

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

- 1.) (a) You want to keep water tower mostly full to increase the _____ Pressure.
 A = Absolute B = Gauge C = Potential D = Kinetic A B C D
- (b) When you open a sealed can of cat food, you hear a *hiss*, meaning that the _____ Pressure is negative.
 A = Absolute B = Gauge C = Potential D = Kinetic A B C D
- (c) A water jet cutting tool can slice through thick steel or aluminum with _____ Pressure.
 A = Absolute B = Gauge C = Potential D = Kinetic A B C D
- (d) Kelvins must always be a positive number because it represents an _____ Temperature.
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 Useful Work plus Waste Heat must equal the Total Energy of a heat engine because of the _____.
A = Thermo 1st law B = Thermo 2nd 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 ratio of the _____ divided by the theoretical best efficiency.
 A = Thermo 1st law B = Thermo 2nd law C = Equilibrium
D = Actual Efficiency E = Carnot Efficiency F = None of these A B C D E F
- (g) The Actual Efficiency can never be 100% as a consequence of the _____.
 A = Thermo 1st law B = Thermo 2nd law C = Equilibrium
 D = Actual Efficiency E = Carnot Efficiency F = None of these A B C D E F

The following regards a marshmallow floating in hot chocolate milk. (Something which might be more suitable for January than June.)

- (h) The mass-to-volume ratio of the marshmallow must be _____ than the hot chocolate milk.
 A = Larger B = Smaller C = The Same D = None of these A B C D
- (i) The mass of the marshmallow is _____ than the mass of the hot chocolate milk displaced by the marshmallow.
 A = Larger B = Smaller C = The Same D = None of these A B C D
- (j) The volume of the marshmallow is _____ than the volume of hot chocolate milk displaced by the marshmallow.
A = Larger B = Smaller C = The Same D = None of these A B C D

Sunday Night TV on The History Channel: *Titanic's Achilles Heel* (35,000 points)

2.) The History Channel has a new two-hour show on the wreck of the *RMS Titanic*. One of the first things they looked at was an *expansion joint* which might've allowed the ship to crack in half. Why does the ship need an expansion joint? Because the hull is going to be in cold North Atlantic waters, while the interior is going to be warm and comfortable for the passengers. (a) If the *Titanic* was 245.000 meters long at 68°F (20°C, 293 K) when it was built, then what was the length of the ship at time of its sinking, assuming that the temperature of

the sea water was 28°F (-2.22°C, 270.78 K) which is below the freezing point of plain water? $\alpha_{\text{iron}} = 12.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$

$$\Delta L = \alpha L_0 \Delta T$$

$$= (12.0 \times 10^{-6} \text{ } ^\circ\text{C}^{-1})(245.000\text{m})(-2.22^\circ\text{C} - 20.0^\circ\text{C}) = -0.06533\text{m}$$

$$L = L_0 + \Delta L = 245.000\text{m} - 0.06533\text{m} = 244.935\text{m}$$

If the mass of *Titanic* was 60,000,000 kg (that would correspond to a displacement of about 66,000 tons), then find (b) the weight of the ship...

$$w = mg = (60,000,000\text{kg})(9.81\text{m/s}^2)$$

$$= 588,600,000\text{N}$$



... and (c) the mass of the sea water displaced by the ship.

$$m_{\text{displaced}} = m_{\text{boat}} = 60,000,000\text{kg}$$

(d) *RMS Titanic* was about 800 feet long (245 meters) and according to the numbers painted on the bow of the ship, she was drafting about 37 feet (11.3 meters) – that means that 11.3 meters of the ship was below the water. Assume that the part of the ship under the water is a rectangular box with these dimensions – what is the width of this box – and hence the width of the ship? $\rho_{\text{sea water}} = 1030 \text{ kg/m}^3$



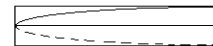
$$\rho_{\text{seawater}} = \frac{m_{\text{boat}}}{V_{\text{displacedwater}}}$$

$$V_{\text{displacedwater}} = \frac{m_{\text{boat}}}{\rho_{\text{water}}} = \frac{60,000,000\text{kg}}{1030\text{kg/m}^3} = 58,250\text{m}^3$$

$$V_{\text{displacedwater}} = (245\text{m})(11.3\text{m})h$$

$$h = \frac{V_{\text{displacedwater}}}{(245\text{m})(11.3\text{m})} = \frac{58,250\text{m}^3}{(245\text{m})(11.3\text{m})} = 21.04\text{m}$$

