3 (Sem–4/CBCS) PHY HC 1

2023

PHYSICS

(Honours Core)

Paper : PHY–HC–4016

(Mathematical Physics–III)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Give short answers to the following questions : 1×7=7

   (a) Find the principal value of i^i.

   (b) Define a multiply connected region in complex plane.

   (c) Find the value of $L^{-1}\left\{\frac{1}{s(s-a)}\right\}$ for $s > a$.

(d) What does the equation $|z-i|=2$ represent ?

(e) State convolution theorem of Fourier transform.

(f) Write the transformation rule for a covariant tensor of rank two.

(g) Plot the number $e^{\left(1+i\frac{\pi}{4}\right)}$.

2. Answer the following questions : 2×4=8

(a) Define simple pole and essential singularity.

(b) Establish the shifting property of Fourier transform.

(c) Find inverse Laplace transform of $t^{-\frac{1}{2}}$.

(d) Show that the number of independent components of a skew-symmetric tensor of rank 2 in n-dimensional space is $\frac{n(n-1)}{2}$.

3. Answer ***any three*** questions of the following : 5×3=15

(a) Check the analyticity and hence find derivative of the function $f(z)=\sin z$. 3+2=5

(b) Find the value of the integral $\int_0^{1+i}\left(x-y-ix^2\right)dz$ along real axis from $z=0$ to $z=1$ and then along the line parallel to imaginary axis from $z=1$ to $z=1+i$.

(c) Find the Fourier sine transform of a function defined by

$$f(t)=\begin{cases}\cos \propto t, 0 \le t \le \dfrac{\pi}{\propto} \\ 0\ , \quad t > \dfrac{\pi}{\propto}\end{cases}$$

(d) Evaluate :

$$L^{-1}\left\{\frac{(s+1)}{s^2(s+2)^3}\right\}$$

(e) Define Levi-Civita symbol in three dimensional space. Show that

$\left(\vec{A}\times\vec{B}\right)_i = \varepsilon_{ijk}\ A_j\ B_k$ 2+3=5

4. Answer the following questions : ***(any three)*** 10×3=30

(a) (i) Prove Cauchy-Riemann conditions for analytical functions. What is the sufficient condition for a function to be analytic ? 4+1=5

(ii) Show that $|z_1+z_2| \le |z_1|+|z_2|$ 3

(iii) Give Laurent series expansion for function $f(z)$. 2

(b) (i) What are symmetric and antisymmetric tensors ? Show that every tensor can be expressed as the sum of two tensors, one of which is symmetric and the other antisymmetric in a pair of co-varient or contravarient indices. 2+3=5

(ii) What is Kronecker delta ? Prove that Kronecker delta is a mixed tensor of second rank. 1+4=5

(c) (i) Define Laplace transform of a function $F(t)$. Show that

$L(1)=\dfrac{1}{s},\ s>0$ and

$L\left(e^{kt}\right)=\dfrac{1}{s-k},\ s>k$ 1+2+2=5

(ii) Find the inverse Laplace transform of

$$\frac{6}{2s-3}-\frac{3+4s}{9s^2-16}+\frac{8-6s}{16s^2+9}$$ 5

(d) Find the Fourier transform of

$$f(x)=\begin{cases}1-x^2, & |x|\le 1\\ 0 & |x|>1\end{cases}$$

Hence, evaluate :

$$\int_0^{\infty}\frac{x\cos x-\sin x}{x^3}\cos\frac{x}{2}dx$$

(e) Evaluate *any two* of the following integrals : 5×2=10

(i) $$\int_{-\infty}^{+\infty}\frac{\sin x}{x}\,dx$$

(ii) $$\int_0^{\infty}\frac{dx}{x^2+1}$$

(iii) $$\int_0^{2\pi}\frac{d\theta}{5+4\cos\theta}$$

(f) (i) The Laplace transform of $\sin 3t=\frac{3}{s^2+9}$ and the Laplace transform of $\cos 5t=\frac{s}{s^2+25}$. Find the Laplace transform of $5\sin 3t+3\cos 5t$ using linearity property of Laplace transform. 5

(ii) Find the inverse Laplace transform of $4s+5/(s-1)^2(s-2)$. 5

3 (Sem–4/CBCS) PHY HC2

2023

PHYSICS

(Honours Core)

Paper : PHY–HC–4026

(Elements of Modern Physics)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×7=7

   (a) What is the quantum of light ?

   (b) What is the momentum of an electron if its de Broglie wavelength is $1\,\mathring{A}$?

   (c) What is wave particle duality ?

   (d) Write *one* limitation of wave function ψ .

(e) Write the relation between half life and mean life of a radioactive sample.

(f) What is the radius of a nucleus of mass number 125 ?

(g) What is the function of a moderator in a nuclear reactor ?

2. Answer the following questions : 2×4=8

(a) Explain why Compton effect cannot be observed with visible light.

(b) The threshold wavelength of a metal is 6000 Å. Find the work function of the metal.

(c) What is the physical significance of a wave function ?

(d) Explain why pair production cannot take place in vacuum.

3. Answer ***any three*** questions from the following : 5×3=15

(a) Find the expression of minimum energy of a confined particle using uncertainty principle.

(b) Define commutator. Show that position and momentum operators do not commute. 1+4=5

(c) What is binding energy of a nucleus ? Draw a graph of binding energy per nucleon *vs* mass number of different nuclei. Write *one* conclusion that can be drawn from the graph. 2+2+1=5

(d) Write how magic numbers can be explained from nuclear shell model.

