DPP – 4 (WEP)

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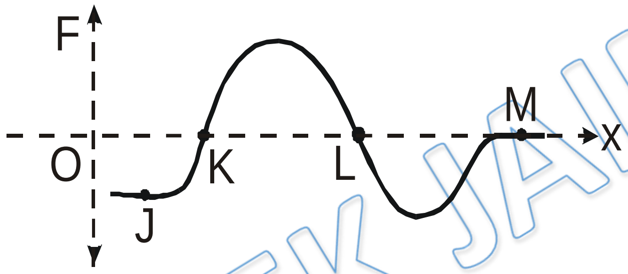
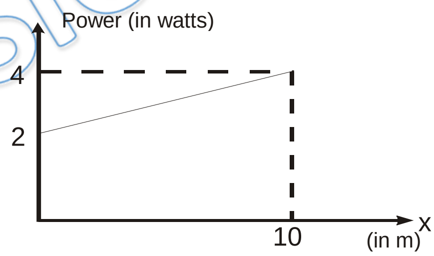
Q 1. A particle moving along x-axis is being acted upon by one dimensional conservative force F. In the F–x curve shown, four points J, K, L, M are marked on the curve. Column II gives different type of equilibrium for the particle at different positions. Column I gives certain positions on the force position graphs. Match the positions in Column-I with the corresponding nature of equilibrium at these posit



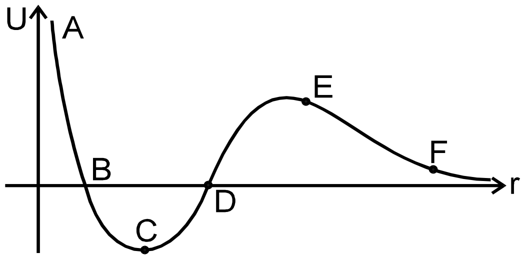
Column I	Column II
(A) Point J is position of	(p) Neutral equilibrium
(B) Point K is position of	(q) Unstable equilibrium
(C) Point L is position of	(r) Stable equilibrium
(D) Point M is position of	(s) No equilibrium

Q 2. A particle A of mass 10/7 kg is moving in the positive direction of x. Its initial position is x = 0 & initial velocity is 1 m/s. The velocity at x = 10 is: (use the graph given)



(a) 4 m/s
(b) 2 m/s
(c) $3\sqrt{2}$ m/s
(d) 100/3 m/s

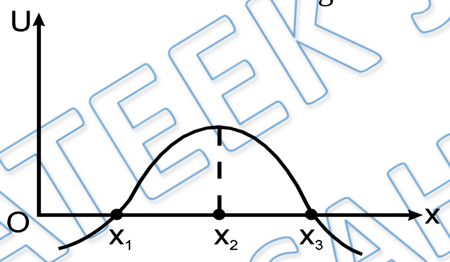
Q 3. The given plot shows the variation of U, the potential energy of interaction between two particles with the distance separating them, r. Then which of the following statements are correct.:



(a) B and D are equilibrium points
(b) C is a point of stable equilibrium
(c) The force of interaction between the two particles is attractive between points C and D and repulsive between points D and E on the curve.
(d) The force of interaction between the particles is repulsive between points E and F on the curve.

Q 4. An engine exerts a force $\vec{F} = (20\hat{i} - 3\hat{j} + 5\hat{k})N$ and moves with velocity $\vec{v} = (6\hat{i} + 20\hat{j} - 3\hat{k})$ m/s. The power of the engine (in watt) is:
(a) 45 (b) 75 (c) 20 (d) 10

Q 5. In the figure shown the potential energy U of a particle is plotted against its position ' x ' from origin. Then which of the following statement is correct. A particle at:



(a) x_1 is in stable equilibrium (b) x_2 is in stable equilibrium
(c) x_3 is in stable equilibrium (d) none of these

Q 6. Power supplied to a particle of mass 2 kg varies with time as P $=3t^2 / 2$ watt. Here t is in second, velocity of particle at t = 0 is v = 0. The velocity of particle at time t=2s will be
(a) 1 m/s (b) 4 m/s (c) 2 m/s (d) $2\sqrt{2}$ m/s