(e) The ship'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 cold air is 334 m/s.*



$$v = f\lambda$$

$$\lambda = \frac{v}{f} = \frac{334\text{m/s}}{50.0\text{Hz}} = 6.680\text{m}$$

$$L = \frac{\lambda}{4} = \frac{6.680\text{m}}{4} = 1.670\text{m}$$

**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).**

24 Heures du Mans – Circuit de la Sarthe (35,000 points)

3.) It was a miserable, wet, rainy Saturday and Sunday in France six years ago for the 69th 24 Hours of Le Mans. (a) The eighth finisher and winner of the GTS class was the number 63 Chevrolet Corvette C5-R. If the cold side of the engine is $T_C = 221^\circ F = 105^\circ C = 378 K$ and the Carnot efficiency of this engine is 0.550 (55.0%), then what is the temperature of the hot side of this heat engine, T_H ?

$$\begin{aligned} \epsilon_{Carnot} &= 1 - \frac{T_C}{T_H} \\ \frac{T_C}{T_H} &= 1 - \epsilon_{Carnot} \\ T_H &= \frac{T_C}{1 - \epsilon_{Carnot}} \\ &= \frac{378K}{0.550} = 687.3K = 414.3^\circ C = 777.7^\circ F \end{aligned}$$

(b) They talked about “parasitic engine losses” in the Corvettes. The factory rates the engine at 600 hp (448 kW). The engine actually makes a lot more, but some of that is needed just to turn the engine! Get that loss down to a theoretical best and you’d have a 620 hp (463 kW) engine. If you think about this carefully, you might be able to come up with an estimate of the Second Law Efficiency with this information.



NOTE: You didn't need to show all this work, just the calculation.

$$\begin{aligned} \epsilon_{2ndLaw} &= \frac{\epsilon_{Actual}}{\epsilon_{Carnot}} \\ &= \frac{P_{Useful} / P_{Total}}{P_{theoretical Useful} / P_{Total}} \\ \epsilon_{2ndLaw} &= \frac{P_{Useful}}{P_{theoretical Useful}} \\ &= \frac{448,000W}{463,000W} \\ &= 0.9676 = 96.76\% \end{aligned}$$

(c) With the Second Law Efficiency, you can now find the Actual Efficiency. *If you did not get an answer to (b), use a Second Law Efficiency of 0.800 (80.0%).*

$$\begin{aligned} \epsilon_{2ndLaw} &= \frac{\epsilon_{Actual}}{\epsilon_{Carnot}} \\ \epsilon_{Actual} &= (\epsilon_{2ndLaw})(\epsilon_{Carnot}) \\ &= (0.9676)(0.550) \\ &= 0.5322 \end{aligned}$$

(d) If the C5-R Corvette weighs 2510 pounds, $m = 1141 kg$, and the 600 hp (448 kW) engine is used at full power, then how long (time) does it take to go from zero to 100 mph (44.7 m/s)? *Note: If you use the definition of Power and the Work-Energy Theorem, then it doesn't matter if the acceleration is constant or not.*



$$\begin{aligned} W &= \Delta KE = KE_f - KE_i = KE_f \\ &= \frac{1}{2}mv^2 = \frac{1}{2}(1141kg)(44.7m/s)^2 \\ &= 1,140,000J \\ P &= \frac{W}{t} \\ t &= \frac{W}{P} = \frac{1,140,000J}{448,000W} = 2.545sec \end{aligned}$$

(e) The lubrication system uses oil pressurized to an absolute pressure of 74.7 psi (514,800 Pa), when the outside air is at one atmosphere (14.7 psi, 101,300 Pa). If the oil tank springs a leak, at what speed v would the oil spray out of the hole?
 $\rho_{oil} = 840. kg/m^3$

$$\begin{aligned} P_1 + \rho gh_1 + \frac{1}{2}\rho v_1^2 &= P_2 + \rho gh_2 + \frac{1}{2}\rho v_2^2 \\ P_1 &= P_2 + \frac{1}{2}\rho v_2^2 \quad ; \quad P_1 - P_2 = \frac{1}{2}\rho v_2^2 \\ v_2^2 &= \frac{2(P_1 - P_2)}{\rho} \\ v_2 &= \sqrt{\frac{2(P_1 - P_2)}{\rho}} \\ &= \sqrt{\frac{2(514,800Pa - 101,300Pa)}{840. kg/m^3}} \\ &= 31.38m/s \end{aligned}$$

2001 C5-R Specs
Engine: LS-1 Pushrod V8 with Aluminum Block and Heads
Displacement: 427 cid
Intake System: Electronic Sequential Fuel Injection
Compression Ratio: 12.5:1
Horsepower: 620bhp @ 6400RPM
Torque: 495lb/ft @ 5200RPM
Transmission: 6-Speed Manual with Drop Gear
Final Drive Ratio: 3.11:1
Curb Weight: 2510 lbs.
Fuel Capacity: 100 liters
Brakes: 4-wheel vented monoblock calipers w/carbon rotors & pads