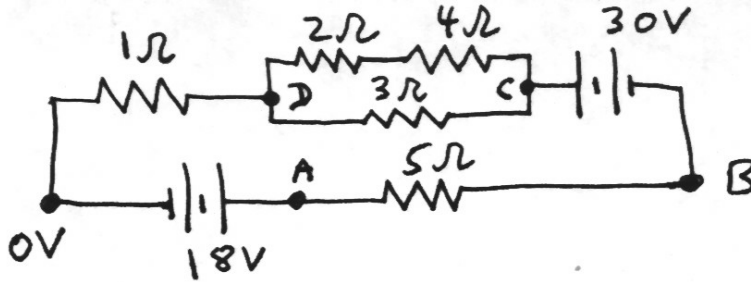


PHYSICS 112 - FALL 2003 - EXAM 2

**SHOW YOUR WORK!** Although some of these problems are multiple-choice, 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.

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1. (17 points) Determine the currents flowing through each of the resistors and the batteries in this circuit, the potential differences across each resistor, the power dissipated through each resistor and each battery; fill out the table below. Also, determine the electric potential at the points A, B, C, and D in the circuit; note that the negative terminal of the 18-volt battery is taken to have a potential of 0 volts. There are several checks you can make to be sure you have the correct answers.

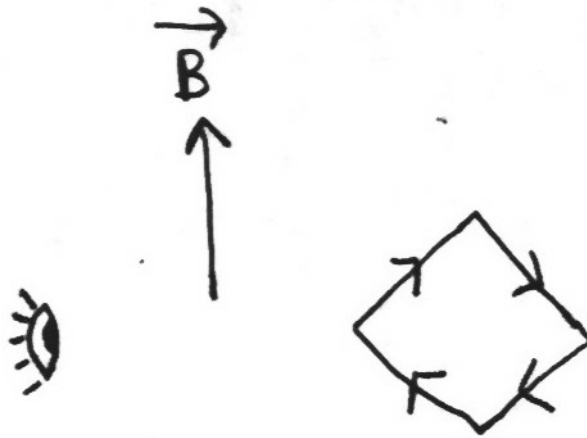
$R$	$I$	$\Delta V$	$P$
1 $\Omega$			
2 $\Omega$			
3 $\Omega$			
4 $\Omega$			
5 $\Omega$			
----		30 V	
----		18 V	



2. (7 points) Shown above are four circuits, each with the same battery. The resistors are individually labeled, but each has the same resistance  $R$  ( $R_1 = R_2 = \dots = R_8 = R$ ). Suppose that in the circuit at the left, the power dissipated through  $R_1$  is 72 watts. Determine the power dissipated in each of the other seven resistors. (This can be done without assigning values to  $R$  or  $V_0$  — use your ingenuity.) Be sure to show enough work to indicate how you arrived at the answer.

$$P_1 = 72 \text{ watts} \quad P_2 = \underline{\hspace{2cm}} \quad P_3 = \underline{\hspace{2cm}} \quad P_4 = \underline{\hspace{2cm}}$$

$$P_5 = \underline{\hspace{2cm}} \quad P_6 = \underline{\hspace{2cm}} \quad P_7 = \underline{\hspace{2cm}} \quad P_8 = \underline{\hspace{2cm}}$$



3. (8 points) A square current loop is lying in the plane of the paper, with current as indicated. The loop lies in a uniform magnetic field directed north, as shown. Determine the direction of the force on each side of the current loop (indicate with arrows,  $\odot$  or  $\otimes$ ). Also show (and label) the magnetic field of the loop itself,  $B_{\text{loop}}$ , in the interior of the loop. Determine the net force and net torque, if any; if there is a net torque, describe how the loop will rotate as viewed along the plane of the paper from the left edge of the paper — from the perspective of the eye shown).