Q 7. A force F acting on a body depends on its displacement S as $F \propto S^{-1/3}$ The power delivered by F will depend on displacement as
(a) $S^{2/3}$ (b) $S^{-5/3}$ (c) $S^{1/2}$ (d) S^0

Q 8. A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t is proportional to
(a) $t^{1/2}$ (b) $t^{3/4}$ (c) $t^{3/2}$ (d) t^2

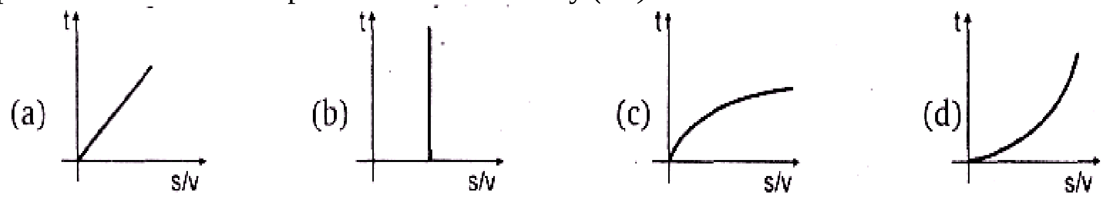
Q 9. A constant power P is applied to a particle of mass m. The distance travelled by the particle when its velocity increases from v_1 to v_2 is (neglect friction)
(a) $3p / m (v_2^2 - v_1^2)$ (b) $m / 3p (v_2 - v_1)$

(c) $m/3p\ (v_2^3 - v_1^3)$ (d) $m/3p\ (v_2^2 - v_1^2)$

Q 10. A block of mass m is pulled by a constant power P placed on a rough horizontal plane. The friction coefficient between the block and the surface is μ. Maximum velocity of the block will be

(a) μp/mg (b) μmg/p (c) μmgp (d) p/μmg

Q 11. A body is moved from rest along a straight line by a machine delivering constant power. The ratio of displacement and velocity *(s/v)* varies with time *t* as:



Q 12. A particle moves in a straight line with constant acceleration under a constant force F. Select & correct alternatives).

(a) power developed by this force varies linearly with time.
(b) power developed by this force varies parabolically with time.
(c) power developed by this force varies linearly with displacement.
(d) power developed by this force varies parabolically with displacement.

Q 13. In projectile motion power of the gravitational force

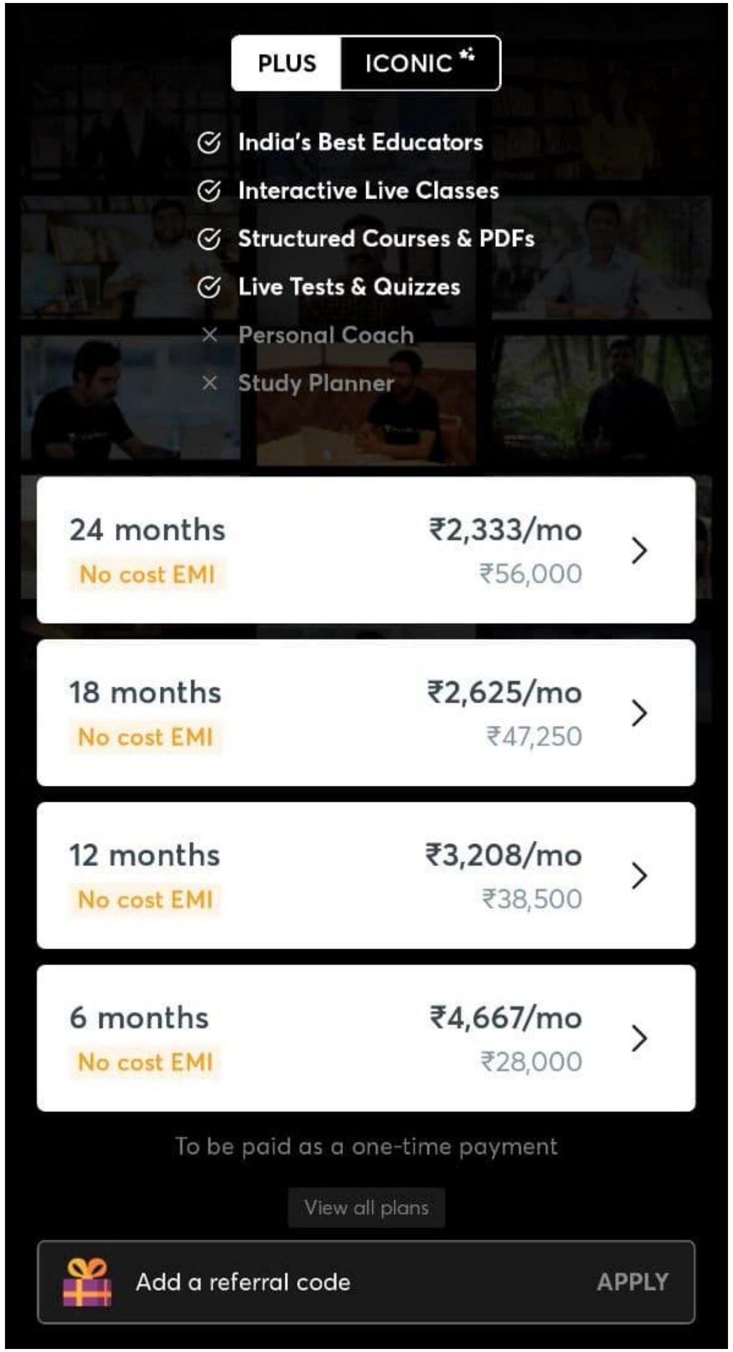
(a) is constant throughout
(b) is negative for first half, zero at topmost point and positive for rest half
(c) varies linearly with time
(d) is positive for complete path

