"Dissemination of Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe
Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Autonomous)

Department of Physics

M.Sc. Part- I

Classical Mechanics

Surprise Test

Date : 21/10/2022
Day: - Friday **Total Marks: 20**
Instructions:- **Time :- 3pm to 4pm**

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q1. Fill in the Blanks (1 mark for each) **(05)**

1. Hamiltonian function is ……

a) $H = L\sum_j p_j q_j$ b) $= \sum_j p_j q_j + L$ c) $= \sum_j p_j q_j - L$ d) $= \sum_j p_j q_j$

2. The generalized momentum is also called as ………

a) Conjugate momentum b) Canonical momentum
c) both a & b d) None of above

3. Hamiltonian is defined as……….

a) the total energy of system b) the difference of KE & PE of system
c) the product of KE & PE of system d) None of above

4. Generalised coordinates are………..

a)depends on each other b) spherical coordinates
c)) independent of each other d) None of above

5. In variational principal, line integral of some function two end points is …….

a) zero b) infinite c)extreme d) one

Q2. Answer the following (Any one) **(10)**

1. State equivalence of Lagrange's and Newton's equations
2. Find the equation of motion of charged particle in an EM field.

Q3. Answer the following (Any one) **(05)**

1. Derive Hamilton's canonical equations from a variational principal.
2. Derive an equation of motion of simple pendulum.

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Surprise Test

Attendance Sheet

Date : 21/10/2022

Roll. No.	Name of Candidate	Sign
1601	Ahiwale Snehal Nitin	Ahiwale
1602	Bam Shruti Harish	Bam
1603	Biradar Anand Nagapp	AB
1604	Chuhan Aditi Rajes	Chauhan
1605	Jattoli Smith Kallapa	Smith
1608	Mithari Shweta Sardar	PShweta
1610	Randive Ranjashree Mahesh	[illegible]
1611	Sagar Shivani D	Sagar
1612	Shirke Pranali Pradip	Shirke
1614	Todkar Dynaneshwari P.	TDgane

Teacher Incharge...... PHawalale ......
(Miss P.Y. Hawaldar)

Head of the
Department of Physics
Vivekanand College, Kolhapur

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Result

Date : 21/10/2022

Roll. No.	Marks	Roll. No.	Marks
1601	06		
1602	07		
1603	09		
1604	10		
1605	19		
1606	-		
1607	-		
1608	13		
1609	-		
1610	11		
1611	18		
1612	09		
1613	-		
1614	11		

Teacher Incharge........Hawaldar............

(Miss P. Y. Hawaldar)

Head of the
Department of Physics
Vivekanand College, Kolhapur

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-शिक्षणमहर्षी डॉ. बापूजी साळुंखे

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor

Suppliment No. :

Roll No. : 1608

Class : MSC-I physics

Subject : Classical Mechanics

Test / Tutorial No. :

Div. :

13/29

Q.1

1 i) b) $H = \sum_j p_j q_j - L$

ii) b) Cononical momentum

iii) b) the difference of K.E & P.E of system

iv) b) independent of each other

v) a) zero

Q.2

1)

~~Ea~~ Newton's Equation	Langrage's Equation
1) Vectors $\bar{a}$, $\bar{b}$, $\bar{c}$, $\bar{r}$ are used.	1) Scalar vectors are used T, V.
2) All forces are consider.	2) Force is not consider.
3) The equation of force is, $\bar{F} = m\,\bar{a}$	3) The equation of motion of system is, $\frac{d}{dt}\,\partial q_j \left(\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial \dot{q}_j}\right) = 0$
4) It is rectangular co-ordinate ~~axis~~ system.	4) It is generalised ~~angular~~ co-ordinate ~~axis~~ system
5) It is frame dependent.	5) It is frame independent.

Q.3

1) Halmilton's Variational principal.

The integral form of the equation of system $\int_{t_1}^{t_2} L\, dt$ statisfies the ~~equatio~~ system. $(L = T - V)$

Here, T is the K.E. of the co-ordinates of the system & its derivatives & V is the potential energy of the system.

