PHYS 212 Test #4 Spring 2012 Name: KEY

Ohm's law: $v = iR$ R in Series = add; R in parallel= $R^{-1}=R_1^{-1}+R_2^{-1}+R_3^{-1}$....

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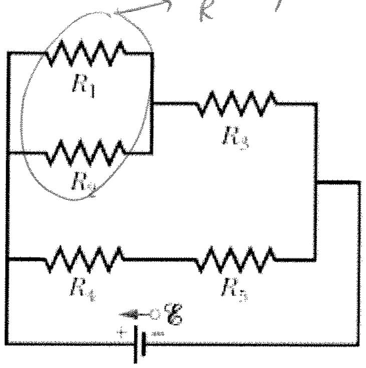
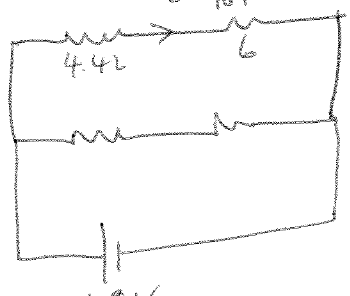
1. In the figure below, an ideal battery of emf = 18 V is connected to a network of resistances $R_1 = 7\ \Omega$, $R_2 = 12\ \Omega$, $R_3 = 6\ \Omega$, $R_4 = 4\ \Omega$, and $R_5 = 5\ \Omega$. What is the potential difference (in V) across resistance 1?

$\frac{1}{R} = \frac{1}{7} + \frac{1}{12} \rightarrow R = \frac{7\times12}{19} = 4.42\Omega$

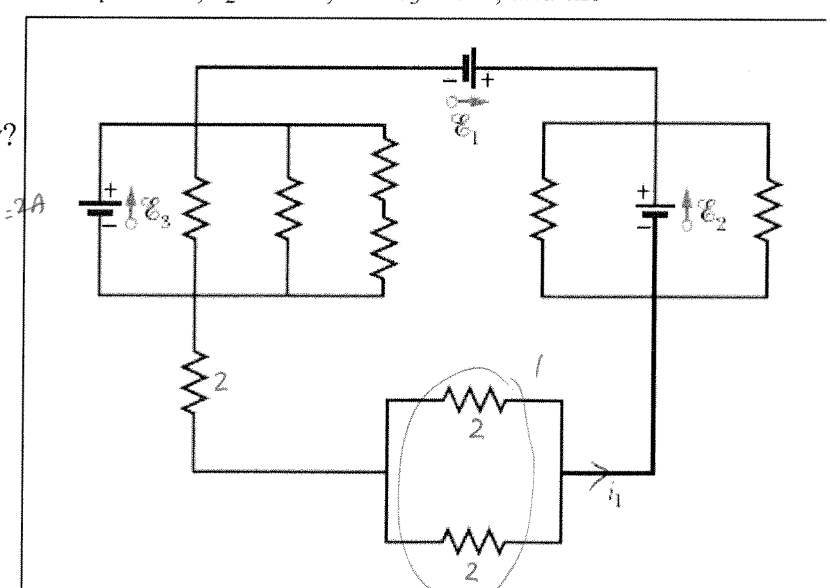
$i = \frac{18}{10.42} =$

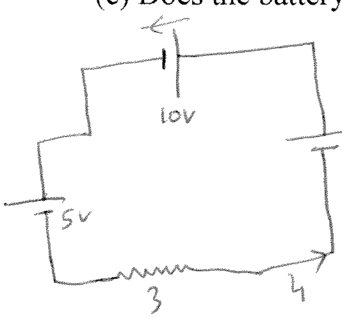
$V_1 = i \cdot 4.42 = 7.63V$





2. In the figure below, the ideal batteries have emfs $\varepsilon_1 = 10V$, $\varepsilon_2 = 21V$, and $\varepsilon_3 = 5V$, and the resistances are each 2.0 Ω.
(a) Determine the current i_1?
(b) What is the power of battery 1?
(c) Does the battery1 supply or absorb energy?



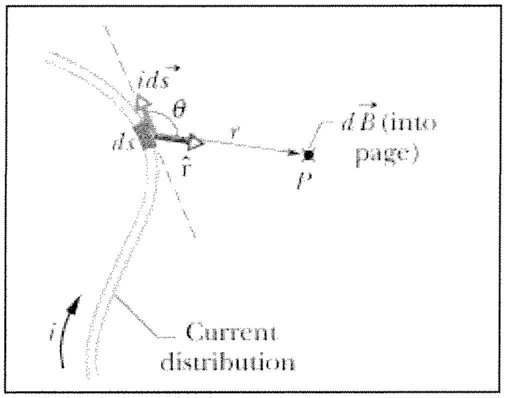


$i_1 = \frac{21-10-5}{3} = \frac{6}{3} = 2A$

$i_1 = 2A \rightarrow$

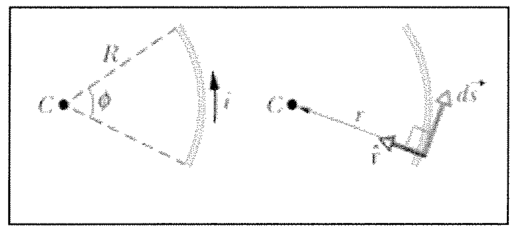
$P = iV = 2\times10 = 20W$, absorb

III. A current-length element $i\,d\vec{s}$ produces a differential magnetic field $d\vec{B}$ at point *P*, directed *into* the page there. Its value is given by Biot-Savart law as follows: ($\mu_0 = 4\pi \times 10^{-7}$ T.m/A)



