JEE MAIN | IIT JEE

Motion in 1-D

Concept + 10 Numerical

REVISION in 30 Min

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Motion in One Dimension

- Direct Numerical
  - Avg v, Avg a
  - Instantaneous (calculus)
  - Uniform acc^n
- Graphical Question
  - Finding value of a parameter using Graph
  - Converting graphs.

10 Numerical Examples

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Prerequisite

1. Vectors
2. Calculus (very basic)
3. Straight Lines & parabola

$y = mx + c$

$m = \tan\theta$

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Chapter	Formulae_Concept VIDEO LINK
Unit & Dimensions	https://youtu.be/wdd-wlZF4Hk
Errors and Vectors	
Vernier Caliper	https://youtu.be/pVoN045dV8I
Screw Gauge	https://youtu.be/gYd2PtmZ0mw
Kinematics_Motion in 1d	
Kinematics_Motion in 2d	
Laws of Motion	
Work Energy Power	https://youtu.be/kjrXoE-kDI8
Centre of Mass	
Centre of Mass of Standard Bodies	https://youtu.be/oCeACfryB-U
Collision	
Rotational Motion_Moment of Inertia	https://youtu.be/9ckZdOhy3z0
Gravitation	https://youtu.be/rAj2huLVaEk
Properties of Solids	https://youtu.be/gSXxjk89I_c
Fluids Statics (Part 1)	https://youtu.be/RFKx9B9yo3M
Fluid Dynamics (Part 2)	https://youtu.be/Y717vQpUEJQ
Fluid Properties (Part 3)	https://youtu.be/V8xUWWK2oT0
Simple Harmonic Motion	https://youtu.be/RIb7ofNG09I
Thermal Properties	
KTG	https://youtu.be/XO1tvFhIa0I
Thermodynamics	https://youtu.be/iz_kf1jRDRw
Wave Motion -Organ Pipes and Resonance Tube	https://youtu.be/fB7pfJ77za8
Wave Motion - Doppler's Effect	https://youtu.be/9-BxOaamnwg
Electrostatics	https://youtu.be/3stXbGRMcrk
Capacitors	https://youtu.be/EXEiickNUkY
Current Electricity	https://youtu.be/gm8FUfjrX18
Moving Charges and Magnetic Effect of Current	https://youtu.be/ULD2Ok1CGJk
Earth's Magnetism	https://youtu.be/a4CT5uVwAK4
Magnetic Properties	https://youtu.be/63cwdYXNlYE
EMI	https://youtu.be/puVavm_GFRM
Alternating Current	https://youtu.be/74dTY-pzM_o
Ray Optics	https://youtu.be/BhnyTWzIlBA
Wave Optics Part 1_Interference	https://youtu.be/LG5nlE8XTeI
Wave Optics Part 2_Diffraction_Polarization	https://youtu.be/ymMyyJGGqnY
Optical Instruments	https://youtu.be/OQssbDH0A4I
Electromagnetic Waves	https://youtu.be/bcVXgEkyQZY
Semiconductors_Basics + Zener Diode	https://youtu.be/_A2JomQ7-50
Semiconductors_Transistors	https://youtu.be/psDwl84Nzb0
Semiconductors_Logic Gates	https://youtu.be/pZdQAzLbFTo
Communication Systems	https://youtu.be/8NgMqK9X79Y
Modern Physics_Part 1_Atomic Physics	https://youtu.be/9VKUnE3mpHk
Modern Physics_Part 2_Photoelectric Effect	https://youtu.be/24oTQp84jrk
Modern Physics_Part 3_Dual Nature of Light	https://youtu.be/0zoR_saMAQY
Modern Physics_Part 4_Radioactivity	https://youtu.be/AdX3YBhQyog
Modern Physics_Part 5_Nuclear Physics	https://youtu.be/VDWqVahGixc
Modern Physics_Part 6_X Rays	https://youtu.be/dSHXdzX7NX0

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1. Average Velocity & acceleration

(a) $\vec{v}_{av} = \dfrac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \dfrac{\Delta\vec{r}}{\Delta t}$ or

