X3.0 107

Physics 107 (Kaldon-22243) **Name** ______________________________

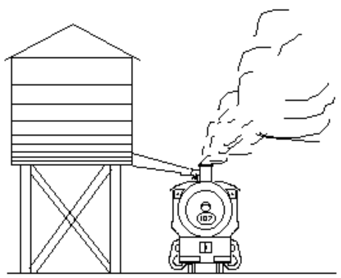
WMU - Spring 2001 **Book Title** ***This is for Topic 1, not your textbook!***

Exam 000 - 000,000 points

Sample – Not a Real Exam

Rev. 10/25/99M

State Any Assumptions You Need To Make -- Show All Work -- Circle Any Final Answers
Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations
Short Answers Should Be Short! - Feel Free to Ask Any Questions



The Story of Ol' Number 107 (50,000 points)

1.) A long time ago on the Western Michigan Railroad, Engine No. 107 needs to take on water from a wooden water tower. The sides of the round tower are wrapped in steel bands. (a) Why are the bands spaced closer together on the bottom than on the top? *Short answer.*

(b) The tower is 12.0 m tall and the water spout is 6.0 m off the ground. What is the pressure from the column of water behind the mouth of the spout? *Assume that like most water towers, that the top of the tower is vented to the outside air.*

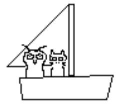
(c) Why do you not need to know the air pressure to use Bernoulli's Law from the top of the water in the tank to the mouth of the spout? *Short answer.*

(d) What is the speed of the water coming out of the spout?

(e) If the round pipe of the spout is twice as wide at its base than it is at the mouth, what is the speed of the water as it enters the pipe? *Assume that the spout pipe is level.*

"The Owl and the Pussycat Went To Sea In A Beautiful Pea Green Boat" (50,000 points)

2.) The 9.0 kg Owl and the 7.0 kg Pussycat bought a 100.0 kg aluminum boat: 2.00 m long, 1.00 m wide, with sides 0.40 m high. They are carrying 100.0 kg of supplies with them, consisting of honey and money. (a) The density of aluminum is 2.7 g/cm^3 (2.7 x 10^3 kg/m^3) and the density of water is 1.0 g/cm^3 (1.0 x 10^3 kg/m^3) – so why does the boat float? *Short answer.*

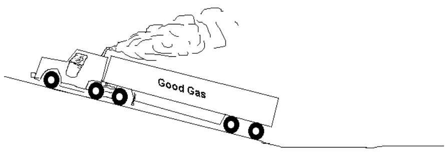


Find the mass-to-volume ratio (the mass density) of : (b) the empty boat and (c) the loaded boat.

(d) What is the volume of water displaced by the boat, when it is loaded with the Owl, the Pussycat and the 100.0 kg of provisions? *Hint: What is the total mass of the loaded boat?*

(e) Assuming that the boat is just a rectangular block, for easier calculations, how deep does the boat sit in the water? *Note: This actually is a hard problem for most people, but if you can figure this out, then you really understand this stuff!*

How They *Really* Figure Out The Price of Gasoline (50,000 points)



3.) A tank trucker gets a load of gasoline, 20,000 gallons, from a distributor in Dallas, Texas, on a day when the temperature is 100°F (37.7°C). He pays 83.9¢ per gallon wholesale. (a) How many dollars did he have to shell out for the gasoline?

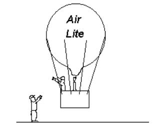
(b) In the mountains north of Phoenix, the snow is already falling and the temperature has dropped to 30°F (-1.11°C). Find the volume of the gasoline now that the temperature has dropped. $\beta = 950 \times 10^{-6}\ °C^{-1}$.

(c) Why do you not have to convert gallons to a metric volume in this problem?

(d) Find the new price per gallon, given the results from (a) and (b).

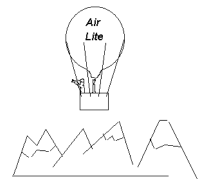
(e) What price per gallon must the tank truck driver charge the gas station in the mountains if he is to break even?

