

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(END SEMESTER EXAMINATION)**

CLASS: BTECH/IMSC  
BRANCH: BT/CIVIL/CHEMICAL/MECH/PIE/FT/PHYSICS

SEMESTER : I  
SESSION : MO/2025

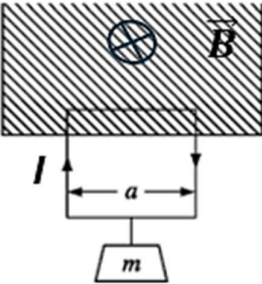
SUBJECT: PH24101 PHYSICS

TIME: 3 Hours

FULL MARKS: 50

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
  2. Attempt all questions.
  3. The missing data, if any, may be assumed suitably.
  4. Before attempting the question paper, be sure that you have got the correct question paper.
  5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.
- Useful Info.: Electron mass =  $9.11 \times 10^{-31}$  Kg, Speed of light ( $c$ ) =  $3 \times 10^8$  m/s,  $1 \text{ eV} = 1.6 \times 10^{-19}$  J, Planck's constant ( $h$ ) =  $6.63 \times 10^{-34}$  Js,  $\mu_0 = 4\pi \times 10^{-7}$  Hm $^{-1}$ ,  $\epsilon_0 = 8.85 \times 10^{-12}$  Fm $^{-1}$

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|---|-----|----|-------|
| Q.1(a) Draw the schematic of Newton's rings setup. Use it to derive the expressions for the radius of the $m^{\text{th}}$ order dark and bright rings respectively.   | [5] | 1  | 1,2   |
| Q.1(b) What is the difference between interference and diffraction ?<br>A uniform thin film of thickness $t = 4 \times 10^{-5}$ cm and refractive index $\mu = 1.5$ is illuminated normally by white light. Of what color will the thin film appear in reflected light ?  | [5] | 1  | 1,3   |
| Q.2(a) Define Ampere's law.<br>A rectangular loop of wire supporting a mass $m$ , hangs vertically with one end in a uniform magnetic field $B$ , which points into the page (See Fig. below). For what current $I$ in the loop, would the upward magnetic force exactly balance the gravitational force downward ?   | [5] | 2  | 1,3   |
|    |     |    |       |
| Q.2(b) Write down Maxwell's equations in free space and name each one of them.<br>Apply Gauss law to calculate the electric field vector ( $\vec{E}$ ) at point P which is at a distance Z above an infinite line charge of linear charge density $\lambda$ .   | [5] | 2  | 1,3   |
| Q.3(a) Define relativistic momentum. Write down the formula for relativistic kinetic energy. Derive the relativistic energy-momentum relationship.  | [5] | 3  | 1,1,2 |
| Q.3(b) Using special theory of relativity, show that a particle of zero rest mass must always travel at the speed of light.<br><br>A cosmic ray particle has a lifetime of $10^{-7}$ s when it is at rest, how far does it travel (in the earth frame) before decaying, if its speed is $0.99c$ when it is created ?  | [5] | 3  | 2,3   |
| Q.4(a) Write down the Schrodinger equation for a particle in a 1-dimensional infinite potential box of length L:<br>$V(x) = 0, \text{ if } 0 < x < L$ $V(x) = \infty, \text{ if } x \leq 0 \text{ or } x \geq L$ Solve it to obtain the normalized wave function and energy eigenvalue for the $n^{\text{th}}$ energy level.<br>Use these expressions to calculate the ground state energy of an electron (in eV) confined to a 1-Dimensional infinite potential box 0.1 nm wide. | [5] | 4  | 1,2,3 |

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Q.4(b) Derive the expression for the shift in wavelength of a photon scattered from an electron (at rest) in Compton scattering. [5] 4 2,3

X-rays of wavelength 10 pico-meter are Compton scattered through a target, calculate the maximum kinetic energy (in eV) of the recoil electrons.

Q.5(a) What is the difference between spontaneous and stimulated emission? [5] 5 1,2

Derive the relationship between Einstein's A and B coefficients.

Q.5(b) Define Nuclear Binding energy of an atomic nucleus. Draw the Binding energy per nucleon vs mass number curve with suitable labels. [5] 5 1,2,3

The binding energy per nucleon for  $^{12}\text{C}$  is 7.68 MeV and that for  $^{13}\text{C}$  is 7.5 MeV. Determine the energy required to remove a neutron from  $^{13}\text{C}$ .

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