PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Lagrangian and Hamiltonian - CSIR NET Physics PYQs

Classical Mechanics . All PYQs (2015-2025) with answer key

25 questions . Answer key included

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Q1. [Dec 2015] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2015 Dec	5 M

The Lagrangian of a particle moving in a plane s given in Cartesian coordinates as

$$L = \dot{x}\dot{y} - x^2 - y^2$$

In polar coordinates the expression for the canonical momentum p_r (conjugate to the radial coordinate r) is

1. $\dot{r}\sin\theta + r\dot{\theta}\cos\theta$
2. $\dot{r}\cos\theta + r\dot{\theta}\sin\theta$
3. $2\dot{r}\cos\theta - r\dot{\theta}\sin 2\theta$
4. $\dot{r}\sin 2\theta + r\dot{\theta}\cos 2\theta$

Q2. [June 2015] . 3.5 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2015 June	3.5 M

If the Lagrangian of a dynamical system in two dimensions is $L = \frac{1}{2}m\dot{x}^2 + m\dot{x}\dot{y}$, then its Hamiltonian is

1. $H = \frac{1}{m}p_x p_y + \frac{1}{2m}p_y^2$
2. $H = \frac{1}{m}p_x p_y + \frac{1}{2m}p_x^2$
3. $H = \frac{1}{m}p_x p_y - \frac{1}{2m}p_y^2$
4. $H = \frac{1}{m}p_x p_y - \frac{1}{2m}p_x^2$

Q3. [Dec 2016] . 3.5 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2016 Dec	3.5M

The dynamics of a particle governed by the Lagrangian $L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2 - kx\dot{x}t$ describes

1. an undamped simple harmonic oscillator
2. a damped harmonic oscillator with a time varying damping factor
3. an undamped harmonic oscillator with a time dependent frequency
4. a free particle

Q4. [June 2016] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2016 June	3.5M

The Hamiltonian of a system with generalized coordinate and momentum (q,p) is $H = p^2q^2$. A solution of the Hamiltonian equation of motion is (in the following A and B are constants)

1. $p = Be^{-2At}, q = \frac{A}{B}e^{2At}$

2. $p = Ae^{-2At}, q = \frac{A}{B}e^{-2At}$

3. $p = Ae^{At}, q = \frac{A}{B}e^{-At}$

4. $p = 2Ae^{-A^2t}, q = \frac{A}{B}e^{A^2t}$

Q5. [June 2016] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2016 June	5M

The Lagrangian of a system moving in three dimensions is

$$L = \frac{1}{2}m\dot{x}_1^2 + m\left(\dot{x}_2^2 + \dot{x}_3^2\right) - \frac{1}{2}kx_1^2 - \frac{1}{2}k(x_2 + x_3)^2$$

The independent constant(s) of motion is/are

1. energy alone
2. only energy, one component of the linear momentum and one component of the angular momentum.
3. only energy and one component of the linear momentum
4. only energy and one component of the angular momentum

Q6. [June 2017] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2017 June	3.5M

The Hamiltonian for a system described by the generalised coordinate x and generalised momentum p is

$$H = \alpha x^2 p + \frac{p^2}{2(1+2\beta x)} + \frac{1}{2}\omega^2 x^2$$

where α, β and ω are constants. The corresponding Lagrangian is

1. $\frac{1}{2}(\dot{x} - \alpha x^2)^2(1+2\beta x) - \frac{1}{2}\omega^2 x^2$
2. $\frac{1}{2(1+2\beta x)}\dot{x}^2 - \frac{1}{2}\omega^2 x^2 - \alpha x^2 \dot{x}$
3. $\frac{1}{2}(\dot{x}^2 - \alpha^2 x)^2(1+2\beta x) - \frac{1}{2}\omega^2 x^2$
4. $\frac{1}{2(1+2\beta x)}\dot{x}^2 - \frac{1}{2}\omega^2 x^2 + \alpha x^2 \dot{x}$

