LIBRARY

This question paper contains 4+2 printed pages]

09/5/17

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 867

Unique Paper Code : 222401 G

Name of the Paper : **Mathematical Physics IV (PHHT-411)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all,

taking at least *one* question from each Section.

Section A

1. (*a*) Determine the identity element for the binary operation,

$(a, b) * (c, d) = (ac, bc + d)$.

(*b*) Is the set $\{1, -1, i, -i\}$ a group under multiplication ?

$\left(i = \sqrt{-1}\right)$

(*c*) Given a set of vectors, $U = \{(a, b, c) : a \leq b \leq c\}$ in R^3. Determine whether U forms a subspace of R^3 or not.

(*d*) Find the basis and dimension of the solution space W of the system of homogeneous linear equations :

$$x + 4y + 2z = 0$$

$$2x + y + 5z = 0.$$

3+3+4+5

2. (*a*) It is given that $\{\alpha, \beta, \gamma\}$ is a set of linearly independent vectors. Determine whether the vectors, $\alpha - 2\beta$, $\alpha + \beta + \gamma$, $\beta - \gamma$ are linearly independent or linearly dependent.

(*b*) Show that the transformation, $T : R^3 \to R^2$ defined by,

$$T(x, y, z) = (x + 2y - 3z, 4x - 5y + 6z)$$

is a linear transformation.

(*c*) Let T be a linear transformation, $T : R^3 \to R^3$, such that,

$$T\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x + z \\ x - z \\ z \end{pmatrix}.$$

Find the matrix representation of T, with respect to the basis, $\{e_1, e_2, e_3\}$, where,

$$e_1 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, e_2 = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, e_3 = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}.$$

5+5+5

Section B

3. (*a*) Show that all the eigen values of a unitary matrix have unit magnitude.

(*b*) Assuming that A, $I - A$, $I - A^{-1}$ are all non-singular matrices, show that :

$$(I - A)^{-1} + (I - A^{-1})^{-1} = I.$$

(c) Show that any *two* eigen vectors corresponding to two distinct eigen values of a Hermitian matrix are orthogonal. 5+5+5

4. (a) Determine the eigen values and eigen vectors of the matrix,

$$A = \begin{pmatrix} 3 & 1 \\ -6 & -4 \end{pmatrix}.$$

(b) Diagonalize the matrix,

$$A = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}.$$

5+10

5. (a) Solve the coupled differential equations, using the matrix method :

$$\frac{dx}{dt} = -ax - by$$

$$\frac{dy}{dt} = bx - ay$$

The initial conditions are, $x(0) = 0$; $\left.\frac{dy}{dt}\right|_{t=0} = 1$.

(b) Using Cayley-Hamilton theorem, for the matrix,

$$A = \begin{pmatrix} 3 & 1 \\ 2 & 2 \end{pmatrix},$$

determine A^{-1}. 10+5

Section C

6. Consider a uniform flexible chain hanging from a support under the action of gravity. At time $t = 0$, the chain is given an arbitrary displacement, $y(x, 0) = y_0(x)$ and is released from rest. Establish the wave equation for this system, and solve it to determine the displacement $y(x, t)$ at a later time t. Here, x is the vertical distance measured from the free end of the chain and $y(x, t)$ is the displacement in the transverse direction. 5+10

7. Solve the one-dimensional wave equation :

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}, \quad 0 < x < L$$

The initial conditions are,

$$u(x,\ 0) = \begin{cases} \dfrac{2kx}{L} & \text{if } 0 < x < L/2 \\ \dfrac{2k}{L}(L - x) & \text{if } L/2 < x < L \end{cases}$$

$$\left.\frac{\partial u}{\partial t}\right|_{t=0} = 0.$$ 15

8. Derive the one-dimensional heat conduction equation, given by,

$$\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$$

Find the temperature in a laterally insulated bar of length L, whose ends are kept at 0°C, assuming the initial temperature is given by :

$$u(x,\ 0) = \begin{cases} x & \text{if } 0 < x < L/2 \\ L - x & \text{if } \dfrac{L}{2} < x < L \end{cases}$$ 15

This question paper contains 4+2 printed pages]

Roll No. | | | | | | | | | | | |

COLLEGE LIBRARY

S. No. of Question Paper : **868**

Unique Paper Code : **222402** **G**

Name of the Paper : **Optics [PHHT-412]**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

Use of Non-programmable scientific calculator is allowed.

