PHYS 272 Fall 2009
Saturday, December 19, 2009

Final Exam - A

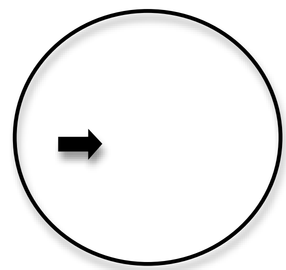
There is only one part to the final exam. It is worth 200 points towards your total of 700 points for the course. Each multiple choice problem is worth **8** points.

Using a pencil, fill in Last Name, First Name, & Middle Initial, plus your 10-digit Purdue University ID number. Enter Instructor (Hirsch), Course (PHYS 272), Date (12/19/09), and Test (3). **You must include your Signature. Fill in circle "A" for Test Form.**

When finished bring this to the front of the classroom, show your Purdue ID card to the Instructor, and turn in the machine-graded answer sheet.

Problem 1

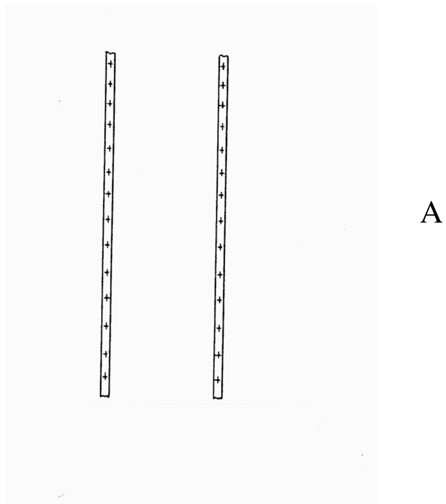
Inside a thin plastic shell, over which a charge +Q has been uniformly distributed, is a small electric dipole shown as vector $\vec{p}$ pointing towards the center of the sphere. In which direction is the force on the dipole due to the charge +Q? You may neglect the polarization of the plastic due to the presence of the dipole.



1) The force on the dipole is to the right.
2) The force on the dipole is to the left.
3) The force on the dipole is towards the top of the sphere.
4) The force on the dipole is towards the bottom of the sphere.
5) The force on the dipole is nonzero but in none of the above directions.
6) There is no force on the dipole.

Problem 2

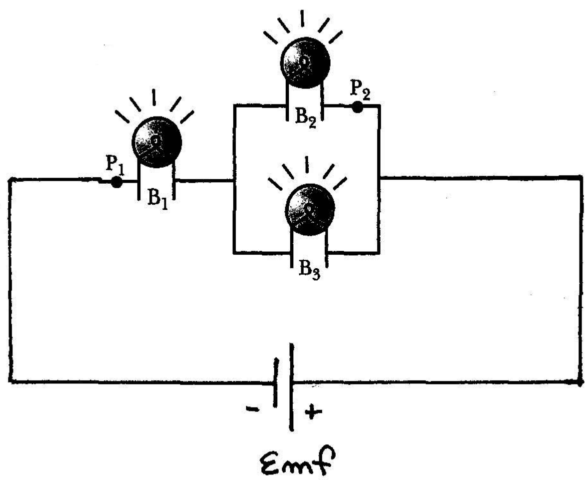
Two large non-conducting sheets with the same positive charge per unit area, σ C/m^2, face each other as in the figure below. What is the magnitude of the electric field at point A? (Ignore any edge effects.)



1. 0
2. $E = 2\sigma/\varepsilon_0$
3. $E = \sigma/2\varepsilon_0$
4. $E = \sigma/\varepsilon_0$
5. None of the above.

