

PHYSICS 112 - SPRING 2003 - EXAM 2 - March 12, 2003

Name: _____ Recitation Section Number: _____

SHOW YOUR WORK! Full credit will be given only if you explain how you arrived at your answer. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required, but the grader must be able to follow your reasoning clearly.

1. [9 points] In the circuit shown, assume that the resistances are such that $R_4 > R_3 > R_2 > R_1$. Rank the resistors as asked for, from largest to smallest, indicating those that are equal by the equals sign "=" [e.g., $R_3 > R_1 = R_2 > R_4$ if R_3 is the largest, R_4 is the smallest, and R_1 and R_2 are equal].

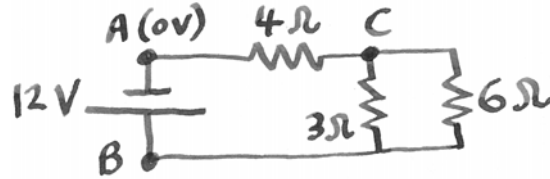


(a) Rank the resistors by the magnitudes of the currents flowing through them, from the one with the largest current to the one with the smallest. Explain your reasoning (this is important!).

(b) Rank the resistors by the magnitudes of the potential differences across them, from the one with the largest potential difference to the one with the smallest. Explain your reasoning (this is important!).

(c) Rank the resistors by the magnitudes of the electric power dissipated, from the one with the largest power dissipation to the one with the smallest. Explain your reasoning (this is important!).

2. [18 points] Here is a three-resistor, one-battery circuit.



(a) Determine the equivalent resistance of the whole circuit.

(b) Determine the electric current through the battery, and show its direction on the diagram.

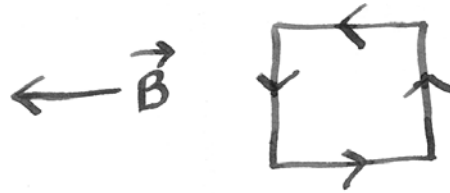
(c) Determine the potentials at the points B and C, where point A is taken to have potential 0 volts.

(d) Fill out the table below, with the resistance, current, potential difference, and power dissipated for each resistor. Use the last row for the equivalent resistance and information about the battery. (You may fill out extra tables to help yourself out, if you wish.)

R	I	ΔV	P
$4\ \Omega$			
$3\ \Omega$			
$6\ \Omega$			

(e) Verify that the electric power supplied by the battery equals the sum of the magnitudes of the electric powers dissipated by the three resistors.

3. [13 points] The diagram below shows a square current loop, with the direction of the current indicated, and the direction of the uniform magnetic field in which it is placed.



Show (using arrows or \odot or \otimes if necessary) the magnetic forces on all four sides of the loop.

What is the net force on this loop?

Is there a net torque on this loop? If so, describe how the loop will tend to rotate.

PHYSICS 112 - SPRING 2003 - EXAM 2 SOLUTIONS

1. [9 points] In the circuit shown, assume that the resistances are such that $R_4 > R_3 > R_2 > R_1$. Rank the resistors as asked for, from largest to smallest, indicating those that are equal by the equals sign "=" [e.g., $R_3 > R_1 = R_2 > R_4$ if R_3 is the largest, R_4 is the smallest, and R_1 and R_2 are equal].



(a) Rank the resistors by the magnitudes of the currents flowing through them, from the one with the largest current to the one with the smallest. Explain your reasoning (this is important!).

$$R_4 = R_3 > R_1 > R_2$$

The whole current of the circuit passes through R_4 and R_3 , and less through the resistors in parallel; since $R_2 > R_1$, more current passes through R_1 than R_2 .

(b) Rank the resistors by the magnitudes of the potential differences across them, from the one with the largest potential difference to the one with the smallest. Explain your reasoning (this is important!).

$$R_4 > R_3 > R_2 = R_1$$

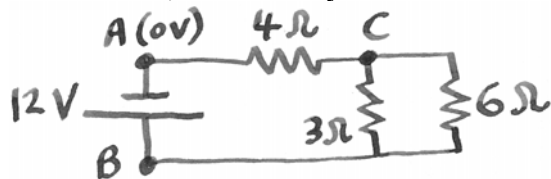
Since R_4 and R_3 have the same current, the potential difference is greater through the larger resistance; the parallel part must have a low equivalent resistance since it has the two smallest resistances (and the equivalent resistance is even smaller), and the potential difference is the same across the two resistors of resistance R_2 and R_1 .