1. Answer any *five* of the following : 5×3=15

(*a*) Write down *two* conditions for observing a sustained interference pattern.

(*b*) Show that when light is reflected from a denser surface, a phase change of π is introduced in the reflected ray.

(*c*) What is the total number of lines a grating must have in order just to separate the sodium doublet (λ_1 = 5890 Å and λ_2 = 5896 Å) in the second order ?

(*d*) What are the requirements for recording a hologram ? Give at least *two*.

(*e*) Two coherent beams of wavelength 5000 Å reaching a point would individually produce intensities 1.44 and 4.00 units. If they reach there together, the intensity is 3.04 units. Calculate the lowest phase difference with which the beams reach that point.

(*f*) The observed visibility is 0.3 with the two light beams having intensities in the ratio 1 : 9. Find the degree of coherence.

(*g*) What is the radius of the first half-period zone in a zone plate behaving like a convex lens of focal length 70 cm for light of wavelength 7000 Å ?

(*h*) Using Fermat's principle, establish the law of reflection.

2. (*a*) Derive expressions for the equivalent focal length and the positions of principal points and focal points of a coaxial system of two thin lenses separated by a finite distance. 6,2,2

(*b*) Plot the principal points and focal points for a hemisperical glass lens of radius 10 cm and refractive index 1.5 placed in air. 5

3. (*a*) What are coherent sources ? 2

(*b*) Derive an expression for the resultant intensity of the interference pattern when two coherent beams of light (intensities I_1 and I_2 having phase difference ϕ) are superposed. Find the visibility of fringes if :

(*i*) $I_1 = I_2$

(*ii*) $I_2 = 2I_1$. 7,2,2

(c) What will be the resultant intensity when the sources of intensities I_1 and I_2 are incoherent ? 2

4. (a) Calculate the path difference between two consecutive reflected rays in a wedge shaped film (formed by two plane surfaces inclined at an angle θ) and prove that the fringe width β is given by :

$$\beta = \frac{\lambda}{2\tan\theta\sqrt{\mu^2 - \sin^2 i}}$$

where, μ is the refractive index of the film, '*i*' is the angle of incidence and 'λ' is the wavelength of the incident light. 7,4

(b) What do you mean by localised and non-localised fringes ? Give *one* example of each. 4

5. (a) Prove that the diameters of Newton's dark rings are proportional to the square roots of natural numbers in reflected mode for normal incidence. 7

(b) Explain how Michelson's interferometer can be used to determine : 4,4

(i) the wavelength of monochromatic light

(ii) the refractive index of thin transparent film.

6. (a) Plane waves of wavelength λ impinge normally on a double-slit arrangement (two slits each of width *a* separated by an opaque space of width *b*), prove that intensity at any point P on screen (parallel to the plane containing double slits) due to Fraunhofer diffraction is given by :

$$I = 4I_0 \frac{\sin^2\beta}{\beta^2}\cos^2\gamma$$

where, $\beta = \frac{\pi}{\lambda} a \sin\theta$, $\gamma = \frac{\pi}{\lambda}(a + b)\sin\theta$, θ is the angle of diffraction and I_0 is the intensity at centre on the screen. Show the intensity pattern graphically. 8,3

(b) Prove that in the limit $a \to 0$, the above equation can be reduced to the equation for the intensity distribution in Young's double slit experiment. 2

(c) Prove that in the limit $b \to 0$, the above equation can be reduced to the equation for the intensity distribution for a single-slit of width $2a$. 2

7. (*a*) Derive Fresnel's integrals. Calculate the value of intensity by an unobstructed wavefront. 6,2

