No. of Printed Pages : 8

MPH-013/MPH-014

M. SC. (PHYSICS) (MSCPH)
Term-End Examination
December, 2025

PART- A : MPH-013 : OPTICS

AND

PART- B : MPH-014 : COMPUTATIONAL PHYSICS

Time : 3 Hours *Maximum Marks : 50*

Instructions :

1. *Students registered for both MPH–013 and MPH–014 courses should answer both the question papers in two separate answer books entering their enrolment number, course code and course title clearly on both the answer books.*
2. *Students who have registered for any of the MPH–013 or MPH–014 should answer the relevant question paper after entering their enrolment number, course code and course title on the answer book.*

PART— A

MPH-013 : OPTICS

Time : $1\frac{1}{2}$ *Hours* *Maximum Marks 25*

Note : *All questions are compulsory. However, internal choices are given. Marks are indicated against each question. Symbols have their usual meanings. You can use a calculator.*

1. Answer any *three* parts : 3×5=15

   (a) The electric and magnetic field vectors associated with a plane electromagnetic wave propagating in $\vec{k}$ direction are given as :

$$\vec{E} = \vec{E}_0 e^{i(\vec{k}.\vec{r}-\omega t)}$$

$$\vec{H} = \vec{H}_0 e^{i(\vec{k}.\vec{r}-\omega t)}$$

   Show that the above fields will satisfy Maxwell's curl equations only when the field vectors $\vec{E}$, $\vec{H}$ and the propagation vector $\vec{k}$ are at right angle to each other. 5

(b) Determine the normalised Jones vector for a Left Circularly Polarised (LCP) light propagating in the z-direction. 5

(c) Consider a plane wave incident normally on a long narrow slit of width 0.6 mm and the wavelength of light is 500 nm. A screen is placed at a distance of 50 cm from the slit. Calculate the separation between second minima on either side of the central maxima. 5

(d) A laser radiation of 6000 Å is sustained in a cavity in which mirrors are separated by 40 cm distance. Estimate the (i) number of modes, m and (ii) mode separation for the cavity. 3+2

(e) Differentiate between material dispersion and waveguide dispersion in an optical fibre. Explain how Dispersion Compensating Fibre (DCF) overcome dispersion in optical communication line. 2+3

2. Answer any *one* part : 1×10=10

(a) Describe the working of Michelson's interferometer with the help of an appropriate diagram. Why do we use the compensating plate in it ? Discuss the conditions for obtaining circular and straight fringes. 4+1+3+2

(b) What do you understand by a planar waveguide ? Write the expressions for electric and magnetic fields associated with light propagating in the planar waveguide along the z-direction. Derive the set of equations relating various components of electric and magnetic fields in the waveguide for Transverse Electric (TE) and Transverse Magnetic (TM) modes. 2+2+6

PART- B

MPH-014 : COMPUTATIONAL PHYSICS

Time : $1\frac{1}{2}$ Hours *Maximum Marks : 25*

Note : *Answer all questions. Symbols have their usual meanings. You may use a calculator.*

1. Answer any *three* parts : 3×5=15

   (a) Define approximate error and relative approximate error. The value obtained for an integral using the multiple segment Trapezoidal rule for different number of segments is given by :

Number of Segments (*n*)	**Approximate value**
2	1126
4	1113
8	1107

   Calculate the absolute relative approximate error in percentage for $n = 4$ and $n = 8$.

(b) Use the Newton-Raphson method with an initial guess $x_0 = 1$ to calculate the root of the polynomial $x^2 - 2 = 0$ upto two iterations. Calculate the relative true error for your answer.

(c) How is the Simpson's 1/3 rule of integration different from the Trapezoidal rule of integration ? Calculate the integral $\int_0^{\pi/2} \sin x \, dx$ using the Simpson's 1/3 rule.

(d) Write the backward difference approximation for the derivative of function $f(x)$. What is error in the approximate value ? Given that the velocity of a rocket is given by :

$$v(t) = 2000 \ln\left[\frac{12 \times 10^4}{12 \times 10^4 - 2000\, t}\right] - 10\, t \text{ ms}^{-1}$$

Calculate the acceleration at t = 16 s using the backward difference method, using a step size of 2 s.

(e) Explain what are pseudo random numbers. How does one approximate the value of the integral $\int_a^b f(x)dx$ in the Monte-Carlo method of integration ? Explain important sampling in the context of Monte-Carlo integration.

2. Answer any *one* part : 1×10=10

(a) How does one overcome the problem of division by zero in the Naïve-Gauss elimination method ? Transform the matrix :

$$\begin{bmatrix} 1 & -2 & 4 \\ -3 & 6 & -11 \\ 4 & 3 & 5 \end{bmatrix}$$

into an upper triangular form using the Gauss elimination method. Calculate the determinant of the matrix so obtained. Comment on your result with respect to the determinant of the original matrix.

(b) What kind of differential equations can be solved using the Runge-Kutta second order method ? Derive the 2nd order Runge-Kutta's formula for the approximate solution of the ODE :

$$\frac{dy}{dx} + y = e^{-x}; \quad y(0) = 2$$

and determine the value of y at $x = 3$, using the value of $h = 1$.

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