April Examination Physics 100

April 14, 2012

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 80 points.

For multiple choice questions clearly indicate the correct answer. There is mark breakdown shown for the multiple choice answer and the work associated with the question/answer.

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.

1. A wave on a string can be described by the equation

$$y(x,t) = A\cos\left(\frac{2\pi}{0.32}x - 2\pi(330)t\right) \tag{1}$$

(x is in metres and t is in seconds). $A = 5.00 \times 10^{-4}$ m.

   (a) Describe this wave in the form that is currently given. Give the wavelength, frequency, and speed. (3)

   (b) Draw a snapshot graph with $t = 0$ from $x = 0$ to $x = 0.64$ m. (2)

   (c) Draw a snapshot graph with $t = 7.58 \times 10^{-4}$ s from $x = 0$. Hint: just determine how far the wave has moved rather worry about substituting into the cosine function. (2)

2. Suppose that you have a standing sound wave in an open-closed pipe of length 0.18 m. Take the speed of sound to be 330 m/s.

   (a) What is the frequency of the fundamental harmonic? Please include a diagram that shows the standing wave. (3)

   (b) What is the frequency of the next highest harmonic? Again, please include a diagram. (3)

3. Consider the following problems in ray optics.

   (a) Calculate the critical angle for glass with $n = 1.55$. Make a quick sketch to show the path of the ray just before the critical angle is reached. (3)

   (b) (2 points for this multiple choice) The index of refraction is slightly different for different wavelengths of light. This means:

      i. Red light travels at the same speed as violet light in glass but they are refracted (bent) different amounts.

      ii. Red light travels at a different speed in the glass compared to violet light and they are refracted different amounts.

      iii. Red light has a different speed in the glass than violet light but they are refracted the same amount.

      iv. This isn't possible; all electromagnetic waves have the same speed c.

(c) A converging lens has a $f = 15$ cm and an object 5.0 cm tall is 45 cm away.

i. Calculate the position and size of the image. (Use $s' = 25$ cm and $h_i = -3.0$ cm for dummy answer for the next part if you like). (2)

ii. Draw the ray diagram that shows how the real image is formed. Make your scale at least roughly correct (you can take the lens radius to be 8 cm but that doesn't enter into any of the calculations). A ruler makes this easier. (4)

iii. Suppose that the object is moved farther away from the lens until $s \gg f$. Where is the image? (2)

4. For the following give explanations 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. (11 points total)

(a) I rub the end of a plastic rod with wool and the end of a glass rod with silk. 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 farther apart. (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.)

5. (a) Consider a wire that is perpendicular to the page and 6.0 A of current is flowing into the page. Draw the magnetic field lines. (2)

(b) A beam of positively charged particles is 4.0 cm to the right of the wire and is also moving into the page. $q = 1.6 \times 10^{-19}$ C and $v = 5.00 \times 10^6$ m/s. What is force on the particles due to the magnetic field of the wire? Give magnitude and direction and explain how you use the right hand rule. (as a dummy answer assume the magnetic field is pointing to the right with $B = 2.5 \times 10^{-5}$ T) (5 points)

6. An electric dipole consists of a postive and negative charge that are separated by some distance. Suppose that the positive charge is 1.0 nC and it is 0.50 cm above the origin. The negative charge is -1.0 nC and is -0.50 cm below the origin.

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

(b) Calculate the magnitude and direction of the electric field that is 2.0 cm to the right of the line connecting the charges. (this would be on the x-axis if the charges are on the y-axis). As a required intermediate step calculate the electric field (mag and direction) from the positive charge only. (6)

7. A laser with $\lambda = 627$ nm illuminates a Young's double slit apparatus. The slits are 0.30 mm apart. The viewing screen is 2.0 m away from the slits.

(a) What is the separation of the $m = 0$ and $m = 1$ bright fringes? (2)

(b) For the $m = 2$ bright fringe how much farther away is the "far" slit than the "near" slit? (2)

(c) What is the energy of one photon at this wavelength? (2)

(d) If the intensity of the laser is 6.5×10^8 W/m^2 what is the electric field amplitude E_0. (2)

8. (a) Following our discussion of the Bohr model for hydrogen what is the deBrogile wavelength of an electron in the $n = 2$ orbit. You should be able to give a quantitative answer using $a_B = 0.0529$ nm. (hint: the electron forms a standing wave that is matched to the circumference of the orbit). (3)

   (b) Calculate the energy in eV for the $n = 2$ and $n = 3$ levels. (2)

   (c) Calculate ΔE for the $n = 3$ to $n = 2$ transition and also the wavelength of the emitted photon. (Use $\Delta E = 2.9$ eV as a dummy answer to find the photon wavelength if you like.) (4)

9. For the circuit diagram in Fig. 1 determine:

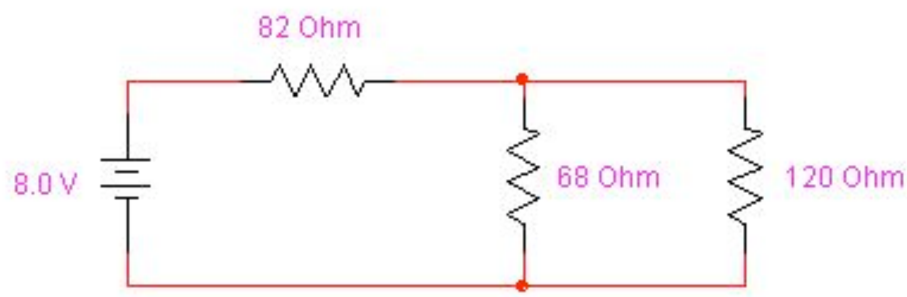

Figure 1: Figure for question 9

   (a) the equivalent resistance of the 68 Ω (Ohm) and 120 Ω resistor combination as appropriate for this circuit (2)

   (b) the current through the 8.0 V battery (2)

   (c) the electric potential at the junction of 82, 68, and 120 Ω resistors (you may assume the electric potential on the "negative" terminal of the battery is at ground or $V = 0$) (2)

   (d) the current through the 68 Ω resistor (2)

   (e) use Kirchhoff's current law to determine the current through the 120 Ω resistor (2)