(*b*) Using Cornu's spiral, explain the Fresnel diffraction pattern due to a straight edge. 7

8. (*a*) What are half period zones ? Discuss Fresnel's diffraction due to a circular aperture in terms of half period zones. 2,10

(*b*) A zone plate has focal length of 50 cm at a wavelength of 6000 Å. What will be its focal length at a wavelength of 5000 Å ? 3

This question paper contains 4+2 printed pages]

3

23/5/17

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **870**

Unique Paper Code : **222403**

G

Name of the Paper : **Numerical Analysis**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **IV**

DESHBANDHU COLLEGE LIBRARY Kalkaji, New Delhi-19

Duration : **3 Hours**

Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Question No. **1** is compulsory.

Attempt any *four* from the rest.

Attempt *five* questions in all.

(Non-programmable scientific calculators are allowed)

1. Answer any *five* of the following :

(*a*) Find the dominant eigenvalue of the following matrix :

$$\begin{bmatrix} 2 & 1 \\ 4 & 3 \end{bmatrix}$$

(*b*) If $f(x) = ax$, show that :

$$(E + E^{-1})\, f(x) = 2f(x)$$

where E is shift operator.

(*c*) Find the minimum number to iterations required to attain an accuracy of 0.001 in the interval [1, 2] using bisection methods.

(*d*) What are forward and backward differences in a difference table ? How are they related ?

(*e*) Find the relative error in x = 0.003444, if its value is truncated to three decimal places.

(*f*) Show that the rate of convergence of Secant method is approximately 1.62. 5×3

2. (*a*) Deduce the Newton-Raphson method to find the roots of the equation $f(x) = 0$.

(*b*) Find the root of the equation by any method correct upto two decimal places :

$$x^2 - 5x + 4 = 0 \cdot$$

(*c*) Find the solution of system of linear algebraic equation :

$$4x_1 + x_2 + x_3 = 4$$

$$x_1 + 4x_2 - 2x_3 = 4$$

$$3x_1 + 2x_2 - 4x_3 = 6$$

Using Guass-Seidel method (at least *two* iterations).

5,5,5

3. (*a*) Calculate :

$$\frac{dy}{dx} \text{ and } \frac{d^2y}{dx^2}$$

at x = 0.70 from the table of values of x and y :

x	y
0.68	0.8086
0.69	0.8253
0.70	0.8422
0.71	0.8595

(*b*) Using Euler's method solve :

$$\frac{dy}{dx} = x - y^2, \quad y(0) = 1$$

in the interval [0, 1] with step size 0.2. 10,5

4. (*a*) Using Newton Backward difference formula, compute $f(x)$ and $f(4.5)$ from the following set of data :

x	y
1	14
2	27
3	40
4	55
5	68

(*b*) Solve using Bisection method the equation :

$$x^3 - x - 1$$

in the interval [1, 2]. 10,5

5. (*a*) Derive second order Runge-Kutta formula.

(*b*) Hence find the solution of differential equation :

$$\frac{dy}{dx} = x - y; \quad y(0) = 1$$

with $h = 0.2$ on the interval [0, 1]. 5,10

6. (*a*) Derive the trapezoidal rule to solve numerically the integral :

$$I = \int_a^b f(x)\, dx.$$

(*b*) Evaluate $\int_1^2 x^2 dx$ by the trapezoidal rule when the interval (1, 2) is subdivided into four equal parts.

(*c*) Use Simpson's rule to compute the integral :

$$I = \int_5^{13} \frac{dx}{x} \text{ with } n = 4.$$ 5,5,5

7. (*a*) Derive Gauss Legendre's three point formula to solve the integral :

$$I = \int_a^b f(x)\, dx$$

(*b*) Discuss the Least square fitting for a quadratic curve.

