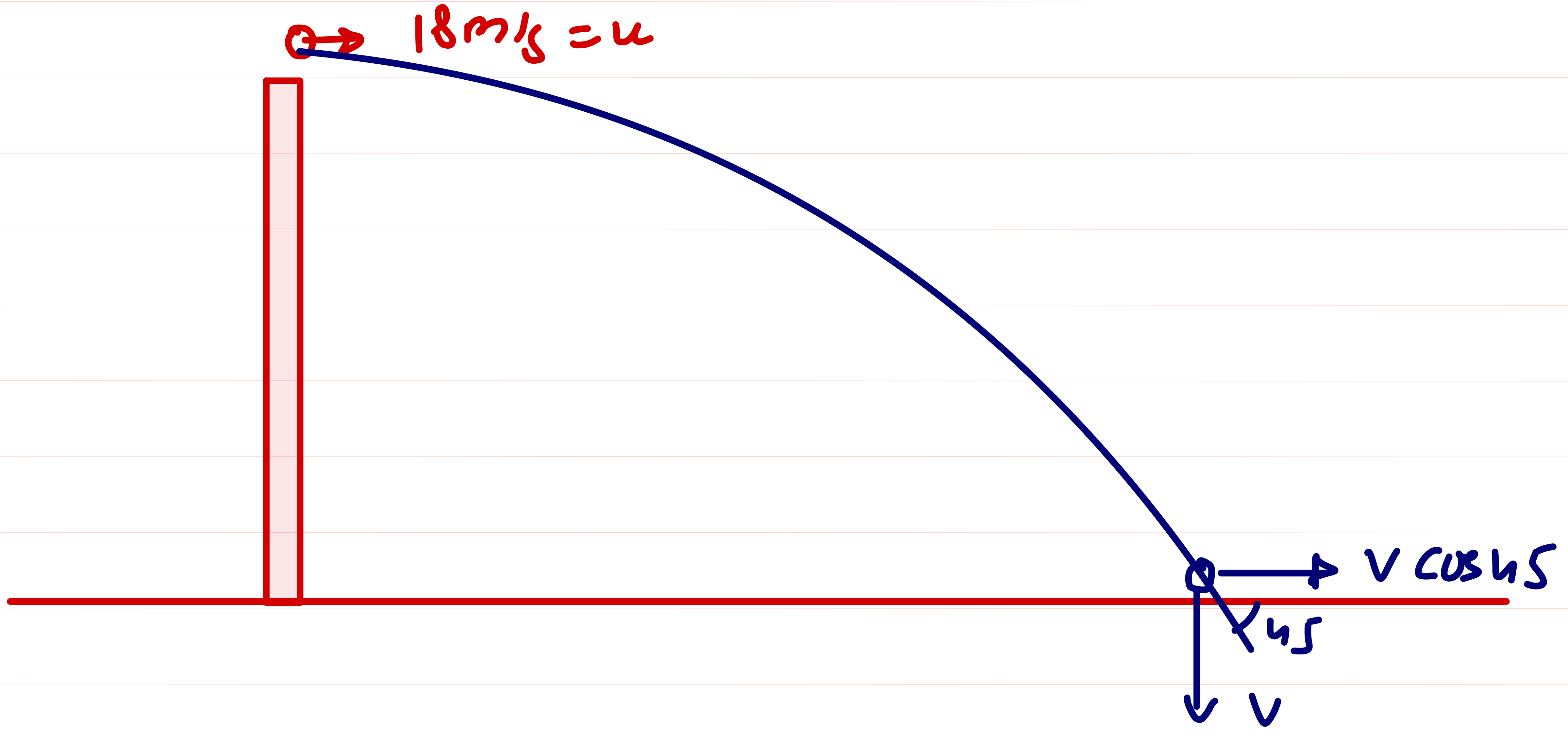
BB #2

**7.** A body is projected horizontally from top of a tower with initial velocity 18m/s. It hits the ground at an angle of 45°. What is vertical component of its velocity just before hitting the ground?




$v_y = v\sin 45$

$u_x = \text{constant}$

$18 = v\cos 45 = v_x$

$18 = v_x$

$\tan 45 = \dfrac{v_y}{v_x} \Rightarrow \boxed{v_y = v_x = 18 \text{ m/s}}$

Ans

BB#3

**4.** A particle is projected at an angle θ with an inclined plane making an angle β with the horizontal as shown in figure, speed of the particle is u, after time t find :

(a) x component of acceleration ?

