Name:________________	ID:________________

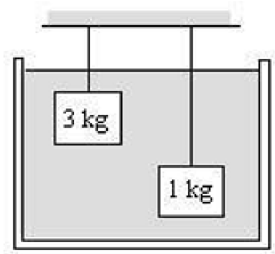
Physics 202
Midterm Exam 2
2/21/2018

** Note **
The answer boxes are for the final number or yes/no type answers. You must still explain your reasoning outside of the box

Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating/graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

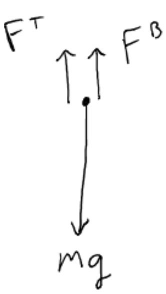
Constants and Conversions
$k_B = 1.38\times10^{-23}$ J/K, R = 8.31 J/mol·K, p_{atm} = 101,300 Pa, 1 cal = 4.19 J, 1 liter = 1×10^{-3} m^3, c_{water} = 4190 J/kg·K, c_{ice} = 2090 J/kg·K, c_{copper} = 385 J/kg·K, $c_{aluminum}$ = 900 J/kg·K, $L_{f,water} = 3.33\times10^5$ J/kg, $L_{v,water} = 22.6\times10^5$ J/kg, k_{copper} = 400 W/m·K, $k_{aluminum}$ = 157 W/m·K, $\sigma = 5.67\times10^{-8}$ W/m^2·K^4, $k_{human\ tissue}$ = 0.20 W/m·K, $\rho_{aluminum}$ = 2700 kg/m^3, ρ_{air} = 1.28 kg/m^3, ρ_{water} = 1000 kg/m^3, $\rho_{mercury}$ = 13.6 x 10^3 kg/m^3, ρ_{lead} = 11.3 x 10^3 kg/m^3

1. (6 points) Two blocks, of unequal size, are suspended by strings and hung fully submerged in water. The 3 kg block is made of lead while the 1 kg block is made of aluminum. Find the tension in each string?



Volume of Block: $V = \frac{m}{\rho}$ (density of block → ρ), Buoyancy Force: $F^B = \rho_w V g = \rho_w \frac{m}{\rho} g$

FBD (Block)



$$\sum F_y \Rightarrow F^T + F^B - mg = m a_y^{\,0}$$

$$F^T = mg - F^B$$

$$F^T = mg - \rho_w \frac{m}{\rho} g = mg\left(1 - \frac{\rho_w}{\rho}\right)$$

1kg block: w/ ρ_{Al}, $F_1^T = 6.17\,N$

3kg block: w/ ρ_{lead}, $F_3^T = 26.8\,N$

Rubric
1pt - Volume of Block
1pt - F^B equation
1pt - F^B application w/ $V = \frac{m}{\rho}$
0.5pt - FBD
1pt - $\sum F$
1pt - finding F^T
0.5pt - Answer + units

answers

T_1 =	T_3 =

For questions 2 through 5 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **8** correct answers in this section and only the first **8** circled answers will be graded. There is no partial credit.

2. You may have noticed that when you get out of a swimming pool and stand dripping wet in a light breeze, you feel much colder than you feel after you dry off. Which *one* of the following statements is *most* true regarding this situation?

[N] (a) The moisture on your skin has good thermal conductivity.
[Y] (b) 540 calories of heat are required to evaporate each gram of water from your skin, and most of this heat flows out of your body, an effect called evaporative cooling.
[N] (c) Water has a relatively large heat capacity.
[N] (d) The water on your skin is colder than the surrounding air.
[N] (e) This is a purely psychological effect resulting from the way in which sensory nerves in the skin are stimulated.

3. bad problem

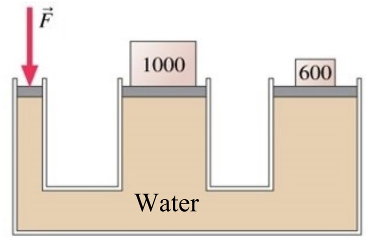
4. The tires of a car support the weight of a stationary car. If one tire has a slow leak, the air pressure within the tire will _______ with time, the surface area between the tire and the road will ________ with time, and the net force the tire exerts on the road will ___________ with time.

