2021

(Held in 2022)

PHYSICS

(Major)

Paper : 1·1

Full Marks : 60

Time : Three hours

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

GROUP–A

(Mathematical Methods)

Marks : 20

1. *(a)* The co-ordinates of the two points P and Q are (3, 4, –6) and (1, –2, 3). Find PQ. 2

(b) What is the geometrical interpretation of the vector product of two vectors ? 2

(c) Show that $\frac{d}{dt}\left(\bar{f}\times\frac{d\bar{f}}{dt}\right)=\bar{f}\times\frac{d^2\bar{f}}{dt^2}$ 2

(d) Show that $\text{grad}\left(\frac{1}{r}\right)=-\frac{\bar{r}}{r^3}$ 2

(e) Find a unit vector normal to the surface $z=x^2+y^2$ at the point (1, 2, 5). 2

2. (a) The position vector of a particle is $\bar{r}=6\hat{i}m$ and its velocity is

$$\bar{v}=\left(3\hat{i}+5\hat{j}\right)m/s.$$

Find (i) $\bar{r}.v$, and (ii) $\bar{r}\times\bar{v}$. 3

(b) Prove that if $\bar{a}$ and $\bar{b}$ are two proper non-collinear vectors and p and q are two scalars such that $p\bar{a}+q\bar{b}=0$, then $p=q=0$. 3

(c) Prove that

$$\left[\bar{A}\times\left(\bar{B}\times\bar{C}\right)\right]+\left[\bar{B}\times\left(\bar{C}\times\bar{A}\right)\right]+\left[\bar{C}\times\left(\bar{A}\times\bar{B}\right)\right]=0$$

4

Or

3. (a) Show that $\nabla(u+v)=\nabla u+\nabla v$. 2

(b) Electric field in a region is zero. What would you conclude about electric potential ? 2

(c) Define curl of a vector. Show that when a body is in motion, the curl of its linear velocity v at any point is twice the angular velocity. 1+5=6

GROUP–B

(Mechanics)

Marks : 40

4. *(a)* State work energy theorem. 1

(b) Name the fictitious force obtained in the rotating frame of reference. 1

(c) Give *one* property of a conservative force. 1

(d) "When a rotating body contracts, its angular velocity increases." Give reason. 1

(e) Write the physical interpretation of moment of inertia. 1

(f) Can we have equipotential surfaces of the gravitational field of a point mass ? 1

5. *(a)* Prove that force $F = x^2yz\hat{i} - xyz^2\hat{k}$ is a non-conservative force. 2

(b) Show that the inertial masses and gravitational masses are equivalent to each other. 2

6. Answer ***any two*** questions : 5×2=10

(a) Find the gravitational potential at an outside point of a spherical shell.

(b) State and prove the parallel axis theorem in moment of inertia.

(c) Find the C.M. of a semicircular disc of radius *r*.

7. Answer ***any two*** questions : 10×2=20

(a) *(i)* What do you mean by inertial and non-inertial frame of references ? 2

(ii) A frame of reference *a* rotates with respect to another reference *b* with uniform angular velocity ω. Show that the fictious force appearing in the accelerated frame of reference can be expressed as a combination of Coriolis force and centrifugal force. 8

(b) (i) Show that the relationship between the angular momentum relative to C.M. frame of reference of a system of particles and the angular momentum relative to the laboratory frame is given by

$$\bar{L} = \bar{L}_{CM} + \bar{r}_{CM} \times \bar{P}$$ 6

(ii) A body of mass 0.2 *kg* is revolving along a circular path of radius 1 *m* with a frequency 4 *Hz*. Determine the magnitude of orbital angular momentum. 4

(c) Show that if a heavy (moving) particle collides elastically with a lighter particle at rest, the particle can never be scattered perpendicular to the initial direction. 10

(d) Write the difference between a simple pendulum and a compound pendulum. Derive an expression for time period in a compound pendulum. Show that the centre of suspension and centre of oscillation for a compound pendulum are interchangeable. 2+5+3=10

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6. *(a)* Explain coma in case of aberration in optics. 2

Or

(b) What is achromatic doublet ? 2

7. *(a)* Establish the refraction matrix for refraction of a ray of light at a spherical surface separating media of refractive indices n_1 and n_2. 5

Or

(b) Find the condition of achromatism of two thin lenses separated by a small distance. 5

8. Answer ***either*** *(a)* ***or*** *(b)* :

(a) *(i)* Using Fermat's principle, establish the laws of reflection of light at a plane surface. 5

(ii) Obtain the conjugate foci relation for refraction at a single spherical surface with pole as origin. 5

Or

(b) Deduce Helmholtz equation showing the relation between linear and angular magnification of two conjugate planes in an optical system. Indicate how the equation is modified *(i)* when one of the conjugate planes is at infinity, and *(ii)* when the system is telescopic. 6+2+2=10

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3 (Sem–1) PHY M2

2021

(Held in 2022)

PHYSICS

(Major)

Paper : 1·2

(Waves, Oscillations and Ray Optics)

Full Marks : 60

Time : Three hours

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

SECTION–I

(Marks : 40)

1. Answer the following questions : 1×4=4

(a) What is reverberation of sound ?

(b) What is the phase difference between velocity and acceleration of a particle executing SHM ?

(c) What is the ratio between the intensities of first and third harmonics produced in a string plucked at the midpoint ?

(d) What simplification is obtained in the Fourier series if the function is odd ?

2. *(a)* What is sharpness of resonance? Explain the effect of damping on the sharpness of resonance. 2

(b) A particle is executing SHM of period 4 *sec* amplitude 5 *m*. Find the velocity when the particle is 2 *m* away from the mean position. 2

(c) Write the properties of stationary waves. 2

3. Answer ***any two*** questions : 5×2=10

(a) Derive the expression for average energy density of a plane progressive wave. 5

(b) What is velocity resonance? Show that at velocity resonance the maximum velocity is inversely proportional to the damping. 5

(c) Show that the acoustic intensity for a plane wave is the product of the r.m.s. sound pressure and the r.m.s. particle velocity. 5

4. *(a)* State Fourier theorem. Analyse with the help of Fourier theorem a square periodic wave given by

$y = A$ (constant) for $0 \le t \le \frac{T}{2}$

$= 0$ for $\frac{T}{2} \le t \le T$

Also plot the Fourier synthesis with first four terms. 2+6+2=10

Or

(b) Derive an expression for growth and decay of the acoustic energy density with time in an enclosure. Give Sabine's definition of reverberation time. 8+2=10

(c) Obtain the differential equation for the transverse vibration of a stretched string. Solve the differential equation by the method of separation of variables. 5+5=10

Or

(d) Two simple harmonic motions act simultaneously on a particle at right angles to each other. Show that the path of the particle will be an ellipse when the two motions have the same period but different amplitudes and initial phases. What happens when the phase difference between the motions are *(i)* 0, and *(ii)* $\frac{\pi}{2}$? 6+(2+2)=10

SECTION–II

(Marks : 20)

5. *(a)* What is Fermat's principle? 1

(b) What is circle of least confusion? 1

(c) What are conjugate foci? 1