

Problem #	1	2	3	4	5	6
Max Grade points	10	6	14	12	12	6
Your Grade						

1. In the circuit below calculate the current in each element and enter it in the table below. You must use the direction of currents shown on the figure. $R_1 = 10$ Ohms, $R_2 = 25$ Ohms, $V_1 = 10$ volts, $V_2 = 20$ volts, $V_3 = 30$ volts.

	R_1	V_1	R_2	V_2	V_3
Current (A)	2	2	0.4	0.4	2.4

Left loop - move clockwise

$$+V_2 + R_2 I_2 - V_3 = 0$$

$$20 + 25 I_2 - 30 = 0$$

$$I_2 = 0.4 \text{ A}$$

Right loop - move CW

$$+V_3 - I_1 R_1 - V_1 = 0$$

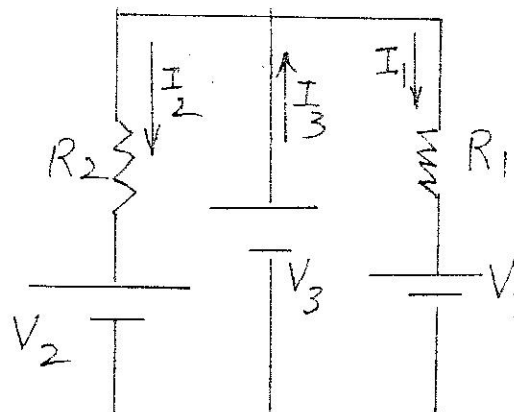
$$30 - 10 I_1 - 10 = 0$$

$$I_1 = 2 \text{ A}$$

Current Rule

$$I_3 - I_2 - I_1 = 0$$

$$I_3 = I_1 + I_2 = 2 + 0.4 = 2.4 \text{ A}$$



2. In an RC circuit $R = 10,000$ Ohms, $C = 0.1$ microfarads, and the battery emf $\epsilon = 10$ volts. The capacitor is initially fully discharged.

a. What is the time constant of this circuit?

time const: $\tau = RC$

$$\tau = 10^4 \times 0.1 \times 10^{-6} = 0.001 \text{ sec} = 1 \text{ msec}$$

b. Is this capacitor fully charged after one second? Your answer should be followed by the reasoning.

$$q = C\epsilon(1 - e^{-t/\tau})$$

$$q_{\max} = C\epsilon$$

$$q = q_{\max}(1 - e^{-t/\tau})$$

$$q = q_{\max}(1 - e^{-1/0.001}) = q_{\max}(1 - e^{-1000})$$

$$q = q_{\max} \quad \text{since } e^{-1000} \approx 0$$

The capacitor is fully charged after 1 sec.

3. Use Ampere's law to prove that magnetic field B at a distance x near a long wire with current I is given by

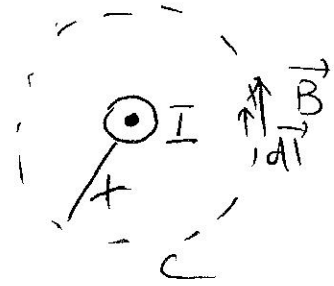
$$B = \mu_0 I / 2\pi x$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I, \quad \vec{B} \parallel d\vec{l}$$

$$\oint B dl \cos 0 = \oint B dl \cos 0$$

$$\oint \vec{B} \cdot d\vec{l} = B \oint dl = B (2\pi x) = \mu_0 I$$

$$B = \mu_0 I / 2\pi x$$



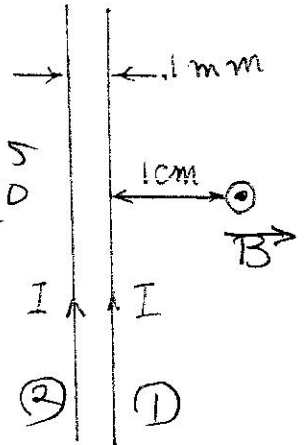
Two very long parallel wires with the distance of 0.1 mm from each other have a current $I = 1.0$ Amp each in the same direction.

i. What is the strength of the magnetic field at a distance 1 cm from one wire outside two wires?

$$B_1 = \frac{\mu_0 I}{2\pi x_1} = \frac{4\pi \times 10^{-7} \times 1}{2\pi \times 10^{-2}} = 2 \times 10^{-5} \text{ T}$$

$$B_2 = \frac{\mu_0 I}{2\pi x_2} = \frac{4\pi \times 10^{-7} \times 1}{2\pi \times (1.0 + 0.1 \times 10^{-1}) \times 10^{-2}} \approx 2 \times 10^{-5} \text{ T}$$

