UNIVERSITY OF THE PUNJAB

Roll No. ....

Fifth Semester 2018

Examination: B.S. 4 Years Programme

PAPER: Classical Mechanics | **TIME ALLOWED: 30 mins.**

Course Code: PHY-301 | **MAX. MARKS: 10**

Attempt this Paper on this Question Sheet only.

Attempt all questions.

SECTION-I (Multiple Choice Questions) (10 Marks)

1. Select and tick one answer from the given multiple choice (10)

(i) The degree of freedom of a double pendulum is

(a) 4
(b) 2
(c) 3
(d) 1

(ii) Equation of conics $r = \frac{h}{1+e\cos\theta}$ draws a hyperbola when

(a) $e = 1$
(b) $e > 1$
(c) $e < 1$
(d) $e = 0$

(iii) The geodisic on the surface of a sphere is a

(a) great circle
(b) straight line
(c) helix
(d) ellipse

(iv) For a system of N particles the dimension of the phase space is

(a) $2N$
(b) $3N$
(c) $4N$
(d) $6N$

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(v) The Hamiltonian can be constructed from the Lagrangian using the formula:

(a) $H = p_i\dot{q}_i - L$.
(b) $H = \dot{p}_i\dot{q}_i - L$.
(c) $H = \frac{\partial L}{\partial \dot{q}_i}$
(d) $H = \frac{1}{L}$.

(vi) A usual expression for the conserved angular momentum in a central force prob
is:

(a) $\ell = mr^2\theta$.
(b) $\ell = mr^2\theta^2$.
(c) $\ell = mr^2\dot{\theta}$.
(d) $\ell = mr^2\dot{\theta}^2$.

(vii) In the central force problem, conservation of angular momentum is equivalent
saying

(a) the linear momentum is constant
(b) the total energy is constatnt
(c) the effective potential is constant
(d) the areal velocity is constant

(viii) If the Lagrangian is cyclic in θ , then:

(a) $mr^2\dot{\theta}$is not conserved.
(b) $mr^2\dot{\theta}$ is conserved.
(c) θ appears in the Lagrangian
(d) $\dot{\theta}$ does not appear in the Lagrangian

(xi) If A and B are any two constants of motion, their Poisson bracket $\{A, B\}$

(a) is zero
(b) is invariant
(c) is a constant of motion
(d) is covariant

(x) Kepler's third law of planetry motion states that

(a) $T^3 \propto a^3$
(b) $T^2 \propto a^3$
(c) $T^3 \propto a^2$
(d) $T^2 \propto a^4$

UNIVERSITY OF THE PUNJAB

Fifth Semester 2018
Examination: B.S. 4 Years Programme

Roll No. ....

PAPER: Classical Mechanics **TIME ALLOWED: 2 hrs. & 30 mins.**
Course Code: PHY-301 **MAX. MARKS: 50**

Attempt this Paper on Separate Answer Sheet provided.

SECTION-II (20 Marks)

2. If L is a Lagrangian for a system of n degrees of freedom satisfying Lagrange equation of motion, show by direct substitution that

$$L' = L + \frac{d}{dt}F(q_1, \cdots, q_n; t),$$

satisfies the Lagrange equation of motion. (5)

3. Show that the transformation

$$P = 2(1+\sqrt{q}\cos p)\sqrt{q}\sin p$$
$$Q = \ln(1+\sqrt{q}\cos p)$$

is canonical.
(5)

4. The Lagrangian for two particles of masses m_1 and m_2 and coordinates $\mathbf{x}_1$ and $\mathbf{x}_2$,interacting via a potential $V(\mathbf{x}_1-\mathbf{x}_2)$, is

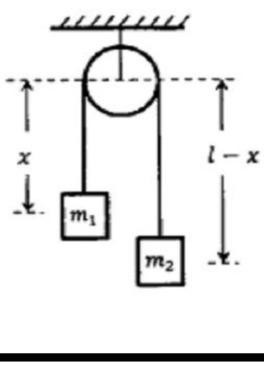
$$L = \frac{1}{2}m_1\mathbf{x}_1^2 + \frac{1}{2}m_1\mathbf{x}_2^2 - V(\mathbf{x}_1 - \mathbf{x}_2)$$

Rewrite the Lagrangian in terms of the center of mass coordinates

$$\mathbf{R} = \frac{m_1\ \mathbf{x}_1 + m_2\ \mathbf{x}_2}{m_1 + m_2}$$

and the relative coordinates $\mathbf{x} = \mathbf{x}_1 - \mathbf{x}_2$. Use Lagrange's equation to show that the center of mass and relative motion separate, the center of mass moving with constant velocity and relative motion being like that of a particle of reduced mass $\mu = \frac{m_1\ m_2}{m_1 + m_2}$ in a potentail $V(\mathbf{x})$.(5)

5. Consider.the Atwood machine as shown in Figure. Find the equation of motion. (5)



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SECTION-III (30 Marks)

6. (a) State Kepler's Laws of planetary motion.

