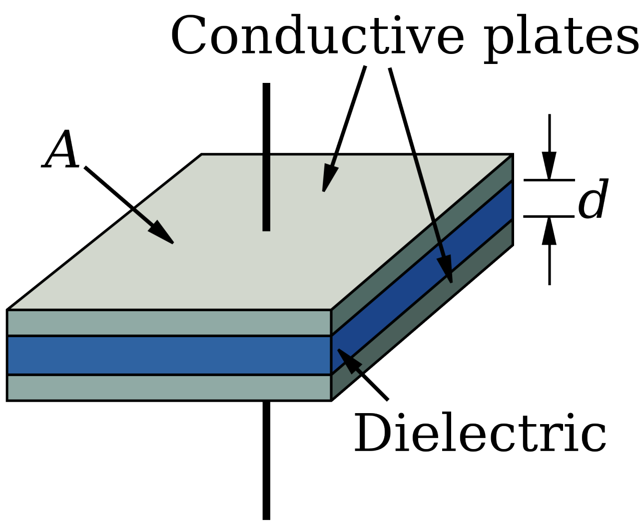
Sample Question: Starting with the following capacitor, list three things that you could change about it to increase its capacitance, and describe why those would increase the capacitance.



Sample Question: Consider a parallel-plate air-gap capacitor with charge q and plate area A.

A. Find the work necessary to increase the plate separation from x to x+dx.

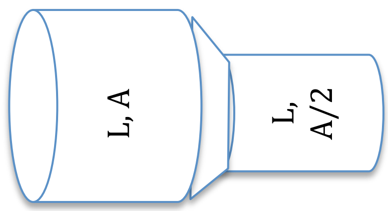
B. Calculate the force between the plates from the answer above
(recall that F = -dU/dx for a potential field).

C. State the force per area between the plates in terms of the electric field between the plates, and compare the result to the electric field energy density.

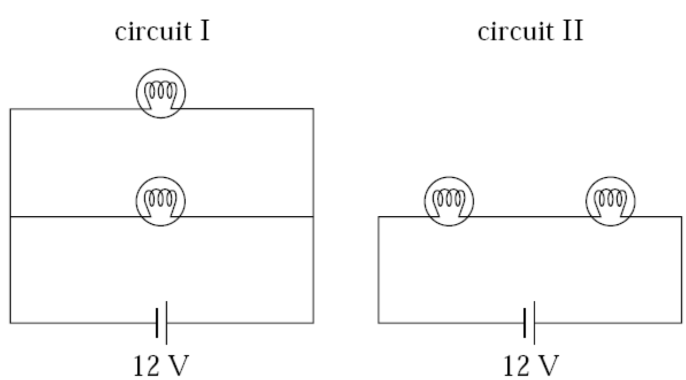
D. How would your answers change if there was a dielectric between the plates?

Sample Question: A potential difference V is applied to a resistor with cross-sectional area A, length L, and resistivity ρ. Imagine that you can stretch the resistor, preserving the total volume, mass density, and resistivity, but changing the length and area. What would the new length and area be for a "stretched" resistor that had 9 times higher power dissipation? State the new values L' and A' in terms of L and A.

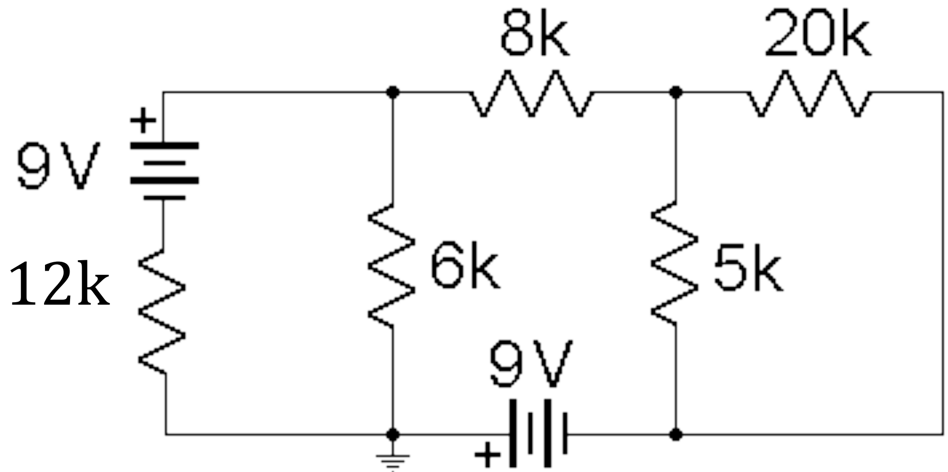
Sample Question: A single resistor is made out of two segments of a resistive material with resistivity ρ, both in the shape of a cylinder with length L, but with different cross-sectional areas A and A/2, connected end-to-end with a short conducting join, as shown below. This resistor is then connected in series to a battery with emf V_0. What are the current, current density, electric field, and potential drop across the two segments of the resistor? If you do not have enough information to compute any quantities, list the ratio between the quantities in the two segments.



Sample Question: What is the ratio of light output between the two circuits shown (assuming brightness is proportional to power dissipation, and all light bulbs are identical)? Be explicit and show all steps.



