

X3.18a

PHYS-1070(18) (Kaldon-20592)

WMU - Summer I 2006

Exam 3 - 100,000 points

1070

Name SOLUTION

Remember Your Paper!

Rev. 06/15/06 Th.2

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-1070 (KALDON-18)

### SUMMER I 2006

## WMU

"I wanna be a fireman  
when I grow up."

### "Fact or Fraction" (30,000 points) Multiple-Guess-Pick-The-Best-Answer-Fill-In-The-Bubbles

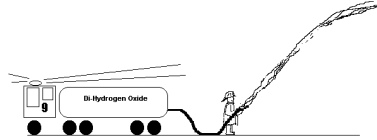
- 1.) (a) Refilling a half-empty water tower is designed to increase the \_\_\_\_\_ Pressure.  
A = Absolute B = Gauge C = Potential D = Kinetic  A  B  C  D
- (b) When you open a bottle of champagne, you hear a *pop*, meaning that the \_\_\_\_\_ Pressure is positive.  
A = Absolute B = Gauge C = Potential D = Kinetic  A  B  C  D
- (c) Both the \_\_\_\_\_ Pressure...  
A = Absolute B = Gauge C = Potential D = Kinetic  A  B  C  D
- (d) ... and the \_\_\_\_\_ Pressure must always be a positive number.  
A = Absolute B = Gauge C = Potential D = Kinetic  A  B  C  D
- In parts (e)-(g), select which of the laws and definitions of Thermodynamics is best used to solve or describe the problem.
- (e) The Carnot Efficiency is zero when the hot and cold reservoirs are in thermal \_\_\_\_\_.  
A = Thermo 1<sup>st</sup> law B = Thermo 2<sup>nd</sup> law C = Equilibrium  
D = Actual Efficiency E = Carnot Efficiency F = None of these  A  B  C  D  E  F
- (f) Second Law Efficiency is a measure of the fraction of the \_\_\_\_\_ that a heat engine achieves.  
A = Thermo 1<sup>st</sup> law B = Thermo 2<sup>nd</sup> law C = Equilibrium  
D = Actual Efficiency E = Carnot Efficiency F = None of these  A  B  C  D  E  F
- (g) The waste heat rejected cannot be zero as a consequence of the \_\_\_\_\_.  
A = Thermo 1<sup>st</sup> law B = Thermo 2<sup>nd</sup> law C = Equilibrium  
D = Actual Efficiency E = Carnot Efficiency F = None of these  A  B  C  D  E  F

The following regards boats floating in water.

- (h) The density of the material the boat is made out of is always \_\_\_\_\_ than the water.  
A = Larger B = Smaller C = The Same D = None of these  
*The material of the boat is irrelevant, only mass/volume.*  A  B  C  D
- (i) The volume of the boat is \_\_\_\_\_ than the volume of the water displaced by the boat.  
A = Larger B = Smaller C = The Same D = None of these  A  B  C  D
- (j) The mass of the boat is \_\_\_\_\_ than the mass of the water displaced by the boat.  
A = Larger B = Smaller C = The Same D = None of these  A  B  C  D

**"Engine Company 107, Time Out, 15:48." "Roger." (35,000 points)**

2.) (a) The fire truck's horn goes *BLA-AAT!* with a frequency  $f = 50.0 \text{ Hz}$ . If the horn consists of a tube open at one end and closed at the other, how long  $L$  should this tube be? The speed of sound in air is  $345 \text{ m/s}$ .

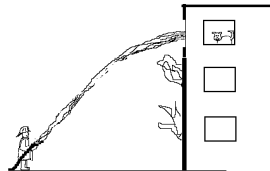


For a tube open at one ends and closed at the other...  
The Fundamental is one-quarter of a wave  
(anti-nodes at one end, node at other).

$$\begin{aligned} v &= f\lambda \\ \lambda &= \frac{v}{f} = \frac{345 \text{ m/s}}{50.0 \text{ Hz}} = 6.900 \text{ m} \\ L &= \frac{\lambda}{4} = \frac{6.900 \text{ m}}{4} = 1.725 \text{ m} \end{aligned}$$

(b) The water tank in the fire truck is pressurized to gauge pressure of 147 psi (10 atmospheres = 1,013,000 Pa). The pressure outside is the normal atmospheric pressure of 1 atmosphere = 101,300 Pa = 14.7 psi. What is the speed of the water coming out of the fireman's hose? Assume no height difference between the nozzle and the tank.  $\rho_{\text{water}} = 1000 \text{ kg/m}^3$

$$\begin{aligned} P_1 + \rho gh_1 + \frac{1}{2} \rho v_1^2 &= P_2 + \rho gh_2 + \frac{1}{2} \rho v_2^2 \\ P_1 &= P_2 + \frac{1}{2} \rho v_2^2 \\ P_1 - P_2 &= \frac{1}{2} \rho v_2^2 \\ v_2^2 &= \frac{2(P_1 - P_2)}{\rho} \\ v_2 &= \sqrt{\frac{2(P_1 - P_2)}{\rho}} \\ &= \sqrt{\frac{2(1,013,000 \text{ Pa})}{1000 \text{ kg/m}^3}} \\ &= 45.01 \text{ m/s} \end{aligned}$$