(b) y component of acceleration ?

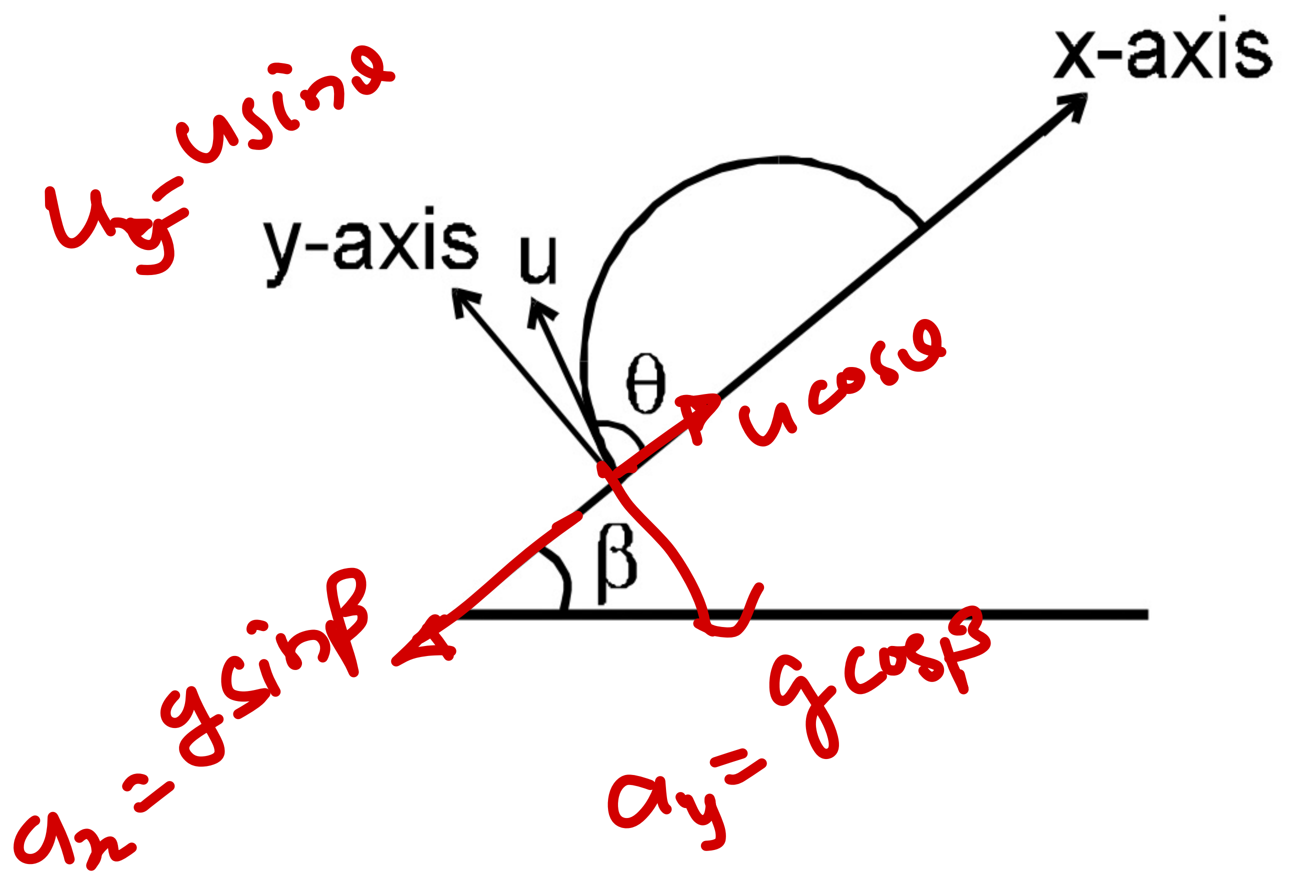
(c) x component of velocity ?

(d) y component of velocity ?

(e) x component of displacement ?

(f) y component of displacement ?

(g) y component of velocity when particle is at maximum distance from the incline plane ?

