DEPARTMENT OF PHYSICS

PHYCS 102

TEST # 2

Time: 11:00 – 11:55 am

Use BLOCK LETTERS:

Full Name:

Student ID #:

Section:

Student Signature:

Date: 30/5/2006

<table>
<thead>
<tr>
<th>Question</th>
<th>Marks</th>
<th>Use: $\pi = 3.14$</th>
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</thead>
<tbody>
<tr>
<td>MCQ</td>
<td>/50</td>
<td>Charge of an electron or a proton = $1.6\times 10^{-19}$ C,</td>
</tr>
<tr>
<td>Problem 1</td>
<td>/25</td>
<td>$m_e = 9.11\times 10^{-31}$ kg, $m_p = 1.67\times 10^{-27}$ kg,</td>
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<tr>
<td>Problem 2</td>
<td>/25</td>
<td>$k = 9\times 10^9$ N.m$^2$/C$^2$, $\varepsilon_0 = 8.84\times 10^{-12}$ C$^2$/N.m$^2$, $\mu_0 = 4\pi\times 10^{-7}$ Wb/A.m</td>
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<tr>
<td>Total</td>
<td>/100</td>
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<tr>
<td>Total</td>
<td>/15</td>
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* Use: $\pi = 3.14$
PART A: MCQs
* Choose the correct answer.
* Each one of the 10 questions carries the same weight (5 Marks).

1) If the current passing through the 4 Ω resistor is 1A, then the emf of the battery ε (in V) is:
   a) 3
   b) 6
   c) 12
   d) 18
   e) 24

2) A 100 W light bulb operates using a 200V potential difference. The amount of charge (in C) passing through the light bulb in 3 minutes is:
   a) 30
   b) 60
   c) 90
   d) 120
   e) 150

3) In the figure shown R= 1kΩ, C = 10 µF and ε = 10 V. If, initially, the capacitor was uncharged, after closing the switch for a time t = 5x10^{-3} s the current i (in mA) is:
   a) 6.07
   b) 3.68
   c) 2.23
   d) 1.35
   e) zero

4) A wire of diameter D_1 and length L is connected to a battery with an emf ε. The current density in the wire is J_1. If the wire is replaced by another wire of the same material and length but with diameter D_2 = 2D_1, the current density J_2 is equal to:
   a) 2J_1
   b) J_1
   c) J_1/2
   d) 4J_1
   e) J_1/4
5) In the circuit shown, at junction c the currents $I_1$ and $I_2$ are entering, while the current $I_3$ is leaving. Which of the following is correct?

a) $I_1 + I_2 + 2I_3 = 0$
b) $-I_1 + I_2 - I_3 = 0$
c) $-I_1 - I_2 + I_3 = 0$
d) $I_1 - I_2 - I_3 = 0$
e) $2I_1 + 3I_2 - I_3 = 0$

6) An ion is moving with $v_0 = 2 \times 10^6 \text{ m/s}$ enters a uniform magnetic field $B = 500 \text{ mT}$ directed into the page. If the ion is deflected as shown in the figure, then the ratio of its charge to mass (in C/kg) is:

a) $-6 \times 10^7$
b) $8 \times 10^7$
c) $-4 \times 10^7$
d) $4 \times 10^7$
e) $-8 \times 10^7$

7) A rectangular loop carrying a current $I$ is placed in a uniform magnetic field $B$ pointing into the page, as shown in the figure. If the loop is free to rotate about the axis shown, then the net force and torque on the current loop is:

a) $F = 0$, $\tau = 0$
b) $F = 0$, $\tau \neq 0$
c) $F \neq 0$, $\tau = 0$
d) $F \neq 0$, $\tau \neq 0$
e) None of the above

8) A long straight wire carries current $I = 10 \text{ A}$ pointing into the page at the origin. In addition to the magnetic field due to the wire, there is a uniform external magnetic field $B_0 = 2 \mu \text{T}$ directed along the positive y-axis as shown in the figure. The total magnetic field (in $\mu$T) at point $P$ is:

a) zero
b) 2
c) 4
d) 8
e) 16
9) An infinitely long hollow conductor has an inner radius \( a \) and an outer radius \( b \). The conductor carries current \( I \) uniformly distributed across a section of the shell as shown in the figure. The magnetic field at point \( P \) located in the hollow region is given by:

a) \( \frac{\mu_0 I}{2\pi b} \)

b) \( \frac{\mu_0 I}{2\pi a} \)

c) \( \frac{\mu_0 I}{2b} \)

d) \( \frac{\mu_0 I}{2a} \)

e) zero

10) A toroid has inner radius \( a = 9 \) cm and outer radius \( b = 11 \) cm as shown in the figure. If the toroid consists of 100 turns and carries current of 3 A, the magnetic field (in \( \mu T \)) at radius \( r = 10 \) cm from its center is:

a) 200

b) 400

c) 600

d) 800

e) zero
Answers for multiple choices (MCQ) of test two

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<tr>
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<tr>
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<td>E</td>
<td>C</td>
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PART B: Problems

• Each problem carries 25 marks.