"Would You Like To Ride In My Beautiful Balloon…?" (50,000 points)

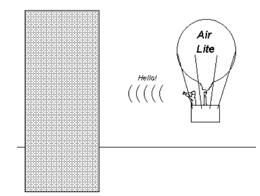


4.) It is a pretty fall day, with a temperature of 10°C (about 50°F), when the balloonist fires up the propane torch and the balloon lifts off. The balloonist, the basket, the balloon itself and the torch have a mass of 224 kg. (a) For the balloon to just barely lift off the ground, what must be the *minimum* volume of the balloon? (It is actually greater than this in order to *rise* up through the air, right?) The density of the air is 1.29 kg/m³. (Note that this is *significantly* smaller than the density of water, which is nearly 800 times greater.) The air pressure down on the ground is 101,300 Pa, but you probably won't care about that just yet. *Ignore the mass of the air inside the balloon.*

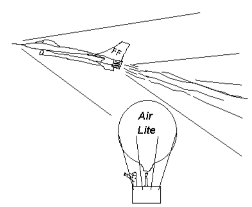
(b) High above the mountains, the outside temperature has dropped to -20°C (about 0°F) and the air pressure is down to 81,200 Pa. If the balloon's original volume on the ground was 275 m³, what is its volume now? *Assume that the air acts like an ideal gas, and that the air inside the balloon is always about 15°C (or 15 K) warmer that outside the balloon.*



(c) The cables holding the basket to the balloon are made of copper; they were each 3.000 m long on the ground. How long are they, now that they are high up in the cold? $\alpha_{copper} = 17 \times 10^{-6}\ °C^{-1}$.



(d)[1] The balloon floats near a building. Our intrepid balloonist shouts a cheery "Hello!" to the bored worker bees droning on inside, but they don't hear him. However, after 5.32 seconds, the balloonist hears a cheery "Hello!" The "o" sound included a wave that had f = 240 Hz and λ = 1.341 m. How far was the balloon from the building?



(e) Suddenly an F-16 fighter jet blasts by from behind at 654 m/s. Why didn't the balloonist hear the jet coming? And what *three* things does the balloonist hear *after* the jet goes by? *Use SHORT answers!*

[1] Parts (d) and (e) in this problem will likely be on Exam 3, but won't be covered until after Thermodynamics.

Hot Potato, Cold Potato… (50,000 points)

5.) A 1.00 kg lead ball is dropped from a height and impacts the ground with a KE of 1500 J. (a) If all the kinetic energy gets used up in heating the lead ball, what is the final temperature of the lead ball?

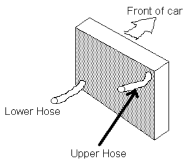
c_{lead} = 130 J/kg·°C ; T_0 = 25 °C

(b) The same lead ball is dropped repeatedly from the same height, being pulled up and dropped again before it ever has a chance to cool. Find it's final temperature after it has been dropped a total of ten times. T_0 = 25 °C.

(c) Ten drops worth of KE is a total energy of 15,000 J. What would be the final temperature of 1.00 kg of water at T = 20 °C, if you added 15,000 J to the water?

(d) Suppose the heated lead ball in (b) is placed in an insulated container with 1.00 kg of water at T = 20 °C. What is the final temperature of the water and lead ball when they reach equilibrium?

Overheating Blues (50,000 points)



6.) (a) The *gauge* pressure in a hot automobile radiator is 1.00 atmospheres (101,300 Pa). If the top radiator hose develops a leak, with what speed will the coolant come out of the hole? $\rho_{coolant}$ = 950. kg/m³

(b) If the bottom radiator hose develops a leak, 0.800 m below the top of the liquid, with what speed will the coolant come out of the hole?

(c) There is a small amount of air in the top of the radiator. If T_1 = 20°C, T_2 = 95°C, and the gauge pressure reads zero at T_1 and 101,300 Pa at T_2, then find the ratio of the initial to final volumes, V_2 / V_1 . *The air pressure is 101,300 Pa on this day.*

The *liter* (L) is the metric unit of liquid volume – it is a little bigger than a quart and 1 L = 0.001 m³. At T_0 = 20°C, the radiator contains 16.0 L (0.0160 m³) of coolant in a hollow aluminum box that has outside dimensions of 0.800 m × 0.800 m × 0.0300 m. Which expands *more*? The radiator or the coolant in the radiator? Find the change in (d) the volume of the coolant and also (e) that of the radiator (the metal box) at T = 95°C.