(*c*) Linearly fit the following data :

x	y
1	1.1
1.5	1.3
2	1.6
2.5	2.0
3.0	2.7
3.5	3.4
4.0	4.1

5,5,5

(4) May 2017

This question paper contains 7 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1129**

Unique Paper Code : **235463** G

Name of the Paper : **Mathematics II (Analysis and Statistics)**

PHHT-413

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : 75

DESHBANDHU COLLEGE LIBRARY Kalkaji, New Delhi

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt as per directions.

Section A

Do any *two* questions.

1. (*a*) State and prove M_n-Test for uniform convergence of a sequence of functions.

(*b*) Show that :

$$\tan^{-1}(x) = x - \frac{x^3}{3} + \frac{x^5}{5} \text{ .... for } x \in [-1, 1]$$

and hence deduce that :

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} \text{ ....}$$ 6½+6

P.T.O.

2\. (a) Show that the sequence $<f_n>$ where :

$$f_n(x) = \frac{nx}{1+n^2x^2}, \quad x \in \mathrm{R}$$

is not uniformly convergent on R.

(b) Show that if a series $\sum f_n$ converges uniformly to f in an interval $[a, b]$ and its terms f_n are continuous at a point x_0 in the interval (a, b), then the sum function f is also continuous at x_0. 6½+6

3\. (a) Prove that if a power series :

$$\sum a_n x^n,$$

is such that $a_n \neq 0$, for all n and

$$\lim_{n\to\infty}\left(\frac{a_{n+1}}{a_n}\right) = \frac{1}{\mathrm{R}},$$

then $\sum a_n x^n$ is convergent for $|x| < \mathrm{R}$ and divergent for $|x| > \mathrm{R}$. Show that series $\sum_{n=1}^{\infty} \frac{x^{n-1}}{n^2}$ is convergent for all $x \in (-1, 1)$. Also check the convergence of this series at $x = \pm 1$.

(b) State Weierstrass M-Test for uniform convergence of series of functions. Show that the series :

$$\sum_{n=1}^{\infty} \frac{x}{n(1+nx^2)}$$

is uniformly convergent on R. 6½+6

Section II

4\. Do any *three* parts :

(a) Show that the integral :

$$\int_0^{\pi/2} \frac{\sin^m x}{x^n}\, dx$$

is convergent if $n < m + 1$.

(b) Test the convergence of :

$$\int_0^{\infty} e^{-x^2}\, dx.$$

(c) Prove that the Gamma function :

$$\int_0^{\infty} x^{m-1}e^{-x}\, dx$$

is convergent if $m > 0$.

(*d*) Test the convergence of :

$$\int_0^{\pi/2} \frac{\sin x}{x^p}\, dx .$$

(*e*) Show that :

$$\int_0^{a} \frac{\log(1+ax)}{1+x^2}\, dx = \frac{1}{2} \log(1+a^2) \tan^{-1} a .$$ 5,5,5,5,5

Section III

5. Do any *one* part :

(*a*) Find a formula for the probability distribution of the total number of heads obtained in four tosses of a balanced coin.

(*b*) If X has the probability density :

$$f(x) = \begin{cases} ke^{-3x} & \text{for } x > 0 \\ 0 & \text{elsewhere} \end{cases}$$

find *k*, the distribution function of the random variables X and use it to evaluate :

P(0.5 ≤ X ≤ 1). 5,5

6. Do any *three* parts :

(*a*) Find the moment generating function of the random variable whose probability density is given by :

$$f(x) = \begin{cases} e^{-x} & \text{for } x > 0 \\ 0 & \text{elsewhere} \end{cases}$$

and use it to find an expression for μ_r'.

(*b*) If the joint probability density of two random variables X and Y is given by :

$$f(x, y) = \begin{cases} x+y & \text{for } 0 < x < 1,\ 0 < y < 1 \\ 0 & \text{elsewhere} \end{cases}$$

Find the joint distribution function of these two random variables.

(*c*) Find the probabilities that a random variable having the standard normal distribution will take on a value :

(*i*) less than 1.72;

(*ii*) between 1.30 and 1.75.

