No. of Printed Pages : 8

MPH–013/MPH-014

M. Sc. (PHYSICS)

(MSCPH)

Term-End Examination

June, 2026

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 (Marks : 25)

MPH-013 : OPTICS

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) Show that the relation between the ray refractive index n_r and the wave refractive index n_w in an anisotropic crystal is given as :

$$n_r = n_w \cos\phi$$

where ϕ is the angle between the wave vector $\vec{k}$ and the direction of the Poynting vector $\vec{S}$ which is along the ray direction. 5

(b) White light is incident normally on a Fabry-Perot interferometer with a plate separation 3.5×10^{-16} m. Calculate the wavelength for which there is interference maxima in the transmitted beam in the range 4000 Å to 4250 Å ? 5

(c) List any *five* properties of a Gaussian beam which makes it indispensible in modern day optical communication. 5

(d) Plot the modal field profiles of TE_0 and TE_1 modes of a symmetric planar waveguide and discuss its salient features. 5

(e) A silica optical fiber with a core diameter of $25\,\mu m$ has core refractive index of 1.50 and a cladding refractive index of 1.45. Calculate (i) the critical angle at the core-cladding interface, (ii) the numerical aperture for the fiber, (iii) the acceptance angle in air for the fiber. 5

2. Answer any *one* part : 1×10=10

(a) What do you understand by scalar theory of diffraction ? Derive Fresnel-Huygens diffraction integral for diffraction of light by an aperture. 10

(b) (i) Discus the guided propagation of light in optical fiber as per the ray optics. 5

(ii) Explain the cause of mono-chromaticity and directionality of laser beams. 5

PART- B (Marks : 25)

MPH-014 : COMPUTATIONAL PHYSICS

1. Answer any *three* parts : 3×5=15

   (a) Explain round-off and truncation error in numerical methods. What is the round-off error when $\frac{1}{3}$ is represented as 0.333333 ? How is truncation error controlled while implementing a numerical method ?

   (b) Use the secant method to estimate the root of the polynomial $f(x) = \exp(-x) - x$ upto the first iteration. Use $x_0 = 1.0$ and $x_{-1} = 0$ as the initial guesses. What is the advantage of the secant method over the Newton-Raphson method ?

(c) The coefficients and arguments C_i and x_i for the two-point Gauss quadrature rule for integrals of the form

$$\int_{-1}^{1} f(x)\,dx = \sum_{i=1}^{2} C_i f(x_i)$$

are : $C_1 = 1$, $C_2 = 1$, $x_1 = -0.5773$, $x_2 = 0.5773$.

Calculate $\int_{1}^{2} x^2 \ln x \; dx$.

(d) Use Euler's method to obtain the approximate value of y at $x = 2$ by solving the following ordinary differential equation :

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

Use a step size $h = 0.5$.

(e) Determine the first 6 random numbers generated using the linear congruential random number generator with $a = 13$,

$c = 0$, $m = 64$ and $x_0 = 4$. What is the period of this random number sequence ? How do you check the uniformity and randomness of a generated random number sequence ?

2. Answer any *one* part : 1×10=10

(a) A set of simultaneous linear equations is defined by the matrix equation $[A][X] = [C]$, where $[A]$ is an non-singular matrix. Derive the set of matrix equations for solving this set of equations.

Obtain the LU decomposition of the matrix :

$$[A] = \begin{bmatrix} 1 & 2 & 4 \\ 3 & 8 & 14 \\ 2 & 6 & 13 \end{bmatrix}$$

(b) What do you understand by regression analysis for a data set ? Explain linear and non-linear regression models for a

data set (x_1, y_1), (x_2, y_2).....,(x_n, y_n). Obtain the constants for the straight line regression model for the following data :

x	y
1.0	2.0
2.0	5.0
3.0	3.0
4.0	8.0
5.0	7.0

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