Problem 3

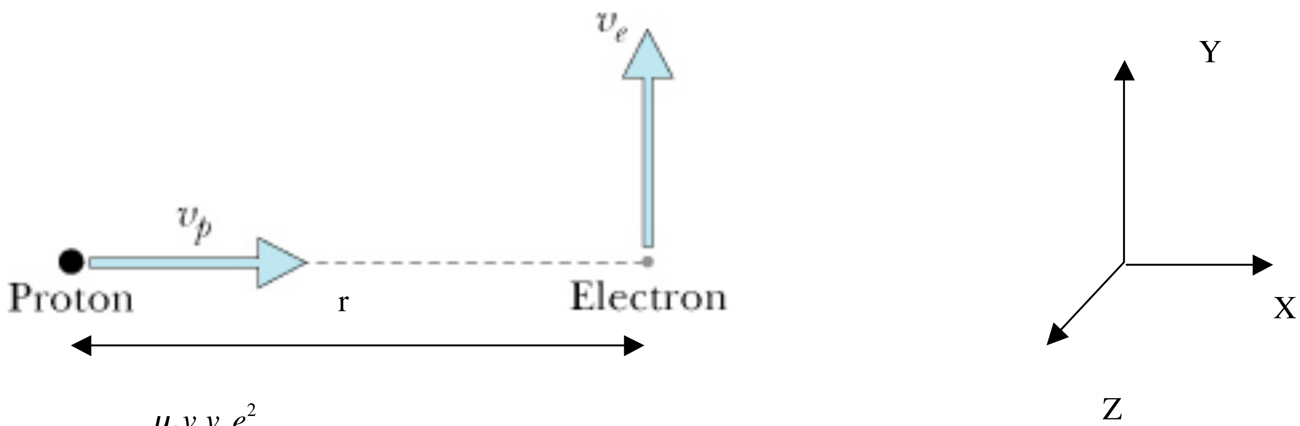
The circuit shown below contains three identical bulbs, B_1, B_2, and B_3. Let us denote the brightness (power emitted) of each of these bulbs by P_1, P_2, and P_3, respectively. Now, suppose bulb B_3 is removed from its socket, changing the brightness of the remaining bulbs to P_1^* and P_2^*. Compare the brightness of B_1 and B_2 before and after B_3 is removed.



1. $P_1^*/ P_1 = 3/2, P_2^*/ P_2 = 4/3$
2. $P_1^*/ P_1 = 2/3, P_2^*/ P_2 = 3/4$
3. $P_1^*/ P_1 = 9/16, P_2^*/ P_2 = 9/4$
4. $P_1^*/ P_1 = 16/9, P_2^*/ P_2 = 4/9$
5. No change in either bulb.

Problem 4

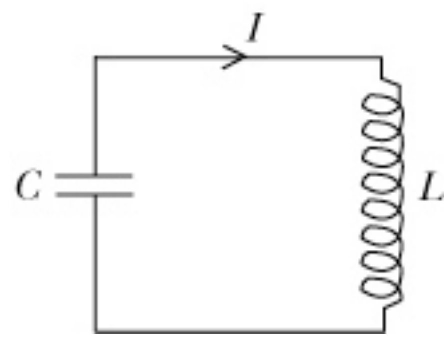
A proton and an electron are moving at a particular instant as shown in the figure below. What is the magnetic force on the proton due to the electron when the proton is at the location shown in the diagram below? (Neglect retardation effects.)



1. $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{z}$
2. $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{z}$
3. $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{y}$
4. $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{y}$
5. $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{x}$
6. $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{x}$

Problem 5

Just prior to $t = 0$, the capacitor ($C = 1\times10^{-3}F$) in the circuit below has a charge of 1 μC. The inductor has inductance, $L = 1\times10^{-6}H$. At $t=0$, a switch (not shown) is closed, allowing current to flow around the circuit. What is the magnitude of the current when there is no charge on the capacitor? [Hint: $Q(t) = Q_0\cos(\frac{1}{\sqrt{LC}}t)$]



1. 1.0 x 10^{3} A
2. 3.2 x 10^{-2} A
3. 2.0 x 10^{-2} A
4. 2.7 x 10^{-2} A
5. 7.5 x 10^{-4} A

Problem 6

Referring to the above circuit, at the instant when there is no charge on the capacitor, what is the magnitude of the rate of change in current?

