REV-00
MPH/68/75

2017/12

M. Sc. PHYSICS

FIRST SEMESTER

CLASSICAL MECHANICS

MPH - 102

Duration: 3 Hrs. **Marks: 70**

Part : A (Objective) = 20
Part : B (Descriptive) = 50

[PART-B : Descriptive]

Duration: 2 Hrs. 40 Mins. **Marks: 50**

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

1. a) State D'Alembert's principle. 1+6+3=10
b) Derive Lagrange's equation from D'Alembert's principle.
c) Construct the equation of motion for a simple pendulum with the help of Lagrange's equation.

2. a) Applying variational principle, show that the shortest distance between two points in a plane is a straight line. 5+5=10

b) A particle of mass m falls a given distance z_0 in time $t_0 = \sqrt{\frac{2z_0}{g}}$ and the distance travelled in time t is given by $z = at + bt^2$, where constants a and b are such that the time t_0 is always the same. Show that the integration $\int_0^{t_0} L dt$ is an extremum for real values of the coefficients only when $a = 0$ and $b = g/2$.

3. a) Obtain the canonical transformation equations corresponding to generating function of the form $F(q_k, Q_k, t)$. 5+2+3=10

b) Show that the function $F = \sum_i q_i P_i$ generates the identity transformation.

c) Prove that the following transformation is canonical
$Q = \sqrt{2q}\, e^{\alpha} \cos p; \quad P = \sqrt{2q}\, e^{-\alpha} \sin p.$

4. a) If $[\phi, \psi]$ represents the Poisson's bracket between two functions ϕ and ψ, then prove that 4+4+2=10

$$\frac{\partial}{\partial t}[\phi, \psi] = \left[\frac{\partial \phi}{\partial t}, \psi\right] + \left[\phi, \frac{\partial \psi}{\partial t}\right]$$

b) Prove the following relations:

(i) $[J_y, J_z] = J_x$

(ii) $\sum_{k=1}^{n}\{q_k, q_i\}[q_k, q_j] + \sum_{k=1}^{n}\{p_k, q_i\}[p_k, q_j] = \delta_{ij}$

5. Define inertia tensor and principal axes. 4+1+5= 10
Considering the origin at one corner and the axes along the edges of a homogeneous cube having density ρ, mass M, and sides a, determine the inertia tensor.

6. State and establish Bernoulli's equation for an incompressible liquid. 6+2+2= 10
Water flows along a horizontal pipe, which cross-section is not uniform along the length. If the pressure is $1334\ N/m^2$ when velocity is 35 cm/s, then find the pressure at a point where the velocity is 65 cm/s (density of water $1gm/cm^3$).

7. Two identical harmonic oscillators, each of mass m, are coupled together. Set up the equations of motion and obtain the general solutions for the system of coupled oscillators.. 4+6=10

8. Solve the problem of one-dimensional harmonic oscillator using Hamilton-Jacobi method. 10

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[PART-A : Objective]

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

1. A rigid body moving freely in space has degrees of freedom
   a. 3
   b. 6
   c. 9
   d. 4

2. Generalised momenta p_j is associated with generalised coordinate q_j as
   a. $p_j = \frac{\partial L}{\partial q_j}$
   b. $p_j = \frac{\partial L}{\partial q_j}$
   c. $p_j = \frac{\partial H}{\partial q_j}$
   d. $p_j = \frac{\partial H}{\partial q_j}$

3. In case of inertia tensor, I_{xy} is expressed as
   a. $I_{xy} = \sum_i m_i x_i y_i$
   b. $I_{xy} = -\sum_i m_i x_i y_i$
   c. $I_{xy} = -\sum_i m_i (x_i^2 + y_i^2)$
   d. $I_{xy} = 0$

4. If a particle moves near the surface of earth under a coordinate system (x, y, z) where z axis is in vertical direction, then the equation of motion in z-axis is given by
   a. $m\ddot{z} + mg = 0$
   b. $m\ddot{z} - \dot{p}_z = 0$
   c. $m\ddot{z} - \dot{p}_x = 0$
   d. $m\ddot{z} - \dot{p}_y = 0$

5. The precessional period of a symmetrical rigid body about the symmetry axis is
   a. $T = \frac{2\pi}{\Omega}$
   b. $T = \frac{2\pi}{\omega}$
   c. $T = \frac{\omega}{2\pi}$
   d. $T = \frac{I_1}{I_3 - I_1}$