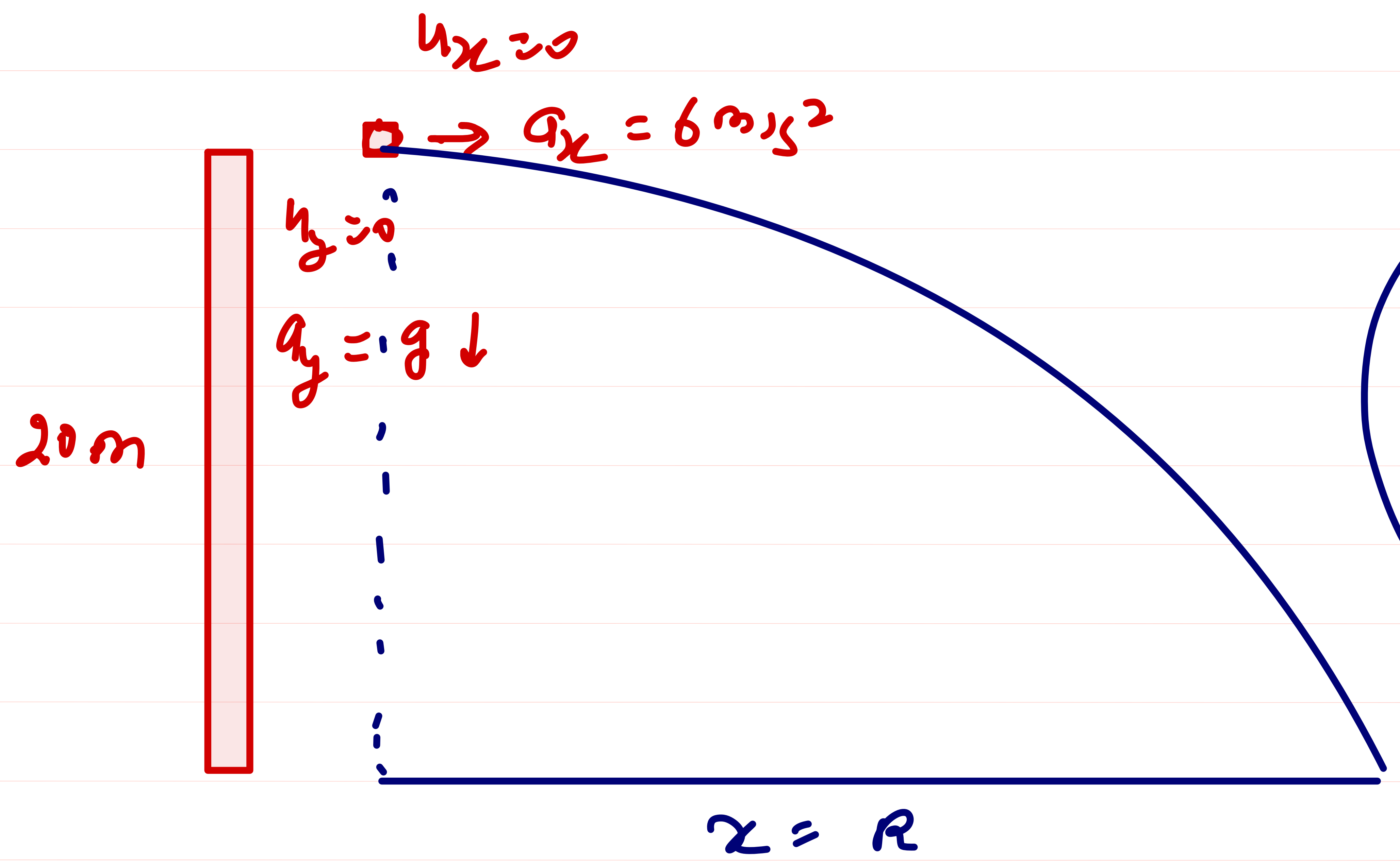



$a_x = -g\sin\beta$ $\qquad a_y = -g\cos\beta$

$x = u\cos\theta\, t - g\sin\beta\, t^2$ $\qquad y = u\sin\theta\, t - g\cos\beta\, t^2$

**2.** Particle is dropped from the height of 20m on horizontal ground. There is wind blowing due to which horizontal acceleration of the particle becomes 6 $ms^{-2}$. Find the horizontal displacement of the particle till it reaches ground.

