STATE UNIVERSITY OF NEW YORK
New Paltz, New York.

General Physics 2
Second Exam

Instructor: Dr. T. Biswas
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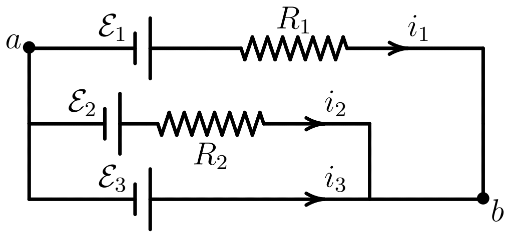
Solutions

Constants and Formulas

$$
\begin{aligned}
\mu_0 &= 4\pi \times 10^{-7}\ Tm/A. \\
V &= iR \\
q &= CV \\
C &= C_1 + C_2 \\
1/C &= 1/C_1 + 1/C_2 \\
\vec{\mathbf{F}} &= i\vec{\mathbf{L}} \times \vec{\mathbf{B}} \\
d\vec{\mathbf{B}} &= \frac{\mu_0 i}{4\pi r^2} d\vec{\mathbf{s}} \times \hat{\mathbf{r}} \\
&= \frac{\mu_0 i}{4\pi r^3} d\vec{\mathbf{s}} \times \vec{\mathbf{r}}
\end{aligned}
$$

Name______________________________

Problem I



The above circuit has components of the following values: $R_1 = 4.0\ \Omega$, $R_2 = 8.0\ \Omega$, $\mathcal{E}_1 = 20$ V, $\mathcal{E}_2 = 30$ V, and $\mathcal{E}_3 = 50$ V. Consider the current directions as shown.

Solution

Question 1

The outer rectangular loop gives

$$\mathcal{E}_1 - i_1 R_1 - \mathcal{E}_3 = 0.$$

Hence,

$$i_1 = \frac{\mathcal{E}_1 - \mathcal{E}_3}{R_1} = -7.5 \text{ A}$$

Question 2

The lower rectangular loop gives

$$\mathcal{E}_2 - i_2 R_2 - \mathcal{E}_3 = 0.$$

Hence,

$$i_2 = \frac{\mathcal{E}_2 - \mathcal{E}_3}{R_2} = -2.5 \text{ A}$$

Question 3

The junction equation gives

$$i_1 + i_2 + i_3 = 0$$

Hence,

$$i_3 = -i_2 - i_1 = 10 \text{ A}$$

Question 4

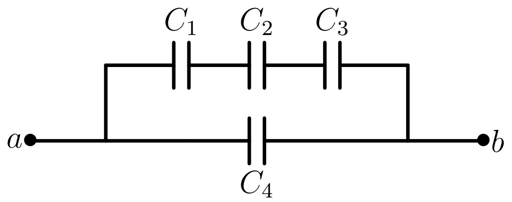
Starting at a, going down and then going right along the bottom branch to b encounters the source $\mathcal{E}_3$. Hence,

$$V_a + \mathcal{E}_3 = V_b$$

Hence,

$$V_b - V_a = \mathcal{E}_3 = 50 \text{ V}$$

Problem II



Four capacitors are connected as shown above. Each capacitor has a capacitance of 6.0μF. A voltage of 10V is applied between the points a and b.

Solution

Question 5

C_1, C_2 and C_3 are in series. So their combination has capacitance C_s given by

$$1/C_s = 1/C_1 + 1/C_2 + 1/C_3 = 1/2$$

Hence,

$$C_s = 2.0$$

C_s and C_4 are in parallel. Hence, the net capacitance C is given by

$$C = C_s + C_4 = 8.0\mu\text{F}$$

Question 6

The full voltage of 10V is across the capacitance C_s. The charge in the series combination is the same as the charge in each member of the combination. Hence,

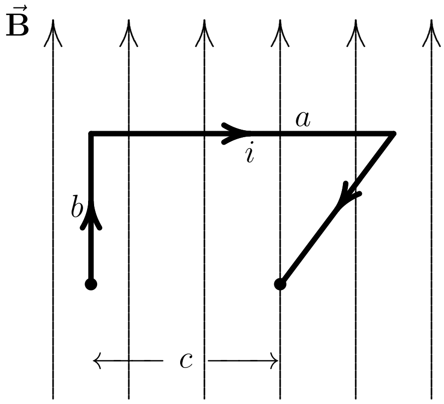
$$q_1 = q_s = C_s V = 2.0 \times 10 = 20\mu\text{C}$$

Question 7

The voltage across C_4 is 10V. Hence the charge in it is

$$q_4 = C_4 V = 6.0 \times 10 = 60\mu\text{C}.$$

Problem III



The figure above shows a magnetic field $\vec{\mathbf{B}}$ directed towards the top of the page. Its magnitude is 2.0T. A piece of wire is placed in this magnetic field in the plane of the page as shown. The top segment has a length $a = 4.0$m and the left segment has a length $b = 2.0$m. The distance between the ends of the wire is $c = 2.5$m. A current of $i = 5.0$A is flowing in the wire in the direction shown.

