 = \rho g L + \frac{1}{2}\rho {v_2}^2,$$

where $\rho = 1000\ \ kg/m^3$ is the density of water and $L = 1.09\, m$ is the height of the nozzle above the pump. Therefore, the gauge pressure supplied by the pump must be

$$P_1 = \rho g L + \rho({v_2}^2 - {v_1}^2).$$

The velocities v_1 and v_2 are related by the continuity equation, $A_1 v_1 = A_2 v_2$, or equivalently, $v_1 = v_2 (d_2/d_1)^2$, since the area is proportional to the square of the diameter. Then

$$P_1 = \rho g d + \rho v^2 \left[1 - \left(\frac{d_2}{d_1}\right)^4\right] \qquad (3)$$

Applying Bernoulli's equation to the nozzle and the top of the trajectory when the water shoots up gives another relation, $\frac{1}{2} 1025 {v_2}^2 = 1025 g h$, where $h = 0.1\, m$ is the height the water shoots up. Substituting this relation for ${v_2}^2$ in the previous equation for P_1 gives

$$P_1 = \rho g \left\{ d + h \left[1 - \left(\frac{d_2}{d_1}\right)^4\right]\right\}. \qquad (4)$$

Substituting the given parameters now gives $P_1 = 1.20 \times 10^4\, N/m^2$.