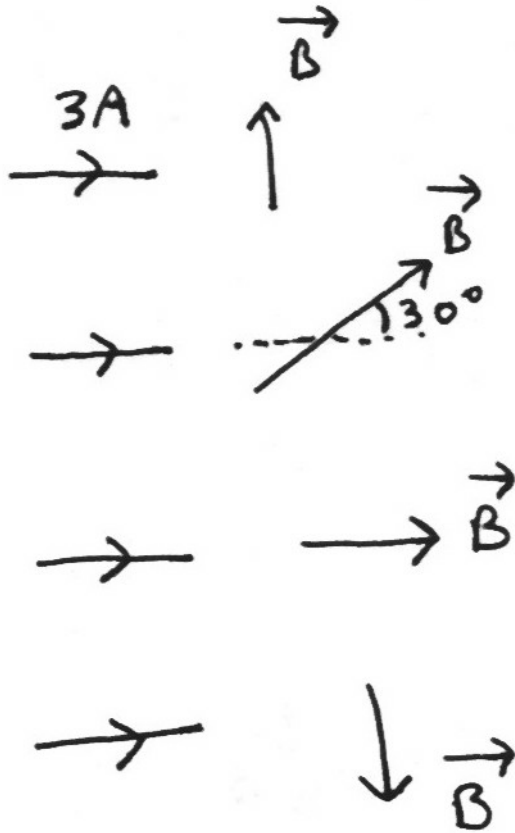
Net force? \_\_\_\_\_

Net torque? \_\_\_\_\_

Direction of rotation (if any): \_\_\_\_\_

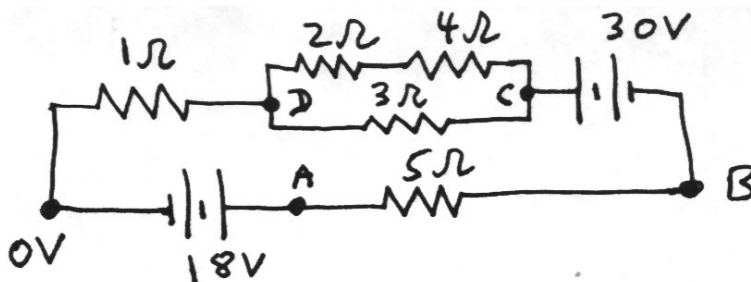
4. ( 8 points) A 1.5-meter length of wire carries a current of 3.0 A in the "north" direction as shown. Four possible magnetic fields are shown; suppose that  $B = 4.0$  T. For each case, determine the force (magnitude in newtons, direction by north, east, south, west, up ( $\odot$ ), or down ( $\otimes$ )).

Note: you can use  $\cos 60^\circ = \sin 30^\circ = 0.5$  and  $\cos 30^\circ = \sin 60^\circ = 0.9$ .



PHYSICS 112 - FALL 2003 - EXAM 2

**SHOW YOUR WORK!** Although some of these problems are multiple-choice, 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.



1. (17 points) Determine the currents flowing through each of the resistors and the batteries in this circuit, the potential differences across each resistor, the power dissipated through each resistor and each battery; fill out the table below. Also, determine the electric potential at the points A, B, C, and D in the circuit; note that the negative terminal of the 18-volt battery is taken to have a potential of 0 volts. There are several checks you can make to be sure you have the correct answers.

$R$	$I$	$\Delta V$	$P$
1 $\Omega$	6 A	6 V	36 W
2 $\Omega$	2 A	4 V	8 W
3 $\Omega$	4 A	12 V	48 W
4 $\Omega$	2 A	8 V	16 W
5 $\Omega$	6 A	30 V	180 W
----	6 A	30 V	180 W
----	6 A	18 V	108 W

The total battery voltage in the circuit is  $30\text{ V} + 18\text{ V} = 48\text{ V}$ .

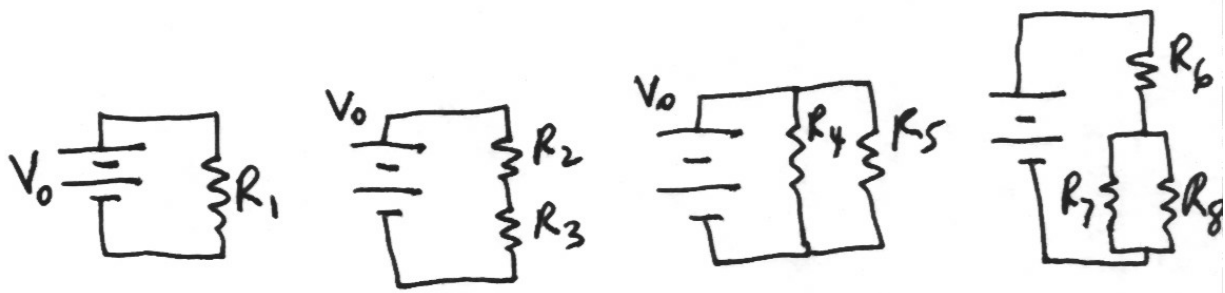
The equivalent resistance is  $1\ \Omega + \frac{1}{\frac{1}{2\ \Omega + 4\ \Omega} + \frac{1}{3\ \Omega}} + 5\ \Omega = 8\ \Omega$ .

