Review Problems: Unit 5

1. A cube of some material is at a certain temperature T, and so it emits a certain amount of energy per second by radiation. Suppose that the cube were cut into two separate pieces, with each piece still at temperature T. The radiant power emitted by the two cut pieces is

_____larger than before cutting
_____equal to that before cutting
_____smaller than before cutting
_____depends on the sizes of the new pieces.

2. A weight is hung from the end of a spring scale, and the scale reads 20 N. A beaker of water is sitting on a platform scale that reads 90 N. When the weight is lowered into this water, the spring scale reads 5 N. The platform scale will now

_____still read 90 N
_____read 95 N
_____read 105 N
_____read 110 N

3. Is a material with a density of 10 kg/m^3 more or less dense than a material that causes a pressure of 10 N/m^3?

____more
____less
____the same
____not enough information to answer

4. Explain which methods of heat transfer are involved in each of the following situations.

a. after sitting in your cold car in the parking lot all day, your wool mittens feel warm to the touch, while the steering wheel feels cold.

b. on a cold winter day, you feel colder if a strong wind is blowing.

c. on a sunny summer day, the grass feels pleasant to your bare feet while the asphalt feels very hot.

d. a common method of thawing a turkey is to put it in the sink and let cold water run over it for several hours.

e. the water pipes in your cabin are more likely to freeze in a winter in which the snow comes late.

5. An ice cube floats in a glass of water. As the ice cube melts, does the water level in the glass rise, fall, or stay constant? Explain your reasoning.

Suggestion: you can do this by reasoning alone. But if you prefer, pick a mass for your ice cube and do a problem. The question is, does the ice displace more water when it is ice, or after it has melted. Or is it the same?

6. An exterior wall in your house consists of an outer layer of wood and an inner layer of insulation. The layers are equally thick.

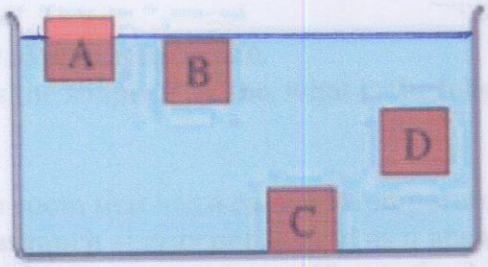
a. which material would you expect to have a higher coefficient of thermal conductivity?

b. on a cold winter day, your furnace is on. Is the temperature at the wood/insulation interface closer to the temperature inside your house or closer to the temperature outside? Explain your reasoning.

7. Four objects are at rest in a tub of fluid. A is partially submerged, and B, C, and D are totally submerged. All have the same volume.

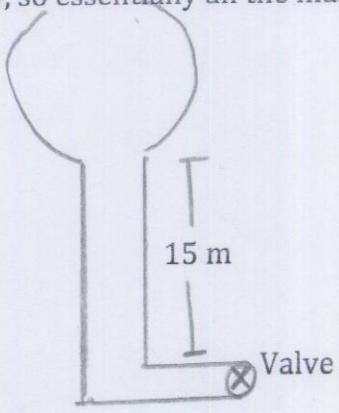
a. rank the densities of the objects, from highest to lowest.

b. rank the magnitude of the buoyant force on each object, highest to lowest.



8. Several days after a snowstorm, you notice that one neighbor's house has its roof uniformly covered with snow, while the snow has largely melted on another roof. Which house is better insulated? Explain.

9. The water tower in the drawing is drained by a pipe at ground level which can be closed by a valve. The water is held in a spherical reservoir which is vented to the atmosphere at the top. When the reservoir is full and the vale at the bottom is closed, the pressure at the valve is 3.45×10^5 N/m^2. Find (a) the radius of the spherical chamber, and (b) the mass of water stored. Assume that the stem is quite narrow, so essentially all the mass of stored water is in the sphere.

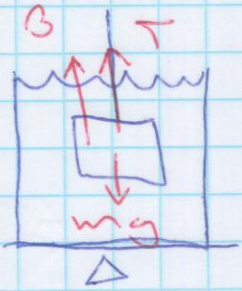


Rev Probs Unit 5

1.  Same amount of material, but more surface area.

$$\frac{Q}{\Delta t} = e\sigma A T^4$$

A larger means $Q/\Delta t$ larger

2. 

Water exerts B upward on mass, so mass exerts B downward on water. Scale reading increases by B.

Since spring scale decreased by 15 N, B must = 15 N.

Platform scale now reads 105 N.

