BRAC UNIVERSITY

Department of MNS
Fall Semester 2014
Final Examination
Course No: PHY 112
Course Title: Principles of Physics - II

CHD

Time: 3 hours
Total Marks: 90

Date: 20 December 2014

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 Part II, on the answer script.
- You must return the question paper along with your answer script.

Part I: Analytic Questions

Answer any five questions:

1. In Fig. 1, the four particles form a square of length a = 5.00 cm and have charges $q_1 = +10.0$ nC, $q_2 = -20.0$ nC, $q_3 = +20.0$ nC, and $q_4 = -10.0$ nC.

$(1.02 \times 10^5\ N/C)\hat{j}$

(a) In unit-vector notation, what net electric field do the particles produce at the square's center? (12)

(b) Calculate the force on a particle of 3.0 nC charge if placed at the square's center. (4)

3.11×10^{-4} N

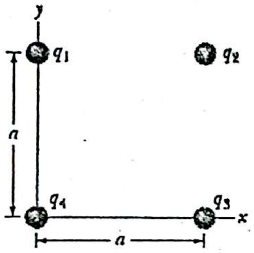

Fig. 1

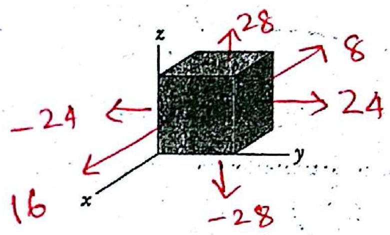

Fig. 2

2. Fig. 2 shows a closed Gaussian surface in the shape of a cube of edge length 2.00 m. It lies in a region where the nonuniform electric field is given by $\vec{E} = (3x + 4)\hat{i} + 6\hat{j} + 7$ N/C, with x in meters.

(a) Find the electric flux through each of the six cube faces. (12)

(a) Find the total electric charge inside the cube. (4)

$\Phi_{net} = 24\ Nm^2/C$ $\therefore q_{enc} = 2.13 \times 10^{-10}$ C

3. The plates of a parallel-plate capacitor in vacuum are 1.0 mm apart and 40 cm^2 in area. A 600 V potential difference is applied across the capacitor.

(a) Compute the capacitance of the parallel-plate capacitor. 35 pF (4)

(b) Find the charge on each plate. 21 nC (4)

(c) Calculate the stored energy in the capacitor. 6.3×10^{-6} J (4)

(d) What are the magnitude and direction of the electric field between the plates? (4)

6×10^5 V/m

4. (a) Find the equivalent resistance between points A and B in of Fig. 3. $4.6\,\Omega$ (6)

(b) Find the current in the 5.00 Ω resistor in Fig. 4. $I_1 = 0.15\,A$ (10)

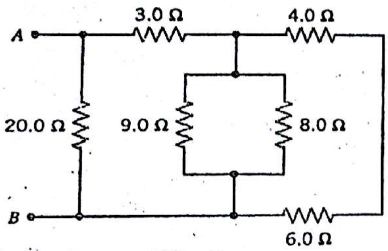

Fig. 3

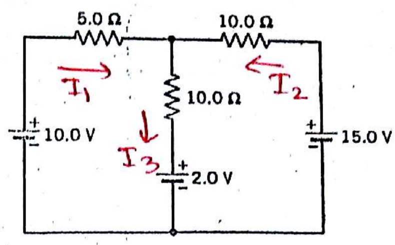

Fig. 4

5. (a) A proton travels with a speed of 3.00×10^6 m/s at an angle of 37.0° with the direction of a magnetic field of 0.300 T in the +y direction. What are the magnitude of (*i*) the magnetic force on the proton and (*ii*) its acceleration? (The mass of the proton is 1.673×10^{-27} kg) 8.67×10^{-14} N 5.19×10^{13} m/s² (8)