(A) 6m (B) 10 m ✓(C) 12m (D) 24 m




$x = R = \frac{1}{2} a_x t^2$

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{10}} = 2\ sec$

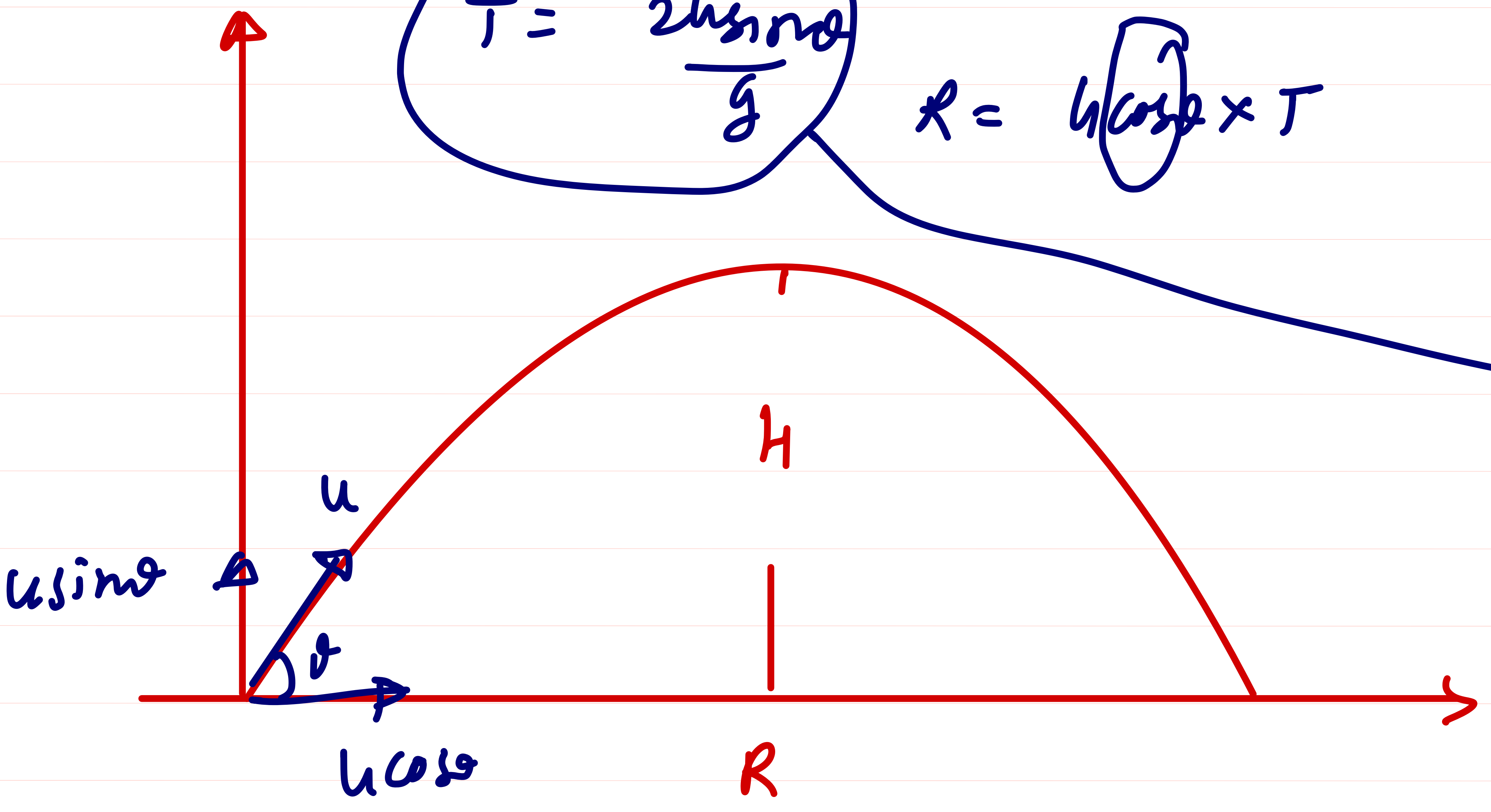
$x = R = \frac{1}{2} \times 6 \times 2^2$

$\boxed{x = R = 12m}$ Ans

**12.** The horizontal range of a projectile is R and the maximum height attained by it is H. A strong wind now begins to blow in the direction of motion of the projectile, giving it a constant horizontal acceleration = g/2. Under the same conditions of projection. Find the horizontal range of the projectile.