3. Not enough info. Pressure and density are different concepts.

4. a. Conduction. Wool is a good insulator; steering wheel is a conductor.

b. Convection. You warm a layer of air around yourself, and it is blown away.

c. Radiation. Asphalt has emissivity much higher than grass, so radiates more energy into you.

d. Convection + Conduction. Heat conducts from water → turkey. That water, which is now colder, flows away & is replaced by warmer water.

e. Conduction. Snow would insulate ground and keep it warmer.

3. Method 1: Since you like numbers, pick a mass for the ice cube. The Question is: does the ice displace more water when frozen or after it melts? Or same either way?

- redo problem 2 with fresh water. You should find the % underwater is 0.917 %.

Let $m = 0.50$ kg. What is volume of 0.50 kg ice and 0.50 kg water?

$V = \frac{m}{\rho}$ Ice: $V = \frac{0.50}{917} = 5.45 \times 10^{-4}\ m^3$

Water: $V = \frac{0.50}{1000} = 5.00 \times 10^{-4}\ m^3$

Ice: $V_{DISP} = 0.917V = 0.917(5.45 \times 10^{-4}) = 5.0 \times 10^{-4}$

Water: $V_{DISP} = V = 5.00 \times 10^{-4}\ m^3$

SAME. Water level does not change.

Method 2: Think $B = \rho V g]_{DISP}$.

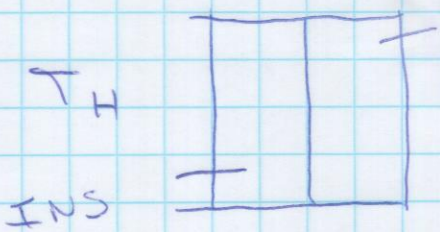
The water supports the ice whether it is frozen or melted. Since B does not change as it melts, V_{DISP} does not change.

4. Anchor displaces more water when in Boat than at bottom.

Less V_{DISP} after you drop anchor. Boat sits higher.

So water level at side goes down.

6.

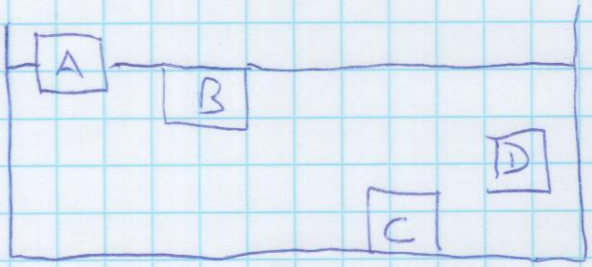


$k_{WOOD} > k_{INS}$.

High k means good conductor of heat.

Insulation 'insulates'. It means heat does not flow easily across the material. ΔT across insulation should be large. So T_{MIDDLE} is closer to $T_{OUTSIDE}$

7.



Densities: $C > (D = B) > A$

D and B are both fully submerged, so displace same V of fluid. Must have same ρ, since for all blocks

$(\rho V g)_{FLUID\ DISP} = (\rho V g)_{BLOCK}$

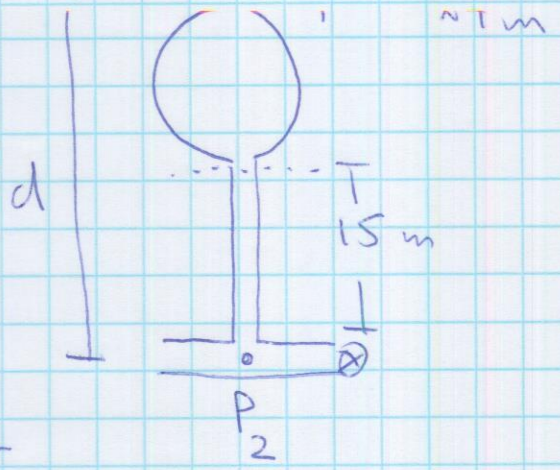
B: $(C = D = B) > A$ A has less volume displaced.

