T.Y.B.Sc. PHYSICS

PHY 3501-Mathematical Methods of Physics-II

Question Bank

1) Chapter I : Curvilinear Coordinate Surfaces

A) Short Answer Type Questions

1. What is coordinate system
2. Explain the necessity of a coordinate system
3. Explain the Cartesian coordinate system
4. Explain the Spherical poral coordinate system
5. Explain the Cylindrical coordinate system
6. Set up the transformation equations for Cartesian coordinate system and Spherical poral coordinate system
7. Set up the transformation equations for Cartesian coordinate system and Cylindrical coordinate system
8. Explain what is meant by a general curvilinear coordinate system
9. Define the terms i) Coordinate surface ii) Coordinate Curve iii) Coordinate lines iv) Coordinate axes V) Metric coefficient VI) Scale coefficient
10. Draw a net diagram to show the coordinate surfaces, Coordinate curves or lines in spherical polar coordinate system
11. Draw a net diagram to show the coordinate surfaces, Coordinate curves or lines in Cylindrical system
12. Draw a net diagram to show the volume element in Cylindrical system
13. Draw a net diagram to show the volume element in spherical polar coordinate system

B) Long Answer Type Questions

1. Obtain unit vectors in spherical polar coordinate
2. Obtain unit vector s in Cylindrical system
3. Show that Cylindrical system is orthogonal
4. Show that Spherical polar is orthogonal
5. Obtain unit vectors in spherical polar coordinates in terms of Cartesian unit vectors
6. Obtain unit vectors in Cylindrical coordinates in terms of Cartesian unit vectors
7. Establish the expression for the square of the arc length in the general curvilinear coordinates
8. Determine metric coefficients and the scale factors in the spherical polar coordinates
9. Determine metric coefficients and the scale factors in the Cylindrical coordinates
10. Derive the expression for the volume element in Cartesian coordinate system

11. Derive the expression for the volume element in Cylindrical coordinate system
12. Derive the expression for the volume element in Spherical poral coordinate system
13. Obtain expression for gradient , Divergence , Curl and Laplacian in Cartesian coordinate
14. Obtain expression for gradient , Divergence , Curl and Laplacian in Cylindrical coordinate
15. Obtain expression for gradient , Divergence , Curl and Laplacian in Spherical poral coordinate system

C) Multiple Choose Questions

1. The cylindrical coordinate system is also referred to as
   a) Cartesian system
   b) Circular system
   c) Spherical system
   d) Space system
2. Transform the vector B=yi+(x+z)j located at point (-2,6,3) into cylindrical coordinates.
   a) (6.325,-71.57,3)
   b) (6.325,71.57,3)
   c) (6.325,73.57,3)
   d) (6.325,-73.57,3)
3. Cylindrical systems have the following scalar values respectively
   a) 1, ρ ,1
   b) 1, 1, 1
   c) 0,1,0
   d) 1,0,0
4. A charge located at point p $(5,30^0,2)$ is said to be in which coordinate system?
   a) Cartesian system
   b) Cylindrical system
   c) Spherical system
   d) Space system
5. Cylindrical system is employed in waveguides. State True/False.
   a) True
   b) False
6. The pressure inside a piston cylinder is a variable of
   a) Radius
   b) Plane angle
   c) Z plane distance
   d) Constant, not a variable
7. Transform the spherical system B = (10/r)i + (10cos θ)j + k into cylindrical form at (5, π/2, -2)

a) 2.467i + j + 1.167k
b) 2.467i – j + 1.167k
c) 2.467i – j – 1.167k
d) 2.467i + j – 1.167k

8. Convert the given rectangular coordinates A(2,3,1) into corresponding cylindrical coordinates
a) (3.21,56.31,1)
b) (3.21,57.31,0)
c) (3.61,57.31,0)
d) (3.61,56.31,1)

