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

Time: 3 hour
Total Marks: 90

Date: 21 August 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. Two point charges $q_1 = +2.40$ nC and $q_2 = -6.50$ nC are placed 0.10 m apart in air. Point A is midway between them; point B is 0.08 m from q_1 and 0.06 m from q_2 (Fig. 1).

(a) Find the electric field (magnitude and direction) at point A. (4)

(b) Find the potential at point A and B. (5)

(b) Calculate the force on a charge of 2.50 nC located at point A. (3)

(d) Find the work done by the electric field on a charge of 2.50 nC that travels from point B to point A. (4)

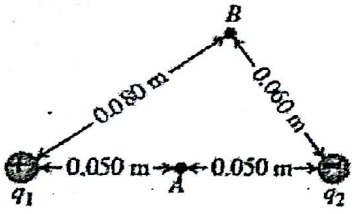

Fig. 1

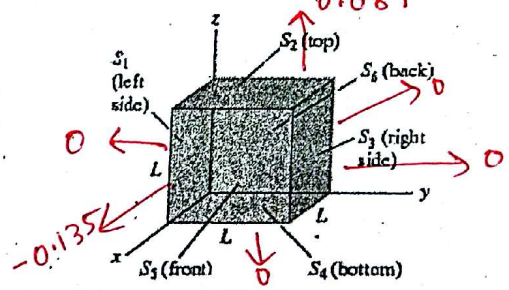

Fig. 2

2. A cube has sides of length $L = 0.300$ m. It is placed with one corner at the origin as shown in Fig. 2. The electric field is not uniform but is given by $\vec{E} = (-5.00x\hat{i} + 3.00z\hat{k})\text{N/C} \cdot \text{m}$.

(a) Find the electric flux through each of the six cube faces S_1, S_2, S_3, S_4, S_5, and S_6. (12)

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

3. The plates of a parallel-plate capacitor in vacuum are 5.00 mm apart and 2.00 m^2 in area. A10.0-kV potential difference is applied across the capacitor.

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

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

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

(d) If a point charge of mass 2×10^{-6} kg and charge 1.6×10^{-9} C is placed in between the plates and released, what would be its acceleration (magnitude and direction) just after being released? (4)

4. (a) Find the equivalent resistance between points A and B in of Fig. 3. 4.66 Ω, (6)

(b) Find the current in the 4.00 Ω resistor in Fig. 4. (10)

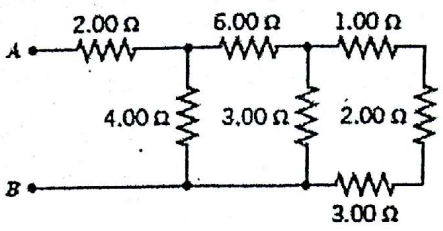

Fig. 3

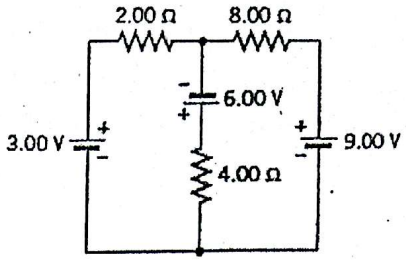

Fig. 4

5. (a) A proton travels through uniform magnetic and electric fields. The magnetic field is $\vec{B} = -2.50\hat{\imath}$ mT. At one instant the velocity of the proton is $\vec{v} = 2000\hat{\jmath}$ m/s. At that instant and in unit-vector notation, what is the net force acting on the proton if the electric field is (*i*) $4.0\hat{k}$ V/m and (*ii*) $4.0\hat{\imath}$ V/m ? (i) $1.44\times10^{-18}\,\hat{k}$ (ii) $8\times10^{-19}\,\hat{k} + 6.4\times10^{-19}\,\hat{\imath}$ (8)

(b) A 13.0 g wire of length $L = 62.0$ cm is suspended by a pair of flexible leads in a uniform magnetic field of magnitude 0.440 T (Fig. 5). What are the magnitude and direction (left or right) of the current required to remove the tension in the supporting leads? 0.467 Amp. (8)

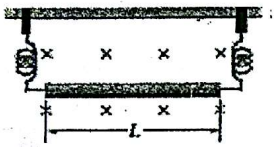

Fig. 5

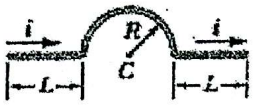

Fig. 6

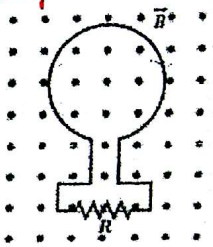

Fig. 7

6. (a) In Fig. 6, a wire forms a semicircle of radius R = 9.26 cm and two straight segments each of length L = 13.1 cm. The wire carries a current i = 34.8 mA. What are the magnitude and direction (into or out of the page) of the net magnetic field at the semicircle's center C? (8)

(b) In Fig. 7, the magnetic flux through the loop increases according to relation $\Phi_B = 6.0t^2 + 7.0t$, where Φ_B is in milliwebers and t is in seconds. (8)

(*i*) What is the magnitude of the emf induced in the loop when t = 2.0 s?