$\alpha_{Al} = 25 \times 10^{-6}$ °C^{-1} and $\beta_{Coolant} = 750 \times 10^{-6}$ °C^{-1}

Roaring Along in My Automobile… (50,000 points)

7.) An automobile engine has T_C = 95°C and T_H = 400°C. If the Second Law Efficiency is 96.0% (0.960), then find the (a) Carnot Efficiency…

… and (b) the Actual Efficiency of this engine.

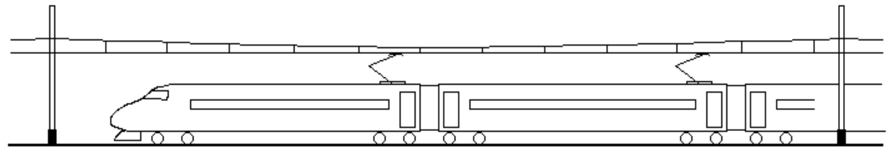
If the engine generates a useful power of 100 hp, then there is 74,600 J of useful work generated every second. How much (c) total energy input,

and (d) waste heat rejected, does this engine account for each second? *If you didn't get (a) and/or (b), use 30% as the efficiency you need to do this problem.*

(e) Once a Hot or Cold Reservoir is established for this heat engine, what would be the *net* heat flow in or out of either reservoir? Why? (Short Answer) *Hint: You might ask yourself what is the one important thing about a Reservoir.*

Whoosh! (50,000 points)

8.) Most high speed trains are powered by electricity from overhead wires. One thing you have to watch out for is making sure that the motion does not cause a *resonance* in the wire. The collectors touch the wire every train car length, or about every 30.0 m. The train is traveling at 180 mph (81.0 m/s). (a) If this motion excites a *fundamental* on the wire, what is the wavelength of this wave?



(b) The first and second overtones?

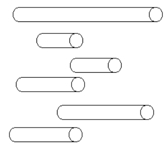
(c) Suppose that the wave speed is the same as the train. What would be the frequencies of the 3 waves that you got in (a) and (b)?

(d) On the other hand, maybe the motion of the train is likely to start up *sound* waves in the steel overhead wires. What would be the frequencies of the 3 waves that you got in (a) and (b)?

(e) The vibrating steel wire starts making sounds in the air. Find the wavelengths, λ, and the frequencies, f, of these 3 waves in the air. Assume that the air temperature is 20°C (68°F).

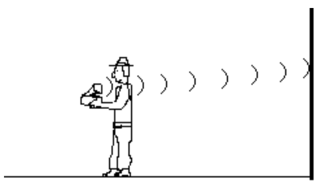
Making Waves (50,000 points) ***Hint: Try the problem below first…***

9.) A device ends up shoving air back and forth at a frequency $f = 60$ Hz. At 20° C (68° F), the speed of sound is 343 m/s. (a) If this device is making a sound in the air, what is the wavelength, λ, of this sound?



A series of glass tubes, open at both ends and of different lengths, are lying nearby. Two of the tubes end up "singing" as standing waves corresponding to (b) a fundamental and (c) a third overtone are set up resonating in them. What are the lengths of these two tubes?

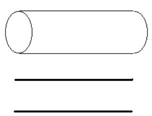
(d) Suppose a man held this sound device in his hands and turns it on. There is a wall 2.145 m behind the man. How much time does it take for the echo to reach the man?



(e) Does the sound and its echo off the back wall add constructively or destructively? Or is it impossible to tell? You must have a calculation to support your argument in any case to get credit for this, of course.

Making Waves *II* (50,000 points)

10.) Consider a tube (L = 25.0 cm = 0.250 m) that is *open* at both ends. (The top picture shows the tube, the bottom a schematic to make a sketch in.) (a) What are the criteria needed to set up a standing wave in this tube? *i.e., where do you need nodes and antinodes?*



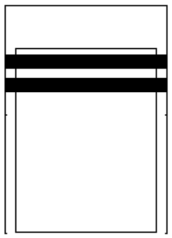
(b) Sketch in the diagram at the right, what the fundamental wave must look like.