(A) R + H (B) R + 2H (C) R (D) R + H/2

$T = \frac{2u\sin\theta}{g}$ $R = u\cos\theta \times T$




$H = \frac{u^2\sin^2\theta}{2g}$ $R = \frac{u^2\sin 2\theta}{g}$

$a_x = g/2$

$R' = (u_x T) + \frac{1}{2}\frac{g}{2}T^2$

$R' = R + \frac{g}{4}T^2 \Rightarrow R' = R + \frac{8H}{4}$

$\boxed{R' = R + 2H}$

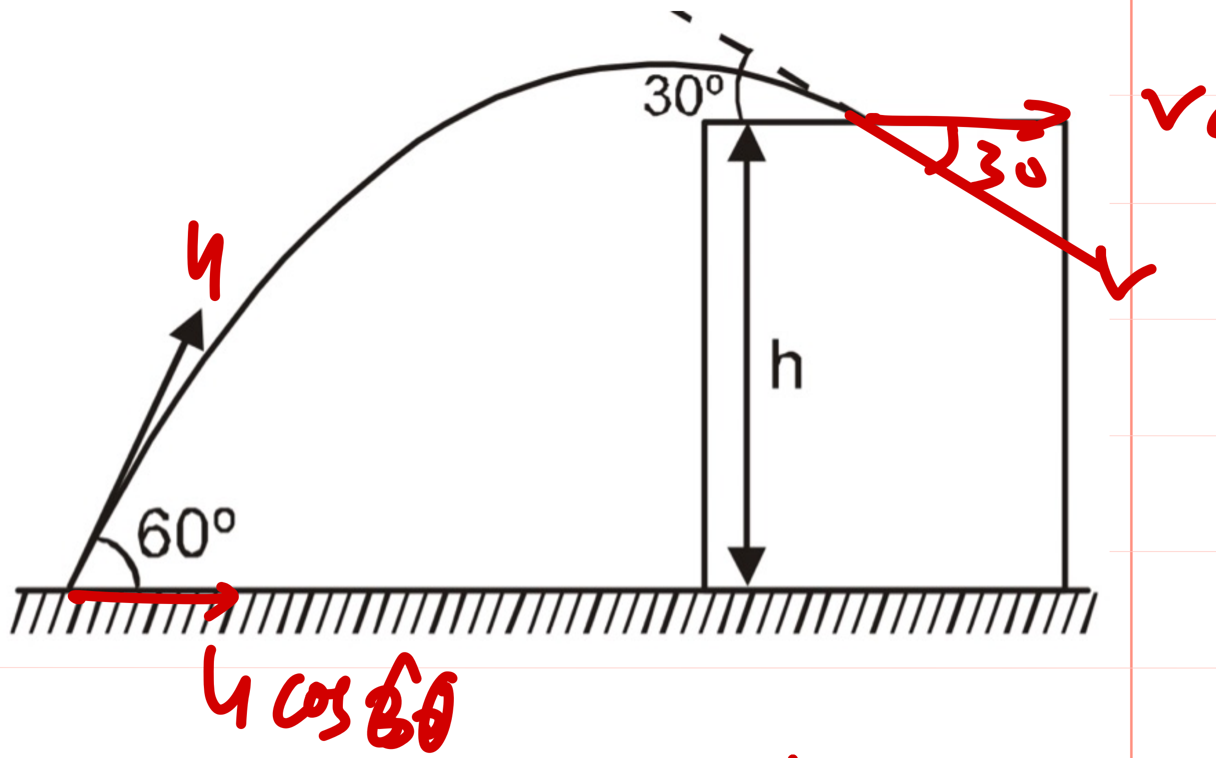
$\frac{H}{R} = \frac{\sin\theta}{4\cos\theta}$

$\frac{H}{R} = \frac{Tg}{2\cancel{u}} \times \frac{1}{4\frac{R}{T\cancel{u}}} \Rightarrow \frac{H}{\cancel{R}} = \frac{T^2 g}{8\cancel{R}}$

**15*.** A stone projected at an angle of 60° from the ground level strikes at an angle of 30° on the roof of a building of height 'h= 30m '. Find the speed of projection(in m/s) of the stone.

