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[This question paper contains 4 printed pages]

Your Roll No. : ....

Sl. No. of Q. Paper : **2264** **IC**

Unique Paper Code : 32221401

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

Name of the Paper : Mathematical Physics-III

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

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

(b) Attempt **five** questions in all.

(c) Question **No.1** is compulsory.

(d) **All** questions carry equal marks.

(e) Attempt **two** questions from **Section - A** and **B** each.

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

(a) Find $(1 + i)^8$.

(b) Given a complex number z, represent geometrically iz in the Argand plane.

(c) Evaluate $\oint_C \frac{4-3z}{(z-1)(z-2)} dz$; if C is the circle $|z| = \frac{3}{2}$.

P.T.O.

(d) Locate and name all the singular points of the function (in finite z - plane) $\frac{\sin\sqrt{z}}{\sqrt{z}}$.

(e) If $F(\alpha)$ is the Fourier Transform of $f(x)$, then find the Fourier Transform of $f(x)\sin ax$, where, a is any positive number.

(f) Show that derivative of unit step function is a Dirac Delta function.

(g) If the Laplace Transform of f(t) is F(s), then show that the Laplace Transform of $\int_0^t F(u)\,du$ is $\frac{F(s)}{s}$.

(h) Find the Laplace Transform of function $f(t) = (\sin t - \cos t)^2$.

Section - A

2. (a) Construct an analytic function f (z) = u + iv, whose $u(x, y) = x^2 - y^2 - y$. 8

(b) Using De Moivre's theorem, verify that

$$\cos 5\theta = 16\cos^5\theta - 20\cos^3\theta + 5\cos\theta, \text{ and}$$

$$\frac{\sin 5\theta}{\sin\theta} = 16\cos^4\theta - 12\cos^2\theta + 1$$ 7

3. (a) Expand $f(z) = \frac{z}{z-3}$ in a Laurent's series valid for the given regions : 8

(i) $|z| < 3$, (ii) $|z| > 3$

(b) Evaluate $\oint_C \frac{ze^{zt}}{(z+1)^3}dz$, where C is circle $|z| = 2$ and $t > 0$. 7

4. Using the method of contour integration prove any **two** of the following : 7.5×2=15

(a) $\int_{-\infty}^{\infty} \frac{x^2}{(x^2+9)(x^2+4)}dx = \frac{\pi}{5}$

(b) $\int_0^{2\pi} \frac{d\theta}{1-2p\cos\theta+p^2} = \frac{2\pi p^2}{1-p^2}, 0 < p < 1$

(c) $\int_{-\infty}^{\infty} \frac{\sin x}{x}dx = \frac{\pi}{2}$

Section - B

5. (a) Find the Fourier Integral of the function : 8

$f(x) = e^{-kx}$, when $x > 0$, $k > 0$ and $f(-x) = f(x)$ Hence deduce that

$$\int_0^{\infty} \frac{\cos \pi u}{1+u^2}du = \frac{\pi}{2}e^{-x} \; ; \; x > 0$$

(b) Find the Fourier Transform of Gaussian function. 7

6. (a) Using Laplace Transforms, solve the following set of simultaneous differential equations :

$$\frac{dx}{dt} - y = e^t, \qquad \frac{dy}{dt} + x = \sin t$$

given that x(0) = 1 and y(0) = 0. 8

(b) Find $L^{-1}\left\{\frac{1}{\left(s^2+a^2\right)\left(s^2+b^2\right)}\right\}; a^2 \neq b^2$ 7

7. (a) If $f(t) = t^a$ and $g(t) = t^b$, where a and b are integers, then using the Convolution Theorem for Laplace Transform, prove that : 8

$$\int_0^1 y^a (1-y)^b \, dy = \frac{a!\, b!}{(a+b+1)!}$$

(b) Prove that the Fourier transform of an even function is even. 7

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[This question paper contains 4 printed pages]

Your Roll No. : ....

