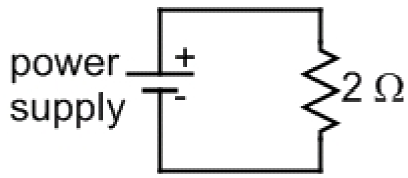
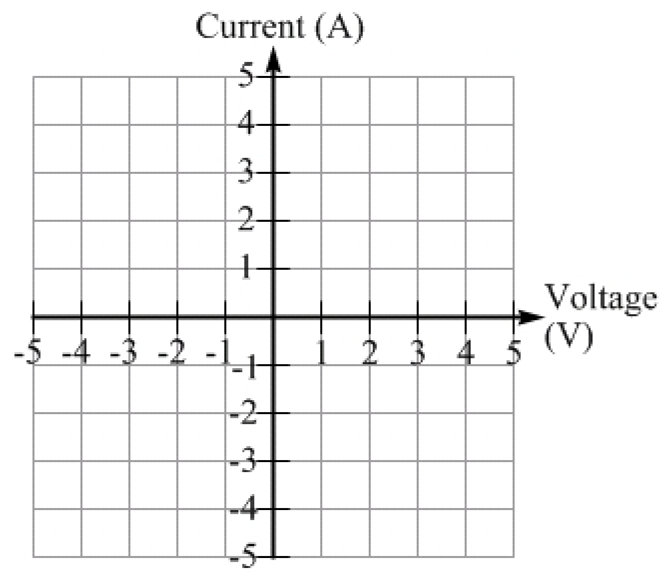
PROBLEM 1 – 15 points

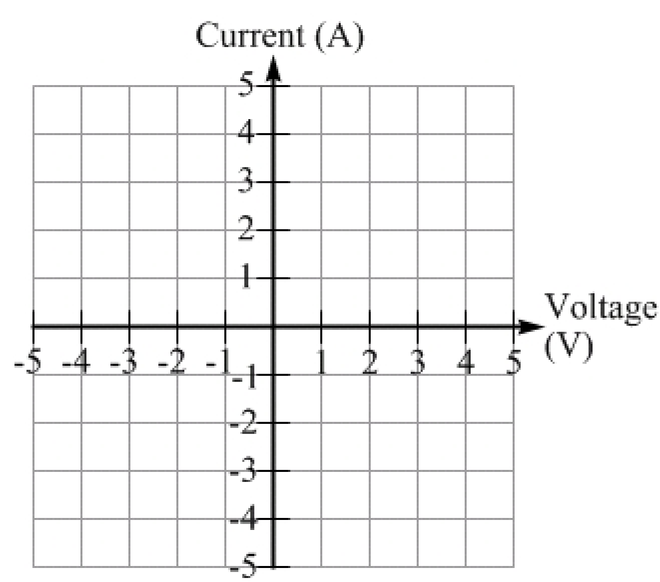




[5 points] (a) In an Ohm's Law experiment, a power supply is connected to a resistor, as shown in the circuit diagram above. Assuming the resistance of the resistor is always 2 Ω, and that the voltage of the power supply is varied from -5 V to +5 V, plot a graph of the current through the resistor as a function of the power-supply voltage.

[5 points] (b) A 3 Ω resistor is now connected in series with the original resistor and the power supply. Draw the circuit diagram for this circuit, and briefly discuss how the current through the 2 Ω resistor in the new circuit compares to the current through the 3 Ω resistor.

[5 points] (c) If the voltage of the power supply is again varied from -5 V to +5 V, plot a graph of the current through the 2 Ω resistor as a function of the power-supply voltage for the circuit in part (b), when the 3 Ω resistor is in series with the 2 Ω resistor and the power supply.



PROBLEM 2 – 15 points

Three resistors, of resistance 4.0 Ω, 3.0 Ω, and 6.0 Ω, are connected in the circuit shown at right with a battery that has a voltage of 18 volts.