1. 1000 A/s
2. 637 A/s
3. 0 A/s
4. 10 A/s
5. 500 A/s
6. Not enough information

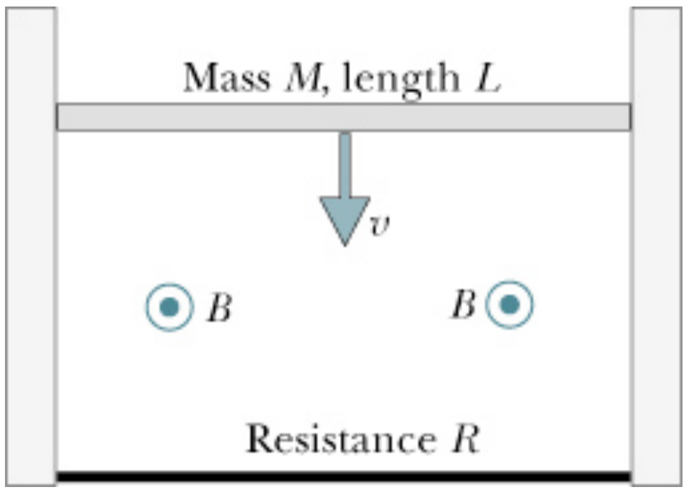
Problem 7

A thick wire of radius $R = 1\ cm$ carries a current $I = 2\ A$. The magnetic field inside the wire, a distance $r = 0.5\ cm$ from the center of the wire is?

1. 2×10^{-5} T
2. 4×10^{-5} T
3. 1×10^{-6} T
4. 8×10^{-5} T
5. 16×10^{-5} T

Problem 8

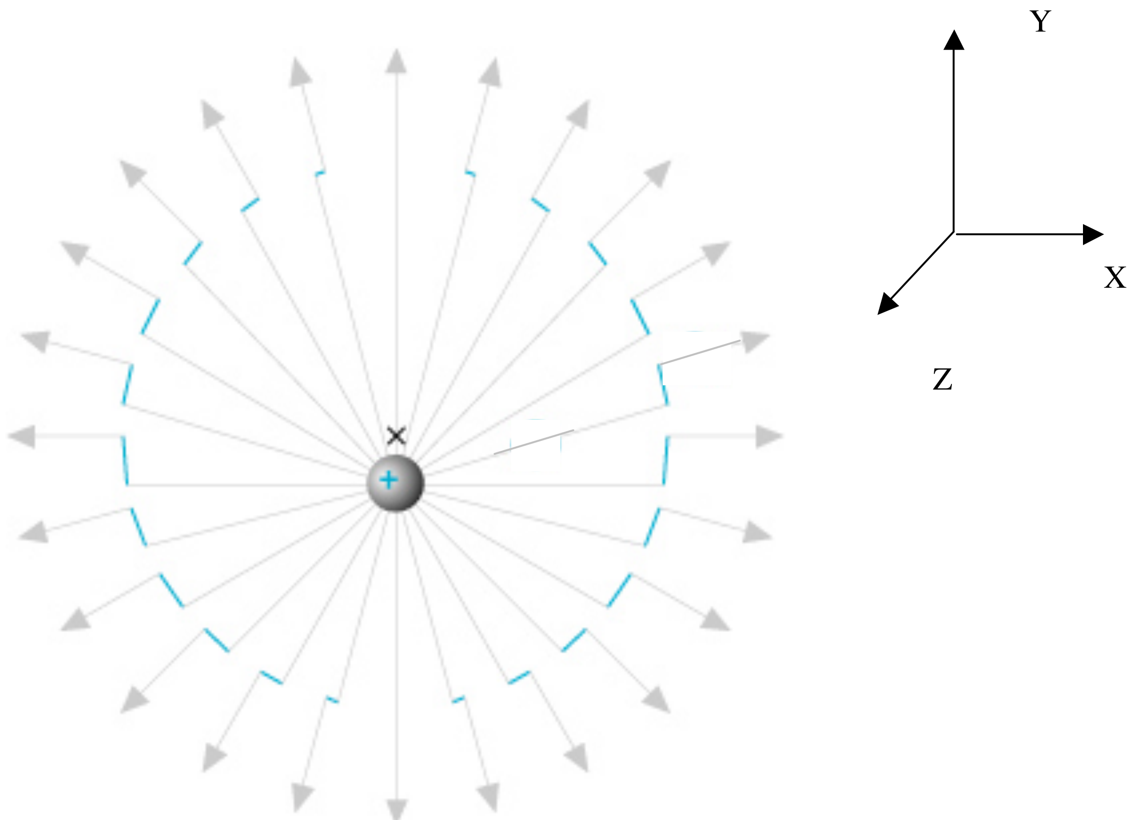
A metal bar of mass *M = 0.01 kg* and length *L=0.2 m* slides with negligible friction but with good electrical contact down between two vertical metal posts. The bar falls at a constant speed v (zero acceleration). The falling bar and the vertical metal posts have negligible electrical resistance, but the bottom rod is a resistor with resistance *R* = 2 ohms. Throughout the entire region there is a uniform magnetic field of magnitude *B = 1.0 T* coming straight out of the page. Find the value of v.



