Physics 22 Practice Final - 3 hours, 4 Pages

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Write your answers in a blue book. Calculators and one page of notes (both sides) allowed. No textbooks or wireless communications allowed. For multiple choice, write the appropriate letter or letters in your bluebook; showing your work is of course a good idea, but not required. For non multiple choice, *please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately.* Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**
For numerical work, you can always take: the acceleration of gravity to be $g = 10\,\mathrm{m/s^2}$, the ideal gas constant $R = 8.31\,\mathrm{J/(mole\ K)}$, absolute zero to be at T=-273° C, and 1 atm to be 10^5 Pa.

The first eight are multiple choice: write the letter corresponding to the correct answer in your bluebook.

For the next 2 questions, assume the x-direction is horizontal, with $x < 0$ to the left and $x > 0$ to the right. A wave on a string is described by the equation:

$$y(x,t) = 0.01\ \sin(\pi x + 2\pi t)$$

where the amplitide and the coordinate x are both in meters, and t is in seconds.

1. Which direction does the wave move?
   (a) From left to right.
   (b) From right to left
   (c) Neither of the above.
2. What is the wavelength of the wave?
   (a) 1/4 meter
   (b) π meters
   (c) $\pi/2$ meters
   (d) 1/2 meter
   (e) None of the above.

3. A wave is initiated *on the surface* of a smooth ocean when a tiny pebble falls into the ocean; there is no dissipation of wave energy. One meter from the point where the pebble falls in, the amplitude of the wave is 1 cm. What is the amplitude of the wave four meters from the point where the pebble falls in?

   (a) 1/2 cm

   (b) 1/4 cm

   (c) 1 cm

   (d) 1/16 cm

   (e) None of the above.

4. You move toward a trumpet that is playing a note toward you with frequency $\nu = 400\,\text{Hz}$. Your speed is $u = 30\,\text{m/s}$ and the speed of sound is $v = 300\,\text{m/s}$. The frequency that you hear, to the nearest Hz, is:

   (a) 444 Hz

   (b) 364 Hz

   (c) 440 Hz

   (d) 360 Hz

   (e) None of the above.

5. A thin ring of Aluminum (coefficient of linear expansion $\alpha_A = 23 \times 10^{-6}/^\circ\text{C}$) has inner diameter 5.000 mm and outer diameter 5.500 mm, at $T_0 = 20^\circ\text{C}$. A ball of steel, (coefficient of linear expansion $\alpha_S = 11 \times 10^{-6}/^\circ\text{C}$), has an outer diameter of 5.002 mm. Both are heated up to $T = 120^\circ\text{C}$. Will the ball of steel be able to slip through the aluminum ring at this higher temperature?

   (a) No

   (b) Yes

   (c) Impossible to tell

6. Compare Helium and Nitrogen gas. There is one mole of each, and both are at room temperature and atmospheric pressure.

   (a) Helium has a higher root-mean-square speed.

   (b) Nitrogen has a higher root-mean-square speed.

   (c) The root-mean-square speeds of the two gases are equal.

7. Initially, a system of a constant quantity of Argon gas has a volume of $V_i = 10^{-3}\,\mathrm{m}^3$ and pressure of $p_i = 10^5\,\mathrm{Pa}$. A process where work W is done on the gas and heat Q is added to the gas takes this Argon gas to a final volume of $V_f = (1/2) \times 10^{-3}\mathrm{m}^3$ and a final pressure of $p_f = (1/2) \times 10^5\,\mathrm{Pa}$. The process is reversible, and you can assume that a temperature of $T = 0$, that is, absolute zero, is attainable, which is a reasonable approximation. What is the *minimum* magnitude of work, $|W|$, that is necessary in moving the system from its initial state to its final state?

   (a) 0 Joules

   (b) 25 Joules

   (c) 37.5 Joules

   (d) 50 Joules

   (e) 75 Joules

   (f) None of the above.

8. Consider a system consisting of a volume of gas that is transported through a reversible cycle in the p-V plane. Which of the following are true?

   (a) The work done on the system is 0.

   (b) The change in internal energy of the system is 0.

   (c) The heat added to the system is 0.

   (d) The change in entropy of the system is 0.

9. A guitar string of mass density $\mu = 10\,\text{grams/meter}$ is stretched between supports that are a distance $L = 25\,\text{cm}$ apart. The string is plucked and vibrates in a standing wave pattern with 2 antinodes, with frequency $\nu = 400\,\text{Hz}$. What tension is in the string?

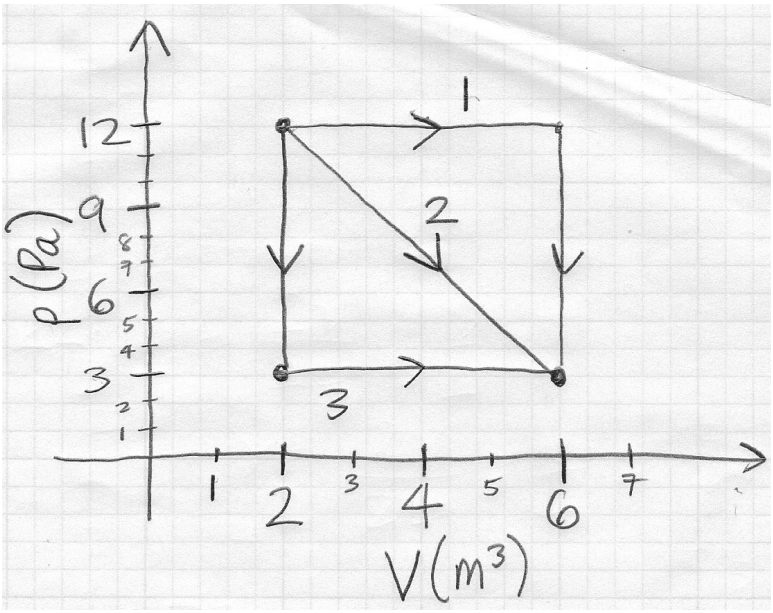

Figure 1: Problem 10.

10. A sample of a monatomic gas expands from 2.0 to 6.0 m^3 while its pressure decreases from 12 to 3.0 Pa. Consider the three processes shown in Fig. 1 numbered by 1, 2, and 3. Give symbolic and numerical answers.

    (a) How much work is done on the gas for each of the three processes 1, 2, and 3?

    (b) What is the change in internal energy of the gas for each of the three processes 1, 2, and 3?

    (c) What is the heat absorbed by the gas for each of the processes 1, 2, 3?

11. Consider an ideal Carnot refrigerator that removes heat from a temperature $T_L = 5^\circ\,\text{C}$. You can make the approximation that absolute zero is at $T = -273^\circ\,\text{C}$.

    (a) If $T_H = 25^\circ\,\text{C}$, what is the coefficient of performance, K, numerically and symbolically?

    (b) In the isothermal leg of the Carnot refrigerator at T_L, the Nitrogen gas starts at a pressure of $p_i = 10\,\text{atm}$ and a volume of $V_i = 0.001\,\text{m}^3$. What final pressure and volume must the gas end up with in order to absorb 1000 J during this leg?

    (c) How much entropy is absorbed by the gas in the portion of one cycle which occurs at T_L?

    (d) In a *complete cycle*, how much work must be done on the gas?