Sl. No. of Q. Paper : **2265** **IC**

Unique Paper Code : 32221402

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

Name of the Paper : Elements of Modern Physics

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

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

(b) Attempt **five** questions in all.

(c) Question **No.1** is compulsory.

(d) **All** questions carry equal marks.

(e) Non programmable calculators allowed.

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

(a) Which of the following wave functions are physically acceptable ? Justify your answer.

(i) cos x

(ii) sec x.

(b) Calculate the de-Broglie wavelength of an electron moving with velocity $\frac{3}{5}$c, where 'c' is the velocity of the light in vacuum.

P.T.O.

(c) An electron has the speed of 600 ms^{-1} with an accuracy of 0.005%. Calculate the minimum uncertainty in determining its location.

(d) Prove that the group velocity is same as the particle velocity for a free particle.

(e) Calculate the permitted energy levels of an electron in a one dimensional box 0.1 nm wide.

(f) A certain radioactive material has a half-life of 20 days. What is the decay constant and mean life of this element ?

(g) Determine the ratio of nuclear radii of ${}^{12}_{6}C$ and ${}^{16}_{8}O$.

2. (a) What is Compton Effect ? Derive an expression for the Compton shift. If θ and φ are the angles of scattering of photon and electron respectively in the Compton Effect, then show that :

$$\cot\varphi = \left(1 + \frac{E}{m_O c^2}\right)\tan\frac{\theta}{2}$$

where 'E' is the energy of the incident photon and 'm_o' is the rest mass of the electron. 10

(b) Obtain the time-independent Schrödinger equation satisfied by the monochromatic plane wave in 1-D, $\psi(x, t) = A\exp\left(\frac{i}{h}(px-Et)\right)$, where 'A' is constant, 'p' is the momentum and 'E' is the energy of the particle. 5

3. (a) Describe the Davisson-Germer experiment. How did this experiment verify the de-Broglie hypothesis ? 7

(b) Determine the frequency of the light needed to produce electrons of kinetic energy 3eV from illumination of Li Surface. (Given work function of Li is 2.93 eV.) 5

(c) Illustrate uncertainty principle using Gamma Ray Microscope thought experiment. 3

4. (a) Consider a particle of mass 'm' and energy 'E' approaching a potential barrier of height 'V_0' and width 'L'. Assuming E < V_0, obtain an expression for the Transmission Coefficient (T). Prove that in the limit kL >> 1, where $k^2 = \frac{2m(V_0 - E)}{h^2}$, the Transmission Coefficient is given by the expression

$$T = \frac{16E}{V_0}\left(1 - \frac{E}{V_0}\right)e^{-2kL}.$$

10

(b) Prove that the de-Broglie wavelength of a particle of rest mass 'm_0' and kinetic energy 'E_k' is $\frac{hc}{\sqrt{E_k(E_k + 2m_0c^2)}}$, where 'c' is the velocity of the light in vacuum. 5

5. (a) Discuss the Liquid Drop Model of the nucleus and derive the semi empirical mass formula. 10

(b) Tritium $\left({}_{1}^{3}H\right)$ has a half -life of 12.5 years against β-decay. What fraction of a sample of tritium $\left({}_{1}^{3}H\right)$ will remain undecayed after 25 years. 2.5

(c) Calculate the binding energy of α - particle in MeV.

(Given mass of proton (mp) = 1.007276 amu, mass of neutron (mn) = 1.008665 amu and mass of α-particle (m_α) = 4.001506 amu) 2.5

6. (a) Explain the β-decay process in the context of prediction of neutrino. 6

(b) State differences between nuclear fusion and nuclear fission. 4

(c) Explain the origin of solar energy. 5

7. (a) Explain the terms : 6

(i) Spontaneous emission

(ii) Stimulated emission

(iii) Metastable states

(b) Explain the phenomenon of optical pumping and population inversion. 4

(c) Draw NZ graph. Explain why the stable nuclei have more number of neutrons than protons ? 5

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[This question paper contains 7 printed pages]

Your Roll No. : ....

