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.*

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 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 :

$$\frac{d^2 \mathrm{E}_y}{dx^2} + \left[k_0^2 n^2(x) - \beta^2 \right] \mathrm{E}_y = 0$$

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 : 1×10=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 : 3×5=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 $f(x) = \sin(2x)$ at $x = \frac{\pi}{4}$ 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 ?

× × × × ×