MNS Department
Final Examination
Spring Semester 2015
Course Title:Principles of Physics II
Course ID: PHY 112

Total Marks: 90
Times: 3 hours

Date: April 18, 2015

Instructions:

- **DO NOT** make any rough work on the question paper. Do it on the last page of your answer script.
- Answer the MCQ part in Section B, **on the question paper** and NOT on the answer script.
- **Write your name and ID** at the top of the page of MCQ part (*i.e.* on pages-4 to 6).
- You **must return the question paper** along with your answer script.

SECTION A: Problem Solving

Answer any five questions. Marks are as indicated:

1. Two point charges hung by massless $1.0\,m$ long threads repel each other after being equally charged as shown in Figure-1. Mass and charge of the each ball are $0.3\,gm$ and q Coulomb respectively.

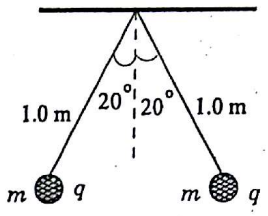

Figure 1

(a) (6 marks) Calculate the net electric force acting on each ball.
(b) (4 marks) Find the tension in each of the threads.
(c) (5 marks) Calculate the magnitude of the charge on each ball.

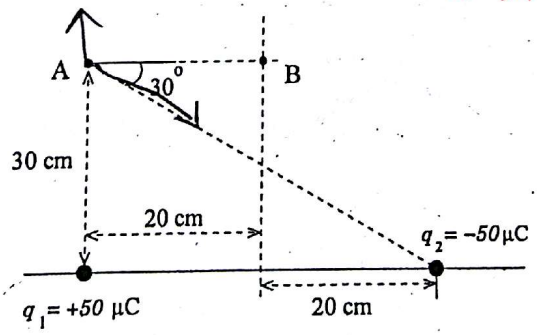

Figure 2

2. Two point charges q_1 and q_2 are held in two fixed location, separated by a distance $40\,cm$ as shown in Figure-2. One charge has a magnitude of $q_1 = +50\,\mu C$ and another has the magnitude $q_2 = -50\,\mu C$.

(a) (6 marks) Determine the net electric field at point A due to charges q_1 and q_2.
(b) (6 marks) Calculate the net electric potential at points A and B due to charges q_1 and q_2.
(c) (3 marks) How much work you have to do to move an electron from point A to B?

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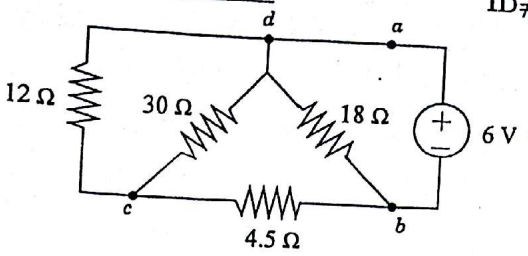

Figure 3

3. A 6 V dc voltage source is connected with a combination of four resistors as shown in Figure-3.
   (a) (5 marks) Calculate the equivalent resistance between the points a and b. 7.57 Ω
   (b) (6 marks) Calculate the current through 18 Ω and 12 Ω resistors. $I_{12} = I_{18} = 0.33$ A
   (c) (2 marks) What is the power dissipation in the 4.5 Ω resistor? 0.95 W
   (d) (2 marks) Calculate the value of $v_d - v_c$. 3.94 V

4. Two long straight wires are as oriented so that they are perpendicular to each other as shown in Figure-4. At their closest distance they are 20 cm apart. The top wire carries a current $I_t = 20.0$ A which is out of the page (direction of x) and the bottom wire caries $I_b = 5.0$ A towards the right.

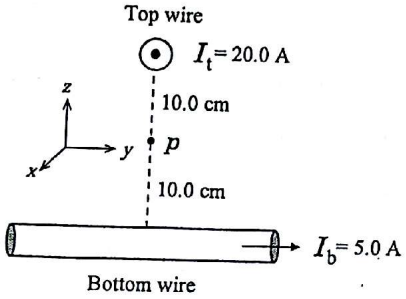

Figure 4

   (a) (7 marks) Calculate the net magnetic field at the point p in unit vector notation due to current in both the wires. $4\times10^{-5}\,\hat{j} + 1\times10^{-5}\,\hat{k}$
   (b) (6 marks) If an electron is moving with a velocity $\vec{v} = 453\,m/s\,\hat{j}$, find out the magnitude and direction of the magnetic force acting on the electron at point p. $-7.2\times10^{-22}\,\hat{i}$
   (c) (2 marks) At what acceleration does the electron move? You may use mass of the electron is $m_e = 9.1\times10^{-31}\,kg$. $-8\times10^{8}\,\hat{i}$

