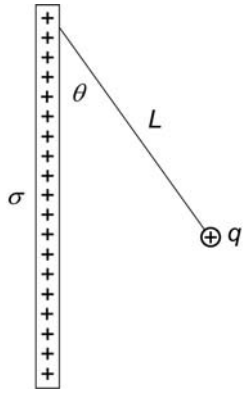
**1**. A small sphere with mass $m$ carries a positive charge $q$ and is attached to one end of a silk fiber of length $L$. The other end of the fiber is attached to a large vertical insulating sheet that has a positive surface charge density $\sigma$.

(a) (10 points) Find the magnitude and direction of the electric force on the sphere;

(b) (10 points) Show that when the sphere is in equilibrium, the fiber makes an angle $\theta$ equal to arctan ($q\sigma/2mg\varepsilon_0$) with the vertical sheet. g is the acceleration due to gravity.

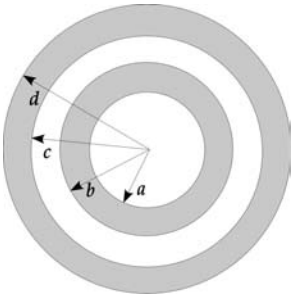



**2**. A small conducting spherical shell with inner radius $a$ and outer radius $b$ is concentric with a larger conducting spherical shell with inner radius $c$ and outer radius $d$. The inner shell has total charge + $2q$, and the outer shell has total charge + $4q$.

(a) (20 points) Find the charges on all four surfaces on these two conducting shells;

(b) (10 points) Find the magnitude and direction of the electric field for $r < a$ and for $b < r < c$;

(c) (10 points) Find the electric potential at $r = d$ relative to that at the infinity.

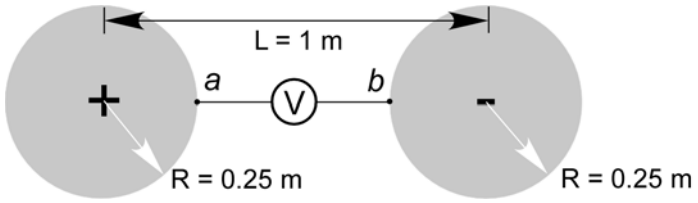



**3**. Two oppositely charged insulating spheres, each with radius R = 0.25 m and carrying a uniformly distributed charge of magnitude 7.5 μC, are placed at L = 1 m

apart from center to center. Let *a* and *b* be the nearest points on their surfaces as shown in the figure below. ($1/4\pi\varepsilon_0 = 9.0 \times 10^9$ N·m$^2$/C$^2$)

(a) (10 points) Find the electric potential at point *a* relative to that at the infinity;

(b) (10 points) If a voltmeter is connected between *a* and *b*, what will it read?

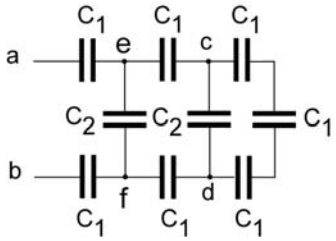



**4**. In the following capacitor network, $C_1 = 6.9$ μF and $C_2 = 4.6$ μF. A potential difference ($V_a - V_b$) of 420 V is applied to the network between point *a* and point *b*.

(a) (15 points) Find the equivalent capacitance between point *a* and *b*;

(b) (10 points) Find the charges on the three capacitors nearest *a* and *b*, i.e., $C_1$ between *a* and *e*, $C_2$ between *e* and *f*, and $C_1$ between *f* and *b*;

(c) (10 points) Find $V_{cd} = V_c - V_d$.

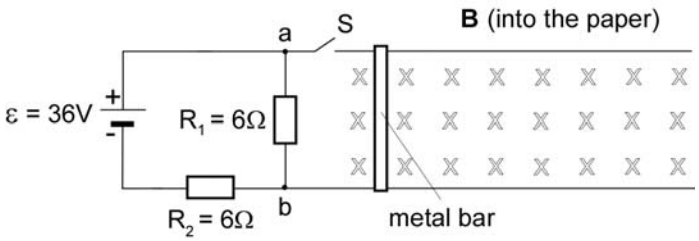



**5**. A metal bar with length $L = 1.5$ m and resistance $R = 6\Omega$, rests horizontally on two infinitely long, parallel conducting rails that connect the bar to a circuit through a switch *S*. The metal bar itself is in a uniform magnetic field **B** of magnitude 2T pointing into the paper.

(a) (10 points) Immediately after the switch is closed, find the direction and magnitude of the current through the metal bar;

(b) (10 points) Find the magnitude and direction of the magnetic force on the bar immediately after the switch is closed;

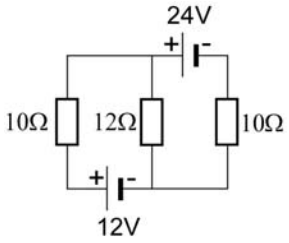
(c) (10 points) Under the influence of the magnetic force, the bar is accelerated in the direction of the magnetic force and gains the speed. Find the terminal speed of the bar when the current through the bar becomes zero (if you can't find the exact answer, explain why the acceleration of the bar decrease as it gains speed.)



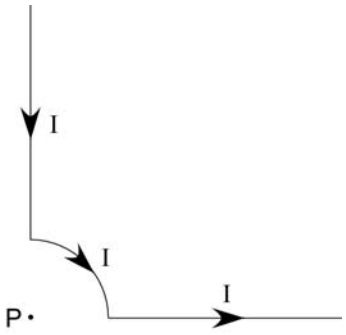

**6**. In the following circuit,

(a) (15 points) Find the direction and magnitude of the current through 12-V battery;

(b) (10 points) Find the power dissipation in 12-Ω resistor.



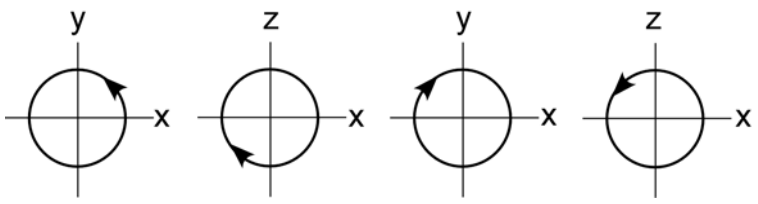

**7**. (20 points) The wire in the following figure carries current *I* as shown. The wire consists of a long, straight section, a quarter circle section with radius R, and another long, straight section (perpendicular to the first straight section). The three sections are in the same plane. Find the direction and magnitude of the magnetic field produced by each section of the wire at point P (the center of the quarter circle).




**8.** A circular coil with area *A* and *N* turns is free to rotate about a diameter that coincide with the x-axis. Current *I* is circulating in the coil as shown. There is a uniform magnetic field B in the negative z-direction.

(a) (12 points) Find the direction and magnitude of the torque when the coil is in each of the following four orientations;

(b) (8 points) Find the potential energy of the coil when it is in each of the following four orientations.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