Sample Question: Consider the following circuit, with two batteries and five resistors:



A. Simplify the right portion of the circuit as much as possible, by using series and parallel equivalent resistances, and draw the simplified equivalent circuit

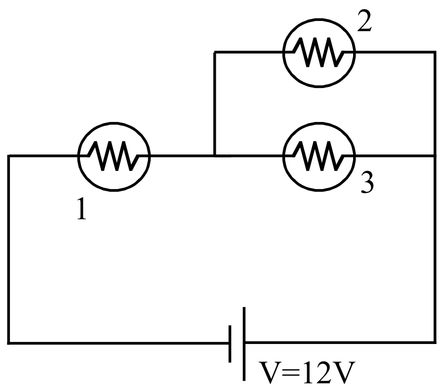
B. Define three currents I_1, I_2, and I_3 through the remaining branches of the circuit and draw their assumed directions on the new simplified circuit.

C. Write down two loop-rule equations summarizing the voltage drops across the two loops of this circuit, in terms of I_1, I_2, and I_3.

D. Write down a junction rule relating the three currents.

E. Solve for the three currents I_1, I_2, I_3. Note explicitly if any of the currents are opposite to the sign you originally assumed.

Sample Question: Consider the following circuit, before and after Bulb 3 burns out (i.e. its resistance becomes infinite) assuming all bulbs are identical, and brightness is proportional to power dissipation. Be quantitative with your answers – state the ratio between the final and original brightness for each question below.



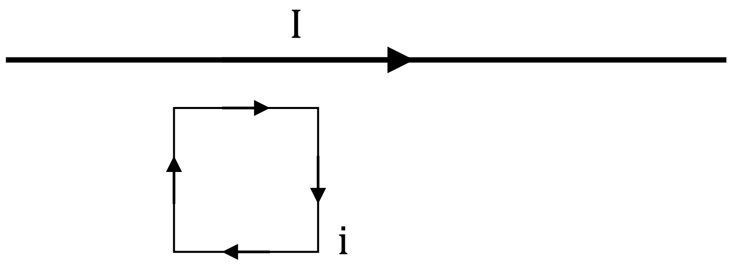
A. What happens to the brightness of Bulb 1 after Bulb 3 burns out?

B. What happens to the brightness of Bulb 2 after Bulb 3 burns out?

Sample Question: A uniform magnetic field is in the positive *z* direction. A positively charged particle is moving in the positive *x* direction through the field. The net force on the particle can be made zero by applying an electric field in what direction? Given a field strength B and speed v, what is the magnitude of that electric field E?.

Sample Question: A current is clockwise around the outside edge of this page and a uniform magnetic field is directed parallel to the page, from left to right. If the magnetic force is the only force acting on the page, how will the page rotate? Draw vectors for the forces on the four sides of the paper to support your answer.

Sample Question: Consider the arrangement shown below, with a square current loop next to a long current-carrying wire.



A. Which direction is the net force on the square current loop with current i, resulting from the magnetic field of the long wire with current I?

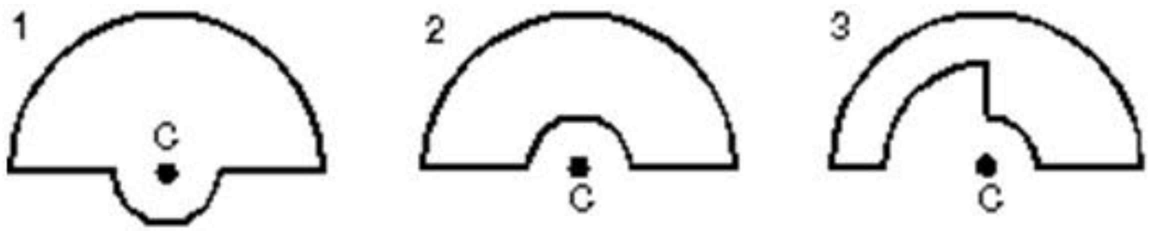
B. If the current loop has side L, and the distance from the closest edge of the loop to the long wire is d, evaluate the net force on the loop in terms of i, I, d, and L.

C. Is there a torque on the loop? Why or why not?

D. Evaluate the net force on an ideal magnetic moment with magnitude $\mu = iA = iL^2$ pointing into the page, located at a distance d from the wire.

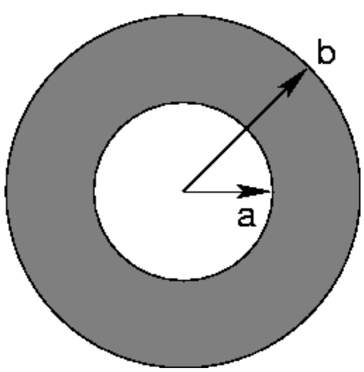
E. What is the limit of the force you got in part B, as d becomes large with respect to L?

Sample Question: The diagrams show three circuits consisting of concentric circular arcs (either half or quarter circles of radii *r*, 2*r*, and 3*r*) and radial lengths. The circuits carry the same current. Rank them according to the magnitudes of the magnetic fields they produce at C, least to greatest, and explain your ranking.



Sample Question: Consider the long cylindrical conductor with the cross section shown below, which carries a current I uniformly distributed across the area of the conductor, and going into the page.

A. Calculate the magnetic field magnitude as a function of r for $a<r<b$.



B. Sketch the direction of the field.