(*d*) Let X and Y be two random variables with variance σ_x^2 and σ_y^2 respectively and r is the coefficient of correlation between them. If $U = X + KY$ and $V = X + (\sigma_x/\sigma_y)Y$, find the value of K so that U and V are uncorrelated.

5,5,5,5

7. Do any *three* parts :

(*a*) The means of two single large samples of 1000 and 2000 members are 67.5 inches and 68 inches respectively. Can the samples be regarded as drawn from the same population of standard deviation 2.5 inches ?

(*b*) A random sample of 10 boys had the following I.Q's 70, 120, 110, 101, 88, 83, 95, 98, 107, 100. Do these data support the assumption of a population mean I.Q. of 100 ?

($t_{0.05}$ at 9 d.f. = 2.262)

(*c*) Two random samples of sizes 8 and 10, drawn from the two normal populations are characterized as follows :

Population	Sum of squares of deviations from their respective means
I	84.4
II	102.6

Can they be regarded as drawn from the two normal populations with the same variance ?

($F_{0.05}$ for 7 and 9 d.f. = 3.29)

(*d*) The theory predicts the proportion of beans in the four groups A, B, C and D should be 9 : 3 : 3 : 1. In an experiment among 1600 beans, the numbers in the four groups were 882, 313, 287 and 118. Does the experimental result support the theory ?

($\chi^2_{0.05}$ for 3 d.f. = 7.815)

5,5,5,5

This question paper contains 4+1 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **2820**

Unique Paper Code : **32221401** **GC-4**

Name of the Paper : **Mathematical Physics-III**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

DESHBANDHU COLLEGE LIBRARY Kalkaji, New Delhi-19

(Write your Roll No. on the top immediately on receipt of this question paper.)

All questions carry equal marks.

Question No. **1** is compulsory.

Attempt **2** questions from Section A

and **2** questions from Section B.

Use of scientific calculators is allowed.

1. Attempt any *five* questions : 5×3=15

(*a*) Determine the solutions of the equation $z^4 = 1$ where z is a complex number. Represent the solutions graphically.

P.T.O.

(*b*) Locate the name the singularities in the finite z plane of the function :

$$f(z) = \frac{\ln(z-2)}{(z^2-1)^2}.$$

(*c*) Evaluate :

$$\oint_C \frac{3z^2 - 6}{z - 2}\, dz$$

over a circle C in the counterclockwise direction. C is described by $|z| = \pi$.

(*d*) Find the real part of (i^{2i}).

(*e*) Show that $x\delta(x) = 0$, where $\delta(x)$ is the Dirac delta function.

(*f*) If F(ω) is the Fourier transform of $f(t)$, then prove that the Fourier transform of :

$$f(at) = \frac{1}{a} F\left(\frac{\omega}{a}\right)$$

where a is a constant.

(*g*) Determine the Laplace transform of :

$$f(t) = \sin^2 2t.$$

(*h*) Evaluate :

$$\int_0^\infty t e^{-3t} \sin t\, dt$$

using Laplace transform.

Section A

Attempt any *two* questions from this section.

2. (*a*) Verify Cauchy's theorem for the function :

$$f(z) = 2z^2 + 3z - 7.$$

if C is a square with vertices at $-1 \pm i, 1 \pm i$.

(*b*) Using De Moivre's theorem, prove that : 10,5

$$\cos 3\theta = 4\cos^3\theta - 3\cos\theta$$
$$\sin 3\theta = 3\sin\theta - 4\sin^3\theta$$

3. (*a*) Expand :

$$f(z) = \frac{z}{(z-1)(2-z)}$$

in a Laurent's series valid for the given regions :

(*i*) $1 < |z| < 2$

(*ii*) $|z - 1| > 1$

(*b*) Evaluate :

$$\frac{1}{2\pi i}\int_C \frac{\cos \pi z}{z^2 - 1} dz$$

around a square with vertices at $\pm i, 2 \pm i$. 10,5

4. Using the method of contour integration prove any two of the following : 7½+7½

(*a*) $\displaystyle\int_0^\infty \frac{dx}{1 + x^6} = \frac{\pi}{3}$

(*b*) $\displaystyle\int_0^\pi \frac{d\theta}{1 + \sin^2 \theta} = \frac{\pi}{\sqrt{2}}$

(*c*) $\displaystyle\int_0^\infty \frac{\cos 3x}{(1 + x^2)(x^2 + 4)} dx = \frac{\pi}{2}\left(\frac{e^{-3}}{3} - \frac{e^{-6}}{6}\right).$

Section B

Attempt any *two* questions from this section.