The current through the batteries is  $I = (48\text{ V}) / (8\ \Omega) = 6\text{ A}$ .

The potential difference across the parallel part of the circuit is  $(6\text{ A})(2\ \Omega) = 12\text{ V}$ .

Going counterclockwise around the circuit, starting from the point labeled "0 V," we find that the potential at A is  $0\text{ V} + 18\text{ V} = 18\text{ V}$ , that at B is  $18\text{ V} - 30\text{ V} = -12\text{ V}$ , that at C is  $-12\text{ V} + 30\text{ V} = 18\text{ V}$ , and that at D is  $18\text{ V} - 12\text{ V} = 6\text{ V}$ . Then across the 1-ohm resistor the potential drops 6 V back down to 0 V.

In the table, note that the batteries supply a total of 288 W and the resistors dissipate 288 W.



2. (7 points) Shown above are four circuits, each with the same battery. The resistors are individually labeled, but each has the same resistance  $R$  ( $R_1 = R_2 = \dots = R_8 = R$ ). Suppose that in the circuit at the left, the power dissipated through  $R_1$  is 72 watts. Determine the power dissipated in each of the other seven resistors. (This can be done without assigning values to  $R$  or  $V_0$  — use your ingenuity.) Be sure to show enough work to indicate how you arrived at the answer.

$$P_1 = 72 \text{ watts} \quad P_2 = \underline{\hspace{2cm}} \quad P_3 = \underline{\hspace{2cm}} \quad P_4 = \underline{\hspace{2cm}}$$

$$P_5 = \underline{\hspace{2cm}} \quad P_6 = \underline{\hspace{2cm}} \quad P_7 = \underline{\hspace{2cm}} \quad P_8 = \underline{\hspace{2cm}}$$

Key idea: If we use  $I$  for the current through  $R_1$ , we see that  $I^2 R = 72 \text{ W}$ . Suppose the current through one of the other resistors turns out to be  $kI$ . Then the power dissipated through that resistor is  $(kI)^2 R = k^2(I^2 R) = k^2(72 \text{ W})$ .

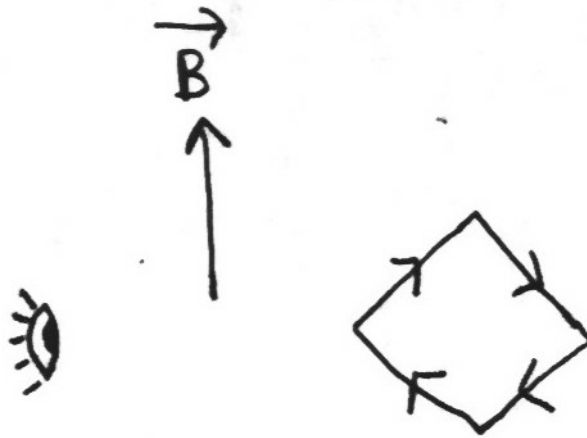
$R_2, R_3$  : Compared to the first circuit, this one has twice the equivalent resistance so it must have half the current. Thus  $k = \frac{1}{2}$  so  $k^2(72 \text{ W}) = \frac{1}{4}(72 \text{ W}) = 18 \text{ W}$ . This is the value of  $P_2$  and of  $P_3$ .

$R_4, R_5$  : These resistors, which form a parallel circuit, both have the same voltage  $V_0$  across them and thus the same current as in the first one, so they must each have the same power as the first resistor ( $k = 1$ , in other words). Thus  $P_4 = 72 \text{ W}$  and  $P_5 = 72 \text{ W}$ .

