1A (Sem–1/ITEP) PHY01 MJ

2025

PHYSICS

(Major)

Paper : PHY0100104–N

(Mathematical Physics and Mechanics)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : 1×5=5

   (a) What is the value of the curl of the gradient of a scalar field ϕ.

   (b) If $\delta(x)$ is an even function of x, then find the value of $\delta(-x)$.

   (c) Define gravitational potential.

   (d) What is the difference between elastic and inelastic collision ?

   (e) State work-energy theorem.

2. Answer the following questions : ***(any five)*** 2×5=10

(a) Find $\vec{\nabla}\phi$ if $\phi = \frac{1}{r}$, $\vec{r}$ being the position vector.

(b) Show that the vector field $\vec{F} = 2x\left(y^2 + z^3\right)i + 2x^2yj + 3x^2z^2k$ is conservative.

(c) What is the value of

$\int_{-\infty}^{\infty} f(x)\,\delta(x-a)\,dx$? Evaluate

$\int_{-\infty}^{\infty} e^{-5t}\,\delta(t-2)\,dt$.

(d) Three particles of masses $1kg$, $2kg$, and $3kg$ are placed at $0m$, $2m$, and $4m$ respectively. Find the centre of mass.

(e) Define Impulse.

(f) State the theorem of perpendicular axes.

(g) Why is friction considered as non-conservative force ?

(h) State the limitations of Hooke's law.

(i) A circular disc of mass $0.5kg$ and radius $0.1m$ is making 60 revolutions per minute about an axis passing through its centre and perpendicular to its plane. Calculate its kinetic energy.

(j) On what factors does the twisting torque of a wire depend ?

3. Answer the following questions : ***(any four)*** 5×4=20

(a) Define gradient of a scalar function. Find the directional derivative of $\phi = x^2yz + 4xz^2$ at $(1, -2, -1)$ in the direction of $(2i - j - 2k)$.

(b) Define solenoidal and irrotational vectors. Prove that $\left(y^2 - z^2 + 3yz - 2x\right)\hat{i} + (3xz + 2xy)\hat{j} + (3xy - 2xz + 2z)\hat{k}$ is both solenoidal and irrotational.

(c) (i) If $\vec{A} = \left(3x^2 + 6y\right)\hat{i} - 14yz\hat{j} + 20xz^2\hat{k}$, evaluate the line integral $\oint \vec{A}.\vec{dr}$ from (0, 0, 0) to (1, 1, 1) along the curve C and $x = t$, $y = t^2$, $z = t^3$.

(ii) Prove that div curl $\vec{A} = 0$. 3+2=5

(d) Prove that $\vec{\nabla} \times \left(\vec{A} + \vec{B}\right) = \vec{\nabla} \times \vec{A} + \vec{\nabla} \times \vec{B}$.

(e) A body moving in central field follows a trajectory given by $r = a\cos\theta$. Find the law of force.

(f) Derive the expression for fictitious forces which comes into play in uniformly rotating frame of reference.

(g) In case of an inelastic collision between two bodies in one dimension, obtain the expression for final velocity and the loss of kinetic energy.

(h) Derive Poiseuille's equation for the steady flow of a liquid through a capillary tube.

4. Answer the following questions : ***(any one)*** 10×1=10

(a) Define Stokes' theorem and mention its significance. Evaluate

$$\int_C \left[(2x-y)\,dx - yz^2 dy - y^2 z\,dz\right]$$

where C is the circle $x^2+y^2=1$, corresponding to the surface sphere of unit radius. 3+2+5=10

(b) Prove that a cylindrical coordinate system is orthogonal. Represent the vector $\vec{A} = z\hat{i} - 2x\hat{j} + \hat{y}k$ in cylindrical coordinates. 5+5=10

(c) Derive the expression for moment of inertia of both the solid sphere and spherical shell (a) about the diameter and (b) about a tangent.

