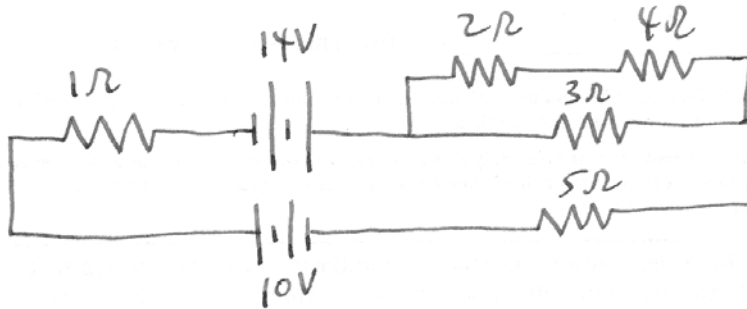


PHYSICS 112 - FALL 2004 - EXAM 2

Name _____ Section _____

NO CALCULATORS. 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.

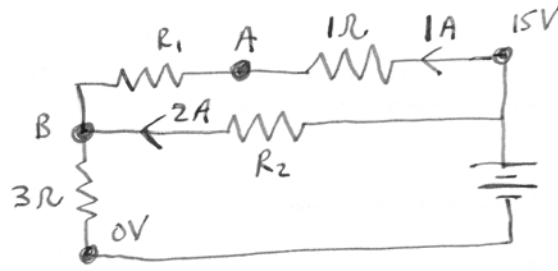


1. (13 points) For the circuit shown, determine the equivalent voltage of the circuit, the equivalent resistance of the circuit and all the currents, potential differences, and powers, filling them in the table below. Show the direction of all currents on the diagram.

$\Delta V_{\text{tot}} =$ _____

$R_{\text{eq}} =$ _____

| R | I | ΔV | P |
|-------------|-----|------------|-----|
| $1\ \Omega$ | | | |
| $3\ \Omega$ | | | |
| $2\ \Omega$ | | | |
| $4\ \Omega$ | | | |
| $5\ \Omega$ | | | |
| | | 10 V | |
| | | 14 V | |



2. (12 points) A circuit is shown which consists of one battery and four resistors. Only partial information is known: the current at two points, the potential at two points, and two resistances. Determine the rest of the resistances and currents, as well as the voltage of the battery, and fill out the rest of the table below (including the powers). Show the direction of any currents not given in the diagram. Also determine the potentials at points A and B. Check your results.

$V_A =$ _____ $V_B =$ _____

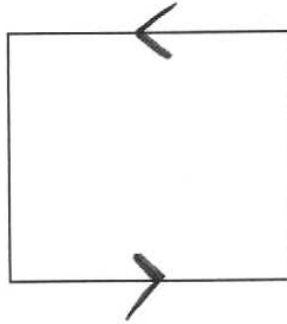
| | R | I | ΔV | P |
|---------|------------|-----|------------|-----|
| | 1Ω | | | |
| R_1 | | | | |
| R_2 | | | | |
| | 3Ω | | | |
| battery | | | | |

3. [6 points] In a certain region of space there is a uniform horizontal magnetic field \vec{B} of magnitude 0.30 T pointing towards the east. Parts (a) and (b) both refer to this same field.

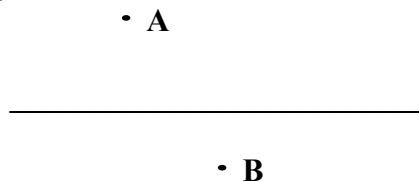
(a) A vertical wire 3.0 m long is carrying a current of 2.0 A in the direction north-to-south. Determine the magnitude and direction of the magnetic force on the wire.

(b) At a certain instant, an electrically charged object with a charge of $+5 \mu\text{C}$ is moving down (\otimes) with a speed of $v = 30 \text{ m/s}$ in this region. Determine the magnitude and direction of the magnetic force on this charge due to the magnetic field specified above.

4. [5 points] A square current loop is allowed to reorient itself in a uniform magnetic field, and ends in the configuration shown below, with a counterclockwise electric current. Determine the direction of that uniform magnetic field, and indicate the direction of the force on each of the four sides of the current loop due to that field. Also determine the direction of the magnetic field of the loop itself, \vec{B}_{loop} .