(b) Discuss the properties of motion in effective potential in a central force two-body problem. (5+5)

7. (a) A particle moves in an elliptical orbit in an inverse square law central force field. If the ratio of the maximum angular velocity to the minimum angular velocity of the particle in its orbit is n, then show that the eccentricity of the orbit is

$$\epsilon = \frac{\sqrt{n}-1}{\sqrt{n}+1}.$$

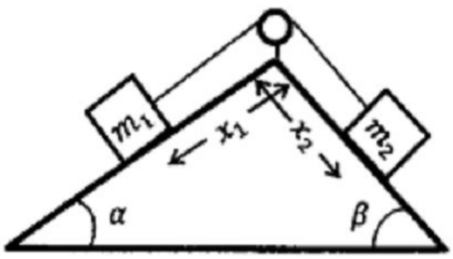
(b) Show that the path followed by a particle in sliding from one point to another under the action of gravity in the absence of friction and in the shotest time is a cycloid. (5+5)

8. (a) Show that, if a transformation from (q, p) to (Q, P) be canonical then the bilinear form

$$\sum_i (\delta p_i dq_i - \delta q_i dp_i),$$

is invariant under the canonical transformation.

(b) Consider two masses tied together on a frictionless inclined plane as shown in Figure. Find the equations of motion.



(5+5)

UNIVERSITY OF THE PUNJAB

BS Mid Semester Examination (2019)

Subject: Physics
Paper: (Classical Mechanics)

Time Allowed: 1.5 hrs
Max. Marks: 35

Attempt all questions.

1. A bead slides along a smooth wire bent in the shape of a parabola $z = cr^2$. The bead rotates in a circle of radius R when the wire is rotating about its verticle axis with angular velocity ω. Find the value of c. (6)

2. Show that the kinetic energy of a two-particle system is

$$\frac{1}{2}M\dot{R}^2 + \frac{1}{2}\mu v^2$$

where $M = m_1 + m_2$, v is the relative speed, R is the position vector of centre of mass and $\frac{1}{\mu} = \frac{1}{m_1} + \frac{1}{m_2}$ (reduced mass). (6)

3. State principle of virtual work and D'Alembert's Principle. Use D'Alembert's Principle to derive the Lagrange's equation of motion

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} = Q_i \ .$$

where T is the kinetic energy, q_i are generalized coordinates and Q_i are generalized forces. Show taht for a conservative system it is expressed as

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$$

where $L = T - V$ is the Lagrangian function. (8)

4. Define holonomic and non-holonomic constraints. Give at least two examples of each case, to illustrate your definition. Also distinguish between rheonomic and scleronomic constraints by giving suitable examples. (8)

5. The Lagrangian of a particle of mass m moving in a central potential is given by

$$L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin^2\theta\,\dot{\varphi}^2\right) + \frac{k}{r}$$

Write down the Euler-Lagrange equations of motion. What does equation of motion of φ tell us about. (7)

1

UNIVERSITY OF THE PUNJAB

BS Physics Final Examination (Semester V) (2020)

Subject: Physics
Paper: (Classical Mechanics)

Time Allowed: 2 hrs
Max. Marks: 40

Attempt all questions.

1. Consider Coulomb scattering of charged particles. The Coulomb repulsive potential is $V(r) = \frac{k}{r}$. Start with the equation

$$\theta(r) = \int \frac{l\, dr}{r^2\sqrt{2\mu\left(E - V - \frac{l^2}{2\mu\, r^2}\right)}} + \text{constant},$$

and by making suitable substitutions, derive the following expression of the impact parameter

$$b = \frac{k}{2E}\cot\left(\frac{\varphi}{2}\right)$$

where φ is the scattering angel and E is the total energy of the particle. (10)

2. A particle of mass m moves without friction under the action of gravitation on the inner surface of a paraboloid, given by

$$x^2 + y^2 = az$$

Use the method of Lagrange multipliers to determine the Lagrangian and the equations of motion. Show that the particle moves on a horizontal circle in the plane $z = h$, provided that it gets an initial angular velocity. Find this angular velocity. (10)

3. Define Poisson bracket of two dynamical variables and show that the Poisson bracket obeys the Jacobi identity

$$\{A, \{B, C\}\} + \{B, \{C, A\}\} + \{C, \{A, B\}\} = 0$$

where A, B and C are arbitrary dynamical variables. (10)

4. State Hamilton's principle of least action and use it to derive Hamilton's equations of a dynamical system. Also express Hamilton's equations in terms of Poisson brackets.

Pending

Govt. Post Graduate College of Science Faisalabad

BS Physics | Classical Mechanics | Mid term

Total Time: 1:00Hrs | Total Marks: 12 | Semester: 5^{th}

Question 1:

What are degrees of freedom? Write degrees of freedom of single particle cylinder and Scissors in space.

Question 2:

For a system in equilibrium find the virtual work done by all the forces except forces of constraints. (Take work done by forces of constraints zero.)

Question 3:

A massive fast moving truck crashed into a small car now truck is pushing car with it. Discuss which of them is putting more force on the other.