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3 (Sem–4/CBCS) PHY HC 1

2024

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. Answer the following questions : 1×7=7

   (a) What is the smallest positive integer n for which $\left(\frac{1+i}{1-i}\right)^n = 1$?

   (b) What is Argand diagram ?

   (c) State Taylor's theorem.

Contd.

(d) State convolution theorem of Fourier transform.

(e) Name *any two* branches of physics where tensors are applied.

(f) Find the Laplace transform of the function $f(t) = 1$.

(g) Write down the conditions for existence of Fourier transform.

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

(a) Express the following complex number in polar form and plot in Argand diagram

$$2 + 2\sqrt{3}\,i$$

(b) Find Laplace transform of the function

$$F(t) = 3e^{3t} + 5t^4 - 4\cos 2t$$

(c) Check whether the complex function $f(z) = \frac{1}{2}$ is analytic or not.

(d) Prove that $\partial_{ij}\varepsilon_{ijk} = 0$.

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

(a) Show that the real and imaginary parts of the function $w = \log z$ satisfy the Cauchy-Riemann equations when z is not zero. Find its derivative. 3+2=5

(b) Define Fourier transform of a function $f(x)$. Find Fourier transform of $e^{-x^2/2}$. What is your inference ? 1+3+1=5

(c) Evalute $\int_C (z - z^2)\,dz$, where C is upper half of the circle $|z| = 1$. What is the value of this integral if C is the lower half of the above circle ? 3+2=5

(d) Using Laplace transform, find the solution of the initial value problem

$$y'' + 9y = 6\cos 3t,\ y(0) = 2,\ y'(0) = 0$$

(e) What are raising and lowering of indices of a tensor? Prove that the two operations of raising and lowering the indices are reciprocal to each other.

2+3=5

4. Answer ***any three*** of the following questions :

10×3=30

(a) (i) Obtain the Cauchy-Riemann conditions for the function $f(z) = u + iv$ to be an analytic function where u and v are the functions of x and y. Are the conditions sufficient? 5+1=6

(ii) Find the first *three* terms of the Taylor series expansion of the complex variable function

$$f(z) = \frac{1}{z^2 + 4} \text{ about } z = -i. \quad 4$$

(b) Evaluate the following integrals using calculus of residues : ***(any two)***

5+5=10

(i) $\int_{-\infty}^{\infty} \frac{1}{(1+x^2)^2} dx$

(ii) $\int_0^{2\pi} \frac{d\theta}{5 - 4\sin\theta}$

(iii) $\int_0^{\infty} \frac{\sin x}{x} dx$

(c) State and prove Fourier integral theorem.

(d) (i) Applying change of scale theorem, find

$$L[\sin 3t].$$ 2

(ii) By the Laplace transform method, develop the formal solution of the differential equation which characterizes the motion of a damped harmonic oscillator. 8

(e) (i) Show that $\frac{\partial x^p}{\partial x^q} = \delta^p_q$ 1

(ii) Show that the components of kronecker delta δ^i_j do not change under coordinate transformation. 4

(iii) A covariant tensor has components xy, $2y - z^2$, xz in rectangular coordinates. Find its covariant components in spherical coordinates. 5

(f) (i) Find the inverse Laplace transform

$$\frac{2s^2 - 4}{(s+1)(s-2)(s-3)}$$ 6

(ii) State and prove the first shifting property of Laplace transform. 4

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3 (Sem–4/CBCS) PHY HC2

2024

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) Write down *any one* limitation of classical mechanics in explaining photoelectric effect.

   (b) Write down the dimension of Planck's constant.

   (c) Name an experiment that confirms particle nature of radiation.

   (d) Give one practical application of particle in a box.

(e) What are canonical conjugate pairs?

(f) Give one example of magic nuclei.

(g) Name the method used to achieve population inversion in Ruby laser.

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

(a) Write the basic assumptions of quantum theory of light.

(b) State the conditions for a well-behaved wave function.

(c) What is tunnelling? Mention any two applications of tunnelling.