Sl. No. of Q. Paper : **2266** **IC**

Unique Paper Code : 32221403

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

Name of the Paper : Analog Systems and Applications

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

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

(b) Attempt any **five** questions in all.

(c) Question **NO.1** is compulsory.

(d) **All** parts of a question should preferable by attempted together.

1. Attempt any **five** of the following :

$3\times5=15$

(a) Draw the output characteristics of a photodiode and label important parameters.

(b) Mention some advantages of Schottky barrier diode over the p-n junction diode.

(c) Describe briefly CMRR and Slew rate for an op-amp.

(d) Draw the circuit and describe the working of a log amplifier.

(e) Draw the energy band diagram for insulator, conductor and semiconductor. How does doping affect the Fermi energy level of a semiconductor ?

(f) For a pnp transistor, the current amplification factor (β) is 100. What is the value of α? If I_{CBO} = 10 μA, what is the collector current (I_C) for an emitter current (I_E) of 2 mA ?

(g) An RC coupled amplifier has a voltage gain of 150 in the frequency range of 500 Hz to 50 kHz. On either side of these frequencies, the gain falls such that it is reduced by 3dB at 100 Hz and 100 kHz. Calculate gain in dB at cut of frequencies and also draw a plot of frequency response.

2. (a) Show that the depletion width for a step junction pn diode in equilibrium condition is given as :

$$W=\sqrt{2\varepsilon \frac{V_o}{q} \frac{(N_a+N_d)}{N_a N_d}}$$

where symbols have their usual meaning.

10

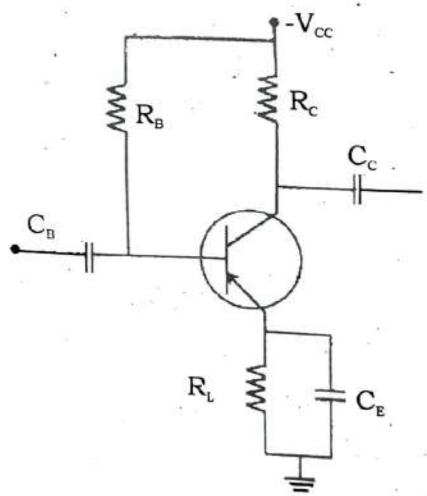
(b) The reverse saturation current at 300K of a pn junction Ge diode is 5 μA. Find the voltage to be applied across the junction to obtain a forward current of 50 mA. Given that the ideality factor for the Ge diode is 1, value of Boltzmann constant is 1.38×10^{-23} J/K and q is 1.6×10^{-19} C. 5

3. (a) Explain the working of a full wave bridge rectifier using suitable diagrams and obtain the expressions for (i) ripple factor and (ii) rectification efficiency. How this rectifier circuit is advantageous over the centre tap full wave rectifier ? 10

(b) In a Zener diode voltage regulator circuit, the source series resistance, $R_s = 20\Omega$ Zener voltage $V_z = 18V$ and load resistance $R_L = 200\Omega$. How load current is related to the values of current flowing through zener diode ? If source voltage V_s is varied from 20V to 30V, find the maximum and minimum current flowing through the zener diode. 5

4. (a) Draw the circuit for a transistor amplifier in CE configuration using voltage divider bias circuit and derive the expressions for I_c and V_{CE}. Explain the origin of phase difference between the input and output voltages in a transistor amplifier in CE configuration. 10

(b) A pnp transistor having a DC current gain of 100 in CE configuration is to be biased at I_c = 5mA and V_{CE} = 3.8 V. The collector load has a resistance of 500Ω. If V_{cc} = – 10V and V_{BE} = – 0.3 V. Calculate the values of R_B and R_E for the figure given below 5



P.T.O.