1. 490 m/s
2. 49 m/s
3. 4900 m/s
4. 4.9 m/s
5. 0.49 m/s

Problem 9

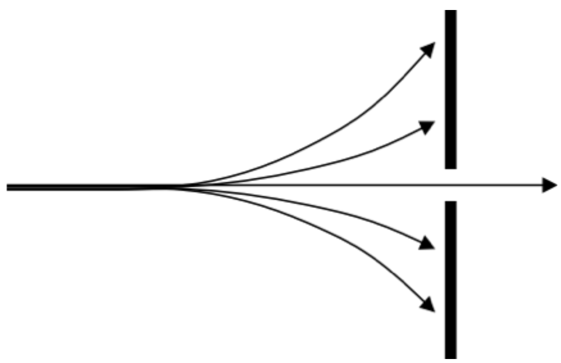
The figure below shows a **proton** initially at rest that is briefly accelerated in the –y direction and then moves at a constant velocity. Suppose that "electric field detectors" are placed around this proton in a sphere of radius *r* when the electromagnetic pulse is emitted. Which detector would measure the largest radiative electric field as the pulse passes the detector?

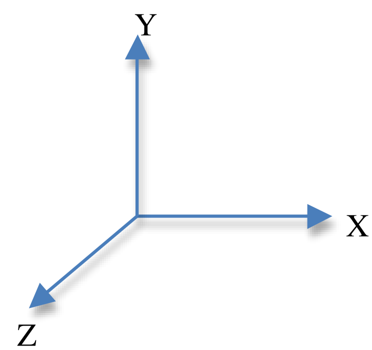


1. The detector on the x-axis
2. The detector on the y-axis
3. The detector on the z-axis
4. Detectors on the x and z axes would both measure the largest radiative field.
5. All of the detectors would measure the same magnitude of radiative electric field.

Problem 10

In the figure below, an electric field in the +y-direction and a magnetic field in the +z-direction are such that a positively charged particle traveling along the +x-direction at speed $v = E/B$ experiences no net force. (We will neglect gravity.) Other positively charged particles follow the curved trajectories as indicated in the figure. Which statement below is true?

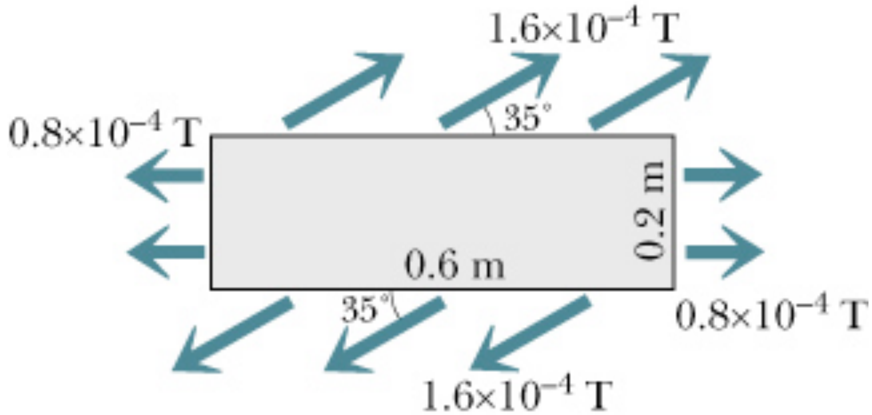




1. Particles traveling with speed less than E/B curve up (toward +y).
2. Particles traveling with speed less than E/B curve down (toward -y).
3. Particles curving up have more charge than those curving down.
4. None of the above statements are true.

Problem 11

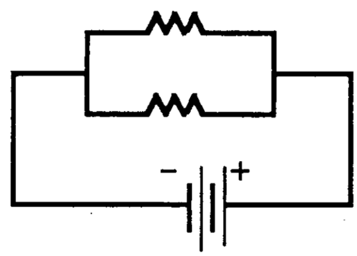
The measured pattern of magnetic field is shown in the figure below. How much current *I* passes through the shaded area and in what direction does it flow?



