

No. of Printed Pages : 10

MPH-013/MPH-014

M. Sc. (PHYSICS) (MSCPH)

Term-End Examination

June, 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.*

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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 : $3 \times 5 = 15$

- (a) The two mutually perpendicular electric field vectors associated with

electromagnetic waves propagating in the z -direction are given as :

$$\vec{E}_1(z, t) = \hat{x} E_{01} \cos(kz - \omega t)$$

$$\vec{E}_2(z, t) = \hat{y} E_{02} \cos(kz - \omega t + \phi)$$

Show that the superposition of these two waves gives elliptically polarized light wave. What will be the nature of polarization of the resultant light wave if the phase difference ϕ between the superposing waves is zero ? 4+1

- (b) The light of wavelength $\lambda = 5.0 \times 10^{-5}$ cm is incident on a glass film with $n_2 = 1.5$ at an angle of incidence 30° . If the angle of the wedge is 30 sec., how many fringes will appear over a distance of 3 cm of the film ? 5

- (c) Obtain the expression for Fourier transform $F(k)$ of the Gaussian function : 5

$$f(x) = e^{-x^2}$$

- (d) The differential equations for Transverse-Electric (TE) mode of a planar waveguide for light propagating in the z -direction is given as :

$$\frac{d^2 E_y}{dx^2} + [k_0^2 n^2(x) - \beta^2] E_y = 0$$

Using the above equation, obtain the expressions for modal fields for symmetric Transverse-Electric (TE) modes in a step-index symmetric planar waveguide. 5

- (e) List the factors which determine the number of modes that can propagate in an optical fiber. Draw the refractive index profile and corresponding ray paths for (i) Step-index single mode, (ii) Step-index multimode, and (iii) Graded-index multimode fibers. 5

2. Answer any *one* part : $1 \times 10 = 10$

- (a) Derive the wave equation for $\vec{E}$ and $\vec{H}$ fields associated with an electromagnetic wave propagating in an isotropic dielectric medium in the z -direction having zero charge and current densities. Write the plane waves solution for the $\vec{E}$ field and show that $\vec{k} \cdot \vec{E} = 0$. $4+4+2$

- (b) Discuss the theoretical arguments put forward by Einstein for the possibility of stimulated emission of radiation. Hence, obtain Einstein's relations.

3+7

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 : $3 \times 5 = 15$

- (a) Define true error and relative true error. Using the following expression

for the approximate value of the derivative of a function $f(x)$:

$$\frac{df}{dx} = \frac{f(x+h) - f(x)}{h}$$

calculate true error in the approximate value of the derivative of the function

$$f(x) = \sin(2x) \text{ at } x = \frac{\pi}{4} \text{ using } h = 0.1$$

radians.

- (b) Use the bisection method to calculate a root of the function $f(x) = x^3 - x - 4$ in the interval $[1, 2]$ upto three iterations.
- (c) Use the multiple-segment trapezoidal rule with two segments to calculate the value of the integral :

$$I = \int_1^2 \frac{dx}{\sqrt{x}}$$

Given that the exact value of the integral is 0.828. Calculate the

absolute relative true error as a percentage.

- (d) Consider the first order differential equation :

$$\frac{dy}{dx} + 2y = 2 - e^{-4x}; \quad y(0) = 1$$

Calculate the approximate value of y at $x = 0.1$ and 0.2 using Euler's method with a step size of 0.1 .

- (e) What is the Monte-Carlo technique of simulation ? Explain its utility. Use the linear congruential generator to determine the first five random numbers using $a = 7$, $c = 1$, $x_1 = 10$ and $m = 15$.

2. Answer any *one* part : 10

- (a) Given the following data for the velocity as a function of time, calculate the velocity at $t = 14$ s using second order polynomial interpolation in the Newton's divided difference method :

Time (s)	0	10	16	24	30
Velocity (ms^{-1})	10	25	35	28	45

Explain why higher order polynomial interpolation should not be used. What would be a preferable method for using information from several data points for interpolation. 7+3

- (b) What are the *two* steps of the Gaussian Elimination method ? Solve

the following set of equation using the Naïve-Gauss Elimination method :

$$x + 4y + 2z = 3$$

$$2x + 3y + z = 2.2$$

$$3x + 2y + 3z = 3.2$$

What are the *two* possible problems you may encounter while using the Naïve-Gauss Elimination method ?

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