5. (*a*) Determine the Fourier transform of the function $f(t)$:

$$f(t) = 1 - t^2 \text{ for } |t| < 1$$
$$= 0 \text{ otherwise}$$

Hence evaluate :

$$\int_0^\infty \frac{t \cos t - \sin t}{t^3} \cos \frac{t}{2} dt$$

(*b*) State and prove the convolution theorem for Fourier transforms. 8,7

6. (*a*) Given $f(t) = 1$ for $-1 < t < 1$;

$= 0$ otherwise

Express $f(t)$ as a Fourier integral and hence evaluate :

$$\int_0^\infty \frac{\sin \omega \cos \omega t}{\omega} d\omega.$$

(*b*) State the convolution theorem for Laplace transform. Use this theorem to evaluate the inverse Laplace transform of : 8,7

$$F(s) = \frac{1}{s^2 (s^2 + 1)}$$

7. (*a*) Using Laplace transform, solve the following set of simultaneous differential equations :

$$\frac{dx(t)}{dt} + y(t) = 0$$
$$\frac{dy(t)}{dt} - x(t) = 0 \text{ given } x(0) = 1;\ y(0) = 0.$$

(*b*) Determine the Laplace transform of a periodic function $f(t)$ with period T. 10,5

[This question paper contains 6 printed pages.]

Your Roll No. ....

Sr. No. of Question Paper : 2821 **GC-4**

Unique Paper Code : 32221402

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question number **1** is compulsory.
4. Symbols have their usual meaning.

1. Answer any **five** of the following : (5×3=15)

(a) Calculate the de Broglie wavelength of an electron accelerated through a potential difference of 100V and 1MV.

(b) Determine the activity of 1 g of ${}_{92}U^{238}$ if its half life is 4.5×10^{9}y.

(c) The maximum energy of photoelectrons from Aluminum is 2.3 eV for radiation of 200 nm and 0.90 eV for radiation of 258 nm. Calculate the Planck's constant and the work function of Aluminium.

(d) Write two special characteristics of the light emitted from a laser. Distinguish between spontaneous emission and stimulated emission.

(e) Why do we associate a wave packet and not a monochromatic de-Broglie wave with a particle ?

(f) Which of the following are eigen functions of the operator d^2/dx^2 ? Give the eigen values where appropriate, (i) cos x, (ii) e^{-ix}, (iii) $\sin^2 x$.

(g) How does the uncertainty principle rule out the possibility of electron being present inside the nucleus ?

2. (a) What is Compton scattering ? What is the origin of presence of the unmodified line at all scattering angles ? Obtain the expression for change in wavelength

$$\Delta\lambda = \frac{h}{m_0 c}(1-\cos\phi)$$

where symbols have their usual meaning. (2,5)

(b) In a Compton scattering experiment, X-ray of wavelength 0.24 nm is scattered at an angle 60° relative to the incident beam. Find the wavelength of scattered X-ray. (3)

(c) Given a dispersion relation

$$w(k) = w(k_0) + (k-k_0)\left(\frac{\partial w}{\partial k}\right)_{k=k_0} + \frac{1}{2}(k-k_0)^2\left(\frac{\partial^2 w}{\partial k^2}\right)_{k=k_0}$$

show that a Gaussian wave packet

$$\psi(x,0) = \sqrt{\frac{2\pi}{\alpha}}\, e^{ik_0 x} e^{-x^2/2\alpha}$$

spreads as it propagates in time. (5)