Statement :- The ~~Hal~~ Hamilton's Variational principal states that the motion of the system of co-ordinates of eq^n,

$$\int_{t_1}^{t_2} T - V \cdot dt \quad \text{- - - -} \quad \text{(the line integral is extrimum)}$$

$$= \int_{t_1}^{t_2} T(q_j, \dot{q}_j) - V q_j \, dt = 0$$

Deduction :- The line integral of independent system of co-ordinates are,

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$$\delta \int_{t_1}^{t_2} \frac{\partial T}{\partial q_j} \delta q_j - \frac{\partial T}{\partial \dot{q}_j} \delta \dot{q}_j - \frac{\partial V}{\partial q_j} \delta q_j \, dt = 0$$

$$\int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial q_j} \delta q_j - \frac{\partial V}{\partial q_j} \delta q_j \cdot dt - \int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial \dot{q}_j} \delta \dot{q}_j \cdot dt = 0$$

$$\int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial q_j} \delta q_j - \frac{\partial V}{\partial q_j} \delta q_j \cdot dt - \int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial \dot{q}_j} \frac{d}{dt} \int_{t_1}^{t_2} \frac{\partial q}{\partial q_j} \cdot \delta q_j \cdot dt = 0$$

$$\int_{t_1}^{t_2} \sum_j \left[\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j}\right] \cdot \delta q_j \, dt - \sum_j \frac{\partial T}{\partial \dot{q}_j} \delta \dot{q}_j \Big|_{t_1}^{t_2} -$$

$$\int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial q_j} \cdot \delta q_j \cdot dt = 0$$

In the variation, line integral of some function two end points is zero.

$$\therefore \delta \dot{q}_j \Big|_{t_1}^{t_2} = 0$$

$\therefore$ Eq^n becomes reduces as,

$$\int_{t_1}^{t_2} \sum_j \left[\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j}\right] \cdot \delta q_j \, dt - \int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial q_j} \cdot \delta q_j \cdot dt = 0$$

$$\therefore \int_{t_1}^{t_2} \sum_i \left[\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j}\right] - \frac{\partial T}{\partial q_j} \cdot \delta q_j \cdot dt = 0$$

Hence, the generalised co-ordinates are independent of eath other and the variation of eq^n becomes,

$$\left[\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j}\right] - \frac{\partial T}{\partial q_j} \cdot dt = 0$$

$\therefore$ This eq^n is sastifies the Hamilton's Variation principal.

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VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor: [signature]

Suppliment No. : 0

Roll No. : 1611

Class : MSc I (physics)

Subject : classical Mechanics

Test / Tutorial No. : Internal

Div. :

18/20

Q.1 1) b) $H = \sum_j p_j \dot{q}_j - L$

2) b) canonical momentum

3 3) a) the total energy of the system

4) b) independent of each other

5) c) Extreme

$$H = \frac{1}{2} ml^2 \dot{\theta}^2 + mgl - mgl\cos\theta$$

$$H = \frac{1}{2} \frac{(P_\theta)^2}{ml^2} + mgl - mgl\cos\theta$$

$$P_\theta = \frac{-\partial H}{\partial \theta} = mgl\sin\theta$$

$$\dot{P}_\theta = mgl\cos\theta \quad \text{------} \quad (2)$$

$$ml^2\ddot{\theta} = mgl\cos\theta$$

$$ml^2\ddot{\theta} - mgl\cos\theta = 0$$

$$\ddot{\theta} - \frac{g}{l}\cos\theta = 0$$

$$\frac{d^2\theta}{dt^2} - \frac{g}{l}\cos\theta = 0$$

this is the required eq^n of motion of simple pendulum

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VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor

Suppliment No. :

Subject : Classical Mechanics

Roll No. : 1614

Test / Tutorial No. : Internal Exam

Class : M.Sc. I

Div. :

11/20

Q.1.

1. Hamiltonian function is .....

Ans:- b) $\sum_j P_j q_j - L$

2. The generalized momentum is also called as ....

Ans:- c) both a & b

3. Hamiltonian H is defined as ....

Ans:- b) The difference of KE & PE of system

4. Generalised Co-ordinates are

Ans:- b) independent of each other

5. In variational principal, line integral of some function two end points is ...

Ans:- c) extreme.

Q.3.

1.

Ans. The principle stated as the integral $\int_{t_1}^{t_2} (T-V)\, dt$

Shall have stationary volume.

where T is Kinetic energy of mechanical system is the function of co-ordinates and their derivatives.

V is the ~~funct~~ potential energy of the mechanical system is the function of co-ordinates only.

Such a system for which V is purely a function of co-ordinates is called conservative system.

Statement :- The hamilton's variational principle ~~state as~~ for conservative system states that The motion of system be from time t_1 to t_2 such that the integral can be written as $I = \int_{t_1}^{t_2} L\, dt$

where, $\boxed{L = T-V}$ This is an extremum path of motion.

