Exam 2

Physics 2049

SOLUTION

There are 11 multiple choice questions which are worth total of 50 points and 2 written questions which are worth 50 points.

Name:

PID:

$\vec{F} = q\vec{v} \times \vec{B}$

$\vec{F} = I\vec{L} \times \vec{B}$

$\mu_0 = 4\pi \times 10^{-7} Tm / A$

$$dB = \frac{\mu_0 I}{4\pi} \frac{dS \times \hat{r}}{r^2}$$

For a current loop with current I, at the center of the loop with radius r, $B = \frac{\mu_0 I}{2r}$

Scores

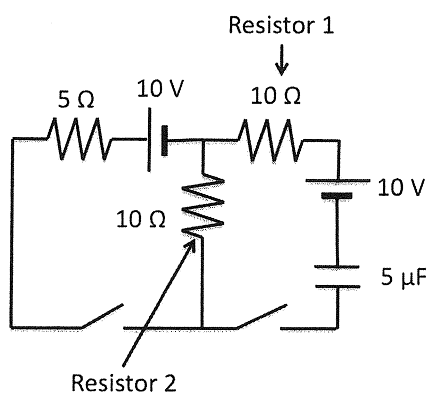
Multiple Choice:

Written:

Free response questions

Make certain that you make clear where your answers are located.

Problem 1 [25 points] : Consider the circuit as depicted below. The switches are closed at t=0

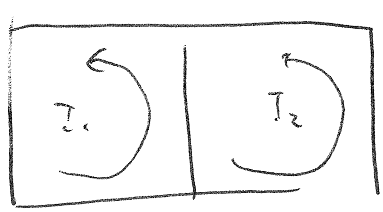


(a) Calculate the current through Resistor 1 at t=0 [10 points]
(b) Calculate the current through Resistor 2 at t=infinity [5 points]
(c) Calculate the magnitude of the voltage across the capacitor at t=infinity [10 points]

a) 1)

$-10I_1 + 10I_2 + 10 - 5I_1 = 0$

$-15I_1 + 10I_2 + 10 = 0 \quad \cdots (1)$



2)

$10 - 10I_2 - 10I_2 + 10I_1 = 0$

$10I_1 - 20I_2 + 10 = 0 \quad \cdots (2)$

$(1) \times 2 \qquad -30I_1 + 20I_2 + 20 = 0$

$-20I_1 + 30 = 0$

$I_1 = 3/2$

SUBSTITUTE INTO (1)

$-\frac{45}{2} + 10I_2 + 10 = 0$

$-\frac{25}{2} + 10I_2 = 0$

$I_2 = \frac{25}{20} = \frac{5}{4}$ A

(a) $\boxed{\frac{5}{4} A}$

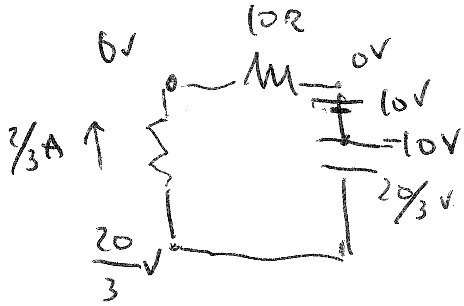
b) AT $t = \infty$ $I_2 = 0$

$-15 I_1 + 10 = 0$

$I_1 = \frac{2}{3}$

$\boxed{\frac{2}{3} A}$ SIGNS ACCEPTED i.e. ± OK.

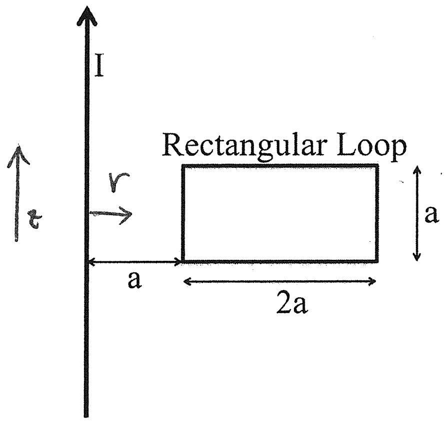
c)



$\left(\frac{20}{3} + 10\right)$ V ACROSS

$\boxed{\frac{50}{3} V}$ ± OK.

Problem 2 [25 points] : A wire carries current in the direction as shown in the figure.