Q7. [June 2017] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2017 June	5M

The Lagrangian of a free relativistic particle (in one dimension) of mass m is given by $L = -m\sqrt{1 - \dot{x}^2}$ where $\dot{x} = dx/dt$. If such a particle is acted upon by a constant force in the direction of its motion, the phase space trajectories obtained from the corresponding Hamiltonian are

1. Ellipses
2. Cycloids
3. Hyperbolas
4. Parabolas

Q8. [June 2017] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2017 June	5M

The energy of a one-dimensional system, governed by the Lagrangian

$$L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^{2n}$$

where k and n are two positive constants, is E_0. The time period of oscillation τ satisfies

1. $\tau \propto k^{-\frac{1}{n}}$
2. $\tau \propto k^{-\frac{1}{2n}} E_0^{\frac{1-n}{2n}}$
3. $\tau \propto k^{-\frac{1}{2n}} E_0^{\frac{n-2}{2n}}$
4. $\tau \propto k^{-\frac{1}{n}} E_0^{\frac{1+n}{2n}}$

Q9. [Dec 2018] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2018 Dec	5M

The motion of a particle in one dimension is described by the Langrangian $L = \frac{1}{2}\left(\left(\frac{dx}{dt}\right)^2 - x^2\right)$ in suitable units. The value of the action along the classical path from $x = 0$ at $t = 0$ to $x = x_0$ at $t = t_0$, is

1. $\frac{x_0^2}{2\sin^2 t_0}$
2. $\frac{1}{2}x_0^2 tan\, t_0$
3. $\frac{1}{2}x_0^2 cot\, t_0$
4. $\frac{x_0^2}{2\cos^2 t_0}$

Q10. [Dec 2018] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2018 Dec	5M

The Hamiltonian of a classical one-dimensional harmonic oscillator is $H = \frac{1}{2}\left(p^2 + x^2\right)$, in suitable units. The total time derivative of the dynamical variable $(p + \sqrt{2}x)$ is

1. $\sqrt{2}p - x$
2. $p - \sqrt{2}x$
3. $p + \sqrt{2}x$
4. $x + \sqrt{2}p$

Q11. [June 2018] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2018 June	5M

The Hamiltonian of a one-dimensional system is $H = \frac{xp^2}{2m} + \frac{1}{2}kx$, where m and k are positive constants. The corresponding Euler-Lagrange equation for the system is

1. $m\ddot{x} + k = 0$
2. $m\ddot{x} + 2\dot{x} + kx^2 = 0$
3. $2mx\ddot{x} - m\dot{x}^2 + kx^2 = 0$
4. $mx\ddot{x} + 2m\dot{x}^2 + kx^2 = 0$

Q12. [Dec 2019] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2019 Dec	3.5M

Which of the following terms, when added to the Lagrangian $L(x, y, \dot{x}, \dot{y})$ of a system with two degrees of freedom will not change the equations of motion?

1. $x\ddot{x} - y\ddot{y}$
2. $x\ddot{y} - y\ddot{x}$
3. $x\dot{y} - y\dot{x}$
4. $y\dot{x}^2 + x\dot{y}^2$

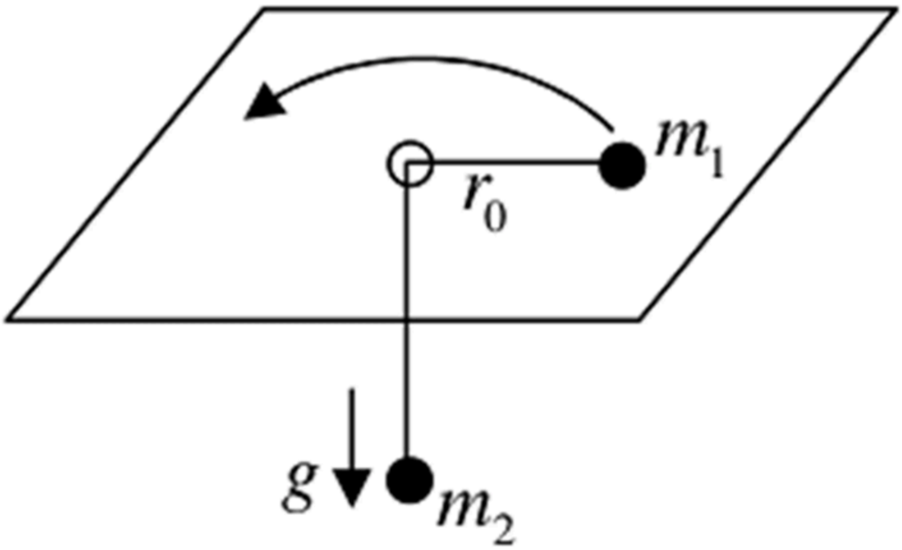
Q13. [June 2019] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2019 June	5M