Deduction :- Let us consider a conservative system of Particle.

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Employing the generalized co-ordinates the integral we have,

$$I = \int_{t_1}^{t_2} T(q_j, \dot{q}_j) - V(q_j)\, dt = 0$$

$$= \int_{t_1}^{t_2} \sum_j \left[\frac{\partial T}{\partial q_j} \delta q_j + \frac{\partial T}{\partial \dot{q}_j} \delta \dot{q}_j - \frac{\partial V}{\partial q_j} \delta q_j \right] dt = 0$$

$$= \int_{t_1}^{t_2} \sum_j \left(\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j} \right) \delta q_j\, dt + \int_{t_1}^{t_2} \sum_j \frac{\partial T}{\partial \dot{q}_j} \delta \dot{q}_j\, dt = 0$$

$$= \int_{t_1}^{t_2} \sum_j \left(\frac{\partial T}{\partial q_j} - \frac{\partial V}{\partial q_j} \right) \delta q_j \, dt + \frac{\partial T}{\partial \dot{q}_j} \delta q_j \Big|_{t_1}^{t_2} - \int_{t_1}^{t_2} \sum_j \frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right) \delta q_j \, dt = 0$$

$$= \frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right) - \frac{\partial T}{\partial q_j} = 0$$

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SUPPLIMENT

Suppliment No. :	—	Signature of Supervisor	
Roll No.	: 1612	Subject :	Classical mechanics
Class	: M.Sc. I	Test / Tutorial No. :	—
		Div. :	—

09/20

Q.1:

1) — B] $H = \cancel{\frac{1}{2}} \Sigma_j p_j \dot{q}_j - L$

2) — B] Canonical momentum.

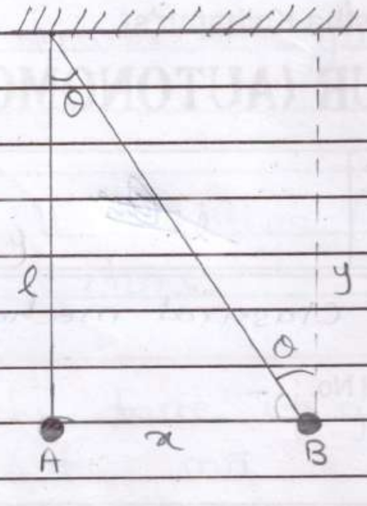
3) — C] The product of KE & PE of system.

4) — B] independent of each other

5) — A] zero

Q. 3.

2)



Consider a simple pendulum of length l, fixed at point ~~and~~ end.
m - mass of pendulum ball.
Suppose the pendulum is disposed through energy to perform oscillation.

The KE & PE of the pendulum can be given as,

$$KE = \frac{1}{2} m (\dot{x}^2 + \dot{y}^2) = T$$

3

$$PE = V = mgh = mg(l - y)$$

We have, $x = l \cdot \sin\theta$, $y = l \cdot \cos\theta$.

Differentiating w.r.t. t,

$$\dot{x} = dx = l \cdot \cos\theta \cdot \dot\theta \quad \& \quad dy = -l \cdot \sin\theta \cdot \dot\theta = \dot{y}$$

$$\therefore \dot{x}^2 + \dot{y}^2 = l^2 (\cos^2\theta + \sin^2\theta)\, \dot\theta^2$$
$$= l^2 \cdot \dot\theta^2$$

$$\therefore T = \frac{1}{2} m l^2 \cdot \dot\theta^2 \quad \& \quad V = mg(l - l \cdot \cos\theta)$$

Now, we have Lagrangian $L = T - V$

$$\therefore L = m\left[\frac{1}{2} l^2 \dot\theta^2 - gl(1 - \cos\theta)\right]$$

Here L is fixed and only generalised co-ordinate is θ.

$\cancel{p_j = dq_j}$

Q. 2.

1)

Newton's equation	Lagrange's equation.
① All quantities $(\bar{a}, \bar{b}, \bar{c}, \bar{r})$ are vectors.	① All quantities (L) are ~~scal~~ scalar.
② The force is given by $\bar{F} = m\bar{a}$	② The force is given by $\frac{d}{dt}\frac{dL}{d\dot{q}_j} - \frac{dL}{dq_j} = 0$
③ It uses standardized co-ordinate system.	③ It uses generalised co-ordinate system.
④ All forces are applied	④ No forces are applied.
⑤ It works in rectangular frame	

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