2) Chapter II: Special theory of Relativity

A. Short Answer Type Questions

1. What do you understand by frame of reference ?
2. What id inertial frame?
3. What id non- inertial frame ?
4. What is Newtonian principle of relativity?
5. What are Galilean transformations ?
6. State the Lorentz transformation equations
7. State the postulates of theory of relativity
8. What do you understand by time dilation?
9. Explain the term observer in relativity
10. What is mean by mass – energy equivalence?
11. Write down the expression for kinetic energy of a body
12. Show that for smaller speed relativistic KE reduces to Classical expression
13. Prove that when v<< c , Lorentz transformations reduce to Galilean transformation
14. Does mass of a substance increases on melting ? Why?
15. At what velocity does the KE of a particle equal its rest energy?
16. Explain term The concept of simultaneity of two events is relative.
17. If a particle could move with the velocity of light , How much KE it possess?
18. Explain terms , Space -like, Time -like , and light – like intervals
19. Show that the velocity of light is not affected by compounding it with any other velocity less than it.

B. Long Answer Type Questions

1. Derive the Lorentz transformation equations which connect the coordinates between two inertial fame of references.
2. Show that the expression $x^2 + y^2 + z^2 = c^2$ is invariant under Lorentz transformation equations.
3. Describe Michelson -Morley experiment and explain the physical significance of negative results

4. Show that the interval between two events is an invariant quantity under the Lorentz transformation.
5. Derive the relativistic law of addition of two velocities.
6. Derive expression of length contraction on the basis of the Lorentz transformation equations.
7. What do you understand time dilation ? Discuss the variation of time with velocity according to special theory of relativity
8. Explain with example , proper time and nonproper time.

9. Prove that four dimensional volume element dxdydz is invariant under Lorentz transformation.
10. Derive expression for a relativistic particle
11. Derive the relativistic expression for kinetic energy of a particle.
12. Prove that momentum of the particle is given by $p = EV/c^2$
13. Prove that $E^2 - p^2c^2$ is invariant under Lorentz transformation
14. What do you mean by Makowskis space
15. Explain and give examples of four vectors

C. Multiple Choose Questions

1. The Michelson-Morley experiment was designed to measure

   a. The relativistic mass of the electron.
   b. The relativistic energy of the electron.
   c. The velocity of the Earth relative to the ether.
   d. The acceleration of gravity on the Earth's surface.

2 T You can build an interferometer yourself if you use the following components:

   a. A light source, a detector screen, a partially silvered mirror, a flat mirror, and a glass plate.
   b. A light source, a detector screen, two partially silvered mirrors, and a glass plate.
   c. A light source, a detector screen, two partially silvered mirrors, a flat mirror, and a glass plate.
   d. A light source, a detector screen, a partially silvered mirror, two flat mirrors, and a glass plate.

3 The theory of special relativity

   a. Is based on a complex mathematical analysis.
   b. Has not been verified by experiment.
   c. Does not agree with Newtonian mechanics.
   d. Does not agree with electromagnetic theory.

4 One of Einstein's postulates in formulating the special theory of relativity was that the laws of physics are the same in reference frames that

- **a.** Accelerate.
- **b.** Move at constant velocity with respect to an inertial frame.
- **c.** Oscillate.
- **d.** Are stationary, but not in moving frames.

5 If you were to measure your pulse rate while in a spaceship moving away from the Sun at a speed close to the speed of light, you would find that it was

- **a.** Much faster than normal.
- **b.** Much slower than normal.
- **c.** The same as it was here on Earth.

6 Relative to a stationary observer, a moving clock

- **a.** Always runs slower than normal.
- **b.** Always runs faster than normal.
- **c.** Keeps its normal time.
- **d.** Can do any of the above. It depends on the relative velocity between the observer and the clock.

7 Suppose one twin takes a ride in a space ship traveling at a very high speed to a distant star and back again, while the other twin remains on Earth. The twin that remained on Earth predicts that the astronaut twin is

- **a.** Younger.
- **b.** The same age
- **c.** Older.
- **d.** Cannot be determined from the given information

8 Relative to a stationary observer, a moving object

- **a.** Appears shorter than normal.
- **b.** Appears longer than normal.
- **c.** Keeps its same length time.
- **d.** Can do any of the above. It depends on the relative velocity between the observer and the object.

