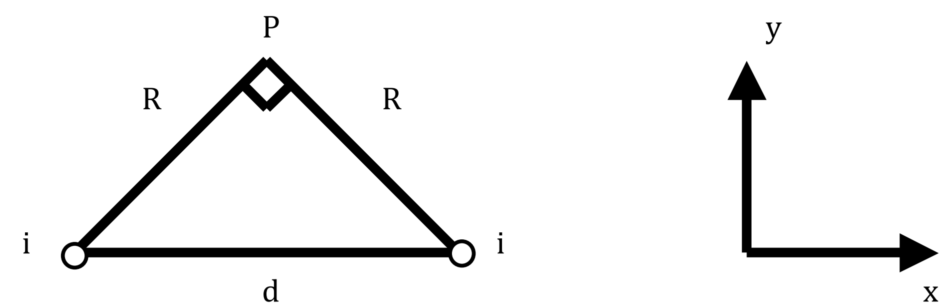
Exam 2 – 272 Spring 2012

1. [chapter 18] A long wire carrying a current of 100 [I] A is placed in a uniform external magnetic field of 50 x 10^{-4} T. The wire is at right angles with respect to this external field. The points at which the net magnetic field is zero lie:
   a. Along a line parallel to the wire and [0.04*I] mm from it.
   b. Along a line parallel to the wire and [0.02*I] mm from it.
   c. Along a line perpendicular to the wire and [0.04*I] mm from it.
   d. Along a line perpendicular to the wire and [0.02*I] mm from it.

2. [chapter 18] Two long straight wires a distance d = 10 cm apart each carry a current I = 100 A. The figure shows a cross section, with wires running perpendicular to the page and point P lying on the perpendicular bisector of d. The angle at P is 90 degrees. The current in the left-hand wire is out of the page, while the current in the right-hand wire is into the page. The magnetic field at P is:



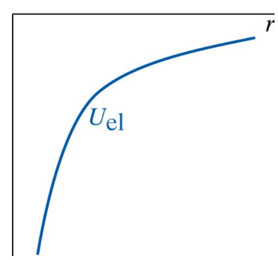
   a. $4 \times 10^{-3} \dfrac{I}{d(cm)} T$ along +y-axis
   b. $2 \times 10^{-3} \dfrac{I}{d(cm)} T$ along +y-axis
   c. $4 \times 10^{-3} \dfrac{I}{d(cm)} T$ along –y-axis
   d. $4 \cdot \sqrt{2} \times 10^{-3} \dfrac{I}{d(cm)} T$ along +y-axis
   e. $4 \cdot \sqrt{2} \times 10^{-3} \dfrac{I}{d(cm)} T$ along –y-axis

3. [chapter 17, 17.P.99, recitation problem] An isolated parallel-plate capacitor of area A =1 cm^2 with an air gap of length s = 1 mm is charged up to a potential difference of [ΔV = 100 V]. A second parallel-plate capacitor, initially uncharged, has the same area A and a gap of length s but is filled with plastic whose dielectric constant is [K = 1.2]. You connect a wire from the

positive plate of the first capacitor to one of the plates of the second capacitor, and you connect another wire from the negative plate of the first capacitor to the other plate of the second capacitor. What is the final potential difference across the first capacitor? Recall that Q=CΔV and that $C=\varepsilon_0 \frac{A}{s}$ for a parallel plate capacitor.

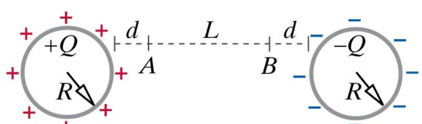
a. $\Delta V \frac{1}{K+1}$
b. $\Delta V \frac{K+1}{K}$
c. $\Delta V \frac{K-1}{K+1}$
d. $\Delta V \frac{K-1}{K}$

4. [chapter 17, 17.X.27] The figure below shows the electric potential energy for a system of two interacting objects, as a function of the distance between the objects. What system(s) might this graph represent?



a. a proton and an electron
b. two protons or two electrons
c. two chlorine ions
d. two sodium atoms

5. [17.P.78] A thin spherical glass shell of radius *R* carries a uniformly distributed charge of +*Q*, and a thin spherical plastic shell of radius *R* carries a uniformly distributed charge –*Q*. The surfaces of the spheres are a distance *L* + 2*d* from each other, and locations *A* and *B* which lie on a line connecting the center of the two spheres are a distance *d* from the surfaces of the spheres as shown in the figure. What is the potential difference, $V_B - V_A$?



a. $\frac{-1}{2\pi\varepsilon_0}\frac{QL}{(R+d)(R+d+L)}$

b. $\frac{1}{2\pi\varepsilon_0}\frac{QL}{(R+d)(R+d+L)}$

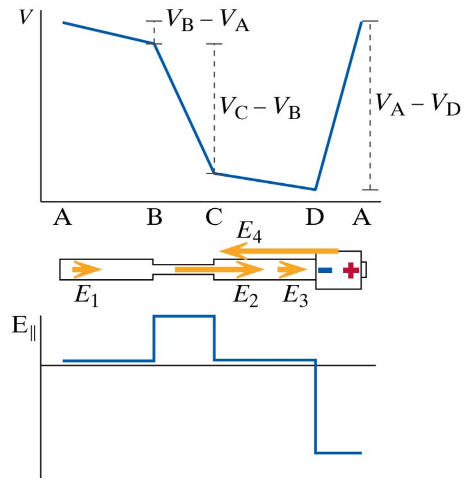
c. $\frac{-1}{2\pi\varepsilon_0}\frac{Q}{(R+d)}$