$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s} \times \hat{r}}{r^2} \qquad \text{(Biot–Savart law).}$$

1. Show that the magnetic field at *C* due to a circular arc of wire is given by the following equation.



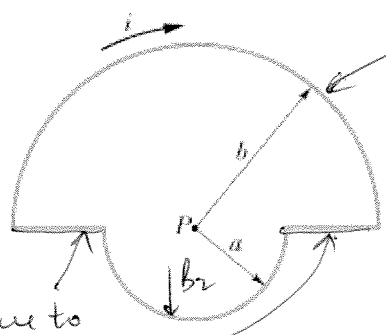
$$B = \frac{\mu_0 i \phi}{4\pi R} \qquad \text{(at center of circular arc).}$$

$$dB = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s} \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi}\frac{i\,ds}{R^2}$$

$$B = \int \frac{\mu_0}{4\pi}\frac{i\,ds}{R^2} = \frac{\mu_0 i}{4\pi R^2}\int ds = \frac{\mu_0 i}{4\pi R^2} R\phi$$

$$B = \frac{\mu_0 i \phi}{4\pi R}$$

2. In the Figure below, current $i = 56.2$ mA is set up in a loop having two radial lengths and two semicircles of radii $a = 5.72$ cm and $b = 9.36$ cm with a common center *P*. What are the (a) magnitude and (b) direction (into or out of the page) of the magnetic field at *P*



$$B_1 = \frac{\mu_0 i \times \pi}{4\pi b} \text{ into page}$$

$$B_2 = \frac{\mu_0 i \cdot \pi}{4\pi a} \text{ into page}$$

B_2

B due to there will be zero because $\theta = 0$ or $180°$

$$B_{net} = (B_1 + B_2) \text{ into page} = \frac{\mu_0 i \pi}{4\pi b} + \frac{\mu_0 i \pi}{4\pi a}$$

$$B_{net} = \frac{4\pi \times 10^{-7} \times 0.0562 \times \pi}{4\pi \times 9.36 \times 10^{-2}} + \frac{4\pi \times 10^{-7} \times 0.056 \times \pi}{4\pi \times 0.0572}$$

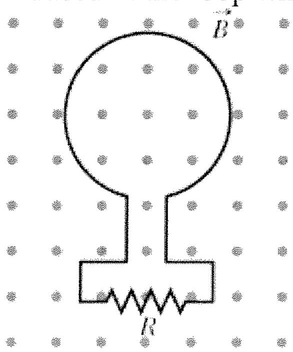
$$= 0.0188 \times 10^{-5} + 0.0308 \times 10^{-5}$$

$$B_{net} = 4.96 \times 10^{-7}\ T$$

IV. Faraday's law of induction is given by:

$$\mathcal{E} = -N\frac{d\Phi_B}{dt}$$

1. In the figure below, the magnetic flux through the loop increases according to the relation $\Phi_B = 4.0t^3 + 3.0t^2$, where Φ_B is in milliwebers and t is in seconds. What is the magnitude of the emf induced in the loop when $t = 3.0$ s?



$\mathcal{E} = -\frac{d}{dt}(4t^3 + 3t^2)$

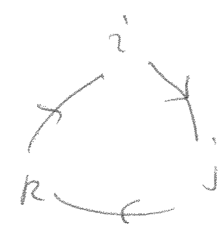
$\mathcal{E} = -[12t^2 + 6t]$

$(\mathcal{E})_{t=3} = -[12\times 3^2 + 6\times 3] = -(108 + 18) = 126\ mV$ ✓

$= -0.126\ V$

V. A 2.0 μC particle moves through a region containing the magnetic field -20 $\hat{i}$ mT and the electric field 350 $\hat{j}$ V/m. At one instant the velocity of the particle is $(5\hat{i} - 7\hat{j} + 9\hat{k})$ km/s. At that instant and in unit-vector notation, what is the net electromagnetic force (the sum of the electric and magnetic forces) on the particle?

(Net force on a moving charge in electric and magnetic fields: $\vec{F} = q\vec{E} + q\vec{v}\times\vec{B}$)



$\vec F = q\vec E + q\vec v \times \vec B$

$= 2\times10^{-6}\left[\vec E + \vec v \times \vec B\right]$

$= 2\times10^{-6}\left[350\hat j + (5\hat i - 7\hat j + 9\hat k)\times10^{3} \times (-20\times10^{-3}\,T)\hat i\right]$

$= 2\times10^{-6}\left(350\hat j - 140\times\cancel{10^{3}}\,\hat k - 180\times\cancel{10^{3}}\,\hat j\right]$

$\vec F\ (2\times10^{-6}\times 170\hat j - 2\times10^{-6}\times140\hat k)\ N$

$\vec F = (3.4\times10^{-4}\hat j - 2.8\times10^{-4}\hat k)\ N$