(A) 30 (B) 40

(C) 50 (D) 60




v cos 30

$u_x$ = constant

$u\cos 60 = v\cos 30$

$\frac{u}{2} = \frac{v\sqrt{3}}{2} \Rightarrow \boxed{v = \frac{u}{\sqrt{3}}}$

Speed Relⁿ

$$\boxed{v^2 = u^2 - 2gh}$$

$$\frac{u^2}{3} = u^2 - 2gh$$

$$\frac{2u^2}{3} = 2gh \Rightarrow u^2 = 3gh$$

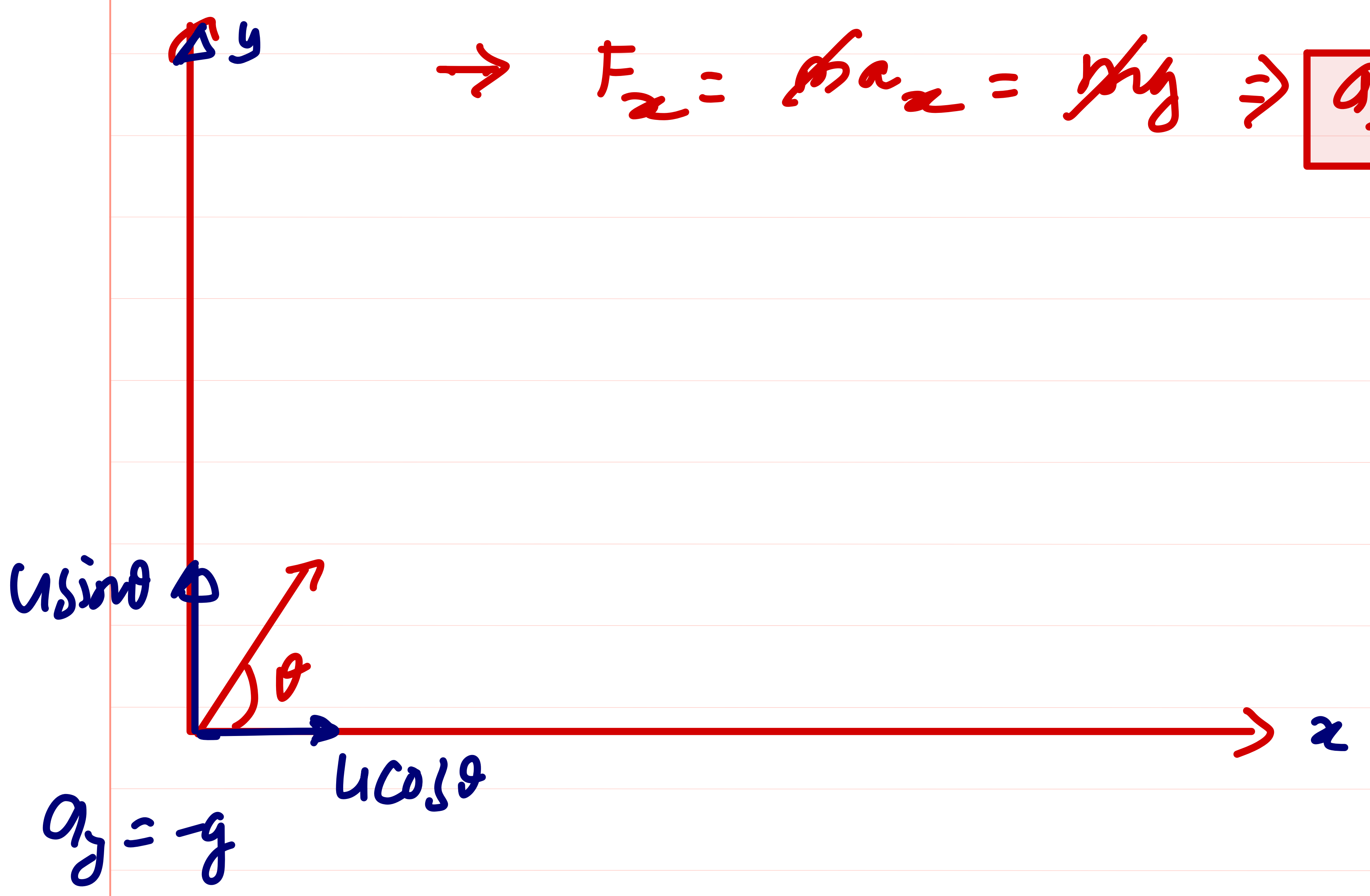
$$u = \sqrt{3gh}$$

$$= \sqrt{3 \times 10 \times 30} \Rightarrow \boxed{u = 30\ m/s}$$

**16.** A ball is thrown eastward across level ground. A wind blows horizontally to the east, and assume that the effect of wind is to provide a constant force to the east, equal in magnitude to the weight of the ball. The angle θ (with respect to horizontal) at which the ball should be projected so that it travels maximum horizontal distance is

(A) 45°  (B) 37°  (C) 53°  (D) 67.5°