Solution

Question 8

The force is given by

$$\vec{\mathbf{F}} = i\vec{\mathbf{L}} \times \vec{\mathbf{B}}$$

The right hand rule gives the direction of $\vec{\mathbf{F}}$ to be out of the page. The magnitude is

$$F = i|\vec{\mathbf{L}} \times \vec{\mathbf{B}}| = iaB\sin 90^\circ = 40 \text{ N}$$

Question 9

The magnitude is

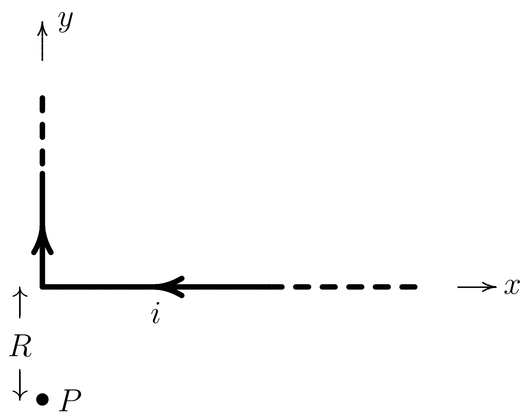
$$F = i|\vec{\mathbf{L}} \times \vec{\mathbf{B}}| = ibB\sin 0^\circ = 0 \text{ N}$$

Question 10

Here, the vector $\vec{\mathbf{L}}$ is the one joining the endpoints in the direction of the current. So, the right hand rule gives the direction of $\vec{\mathbf{F}}$ to be out of the page. The magnitude is

$$F = i|\vec{\mathbf{L}} \times \vec{\mathbf{B}}| = icB\sin 90^\circ = 25 \text{ N}$$

Problem IV



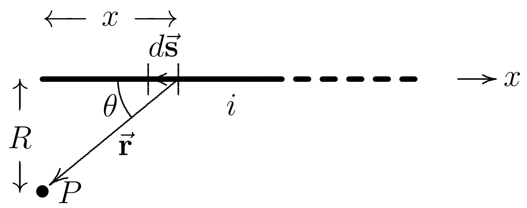
A long thin wire is bent in the shape shown above. Assume it extends to infinity in the positive y and positive x directions as shown. A current i flows in the wire as shown. The point marked P is at a distance R along the negative y axis as shown.

Solution

Biot-Savart law gives

$$d\vec{\mathbf{B}} = \frac{\mu_0 i}{4\pi r^2} d\vec{\mathbf{s}} \times \hat{\mathbf{r}}$$

Question 11



Using the right-hand-rule, the magnetic field direction due to the element of wire $d\vec{\mathbf{s}}$ is found to be out of the page. As this direction is the same for all elements of wire, integrating the magnitude of the field will give the total field.

$$dB = \frac{\mu_0 i}{4\pi r^2} ds\ \sin\theta$$

where $\sin\theta = R/r$. Hence,

$$B = \int dB = \frac{\mu_0 i R}{4\pi} \int \frac{ds}{r^3}$$

Choosing the left end of the wire as the origin of the x axis and the distance of the line element from the origin to be x, it follows that $ds = dx$ and $r = (x^2 + R^2)^{1/2}$. Hence,

$$B = \frac{\mu_0 i R}{4\pi} \int_0^\infty \frac{dx}{(x^2 + R^2)^{3/2}}$$

Question 12

For this part, the angle between $d\vec{\mathbf{s}}$ and $\hat{\mathbf{r}}$ is zero. So, $d\vec{\mathbf{s}} \times \hat{\mathbf{r}} = 0$. Hence, the magnetic field due to this part is zero.

Question 13

Direction is out of the page as seen in the solution of question 11.

Name____________________________________

	a	b	c	d	e	f	g	h	i	j
1	○	○	○	○	○	○	○	○	○	○
2	○	○	○	○	○	○	○	○	○	○
3	○	○	○	○	○	○	○	○	○	○
4	○	○	○	○	○	○	○	○	○	○
5	○	○	○	○	○	○	○	○	○	○
6	○	○	○	○	○	○	○	○	○	○
7	○	○	○	○	○	○	○	○	○	○
8	○	○	○	○	○	○	○	○	○	○
9	○	○	○	○	○	○	○	○	○	○
10	○	○	○	○	○	○	○	○	○	○
11	○	○	○	○	○	○	○	○	○	○
12	○	○	○	○	○	○	○	○	○	○
13	○	○	○	○	○	○	○	○	○	○
14	○	○	○	○	○	○	○	○	○	○
15	○	○	○	○	○	○	○	○	○	○
16	○	○	○	○	○	○	○	○	○	○
17	○	○	○	○	○	○	○	○	○	○
18	○	○	○	○	○	○	○	○	○	○
19	○	○	○	○	○	○	○	○	○	○
20	○	○	○	○	○	○	○	○	○	○