9 An object moves in a direction parallel to its length with a velocity that approaches the velocity of light. The width of this object, as measured by a stationary observer

- **a.** Approaches infinity.
- **b.** Approaches zero.
- **c.** Increases slightly.
- **d.** Does not change.

10 An object moves in a direction parallel to its length with a velocity that approaches the velocity of light. The length of this object, as measured by a stationary observer,

- **a.** Approaches infinity.
- **b.** Approaches zero.
- **c.** Increases slightly.
- **d.** Does not change.

11 As the speed of a particle approaches the speed of light, the mass of the particle

- **a.** Increases.
- **b.** Decreases.
- **c.** Remains the same.
- **d.** Approaches zero.

12 As the speed of a particle approaches the speed of light, the momentum of the particle

- **a.** Increases
- **b.** Decreases.
- **c.** Remains the same.
- **d.** Approaches zero.

13 A spear is thrown by you at a very high speed. As it passes, you measure its length at one-half its normal length. From this measurement, you conclude that the moving spear's mass must be

- **a.** One-half its rest mass.
- **b.** Twice its rest mass.
- **c.** Four times its rest mass.
- **d.** None of the given answers

14 What happens to the kinetic energy of a speedy proton when its relativistic mass doubles?

- **a.** It doubles.
- **b.** It more than doubles.
- **c.** It less than doubles.
- **d.** It must increase, but it is impossible to say by how much.

15 What happens to the total relativistic energy of a speedy proton when its relativistic mass doubles

- **a.** It doubles.
- **b.** It more than doubles
- **c.** It less than doubles.

d. It must increase, but it is impossible to say by how much.

16 Consider two spaceships, each traveling at 0.50c in a straight line. Ship A is moving directly away from the Sun and ship B is approaching the Sun. The science officers on each ship measure the velocity of light coming from the Sun. What do they measure for this velocity?

a. Ship A measures it as less than c, and ship B measures it as greater than c.
b. Ship B measures it as less than c, and ship A measures it as greater than c.
c. On both ships it is measured to be less than c.
d. On both ships it is measured to be exactly c.

17 Which of the following depends on the observer's frame of reference?

a. The mass of the proton
b. The length of a meter stick
c. The half-life of a muon
d. All of the given answers

18 As the velocity of your spaceship increases, you would observe

a. That your precision clock runs slower than normal.
b. That the length of your spaceship has decreased.
c. That your mass has increased.
d. All of the given answers
e. None of the given answers

19 A boat can travel 4.0 m/s in still water. With what speed, relative to the shore, does it move in a river that is flowing at 1.0 m/s if the boat is heading upstream?

a. 3.0 m/s
b. 4.1 m/s
c. 4.8 m/s
d. 5.0 m/s

20 A boat can travel 4.0 m/s in still water. With what speed, relative to the shore, does it move in a river that is flowing at 1.0 m/s if the boat is heading downstream?

a. 3.0 m/s
b. 4.1 m/s
c. 4.8 m/s
d. 5.0 m/s

21 A boat can travel 4.0 m/s in still water. With what speed, relative to the shore, does it move in a river that is flowing at 1.0 m/s if the boat is heading straight across the river

a. 3.0 m/s
b. 4.1 m/s
c. 4.8 m/s
d. 5.0 m/s

22 Fast should a moving clock travel if it is to be observed by a stationary observer as running at one-half its normal rate?

a. 0.50c
b. 0.65c
c. 0.78c
d. 0.87c

23 A spaceship takes a nonstop journey to a planet and returns in 10 hours according to a clock on the spaceship. If the speed of the spaceship is 0.80c, how much time has elapsed on the Earth?

a. 3.2 h
b. 7.0 h
c. 15 h
d. 17 h

3) Chapter III: Differential Equations

A. Short Answer Type Questions

1. What is ordinary differential equations?
2. State any three differential equations
3. What is partial differential equation?
4. State any three ordinary differential equations
5. Explain the term order of differential equation
6. Explain degree of differential equation
7. Explain the term linearity of differential equation
8. Explain the term homogeneity of differential equation
9. State any five partial differential equations occurring in physics
10. State the conditions on P(x) and Q(x) in the differential equation $Y'' + P(x) Y' + Q(x) Y = 0$, such that given point $x = x_0$ is an ordinary point

