UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 106-4 / LeClair Fall 2008

Problem Set 9: Mixed

Instructions:

1. Answer all questions below. Show your work for full credit.
2. Due at the end of **Friday** 21 Nov. 2008
3. You may collaborate, but everyone must turn in their own work

1. 10 points. A taut wire passes through the gap of a small magnet, where the field strength is $0.5\,\mathrm{T}$. The length of the wire within the gap is $1.8\,\mathrm{cm}$. Calculate the amplitude of the induced alternating voltage when the wire is vibrating at its fundamental frequency of $2000\,\mathrm{Hz}$ with an amplitude of $0.03\,\mathrm{cm}$.

2. 15 points. A sphere of radius R has a uniform volume charge density ρ. Determine the magnetic field at the center of the sphere when it rotates as a rigid object with angular speed ω about an axis through its center.

3. 10 points. The lead-in wires from a television antenna are often con- structed in the form of two parallel wires. **(a)** Why does this configuration of conductors have an inductance? **(b)** What constitutes the flux loop for this configuration? **(c)** Ignoring any magnetic flux inside the wires, show that the inductance of a length x of this type of lead-in is

$$L = \frac{\mu_o x}{\pi} \ln\left(\frac{w-a}{a}\right)$$

where a is the radius of the wires and w is their center-to-center separation.

4. 15 points. As light from the Sun enters the atmosphere, it refracts due to the small difference between the speeds of light in air and in vacuum. The optical length of the day is defined as the time interval between the instant when the top of the Sun is just visibly observed above the horizon, to the instant at which the top of the Sun just disappears below the horizon. The geometric length of the day is defined as the time interval between the instant when a geometric straight line drawn from the observer to the top of the Sun just clears the horizon, to the instant at which this line just dips below the horizon. The day's optical length is slightly larger than its geometric length.

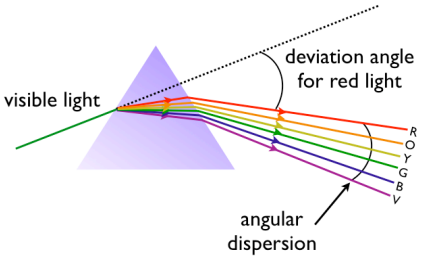
By how much does the duration of an optical day exceed that of a geometric day? Model the Earth's atmosphere as uniform, with index of refraction $n = 1.000293$, a sharply defined upper surface, and depth $8767\,\mathrm{m}$. Assume that the observer is at the Earth's equator so that the apparent path of the rising

and setting Sun is perpendicular to the horizon. You may take the radius of the earth to be 6.378×10^6 m. Express your answer to the nearest hundredth of a second.

5. 10 points. What is the apparent depth of a swimming pool in which there is water of depth 3 m, **(a)** When viewed from normal incidence? **(b)** When viewed at an angle of 60° with respect to the surface? The refractive index of water is 1.33.

6. 15 points. The index of refraction for **violet** light in silica flint glass is $n_{\text{violet}} = 1.66$, and for **red** light it is $n_{\text{red}} = 1.62$. In air, $n = 1$ for both colors of light.

What is the **angular dispersion** of visible light (the angle between red and violet) passing through an equilateral triangle prism of silica flint glass, if the angle of incidence is 50°? The angle of incidence is that between the ray and a line *perpendicular* to the surface of the prism. Recall that all angles in an equilateral triangle are 60°.



7. 10 points. Prove that any incoming ray that is parallel to the axis of a parabolic reflector will be reflected to a central point, or "focus."