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E–302

M. Sc. (First Semester)
EXAMINATION, Dec.-Jan., 2020-21

PHYSICS

Paper Second

(Classical Mechanics)

Time Three Hours] [*Maximum Marks : 80*

Note : Attempt all Sections as directed.

Section—A 1 each

(Objective/Multiple Choice Questions)

Note : Attempt all questions.

Choose the correct answer :

1. The homogeneity of time leads to the law of conservation of :
   (a) Linear momentum
   (b) Angular momentum
   (c) Energy
   (d) Parity

2. The Lagrange's equation of motion for L – C circuit :
   (a) $L\frac{d^2q}{dt^2}+\frac{q}{C}=0$

(b) $L\frac{d^2q}{dt^2}+\frac{1}{C}=0$

(c) $\frac{d^2q}{dt^2}+\frac{1}{C}=0$

(d) $\frac{d^2q}{dt^2}+\frac{1}{L}=0$

3. The Lagrangian of a particle moving in a plane under the influence of a central potential is given by $L=\frac{1}{2}M(\dot{r}^2+r^2\dot{\theta}^2)-V(r)$. The generalited momenta corresponding to 'r' and 'θ' :

(a) $M\dot{r}$ and $Mr\dot{\theta}$

(b) $M\dot{r}$ and $Mr^2\dot{\theta}$

(c) $M\dot{r}^2$ and $Mr^2\dot{\theta}$

(d) $M\dot{r}^2$ and $Mr^2\dot{\theta}^2$

4. Rutherford's differential scattering cross-section :

(a) is inversely proportional to $\cos ec\mu^4\left(\frac{\phi}{2}\right)$, where '$\phi$' is the scattering angle.

(b) is proportional to the square of the kinetic energy of the incident particle.

(c) has the dimensions of the solid angle.

(d) has the dimensions of area.

5. Hamilton's principle function 'S' and Hamilton's characteristic function 'W' for conservative system are related as :

   (a) $S = W$

   (b) $S = W - Et$

   (c) $S = W + Et$

   (d) S is not related to W

6. For a one-dimensional harmonic oscillator, the representative print in two dimensional phase space traces :

   (a) an ellipse

   (b) a parabola

   (c) a hyperbola

   (d) always a straight line

7. Whatever dimension a generalized co-ordinate has the product of the generalized force and generalized displacement must have the dimension of :

   (a) Work

   (b) Force

   (c) Torque

   (d) None of the above

8. When constraints are introduced into a system, its number of degrees of freedom is :

   (a) increased

   (b) decreased

   (c) remains same

   (d) None of the above

9. The path followed by a particle is sliding from one point to another in the absence of friction in the shortest time is a :

   (a) Cycloid

   (b) Sphere

   (c) Catenary

   (d) Sigmoid

10. Write an expression for the Hamilton's principle function :

   (a) $S = \int L\, dt + \text{constant}$

   (b) $S = \int L^2 dt$

   (c) $S = \int L\, dt + \dot{q}^2$

   (d) $S = \int L\, dt$

11. Poisson brackets have the relations :

   (a) $[u, v] = [v, u]$

   (b) $[u, v] = -[v, u]$

   (c) $[u, u] = [v, v]$

   (d) $[u, v] = 0$

12. If a co-ordinate is cyclic, Hamiltonian would reduce the number of variables in new formulation by :

   (a) Four

   (b) One

   (c) Two

   (d) Three

13. The areal velocity of the particle in a central force field is :

    (a) Zero

    (b) Maximum

    (c) Minimum

    (d) Constant

14. If the total energy of a particle in a conservative force field is zero, then the velocity obtained in such case is :

    (a) zero

    (b) escape velocity

    (c) recoil velocity

    (d) None of the above

15. Kepler's second law says that :

    (a) areal velocity is zero.

    (b) areal velocity is constant.

    (c) areal velocity is positive.

    (d) areal velocity is negative.

16. The angle of recoil of the target particle relative to the incident direction of the scattered particle is :

    (a) $\frac{1}{2}\ \pi + \theta$

    (b) $\pi - \theta$

    (c) $\frac{1}{2}\ \pi - \theta$

    (d) $\pi + \theta$

17. A particle describes a circular orbit under the influence of an attractive central force directed towards a point on the circle. The force inversely proportional to :

(a) r^5

(b) r^2

(c) r^3

(d) r^4

18. Hamilton's equations of motions are :

(a) $\frac{\partial H}{\partial p} = \dot{q}\ ;\ \frac{\partial H}{\partial q} = \dot{p}$

(b) $\frac{\partial H}{\partial p} = -q\ ;\ \frac{\partial H}{\partial q} = p$

(c) $\frac{\partial H}{\partial p} = q\ ;\ \frac{\partial H}{\partial q} = -p$

(d) None of the above

19. Energy of a particle of mass M is E and its momentum is P. Then the relation between E and P is :

(a) $E = \frac{P}{2M}$

(b) $E = \sqrt{2PM}$

(c) $P = \sqrt{2ME}$

(d) $P = \frac{2M}{E}$

20. In case of elliptical orbits, energy is proportional to :

(a) a^{-3}

(b) a^{-1}

(c) a

(d) a^{3}

Section—B

2 each

(Very Short Answer Type Questions)

Note : Attempt all questions.

1. Define constraints.
2. What is a rigid body ?
3. What do you understand by cyclic co-ordinate ?
4. Identify 6 independent generalized co-ordinates necessary for complete specification of a rigid body containing 'N' particles.
5. What is a δ-variation ? How is it differ from Δ-variation ?
6. Describe a Poisson brackets.
7. Define a Gyroscopic force.
8. Explain the canonical transformation in brief.

Section—C

3 each

(Short Answer Type Questions)

Note : Attempt all questions.

1. Discuss a Hamilton's principle (action or action integral) and derive a Lagrange's equations of motion for Hamilton's principle.
2. What do you mean by virtual work ? State and prove D'Alembert's principle.
3. Describe the inverse square law force and discuss Kepler's laws with its help.

4. Discuss the two body central force problem reduced to equivalent one body problem and obtained Lagrangian function.
5. Define inertia tensor and give its physical significance.
6. What is a generating function ? Prove type-I transformation.
7. Derive an Hamiltonian function H and conservation of energy Jacobi's Integral.
8. Describe the Euler's theorem.

Section—D 5 each

(Long Answer Type Questions)

Note : Attempt any *four* questions.

1. As an example of canonical transformation, discuss the problem of 1-D simple harmonic oscillator and obtain the equation of motion.
2. Discuss the principle of least action and obtain necessary equation.
3. What do you mean by action and angle variables ? Find the equation for harmonic oscillator.
4. Derive Hamilton function H and conservation of energy Jacobi's integral and physical significance.
5. Derive a Rutherford's scattering cross-section.
6. Discuss a solution of Harmonic oscillator and prove by H-J method.