## AP Physics 2: Spring Semester Wizard Challenges by Unit

These problems are more advanced than those in the regular homework: successfully completing them will earn you one point per problem, applied to the Assessments category of your grade. Limit of ten points: partial credit is given for legitimate attempts.

Please print this PDF and complete these on another sheet of paper.

## Unit 3.C: Basic Circuits

1. (Section 3.C.2) A wire made of brass and a wire made of silver have the same length, but the diameter of the brass wire is 4 times that of the silver wire. The resistivity of brass is 5 times greater than the resistivity of silver. If $R_{\mathrm{B}}$ denotes the resistance of the brass wire and $R_{\mathrm{S}}$ denotes the resistance of the silver wire, what is the ratio of resistance between brass and silver (in the form $R_{\mathrm{B}}: \mathrm{R}_{\mathrm{s}}$ ).
2. A series RC Circuit consisting of a $5.0 \mathrm{M} \Omega$ resistor and a $0.40 \mu \mathrm{~F}$ capacitor is connected to a 12.0 V battery. The capacitor is initially uncharged.
A. What is the change in voltage across it between $t=2 \tau$ and $t=4 \tau$ ?
B. By how much does the capacitor's stored energy change in the same time interval?

## Unit 4: Magnetism

1. (Section 4.4) In a physics lab, a student discovers that the magnitude of the magnetic field at a certain distance from a long wire is $4.0 \mu \mathrm{~T}$. If the wire carries a current of 5.0 A , what is the distance of the magnetic field from the wire?
2. (Section 4.4) Two long, straight wires are hanging parallel to each other and are 1 cm apart. The current in Wire 1 is 5 A , and the current in Wire 2 is 10 A , in the same direction. What is the magnetic force between the wires? Is it attractive or repulsive?
3. (Section 4.5) A loop ( $\mathrm{r}=20.0 \mathrm{~cm}$ ) is in a uniform magnetic field of 0.15 T . What angle(s) between the normal to the plane of the loop and the field would result in a flux with a magnitude of $0.014 \mathrm{~T} \cdot \mathrm{~m}^{2}$ ?
4. (Section 4.5) In the figure, a small, circular loop of wire (radius $r$ ) is placed on an insulating stand inside a hollow solenoid of radius $R$. The solenoid has $n$ turns per unit length and carries a counter-clockwise current $I$. If the current in the solenoid is decreased at a steady rate of $a \mathrm{amps} / \mathrm{s}$, determine the induced emf, $\boldsymbol{\varepsilon}$ (symbolically - no numbers needed), and the direction of the induced current in the loop (clockwise or counterclockwise).

5. Due to the magnetic force, a positively charged particle executes uniform circular motion within a uniform magnetic field, $B$. If the charge is $q$ and the radius of its path is $r$, which of the following expressions gives the magnitude of the particle's linear momentum?
A. qBr
B. $\mathrm{qB} / \mathrm{r}$
C. $\mathrm{q} /(\mathrm{Br})$
D. $\mathrm{B} /(\mathrm{qr})$
E. $\mathrm{r} /(\mathrm{qB})$

## Unit 5.B: Geometric Optics

1. If you hold a $900 . \mathrm{cm}^{2}$ square plane mirror 45 cm from your eyes and can just see the full length of an 8.5 m flagpole behind you, how far are you from the pole?
2. A child looks at a reflective Christmas tree ball ornament that has a diameter of 9.0 cm and sees an image of her face that is $1 / 8$ the real size. How far is the child's face from to ball?

## Unit 5.C: Physical Optics

1. To study wave interference, a student uses two speakers driven by the same sound wave of wavelength 0.50 m . If the distances from a point to the speakers differ by 0.75 m , will the waves interfere constructively or destructively at that point? What if the distances differ by 1.0 m ?
2. A slit of width 0.15 mm is illuminated with monochromatic light of wavelength 632.8 nm . At what angle will the first maximum occur?
3. A teacher standing in a doorway 1.0 m wide blows a whistle with a frequency of 1000 Hz to summon children from the playground. Two boys are playing on swings 20.0 m away from the school building. One boy is at an angle of $0.0^{\circ}$ and another one is at $19.6^{\circ}$ from a line normal to the doorway. Taking the speed of sound in air to be $335 \mathrm{~m} / \mathrm{s}$, which boy may not hear the whistle? Prove your answer.
4. A film on a lens with an index of refraction of 1.5 is $1.0 \mathrm{E}-7 \mathrm{~m}$ thick and is illuminated with white light. The index of refraction of the film is 1.4.
A. The number of waves that experience the $180^{\circ}$ phase shift is (1) zero, (2) one,
(3) two. Explain.

B. For what wavelength of visible light will the lens be nonreflecting?
5. Some types of glass have a range of indices of refraction of about 1.4 to 1.7. What is the range of the polarizing (Brewster) angle for these glasses when light is incident on them from air?

## Unit 6: Modern Physics

1. The work function of a material is 3.5 eV . If the material is illuminated with monochromatic light $(\lambda=$ 300 nm ), what are the stopping potential and the cutoff frequency?
2. (Section 6.7) An electron is accelerated from rest through a potential difference of 2.50 MV . Find the electron's a) speed, b) kinetic energy, and c) momentum.
3. (Section 6.7) If a reactor produces an average power of 1000 MW for a year, how much 235 U is used up assuming 200 MeV are released per fission?