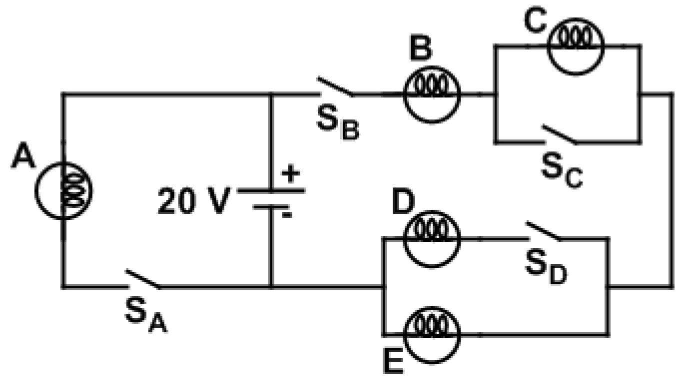
[3 points] (a) Determine the equivalent resistance of this circuit.

[3 points] (b) Calculate the current through the 3 Ω resistor.

[4 points] (c) Could you add a 5 Ω resistor to the circuit so that some current passes through it, while at the same time the currents through the original three resistors are unaffected? If so, re-draw the circuit to show how this could be done. If not, explain why not.

[5 points] (d) Could you add a 5 Ω resistor to the original circuit so that one or more of the currents through the original three resistors increases? If so, re-draw the circuit to show how this could be done. If not, explain why not.

PROBLEM 3 – 10 points



Five identical light bulbs, and four switches, are connected in the circuit shown. Assume the resistance of each bulb is constant no matter what the current is through it.

[4 points] (a) What is the minimum number of switches that should be closed so that at least one light bulb will turn on?

[ ] 0 [ ] 1 [ ] 2 [ ] 3 [ ] 4

Justify your answer. If you think one or more switches need to be closed then specify which need to be closed.

[3 points] (b) Explain which switches should be closed to maximize the brightness of bulb C. Are there any switches that, whether they are open or closed, do not affect the brightness of bulb C?

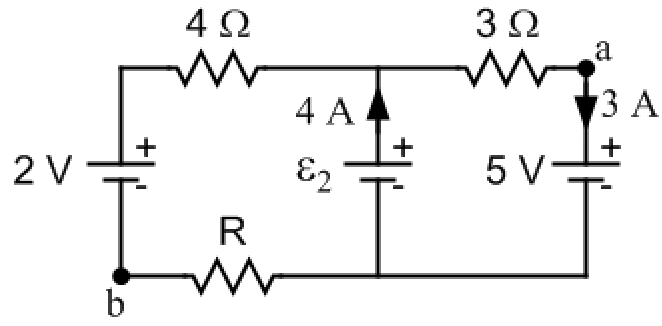
[3 points] (c) If every switch is closed, rank the bulbs based on their brightness, from brightest to dimmest.

[ ] All bulbs are equally bright [ ] A>B=D=E>C [ ] A>B=C>D=E

[ ] A=B>D=E>C [ ] A>B>D=E>C [ ] A=B=C>D=E [ ] A>B>C=D=E

PROBLEM 4 – 15 points

Three batteries are connected in a circuit with three resistors, as shown in the diagram. The currents in two of the branches are known and marked correctly on the diagram. There are three unknowns in the circuit: the resistance R of one resistor; the current through the 2-volt battery; and the emf of the battery in the middle branch of the circuit.



[9 points] (a) Solve for the three unknowns in the problem. Note that you should not have to do lots of algebra.

The current through the 2-volt battery has a magnitude of _______,
and is directed [ ] up [ ] down through the battery.

The resistance R is equal to _________.

The emf of the battery in the middle branch of the circuit is _________.

[3 points] (b) What is the potential difference, $V_a - V_b$, between points *a* and *b* in the circuit?

[3 points] (c) Which resistor has the largest power dissipated in it? How much power is dissipated in that resistor?