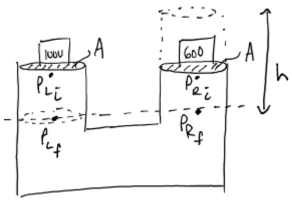
[T] (a) decrease, increase, remain constant
[F] (b) increase, decrease, remain constant
[F] (c) decrease, increase, decrease
[F] (d) decrease, decrease, decrease
[F] (e) increase, increase, increase
[F] (f) decrease, increase, increase

5. A long bar of copper is placed vertically in a large boiling pot of water that maintains a boil. A block of ice is placed on top of the bar and allowed to melt. If you assume the only transfer of energy to the ice is through the bar, which of the following actions will melt the ice more quickly.

[F] (a) Lengthening the bar.
[T] (b) Using a bar that is identical in every way but that it has a larger diameter.
[F] (c) Using a aluminum bar.
[F] (d) Create a more rigorous boil in the water.
[F] (e) Vaporize the water but don't raise the resulting (contained) gas past 100 ºC.
[T] (f) Vaporize the water and raise the resulting (contained) gas up past 100 ºC.

6. (6 points) Two different masses, 1000 kg and 600 kg, are initially placed on top of equal 1.20-m-diameter low friction pistons. The pistons are connected to a third piston where a force **F** is applied such that it doesn't move. Water is the hydraulic fluid. Do the pistons move? If so, how much, if not, why?





w/ $P = \frac{F}{A}$, A = constant but $F \neq$ constant

$P_L \neq P_R$ & system is not in equilibrium

The 1000kg mass moves down & the 600kg moves up until the pressures are equal at the same height in the fluid.

$P_{Lf} = \frac{1000g}{A}$, $P_{Rf} = \frac{600g}{A} + \rho g h$, so, $\frac{1000g}{\pi r^2} = \frac{600g}{\pi r^2} + \rho g h$

$h = 0.354m$ ... but each moves $\frac{h}{2} = 0.177m$

Rubric

0.5pt - pistons move

0.5pt - 1000 moves down while 600 moves up

1pt - $P = \frac{F}{A}$ eq.

1pt - P @ depth $= P_{top} + \rho g h$ eq.

2pts - Application ... setting $P_{Lf} = P_{Rf}$

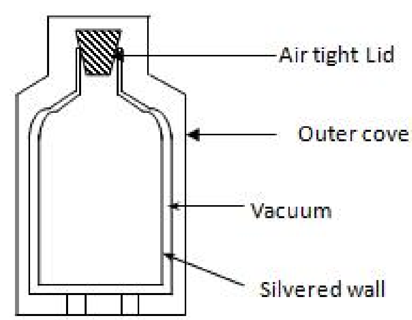
0.5pts - $A = \pi r^2$ eq.

0.5pt - Correct Answer + units

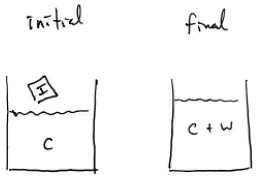
answer

7. (4 points) Thermoses are designed to minimize temperature changes of their contents. The figure shows a schematic of a thermos. Explain how the design addresses all three heat transfer mechanisms.

Air tight lid and outer cover prevent **convection**.
Vacuum minimizes **conduction**.
Silvered wall reflects **radiation**.



8. (7 points) How many grams of ice, initially at -5 °C, must be added to 300 g of coffee at 45 °C if the goal is to cool the coffee to 35 °C?



$$\Sigma Q = 0, \quad Q_{I_{-5\to 0}} + Q_{I_f} + Q_{I_{0\to 35}} + Q_{c_{45\to 35}} = 0$$

$$M_I C_I (0°C - (-5°C)) + M_I L_{f,I} + M_I C_w (35°C - 0°C) + M_c C_w (35°C - 45°C) = 0$$

$$M_I (5 C_I + L_{f,I} + 35 C_w) = 10 M_c C_w$$

$$M_I = 2.56 \times 10^{-2} \text{ Kg} = \underline{25.6 \text{ g}}$$

Rubric

1pt - $Q = mC\Delta T$ eq.

1pt - $Q = mL_f$ eq.