(b) A wire carries a current of 2.40 A. A straight section of the wire is 0.750 m long and lies along the x-axis within a uniform magnetic field, $\vec{B} = 1.6\hat{k}$ T. What are the magnitude and direction of magnetic force on the section of wire, if the current is in the (*i*) + x direction (*ii*) - x direction? (8)

$(-2.88\,\hat{j})$ N

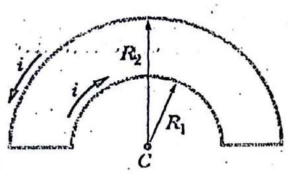

Fig. 5

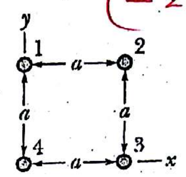

Fig. 6

6. (a) In Fig. 5, two semicircular arcs have radii $R_2 = 7.80$ cm and $R_1 = 3.15$ cm, carry current $i = 0.281$ A, and share the same center of curvature C. What are the magnitude and direction (into or out of the page) of the net magnetic field at C? $B = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 1.67\times10^{-6}\,T$ (8)

(b) In Fig. 6, four long straight wires are perpendicular to the page, and their cross sections form a square of length a = 20 cm. The currents are out of the page in wires 1 and 4 and into the page in wires 2 and 3, and each wire carries 20 A. In unit-vector notation, what is the net magnetic field at the square's center? (8)

8×10^{-5} T

7. (a) Determine the frequency and wavelength of the photon emitted when an electron drops

(*i*) from E_3 to E_2 in an excited hydrogen atom. 4.56×10^{14} Hz, 6.58×10^{-7} m (3)

(*ii*) from E_4 to E_3 in an excited hydrogen atom. 1.6×10^{14} Hz, 1.875×10^{-6} m. (3)

(b) A spacecraft is moving with respect to the earth. A searchlight in the spacecraft is on for 12 ms. A person on earth measures that the searchlight is on for 0.190 s.

(*i*) How fast is the spacecraft moving relative to the earth? 299.4×10^6 m/s. (6)

(*ii*) Find the length of a meter stick which is in the spacecraft observed by a person on earth. (4)

6.3 cm.

8. The half-life of the radioactive nucleus $^{57}_{27}Co$ is 272 days.

(a) What is the decay constant and mean life of $^{57}_{27}Co$? $\lambda = 2.95\times10^{-8}\,s^{-1}$, $T_{mean} = 392$ days (3)

(b) If the sample contains 2.51×10^{12} such nuclei at t = 0, determine its activity (decay rate) at this time. (3)

$7.4\times10^{4}\,s^{-1}$

(c) What is the decay rate after the sample is 2 years old? 1.2×10^4

(d) How many undecayed nuclei will remain after 3 years? 1.615×10^{11} (3)

(e) Complete the following decay processes by stating what the symbol X represents. (3)

(4)

(*i*) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + X$ ^4_2He

(*ii*) $^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + X$ $^{0}_{-1}e$

(*iii*) $^{64}_{29}Cu \rightarrow {}^{64}_{28}Ni + X$ $^{0}_{+1}e$

(*iv*) $^{87}_{38}Sr^* \rightarrow {}^{87}_{38}Sr + X$ γ

Part II: Multiple Choice Questions

Answer any ten questions: (1 mark each)

9. (*i*) Four point charges, each of the same magnitude, with varying signs are arranged at the corners of a square as shown in Fig. 7. Which of the arrows labeled **A, B, C,** and **D** gives the correct direction of the net force that acts on the charge at the upper right corner?

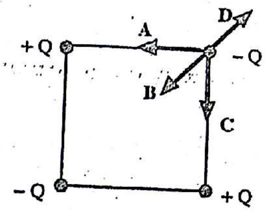

Fig. 7

A) **A** B) **B** C) **C** D) **D**

(*ii*) A positive point charge q_1 creates an electric field of magnitude E_1 at a spot located at a distance r_1 from the charge. The charge is replaced by another positive point charge q_2, which creates a field of magnitude $E_2 = E_1$ at a distance of $r_2 = 2r_1$. How is q_2 related to q_1?