(e) What is α decay ? Explain fine structure of α energy spectrum. 1+4=5

4. Answer ***any three*** questions taking ***at least one*** from each group (maximum ***two*** questions from ***one*** group) : 10×3=30

GROUP–A

(a) What are phase velocity and group velocity ? Deduce the expressions of phase velocity and group velocity. Derive the relation between these velocities. 2+3+3+2=10

(b) Derive Schrödinger equation for a non-relativistic free particle.

(c) A particle of mass m and KE E is moving along positive X axis towards a finite potential step whose potential function is

$$V(x) = \begin{cases} 0 & \text{for } x < 0 \\ V_0 & \text{for } x > 0 \end{cases}$$

Show that for $E > V_0$ the incident particle has certain probability of being reflected and certain probability of being transmitted.

GROUP–B

(d) What are the different modes of beta decay ? Explain the nature of β particle spectrum. What are the difficulties in interpreting the spectrum ? 3+3+4=10

(e) Explain, in detail, the construction and different operating regions of a gas-filled detector. 3+7=10

(f) Explain the terms 'optical pumping' and 'population inversion'. Explain the three level pumping LASERS and mention *two* drawbacks of this type of LASER. 2+2+4+2=10

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3 (Sem–4/CBCS) PHY HC 3

2023

PHYSICS

(Honours Core)

Paper : PHY–HC–4036

(Analog Systems and Applications)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions as directed : 1×7=7

   (i) The random motion of holes and free electrons due to thermal agitation is called _____. *(Fill in the blank)*

   (ii) A photodiode is normally
   - *(a)* forward biased
   - *(b)* reverse biased
   - *(c)* emitting light
   - *(d)* neither forward nor reverse biased

   (Choose the correct option)

(iii) The voltage gain of a transistor connected in _____ arrangement is the highest.

(a) common base

(b) common collector

(c) common emitter

(d) None of the above

(Choose the correct option)

(iv) Which of the following amplifiers has the highest linearity and lowest distortion ?

(a) Class A

(b) Class B

(c) Class C

(d) Class AB

(Choose the correct option)

(v) In an RC phase-shift oscillator, the frequency determining elements are _____. *(Fill in the blank)*

(vi) Negative feedback in an OP-Amp increases the input impedance and bandwidth. *(Write True **or** False)*

(vii) A voltage follower has a voltage gain of _____. *(Fill in the blank)*

2. Give short answers of the following questions : 2×4=8

(i) How are potential barrier and depletion region formed in a *p-n* junction ?

(ii) Draw a capacitor filter circuit. How the value of capacitor is choosen in a shunt capacitor filter ?

(iii) In a CB transistor amplifier, if the collector current $I_C = 2\,mA$ and the base current $I_B = 0.04\,mA$, calculate the current amplification factors α and β respectively.

(iv) What are d.c and a.c load lines ? What do they specify ?

3. Answer the following questions : ***(any three)*** 5×3=15

(i) Draw a fixed biased circuit. Derive the expression for its stability factor. Mention the disadvantage of this circuit. 2+2+1=5

(ii) State Barkhausen criterion for self-sustained oscillations. Explain the conditions that must be satisfied for a sinusoidal oscillators to produce steady oscillations. 2+3=5

(iii) Write *two* advantages of negative feedback. The gain of an amplifier is 150. When negative feedback is applied, the voltage gain is reduced to 50. (a) Determine the percentage of feedback. (b) If the gain of the amplifier with feedback is 80, calculate the gain of the amplifier without feedback. 2+1½+1½=5

(iv) Write down the characteristics of an ideal Op-Amp. With the help of a circuit diagram, describe the non-inverting Op-Amp with feedback. 2+3=5

(v) Write short notes on : ***(any one)***

(a) Fullwave bridge rectifier

(b) Class AB amplifier

4. Answer the following questions : ***(any three)*** 10×3=30

(i) What are intrinsic and extrinsic semiconductors ? Define mobility of a charge carrier and mention its unit. Derive an expression for the conductivity of an extrinsic semiconductor in terms of the concentration n and P and the mobilities μ_n and μ_P. 2+2+6=10

(ii) Draw the circuit diagram of a fullwave rectifier and calculate its ripple factor and efficiency.

A halfwave rectifier uses an internal resistance $r_f = 20\,\Omega$. If the applied voltage is $V = 40 \sin \omega t$ and load resistance is 780 Ω, then find —

(i) I_m, I_{dc} and I_{rms} ;

(ii) ac power input and dc power input. (1+2+2)+(3+2)=10

(iii) State and explain the characteristics of CE transistor amplifier. What is meant by the leakage current in transistor ? Show that $I_C = \beta I_B + I_{CBO}$, where I_C, I_B and I_{CBO} are collector current, base current and collector to base leakage current respectively.

(1+2)+1+6=10

(iv) Draw a neat diagram of two stage RC coupled transistor CE amplifier. Derive the expression for the voltage gain of RC coupled amplifier for high frequency range by drawing its ac equivalent circuit. What is half-power frequency ? Why it is called 3 *db* frequency ?

2+6+2=10

(v) Explain how an OP-Amp can be used as (a) a summing amplifier, and (b) logarithmic amplifier.
A non-inverting amplifier has $R_1 = 20\,k\Omega$ and $R_f = 100\,k\Omega$. What would be the output voltage for an input voltage of $1\,V$ if the power supply voltage is $\pm 12\,V$?

(4+4)+2=10

(vi) Write short notes on : ***(any two)***

5×2=10

(a) Colpitt's oscillator

(b) Analog to digital converter

(c) Wien bridge oscillator

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