Two particles of masses m_1 and m_2 are connected by a mass less thread of length l as shown in figure.

The particle of mass in on the plane undergoes a circular motion with radius r_0 and angular momentum L. When a small radial displacement ∈ (whew $\in \ll r_0$) is applied, its radial coordinate is found to found to oscillate about r_0. The frequency of the oscillations is



1. $\sqrt{\frac{7m_2g}{\left(m_1+\frac{m_2}{2}\right)r_0}}$
2. $\sqrt{\frac{7m_2g}{(m_1+m_2)r_0}}$
3. $\sqrt{\frac{3m_2g}{\left(m_1+\frac{m_2}{2}\right)r_0}}$
4. $\sqrt{\frac{3m_2g}{(m_1+m_2)r_0}}$

Q14. [June 2020] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2020 June	3.5M

A point mass m, is constrained to move on the inner surface of a paraboloid of revolution $x^2 + y^2 = az$ (where $a > 0$ is a constant). When it spirals down the surface, under the influence of gravity (along $-z$ direction), the angular speed about the z - axis is proportional to

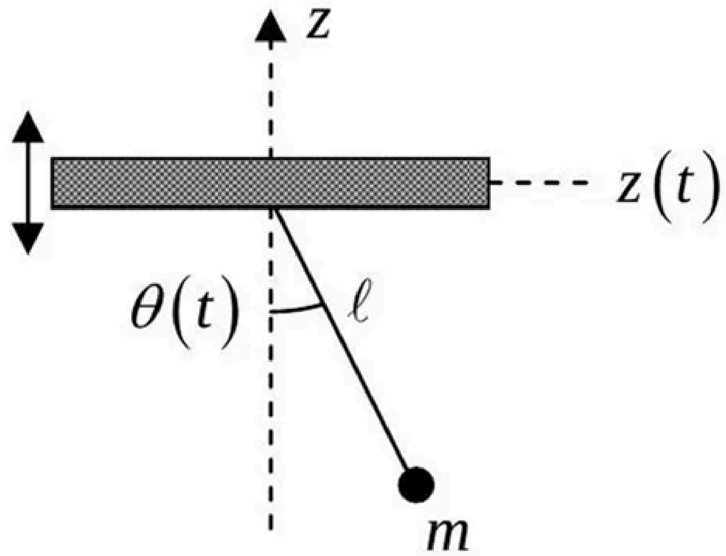
1. 1 (independent of z)
2. Z
3. Z^{-1}
4. z^{-2}

Q15. [June 2021] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2021 June	5M

The fulcrum of a simple pendulum (consisting of a particle of mass m attached to the support by a massless string of length ℓ) oscillates vertically as $\sin z(t) = a\sin\omega t$, where ω is a constant. The pendulum moves in a vertical plane and $\theta(t)$ denotes its angular position with respect to the z-axis.