1. 87.6 A, current is flowing out of the page
2. 87.6 A, current is flowing into the page
3. 87.6 A, current is flowing to the left
4. 87.6 A, current is flowing to the right
5. 125 A, current is flowing out of the page
6. 125 A, current is flowing into the page
7. 125 A, current is flowing to the right
8. 125 A, current is flowing to the left

Problem 12

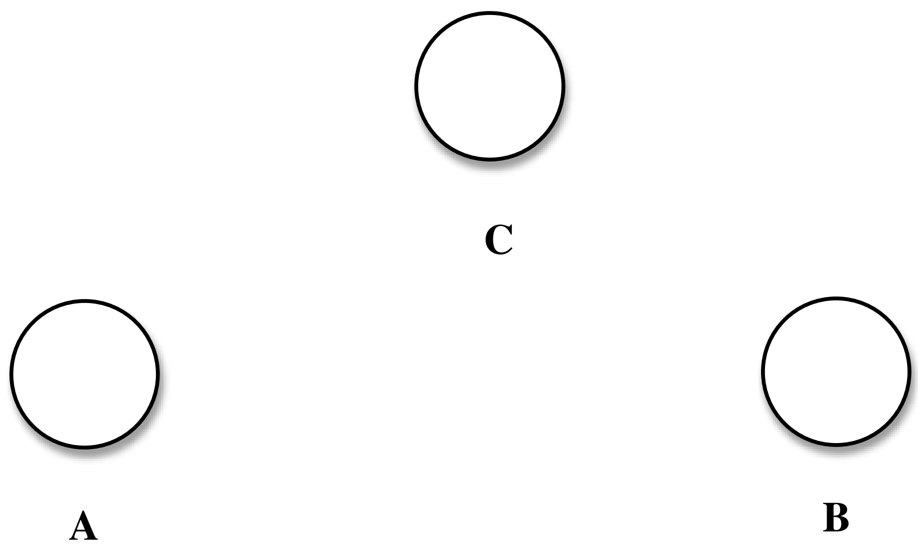
Two **unequal** resistors are connected in parallel across a battery with negligible internal resistance. One of the resistors carries a current of 1 A while the other carries a current of 2 A. What will be the current in the circuit if the two resistors are now connected in series instead of in parallel?



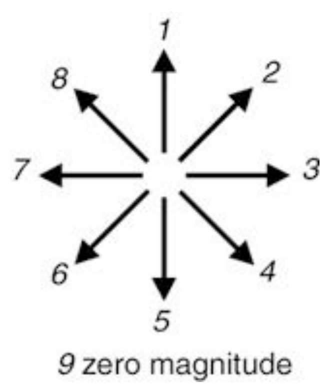
1. 1 A
2. 1.3 A
3. 1.5 A
4. 2 A
5. 2.5 A
6. 0.67 A
7. Not enough information

Problem 13

Two wires A and B lie perpendicular to the plane of the paper and carry equal conventional currents. Wire A's current is into the page, while wire B's current is out of the page. A third wire, C, carrying conventional current into the page is equidistant from wires A and B. In what direction is the force on wire C?

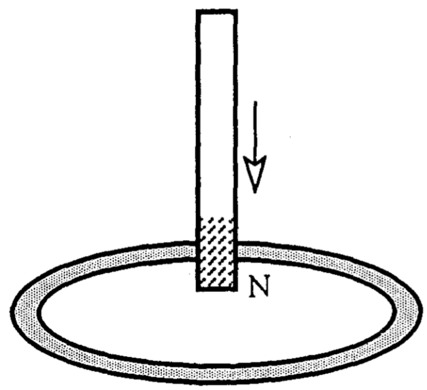


What is the direction of the force on wire C?