1pt - $\Sigma Q = 0$ concept

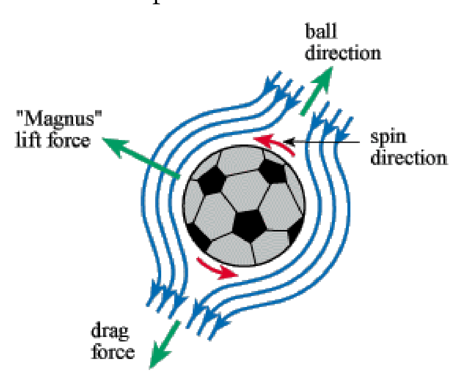
2pts - 4 differents Q's

1.5pts - Application & algebra

0.5pts - Answer + units

answer

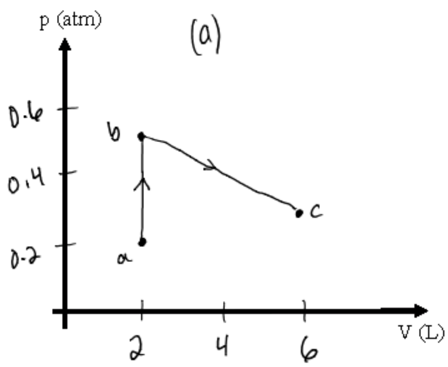
9. (3 points) In soccer and baseball you can see examples of the ball curving while in mid-air. The diagram shows a ball spinning that would curve in the direction of the "Magnus" lift force. Explain how this effect occurs.



This is due to the **Bernoulli effect**. Because of the rotation of the ball the *relative* speed of the air passing by it is different on each side. Considering the diagram, on left-hand-side (LHS) of the ball the direction of the rotation is opposite the direction the ball is moving. On the RHS the direction of the balls rotation is in the same direction the ball is moving. This results in relative difference in the speed of the moving air with respect to the ball. The Bernoulli effect states that as the velocity of the fluid increase, the pressure decreases. There is a larger relative velocity of the ball on the LHS than on the RHS. That means there is a larger pressure on the RHS than on the LHS and this pressure difference creates a net force called the Magnus lift force.

10. (12 points) A monatomic ideal gas consists of 0.0175 moles of atoms. The initial (state *a*) of the gas occupies 2.0 liters at a pressure of 0.20 atm. The gas first undergoes an isochoric process *ab* where the pressure is increased to 2.5 times the original. After that the gas undergoes a second process *bc*, where the pressure is decreased to 1.5 times its initial value and the volume is increased by a factor of three. The line connecting state *b* and state *c* is a straight line in a PV-diagram. (a) Draw a PV-diagram for the processes using the provided axis. (b) What is the lowest temperature the gas displays and where in the processes does it occur? (c) How much work is done on the gas from *a* to *b* and from *b* to *c*? (d) If 215 J of net heat is added to the system during the entire *abc* process, how many of those joules went into internal energy? (e) What is lowest average speed of the atoms in the gas and where does it occur?

(a)



(b) T_{min} @ point a

$$T_a = \frac{P_a V_a}{nR} = 278.6\ K$$

(c) $W_{ab} = 0\ J$ b/c area under curve is zero

$$W_{bc} = -\frac{P_b + P_c}{2} \Delta V_{bc}$$ ← area under curve

$$W_{bc} = -162\ J$$

(d) $\Delta E = Q + W = +215\ J - 162\ J = 52.9\ J$

(e) $\bar{K} = \frac{1}{2} m \bar{v}^2 = \frac{3}{2} k_B T$, T_{min} @ T_a, so $\bar{v}_a = \sqrt{\frac{3 k_B T_a}{m}}$

the type of gas was missing from exam, so mass is unknown.

Rubric

(a)

+2pts - PV diagram

(b)

+1pt - T_{min} @ T_a

+1pt - Ideal gas eq.

+0.5pt - answer + units

(c)

+1pt - Work is area under PV-curve

+0.5pt - $W_{ab} = 0$

+1pt - W_{bc}

(d)

+1.5pt - 1st Law eq.

+1.0pt - Application

+0.5pt - Answer + Units

(e)

+1pt - V_{min} @ T_a

+1pt - $\frac{1}{2} m v^2 = \frac{3}{2} k_B T$ eq.

extra space if needed