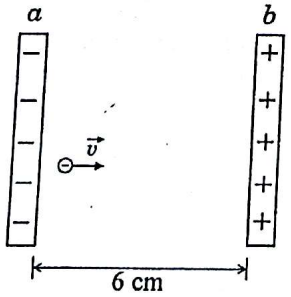

Figure 5

5. An electron is accelerating from rest through a potential difference, $v_{ba} = +50$V inside a capacitor as shown in Figure-5. The distance between the plate is 6.0 cm and the area of each plate is $6 \times 10^{-3}\,m^2$. Consider the mass of the electron is $m_e = 9.1 \times 10^{-31}\,kg$.
   (a) (3 marks) Calculate the electric field inside the capacitor. -833.33 (V/m) $\hat{i}$
   (b) (4 marks) Calculate the charge on each plate. 4.4×10^{-11} C
   (c) (4 marks) What is the speed of the electron just before it strikes the plate b? 4.2×10^{5} m/s.
   (d) (4 marks) How much time does the electron will take to move from plate a to plate b? 0.28 μs.

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6. (a) A freshly prepared sample of a certain radioactive isotope has an activity of 10.0 mCi. After 4.00 h, its activity is 8.0 mCi.

   i. (3 marks) Find the decay constant. $1.55 \times 10^{-5}\ s^{-1}$

   ii. (2 marks) Calculate the half-life. 12.42 hrs.

   iii. (2 marks) What is the sample's activity 30.0 h after it is prepared? 6.93×10^{7} Bq

   iv. (3 marks) How many atoms of the isotope were contained in the freshly prepared sample? 2.387×10^{13} atoms

   (b) (5 marks) Fill in the missing nucleus or particle:

   i. $^{45}_{20}\text{Ca} \longrightarrow\ ? + e^- + \bar{\nu}$ $^{45}_{21}Sc$

   ii. $^{46}_{24}\text{Cr} \longrightarrow\ ^{46}_{23}\text{V} + ? + \nu$ e^+

   iii. $^{58}_{29}\text{Cu} \longrightarrow\ ? + \gamma$ $^{58}_{29}Cu$

   iv. $^{293}_{93}\text{No} \longrightarrow\ ^{239}_{94}\text{Pu} + ? + \bar{\nu}$ e^-

   v. $^{234}_{94}\text{Pu} \longrightarrow\ ? + \alpha$ $^{230}_{92}U$

7. (a) (7 marks) Determine the wavelength and frequency of light emitted when a hydrogen atom makes a transition from $n = 6$ to $n = 2$ energy levels according to the Bohr model. 4.11×10^{-7} m, 7.3×10^{14} Hz

   (b) An astronaut on a spaceship travelling at $0.75\,c$ relative to the earth measures her ship to be 25.0 m long. On the ship she eats her lunch in 23.0 min.

   i. (4 marks) What is the length of spaceship according to the observer on earth? 16.54 m.

   ii. (4 marks) How long does the astronaut take to eat her lunch according to the observer on earth? 34.77 min

8. A flexible wire loop with a radius of 12.0 cm is in a magnetic field of magnitude $\vec{B} = 0.150$ T as shown in Figure-6. The loop is grasped at points a and c and stretched until its area is nearly zero. Consider the time interval $\Delta t = 0.200\,s$ to close the loop. The wire has a uniform resistance per unit length of $3.00\,\Omega/m$.

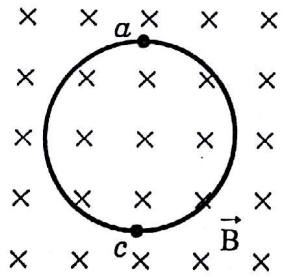

Figure 6

(a) (4 marks) Calculate the flux through the loop at $t = 0$ sec. $1.7 \times 10^{-3}\ Tm^2$

(b) (6 marks) What are the magnitude and direction of the average induced emf in the loop during this time interval? 8.48×10^{-3} V, clockwise.