8. The roof with snow on is better insulated. Has larger ΔT across it, so outside is too cold to melt.

4. $P_2 = P_1 + \rho g d$

$3.45 \times 10^5 = 1.013 \times 10^5 + (1000)(9.8)d$

$d = 25 \text{ m}$



so sphere has diameter $25 - 15 = 10$ m

$r_{SPHERE} = 5$ m

$V_{SPHERE} = \frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi (5)^3$

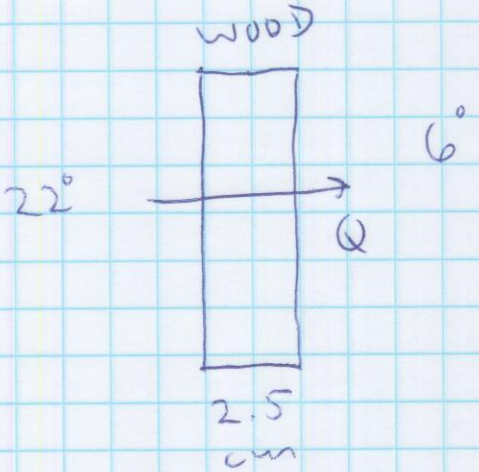
$= 524 \text{ m}^3$

mass of water that completely fills sphere is $m = \rho V$

$m = (1000 \text{ kg/m}^3)(524 \text{ m}^3)$

$m = 5.24 \times 10^5 \text{ kg}$

10.

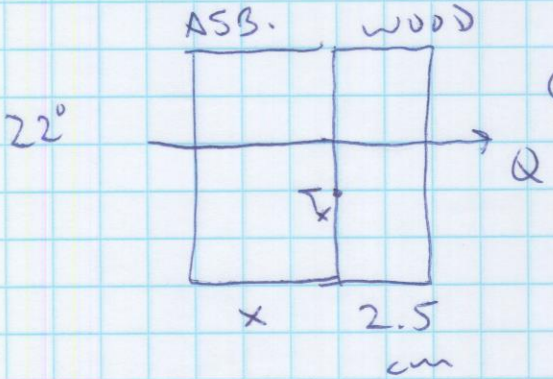


$$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L} = \frac{(0.15)(18)(22-6)}{0.025}$$

$$\frac{Q}{\Delta t} = 1728 \text{ J/s}$$

Want 10% of this:

Want new $\frac{Q}{\Delta t} = 172.8$ J/s



$$\left(\frac{Q}{\Delta t}\right)_{WOOD} = \left(\frac{Q}{\Delta t}\right)_{ASB.}$$

$$\left(\frac{kA\Delta T}{L}\right)_{WOOD} = \left(\frac{kA\Delta T}{L}\right)_{ASB}$$

and both = desired $Q/\Delta t = 172.8$ J/s

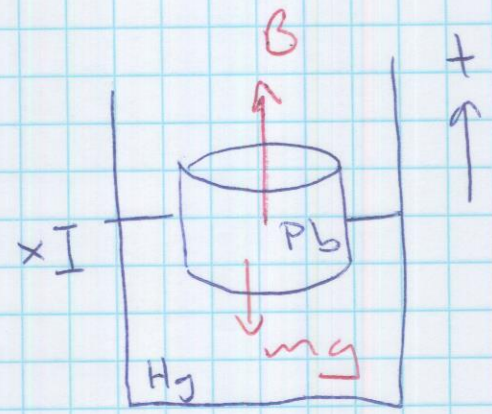
Wood: $172.8 = \frac{(0.15)(18)(T_x - 6)}{0.025}$

$T_x = 7.6°C$

Asb: $172.8 = \frac{(0.09)(18)(22 - 7.6)}{x}$

$x = 13.5$ cm

11.



$$\Sigma F = ma$$

$$B - w = 0$$

$$(\rho V g)_{Hg} = (\rho V g)_{puck}$$

$$\rho_{Hg}(\pi r^2 x) = \rho_{Pb}(\pi r^2 h)$$

$$x = \frac{\rho_{Pb}}{\rho_{Hg}} h$$

$$x = \frac{11300}{13600}(2.5\ cm)$$

$$x = 2.08\ cm$$

$$V_{DISP} = \pi r^2 x$$

$$= \pi(0.0375\ m)^2(2.08 \times 10^{-2}\ m)$$

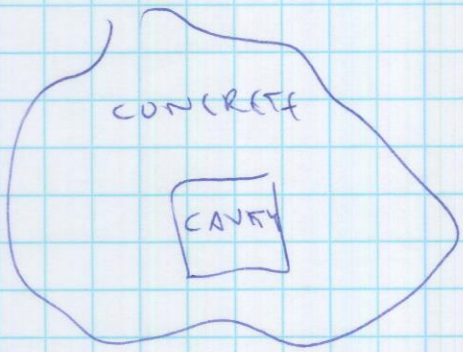
$$= 9.2 \times 10^{-5}\ m^3$$

(83 percent submerged)

#12.

