X3.17a **107**

PHYS-107 (17) (Kaldon-37944) Name S O L U T I O N

WMU - Fall 2004

Exam 3A - 100,000 points Book Title

Rev. 11/14/04 Su.A6b

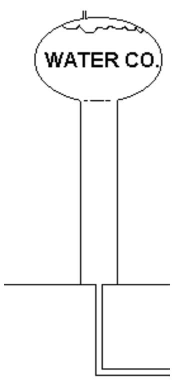
State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Short Answers Should Be Short! – Feel Free to Ask Any Questions

EXAM 3 [FORM - A]

PHYS-107 (KALDON-17)

FALL 2004

WMU



"Certified free of microbes, dust particles, old tires, pigeon droppings and teenage pranksters by the Department of Homeland Security."

Your Friendly Neighborhood Water Company…

"Heat Waves" (50,000 points) ***Multiple-Guess-Pick-The-Best-Answer-Fill-In-The-Bubbles***

1.) (a) A good can of beans hisses as air rushes in if the absolute pressure inside is ________ the outside.
A = Less Than B = Same As C = More Than D = None of these
The pressure inside the can must be lower.
Answer: A

(b) A putrid can of beans hisses as air rushes out if the gauge pressure (inside - outside) is ________ zero.
A = Less Than B = Same As C = More Than D = None of these
The pressure inside the can must be higher.
Answer: C

(c) A boat of mass 150. kg has dimensions 1.0 m × 0.50 m × 1.5 m. What is the maximum load that can be carefully placed in this boat before it sinks?
A = 150. kg B = 500. kg C = 600. kg D = 750. kg E = 1000. kg
F = None of these
$V = 0.750 m^3$, so m_{max} = 750.kg. Subtract 150.kg for boat, 600.kg for load.
Answer: C

(d) A 9" diameter pipe narrows to 1" diameter. Water flowing in the wide pipe is __ as fast as the narrow pipe.
A = 1/3rd B = 1/9th C = just D = 3 times E = 9 times
F = None of these *Use Continuity Equation. $9^2 = 81$.*
Answer: F

In parts (e)-(g), select which of the laws and definitions of Thermodynamics is best used to solve or describe the problem.

(e) If you had an engine with a Second Law Efficiency equal to 100%, you would violate _______.
A = Thermo 1st law B = Thermo 2nd law C = Entropy
D = Actual Efficiency E = Carnot Efficiency F = None of these
Q_C cannot be zero, so 2nd Law Efficiency is never 100%.
Answer: B

(f) If you had an engine with a Second Law Efficiency equal to 110%, you would violate _______.
A = Thermo 1st law B = Thermo 2nd law C = Entropy
D = Actual Efficiency E = Carnot Efficiency F = None of these
At 110%, you're getting more Work than Q_H put in.
Answer: A

(g) Monitoring the temperature of the hot and cold reservoirs allows you to find the __________.
A = Thermo 1st law B = Thermo 2nd law C = Entropy
D = Actual Efficiency E = Carnot Efficiency F = None of these
Definition of Carnot Efficiency
Answer: E

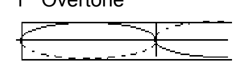
Fred blows into a musical instrument and it sounds with a frequency f = *500. Hz*. He blows harder and it sounds with a frequency f = *1500. Hz*. The speed of sound in air is 343 m/s. *Use $v = f\lambda$*

(h) The wavelength of the 500. Hz tone is ________.
A = 0.229 m B = 0.343 m C = 0.500 m
D = 0.686 m E = 0.916 m F= None of these
Answer: D

(i) For the 1500. Hz tone, λ = ________.
A = 0.229 m B = 0.343 m C = 0.500 m
D = 0.686 m E = 0.916 m F= None of these
Answer: A

(j) If one of these standing waves is the Fundamental and the other one is the 1st Overtone, then the pipe in this instrument is:
A = Closed at both ends B = Open at both ends
C = Closed at one end and open at the other end D = None of these
Answer: C

Diagrams for Problem 1(j): Fundamental 1st Overtone



One Million Gallons of Pure Clean Sweet Fresh Water (50,000 points)

2.) A city water tank contains 1,000,000 gallons of water (3.80×10^6 L volume, 3.80×10^6 kg mass) at a temperature of 9.00°C (48.2°F). (a) When a valve is opened at the bottom of the tank, water comes out at a speed of 20.0 m/s. What is the height h to the top of the water in the tank? The properties of water include: c_{water} = *4186 J/kg·°C*, L_f = *334,000 J/kg*, L_v = *2,260,000 J/kg*, ρ_{water} = *1000 kg/m³* and $\beta_{water} = 210 \times 10^{-6}$ °C^{-1}.

$$P_1 + \rho g h_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \tfrac{1}{2}\rho v_2^2$$
$$\rho g h_1 = \tfrac{1}{2}\rho v_2^2$$
$$h_1 = \frac{v_2^2}{2g} = \frac{(20.0 m/s)^2}{2(9.81 m/s^2)} = 20.39m$$

(b) During the day, the temperature of the water rises from 9.00°C to 15.00°C (59.0°F). Find the new volume of the tank of water. *For the purposes of this question only, give your answer to 5 significant figures.*

$$\Delta V = \beta V_0 \Delta T$$
$$= (210 \times 10^{-6}\ {}^\circ C^{-1})(3.80 \times 10^6 L)(15.00^\circ C - 9.0^\circ C)$$
$$= +4788L$$
$$V = V_0 + \Delta V$$
$$= 3.80 \times 10^6 L + 4788L$$
$$= 3{,}804{,}788L = 3{,}804{,}800L$$

Note that you can leave the volume in liters (L), because the only requirement is that V_0 and ΔV have the same units.

(c) How much heat energy Q did the water have to absorb during this expansion?

$$Q = mc\Delta T = (3.80 \times 10^6 kg)(4186\ J/kg\cdot{}^\circ C)(+6.00^\circ C)$$
$$= 95{,}440{,}000{,}000J \ \ or \ \ 9.544 \times 10^{10} J$$

(d) During the night a pump is used to refill the tank, replacing the water used during the day. The 13.1 hp engine driving the pump does a useful work of 9780 J each second, while wasting 5470 J of heat energy each second. The Second Law Efficiency of this engine is 97.0% (0.970). Find the Actual Efficiency of this engine.

$$Q_H = W + Q_C$$
$$= 9780J + 5470J = 15{,}250J$$
$$\varepsilon_{Actual} = \frac{W}{Q_H} = \frac{9780J}{15{,}250J} = 0.6413 \ or \ 64.13\%$$

In case you were wondering, 13.1hp = 9770W = 9770J/s ≈ 9780 J/s. (Dr. Phil worked the problem backwards.)

(e) Find the Carnot Efficiency of this engine. *If you didn't get an answer to (d), use* $\varepsilon_{actual} = 40.0\%$.

$$\varepsilon_{2nd\ Law} = \frac{\varepsilon_{Actual}}{\varepsilon_{Carnot}}$$
$$\varepsilon_{Carnot} = \frac{\varepsilon_{Actual}}{\varepsilon_{2nd\ Law}} = \frac{0.6413}{0.970} = 0.6611 \ or \ 66.11\%$$

For those of you looking only for temperatures, you forgot we had *two* equations with ε_{Carnot} in them.