d. $\frac{-1}{2\pi\varepsilon_0}\frac{Q}{(R+d+L)}$

e. 0

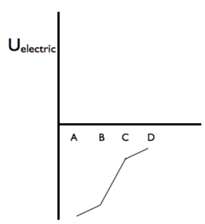
6. [chapter 18 18.P.73] A compass originally points north; at this location the horizontal component of the Earth's magnetic field has a magnitude of 2×10^{-5} T. A bar magnet is aligned east-west, pointing at the center of the compass. When the center of the magnet is [z] 0.25 m from the center of the compass, the compass deflects [θ] $70°$. What is the magnetic dipole moment of the bar magnet?
   a. $100\cdot\tan(\theta)\cdot z^3$ Am²
   b. $100\cdot\sin(\theta)\cdot z^3$ Am²
   c. $100\cdot\cos(\theta)\cdot z^3$ Am²
   d. $100\cdot\tan(\theta)\cdot z^2$ Am²
   e. $100\cdot\tan(\theta)\cdot z$ Am²
7. A certain capacitor has rectangular plates .59 m [L] by .33 m [W], and the gap width is 27 x 10^{-3} m [s]. If the gap is filled with a material whose dielectric constant is 2.9, [K], what is the capacitance of this capacitor?
   a. $8.85\times10^{-12}\frac{L\cdot W\cdot K}{s}$ F
   b. $8.85\times10^{-12}\frac{L\cdot W}{s}$ F
   c. $8.85\times10^{-12}\frac{s\cdot K}{L\cdot W}$ F
   d. $9\times10^{-9}\frac{L\cdot W\cdot K}{s}$ F

8. The figure below shows the potential difference in a circuit consisting of two thick wires, a highly resistive thin wire and a battery.

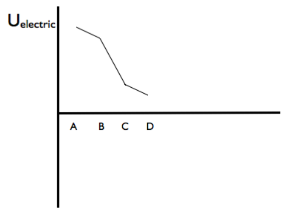


Which figure below shows the correct electric potential energy of a conduction electron for the above circuit?

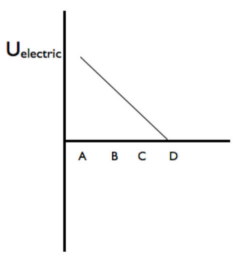
a)



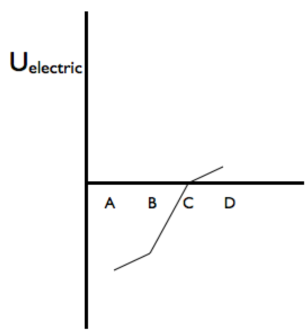
b)



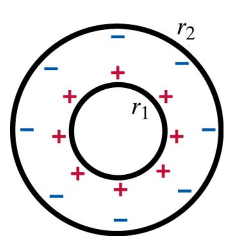
c)



d)



9. The figure below shows a spherical metal shell of radius r_1 with a charge Q on its outer surface. It is surrounded by a concentric spherical metal shell of radius r_2 that has a charge –Q on its inner surface. What is the capacitance of this spherical capacitor? Hint: use the definition of capacitance: $Q = C|\Delta V|$, the electric potential due to a uniformly charged sphere and the superposition principle.



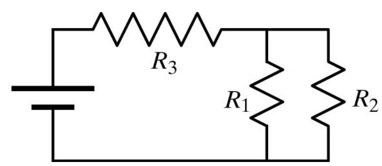
a. $\frac{r_1 r_2}{r_2 - r_1} 4\pi\varepsilon_0$

b. $\frac{r_1 r_2}{r_2 + r_1} 4\pi\varepsilon_0$

c. $\frac{r_1^2 r_2^2}{r_2^2 + r_1^2} 4\pi\varepsilon_0$

d. $\frac{r_1^2 r_2^2}{r_2^2 - r_1^2} 4\pi\varepsilon_0$

10. In the circuit shown below, the emf of the battery is 7.4 volts [V]. The resistor R_1 has a resistance of 31 Ω, resistor R_2 has a resistance of 47 Ω, and resistor R_3 has a resistance of 52 Ω. A steady current flows through the circuit. What is the conventional current through R_1?



a. $I_1 = V\left(\frac{R_2}{R_1R_2 + R_1R_3 + R_2R_3}\right)$

b. $I_1 = V\left(\frac{R_1}{R_1R_2 + R_1R_3 + R_2R_3}\right)$

c. $I_1 = V\left(\frac{R_2}{R_1R_2 + R_1R_3 - R_2R_3}\right)$

d. $I_1 = V\left(\frac{R_3}{R_1R_2 + R_1R_3 + R_2R_3}\right)$

Free Response Question

The charge on an isolated capacitor does not change when a sheet of glass is inserted between the capacitor plates, and we find that the potential difference decreases (because the electric field inside the insulator is reduced by a factor of $1/K$). Suppose instead that the capacitor is connected to a battery, so that the battery tries to maintain a fixed potential difference across the capacitor.

a. A light bulb and an air-gap capacitor of capacitance C are connected in series to a battery with known emf. What is the final charge Q on the positive plate of the capacitor?
b. After fully charging the capacitor, a sheet of plastic whose dielectric constant K is inserted into the capacitor and fills the gap. (The capacitor is still connected to the battery.) Does any current run through the light bulb? Provide an explanation for your answer.
c. What is the final charge on the positive plate of the capacitor?