(*ii*) Is the direction of the current through R to the right or left?

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. 4.6×10^{14} Hz, 6.52×10^{-7} m (3)

(*ii*) from E_4 to E_3 in an excited hydrogen atom. 1.6×10^{14} Hz, 1.88×10^{-6} m. (3)

(b) (*i*) A spacecraft is moving with respect to the earth. A flashing light on the spacecraft generate a flash every 1.5 s. A person on earth measures that the time between flashes is 2.5 s. How fast is the spacecraft moving relative to the earth? 2.4×10^{8} m/s. (6)

(*ii*) What is the apparent length of a meter stick which is in the spacecraft to a person on earth? (4) 0.6 m.

8. The half-life of the radioactive nucleus $^{226}_{88}Ra$ is 1.6×10^3 years.

(a) What is the decay constant of $^{226}_{88}Ra$? (3)

(b) If a sample contains 3.0×10^{16} such nuclei at t = 0, determine its activity at this time. (3)

(c) What is the decay rate after the sample is 2.0×10^3 years old? (3)

(d) How many undecayed nuclei will remain after 3.0×10^3 years? (3)

(e) Complete the following decay processes by stating what the symbol X represents. (4)

(*i*) $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + X$

(*ii*) $^{14}_{6}C \rightarrow {}^{14}_{7}N + X$

(*iii*) $^{30}_{15}P \rightarrow {}^{30}_{14}Si + X$

(*iv*) $^{231}_{90}Th^* \rightarrow {}^{231}_{90}Th + X$

Part II: Multiple Choice Questions

Answer any ten questions (1 mark each)

9. (*i*) Two positive point charges Q and $2Q$ are separated by a distance R. If the charge Q experiences a force of magnitude F when the separation is R, what is the magnitude of the force on the charge $2Q$ when the separation is $2R$?

A) $F/4$ B) $F/2$ C) $2F$ D) $4F$

(*ii*) Which one of the following statements is true concerning the magnitude of the electric field at a point in space?

A) It is a measure of the total charge on the object.
B) It is a measure of the electric force on any charged object.
C) It is a measure of the electric force per unit mass on a test charge.
D) It is a measure of the electric force per unit charge on a test charge.

(*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*) An electron moves perpendicular to a magnetic field as shown in Fig. 8. What is the direction of $\vec{B}$?

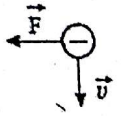

Fig. 8

A) Into the page B) Out of the page C) To the left D) To the right

(*v*) Fig. 9 shows four situations in which two very long wires are carrying the same current, although the directions of the currents may be different. The point P in the drawings is equidistant from each wire. Which one (or more) of these situations gives rise to a zero net magnetic field at P?

A) 2 and 4 B) Only 1
C) Only 2 D) 2 and 3

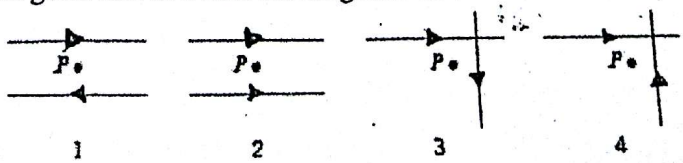

Fig. 9

(*vi*) A circular loop of wire is stationary in a uniform constant magnetic field $\vec{B}$ directed out of the page, as shown in Fig. 10. The current in the loop is:

A) clockwise
B) counter-clockwise
C) no current
D) none of these

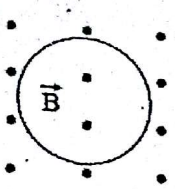

Fig. 10

(*vii*) Fig. 11 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:

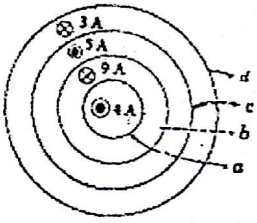

Fig. 11

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

(*viii*) Each atom in the periodic table has a unique set of spectral lines. Which one of the following statements is the best explanation for this observation?

A) Each atom has a dense central nucleus.
B) Electrons in atoms orbit the nucleus.
C) Each atom has a unique set of energy levels that electrons can move between.
D) Electrons in atoms are in constant motion.

(*ix*) 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

(*x*) Which one or more of the three decay processes (α, β^-, or γ) result in a new element?

A) α and β^- B) only α C) only β^- D) β^- and γ

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

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

(*xii*) Which one of the following statements concerning the *proper length* of a meter stick is true?

A) The proper length is always one meter.
B) The proper length depends upon the speed of the observer.
C) The proper length depends upon the acceleration of the observer.
D) The proper length is the length measured by an observer who is moving with respect to the meter stick.