Q 14. A pump motor is used to deliver water at a certain rate from a given pipe. To obtain n times water from the same pipe in the same time

(a) force exerted by the motor should be increased n^2 times
(b) force exerted by the motor should be increased n times
(c) power of the motor must be increased n^3 times
(d) power of the motor must be increased n^2 times

Answer Key

Q.1 (A) s (B) q (C) r (D) p	**Q.2 a**	**Q.3 b, d**	**Q.4 b**	**Q.5 d**
Q.6 c	**Q.7 d**	**Q.8 c**	**Q.9 c**	**Q.10 d**
Q.11 a	**Q.12 a, d**	**Q.13 b, c**	**Q.14 a, c**	



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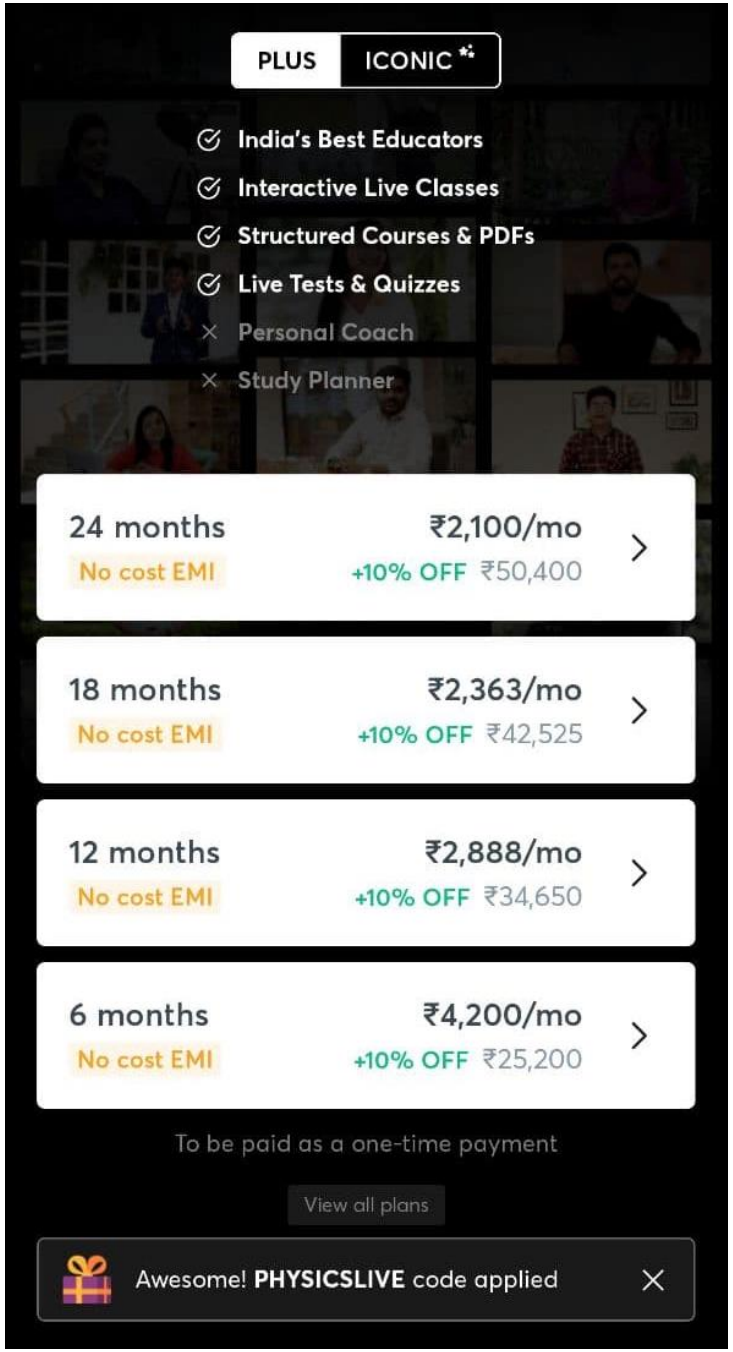

