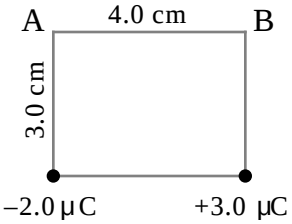
Name _____

Please work the problems on separate sheets of paper and staple these sheets to the front. Read each problem carefully. Show your work and/or give some kind of explanation for every answer; I do give partial credit, but *only* if I can follow your work. Make sure that your answers are given with a reasonable number of sig figs and that you have included appropriate units. Check your answers for physical *reasonableness* whenever possible.

1. Two charges are located at adjacent corners of a rectangle as shown at right.



   a) [5 pts] How much *work* would you need to do to bring the two charges "*from* infinity" *to* these final locations?

   b) [10 pts] What is the *electric field* (magnitude and direction) at corner A?

   c) [5 pts] What *force* (magnitude and direction) would be exerted on a –5.0 μC charge placed at corner A?

   d) [5 pts] What is the *potential difference* $V_B - V_A$?

   e) [5 pts EC] What charge placed at point B would make the total electrostatic potential energy of the three charge system be zero?

2. In a certain series LRC circuit (driven by a generator with a sinusoidal output voltage) the current in the circuit is 50 mA, the voltage across the resistor is 15 V, the voltage across the inductor is 20 V, and the voltage across the capacitor is 40 V. The capacitor has a capacitance of 500 nF.

   a) [6 pts] Draw a *phasor diagram* representing the information given above.

   b) [2 pts] Find the *resistance* of the resistor.

   c) [4 pts] Find the *inductive and capacitive reactances*.

   d) [3 pts] Find the *voltage output* of the generator.

   e) [3 pts] Find the *phase angle* (with sign) between the generator voltage and the current (Remember: "+" "generator voltage leads" and "–" "current leads.")

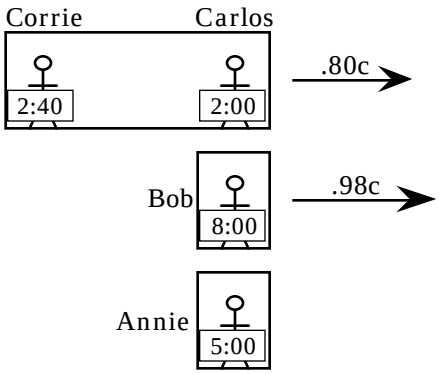
   f) [3 pts] Find the *frequency* of the generator.

   g) [2 pts] Find the *inductance* of the inductor.

   h) [2 pts] Find the re*sonant frequency* for this circuit.

   i) [5 pts EC] At what *other frequency* would the voltage across the resistor be 15 V?

3. Annie observes Bob in a spaceship moving at .98c to the right and Carlos and Corrie (whose watches "are synchronized") in another spaceship moving at .80c. Carlos and Bob pass Annie (and each other) at exactly the same instant. *At* that instant, *Annie observes* that the watches of all four people read as shown at right.



   a) [5 pts] What time will *Annie say* it is when Carlos' watch reads 3:00?

   b) [7 pts] How fast is Bob moving *according to Carlos*?

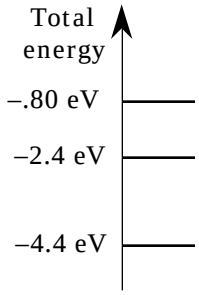
   c) [8 pts] How far apart are Carlos and Corrie *according to Annie*?

   d) [5 pts] *According to Corrie* what time is it when Annie passes Carlos?

   e) [5 pts EC] What were the readings on Corrie's and Bob's watches when they passed?

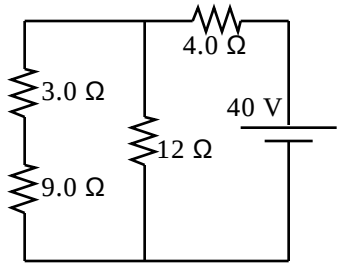
Short Problems [Do any five of the following six problems for 5 pts each]

4. A certain atom has three electron energy levels as shown in the energy diagram at right. When an electron makes "transitions" between these levels, light is emitted. What is the *shortest wavelength* of light that can be emitted due to an electron transition between two of these levels? (Express your answer in nm.)

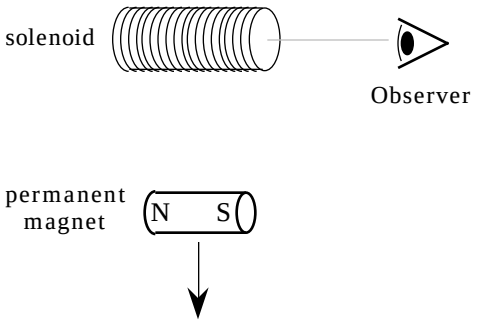


5. A large nuclear reactor generates 1000 MW of electrical power and another 400 MW of power is wasted (in the form of exhaust heat). (This energy is produced by nuclear reactions that rearrange neutrons and protons in the nuclei of atoms in the "fuel rods" into nuclei with larger "mass defects.") How much *mass* do the fuel rods "lose" after running this reactor continuously for one full year?

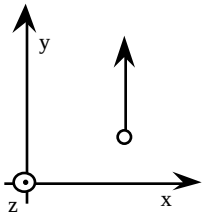
6. How much current passes through the 3.0 Ω resistor in the circuit shown at right? As *always*, explain.



7. A permanent magnet moves away from a solenoid as shown at right. As seen by the observer, what *direction* does the induced current flow in the solenoid—clockwise or counterclockwise? (You *must* explain your reasoning for full credit; a drawing or two would help a lot! Remember that the magnetic field lines of a permanent magnet go *from* N *to* S.)



8. A small particle with a charge of –5.0 μC travels with a velocity of 2.0 x 10^6 m/s in the +y direction through a region in which there is a uniform magnetic field of 200 mT in the +z direction (out of the page) and a uniform electric field of 300 kV/m in the –y direction. What is the *magnitude of the net force* acting on the particle?



9. Two square metal plates 10 cm on a side are separated by 0.20 mm. The space between them is filled with a material having a dielectric constant of 3.5 and a resistivity of 7 x 10^{14} Ω m. The result is a self-discharging, parallel plate capacitor since the material between the plates acts both as a dielectric for the capacitor *and* as a resistor in series with the capacitor plates. Find the time constant for the self-discharge of this capacitor. (In fact, all real capacitors *are* self-discharging for precisely this reason.)