Problem # 1:
Consider the circuit shown in the figure. The circuit is kept running for a very long time.

[15 Marks] (a) Find the currents $I_1$, $I_2$, and $I_3$.

\[ \sum I = 0 \iff I_1 = I_2 + I_3 \ldots \ldots (1) \]

Loop I : \[ \sum \varepsilon = \sum IR \Rightarrow 20 + 12 = 6I_1 + 4I_3 \Rightarrow 32 = 6I_1 + 4I_3 \ldots \ldots (2) \]

Loop II : \[ \sum \varepsilon = \sum IR \Rightarrow 10 - 12 = 3I_2 - 4I_3 \Rightarrow 2 = -3I_1 + 4I_3 \ldots \ldots (3) \]

Substitute Eqn (1) into (2):

32 = 6$I_2$ + 10$I_3$ \ldots \ldots (4)

Multiply Eqn(3) by 2 \Rightarrow 4 = -6$I_2$ + 8$I_3$ \ldots \ldots (5)

Add Eqn(5) and Eqn(4):

36 = 18$I_3$ \Rightarrow $I_3 = 2$ A

Substitute $I_3$ into Eqn(5) \Rightarrow $I_2 = 2$ A

Substitute $I_2$ and $I_3$ into Eqn(1) \Rightarrow $I_1 = 4$ A

[5 Marks] (b) Determine the voltage $V_{AB}$.

\[ V_{AB} = -10V - 20V + (6 \times 4)V = -6V \]

[5 Marks] (c) Calculate the final charge on the capacitor.

\[ \therefore C = \frac{Q}{V_{AB}} \therefore Q = CV_{AB} = (10 \times 10^{-6})(6) = 60\mu C \]
Problem # 2:
Three current-carrying conductors are arranged in the same plane as shown in the figure. A circular loop with radius $R = 10$ cm carries current $I_1 = 4$ A. The centre of the loop is a distance $D_1 = 2R$ and $D_2 = 3R$ above the two -very long- straight wires which are carrying equal but opposite currents $I_2 = I_3 = 10$ A.

[5 Marks] (a) What are the magnitude and direction of the magnetic field produced by current $I_1$ at point P?
\[
\therefore B = \frac{\mu_0 I_1}{2R}, \quad \therefore B_1 = \frac{(4\pi \times 10^{-7} \text{ Wb} / \text{A} \cdot \text{m})(4 \text{ A})}{2(0.1 \text{ m})} = 25.12 \mu T
\]
The field is directed out of the page.

[5 Marks] (b) What are the magnitude and direction of the magnetic field produced by currents $I_2$ at point P?
\[
\therefore B = \frac{\mu_0 I_2}{2\pi D_1},
\therefore B_2 = \frac{(4\pi \times 10^{-7} \text{ Wb} / \text{A} \cdot \text{m})(10 \text{ A})}{2(3.14)(0.2 \text{ m})} = 10 \mu T
\]
The field is directed out of the page.

[5 Marks] (c) What are the magnitude and direction of the magnetic field produced by current $I_3$ at point P?
\[ B = \frac{\mu I}{2\pi D^2} \]
\[ B_{tot} = B_{I_1} + B_{I_2} - B_{I_3} \]
\[ B_{tot} = (25.12 + 10 - 6.67) \mu T \]
\[ B_{tot} = 28.5 \mu T \]

The field is out of the page.

[5 Marks] (d) Determine the magnitude and direction of the net magnetic field at point P.

\[ \vec{F} = q\vec{v} \times \vec{B} \]
\[ \vec{F} = (-1.6 \times 10^{-19} \text{ C})(2 \times 10^6 \text{ m/s})(28.5 \times 10^{-6} \text{ T})(i \times k) \]
\[ \vec{F} = (-1.6 \times 10^{-19})(-57 \hat{j}) \]
\[ \vec{F} = 9.12 \times 10^{-19} \hat{j} \text{ N} \]

\[ \vec{F} = 9.12 \times 10^{-19} \text{ N along the positive y-axis.} \]