(a) Calculate the flux through the rectangular loop [10 points]
(b) Current is increasing with the rate, dI/dt. What is the induced electromotive force in the loop [10 points]
(c) What is the direction of the induced current through the loop if the current is increasing [5 points]

$$\oint B \cdot ds = \mu_0 I$$

$$2\pi r B = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r}$$

a) FIELD $B = \dfrac{\mu_0 I}{2\pi r}$

$$\Phi_B = \int B\, dA = \int_0^a \int_a^{3a} \frac{\mu_0 I}{2\pi r}\, dr\, dz$$

$$= \frac{\mu_0 I a}{2\pi} \ln r \Big]_a^{3a}$$

$$\boxed{\Phi_B = \frac{\mu_0 I a}{2\pi} \ln 3}$$

b) $$\mathcal{E} = -\frac{d\Phi_B}{dt} = \boxed{-\frac{\mu_0 a}{2\pi} \ln 3 \frac{dI}{dt}}$$ $\boxed{\pm \text{ o/c}}$

c) COUNTER CLOCKWISE

Problem 1. The plates of a parallel plate capacitor of capacitance C_0 are horizontal. Into the gap a slab of dielectric material with κ=2 is placed, filling the bottom half of the gap between the plates. What is the resulting new capacitance?

a. 2/5 C_0
b. 3/4 C_0
c. 4 C_0
d. 5/2 C_0
e. 4/3 C_0

e.

$2\frac{\varepsilon_0 A}{d}$

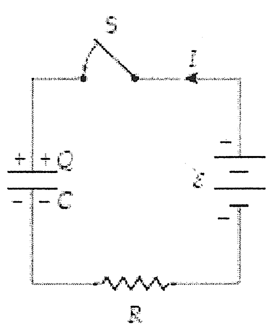
$\frac{d}{2\varepsilon_0 A} + \frac{d}{4\varepsilon_0 A} = \frac{3d}{4\varepsilon_0 A}$

Problem 2. A wire (length = 2.0 m, diameter = 1.0 mm) has a resistance of 0.45Ω. What is the resistivity of the material used to make the wire?

a. $5.6 \times 10^{-7}\ \Omega \cdot \text{m}$
b. $1.2 \times 10^{-7}\ \Omega \cdot \text{m}$
c. $1.8 \times 10^{-7}\ \Omega \cdot \text{m}$
d. $2.3 \times 10^{-7}\ \Omega \cdot \text{m}$
e. $7.1 \times 10^{-7}\ \Omega \cdot \text{m}$

C

Problem 3 At t = 0 the switch S is closed with the capacitor uncharged. If C = 30 μF, ε = 50 V, and R = 10 kΩ, what is the potential difference across the capacitor when I = 2.0 mA?

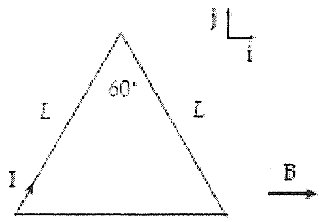


V = [illegible] IQ
= 2.0 × [illegible] · 10 × [illegible] = 20 V ACROSS

a. 20 V
b. 15 V
c. 25 V
d. 30 V
e. 45 V

d.

Problem 4 A straight wire is bent into the shape shown. Determine the net magnetic force on the wire.

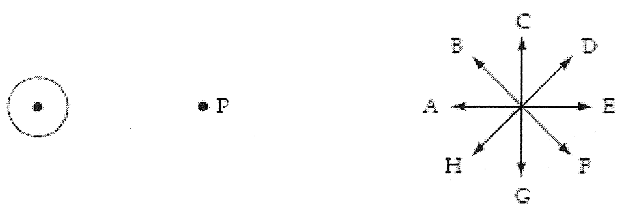


$\vec{F} = I\vec{L} \times \vec{B}$

a. Zero
b. *IBL* in the +*z* direction
c. *IBL* in the −*z* direction
d. 1.7 *IBL* in the +*z* direction
e. 1.4 *IBL* in the −*z* direction

a ZERO ✓

Problem 5 The diagram below shows the position of a long straight wire perpendicular to the page and a set of directions labeled A through H.

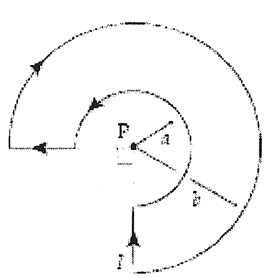


When the current in the wire is directed up out of the page, the direction of the magnetic field at point P is

a. A.
b. B.
c. C.
d. D.
e. E.