(c) What height for an open column of water in a water tower would give the same gauge pressure of 147 psi (10 atmospheres = 1,013,000 Pa)?

$$\begin{aligned} P &= \rho gh \\ h &= \frac{P}{\rho g} = \frac{1,013,000 \text{ Pa}}{(1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} \\ &= 103.3 \text{ m} \end{aligned}$$

(d) There isn't enough 3 inch hose to get the water close enough to the fire, so they have to splice in a section of 1 inch hose in between two pieces of 3 inch hose. What is the speed of the water in the 1 inch section of hose? 1 inch = 0.0254 m. If you didn't get an answer to part (b), use  $v_1 = 25.0 \text{ m/s}$ .

$$\begin{aligned} A_1 v_1 &= A_2 v_2 \\ v_1 &= \frac{A_2 v_2}{A_1} = \frac{\frac{\pi}{4} D_2^2 v_2}{\frac{\pi}{4} D_1^2} = \frac{D_2^2 v_2}{D_1^2} \\ &= \frac{(3(0.0254 \text{ m}))^2 (45.01 \text{ m/s})}{(0.0254 \text{ m})^2} \\ &= 9(45.01 \text{ m/s}) = 405.1 \text{ m/s} \end{aligned}$$

(e) In the fuel tank of the fire truck, a small float goes up and down to let you know how full (or empty) your fuel tank is, sort of like the float in the tank of the toilet in your bathroom. Suppose that a fuel tank float has dimensions  $1.00 \text{ cm} \times 1.00 \text{ cm} \times 0.300 \text{ cm}$  ( $0.0100 \text{ m} \times 0.0100 \text{ m} \times 0.00300 \text{ m}$ ). Find the mass of this fuel tank float, if it is exactly half-submerged in the diesel fuel?  $\rho_{\text{diesel}} = 820. \text{ kg/m}^3$

$$\begin{aligned} V &= (0.0100 \text{ m})(0.0100 \text{ m})(0.00300 \text{ m}) \\ &= 3.000 \times 10^{-7} \text{ m}^3 \\ \rho_{\text{boat}} &= \frac{1}{2} \rho_{\text{diesel}} = \frac{1}{2} (820. \text{ kg/m}^3) = 410.0 \text{ kg/m}^3 \\ \rho &= \frac{m}{V} \\ m &= \rho V = (410.0 \text{ kg/m}^3)(3.000 \times 10^{-7} \text{ m}^3) \\ &= 0.0001230 \text{ kg} = 1.230 \times 10^{-4} \text{ kg} \end{aligned}$$

**Eight Hundred Horsepower's Worth of Fire Truck Power (35,000 points)**

3.) (a) The cast iron engine block of the fire truck in Problem 1 is roughly  $0.800\text{ m} \times 0.600\text{ m} \times 0.400\text{ m}$  when the engine is cold,  $T = 68^\circ\text{F} = 20^\circ\text{C}$ . Find the volume of the engine when cold, and then when it warms to  $T = 450^\circ\text{F} = 232^\circ\text{C}$ .

$$\alpha_{\text{iron}} = 12.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$$

$$\begin{aligned} \beta &= 3\alpha = 3(12.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}) = 36.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1} \\ V_0 &= (0.800\text{m})(0.600\text{m})(0.400\text{m}) = 0.1920\text{m}^3 \\ \Delta V &= \beta V_0 \Delta T \\ &= (36.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1})(0.1920\text{m}^3)(232^\circ\text{C} - 20^\circ\text{C}) \\ &= +0.001465\text{m}^3 \\ V &= V_0 + \Delta V \\ &= 0.1920\text{m}^3 + 0.001465\text{m}^3 \\ &= 0.1935\text{m}^3 \end{aligned}$$

If the engine generates a useful power of 800. hp at full throttle, then there are 597,000 J of useful work generated every second. If the Actual Efficiency is 51.3% (0.513), then find (b) the total energy input,  $Q_H$ , ...

$$\begin{aligned} \varepsilon_{\text{Actual}} &= \frac{W}{Q_H} \\ Q_H &= \frac{W}{\varepsilon_{\text{Actual}}} = \frac{597,000\text{J}}{0.513} \\ &= 1,164,000\text{J} \end{aligned}$$

... and (c) waste heat rejected,  $Q_C$ , this engine accounts for each second?

$$\begin{aligned} Q_H &= W + Q_C \\ Q_C &= Q_H - W \\ &= 1,164,000\text{J} - 597,000\text{J} \\ &= 567,000\text{J} \end{aligned}$$

(d) This engine has  $T_C = 95^\circ\text{C}$  and  $T_H = 723^\circ\text{C}$ . Find the Carnot Efficiency of this engine.

$$\begin{aligned} T_C &= 95^\circ\text{C} = 368\text{K} \\ T_H &= 723^\circ\text{C} = 996\text{K} \\ \varepsilon_{\text{Carnot}} &= 1 - \frac{T_C}{T_H} = 1 - \frac{368\text{K}}{996\text{K}} \\ &= 0.6305 \end{aligned}$$

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

**Zero.**

**The temperature of a Reservoir is supposed to remain essentially constant over time. So the heat flow in and out have to be the same, therefore zero net heat flow.**