

X3.15a

PHYS-107(15) (Kaldon-)
 WMU - Fall 2003
 Exam 3A - 150,000 points

107Name _____ **S O L U T I O N** _____Book Title _____ Rev. 11/16/03 Su.4.r1

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] 8AM**PHYS-107 (KALDON-15)****FALL 2003****WMU**

“The Largest Passenger Ship in the World,
 Of All Time.”

The Cunard Line Presents the Queen Mary 2...

“Fact or Fiction” (50,000 points) Multiple-Guess-Pick-The-Best-Answer-Fill-In-The-Bubbles

1.) (a) A spray can will work if the absolute pressure inside is _____ the absolute pressure outside.

A = Less Than B = Same As C = More Than D = None of these

The pressure inside the can must be higher.

 A B C D

(b) A spray can will work if the gauge pressure inside is _____ zero.

A = Less Than B = Same As C = More Than D = None of these

Accepted 2 answers, depending on which is side 1.

 A B C D

(c) A full 10.0 m tall water tower springs a leak halfway down. How fast does the water come out?

A = 196 m/s B = 98.1 m/s C = 24.5 m/s D = 14.0 m/s E = 9.90 m/s

F = None of these

 A B C D E F

(d) A 1” diameter pipe widens to 4” diameter. Water flowing in the narrow pipe is ___ as fast as the wide pipe.

A = 1/4th B = 1/16th C = just D = 4 times E = 16 times

F = None of these *Use Continuity Equation.*

 A B C D E F

In parts (e)-(g), select which of the laws and definitions of Thermodynamics is best used to solve or describe the problem. (e) You need this to tell exactly how much energy you are wasting in a heat engine.

A = Thermo 1st law B = Thermo 2nd law C = Entropy

D = Actual Efficiency E = Carnot Efficiency F = None of these

 A B C D E F

(f) This says that the total energy remains a constant.

A = Thermo 1st law B = Thermo 2nd law C = Entropy

D = Actual Efficiency E = Carnot Efficiency F = None of these

 A B C D E F

(g) Perpetual Motion machines and other schemes that don’t waste energy are violations of _____.

A = Thermo 1st law B = Thermo 2nd law C = Entropy

D = Actual Efficiency E = Carnot Efficiency F = None of these

 A B C D E F

A special material has the following properties: It melts at 100°C and boils at 200°C. The specific heat of the liquid material is 5000. J/kg·°C. The latent heats of fusion and vaporization are both 500,000 J/kg.

(h) 1.00 kg of pure solid at 100°C has 100,000 J of heat energy added. The final state contains _____.

A = Solid B = Liquid C = Gas

D = Solid + Liquid E = Liquid + Gas F = None of these

100,000 J is not enough to melt all the solid.

 A B C D E F

(i) 1.00 kg of pure solid at 100°C has 500,000 J of heat energy added. The final state contains _____.

A = Solid B = Liquid C = Gas

D = Solid + Liquid E = Liquid + Gas F = None of these

500,000 J exactly melts the solid to all liquid.

 A B C D E F

(j) 1.00 kg of pure solid at 100°C has 1,000,000 J of heat energy added. The final state contains _____.

A = Solid B = Liquid C = Gas

D = Solid + Liquid E = Liquid + Gas F = None of these

The 2nd 500,000 J heats to liquid to its boiling point ONLY.

 A B C D E F

“Tragedy This Weekend in a Shipyard in France...” (50,000 points)

2.) A gangway collapse during an open house of a brand new ship brought the *Queen Mary 2* to the headlines in a way the owners would rather not. The accident had nothing to do with the design or safety of the ship. But as the world's largest passenger ship ever, the *Queen Mary 2* is worth talking about. Its 1132 foot length (345 m) is greater than the largest aircraft carrier, and it stands 23 stories tall (237 feet = 72.3 m). The total cost is over \$800 million. (a) Fully loaded, the ship is listed at 150,000 tons (a mass of 136,000,000 kg). Find the volume of sea water that the *QM2* displaces. $\rho_{\text{sea water}} = 1030 \text{ kg/m}^3$.

$$\begin{aligned} m_{\text{boat}} &= m_{\text{displaced water}} \\ &= 136,000,000 \text{ kg} \\ \rho &= \frac{m}{V} ; V = \frac{m}{\rho} = \frac{136,000,000 \text{ kg}}{1030 \text{ kg/m}^3} = 132,000 \text{ m}^3 \end{aligned}$$

(b) If the average width of the *QM2* is 135 feet (41.2 m), then find the depth h of the submerged part of the fully loaded ship. We assume, as usual, that the bottom of the ship is rectangular.

$$\begin{aligned} V &= Lwh \\ h &= \frac{V}{Lw} = \frac{132,000 \text{ m}^3}{(345 \text{ m})(41.2 \text{ m})} = 9.287 \text{ m} \end{aligned}$$

(c) The ship's length is given at 68.0°F (20.0°C). As the ship moves across the ocean, the temperature drops to 39.2°F (4.00°C). Find the new length of the ship in the colder water. $\alpha_{\text{steel}} = 12 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$.

$$\begin{aligned} \Delta L &= \alpha L_0 \Delta T \\ &= (12 \times 10^{-6} \text{ }^\circ\text{C}^{-1})(345 \text{ m}^3)(4.00^\circ\text{C} - 20.0^\circ\text{C}) \\ &= -0.06624 \text{ m} \\ L &= L_0 + \Delta L \\ &= 345 \text{ m} - 0.06624 \text{ m} \\ &= 344.93376 \text{ m} = 344.9 \text{ m} \end{aligned}$$

(d) The engines from Wartsila of Finland generate 67.2 megawatts (90,000 h.p.) of useful power. That means a maximum of 67,200,000 J of useful work is available each second. If the engines have an Actual Efficiency of 46.0% (0.460), find the total heat pulled from the hot reservoir and the waste heat rejected to the cold reservoir.

$$\begin{aligned} \varepsilon_{\text{Actual}} &= \frac{W}{Q_H} \\ Q_H &= \frac{W}{\varepsilon_{\text{Actual}}} = \frac{67,200,000 \text{ J}}{0.460} \\ &= 146,100,000 \text{ J} \end{aligned}$$

$$\begin{aligned} Q_H &= W + Q_C \\ Q_C &= Q_H - W \\ &= 146,100,000 \text{ J} - 67,200,000 \text{ J} \\ &= 78,900,000 \text{ J} \end{aligned}$$

(e) Of the original *Queen Mary*'s three whistles has been fitted to the *QM2*. If the whistle is considered a tube open at both ends and the second overtone has a frequency of 345 Hz, find the length L of the tube. *The speed of sound is 345 m/s in this problem.*

For a tube open at both ends...
The Fundamental is one-half of a wave
(anti-nodes at both ends, one node in center).
The First Overtone adds one half-wave, to get a full wave.
The Second Overtone adds another half-wave, to get 1½ waves.

$$\begin{aligned} v &= f\lambda \\ \lambda &= \frac{v}{f} = \frac{345 \text{ m/s}}{345 \text{ Hz}} = 1.000 \text{ m} \\ L &= \frac{3\lambda}{2} = \frac{3(1.000 \text{ m})}{2} = 1.500 \text{ m} \end{aligned}$$