Problem 14

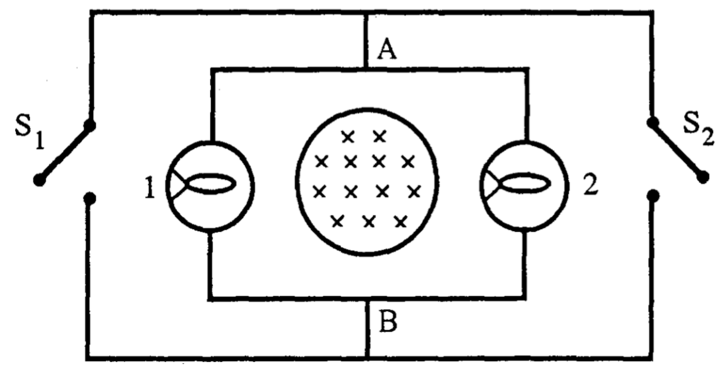
The north pole of a magnet is thrust downward into the horizontally oriented copper ring as shown. In what direction does the ring experience a force?



1) There is no net force on the ring.
2) The ring experiences a force in the downward direction.
3) The ring experiences a force in the upward direction.
4) The ring experiences a force to the left.
5) The ring experiences a force to the right.

Problem 15

The diagram below shows a solenoid that produces a B-field directed into the plane of the paper. The current in the solenoid is increasing at a uniform rate. Two identical flashlight bulbs, 1 and 2, having resistance *r*, are connected in a circuit surrounding the solenoid as shown and light up while the flux increase is taking place. The wires in the circuit have negligible resistance. Switches S_1 and S_2 are initially open. At some later time, $S_1$is closed while S_2 remains open. What happens to the brightness of each bulb while the current in the solenoid is increasing?



1) Bulb 1 goes out and bulb 2 gets brighter.
2) Bulb 1 goes out and bulb 2 gets dimmer.
3) Bulb 1 goes out but bulb 2's brightness remains the same.
4) There is no change in the brightness of either bulb.
5) Both bulbs go out.

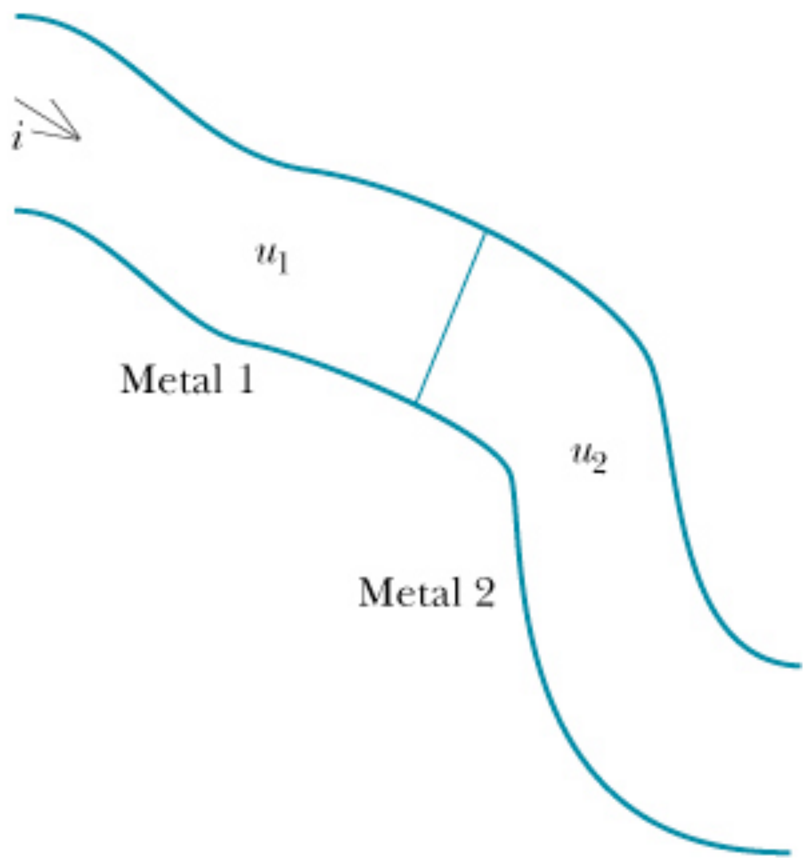
Problem 16

A wire has a mass per unit length of 10 g/m. What is the minimum amount of current it would have to carry if the magnetic force exerted by a horizontal 0.1 Tesla magnetic field on a horizontal length of this wire were able to lift the wire off the ground?

