SET A

B.SC. PHYSICS
FIRST SEMESTER
ELEMENTS OF MECHANICS
BSP – 102 [REPEAT]

[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

Objective

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1×20=20***

1. Galilean transformations are valid under which of the following conditions?
   a. When velocities involved are close to the speed of light.
   b. When velocities involved are much less than the speed of light.
   c. In the presence of strong gravitational fields.
   d. In quantum mechanical systems.

2. A rotating frame of reference is considered to be non-inertial because:
   a. It is at rest.
   b. It involves no external forces acting on objects.
   c. Objects experience centrifugal forces in the frame.
   d. Newton's second law is valid in such a frame.

3. If two objects of different masses are subjected to the same force, the object with the smaller mass will:
   a. Experience a smaller acceleration.
   b. Experience the same acceleration as the heavier object.
   c. Experience a greater acceleration.
   d. Experience no acceleration.

4. According to Galilean transformations, if an observer sees an object moving with velocity v in one inertial frame, and another inertial frame moves with velocity u relative to the first, what is the velocity of the object in the second frame?
   a. v+u
   b. v -u
   c. u -v
   d. v ×u

5. Which of the following statements is true about an inertial frame of reference?
   a. A frame of reference in which Newton's laws of motion are valid.
   b. A frame of reference in which objects experience fictitious forces.
   c. A frame of reference that is accelerating with respect to a fixed point.
   d. A rotating frame of reference.

6. The work-energy theorem states that:
   a. Work is equal to the change in potential energy.
   b. Work is equal to the change in kinetic energy.
   c. Work is equal to the sum of kinetic and potential energy.
   d. Work is conserved in all processes.

7. Which of the following is a non-conservative force?
   a. Gravitational force
   b. Spring force
   c. Frictional force
   d. Electrostatic force

8. The work done by non-conservative forces, such as friction, leads to:
   a. A decrease in kinetic energy only.
   b. A decrease in mechanical energy.
   c. An increase in potential energy only.
   d. Conservation of mechanical energy.

9. If two objects with equal masses collide elastically in the center of mass frame, what happens to their velocities after the collision?
   a. They exchange velocities.
   b. They stick together.
   c. Their velocities become zero.
   d. Their velocities increase exponentially.

10. In an inelastic collision:
   a. Only momentum is conserved, but kinetic energy is not.
   b. Both kinetic energy and momentum are conserved.
   c. Kinetic energy increases after the collision.
   d. No energy is lost to other forms, such as heat or sound.

11. What is the mathematical expression for the angular momentum L of a particle about a point? (terms have their usual meaning)
   a. $L=r\times p$
   b. $L=F\times v$
   c. $L=mv$
   d. $L=r\times F$

12. The torque τ acting on a particle is given by
   a. $\tau=p\times v$
   b. $\tau=F.r$
   c. $\tau=r\times F$
   d. $\tau=ma$

13. Moment of inertia, of a spinning body about an axis, doesn't depend on which of the following factors?
   a. Distribution of mass around axis
   b. Orientation of axis
   c. Mass
   d. Angular velocity

14. In which of the following case the moment of inertia of a uniform rod will be smaller
   a. About an axis passing through its centre perpendicular to its length
   b. About an axis passing through one of its end perpendicular to its length
   c. About an axis 1 meter away from the rod
   d. All of these

15. If the mass of a solid sphere of radius 'R' is tripled, its the moment of inertia will be
   a. $I=\frac{2}{5}MR^2$
   b. $I=\frac{3}{5}MR^2$
   c. $I=\frac{4}{5}MR^2$
   d. $I=\frac{6}{5}MR^2$

16. The moment of inertia of a solid sphere of mass 'M' and radius about its diameter is 'I'. The moment of inertia of the same sphere about a tangent parallel to the diameter is
   a. 5I
   b. 7I
   c. 2.5I
   d. 3.5I

17. For a body rolling down an inclined plane without slipping, the acceleration a is given by

a. $a = \frac{g \sin\theta}{R^2}$

b. $a = \frac{g \sin\theta}{1 + \frac{K^2}{R^2}}$

c. $a = g \cos\theta$

d. $a = g(1 - \cos\theta)$

18. Which of the following shapes has the smallest moment of inertia for the same mass and radius when rotating about an axis through its center?

a. Solid sphere
b. Hollow sphere
c. Solid cylinder
d. Thin ring

19. The gravitational force between two objects depends on

a. Only the distance between the objects
b. Only the masses of the objects
c. The masses of the objects and the distance between them
d. The shape and orientation of the objects

20. If the distance between two masses is doubled, the gravitational force between them

a. Doubles
b. Is halved
c. Is reduced to one-fourth
d. Remains the same

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Descriptive

Time : 2 hrs. 30 min. Marks: 50

[Answer question no.1 & any four (4) from the rest]

1. a. Show that distance is invariant whereas velocity is not invariant to Galilean transformation. 5+5=10

   b. Obtain the expression for the moment of inertia of a circular disc about an axis passing through its centre and perpendicular to its plane.

2. a. Explain the concept of the center of mass for an n-particle system and derive the expression for the position and velocity of the center of mass of the system. 7+3=10

   b. Three masses 3 kg, 4 kg, and 5 kg are located at corners of equilateral triangle of side 1 m. Locate the Centre of Mass.

3. a. State and prove the principle of conservation of Mechanical energy. 3+5+2 =10

   b. Explain in detail the conservation of mechanical energy for a freely falling body and hence draw the diagram showing the variation of K.E. and P.E. with height.

c. Calculate the velocity of the bob of a simple pendulum at its mean position if its able to raise to a vertical height of 10 cm. Take g = 9.8 m/s2.

4. With the help of a neat and labeled diagram, explain elastic collision in two dimensions. Discuss the special cases for (a) Glancing collision, (b) Head-on collision, and (c) Two identical particles. **4+6=10**

5. **a.** Define moment of inertia of a rigid body. What are its unit and dimension? **4+6=10**

   b. The intermolecular distance between two atoms of hydrogen molecule (H2) is 0.77 Å. If the mass of proton is 1.67×10^{-27} kg, then calculate the moment of inertia of the molecule

6. **a.** Write the expressions for the moment of inertia of a sphere of radius R. **2+8=10**

   b. The moment of inertia of a bigger solid sphere about its diameter is I. 64 smaller equal spheres are made out of bigger sphere, what will be the moment of inertia of such smaller sphere about its diameter.

7. **a.** Describe the concept of a frame of reference undergoing uniform acceleration and illustrate how an additional force, known as a pseudo force, comes into play within such a frame. **5+5=10**

   b. What is the moment of inertia of a disc with density ρ=16 kg/m2 about its central axis if it has a radius of 5 m.

8. **a.** State the law of gravitational attraction and hence define the gravitational constant G. **4+6=10**

   b. Calculate the average density of the Earth, given that the radius R of the Earth is about 6.371×106 m, mass of the Earth M is approximately 5.97×1024 kg, gravitational constant G=6.674×10−11N m2/kg2, and acceleration due to gravity g=9.8 m/s2.

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