$\rightarrow F_x = \cancel{m}a_x = \cancel{m}g \Rightarrow \boxed{a_x = g}$




$T = \dfrac{2u\sin\theta}{g}$

$R = u\cos\theta \cdot T + \frac{1}{2} g T^2$

$= \dfrac{2u\sin\theta}{g}\left[u\cos\theta + \dfrac{\cancel{g}}{\cancel{2}} \times \dfrac{\cancel{2}u\sin\theta}{\cancel{g}}\right]$

$R = \dfrac{2u^2}{g}\left\{\sin\theta\cos\theta + \sin^2\theta\right\}$

$R = \dfrac{2u^2}{g}\left\{\dfrac{\sin 2\theta}{2} + \dfrac{1-\cos 2\theta}{2}\right\}$

For maxima / minima

$$\frac{dR}{d\theta} = \frac{2u^2}{g}\left\{\frac{\cancel{2}\cos 2\theta}{\cancel{2}} + 0 + \frac{\cancel{2}\sin 2\theta}{\cancel{2}}\right]$$

$\therefore \frac{dR}{d\theta} = 0$

$$0 = \cos 2\theta + \sin 2\theta \Rightarrow \frac{\sin 2\theta}{\cos 2\theta} = -\frac{\cos 2\theta}{\cos 2\theta}$$

