April Examination Physics 100

April 16, 2013

Instructions: Formulas at the back (you can rip those sheets off). Questions are on both sides of the exam sheet. Calculator permitted. Complete all questions in your examination booklet(s). Point values are shown with the questions. Complete the questions in any order. Total exam is worth 78 points plus two 2-point bonus questions. Maximum grade is still 100%.

For multiple-part questions I have sometimes included dummy-answers. They may or may not be the actual answer but you can use them, the correct answers, or a reasonable "wrong" answer to continue with later parts of the problem with no penalty.

Give your answers to 3 significant figures. Include the correct units with your answer. Pay attention to the units given in the problems.

1. Figure 1 is a snapshot graph of a wave at $t = 0$ s. Draw the history graph for this wave at $x = 6$ m, for $t = 0$ s to 6 s. (6 points)

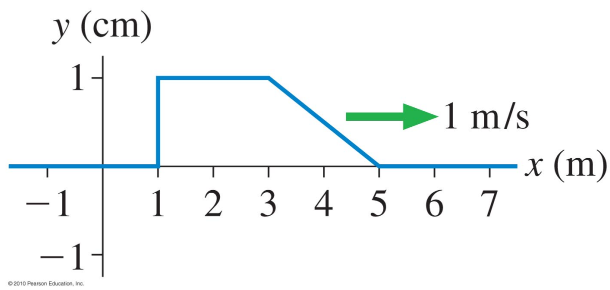

Figure 1: Figure for question 1

2. As we've seen, astronauts measure their mass by measuring the period of oscillation T when sitting in a chair connect to a spring with a spring constant $k = 606$ N/m. The empty chair has a period of 0.901 s. What is the mass of an astronaut who oscillates with a period of 2.09 s when sitting in the chair? (8)

3. A flat slab of styrofoam, with a density of 32 kg/m^3, floats on a lake. ($\rho_f = 1000$ kg/m^3) What minimum volume must the slab have so that a 40 kg boy can sit on the slab without it sinking? (6)

4. How much work is done by the gas in Fig. 2? You need to convert to SI (Pa and m^3) units to get an answer in Joules. 1 cm$^3 = 1.0 \times 10^{-6}$ m^3. You also expect a negative answer since the gas is being compressed. (6 points)

5. Suppose that you have a standing sound wave in an open-open pipe of length 0.360 m. Take the speed of sound to be 334 m/s.

   (a) What is the frequency of the fundamental harmonic? Please include a diagram that shows the envelope of the $m = 1$ standing wave. What physical quantity are you plotting? (Hint: it is different for a sound wave than a wave on a string.) (4)

   (b) In general, when do you hear "beats"? Calculate the beat frequency for this example if a second frequency is generated by the fundamental frequency of an open-open pipe with a length of 0.358 m. (2)

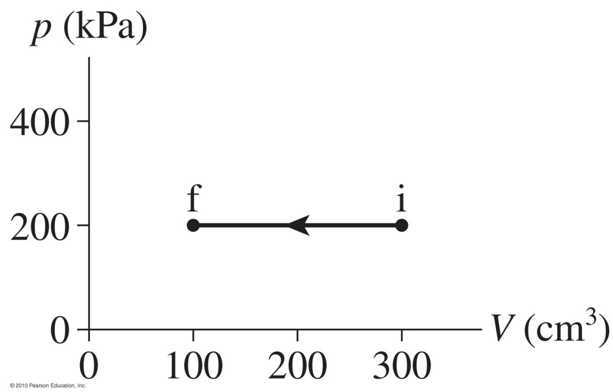

Figure 2: Figure for question 4

(c) What is the frequency of the next highest harmonic for the $L = 0.360$ m case? Again, please include a diagram. (2)

6. For the following give explanations of each of the phenomena in terms of the charge model, Coulomb's Law, and properties of conductors. You may want to include diagrams. One of the phenomena listed is unphysical; identify which one and explain what is incorrect. (10 points total)

   (a) I rub the end of a plastic rod with wool and the end of another plastic rod with wool. I then find that the two rod ends are attracted to each other.