Last circuit: First, let's determine the equivalent resistance of this circuit. It is

$$R_{\text{eq}} = R + \frac{1}{\frac{1}{R} + \frac{1}{R}} = R + \frac{1}{\frac{2}{R}} = R + \frac{1}{2}R = \frac{3}{2}R.$$

Comparing to the first circuit, the current in this circuit is  $2/3$  of the current in the first one, so  $k = 2/3$  and the power dissipated by  $R_6$  is  $(2/3)^2(72 \text{ W}) = 32 \text{ W}$ . The other two resistors each have half as much current, corresponding to  $k = 1/3$ , so  $P_7$  and  $P_8$  are each  $(1/3)^2(72 \text{ W}) = 8 \text{ W}$ .



3. (8 points) A square current loop is lying in the plane of the paper, with current as indicated. The loop lies in a uniform magnetic field directed north, as shown. Determine the direction of the force on each side of the current loop (indicate with arrows,  $\odot$  or  $\otimes$ ). Also show (and label) the magnetic field of the loop itself,  $B_{\text{loop}}$ , in the interior of the loop. Determine the net force and net torque, if any; if there is a net torque, describe how the loop will rotate as viewed along the plane of the paper from the left edge of the paper — from the perspective of the eye shown).

Net force? \_\_\_\_\_

Net torque? \_\_\_\_\_

Direction of rotation (if any): \_\_\_\_\_

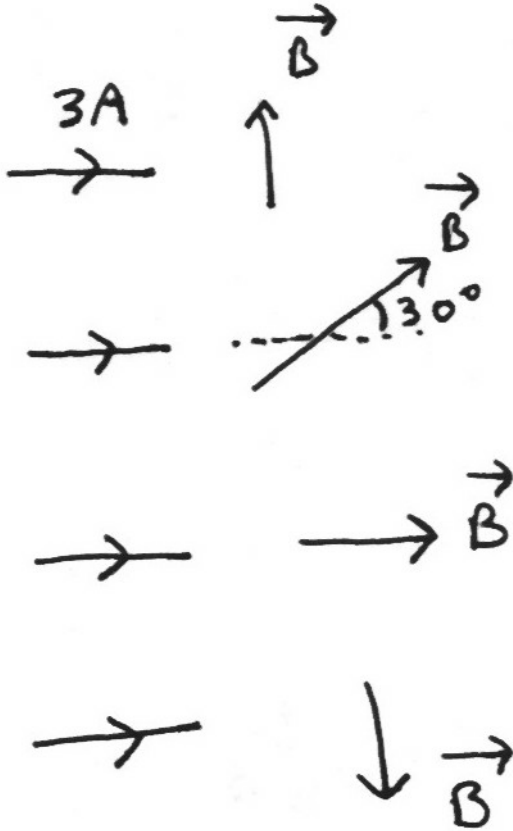
Using the right hand rule, the forces on the top pair of edges of the loop are both up ( $\odot$ ) and those on the bottom pair of edges are both down ( $\otimes$ ).

The direction of  $\vec{B}_{\text{loop}}$  is down ( $\otimes$ ), by the right hand rule.

The net force is zero, but there is a net torque. The direction of rotation of the loop is such that the top two edges rise out of the plane of the page and the bottom two edges go down. Viewed from the left, the loop will appear to rotate clockwise.

4. (8 points) A 1.5-meter length of wire carries a current of 3.0 A in the "north" direction as shown. Four possible magnetic fields are shown; suppose that  $B = 4.0$  T. For each case, determine the force (magnitude in newtons, direction by north, east, south, west, up ( $\odot$ ), or down ( $\otimes$ )).

Note: you can use  $\cos 60^\circ = \sin 30^\circ = 0.5$  and  $\cos 30^\circ = \sin 60^\circ = 0.9$ .



Here,  $BIL = (4.0 \text{ T})(3.0 \text{ A})(1.5 \text{ m}) = 18 \text{ N}$ . The forces will have magnitude  $BIL \sin \theta = (18 \text{ N}) \sin \theta$ .

First case: The magnetic force is  $\odot$  and since  $\theta = 90^\circ$ ,  $F = 18 \text{ N}$ .

Second case: The magnetic force is  $\odot$  and since  $\theta = 30^\circ$ ,  $F = 9 \text{ N}$  (because  $\sin 30^\circ = \frac{1}{2}$ ).

Third case: Since the current and magnetic field are in the same direction,  $\theta = 0$  and the force is zero and has no direction.

Fourth case: The magnetic force is  $\otimes$  and since  $\theta = 90^\circ$ ,  $F = 18 \text{ N}$ .