(d) 99% of a radioactive element disintegrates in 36 hours. Calculate its half-life. (ln 2=0·693 and ln 100=4·605)

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

(a) What are phase velocity and group velocity? Write down the relation between phase velocity and group velocity. Show that, if the phase velocity is constant then group velocity is equal to the phase velocity. 2+1+2=5

(b) What are operators? Derive an expression for linear momentum operator. 2+3=5

(c) Draw the graph showing the variation of binding energy per nucleon with mass number. Illustrate the main features of the graph. 2+3=5

(d) Write down the semi-empirical mass formula explaining briefly each term involved. Write *any two* properties of nuclear force. 3+2=5

(e) State the law of radioactive decay. Derive the relation $N = N_0 e^{-\lambda t}$ (symbols have their usual meaning) for a radioactive substance. 2+3=5

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

(a) Explain Davisson and Germer experiment. What is the significance of the experiment? 8+2=10

Or

(b) State Heisenberg's uncertainty principle. Describe gamma ray microscope experiment. Calculate the uncertainty in momentum of an electron if the uncertainty in its position is 0·4 *nm*. (h= 6·62×10^{-34} $m^2 kg/sec$) 2+6+2=10

(c) Solve Schrödinger equation for a particle in a one-dimensional rigid box and obtain its eigenvalues. Find out an expression for zero point energy. Interpret the result. 7+2+1=10

(d) Distinguish between nuclear fission and fusion. What are the basic requirements for fusion reaction? Explain *any one* thermonuclear reaction which leads to the stellar energy. 2+2+6=10

(e) Discuss in detail the methods of energy loss by gamma photons in a medium.

(f) Distinguish between spontaneous and stimulated emission. Explain the working of He-Ne laser.

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3 (Sem–4/CBCS) PHY HC 3

2024

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) For a PN junction, barrier potential _____ with increase in junction temperature. *(Fill in the blank)*

(ii) Zener breakdown occurs in heavily-doped junction, whereas avalanche breakdown occurs in lightly-doped ones. *(Write True **or** False)*

(iii) LEDs emit light only when _____ biased. *(Fill in the blank)*

(iv) The leakage currents in a transistor are due to _____ carriers.

(Fill in the blank)

(v) Multistage amplifiers are used in order to achieve greater

(a) voltage gain

(b) power gain

(c) frequency response

(d) All of the above

(Choose the correct option)

(vi) For class *A* operation of an amplifier, *Q*-point is located at the ____ of the load line. *(Fill in the blank)*

(vii) The analog to digital converter are employed in

(a) voltmeter

(b) wattmeter

(c) energy meter

(d) digital multimeter

(Choose the correct option)

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

(i) Define ripple as referred to in a rectifier circuit. What is meant by filter?

(ii) What does common-mode rejection ratio (CMRR) of a differential amplifier physically signify? Express CMRR in dB form.

(iii) Draw a fixed-bias circuit of a transistor.

(iv) Explain the need for regulated power supply.

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

(i) The signals applied to be inverting and non-inverting terminals of a differential amplifier are $-0{\cdot}40\,mV$ and $-0{\cdot}42\,mV$ respectively. If the differential gain and the CMRR are 10^5 and $80\,dB$ respectively, find the total output voltage. 5

(ii) Explain with circuit diagram how an op-amp can be used as an adder or summing amplifier. 5

(iii) Define common-base current amplification factor (α) and common-emitter current amplification factor (β). Derive the relation between them. 2+3=5

(iv) Using h-parameter, draw the two-generator form of the equivalent circuit. Define the four h-parameters. Why are the h-parameters very useful for circuit analysis ? 2+2+1=5

(v) Write short notes on : 2½+2½=5

(a) Zener diode

(b) Solar cell

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

(i) Sketch the output characteristics of a transistor in its CB mode. Explain the active, cut-off and saturation regions.

A transistor in a CB mode, with $\alpha = 0{\cdot}98$ gives a reverse saturation current $I_{CBO} = 12\,\mu A$. When used in a CE mode, it gives the base current of $0{\cdot}2\,mA$. Calculate its total collector current in a CE mode. 6+4=10

(ii) Draw circuit diagram of a full-wave bridge rectifier and explain its operation. What are its ripple factor, maximum rectification efficiency and peak inverse voltage ? 7+3=10

(iii) Explain the term 'feedback'. What are positive and negative feedbacks ? Derive an expression for the voltage gain of an amplifier with feedback. Give the advantages of negative feedback.

2+2+3+3=10

(iv) Draw a circuit diagram of a single-stage CE transistor amplifier as well as its equivalent circuit. Derive the expressions for current gain and voltage gain of such an amplifier.

4+6=10

(v) With the help of a neat diagram, explain the working of a weighted registor DAC. What are its advantages and disadvantages ? Write any two major applications of D/A converters.

4+(2+2)+2=10

(vi) Write short notes on : ***(any two)*** 5×2=10

(a) RC phase-shift oscillator

(b) Hartley oscillator

(c) Logarithmic amplifier using OPAMP

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