1) 0.98 A
2) 9.8 A
3) 98 A
4) 980 A
5) Not enough information

Problem 17

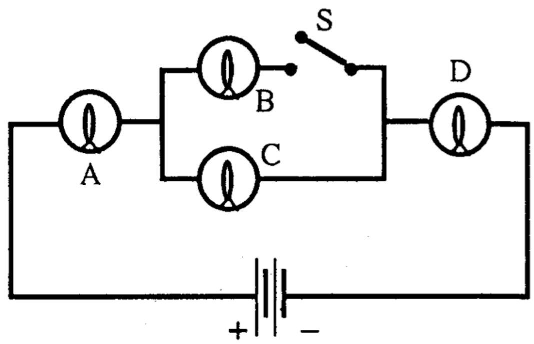
The figure below shows a portion of a circuit in which **electron** current, $i = 3 \times 10^{18}$ electrons per second is flowing in the steady state. In this portion, there is a junction of two conducting wires, both of area A. One wire is tungsten with mobility $u_1 = 1.2 \times 10^{-3}$ (m/s)/(N/C), and number of free charges per cubic meter, $n_1 = 6.3 \times 10^{28}$ and the other is copper $(u_2, n_2) = (1.2 \times 10^{-4}, 8.4 \times 10^{28}$ electrons/m^3). How much charge and of what sign has accumulated at the interface?



1) $+2.3 \times 10^{-18}$ C
2) -2.3×10^{-18} C
3) 0 C
4) 4.2×10^{-16} C
5) -4.2×10^{-16} C
6) Not enough information

Problem 18

The circuit below consists of four identical light bulbs. Initially, switch S is in the open position. After switch S is closed, how does the brightness of bulb C compare to its original brightness?



1) It is brighter after S is closed.
2) It is dimmer after S is closed.
3) There is no difference in its brightness.

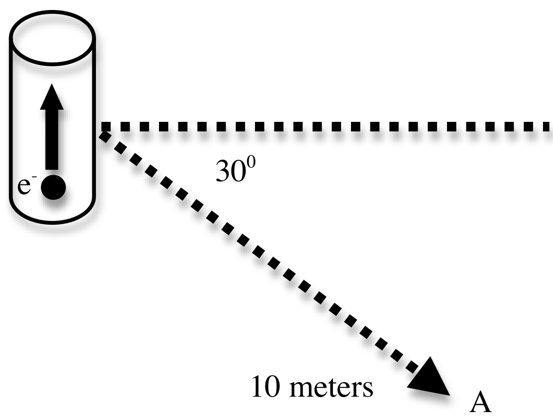
Problem 19

An airplane develops a 0.25-V potential difference between the tips of its aluminum (conducting) wings when flying in a region where the earth's magnetic field points essentially vertically upward with a magnitude of 2×10^{-5} T. If the plane's wingspan is 35 m, approximately how fast is it flying?

1) 360 m/s
2) 36 m/s
3) 3600 m/s
4) 12,500 m/s

Problem 20

At time $t_0 = 0$, 6×10^{22} electrons in a short neutral vertical cooper wire are accelerated very briefly upward at 2×10^8 m/s^2, by a power supply which is not shown. Detectors of electric and magnetic fields are placed at location A, 10 meters from the wire, as shown in the diagram. (The diagram is not to scale; the length of the bar is only a few centimeters.) What is the magnitude of the electric field at location A at time t_1 when detectors at A first detect electric and magnetic fields.



1) 1.66×10^3 V/m
2) 9600 V/m
3) 1.92×10^4 V/m
4) 1.66×10^4 V/m
5) 960 V/m
6) 1.92×10^3 V/m

Problem 21

A circuit consists of a single Eveready 1.5-Volt battery and a resistor of 100-Ohms. In this configuration, the battery has a lifetime of 100 hours. A second circuit has two Eveready 1.5-Volt batteries connected in series to a 100-Ohm resistor. What is the lifetime of the batteries in this circuit?