C. ✓

Problem 6 What is the magnitude of the magnetic field at point P if $a = R$ and $b = 2R$?



$\frac{\mu_0 I}{2r}$

$\frac{3}{4}\frac{\mu_0 I}{2R} - \frac{3}{4}\frac{\mu_0 I}{4R}$

a. $\frac{9\mu_0 I}{16R}$

b. $\frac{3\mu_0 I}{16R}$

c. $\frac{\mu_0 I}{4R}$

d. $\frac{3\mu_0 I}{4R}$

e. $\frac{3\mu_0 I}{8R}$

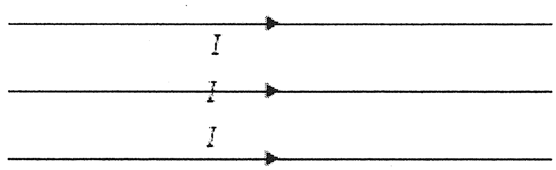
B ✓

Problem 7 A long, straight wire (radius = 2.0 mm) carries a current of 2.0 A distributed uniformly over a cross section perpendicular to the axis of the wire. What is the magnitude of the magnetic field at a distance of 1.0 mm from the axis of the wire?

a. 0.40 mT
b. 0.80 mT
c. 0.10 mT
d. 0.20 mT
e. 0.75 mT

C ← CHECK ✓

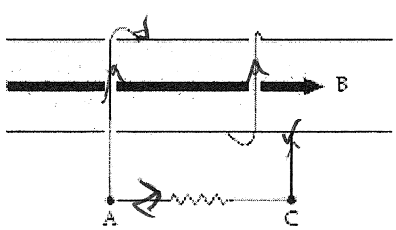
Problem 8 Three coplanar parallel straight wires carry equal currents I to the right as shown below. Each pair of wires is a distance a apart. The direction of the magnetic force on the middle wire



e.

a. is up out of the plane of the wires.
b. is down into the plane of the wires.
c. is in the plane of the wires, directed upwards.
d. is in the plane of the wires, directed downwards
e. There is no magnetic force on the middle wire.

Problem 9 The coil shown in the figure has 2 turns, a cross-sectional area of 0.20 m^2, and a field (parallel to the axis of the coil) with a magnitude given by $B = (4.0 + 3.0t^2)$ T, where t is in s. What is the potential difference, $V_A - V_C$, at $t = 3.0$ s?



2 × 0.2m² × 18

$\frac{dB}{dt} = 6t$

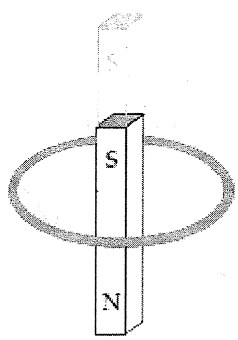
36
0.2
7.2

−7.2

a. −7.2 V
b. +7.2 V
c. −4.8 V
d. +4.8 V
e. −12 V

[a] ✓

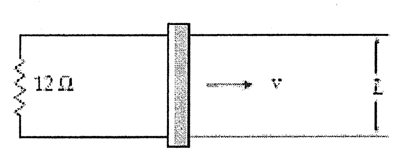
Problem 10 A bar magnet is dropped from above and falls through the loop of wire shown below. The north pole of the bar magnet points downward towards the page as it falls. Which statement is correct?



[d] ✓

a. The current in the loop always flows in a clockwise direction.
b. The current in the loop always flows in a counterclockwise direction.
c. The current in the loop flows first in a clockwise, then in a counterclockwise direction.
d. The current in the loop flows first in a counterclockwise, then in a clockwise direction.
e. No current flows in the loop because both ends of the magnet move through the loop.

Problem 11 A rod (length = 10 cm) moves on two horizontal frictionless conducting rails, as shown. The magnetic field in the region is directed perpendicularly to the plane of the rails and is uniform and constant. If a constant force of 0.60 N moves the bar at a constant velocity of 2.0 m/s, what is the current through the 12-Ω load resistor?



a. 0.32 A
b. 0.34 A
c. 0.37 A
d. 0.39 A
e. 0.43 A

vBL

$0.1 \times 2\,m/s$.

$F = IL \times B = 0.6N = (0.1m)IB$

$\mathcal{E} = 0.2B$

$I = \frac{0.2B}{12}$

$0.6N = \frac{0.02B^2}{12}$

$\frac{7.2}{0.02} = 360 = B^2$

$6\sqrt{10} = B$

[A] ✓