   (b) I rub the end of a plastic rod with wool and then touch the rod to an electroscope. The leaves of the electroscope moves apart.

   (c) I touch the same electroscope and the leaves move together again. (I haven't been touching the Van de Graaff!)

   (d) I hold a metal sphere on an insulating plastic rod near a plastic rod that has been rubbed with wool. There is an attraction between the rod and the sphere. I observer the same thing with a glass rod rubbed with silk. (No special preparation was done to the metal sphere.)

   (e) A person with long hair places her hands on a van der Graaf generator and her hair begins to stand on end.

7. A conducting sphere has a radius of 0.10 m.

   (a) What is the Q required to bring the surface of the sphere to $V = 50000$ V if $V = 0$ at infinity? (2)

   (b) Draw the electric field lines. Do they continue inside of the sphere? (2)

   (c) Find the location of the $V = 25000$ V equipotential. Draw it on the figure. (2)

   (d) The 30000 and 20000 V equipotentials are located at $r = 0.167$ m and $r = 0.250$ m.

      i. Make an estimate of the electric field strength at $r = 0.208$ m using the relationship between electric field and electric potential. (2)

      ii. Calculate the strength of the electric field using the formula $E = \frac{KQ}{r^2}$. (2)

8. (a) Consider a long wire that is perpendicular to the page and 6.0 A of current is flowing into the page. Draw the magnetic field lines. Calculate the strength of the magnetic field 2.0 cm away from the wire. (4)

   (b) A positively charged particle (a proton) is moving in the positive x-direction at 500 m/s. A magnetic field is pointing into the page with $B = 2.5$ T. The particle has a charge of -1.6×10^{-19} C. Give the force on the particle (magnitude and direction). (3)

9. An electric dipole consists of a postive and a negative charge that are separated by some distance. Suppose that the positive charge is 1.0 nC and it is 5.0 cm above the origin. The negative charge is -1.0 nC and is 5.0 cm below the origin. See Fig. 3.

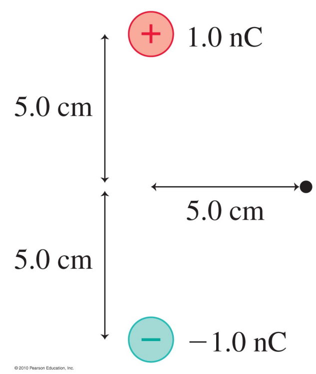

Figure 3: Figure for question 9

   (a) Make a sketch of the electric field using electric field lines. Draw equipotential curves. (3)

   (b) Calculate the magnitude and direction of the electric field that is 5.0 cm to the right of the line connecting the charges. (The dot in Fig. 3.) As a required intermediate step calculate the electric field (magnitude and direction) from the positive charge only. (4)

10. For the circuit diagram in Fig. 4 determine:

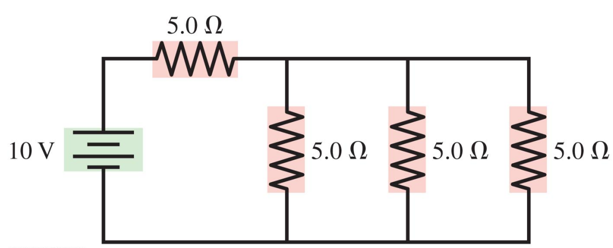

Figure 4: Figure for question 10

   (a) The equivalent resistance of the three 5 Ω (Ohm) resistors that are in parallel. (2)

   (b) The current through the 10.0 V battery. (Use $R_{equiv} = 7.0$ Ω as a dummy answer for part marks if you wish). (2)

   (c) What is the current through the 5 Ω resistor "closest" to the battery? What is the potential drop across this resistor? (2)

(d) What is potential drop across and current through any one of the group of parallel 5 Ω resistors? (2)

(e) Show how Kirchhoff's junction law is satisfied at the junction between the single 5 Ω resistor and the group of parallel resistors. (2)

11. BONUS:

(a) The electric and magnetic fields of a dipole and a bar magnet look quite similar but there is one big difference. What is it? (2)

(b) In the experiment I showed you in the Modern Physics lab with electrons moving in a constant magnetic field what was the shape of the path they followed? (2)