$$B = B_1 + B_2 = 2 B_1 = 4 \times 10^{-5} \text{ T}$$



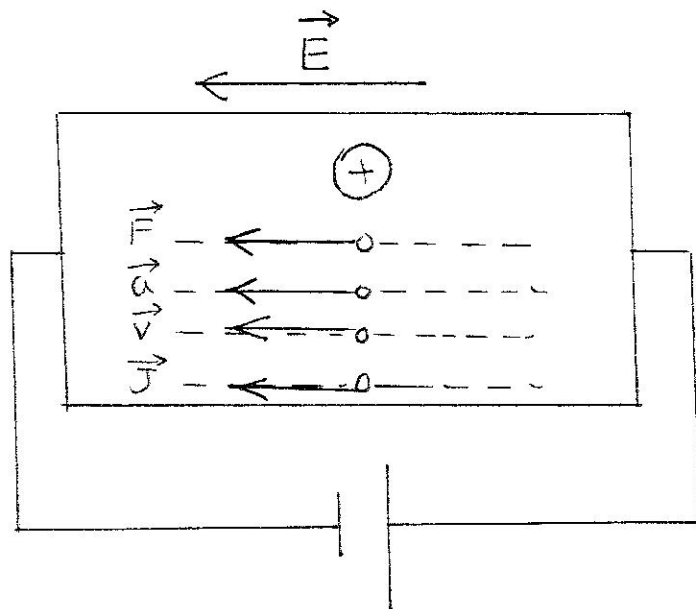
ii. What is the strength of the magnetic field half way between these two wires?

The strength of $\vec{B}$ at the center is zero
 since $|\vec{B}_1| = |\vec{B}_2|$ but $\vec{B}_1$ & $\vec{B}_2$ have opposite directions.

III. Do these wires attract or repel each other.

attract

4. In the figures below show the directions of the vectors $\vec{F}$, $\vec{a}$, $\vec{v}$, and $\vec{J}$ for a positive and negative charges shown. Also write down the formula you use for each vector.

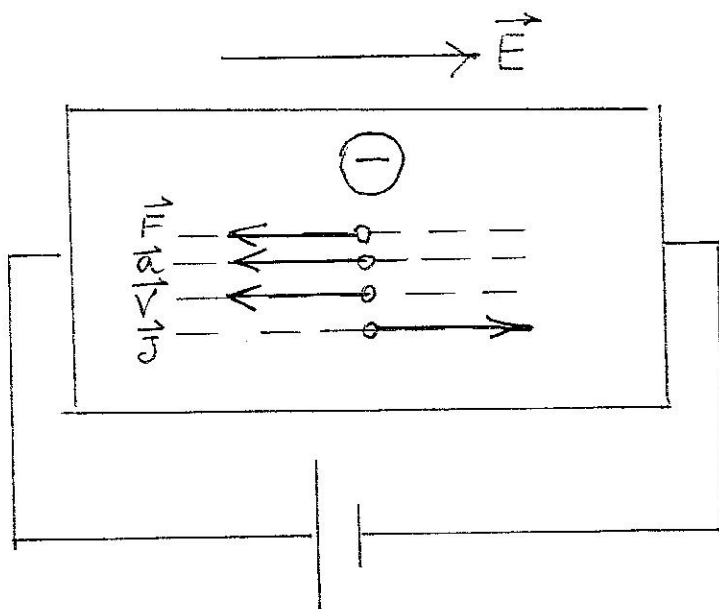


$$\vec{F} = q\vec{E}$$

$$\vec{a} = \frac{q\vec{E}}{m} = \frac{\vec{F}}{m}$$

$$\vec{v} = \int \vec{a} dt$$

$$\vec{J} = nq\vec{v}$$



5. An alpha particle is accelerated by a voltage of 2000 volts from rest.

a. What is the speed of the alpha particle? Alpha particle consists of 2 protons and 2 neutrons.

$$m_p = m_n = 1.67 \times 10^{-27} \text{ kg}, q_p = 1.60 \times 10^{-19} \text{ C}$$

$$\frac{1}{2} m v^2 = qV$$

$$\frac{1}{2} \times 4 \times 1.67 \times 10^{-27} v^2 = 2 \times 1.6 \times 10^{-19} \times 2 \times 10^3$$

$$v = 4.37 \times 10^5 \text{ m/s}$$

b. The alpha particle enters a region with magnetic field $B = 1.0$ Tesla perpendicular to its velocity. Calculate the radius of the circular path.

$$R = \frac{m v}{q B} = \frac{4 \times 1.67 \times 10^{-27} \times 4.37 \times 10^5}{2 \times 1.6 \times 10^{-19} \times 1}$$

$$R = 9.12 \times 10^{-3} \text{ m}$$

c. Calculate the period of the circular motion of the alpha particle?

$$m_p = m_n = 1.67 \times 10^{-27} \text{ kg}, q_p = 1.60 \times 10^{-19} \text{ C}$$

$$T = \frac{2\pi R}{v} = \frac{2\pi \times 9.12 \times 10^{-3} \text{ m}}{4.37 \times 10^5} = 1.31 \times 10^{-7} \text{ sec}$$

6. Enter T (True) or F (False) before each statement below.

Correct answer: 2 points, no answer : 0 points, wrong answer : -1 points. Do not guess if you do not know the correct answer.

F Kilowatt-hour is the unit of power.

T A 2-Ohm resistor with a current 2 Amps dissipates a power of 8 watts.

F The equivalent resistance of series resistors is smaller than resistance of either one of two.

T A stiff rectangular loop with current I and area A is under the effect of a magnetic field B perpendicular to its plane. The force acting on this loop is zero.

T A stiff rectangular loop with current I and area A is under the effect of a magnetic field B perpendicular to its plane, the torque acting on the loop by the field is IAB .

F The magnetic field at the center of a square loop with current I is zero.