If $\ell\frac{d^2\theta}{dt^2} + \sin\theta(g - f(t)) = 0$ (where g is the acceleration due to gravity) describes the equation of motion of the mass, then f(t) is

1. $a\omega^2\cos\omega t$
2. $a\omega^2\sin\omega t$
3. $-a\omega^2\cos\omega t$
4. $-a\omega^2\sin\omega t$

Q16. [June 2022] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2022 June	3.5M

The Lagrangian of a system described by three generalized coordinates q_1, q_2 and q_3 is

$$L = \frac{1}{2}m(\dot{q}_1^2 + \dot{q}_2^2) + M\dot{q}_1\dot{q}_2 + k\dot{q}_1 q_3,$$

where m, M and k are positive constants. Then, as a function of time

1. two coordinates remain constant and one evolves linearly
2. one coordinate remains constant, one evolves linearly and the third evolves as a quadratic function
3. one coordinate evolves linearly and two evolve quadratically
4. all three evolve linearly

Q17. [Dec 2023] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 Dec	3.5 M

The 1-dimensional Hamiltonian of a classical particle of mass m is

$$H = \frac{P^2}{2m} e^{-x/a} + V(x)$$

where a is a constant with appropriate dimensions. The corresponding Lagrangian is,

1. $\frac{m}{2}\left(\frac{dx}{dt}\right)^2 e^{x/a} - V(x)$
2. $\frac{m}{2}\left(\frac{dx}{dt}\right)^2 e^{-x/a} - V(x)$
3. $\frac{3m}{2}\left(\frac{dx}{dt}\right)^2 e^{x/a} - V(x)$
4. $\frac{3m}{2}\left(\frac{dx}{dt}\right)^2 e^{-x/a} - V(x)$

Q18. [Dec 2023] . 5.0 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 Dec	5 M

A Lagrangian is given by

$$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}\dot{z} + \dot{z}^2) - \alpha(2x + 3y + z)$$

The conserved momentum is

1. $m[2\dot{x} + \dot{z}]$
2. $m[2\dot{x} + \dot{y} + \dot{z}]$
3. $m\left[\dot{x} + \frac{3}{2}\dot{y} + \frac{1}{2}\dot{z}\right]$
4. $m[2\dot{x} + 3\dot{z}]$

Q19. [June 2023] . 3.5 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 June	3.5M

A one-dimensional rigid rod is constrained to move inside a sphere such that its two ends are always in contact with the surface. The number of constraints on the Cartesian coordinates of the endpoints of the rod is

1. 3
2. 5
3. 2
4. 4

Q20. [June 2023] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 June	3.5M

The Hamiltonian of a two particle system is $H = p_1 p_2 + q_1 q_2$, where q_1 and q_2 are generalized coordinates and p_1 and p_2 are the respective canonical momenta. The Lagrangian of this system is

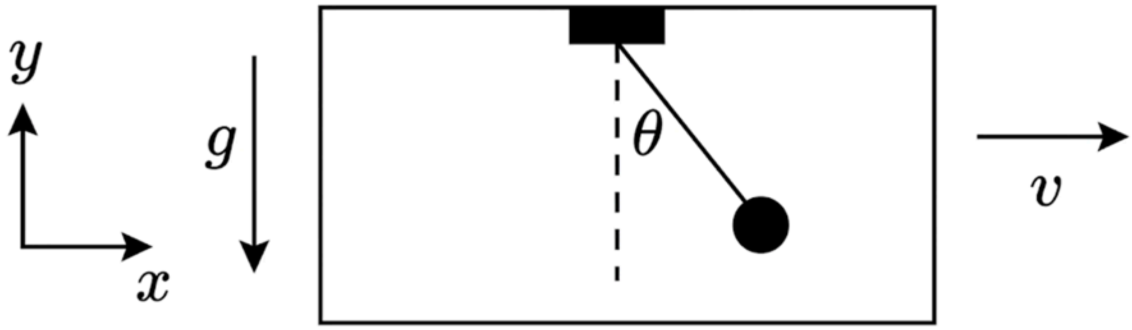
1. $\dot{q}_1\dot{q}_2 + q_1 q_2$
2. $-\dot{q}_1\dot{q}_2 + q_1 q_2$
3. $-\dot{q}_1\dot{q}_2 - q_1 q_2$
4. $\dot{q}_1\dot{q}_2 - q_1 q_2$

Q21. [Dec 2024] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2024 Dec	3.5M

The point of support of a simple pendulum, of mass m and length l, is attached to the roof of a taxi as shown in the figure. The taxi is moving with uniform velocity v. The Lagrangian for the pendulum is



1. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\cos\theta\dot{\theta} - mgl\cos\theta$
2. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\cos\theta\dot{\theta} + mgl\cos\theta$
3. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\sin\theta\dot{\theta} + mgl\cos\theta$
4. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\sin\theta\dot{\theta} - mgl\cos\theta$

Q22. [Dec 2024] . 5.0 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2024 Dec	5M

The Lagrangian of a system is

$$L = \frac{15}{2}m\dot{x}^2 + 6m\dot{x}\dot{y} + 3m\dot{y}^2 - mg(x + 2y)$$

Which one of the following is conserved?