If $v = f(t)$ is given

$$V_{av} = \frac{\int_{t_1}^{t_2} V\,dt}{t_2 - t_1}$$

(b) $\vec{a}_{av} = \dfrac{\vec{V}_2 - \vec{V}_1}{t_2 - t_1} = \dfrac{\Delta\vec{V}}{\Delta t}$ or

If $a = f(t)$ is given

$$a_{av} = \frac{\int_{t_1}^{t_2} a \cdot dt}{t_2 - t_1}$$

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... Continued

Ex1. Suppose $v = 2 + 4t^2$, find a_{av} between $t_1 = 2\,sec$ and $t_2 = 4\,sec$

Sol^n: $V_2 = 2 + 4\cdot(4)^2 = 66\ m/s$, $V_1 = 2 + 4\cdot(2)^2 = 18\ m/s$

$$\therefore\ a_{av} = \frac{V_2 - V_1}{t_2 - t_1} = \frac{66 - 18}{4 - 2} = 24\ m/s^2$$

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2. Instantaneous v & a (calculus based)

$x = f(t)$

$v = dx/dt$

$a = \frac{dv}{dt}$

$v = f(t)$

$= f(x)$

$a = dv/dt$

$= v\frac{dv}{dx}$

$\frac{dx}{dt} = f(t)$

$\Rightarrow \int dx = \int f(t)\, dt$

$\frac{dx}{dt} = f(x)$

$\Rightarrow \int \frac{dx}{f(x)} = \int dt$

$a = f(t)$

$= f(v)$

$= f(x)$

$= \frac{dv}{dt}$ or $v\frac{dv}{dx}$

Ex: $v\frac{dv}{dx} = f(x)$

$\Rightarrow \int v\,dv = \int f(x)\,dx$

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Ex 2. A particle moves along X-axis. The velocity of the particle as function of x is $v^2 = 12x - 3x^3$ (in SI). Find velocity of particle at the instant when acceleration is 1.5 ms^{-2}

(a) 3 ms^{-1}
(b) 4 ms^{-1}
(c) 1.5 ms^{-1}
(d) Zero

... Continued

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(a) $3\ ms^{-1}$ (b) $4\ ms^{-1}$
(c) $1.5\ ms^{-1}$ (d) Zero

Sol^n: $v^2 = 12x - 3x^3$, Diff w.r.t x $\Rightarrow 2v\cdot\underbrace{\frac{dv}{dx}}_{a} = 12 - 9x^2$

$\Rightarrow 2 \times 1.5 = 12 - 9x^2$

$\Rightarrow x^2 = 1$ or $x = \pm 1$

$\therefore v^2 = 12\cdot 1 - 3\cdot 1^3$ & $v^2 = 12(-1) - 3(-1)^3$

$= -12 + 3 = -9$

$\hookrightarrow$ not possible

$\boxed{v = 3\ m/s}$

... Continued

Ex 3. A particle is starting from rest. Its acceleration at an instant t is $a = \frac{10}{v+1} \text{ms}^{-2}$, where v is instantaneous velocity. The distance travelled till the particle attains a velocity of 15 ms^{-1} is

(a) 123.75 m
(b) 1237.5 m
(c) 200 m
(d) 375 m

... Continued

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(a) 123.75 m (b) 1237.5 m
(c) 200 m (d) 375 m

Sol^n: $a = f(v) \longrightarrow v = f(x)$

$$v\frac{dv}{dx} = \frac{10}{v+1} \Rightarrow \int_0^{15}(v^2+v)\,dv = \int_0^{x} 10\,dx$$

$$\Rightarrow \left(\frac{v^3}{3}+\frac{v^2}{2}\right)_0^{15} = 10x \Rightarrow \frac{1}{10}\left(\frac{15^3}{3}+\frac{15^2}{2}\right) = x$$

$$\therefore \boxed{x = 123.75\,m}$$

... Continued

Ex4. A stone thrown up with V_0. Due to air resistance, its retardation is $K\sqrt{V}$. Find (neglect gravity)