(c) Rank the resistors by the magnitudes of the electric power dissipated, from the one with the largest power dissipation to the one with the smallest. Explain your reasoning (this is important!).

$$R_4 > R_3 > R_1 > R_2$$

Use $P = I^2 R$ and $P = I \Delta V$. The first tells us that $R_4 > R_3$ (same I but difference in R) and both are greater than the other two (which have smaller I and smaller R); the latter tells us that $R_1 > R_2$ because they have the same ΔV but different I .

2. [18 points] Here is a three-resistor, one-battery circuit.



(a) Determine the equivalent resistance of the whole circuit.

This is a series combination of a 4-ohm resistor with a parallel circuit of a 3-ohm and a 6-ohm resistor. First, the equivalent resistance of the parallel branch is $1/(1/3 + 1/6) = 1/(3/6) = 2$ ohms. So the equivalent resistance of the whole circuit is $4 \Omega + 2 \Omega = 6 \Omega$.

(b) Determine the electric current through the battery, and show its direction on the diagram.

$$I_{\text{total}} = \Delta V_{\text{bat}} / R_{\text{eq}} = (12 \text{ V}) / (6 \Omega) = 2 \text{ A}.$$

Its direction is down through the battery.

(c) Determine the potentials at the points B and C, where point A is taken to have potential 0 volts.

The potential at B is 0 V plus the battery's potential difference of 12 V, so it is 12 V.

The potential difference across the 4-ohm resistor is $\Delta V = IR = (2 \text{ A})(4 \Omega) = 8 \text{ V}$, and since the current flows right to left through the 4-ohm resistor, C must have the higher potential, so its potential is 8 V.

(d) Fill out the table below, with the resistance, current, potential difference, and power dissipated for each resistor. Use the last row for the equivalent resistance and information about the battery. (You may fill out extra tables to help yourself out, if you wish.)

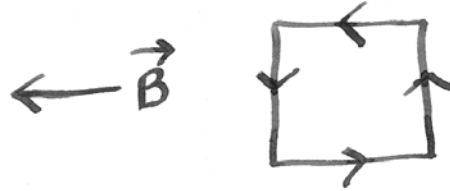
R	I	ΔV	P
4Ω	2A	8V	16 W
3Ω	1.33 A	4 V	5.33 W
6Ω	0.67 A	4 V	2.67 W
6Ω	2 A	12 V	24 W

Most of this table follows from the information above. The extra piece of information is the potential difference across the resistors in parallel. It is the difference between the potentials at B and C, or $12 \text{ V} - 8 \text{ V} = 4 \text{ V}$.

(e) Verify that the electric power supplied by the battery equals the sum of the magnitudes of the electric powers dissipated by the three resistors.

The electric power supplied by the battery is $I \Delta V = (2 \text{ A})(12 \text{ V}) = 24 \text{ W}$. This is the sum of the three powers dissipated, $16 \text{ W} + 5.33 \text{ W} + 2.67 \text{ W} = 24 \text{ W}$.

3. [13 points] The diagram below shows a square current loop, with the direction of the current indicated, and the direction of the uniform magnetic field in which it is placed.



Show (using arrows or dots and crosses if necessary) the magnetic forces on all four sides of the loop.

The forces on the top, left, bottom, and right, respectively, are 0, down or \otimes , 0, and up or \odot .

What is the net force on this loop?

The net force is zero, because the up and down forces must have the same magnitude (both are BIL).

Is there a net torque on this loop? If so, describe how the loop will tend to rotate.

Yes, there is a net torque. It will tend to make the loop rotate so its left side goes down and its right side goes up. This is a counterclockwise rotation about an axis from the bottom to the top side, as viewed from below.

This loop can be regarded as a magnet of its own. Describe where the north and south poles of this magnet would be (like "the north pole is to the north and the south pole is to the south").

Using the right hand rule, wrapping the fingers in the direction of the current around the loop, the thumb points up. Thus the north pole is up (relative to the plane of the page) and the south pole is down.