Winter Midterm Examination Physics 100

February 13, 2012

Name/Student #:

Instructions: Summary sheets with formulas on a separate booklet. My formulas are on this sheet. Questions are on both sides of the exam sheet. Calculator permitted. Put your name and student number at the top of the question sheet and complete all questions on the question sheet. Point values are shown with the questions. Complete the questions in any order. Total exam is worth 50 points.

1. Matching question. 16 points. You may give your answer by the standard connecting lines method or give the letter from the match item in second column behind the first column item e.g. (1) viscous flow B. One item in the first column has no match (write "no match") and one item has two matches. I am looking for *direct* matches.

(1) $E = \frac{1}{2}kx^2 + \frac{1}{2}mv_x^2$	A. linear restoring force
(2) $\Delta S \geq 0$ in closed system	B. $W = 0$
(3) pressure versus depth	C. Bernouilli's principle
(4) constant volume process	D. forced oscillations
(5) simple harmonic motion	E. $\rho_f g \Delta y$
(6) manometer	F. energy for mass and spring system
(7) resonance	G. 2nd Law of Thermodynamics
(8) airplane lift	H. pendulum

2. You have a monatomic ideal gas with pressure 1.01×10^5 Pa and volume of 8.00×10^{-4} m^3 at a temperature of 250 K. The number of particles is 2.34×10^{22}. $k_B = 1.38 \times 10^{-23}$ J/K for your calculation if you need to.

   (a) The gas then undergoes an adiabatic compression and the volume is reduced by a factor of 8 to 1.00×10^{-4} m^3. Calculate the new pressure and the new temperature. (hint: $8^{5/3} = 32$). (5)

   (b) Calculate the work that was done on the gas and the heat. (hint: you may want to calculate ΔE_{th} as an intermediate step. Assume $\Delta T = 425\ K$ as a dummy answer if you wish. (3)

3. Suppose that you have a liquid with a density of 1050 kg/m^3. You insert a tube and you want to raise the level of the liquid in the tube. Also suppose you have some way of lowering the pressure at the top of the tube (i.e. like drinking through a straw).

   (a) Suppose that the pressure at the base of the tube is 250 Pa higher than the pressure at the top of tube. How high does the liquid rise in the tube? What is the *net* force on the liquid? (4)

   (b) Now suppose that the liquid at the base of the tube flows transversely to the tube (you could do this with an inverted "T" joint). How fast does the liquid have to flow before the 250 Pa pressure difference is negated? (just use the $\Delta p = \frac{1}{2}\rho v^2$ formula for Bernouilli effect) (3)

4. A $m = 0.454$ kg mass is suspended from a string $L = 0.99$ m long. You pull the mass slightly sideways and let it swing as a pendulum. Use $g = 9.80$ m/s^2.

   (a) What is the period of oscillation? (3)

   (b) If the amplitude of oscillation (in terms of path length s) is 0.062 m what is the maximum velocity of the mass? (3)

   (c) Suppose that $\tau = 16.0$. How much has the amplitude decayed after $t = 16$ s? What is the quality factor? (You may use a dummy value of 4.0 s for the period if you wish.) (2)

5. You have heat engine placed between a hot reservoir with temperature of $T_H = 700$ K and a cold reservoir of $T_C = 300$ K. $Q_H = 700$ J of energy are taken from the hot reservoir and $Q_C = 600$ J are transferred to the cold reservoir. 100 J are extracted as work. Calculate the efficiency, and the total entropy change. (4)

6. A transverse wave is described by the following expression

$$y(x,t) = 1.0 \cos\left(\frac{2\pi x}{4.0} - \frac{2\pi t}{1.5}\right) \tag{1}$$

   (a) Draw a snapshot graph with $t = 1.5$ over a range of x from 0 to 8. Use quantitative scales for x and y. (Hint: the term that involves t and T may not be that important. Think of the unit circle.) (5)

   (b) How fast is the water moving in the x-direction because of the wave? (2)

———extra formulas———

$$\Delta S = \frac{Q}{T} \tag{2}$$

$$S = k_B \ln(\#\text{ of configurations}) \tag{3}$$

$$pV^{5/3} = \textit{constant} \text{ abiabatic, monatomic} \tag{4}$$

$$x_{max}(t) = x_{max}(t=0)e^{-\frac{t}{\tau}} \tag{5}$$

$$\text{quality factor} = \frac{\tau}{T} \tag{6}$$

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{L}} = \frac{2\pi}{T} = 2\pi f \tag{7}$$