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Written Solution

DPP-4 WEP: Equilibrium, Power

By Physicsaholics Team

JEE Main & Advanced, NSEP, INPhO, IPhO Physics DPP

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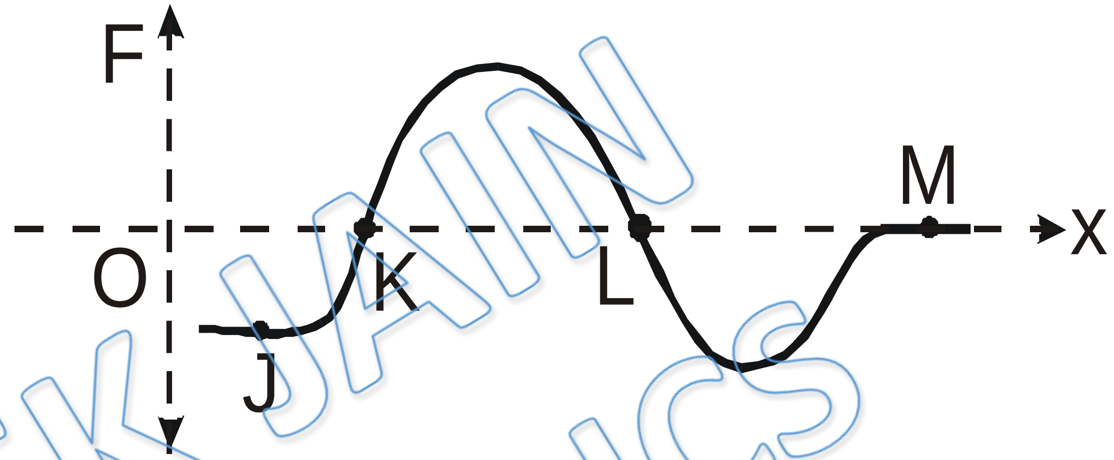
Solution: 1

At J , F $\neq$ 0

$\Rightarrow$ J is not equilibrium.



At K , F = 0

just before K , F = −ve $\Rightarrow$ F is away from K

just after K , F = +ve $\Rightarrow$ " " "

$\Rightarrow$ K is unstable equilibrium.

At L , $F = 0$

just before L , $F = +ve$ $\Rightarrow$ F is towards L

" after L , $F = -ve$ $\Rightarrow$ " " "

$\Rightarrow$ L is stable equilibrium.

At M , $F = 0$

just before M , $F = 0$

" after M , $F = 0$

$\Rightarrow$ M is neutral equilibrium.