3. (a) State Heisenberg uncertainty principle for measurement of position and momentum. Using Gamma ray microscope thought experiment proposed by Heisenberg, obtain an expression for the uncertainty relation. (2,5)

(b) Show that the uncertainty principle can be expressed in the form $\Delta E \Delta t \geq \hbar/2$, where ΔE is the uncertainty in the energy and Δt is the uncertainty in time. (3)

(c) An electron of energy 200 eV is passed through a circular hole of radius 10^{-4} cm. What is the uncertainty introduced in the angle of emergence ? (5)

4. (a) What differences will you observe on the screen of a two-slit experiment if you use (i) photons from a monochromatic source, (ii) electrons from an electron gun, and (iii) bullets from a machine gun? Interpret the results. (4)

(b) The wave function for a particle moving along the positive x-direction is given as

$$\psi(x,t) = A \exp\left(i\left(\frac{px}{\hbar} - \frac{Et}{\hbar}\right)\right)$$

Using this derive expressions for momentum and kinetic energy operators in one dimension. (3,3)

(c) Normalize the wave function given below to find the constant 'A' for the Gaussian wavepacket given as

$$\psi(x) = A \exp\left(-\frac{\alpha^2 x^2}{2}\right) \exp(ikx)$$ given that

$$\int_{-\infty}^{\infty} \exp(-\alpha^2 x^2)\, dx = \sqrt{\frac{\pi}{\alpha}}$$ (5)

5. (a) Consider a particle of mass m and energy $E<V_0$ approaching, from the left, a one-dimensional potential step given by

$$V(x) = V_0 \quad \text{for} \quad x > 0$$
$$= 0 \quad \text{for} \quad x < 0;$$

Show that the reflection coefficient is equal to 1. Explain how penetration into classically forbidden region is not in conflict with Classical Mechanics and find an expression for penetration depth. (5,3)

(b) Estimate the penetration distance Δx for a small dust particle of radius $r = 10^{-6}$ m and density $\rho = 10^4$ kg/m^3, moving at very low velocity $v = 10^{-2}$ m/sec, if the particle impinges on a potential step of height equal to twice its kinetic energy in the region left of the step. (2)

(c) A particle of mass m is confined within a one-dimensional field-free region between two perfectly elastic and impenetrable walls at x = 0 and x = a. Obtain the energy eigenvalues and normalized eigenfunctions for the particle. (5)

6. (a) Discuss the nature of nuclear force. Plot the N-Z graph for stable nuclei. Why do stable nuclei usually have more neutrons than protons ? (3,1,1)

(b) A sample of the isotope ^{131}I, which has a half-life of 8.04 days, has an activity of 5 mCi at the time of shipment. Upon receipt of the ^{131}I in a medical laboratory, its activity is 4.2 mCi. How much time has elapsed between the two measurements ? Calculate the mean life of sample. (4,1)

(c) Calculate binding energy per nucleon for (i) $_5B^{10}$ with mass number 10.0161 a.m.u. (ii) $_{14}Si^{29}$ with mass number 28.9857 a.m.u. Using this calculation find which atom is more stable. Given that mass of proton is 1.0081 a.m.u. and mass of neutron is 1.0089 a.m.u. (4,1)

7. (a) Define mean life and half life of a radioactive substance. Derive expressions for mean life and half life in terms of radioactive constant. (2,5)

(b) A nuclear reactor of 20% efficiency and an output of 700 MW uses ${}_{92}U^{235}$ as fuel. Each fission reaction gives 200 MeV of energy. Calculate (i) the number of uranium atoms undergoing fission per day (ii) mass of uranium consumed by the reactor per day. Given that Avogadro's number is 6.023×10^{23}. (3,2)

(c) What makes large nuclei (A>210) unstable ? Why do they tend to stabilize by the emission of α-particles rather than protons ? (1,2)

BANDHU COLL. LIBRARY ... Delhi

(7) May 2017

This question paper contains 4+1 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **2822**

Unique Paper Code : **32221403** **GC-4**

Name of the Paper : **Analog Systems and Applications**

Name of the Course : **B.Sc. (Hons) Physics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

Non-programmable calculators are allowed.