$\rho_{CONCRETE} = 2200 \text{ kg/m}^3$

$m = 33 \text{ kg}$



$\rho = \frac{m}{V}$

So this mass of concrete should have a volume of

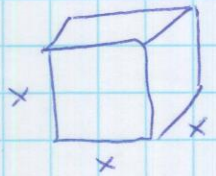
$$V = \frac{m}{\rho} = \frac{33}{2200} = 0.015 \text{ m}^3$$

so $V_{CAVITY} = 0.025 - 0.015 = 0.010 \text{ m}^3$

Cube. $V = x^3$

$0.010 \text{ m}^3 = x^3$

$x = 0.215 \text{ m}$



13. $\left.\frac{Q}{\Delta t}\right]_{EMITTED} = 3\left.\frac{Q}{\Delta t}\right]_{ABSORBED}$

$e\sigma A T_{OBJ}^4 = 3\, e\sigma A T_{ROOM}^4$

$T_{OBJ}^4 = 3T_{ROOM}^4$

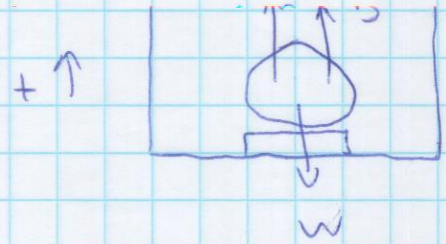
$= 3(20 + 273\ K)^4$

$T_{OBJ} = 386\ K$

$= 113^\circ C$

Emission depends on object: its emissity, surface area, & temperature.

Absorption by object depends on its <u>own</u> emissity & surface area, since <u>it</u> absorbs. & Temperature of environment, since it absorbs from environment.



$\Sigma F = ma$

$n + B - W = 0$

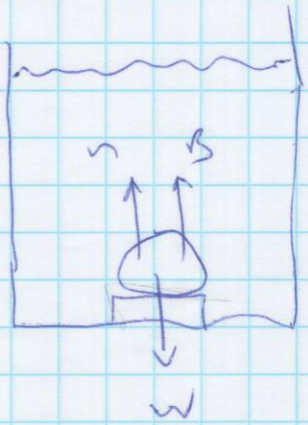
$n = W - B$

$= [\rho V g]_{OBJ} - [\rho V g]_{DISP}$

Completely submerged: $V_{OBJ} = V_{DISP}$

$120\ N = (2660)V(9.8) - (1000)V(98)$

$V = 7.376 \times 10^{-3}\ m^3$ is volume of object



Mystery Fluid:

$\Sigma F = ma$

$n + B - W = 0$

$n = W - B$

$n = \rho_{Qu} V_{Qu} g - \rho_? V_{DISP} g$

again, $V_{OBJ} = V_{DISP}$

$134\ N = (2660)Vg - \rho_? Vg$

$134 = (2660 - \rho_?)(7.376 \times 10^{-3})(9.8)$

$\rho_? = 806\ kg/m^3$

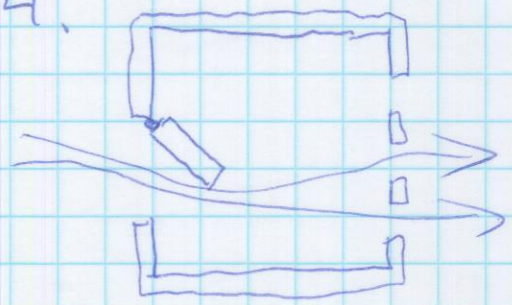
from chart: Ethyl Alc.

Bernoulli

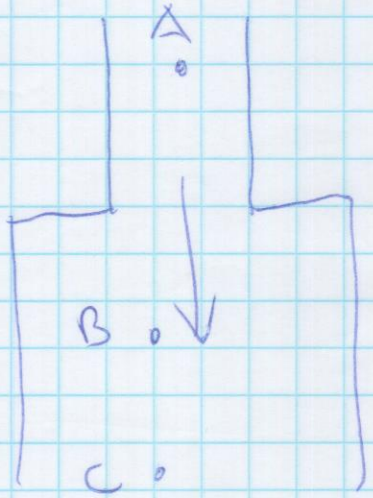
2. In open air: so pressure everywhere in stream is atmospheric.

3. 

Water spreads out and occupies a larger cross-section. v decreases due to gravity, and $A_1 v_1 = A_2 v_2$

4. 

Air flow through house causes high air speed through door (and windows!) Door will swing shut.

5. 

$$P_1 + \rho g Y_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g Y_2 + \tfrac{1}{2}\rho v_2^2$$

and $A_1 v_1 = A_2 v_2$

so
Velocities: $A > (B = C)$

Pressures: B and C have = vel, B has higher Y so lower P.

$B < C$

A has highest v and highest Y_1, so smallest P.

P: $C > B > A$