(a) time to reach highest point

(b) Max height reached

... Continued

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(a) time to reach highest point

(b) Max height reached

Sol^n: (a) $a = -k\sqrt{V} \Rightarrow \frac{dV}{dt} = -k\sqrt{V} \Rightarrow \int_{V_0}^{0} \frac{dV}{\sqrt{V}} = \int_{0}^{t_0} -k\,dt$

$$\therefore \boxed{t_0 = \frac{2\sqrt{V_0}}{k}}$$

(b) $V\frac{dV}{dx} = -k\sqrt{V} \Rightarrow \int_{V_0}^{0} \sqrt{V}\,dV = \int_{0}^{h} -k\,dx$ $\quad \therefore \boxed{h = \frac{2V_0^{3/2}}{3k}}$

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3. Uniform Acceleration (a = constant)

(i) $v = u + at$

(ii) $s = ut + \frac{1}{2}at^2$

(iii) $v^2 = u^2 + 2as$

(iv) $s_n = u + \frac{a}{2}(2n-1)$

here v, u, a & s are vectors.
so be careful about signs.

If $u = 0$, $t = \frac{v}{a}$, $t = \sqrt{\frac{2s}{a}}$, $s = \frac{v^2}{2a}$

$\boxed{s = vt - \frac{1}{2}at^2}$

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... Continued

Ex 5. A stone is dropped from the top of a tower of height h. After 1 s, another stone is dropped from the balcony 20 m below the top. Both reach the bottom simultaneously. What is the value of h? (Take $g = 10\ m\ s^{-2}$).

(a) 3125 m
(b) 312.5 m
(c) 31.25 m
(d) 25.31 m

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... Continued

Ex 5. A stone is dropped from the top of a tower of height h. After 1 s, another stone is dropped from the balcony 20 m below the top. Both reach the bottom simultaneously. What is the value of h? (Take $g = 10\ m\ s^{-2}$).

(a) 3125 m (b) 312.5 m

(c) 31.25 m (d) 25.31 m

Sol^n:

	u	v	a	s	t
stone A	0		10	h	t
stone B	0		10	h-20	t-1

$h = \frac{1}{2}at^2$, $h - 20 = \frac{1}{2}a(t-1)^2 \Rightarrow \frac{1}{2}at^2 - 20 = \frac{1}{2}a(t-1)^2$

$\Rightarrow t = 2.5\ s$

$\therefore h = \frac{1}{2} \times 10 \times (2.5)^2$

$= \boxed{31.25\ m}$

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4. Imp Points in Motion under Gravity

(i) time of ascent = time of decent = $u/g = t$

$\therefore$ Total time, $T = 2u/g$

(ii) $H = \frac{u^2}{2g}$ (iii) $t = \sqrt{\frac{2H}{g}}$

(iii) Particle is at "h" twice in its journey ($h < H$):

$h = ut - \frac{1}{2}gt^2 \longrightarrow$ solving this

t_{AB} t_{AC} $(t_{AC} > t_{AB})$

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... Continued

Ex 6. $u = 20\,m/s$, $g = 10\,m/s^2$

Find time taken to hit ground.

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... Continued

Ex 6. $u = 20\,m/s$, $g = 10\,m/s^2$

Find time taken to hit ground.

Sol^n: From pt. of projection ball went down.

$\therefore$ Displacement, $s = -25\,m$

$$s = ut + \frac{1}{2}at^2$$

$$\Rightarrow -25 = 20t + \frac{1}{2}(-10)t^2$$

$$\Rightarrow -5 = 4t - t^2 \quad \text{or} \quad t^2 - 4t - 5 = 0$$

$$\boxed{t = 5s} \qquad t \neq -1\,s$$

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5. Graphs Basics

Area under Curve $= \int_{x_1}^{x_2} f(x) \cdot dx$

↳ slope, $\frac{dy}{dx} = \tan\theta$

1 → $\tan\theta_1$ +ve

2 → Zero

3 → $\tan\theta$ −ve

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6. Types of Graphs in 1-d Motion

