TURBO

Created by students, for students

Motion in a Straight Line

Class 11 Physics • Complete Formula Sheet

Sr.	Concept	Formulas	Other Information
1	Position vector ($\vec{r}$)	$\vec{r}_A = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$ $\vec{r}_B = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$	Here, $\vec{r}_A(x_1, y_1)$ and $\vec{r}_B(x_2, y_2)$ are the position vectors.
2	Displacement vector ($\Delta\vec{r}$)	$\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$ Displacement vector $\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$	Vector quantity representing change in position.
3	Average speed (v_{avg})	$v_{\text{avg}} = \frac{\text{Total distance travelled}}{\text{Total time taken}} = \frac{\Delta s}{\Delta t}$	Δs = distance travelled Δt = time taken
4	Instantaneous speed (v_{inst})	$v_{\text{inst}} = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$	ds = short displacement dt = short time interval
5	Average speed (different uniform speeds in different time intervals)	$v_{\text{avg}} = \frac{s_1+s_2+s_3+\ldots+s_n}{t_1+t_2+t_3+\ldots+t_n}$ $= \frac{v_1t_1+v_2t_2+v_3t_3+\ldots}{t_1+t_2+t_3+\ldots}$ If $t_1 = t_2 = t_3 = \ldots = t_n$, then $v_{\text{avg}} = \frac{v_1+v_2+\ldots+v_n}{n}$	Different uniform speeds $v_1, v_2, v_3, \ldots v_n$ in different time intervals $t_1, t_2, \ldots t_n$ respectively.
6	Average speed (equal distances with different speeds)	$v_{\text{avg}} = \frac{d}{\frac{d}{nv_1}+\frac{d}{nv_2}+\ldots+\frac{d}{nv_n}}$ For 2 equal distances: $v_{\text{avg}} = \frac{2v_1v_2}{v_1+v_2}$	Particle moves distance d in n equal parts with different speeds $v_1, v_2, \ldots v_n$.
7	Average velocity	$\vec{v}_{\text{avg}} = \frac{\text{Net Displacement}}{\text{Time taken}} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} = \frac{\Delta\vec{r}}{\Delta t}$	$\vec{r}_f$ = final position $\vec{r}_i$ = initial position $\Delta t = t_f - t_i$ = time interval
8	Velocity in vector form	$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d(x\hat{i}+y\hat{j}+z\hat{k})}{dt}$ $= \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k}$ $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$	Velocity can be positive, negative or zero.
9	Average acceleration	$\vec{a}_{\text{avg}} = \frac{\text{Total change in velocity}}{\text{Total time taken}} = \frac{\Delta\vec{v}}{\Delta t}$	$\Delta\vec{v}$ = change in velocity Δt = time interval
10	Acceleration in vector form	$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d(v_x\hat{i}+v_y\hat{j}+v_z\hat{k})}{dt}$ $= \frac{dv_x}{dt}\hat{i} + \frac{dv_y}{dt}\hat{j} + \frac{dv_z}{dt}\hat{k}$ $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$	$d\vec{v}$ = change in velocity dt = time interval
11	Instantaneous acceleration	$a_{\text{inst}} = \frac{dv}{dt} = \frac{d^2r}{dt^2} = \frac{d^2x}{dt^2}$ When v is function of position (x): $a_{\text{inst}} = \frac{dv}{dx} \cdot \frac{dx}{dt} = v\frac{dv}{dx}$	a_{inst} = instantaneous acceleration dx/dt = instantaneous velocity
12	Equations of motion	**Scalar Form:** $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ **Vector Form:** $\vec{v} = \vec{u} + \vec{a}t$ $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$ $\vec{v} \cdot \vec{v} = \vec{u} \cdot \vec{u} + 2\vec{a} \cdot \vec{s}$	v = final velocity u = initial velocity a = acceleration (constant) t = time s = displacement **Valid only when acceleration is constant**
13	Displacement in n^{th} second (S_n)	$S_n = u + \frac{1}{2}a(2n - 1)$	u = initial velocity a = constant acceleration n = time interval in sec

Sr.	Concept	Formulas	Other Information
14	Galileo's law of odd numbers	When particle starts from rest and moves with constant acceleration, ratio of distance travelled in successive equal intervals of time is: $1:3:5:7:\ldots:(2n-1)$	n = time interval in sec
15	Stopping distance (s) & Stopping time (t)	$s = \frac{u_0^2}{2a_0}$ [since a_0 is constant] $t = \frac{u_0}{a_0}$ [since a_0 is constant] $s \propto u_0^2$ $t \propto u_0$	u_0 = initial speed a_0 = constant retardation
16	Position-time graph ($x-t$)	Slope of graph represents instantaneous velocity slope $= \tan\theta = \frac{\text{displacement}}{\text{time}}$ = velocity	$\tan\theta$ = slope of the graph
17	Velocity-time graph ($v-t$)	Slope represents acceleration: $\tan\theta = \frac{\text{velocity}}{\text{time}}$ = acceleration Area of $v-t$ graph: $\int v\,dt$ = displacement	$\tan\theta$ = slope v = velocity dt = time interval
18	Acceleration-time graph ($a-t$)	Area of $a-t$ graph: $\int a\,dt = dv = v_2 - v_1$ = change in velocity	a = acceleration v_2 = final velocity v_1 = initial velocity
19	Motion under gravity	If object falling freely ($u = 0$): (i) $v = u + gt$ (ii) $h = ut + \frac{1}{2}gt^2$ (iii) $v^2 = u^2 + 2gh$ If thrown upward, replace g with $-g$	h = displacement (height) u = initial velocity t = time g = acceleration due to gravity v = final velocity
20	Body thrown vertically up with velocity u	(i) Maximum height: $h = \frac{u^2}{2g}$ (ii) Time of ascent = Time of descent $= \frac{u}{g}$ (iii) Total time of flight $= \frac{2u}{g}$	h = maximum height u = initial velocity g = gravitational acceleration
21	Effect of air resistance (Motion under gravity)	**Ascending:** Time to go up: $t_1 = \sqrt{\frac{2h}{g+a}}$ Velocity of projection: $v_1 = \sqrt{2h(g+a)}$ **Descending:** Time to go down: $t_2 = \sqrt{\frac{2h}{g-a}}$ Velocity on reaching ground: $v_2 = \sqrt{2h(g-a)}$	h = height attained g = gravitational acceleration a = retardation due to air drag t_1 = time of ascent t_2 = time of descent
22	Body thrown upwards crosses a point at times t_1 & t_2	Height of point: $h = \frac{1}{2}gt_1t_2$ Maximum height: $H = \frac{1}{8}g(t_1+t_2)^2$ Time of flight: $T = t_1 + t_2 = \frac{2u}{g}$	t_1 = time while ascending t_2 = time while descending (same point)
23	Relative velocity	Relative velocity of A w.r.t. B: $\vec{v}_{A/B} = \vec{v}_A - \vec{v}_B$ Relative velocity of B w.r.t. A: $\vec{v}_{B/A} = \vec{v}_B - \vec{v}_A$	$\vec{v}_A$ = velocity of A w.r.t. ground $\vec{v}_B$ = velocity of B w.r.t. ground

TURBO *Your complete JEE/NEET formula companion*