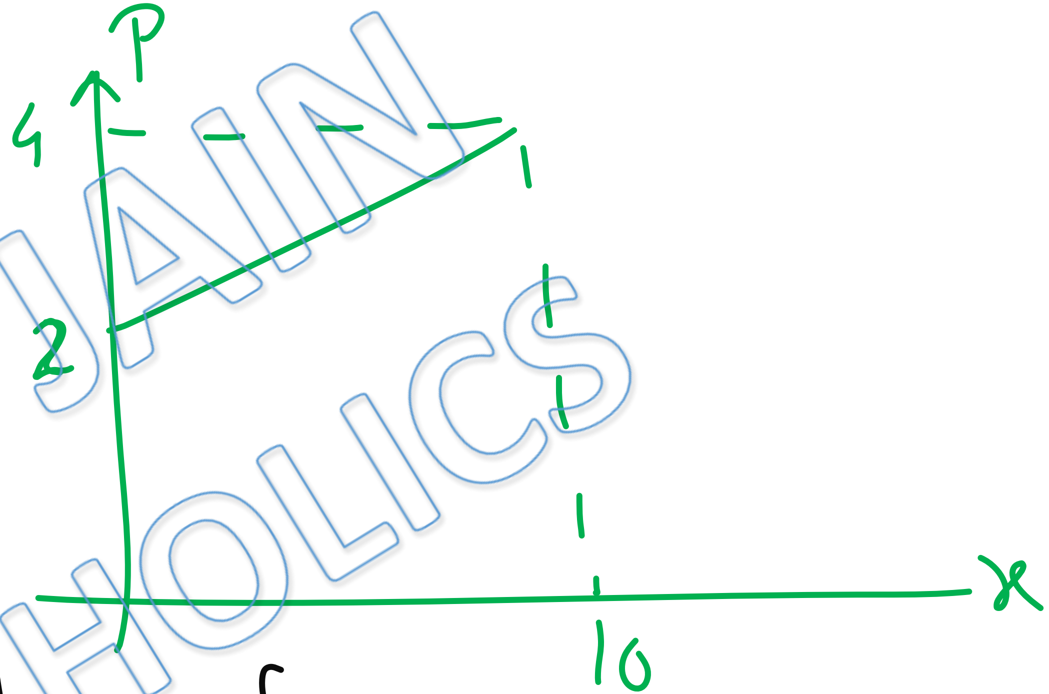
Ans. (A)s (C)r (D)p

Solution:2

$m = 10/7 \text{ Kg}$

at $x = 0$, $u = 1 \text{ m/sec}$

at $x = 10$, $V = ?$



Area under Curve

$$= \int P\,dx = \int F V\,dx = \int m a V\,dx = \int m \frac{V\,dv}{dx} V\,dx$$

$$= m\int_u^V V^2\,dv = \frac{m\left(V^3 - u^3\right)}{3}$$

$$\Rightarrow \text{Area} = \frac{10}{7\times 3}\left(V^3 - 1\right) = \frac{1}{2}\times 10\,(4+2)$$

$$\frac{10}{7\times 3}\left(V^3-1\right) = 10\times 3$$

$$\Rightarrow \quad V^3 = 64$$

$$\Rightarrow \quad V = 4\ m/sec$$

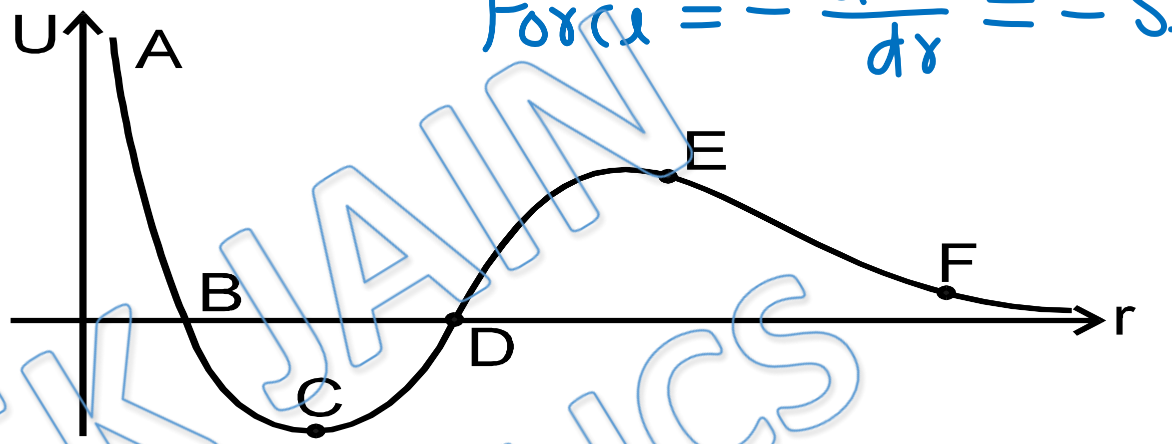
Ans(a)

Solution:3

In U-x graph

At Equilibrium position

Slope = 0



$$\text{Force} = -\frac{dU}{dr} = -\text{Slope}$$

Only C & E are equilibrium.