6. Equation of catenaries are be given by ('a' being a constant)
   a. $y = a\cos\left(\frac{x}{a}\right)$
   b. $y = a\sin\left(\frac{x}{a}\right)$
   c. $y = a\sinh\left(\frac{x}{a}\right)$
   d. $y = a\cosh\left(\frac{x}{a}\right)$

7. If the generalized coordinate is an angle θ, the corresponding generalized force has the dimension of
   a. force
   b. Momentum
   c. torque
   d. energy

8. Property of an ideal fluid is/are
   a. incompressible
   b. laminar flow
   c. non-viscous
   d. all of these

9. According the Bernoulli's theorem,
   pressure energy + kinetic energy + potential energy = _____ (choose the correct option)
   a. 0
   b. ∞
   c. a constant
   d. None of these

10. If the Lagrangian does not depend on time explicitly, then the
    a. Hamiltonian is constant
    b. Hamiltonian cannot be constant
    c. kinetic energy is constant
    d. potential energy is constant

11. The condition satisfying canonical transformation is
    a. $\delta p dq - \delta q dp = 0$
    b. $\delta p dQ - \delta q dP = \delta P dq - \delta q dP$
    c. $\delta p dq - \delta q dp = \delta P dQ - \delta Q dP$
    d. $\delta q \delta p - dq dp = \delta Q \delta P - dQ dP$

12. For a generating function of the form $F(p_k, P_k, t)$, the transformation equations will be
    a. $q_k = -\partial F/\partial p_k$, $Q_k = \partial F/\partial P_k$
    b. $q_k = \partial F/\partial p_k$, $Q_k = \partial F/\partial P_k$
    c. $q_k = -\partial F/\partial p_k$, $Q_k = -\partial F/\partial P_k$
    d. $q_k = \partial F/\partial p_k$, $Q_k = -\partial F/\partial P_k$

13. Hamilton's principle function S and Hamilton's characteristic function W for a conservative system are related as
    a. $S = W$
    b. $S = W - Et$
    c. $S = W + Et$
    d. S is not related to W

14. If the Poisson bracket of a function with the Hamiltonian vanishes, then
    a. the function depends upon time
    b. the function is a constant of motion
    c. the Hamiltonian is zero
    d. the function is undefined

15. The value of the Poisson's bracket $[J_x, x]$ is
    (where terms have their usual meaning)
    a. -1
    b. 0
    c. $-p_x$
    d. J_y

16. The general motion of two coupled identical pendulums oscillating in a plane will be
    a. a damped harmonic motion
    b. a motion of neutral equilibrium
    c. the superposition of two simple harmonic motions of same frequency
    d. the superposition of two simple harmonic motions of different frequency

17. The phase space refers to
    a. position coordinate
    b. momentum coordinate
    c. both position and momentum coordinates
    d. time coordinate

18. The action and angle variables have the dimensions of
    a. force and angle
    b. angular momentum and angle
    c. energy and angle
    d. position and momentum.

19. In case of a linear triatomic molecule XY_2 type, the eigen frequencies ω_1, ω_2 and ω_3 can be represented as
    a. $\omega_1 = 0, \omega_2 \neq \omega_3$
    b. $\omega_1 = \omega_2 = \omega_3$
    c. $\omega_1 = 0, \omega_2 = \omega_3$
    d. $\omega_1 = 1, \omega_2 = \omega_3$

20. An example of stable equilibrium is
    a. an egg standing on one end
    b. a hanging spring-mass system in the stationary position
    c. a book placed flat anywhere on a table
    d. none of the above.

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UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

[PART (A) : OBJECTIVE]

Duration : 20 Minutes

Serial no. of the main Answer sheet

Course : .....

Semester : ..... **Roll No :** .....

Enrollment No : ..... **Course code :** .....

Course Title : .....

Session : 2017-18 **Date :** .....

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Instructions / Guidelines

- The paper contains twenty (20) / ten (10) questions.
- Students shall tick (✓) the correct answer.
- No marks shall be given for overwrite / erasing.
- Students have to submit the Objective Part (Part-A) to the invigilator just after completion of the allotted time from the starting of examination.

Full Marks	Marks Obtained
20	

Scrutinizer's Signature *Examiner's Signature* *Invigilator's Signature*