A) $q_2 = 2q_1$ B) $q_2 = \frac{1}{2} q_1$ C) $q_2 = 4q_1$ D) $q_2 = \frac{1}{4} q_1$

(*iii*) Which one of the following statements best explains why it is possible to define an *electrostatic potential* in a region of space that contains an *electrostatic field*?

A) Work must be done to bring two positive charges closer together.
B) The work required to bring two charges together is independent of the path taken.
C) Like charges repel one another and unlike charges attract one another.
D) A positive charge will gain kinetic energy as it approaches a negative charge.

(*iv*) Which one of the following statements concerning capacitors of *unequal capacitance* connected in series is true?

A) Each capacitor holds a different amount of charge.
B) The equivalent capacitance of the circuit is the sum of the individual capacitances.
C) The total voltage supplied by the battery is the sum of the voltages across each capacitor.
D) The total voltage supplied by the battery is equal to the average voltage across all the capacitors.

(*v*) You have three resistors, each of which has a resistance R. By connecting all three together in various ways, which one of the following resistance values you *cannot* obtain?

A) $3R$ B) 3/2 R C) R D) 1/3R

(*vi*) A proton traveling due west in a region that contains only a magnetic field experiences a vertically *upward force* (away from the surface of the earth). What is the direction of the magnetic field?

A) east B) west C) north D) south

(*vii*) A long, straight wire is carrying a current in the direction shown in the Fig. 8. What is the direction of the magnetic field at point P due to the current in the wire?

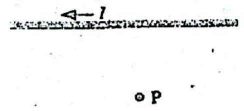

Fig. 8

A) to the right of page
B) to the left of the page
C) into the plane of the page
D) out of the plane of the page

1 B

(*viii*) A magnetic field has the same direction and the same magnitude B everywhere. A circular area A is bounded by a loop of wire. Which of the following statements is true concerning the magnitude of the magnetic flux that passes through this area?

2 C
3 B

A) It is zero. B) It is BA. C) Its maximum possible value is BA.
D) Its minimum possible value is BA.

4 C
5 C

(*ix*) Fig. 9 shows four circular amperian loops (a, b, c, d) in a cross section of four long circular conductors. The currents in the conductors are, from smallest radius to largest radius, 4 *A* out of the page, 9 *A* into the page, 5 *A* out of the page, and 3 *A* into the page. Rank the amperian loops according to the magnitude of $\oint \vec{B} \cdot \vec{dl}$ around each, largest first:

6 D
7 D
8 C

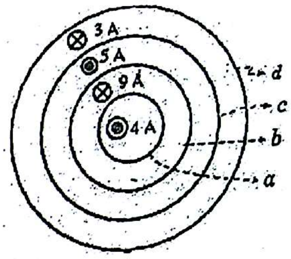

Fig. 9

A) a, b, c, d B) b, a, d, c C) c, b, d, a D) none of these

9 B

(*x*) Which one of the following statements is the assumption that Niels Bohr made about the angular momentum of the electron in the hydrogen atom?

10 B

A) The angular momentum of the electron is zero.
B) The angular momentum can have only certain discrete values.
C) Angular momentum is not quantized.
D) The angular momentum is independent of the mass of the electron.

11 C

(*xi*) Which of the following quantities will two observers always measure to be the same, regardless of the relative velocity between the observers?

12 A

A) The time interval between two events B) The length of an object
C) The speed of light in vacuum D) The relative speed between the observers

13 C

(*xii*) Which one of the following statements is a consequence of special theory of relativity?

A) Clocks that are moving run slower than when they are at rest.
B) The length of a moving object is larger than it was at rest.
C) Events occur at the same coordinates for observers in all inertial reference frames.
D) Events occur at the same time for observers in all inertial reference frames.

(*xiii*) Which one of the following types of nuclear radiation is not affected by a magnetic field?

A) α particles B) β^- rays C) γ rays D) β^+ rays