(c) How much of a wave is this? Write an equation for L and λ for the fundamental.

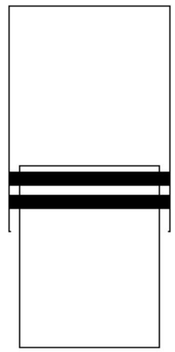
(d) What is the wavelength of the fundamental?

(e) What is the wavelength of the 1st and 2nd overtones?

Engine-uity (50,000 points)



11.) An engine burns fuel at 1000 °C when the piston leaves only a small space in the cylinder, as shown at the left.[2] The combusted gasses expand to seven times their original volume, as shown at the right, cooling to 400 °C at the same time. (a) If the *final* pressure in the cylinder is 1 atm (101,300 Pa), find the *initial* pressure in the cylinder at combustion. *Hints: (1) watch units! (2) treat the gasses as Ideal gasses, (3) $V_2 = 7V_1$.*



(b) The hot side of the engine is 400 °C – the cold side of the engine is 90 °C. Find the Carnot efficiency of this engine.

(c) This engine generates a useful power of 150 hp. What is this power in Watts (1 W = 1 J/sec)?

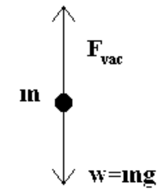
(d) Now figure out how many Joules of useful work and waste heat are generated each second. *Use the Carnot efficiency from (b) as the Actual Efficiency for this problem.*

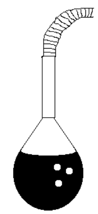
(e) Assuming that the 10.0 kg of coolant in the radiator is just water, how long (time) will it take the coolant to go from 20°C to 90°C? *Hint: Find the energy it takes to heat the water first; then remember what a Watt is.*

[2] These sketches are supposed to show a piston in an engine cylinder. But nobody likes these drawings – they don't understand them. It's so sad… nobody understands Dr. Phil. It's so lo-lonely <*sniff*>, I'm gonna go out in the backyard and eat worms…

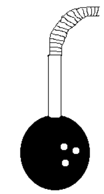
"Hi, I'm Dave Oreck and…" (50,000 points)

12.) "… my eight pound Oreck Hotel Vacuum is *so* powerful that it can pick up a sixteen pound bowling ball." That's what it says on the commercials – let's see how this is done. At the right is the Free Body Diagram of the bowling ball (m = 7.27 kg), being held in place by the force applied by the vacuum cleaner, F_{vac}. This is for the case where the vacuum cleaner applies *exactly* enough force to hold up the bowling ball. (a) Find F_{vac}.



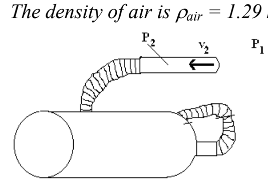


In the commercials, they put a funnel over the bowling ball. Let's find out why. A funnel with a large end 8 inches in diameter has an opening with an area, A = 0.0325 m². A typical vacuum cleaner hose is 2 inches in diameter, and has an opening sixteen times smaller, A = 0.00203 m². (b) Use the definition of Pressure to find the pressure being applied by the vacuum cleaner, P_{vac}, for both cases. *NOTE: You will have two answers here, one with and one without the funnel. If you didn't get an answer to (a), use F_{vac} = 80.0 N.*



(c) If the air pressure on the outside is P_1 = 102,400 Pa, then what is the pressure, P_2, *inside* the vacuum cleaner, for both cases? *If you didn't get answers to (b), use P_{vac} = 55,500 Pa and 105,500 Pa, for with and without the funnel respectively.*

(d) Take the pressure, P_2, for the case of *with* the funnel. If you just ran the vacuum cleaner without trying to hold up a bowling ball, then the air goes into the hose with a speed v_2. Find the speed of the air in the hose, v_2. *The density of air is ρ_{air} = 1.29 kg/m³. If you didn't get answers to (c), use P_2 = 55,500 Pa.*



(e) The vacuum clean hose is 1.75 m long. What are the wavelengths, λ, of the fundamental and first overtone that you might find from a standing wave in the hose?