In U-x graph, minima is stable equilibrium and maxima is unstable equilibrium.

$\Rightarrow$ C is stable and E is unstable equilibrium.

from C to E, Slope = +ve $\Rightarrow$ F = −ve $\Rightarrow$ attraction.

from E to F, Slope = −ve $\Rightarrow$ F = +ve $\Rightarrow$ repulsive

Ans (b, d)

Solution:4

$$\vec{F} = 20\hat{i} - 3\hat{j} + 5\hat{k}$$

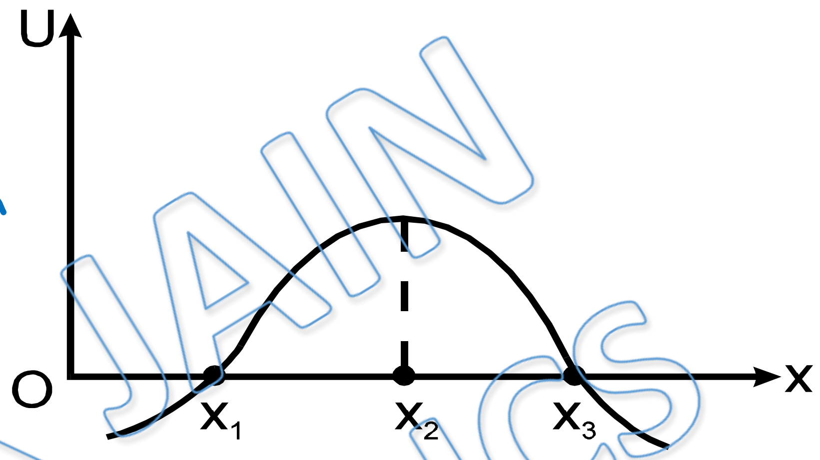
$$\vec{V} = 6\hat{i} + 20\hat{j} + 3\hat{k}$$

$$P = \vec{F}\cdot\vec{V} = 120 - 60 + 15$$

$$= 75 \text{ Watt}$$

Ans.b

Solution:5



At equilibrium in U-x graph

$$\frac{dU}{dx} = 0 \Rightarrow \text{Slope} = 0$$

$\Rightarrow$ only x_2 is equilibrium.

Since x_2 is maxima it is unstable equilibrium.

Ans (d)

Solution:6

$P = \frac{3t^2}{2}$ & at $t=0, v=0$ & $m = 2\,kg$

$$W = \int P\,dt = \int_0^2 \frac{3t^2}{2}\,dt = \left[\frac{t^3}{2}\right]_0^2 = 4\,J$$

Using work - energy theorem

$$W = \Delta K$$

$$\Rightarrow 4 = \frac{1}{2} \times 2v^2 - 0$$

$$\Rightarrow v = 2\,m/sec$$

Ans(c)

Solution:7

$$F \propto s^{-1/3}$$

$$\Rightarrow \quad a \propto s^{-1/3}$$

$$\Rightarrow \quad \int v\,dv \propto \int s^{-1/3}\,ds$$

$$\Rightarrow \quad v^2 \propto s^{2/3}$$

$$\Rightarrow \quad KE \propto s^{2/3}$$

$$\Rightarrow \quad P = \frac{d}{dt}(KE) \propto s^{2/3-1} \qquad \frac{ds}{dt} \propto v s^{-1/3} \propto s^{1/3} s^{-1/3}$$

$$\Rightarrow \quad P \propto s^0$$

Ans (d)

Solution:8

$$P = \text{Constant}$$

$$\Rightarrow \quad W = Pt$$

$$\Rightarrow \quad \frac{1}{2}mv^2 = Pt$$

$$\Rightarrow \quad v \propto t^{1/2}$$

$$\Rightarrow \quad \int ds \propto \int t^{1/2}\,dt$$

$$\Rightarrow \quad s \propto t^{3/2}$$

Ans (c)