11. State the conditions on P(x) and Q(x) in the differential equation Y'' + P(x) Y' + Q(x) Y =0 , such that given point x= x_0 is ansingular point
12. Discuss singularity at x =0
13. Discuss singularity at x = ∞
14. State fuchs theorem

B. Long Answer Type Questions

1. Explain how you will determine x= x_0 i) is an ordinary point ii) regular singular point III) irregular singular point of the given linear, second order homogeneous differential equation.
2. The point at infinity requires a special consideration to decide its singularity structure for a given differential equation
3. When is a given second order differential equation said to be linear?
4. Write the Laplacian equation in Spherical polar coordinate and separate the variable
5. Separate the variables form #D quantum mechanical oscillator

C. Multiple Choose Questions

1. For a function y(x), we denote y 0 = dy dx the derivative with respect to x. Given the ordinary differential equation y 0 + y = e −x with initial condition y(0) = 5. Which of the following is the correct solution to this problem:
    a. y(x) = (x − 5)e 2x
    b. (b) y(x) = (x + 5)e −x
    c. (c) y(x) = e x − e −x
2. Which of the following equations is a second-order, linear ODE:
    a. dy dt = y + 1
    b. (b) d 2y dt2 + y dy dt + y = 1
    c. (c) d 2y dt2 + t 3y = 0
    d. (d) d 3y dt3 + y dy dt = 1
3. Consider the first-order, autonomous equation dy dt = 1 − y Without solving it (e.g. you could sketch the graph of f(y) = 1 − y), what are the equilibrium points of the system and their classification?
    a. y = −1 as stable point.
    b. (b) y = 1 as stable point.
    c. (c) y = 1 as saddle point.
    d. (d) y = 1 as unstable point.
4. Given the differential equation y 0 (t) = 2t − 5 with initial condition y(1) = 4. We want to solve it numerically with Euler's method. What is the formula applied to this problem?
    a. With h being a time step, tn = tn−1 +h and yn+1 = yn +h(2tn + 5) for n = 1, 2, ..; starting with t0 = 1 and y0 = 4.
    b. (b) With h being a time step, tn = tn−1 + h and yn+1 = yn + htn for n = 1, 2, ..; starting with t0 = 0 and y0 = 4.

c. (c) With h being a time step, tn = tn−1 +h and yn+1 = yn +h(2tn −5) for n = 1, 2, ..; starting with t0 = 0 and y0 = 4.
d. (d) With h being a time step, tn = tn−1 +h and yn+1 = yn +h(2tn −5) for n = 1, 2, ..; starting with t0 = 1 and y0 = 4.

5. . The differential equation 2 ( ) 50 ,32 2 yxyx =+=+ dx dy is
   a.linear
   b. (B) nonlinear
   c. (C) linear with fixed constants
   d. (D) undeterminable to be linear or nonlinear
6. A differential equation is considered to be ordinary if it has
   a. (A)one dependent variable
   b. (B) more than one dependent variable
   c. (C) one independent variable
   d. (D)more than one independent variable
7. . Given =+ yxy ( ) = 60 ,2sin32 dx dy y( ) 2 most nearly is
   a.0.17643
   b. (B) 0.29872
   c. (C) 0.32046
   d. (D) 0.58024

4) Chapter IV: Special Functions

A. Short Answer/ Long Type Questions

1. What do you mean by special functions?
2. Sate the important of special functions
3. Using Rodrigues formula for the Legendre polynomials, determine P0(x) , P1(x) and P2(x)
4. What is meant by parity ?
5. Show that Legendre polynomials have even parity
6. Show that pn(1) = 1
7. Show that pn(-1) = -1
8. Using Rodrigues formula for the Legendre polynomials, determine H0(x) , H1(x) and H2(x)
9. Generate Legendre polynomials using generation function
