2021/TDC/CBCS/ODD/
PHSHCC–101T/147

TDC (CBCS) Odd Semester Exam., 2021
held in March, 2022

PHYSICS

(1st Semester)

Course No. : PHSHCC–101T

(Mathematical Physics—I)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer any *ten* of the following questions : 2×10=20

1. Find the values of x, y and z which satisfy the matrix equation

$$\begin{bmatrix} x+3 & 2y+x \\ z-1 & 4a-6 \end{bmatrix} = \begin{bmatrix} 0 & -7 \\ 3 & 2a \end{bmatrix}$$

2. If

$$A = \begin{bmatrix} 0 & 1 & 2 \\ 1 & 2 & 3 \\ 2 & 3 & 4 \end{bmatrix} \text{ and } B = \begin{bmatrix} 1 & -2 \\ -1 & 0 \\ 2 & -1 \end{bmatrix}$$

then obtain the product AB.

3. What do you mean by 'order' and 'degree' of a differential equation?

4. Find the area of the parallelogram whose adjacent sides are $\hat{i} - 2\hat{j} + 3\hat{k}$ and $2\hat{i} + \hat{j} - 4\hat{k}$.

5. Find the volume of the parallelopiped if $\vec{a} = -3\hat{i} + 7\hat{j} + 5\hat{k}$, $\vec{b} = -3\hat{i} + 7\hat{j} - 3\hat{k}$ and $\vec{c} = 7\hat{i} - 5\hat{j} - 3\hat{k}$ are the three coterminous edges of the parallelopiped.

6. At any point of the curve $x = 3\cos t$, $y = 3\sin t$, $z = 4t$, find the tangent vector.

7. If a force $\vec{F} = 2x^2 y\hat{i} + 3xy\hat{j}$ displaces a particle in the xy-plane from (0, 0) to (1, 4) along a curve $y = 4x^2$, then find the work done.

8. Evaluate by Stokes' theorem

$$\oint_C (yzdx + zxdy + xydz)$$

where C is the curve $x^2 + y^2 = 1$, $z = y^2$.

9. State Green's theorem.

10. Write the expression for line element in spherical polar coordinate system.

11. Write the expression for volume element in cylindrical coordinate system.

12. Write the expression for gradient of a scalar function in cylindrical coordinate system.

13. Define the term 'constant error' and give a suitable example.

14. The temperatures of two bodies measured by a thermometer are given by $T_1 = (20 \pm 0\cdot5)°C$ and $T_2 = (50 \pm 0\cdot5)°C$. Calculate the temperature difference and error therein.

15. What do you mean by least square fit method?

SECTION—B

Answer any *five* of the following questions : 6×5=30

16. *(a)* If

$$A = \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix}$$

then show that $A^2 - 4A - 5I = 0$ where I and 0 are unit matrix and null matrix of order 3 respectively. 3

(b) If

$$A = \frac{1}{9}\begin{bmatrix} -8 & 1 & 4 \\ 4 & 4 & 7 \\ 1 & -8 & 4 \end{bmatrix}$$

then prove that $A^{-1} = A'$, A' being the transpose of A. 3

17. (a) Solve the following differential equation by the method of integrating factor

$$(x^3 - x)\frac{dy}{dx} - (3x^2 - 1)y = x^5 - 2x^3 + x$$ 3

(b) Solve the differential equation

$$(2xy + x^2)dy = (3y^2 + 2xy)dx$$ 3

18. (a) Find m so that the vectors $2\hat{i} - 4\hat{j} + 5\hat{k}$, $\hat{i} - m\hat{j} + \hat{k}$ and $3\hat{i} + 2\hat{j} - 5\hat{k}$ are coplanar. 3

(b) Let $\vec{a} = \hat{i} + \hat{j} - \hat{k}$, $\vec{b} = \hat{i} - \hat{j} + \hat{k}$, $\vec{c} = \hat{i} - \hat{j} - \hat{k}$. Find the vector $\vec{a} \times (\vec{b} \times \vec{c})$. 3

19. (a) If $\frac{d\vec{a}}{dt} = \vec{u} \times \vec{a}$ and $\frac{d\vec{b}}{dt} = \vec{u} \times \vec{b}$, then prove that $\frac{d}{dt}(\vec{a} \times \vec{b}) = \vec{u} \times (\vec{a} \times \vec{b})$. 3

(b) If $\phi = 3x^2y - y^3z^2$, then find grad ϕ at the point $(1, -2, -1)$. 3

20. (a) If $\vec{F} = 2y\hat{i} - z\hat{j} + x\hat{k}$, then evaluate $\int_C \vec{F} \times d\vec{r}$ along the curve $x = \cos t$, $y = \sin t$, $z = 2\cos t$ from $t = 0$ to $t = \frac{\pi}{2}$. 3

(b) A vector field is given by $\vec{F} = (\sin y)\hat{i} + x(1 + \cos y)\hat{j}$. Evaluate the line integral over a circular path $x^2 + y^2 = a^2$, $z = 0$. 3