(c) (5 marks) Calculate the magnitude and direction of the average induced current in the loop. 2.83 mA

Name: _____ ID#: _____

SECTION B. Multiple Choice Questions.

Answer any fifteen questions. Each question carries one mark: _____/

9. i. Figure-7 shows three points a, b and c in the vicinity of two point charges. The charges have equal magnitudes. Rank the potentials V_a to V_c in order from most positive to most negative :

A. $V_a > V_b > V_c$ B. $V_b > V_c > V_a$ C. $V_a > V_c > V_b$ D. $V_b < V_a < V_c$

i. _____

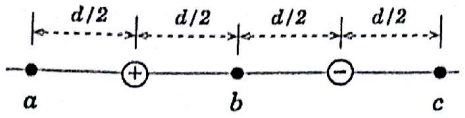

Figure 7

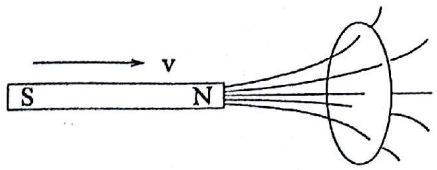

Figure 8

ii. A bar magnet is approaching to an isolated wire loop with a constant speed. The direction of approach is perpendicular to the plane of the loop as shown in Figure-8. The induced magnetic field in the wire loop is directed:

A. towards left B. towards right C. upwards D. downwards

ii. _____

iii. A parallel plate capacitor can store E amount of energy when it is connected to a 10 V battery. How much energy will it store if it is connected to a 20 V battery?

A. $\frac{E}{2}$ B. E C. $2E$ D. $4E$

iii. _____

iv. A positive charge +q enters a region of uniform magnetic field with a speed v at a point and exits the region at a different point as shown in Figure-9. What will be the speed of the particle at the exit point?

A. it will be more than v
B. it will be less than v
C. it will be exactly equal to v
D. none of these

iv. _____

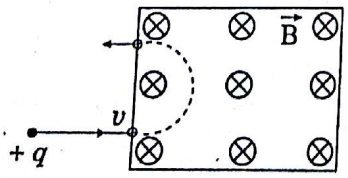

Figure 9

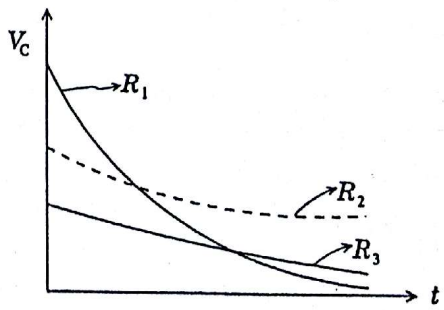

Figure 10

v. Figure-10 shows voltage as a function of time of a capacitor as it is discharged through the three different resistors R_1, R_2 and R_3. Rank the order of the values of the resistances R_1 to R_3 largest first:

A. $R_1 > R_2 > R_3$ B. $R_3 > R_2 > R_1$ C. $R_2 > R_3 > R_1$ D. $R_1 > R_3 > R_2$

v. _____

Name: _____ ID#: _____

vi. A straight thin conductor carries a current i and it splits equally into two identical semi-circular paths of radius R centered at C and them recombine as shown in Figure-11. At the centre C, the net magnetic field B_C is:

A. $B_C = 0$ B. $B_C = \frac{\mu_o i}{2R}$ C. $B_C > \frac{\mu_o i}{2R}$ D. $B_C < \frac{\mu_o i}{2R}$

vi. _____

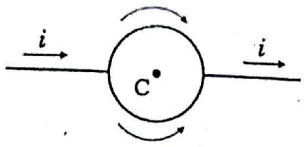

Figure 11

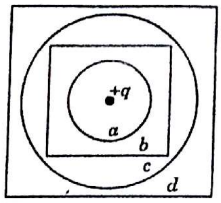

Figure 12

vii. Figure-12 shows, in cross section, two Gaussian spheres a and c and two Gaussian cubes b and d are that are centered on a positively charged particle $+q$. Rank the net flux through the four Gaussian surfaces, greatest first.:

A. d, c, b, a B. a, b, c, d C. d, b, c, a D. all surfaces have equal electric fluxes

vii. _____

viii. If a positive test charge q moves towards an increasing electric potential its velocity will:

A. increase B. decrease C. remain the same D. none of these

viii. _____

ix. The value of the line integral of $\vec{B}$ around the closed path as shown in Figure-13 is $1.38 \times 10^{-5}\, T \cdot m$. The direction and magnitude of I_3 are:

A. 12 A $\odot$ B. 1.02A $\otimes$ C. 15.01A $\odot$ D. 12 A $\otimes$

ix. _____

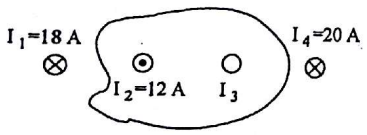

Figure 13

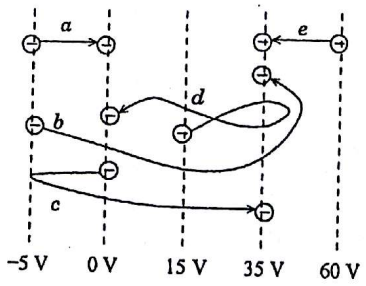

Figure 14

x. Figure-14 shows a series of equipotential surfaces in a particular region of space and five different paths a, b, c, d and e along which an electron moves. Rank the path according to the amount of work done on the electron by the electric field, largest first:

A. $b = c > e > d > a$ B. $b > c > a > d > e$ C. $b > c > d > e = a$ D. $b > c > e > d > a$

x. _____

xi. An electron is moving towards you and it enters a magnetic field that is uniform and directed towards right of you. Due to this magnetic field, the electron experiences a force and deflects:

A. upwards B. downwards C. towards left D. towards right

xi. _____

Name: _____ ID#: _____

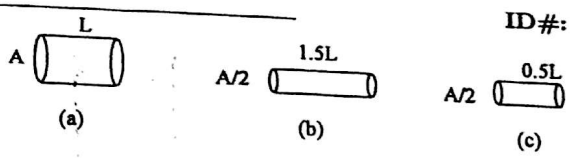

Figure 15

xii. Figure-15 shows three cylindrical copper conductors along with their face areas and lengths. A potential difference V is applied across each of their lengths. Rank them according to their current densities, greatest first:

A. $J_a > J_b > J_c$ **B.** $J_b = J_c > J_a$ **C.** $J_a = J_c > J_b$ **D.** $J_c > J_a > J_b$

xii. _____

xiii. Figure-16 shows four arrangements in which long parallel wires carry equal currents directly into or out of the page at the corners of identical squares. In which Figure-16{(i)-(iv)}, the net magnetic field at the centre of the square is greatest?

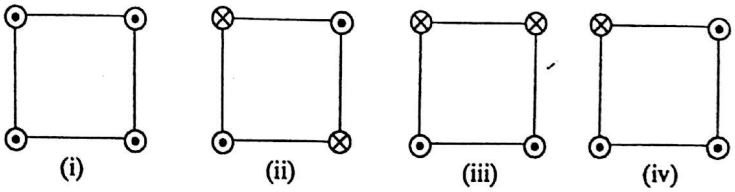

Figure 16

A. Figure-(i) **B.** Figure-(ii) **C.** Figure-(iii) **D.** Figure-(iv)

xiii. _____

xiv. Which of the following decay processes changes the atomic number?

A. beta emission **B.** electron capture **C.** alpha emission **D.** all of these

xiv. _____

xv. Figure-17 gives the electric potential V as a function of x. Rank the five regions according to the magnitudes of the x component of the electric field within them, greatest first:

A. $2 > 4 > 1 = 3 = 5$ **B.** $2 > 4 > 3 > 1 > 5$ **C.** $3 > 2 > 1 > 4 > 5$ **D.** $2 = 4 > 1 = 3 = 5$

xv. _____

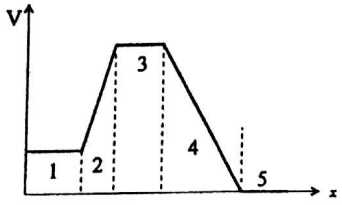

Figure 17

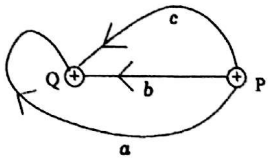

Figure 18

xvi. In which regions shown in Figure-17, the electric field is positive?

A. all regions **B.** only 1 and 3 **C.** only 1, 4 and 5 **D.** only 4

xvi. _____

xvii. In Figure-18, the work done by the electric field due to Q is:

A. zero **B.** positive **C.** negative **D.** need more information

xvii. _____