PHY303L Useful Formulae for Test 2

Magnetic Force on a moving charged particle $\vec{\mathbf{F}}_B = q\vec{v} \times \vec{B}$

Magnetic Force on a current carrying wire $\vec{\mathbf{F}}_B = i\vec{L} \times \vec{B}$

Magnetic dipole moment $\mu = NiA$

Torque on a magnetic dipole: $\vec{\tau} = \vec{\mu} \times \vec{B}$

Cyclotron radius $r = \frac{mv}{qB}$

Cyclotron frequency $\omega = 2\pi\nu = \frac{qB}{m}$

Magnetic field of a current element: $\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{s}\times\vec{r}}{r^3}$

Magnetic field of a long straight wire: $B = \frac{\mu_0 i}{2\pi R}$

Magnetic field of a straight wire segment: $B = \frac{\mu_0 i}{4\pi R}(\cos\theta_1 - \cos\theta_2)$

Magnetic field of a current loop at the center: $B = \frac{\mu_0 i\phi}{4\pi R}$

Magnetic field of a current loop, on axis: $B(z) = \frac{\mu_0 i R^2}{2(R^2+z^2)^{3/2}}$

Ampere's Law: $\oint \vec{B} \cdot d\vec{s} = \mu_0 i$

Constants and Conversion factors:

Magnetic permeability constant, $\mu_0 = 1.26\text{x}10^{-6}$ T·m/A

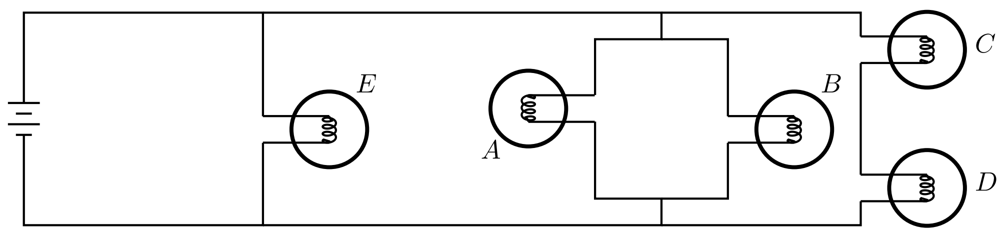
Couloumb's law constant: $k_e = \frac{1}{4\pi\epsilon_0} = 8.89\text{x}10^9$ N·m^2/C^2

1 eV = 1.602 x 10^{-19} J

PHY303L **Test 2** **April 3, 2009** Name:

Instructions: there are 5 questions each worth 20 points.

(1) A circuit is wired up with 5 identical light bulbs and connected to a source of EMF. In the diagram, any point where the connecting wires form a T is considered a junction. If bulb C is replaced with a simple wire,



(1.1) what happens to the brightness of bulb A?

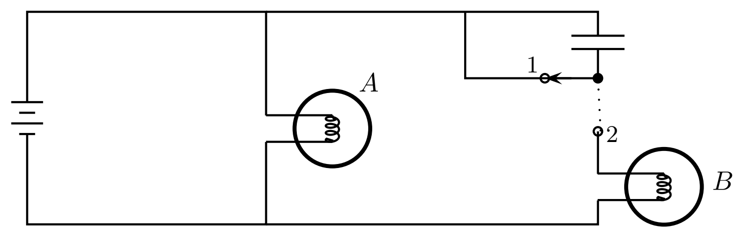
(1.2) what happens to the brightness of bulb D?

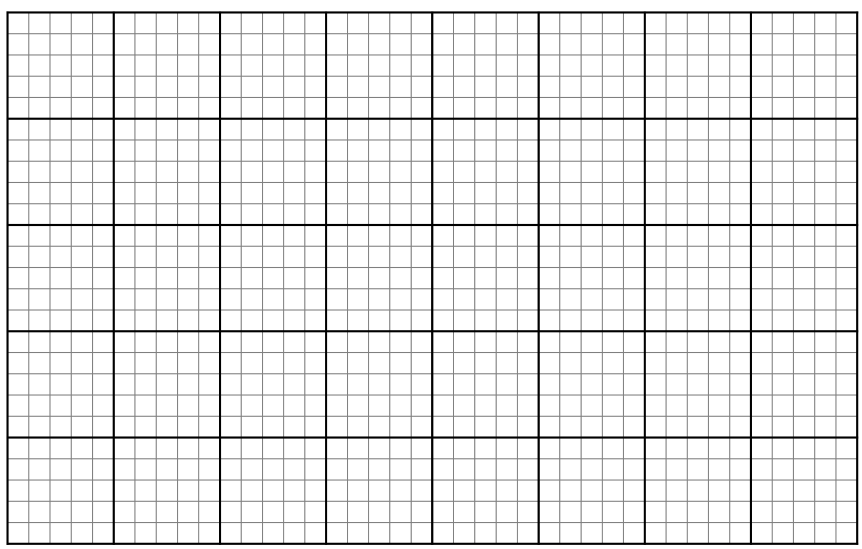
(1.3) what happens to the brightness of bulb E?