21. (a) Using Green's theorem, evaluate $\int_C (x^2 y dx + x^2 dy)$ where C is the boundary described counter-clockwise of the triangle with vertices $(0, 0)$, $(1, 0)$, $(1, 1)$. 3

(b) Using Stokes' theorem, evaluate $\int_C [(2x - y)dx - yz^2 dy - y^2 z dz]$ where C is the circle $x^2 + y^2 = 1$ corresponding to the surface of the sphere of unit radius. 3

22. (a) Find the expression for $\nabla^2 \phi$ in orthogonal curvilinear coordinate system. 3

(b) If $u = 2x + 3$, $v = y - 4$, $w = z + 2$ and $\vec{r}$ be the position vector, i.e., $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$, then show that $\frac{\partial \vec{r}}{\partial u}$, $\frac{\partial \vec{r}}{\partial v}$ and $\frac{\partial \vec{r}}{\partial w}$ are mutually orthogonal. 3

23. *(a)* Use the Newton-Raphson method to find a root of the equation $x^3 - 2x - 5 = 0$. 3

(b) Evaluate

$$I = \int_0^1 \frac{1}{1+x} dx$$

correct to three decimal places using Simpson rule with $h = 0 \cdot 125$. 3

24. *(a)* Discuss the different types of systematic errors associated with a measurement. 3

(b) What is random error?

The period of oscillation of a simple pendulum is

$$T = 2\pi \sqrt{\frac{L}{g}}$$

The measured value of L is 20·0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 sec using a wrist watch of 1 sec resolution. What is the accuracy in the determination of g? 1+2=3

25. *(a)* Define standard error and probable error. What are the rules of testing the significance of correlation? 2+1=3

(b) If two resistors of resistances

$R_1 = (5 \pm 0 \cdot 1)$ ohm and $R_2 = (10 \pm 0 \cdot 2)$ ohm

are connected in *(i)* series and *(ii)* parallel, then find the equivalent resistance in each case with limits of percentage error. 1½+1½=3

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TDC (CBCS) Odd Semester Exam., 2021 held in March, 2022

PHYSICS

(1st Semester)

Course No. : PHSHCC–102T

(Mechanics)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer any *ten* of the following questions : $2\times10=20$

1. Define stable and unstable equilibrium.

2. What are conservative and non-conservative forces?

3. Write two differences between elastic and in-elastic collision.

4. Define angular momentum. How is it related with torque?

5. State and prove the law of conservation of angular momentum.

6. Explain why hollow shafts are preferred over solid ones for transmitting large torques in a rotating machinery.

7. Differentiate between inertial mass and gravitational mass.

8. Calculate gravitational potential on the surface of a spherical shell.

9. Assuming the earth to be a sphere of radius R, show that gravitational field intensity and potential at any point on the earth's surface can be expressed as g and gR respectively, where g is the acceleration due to gravity.

10. If the displacement of a moving point at any instant of time t is given by

$$x = a\cos\omega t + b\sin\omega t$$

where a and b are constants and ω = angular frequency. Show that the motion is simple harmonic.

11. What is meant by simple harmonic motion? Mention some of its properties.

12. What is Coriolis force? Mention its one application.

13. Show that the length is invariant under Galilean transformation.

14. State the postulates of special theory of relativity.

15. Write a short note on relativistic time dilation.

SECTION—B

Answer any *five* of the following questions : 6×5=30

16. Show that the trajectory of a projectile fired at an angle with the horizontal direction is parabolic in nature. Find an expression for the horizontal range.

17. *(a)* State and prove work-energy theorem. 4

(b) Show that force can be expressed as the negative gradient of the potential. 2

18. Define moment of inertia and radius of gyration. Find the moment of inertia of a solid cylinder about an axis passing perpendicularly through the middle of its length. 2+4=6

19. Define Young's modulus, rigidity modulus and Poisson's ratio. Obtain the relation $Y = 2\eta(1+\sigma)$, where $Y =$ Young's modulus, $\eta =$ rigidity modulus and $\sigma =$ Poisson's ratio. 2+4=6

20. Define gravitational potential. Show that the gravitational at the centre of a solid sphere is $\frac{3}{2}$ times that on the surface. 2+4=6

21. *(a)* Give a brief description of GPS. 2

(b) Obtain Kepler's 3rd law from Newton's law of gravitation. 4

22. *(a)* Obtain the differential equation of SHM and solve it. 4

(b) Show that total energy is conserved during simple harmonic motion. 2

23. Obtain the transformation equation for potential velocity for a uniformly rotating frame of reference. Show that such a frame is non-inertial in nature.

24. What is the meaning of mass-energy equivalence? Obtain Einstein's mass-energy relation. Show that 1 a.m.u. = 931 MeV. 2+3+1=6

25. Describe the Michelson-Morley experiment and explain the physical significance of the negative result.

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