Solution:9

$$P = \text{Constant}$$

$$\Rightarrow \quad P = FV = mav$$

$$\Rightarrow \quad P = mv\frac{dv}{dx}v$$

$$\Rightarrow \quad \int_0^x dx = \frac{m}{P}\int_{v_1}^{v_2} v^2\,dv$$

$$\Rightarrow \quad x = \frac{m}{3P}\left(v_2^3 - v_1^3\right)$$

Ans (c)

Solution:10

At $V = V_{max}$, $\frac{dv}{dt} = 0$

by work-Energy theorem →

$$W_{all} = K - K_i = \frac{1}{2}mv^2 - K_i$$

$$\Rightarrow \quad P_{all} = \frac{1}{2}m \times 2v\frac{dv}{dt} - 0$$

$$\Rightarrow \quad P_{all} = 0$$

$$\Rightarrow \quad P - \mu mgV = 0$$

$$\Rightarrow \quad V = \frac{P}{\mu mg}$$

Ans(d)

Solution:11

$$P = \text{Constant}$$

$$\Rightarrow \quad P = mav$$

$$\Rightarrow \quad \frac{P}{m} = \frac{v^2 dv}{dx}$$

$$\Rightarrow \quad \int \frac{P\,dx}{m} = \int v\,dv$$

$$\Rightarrow \quad \frac{Px}{m} = \frac{v^2}{2} \quad \text{---} \quad (1)$$

$$v = \sqrt{\frac{2Px}{m}}$$

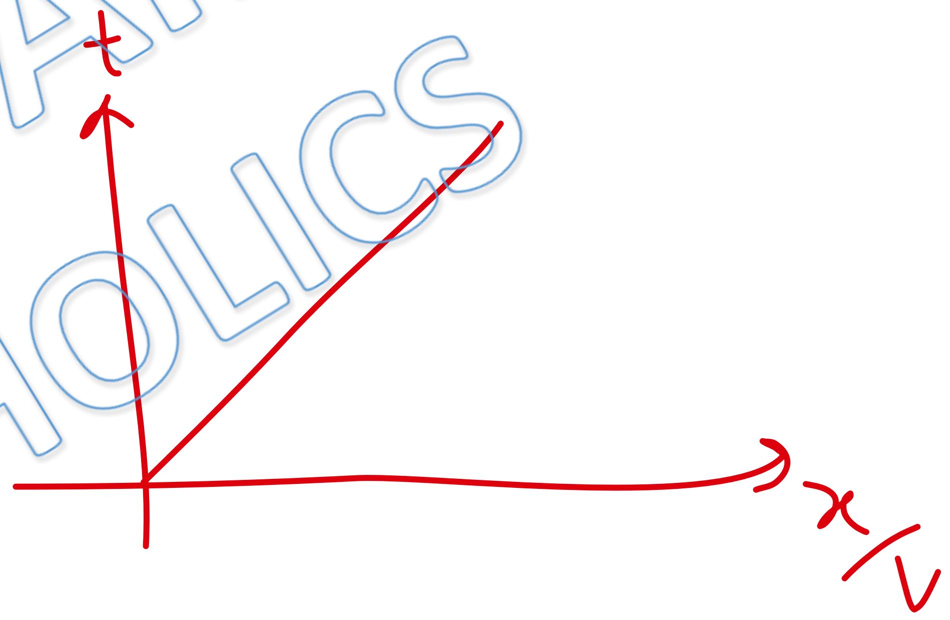
$$\int \frac{dx}{\sqrt{x}} = \sqrt{\frac{2P}{m}} \int dt$$

$$\Rightarrow \quad 2x^{1/2} = \sqrt{\frac{2P}{m}}\, t$$

$$\Rightarrow \quad x = \frac{2P}{4m} t^2$$

$$\Rightarrow \quad v = \frac{P}{m} t$$

$$\Rightarrow \quad \frac{x}{v} = \frac{1}{2} t$$



Ans (a)

Solution:12

$$F = \text{Constant}$$

$$\Rightarrow a = \text{Constant}$$

$$\Rightarrow V \propto t$$

$$\Rightarrow P = FV \propto t \Rightarrow P\text{-}t \text{ graph is straight line.}$$

$$V \propto t \Rightarrow \frac{dx}{dt} \propto t \Rightarrow dx \propto t\, dt$$