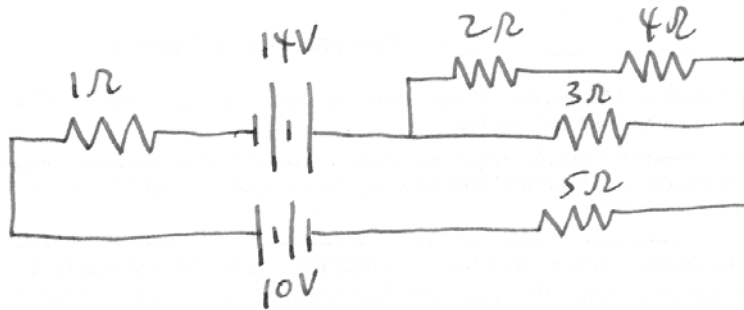
5. [4 points] In the diagram below, point A is 20 cm from the current-carrying wire shown, and point B is 10 cm away. Suppose that at point A the magnetic field due to the wire is 0.24 T and is directed down (\otimes).



(a) What is the direction of the current in the wire? Explain.

(b) What is the magnitude and direction of the magnetic field at point B? Explain how you determined this.

PHYSICS 112 - FALL 2004 - EXAM 2 SOLUTIONS



1. (13 points) For the circuit shown, determine the equivalent voltage of the circuit, the equivalent resistance of the circuit and all the currents, potential differences, and powers, filling them in the table below. Show the direction of all currents on the diagram.

$$\Delta V_{\text{tot}} = 24 \text{ V}$$

$$R_{\text{eq}} = 8 \Omega$$

| R | I | ΔV | P |
|------------|-----|-------------|------|
| 1Ω | 3 A | 3 V | 9 W |
| 3Ω | 2 A | 6 V | 12 W |
| 2Ω | 1 A | 2 V | 2 W |
| 4Ω | 1 A | 4 V | 4 W |
| 5Ω | 3 A | 15 V | 45 W |
| | 3 A | 10 V | 30 W |
| | 3 A | 14 V | 42 W |

The two batteries face the same direction in the circuit, so the total voltage is $14 \text{ V} + 10 \text{ V} = 24 \text{ V}$.

The equivalent resistance of the parallel section is

$$1 / (1 / (2 \Omega + 4 \Omega) + 1 / 3 \Omega) = 1 \Omega / (1/6 + 1/3) = 1 \Omega / (1/2) = 2 \Omega$$

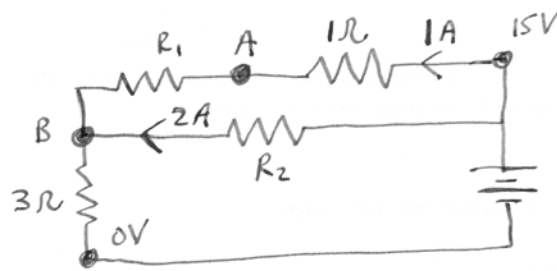
so the equivalent resistance of the whole circuit is $2 \Omega + 1 \Omega + 5 \Omega = 8 \Omega$.

The total current is then $(24 \text{ V}) / (8 \Omega) = 3 \text{ A}$, which is the current through the batteries and the 1Ω and 5Ω resistors.

After determining the potential differences of 3 V across the $1\text{-}\Omega$ resistor and 15 V across the $5\text{-}\Omega$ resistor, totaling 18 V, the potential difference across the parallel section is

$$24 \text{ V} - 18 \text{ V} = 6 \text{ V}.$$

Next, we find that this potential difference leads to current of 2 A through the $3\text{-}\Omega$ resistor and 1 A through the branch with the 2Ω and 4Ω resistors. Now it is possible to complete the table and check that the power supplied by the batteries, $30 \text{ W} + 42 \text{ W} = 72 \text{ W}$, equals the power dissipated through the resistors: $9 \text{ W} + 12 \text{ W} + 2 \text{ W} + 4 \text{ W} + 45 \text{ W} = 72 \text{ W}$.



2. (12 points) A circuit is shown which consists of one battery and four resistors. Only partial information is known: the current at two points, the potential at two points, and two resistances. Determine the rest of the resistances and currents, as well as the voltage of the battery, and fill out the rest of the table below (including the powers). Show the direction of any currents not given in the diagram. Also determine the potentials at points A and B. Check your results.

$$V_A = 14 \text{ V} \qquad V_B = 9 \text{ V}$$

| | R | I | ΔV | P |
|----------------|------------|-----|------------|------|
| | 1Ω | 1 A | 1 V | 1 W |
| R_1 | 5Ω | 1 A | 5 V | 5 W |
| R_2 | 3Ω | 2 A | 6 V | 12 W |
| | 3Ω | 3 A | 9 V | 27 W |
| battery | | 3 A | 15 V | 45 W |

First, note that since the two branches of the parallel section have currents of 1 A and 2 A, totaling 3 A, the current through the 3- Ω resistor and the battery is 3 A. This leads to a potential difference of 9 V across the 3- Ω resistor, so the potential at B is 9 V.