1) 100 hours
2) 200 hours
3) 50 hours
4) 25 hours
5) Not enough information

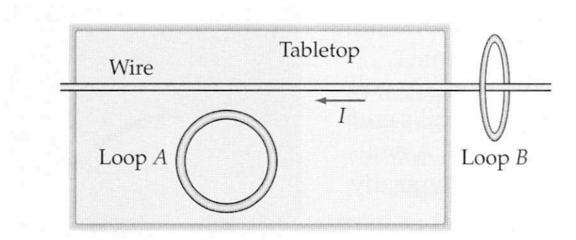
Problem 22

LightSail-1 is a spacecraft that will be launched in late 2010. It is designed to fly far above the Earth (to avoid atmospheric drag), and will test the practicality of using sunlight for propulsion. The spacecraft has a mass of 4.5 kg, and the sail has an area of 32.5 m^2. Assuming that all sunlight strikes the sail at normal incidence (i.e., perpendicular to the plane of the sail) and is perfectly reflected. What will be the spacecraft's speed one hour after the sail opens? Assume that the energy intensity of sunlight is 1400 W/m^2. Ignore all gravitational effects.

1) 0.24 m/s
2) 0.12 m/s
3) 3.4×10^{-2} m/s
4) 1.1 m/s
5) 14.4 m/s

Problem 23

Loop A and a long, straight, current-carrying wire lie near each other on a tabletop in the top view show in the figure below. Loop B is perpendicular to the wire and concentric with it. Assume that the current in the straight wire suddenly **decreases**. In what direction does the induced current flow in loop A, and in what direction does the induced current flow in loop B (when viewed facing the table on its right hand side)?



1) Clockwise in A, clockwise in B
2) Clockwise in A, no induced current in B
3) Clockwise in A, counter-clockwise in B
4) Counter-clockwise in A, clockwise in B
5) Counter-clockwise in A, counter-clockwise in B
6) Counter-clockwise in A, no induced current in B
7) No induced current in either A or B

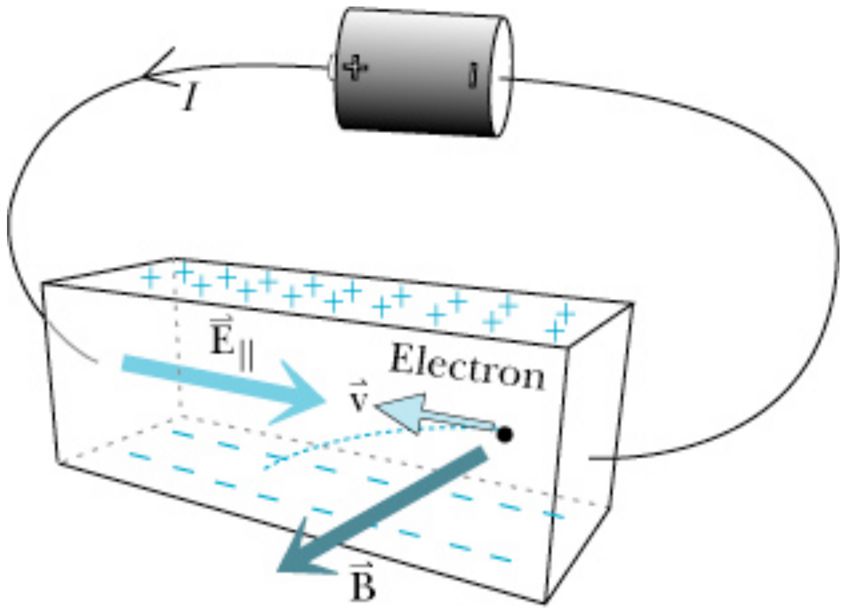
Problem 24

A circuit consists of an inductor L and a resistor R connected in series to a battery via an open switch. After the switch is closed, how long must we wait for the current in the LR circuit to build up to 99.99% of its equilibrium value. Express the answer in terms of the number of "time constants," L/R.

1) 6.9
2) 4.6
3) 9.2
4) .001
5) 0.1

Problem 25

Calculate the Hall voltage for the case of a ribbon of copper 5 mm high and 0.1 mm deep, carrying a current of 20 amperes in a magnetic field of 1 tesla. Copper has $n = 8.4 \times 10^{28}$ free electrons per m^3.



1) 3×10^{-3} V
2) 1.5×10^{-5} V
3) 1.5×10^{-4} V
4) 3×10^{-5} V
5) 5.4×10^{-12} V