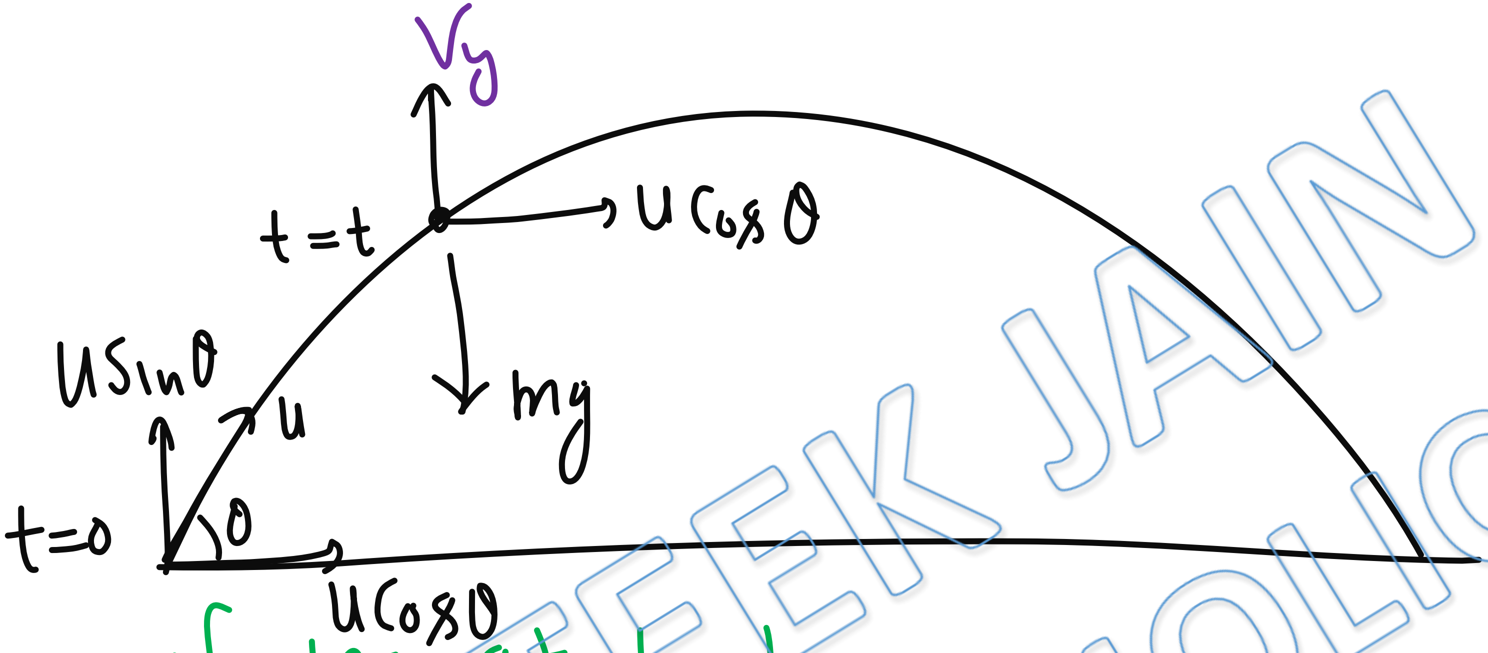
$$\Rightarrow x \propto t^2 \Rightarrow t \propto \sqrt{x}$$

$$\Rightarrow P \propto t \propto \sqrt{x}$$

$$\Rightarrow P^2 \propto x \longrightarrow P\text{-}x \text{ graph is parabola.}$$

Ans (a,d)

Solution:13



Power of mg at $t=t$

$$P = \vec{F}\cdot\vec{V} = -mgV_y = -mg(u\sin\theta - gt)$$

$$\Rightarrow P = -mgu\sin\theta + mg^2t$$

at topmost point $V_y = 0 \Rightarrow P = 0$

before topmost point mg & V_y are opposite $\Rightarrow P = -ve$.

After " " " " ", in same direction $\Rightarrow P = +ve$. Ans (b,c)

Solution:14

$$P \propto \frac{1}{2} \mu V^2$$

μ → mass of water delivered per second

V → speed of water

but $\mu = \rho A V$

ρ → density

A → Cross sectional Area of pipe.

$$\Rightarrow P \propto V^3$$

Ans.a,c

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