(1.4) If you indicated that the brightness of the bulb changed in any of the last 3 questions, by approximately what factor did it change? (for example, twice as bright or half as bright).

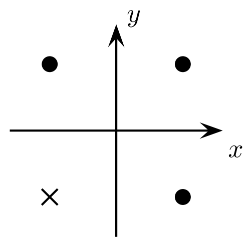
(2) The switch is connected to terminal 1 in the circuit below and the capacitor is completely discharged. At time zero, the switch is moved to connect to terminal 2. The battery has a voltage V, the bulbs have resistance R and the capacitor has capacitance C. Neglect any change in R that might occur because of a temperature change of the light bulb resistance.

(2.1) On the graph below sketch the intensity of bulbs A and B as a function of time. Label the time axis in terms of the variables R, C and/or V.





(3) Four long, parallel wires are are aligned in the z-direction. A schematic view from above is given in the figure. The wires intersect the x-y plane at the corners of a square with sides of length L. The wire in the -x, -y quadrant has a current I flowing the in the -z-direction (into the paper). The other three wires each have the same current I flowing in the +z-direction (out of the paper).



(3.1) What is the magnitude (in terms of L, I and constants) and direction of the magnetic field at the origin? Hint: consider the wires in pairs, along the diagonals of the square.

(3.2) An ion with charge $+q$ is produced at the origin, travelling with velocity v in the positive z-direction. What is the magnitude and direction of the force on the ion?

(4) Clearly mark one answer to each of the following. If you think more than one answer is correct, pick the best answer.

(4.1) The difference between a battery and a fuel cell is (a) in a battery the chemical reactants are in the battery whereas in a fuel cell the reactants are supplied from outside. (b) a fuel cell does not involve any transport of ions between reaction terminals. (c) a battery does not change the chemical formula of the materials involved. (d) a battery always uses an acid as a reaction medium whereas a fuel cell always uses a base.

(4.2) As more lamps are put into a parallel circuit, the overall current in the power source (A) increases. (B) decreases. (C) stays the same.

(4.3) A 1 Ω resistor is connected to a battery and dissipates 1 W of power. If the resistor is replaced by one with a resistance of 2 Ω, how much power does this resistor dissipate? (a) still one watt, it is a property of the battery. (b) one half as much. (c) one quarter as much. (d) one eighth as much.

(4.4) Near the equator the earth's magnetic field is horizontal and points north. If an electron is moving vertically down, what is the direction of the magnetic force on the electron? (a) east. (b) west. (c) up. (d) down. (e) north. (d) south.

(4.5) As a proton is accelerated in a cyclotron, which parameter does *not* change (a) the proton speed. (b) the proton orbital radius. (c) the proton orbital frequency.

(4.6) Why is the flux of cosmic rays at the surface of the earth higher at the poles that at the equator? (a) the sources of cosmic rays lie predominately along the earth's axis of rotation. (b) charged particles coming in parallel to the earth's magnetic field lines are not deflected. (c) the earth's rotation effectively spreads the flux of cosmic rays out over a larger area near the equator. (d) the air is colder near the poles and cosmic rays travel farther without scattering in colder air.

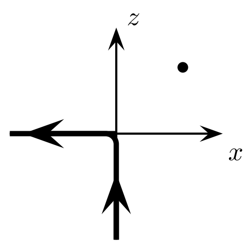
(4.7) How does the Hall potential difference change if the direction of the current flow is reversed? (a) it does not change at all. (b) the sign of the potential difference charges.

(4.8) Positive charge is uniformly distributed over the surface of a flat plastic disc. The disc is rotating about an axis perpendicular to the plane of the disc. Viewed from above (call this the $+z$-direction), the disc is rotating counterclockwise at ω rotations per minute. Where does the magnetic moment of the disc point? (a) it rotates counterclockwise in the plane of the disc at ω. (b) it rotates clockwise in the plane of the disc at ω. (c) it is constant, and points away from the viewer. (d) it is constant, and points toward the viewer. (e) the disc has no magnetic moment since no current is flowing.

(4.9) Which of the following statements about materials is correct. (a) the resistivity of both conductors and semiconductors tends to increase with increasing temperature. (b) the resistivity of both conductors and semiconductors tends to decrease with increasing temperature. (c) the resistivity of conductors tends to increase whereas the resistivity of semiconductors tends to decrease with increasing temperature. (d) the resistivity of conductors tends to decrease whereas the resistivity of semiconductors tends to increase with increasing temperature.

(4.10) Who was basically right about the nature of electricity in muscle action? (a) Luigi Galvani. (b) Alessandro Volta. (c) Micheal Faraday. (d) Pierre Ampère.

(5) A wire carries a current i. The current flows along the negative z-axis from far away ($z = -\infty$) to the origin where the wire makes a 90 degree bend and carries away the current along the -x axis (to $x = -\infty$).



(5.1) For a point in the x-z plane, in indicated by the dot, at coordinates (P,0,P) where does the magnetic field for each segment of the wire point? Where does the net magnetic field point?

(5.2) For the first segment of the wire (bringing the current in from $z = -\infty$), what are the values of θ that should be used to calculate the contribution of this segment to $\vec{B}$ at the point (P,0,P)?