5. (a) Using the h-parameter equivalent circuit for a transistor amplifier in CE configuration, derive the expressions for voltage gain and input impedance. 10

(b) Explain negative and positive feedback using block diagrams ? Discuss the effect of negative feedback on the input impedance of the amplifier. 5

6. (a) Draw the circuit of an Op-amp as a non inverting summing amplifier for three voltage input signals (V_1, V_2 and V_3) and obtain an expression for the output voltage. Mention the conditions under which the circuit will work as an averaging amplifier. 10

(b) Write an expression for the closed loop voltage gain of Op-amp 741 configured in non-inverting mode. What would be the output of this circuit if it has a gain of 10 for a dc input signal of

(i) +1V and

(ii) + 2.5 V ? (V_{cc} = ±15 volts). 5

7. (a) Explain the working of a Hartley oscillator and write the expression for its frequency of oscillation. Determine the value of involved capacitor for obtaining f_o = 100 kHz using inductors of equal inductance of 10 mH. 10

(b) In a R-2R binary ladder based D/A convertor input reference voltage of + 10 V is applied. Find the equivalent analog output voltage for the following digital input states (i) 1001 and (ii) 1011. What should be the value of full scale analog output voltage for the 8-bit D/A converter ? 5

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Roll No.......................

2019

S. No. of Question Paper	:	B 3623
Unique Paper Code	:	222402
Name of the Paper	:	Optics [PHHT - 412]
Name of the Course	:	B. Sc. (Hons.) Physics
Semester	:	IV

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I

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

Q1. Attempt any Five from the following:

(a) State three essential conditions for obtaining sustained interference pattern.

(b) Give any two important differences between Haidinger fringes and Fizeau fringes.

(c) Define visibility of fringes. Show graphically how visibility decreases with increasing path difference.

(d) Define coherence length for a source of light. How coherence length helps in designing an interference experiment?

(e) With the help of suitable diagrams show the difference between the Young's double slit interference pattern and two slit diffraction pattern.

(f) Write at least two essential conditions for recording a hologram? Can we have coloured holograms?

(g) Define resolving power of an optical instrument. How does it varies with increasing the wavelength of light used?

(3×5)

Q2. (a) Explain Fermat's principle of least time and hence derive laws of refraction. **(2, 5)**

(b) What are Cardinal points? Determine various cardinal points for a thick lens. **(2, 6)**

Q3. (a) With the help of proper diagram, describe Llyod's mirror experiment for obtaining interference fringes. How this experiment can be used to determine the refractive index of a thin transparent sheet? **(5, 5)**

(b) In Fresnel biprism experiment, an interference pattern is obtained using light of wavelength 600nm on a screen kept at a distance of 1.2m. If the separation between 5^{th} maximum and 7^{th} minimum is 3mm, calculate the separation between the virtual sources. **(5)**

Q4 (a) Explain how Michelson interferometer can be used for

(i) determining the wavelength of light used, and

(ii) finding the difference between two closely spaced wavelengths of the same source. **(5, 5)**

(b) When a transparent sheet of thickness 5×10^{-2} mm is introduced in the path of one of the interfering beams in Michelson interference experiment, the central fringe shifts to a position originally occupied by 30^{th} fringe. If the wavelength is 600nm, find the refractive index of the sheet. **(5)**

Q5 (a) What are Fresnel's half-period zones? Explain the theory that leads to explanation of rectilinear propagation of light? **(3, 4)**

(b) What is a Zone plate? Obtain an expression for multiple focii of zone plate. Compare it with a convex lens. **(2, 5, 1)**

Q6. (a) What are Fresnel Integrals? How these integrals are used in forming Cornu's spiral? **(3, 4)**

(b) Using Cornu's spiral, explain qualitatively the diffraction due to straight edge. **(8)**

Q7. (a) Obtain an expression for the intensity distribution of Fraunhofer diffraction due to N-slits. **(10)**

(b) What do you understand by dispersive power of diffraction grating? Obtain the expression for it. **(5)**

Q8. (a) What are temporal and spatial coherence? Explain them. **(5)**

(b) What is holography? Give necessary theory of recording and reconstruction of a hologram. **(3,7)**