Now it is clear that the potential difference across R_2 is $15 \text{ V} - 9 \text{ V} = 6 \text{ V}$, so R_2 must be 3 Ω since the current through it is 2 A.

The potential at A is 15 V minus 1 V, the potential difference across the 1- Ω resistor, or 14 V. That leaves $14 \text{ V} - 9 \text{ V} = 5 \text{ V}$ across R_1 , so R_1 must equal 5 Ω .

Finally, note that the potential difference across the battery is $15 \text{ V} - 0 \text{ V} = 15 \text{ V}$.

The powers can be calculated, and the battery power, 45 W, equals the power dissipated by the four resistors: $1 \text{ W} + 5 \text{ W} + 12 \text{ W} + 27 \text{ W} = 45 \text{ W}$.

3. [6 points] In a certain region of space there is a uniform horizontal magnetic field \vec{B} of magnitude 0.30 T pointing towards the east. Parts (a) and (b) both refer to this same field.

(a) A vertical wire 3.0 m long is carrying a current of 2.0 A in the direction north-to-south. Determine the magnitude and direction of the magnetic force on the wire.

The current and magnetic field are 90° apart, so the magnitude of the magnetic force is

$$F = ILB \sin \theta = (2.0 \text{ A})(3.0 \text{ m})(0.30 \text{ T}) \sin (90^\circ) = 1.8 \text{ N}.$$

By the right hand rule, pointing the forefinger in the direction of the current (south) and the middle finger in the direction of the magnetic field (east), the magnetic force is up (\odot).

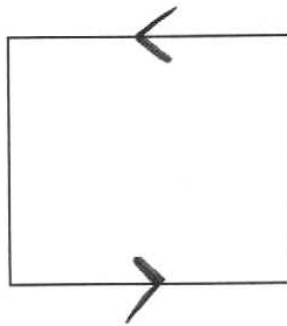
(b) At a certain instant, an electrically charged object with a charge of $+5 \mu\text{C}$ is moving down (\otimes) with a speed of $v = 30 \text{ m/s}$ in this region. Determine the magnitude and direction of the magnetic force on this charge due to the magnetic field specified above.

The magnitude of the magnetic force is

$$F = qvB \sin \theta = (5 \mu\text{C})(30 \text{ m/s})(0.30 \text{ T})(\sin 90^\circ) = 45 \mu\text{N} \text{ or } 4.5 \times 10^{-5} \text{ N}.$$

By the right hand rule, pointing the forefinger in the direction of the velocity of the positive charge (down, \otimes) and the middle finger in the direction of the magnetic field (east), the magnetic force is south.

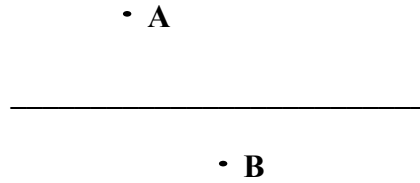
4. [5 points] A square current loop is allowed to reorient itself in a uniform magnetic field, and ends in the configuration shown below, with a counterclockwise electric current. Determine the direction of that uniform magnetic field, and indicate the direction of the force on each of the four sides of the current loop due to that field. Also determine the direction of the magnetic field of the loop itself, \vec{B}_{loop} .



By the curled-finger right-hand rule, curling the fingers counterclockwise around the circuit, the magnetic field of the loop is found to be up (\odot), so that must be the direction of the uniform external magnetic field, since the loop has reoriented itself and must thus have oriented itself so its own magnetic field is parallel to the external magnetic field.

The forces on all four sides can be found by the three-finger right-hand rule to be directed outward from the sides of the current loop.

5. [4 points] In the diagram below, point A is 20 cm from the current-carrying wire shown, and point B is 10 cm away. Suppose that at point A the magnetic field due to the wire is 0.24 T and is directed down (\otimes).



(a) What is the direction of the current in the wire? Explain.

If the magnetic field at A is directed down (\otimes), the current must be directed to the left, because that direction of current, using the curled-finger right-hand rule, would give a downward magnetic field at the point A.

(b) What is the magnitude and direction of the magnetic field at point B? Explain how you determined this.

B is on the other side of the current, so by the curled-finger right-hand rule, the magnetic field at B must be directed up (\odot).

Since B is half as far away from the wire as A, the magnetic field at B must have a magnitude twice as large as the magnitude at A, or $2(0.24 \text{ T}) = 0.48 \text{ T}$.