B Sc Eng. CSE/1st Semester

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF NATURAL SCIENCES (NSc)

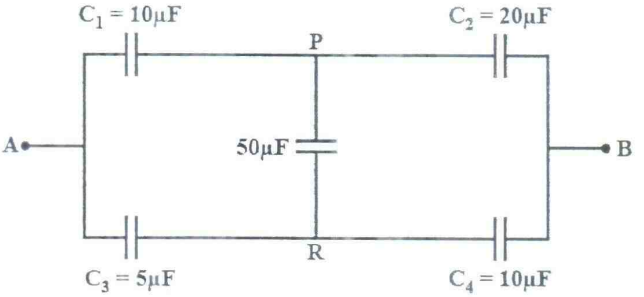
Semester Final Examination | **Winter Semester: 2023-2024**
Course Number: PHY 4141 | **Full Marks: 120**
Course Title: Physics I | **Time: 2 Hours**

Answer all **4 (Four)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses

1. (a) Define equipotential surface. Describe the characteristics of equipotential surfaces. (2 + 4) (CO1) (PO1)

(b) Capacitor can be of any shape, although the capacitance will be different for different geometries. A spherical capacitor consisting of two concentric, conducting spheres of radius a (inner sphere) and b (outer radius). We envision that we apply a voltage V to the inner conductor, as a result of which the inner conductor becomes charged with total charge q, and the outer conductor becomes charged with total charge $-q$. (i) Find an expression for the capacitance of the spherical capacitor. Then if we have a spherical capacitor (nested spheres) where the inner sphere has a radius of 2 cm and the outer sphere has a radius of 4 cm. (ii) Find the capacitance and the charge stored by this capacitor when 10 V is applied? (12 + 3 + 3) (CO2) (PO2)

(c) Calculate the equivalent capacitance between the points A and B in the circuit below. If a battery of 10 V is connected across A and B, calculate the charge drawn from the battery by the circuit. (3 + 3) (CO3) (PO2)



2. (a) Biot-Savart law is one of the major physical laws that govern the behavior of magnetic field due to a moving charge. State Biot-Savart's law and explain briefly with the aid of a sketch. (5) (CO1) (PO1)

(b) A circular loop with radius a carrying current I. (i) Find the magnitude of the magnetic field at a point along the axis of the coil and at a distance x from the center of the loop using Biot-Savart Law. (12 + 3 + 4) (CO2) (PO2)

(ii) Find the magnetic field at the center of a circular loop.

(iii) Along the axis, at what distance from the center of the coil is the field magnitude $\frac{1}{8}$ as great as it is at the center?

(c) In the Bohr model of the hydrogen atom the electron circulates around the nucleus in a path of radius 5.1×10^{-11} meter at a frequency of 6.8×10^{18} rev/sec. (3 + 3) (CO3)

(i) Find the value of B which will set up at the center of the orbit?

(ii) Find the equivalent magnetic dipole moment?

3. (a) Define interference of light? Describe the fundamental conditions for light waves to interfere. (3 + 3) (CO1) (PO1)

(b) (i) Two light waves with amplitudes A_1 and A_2 interfere with a phase difference ϕ, estimate that the intensity at any point in the interference pattern can be expressed as $I = I_1 + I_2 + 2\sqrt{I_1 I_2}cos\phi$, where the I_1 and I_2 are the intensities of the two sources and ϕ is the phase difference. (12 + 3+ 3) (CO2) (PO2)

(ii) Find the resultant intensity if the amplitudes are nearly equal?

(iii) Explain, what is fringe visibility and relate that is expressed by, $V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$.

(c) In Young's double slit experiment, the positions of the dark and bright fringes depend on the separation between the slits (d), the distance from the slits to the screen (D), and the wavelength (λ). (3 + 3) (CO3) (PO2)

(i) Sketch the experiment labelling D, d and y.

(ii) How far do the slits need to be from the screen for the first dark fringe to be at $y = 1.7\ cm$ if the slits are $0.023\ mm$ apart and the wavelength is $560\ nm$? (iii) Using the same slits and the distance found in part (ii), Solve for the position of 4th bright fringe in case of $640\ nm$ light source.

4. (a) Explain briefly the diffraction of light. Describe what do you understand by Fresnel and Fraunhofer diffraction of light. (3 + 3) (CO1) (PO1)

(b) (i) Show that the intensity pattern for the diffraction of light with a wavelength λ through a single slit of width a can be expressed as $I = I_0 \frac{sin^2\beta}{\beta^2}$, where $\beta = \frac{\pi a sin\theta}{\lambda}$ and θ is the angle of the light rays from the slit to a point on a distant screen. (10 + 2) (CO2) (PO1)

(ii) For light of wavelength 480 nm falling on a slit of width 3.5 μm, find the value of β when $\theta = 19^0$.

(c) In the single-slit diffraction experiment of the figure, let the wavelength of the light be $516\ nm$, the slit width be $6.24\ \mu m$, and the viewing screen be at a distance $D = 3.30$ meter. Let a y axis extend upward along the viewing screen, with its origin at the center of the diffraction pattern. Also let I_P represent the intensity of the diffracted light at point P at $y = 16.8\ cm$. (i) How would be the ratio of I_P to the intensity I_m at the center of the pattern? (ii) Determine where point P is in the diffraction pattern by giving the orders of nearest maximum (0 is the central maximum) and minimum between which it lies. (4 + 4 + 4) (CO3) (PO2)