1. $12\dot{x} + 3\dot{y}$
2. $12\dot{x} - 3\dot{y}$
3. $3\dot{x} - 12\dot{y}$
4. $3\dot{x} + 3\dot{y}$

Q23. [Dec 2025] . 5.0 marks
Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2025 Dec	5M	CM

The Hamiltonian of a simple pendulum consisting of mass m attached to a massless string of length l is $H = \frac{P_\theta^2}{2ml^2} + mgl(1 - \cos\theta)$. If L denotes the Lagrangian, then $\frac{dL}{dt}$ is

1. $\frac{g}{l} P_\theta \cos\theta$
2. $\frac{-g}{l} P_\theta \sin\theta$
3. $\frac{-2g}{l} P_\theta \sin\theta$
4. $\frac{g}{l} P_\theta \cos(2\theta)$

Q24. [June 2025] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2025 June	3.5M	CM

The Hamiltonian of a system is given by $H(x,p) = -\left[p^2 + V^2(x)\right]^{1/2}$, where x and p are generalized co-ordinate and momentum respectively and $V(x) \geq 0$. The corresponding Lagrangian is

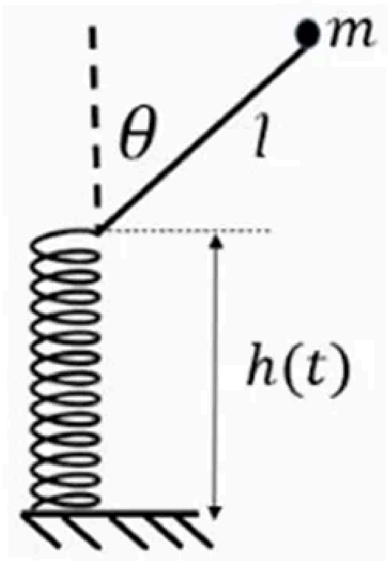
1. $-V(x)\sqrt{1-\dot{x}^2}$
2. $-V(x)/\sqrt{1-\dot{x}^2}$
3. $V(x)\sqrt{1-\dot{x}^2}$
4. $V(x)/\sqrt{1-\dot{x}^2}$

Q25. [June 2025] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2025 June	5M	CM

A massless rod of length l is hinged at the extreme end of a vertical spring whose other end is fixed to the ground. A point mass m is fixed at end of the rod, as shown in the figure. Assume harmonic motion of the spring given by $h(t) = h_0(2 + \cos\omega t)$, where $h_0 > l$. The equation of motion of the mass (confined to the plane of the figure) is given by



1. $l\ddot{\theta} + \omega^2 h_0 \sin\theta \sin\omega t - g\sin\theta = 0$
2. $l\ddot{\theta} + \omega^2 h_0 \sin\theta \cos\omega t - g\sin\theta = 0$
3. $l\ddot{\theta} + \omega^2 h_0 \sin\theta \cos\omega t + g\sin\theta = 0$
4. $l\ddot{\theta} - \omega^2 h_0 \sin\theta \sin\omega t + g\sin\theta = 0$

Answer Key

25 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q2	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q3	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q4	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q5	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q6	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q7	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q8	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q9	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q10	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q11	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q12	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q13	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q14	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q15	Classical Mechanics	Lagrangian and Hamiltonian	**None**
Q16	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q17	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q18	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q19	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q20	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q21	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q22	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q23	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q24	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q25	Classical Mechanics	Lagrangian and Hamiltonian	**2**

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