(d) Derive the expression for finding gravitational potential and field due to a solid sphere at a point (a) outside the shell (b) at the surface of the sphere (c) inside the shell.

Total number of printed pages–7

1A (Sem–1/ITEP) PHY02 MJ

2025

PHYSICS

(Major)

Paper : PHY0100204–N

(Analog Electronics)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : 1×5=5

   (a) What happens to the depletion width when a diode is forward biased ?

   (b) What is the order of magnitude of barrier potential for a *Si* diode at room temperature ?

(c) A solar cell works on _____ .

(d) Give the relation between β and α for a transistor.

(e) Write a few characteristics of an OPAM.

2. Answer ***any five*** questions : 2×5=10

(a) Compare the half-wave and full-wave rectifier on the basis of following with a brief explanation in each case : *(i)* peak alternating current, *(ii)* d.c. output power, *(iii)* efficiency, and *(iv)* ripple factor.

(b) Explain the working principle of a Zener diode as a voltage regulator with necessary circuit diagram.

(c) Write *one* method for the fabrication of $p-n$ junction diode.

(d) β of a transistor is 99. Calculate the collector current when the emitter current is $5mA$.

(e) What is the working principle of a photodiode ?

(f) An amplifier has a voltage gain of 1000. If the negative feedback is applied to the input circuit the voltage gain reduces to $\frac{1}{10}$th of its value without feedback. Find the fraction output that is fed back to the input.

(g) Define *Q*-point of a transistor. How is it located ?

(h) The tuned collector circuit used in the local oscillator of a radio receiver makes use of an LC tuned circuit with $L = 58.6\mu H$ and $C = 300\,pF$. Calculate the frequency of oscillations.

(i) What is the effect of temperature on $I-V$ characteristic of a $p-n$ junction?

(j) Calculate the actual output voltage of an integrator after 2 *sec* for the input voltage of $1V$ d.c. Given that input resistance = $100k\Omega$ and feedback capacitance $1\mu F$.

3. Answer ***any four*** questions : 5×4=20

(a) Draw the block diagram of a regulated power supply. Explain the function of each block.

(b) Write the diode equation of a $p-n$ junction diode. Using this equation calculate the static and dynamic resistance of a $p-n$ junction germanium diode if the room temperature is $27°C$ and reverse saturation current $I_s = 1\mu A$ when a forward bias of $0.2V$ is applied. 1+4=5

(c) Describe the positive and negative feedback in an amplifier. Derive an expression for voltage gain A_f when subjected to negative feedback with proper circuit diagram.

(d) What is a rectifier? What is the need of a rectifier? Explain the working principle of a half-wave rectifier. 1+1+3=5

(e) Describe an inverting and non-inverting amplifier. An inverting amplifier has $R_1 = 20k\Omega$ and $R_f = 100k\Omega$. Find the output voltage, input resistance and the input current for an input voltage of $1V$. 3+2=5

(f) What is an oscillator? State and explain Barkhausen criterion for sustained oscillations. 2+3=5

(g) Discuss how a cathode ray oscilloscope may be used to measure the phase difference between two a.c. signals of the same frequency and amplitude.

(h) Describe how an OPAM may be used as (a) integrator and (b) differentiator.

4. Answer ***any one*** question : 10

(a) What are extrinsic semiconductors? Describe $n-$type and $p-$type semiconductors clearly explaining the term 'donor' and 'acceptor'. What are majority and minority charge carriers in each type of semiconductor? Draw energy level diagrams for $n-$type and $p-$type semiconductors. 2+2+2+1+1+2=10

(b) Derive expression for barrier potential of a $p-n$ junction.

(c) Write the working principle of a full-wave rectifier (centre tapped) with a schematic diagram. Show that ripple factor for a half-wave rectifier is 1.21. 5+5=10

(d) Define hybrid parameters. Obtain expression for current gain and voltage gain of an amplifier in terms of h-parameters. 5+5=10

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