1. Attempt any *five* of the following :

(*a*) Draw the energy band diagram of an unbiased p-n junction diode with appropriate labels.

(*b*) Differentiate between Zener breakdown and Avalanche breakdown in a p-n junction diode.

P.T.O.

(c) The energy gap of the semiconducting material of an LED is 1.37 eV. What is the wavelength of the emitted light ?

(d) Draw the output characteristics of a transistor in CE mode and identify the active, cut-off and saturation regions.

(e) Distinguish between Class A and Class B amplifiers with the hep of load line and Q point.

(f) Explain the Barkhausen's criterion for sustained oscillation.

(g) What is the difference between differential and common mode inputs for an Op-amp ?

(h) For a 4-bit binary R-2R ladder D/A converter the input levels are 0 = 0V and 1 = + 10V.

Find the output voltage caused by :

(i) 0011

(ii) 1001 and

(iii) 1111. 5×3=15

2. (a) Obtain an expression for the barrier width of a p-n junction diode, assuming a step junction.

(b) In a Ge sample a donor type impurity is added to the extent of 1 atom per 10^8 Ge atoms. Find the concentration of electrons and holes in the sample. Given $N_i = 2.5 \times 10^{13}$ electrons/cm^3 and number of Ge atoms is 4.41×10^{22} per cm^3.

3. (a) Explain the working of a center-tap full wave rectifier using suitable diagram and obtain the expressions for :

(i) ripple factor and

(ii) rectification efficiency.

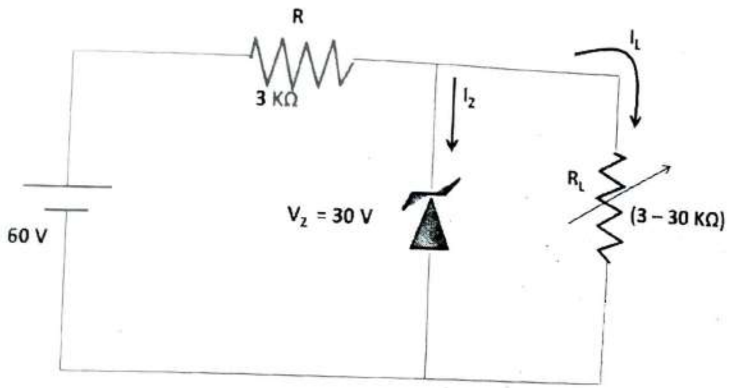
(b) Find the current through the Zener diode in the following circuit when load resistance R_L is :

(i) 30 kΩ

(*ii*) 5 kΩ and

(*iii*) 3 kΩ.

9,6



4. (*a*) What are the factors that affect the bias stability of a transistor ? Compare the "voltage divider bias circuit" with the "fixed bias circuit" with respect to their stability. Explain how the self-biasing resistor improves the stability.

(*b*) Obtain the general expression for stability factor S of a common-emitter configuration. 10,5

5. Explain the working of RC coupled amplifier and give its frequency response. How does the gain change at low, mid and high frequencies ? Derive the expressions for the gain in the mid and high frequency regions. 15

6. (*a*) Draw the circuit diagram of an RC phase shift oscillator using transistor and state the conditions for sustained oscillations. Derive an expression for its frequency.

(*b*) In a Colpitt's oscillator C_1 = 0.1 μF, C_2 = 0.01 μF and L = 50 mH, find the frequency of oscillation. 10,5

7. (*a*) Draw the circuit of an op-amp as an integrator and find an expression for its output. Draw the output waveform when the input to the integrator is a square wave.

(*b*) What would be the output of an op-amp in the inverting mode if input resistance is 1 kΩ and feedback resistance is (*i*) 2 kΩ and (*ii*) 20 kΩ for a dc input signal of 1.5 V ? (V_{sat} = ± 14 V). 10,5