(i) x vs t :

slope, $\frac{dx}{dt} = v$

↳ with t slope ↓ ⇒ v ↓

∴ Retarding Motion

↳ with t slope ↑ ⇒ v ↑

∴ Accelerated Motion

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... Continued

(ii) V vs t

→ slope, $\frac{dv}{dt} = a$

→ area under curve $= \int v\,dt$ = Displacement

(a)

V const. ⇒ $a = 0$

(b)

↳ slope constant and V↑

⇒ a const & +ve

(b)

↳ slope Const. and V↓

⇒ a const & −ve (retardation)

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... Continued

(ii) V vs t

→ slope, $\frac{dv}{dt} = a$

→ area under curve $= \int v\,dt$ = Displacement

Displacement $= A_1 - A_2 + A_3$

Distance $= A_1 + A_2 + A_3$

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... Continued

(iii) a vs t

Area $= \Delta V = V - u$

(if area is below t axis, take it as -ve)

(iv) V vs x

↳ slope, $\frac{dv}{dx} = \frac{a}{V}$

Ex 7.

$\tan\theta = \frac{V_2 - V_1}{x_1}$

$y = mx + c$

$\Rightarrow \boxed{V = x\tan\theta + V_1}$

↳ do $v\frac{dv}{dx}$ to get $a = f(x)$

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... Continued

Ex 8.

The acceleration–time graph of a particle moving along a straight line is as shown in figure.
At what time, the particle acquires its initial velocity?

(a) 12 sec
(b) 5 sec
(c) 8 sec
(d) 16 sec

... Continued

Ex 8. The acceleration–time graph of a particle moving along a straight line is as shown in figure. At what time, the particle acquires its initial velocity?

(a) 12 sec
(b) 5 sec
(c) 8 sec ✓
(d) 16 sec

Sol^n: Area under curve = ΔV

$\Rightarrow A - A = V - u \quad \therefore V = u$

$\therefore$ at $\boxed{t = 8 \text{ sec}}$

... Continued

Ex 9. Acceleration versus velocity graph of a particle moving in a straight line starting from rest is shown in figure. The corresponding velocity time graph would be

(a)

(b)

(c)

(d)

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... Continued

Sol^n: $y = mx + c$

$\Rightarrow a = -mv + a_0 \Rightarrow \frac{dv}{dt} = a_0 - mv$

$$\int_0^v \frac{dv}{a_0 - mv} = \int_0^t dt \Rightarrow -\frac{1}{m} \ln\left(\frac{a_0 - mv}{a_0}\right) = t$$

$$\therefore \boxed{v = \frac{a_0}{m}\left(1 - e^{-mt}\right)}$$

Ex 9. Acceleration versus velocity graph of a particle moving in a straight line starting from rest is shown in figure. The corresponding velocity time graph would be

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... Continued

Ex 10. A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly respesent the motion qualitatively. (a = acceleration, v = velocity, x = displacement, t = time)

(A)

(B)

(C)

(D)

(a) (B), (C)
(b) (A)
(c) (A), (B), (C)
(d) (A), (B), (D)

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... Continued

Sol^n: $u=0$, $a = \text{Const.}$

$v = at$, $x = \frac{1}{2}at^2$

Ex 10. A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly respesent the motion qualitatively. (a = acceleration, v = velocity, x = displacement, t = time)

(A)

(B)

(C)

(D)

(a) (B), (C)
(b) (A)
(c) (A), (B), (C)
(d) (A), (B), (D)

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KINEMATICS PYQs LINKS (JEE MAIN)

2021 Feb	2021 March	2021 July	2021 August	2020
https://youtu.be/A47na5ifAMc	https://youtu.be/ek7EgrGh3fg	https://youtu.be/mQSeejQAVwU	https://youtu.be/ao2TFneTnVM	https://youtu.be/OLKrZuYe150

CLICK
(Practice these Questions)

Revision Series Playlist Link https://bit.ly/3eBbib9

JEE Main PYQs Link https://bit.ly/2S54jzh Chapter wise 2021, 2020, 2018

GoldMine Link https://bit.ly/2VhOGFF

CLICK