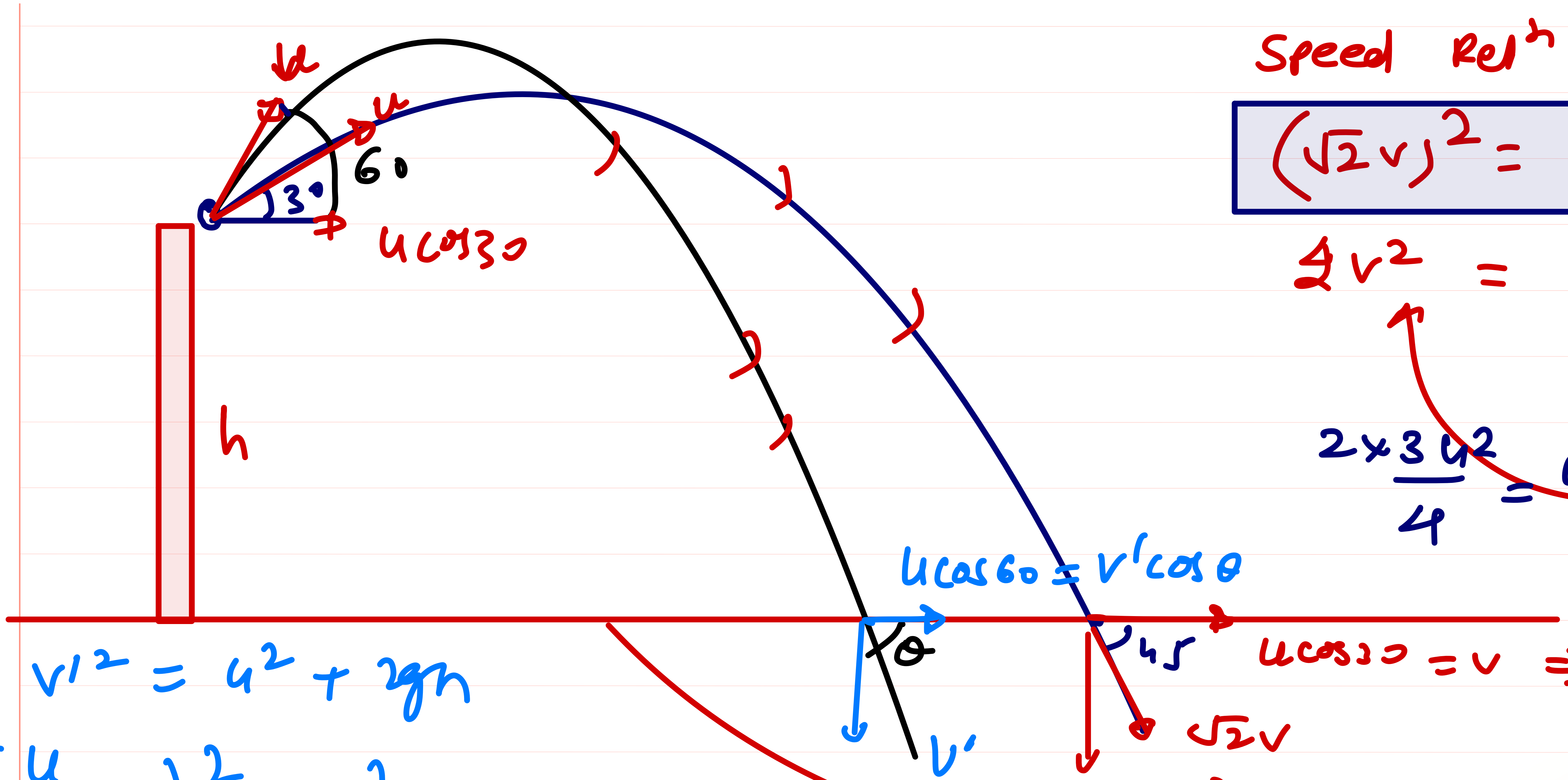
$$\tan 2\theta = -1$$

$$2\theta = 135^\circ$$

$$\boxed{\theta = 67.5^\circ}$$ Ans

**17*.** A particle at a height 'h' from the ground is projected with an angle 30° from the horizontal, it strikes the ground making angle 45° with horizontal. It is again projected from the same point at height h with the same speed but with an angle of 60° with horizontal. Find the angle it makes with the horizontal when it strikes the ground :

(A) $\tan^{-1}(3)$ (B) $\tan^{-1}(5)$ (C) $\tan^{-1}(\sqrt{5})$ (D) $\tan^{-1}(\sqrt{3})$




Speed Rel^n

$\boxed{(\sqrt{2}v)^2 = u^2 + 2gh}$

$2v^2 = u^2 + 2gh$

$2\times\frac{3u^2}{4} = u^2 + 2gh$

$\frac{3u^2}{2} - u^2 = 2gh$

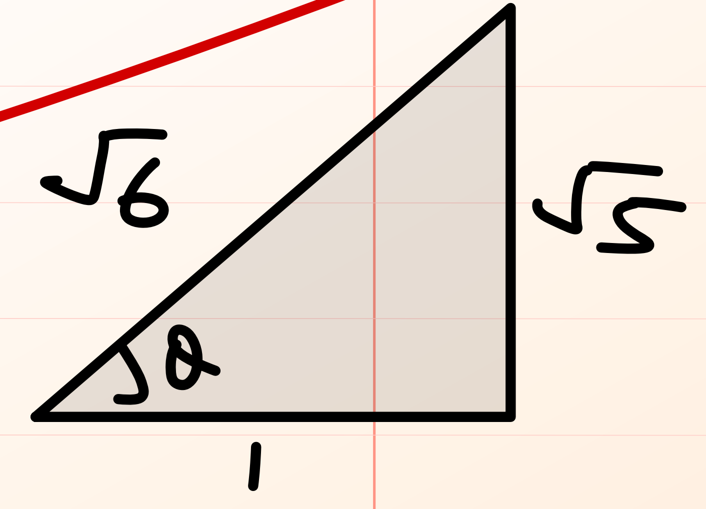
$\boxed{u^2 = 4gh}$

$u\cos 30 = v \Rightarrow \frac{\sqrt{3}}{2}u = v$

$v'^2 = u^2 + 2gh$

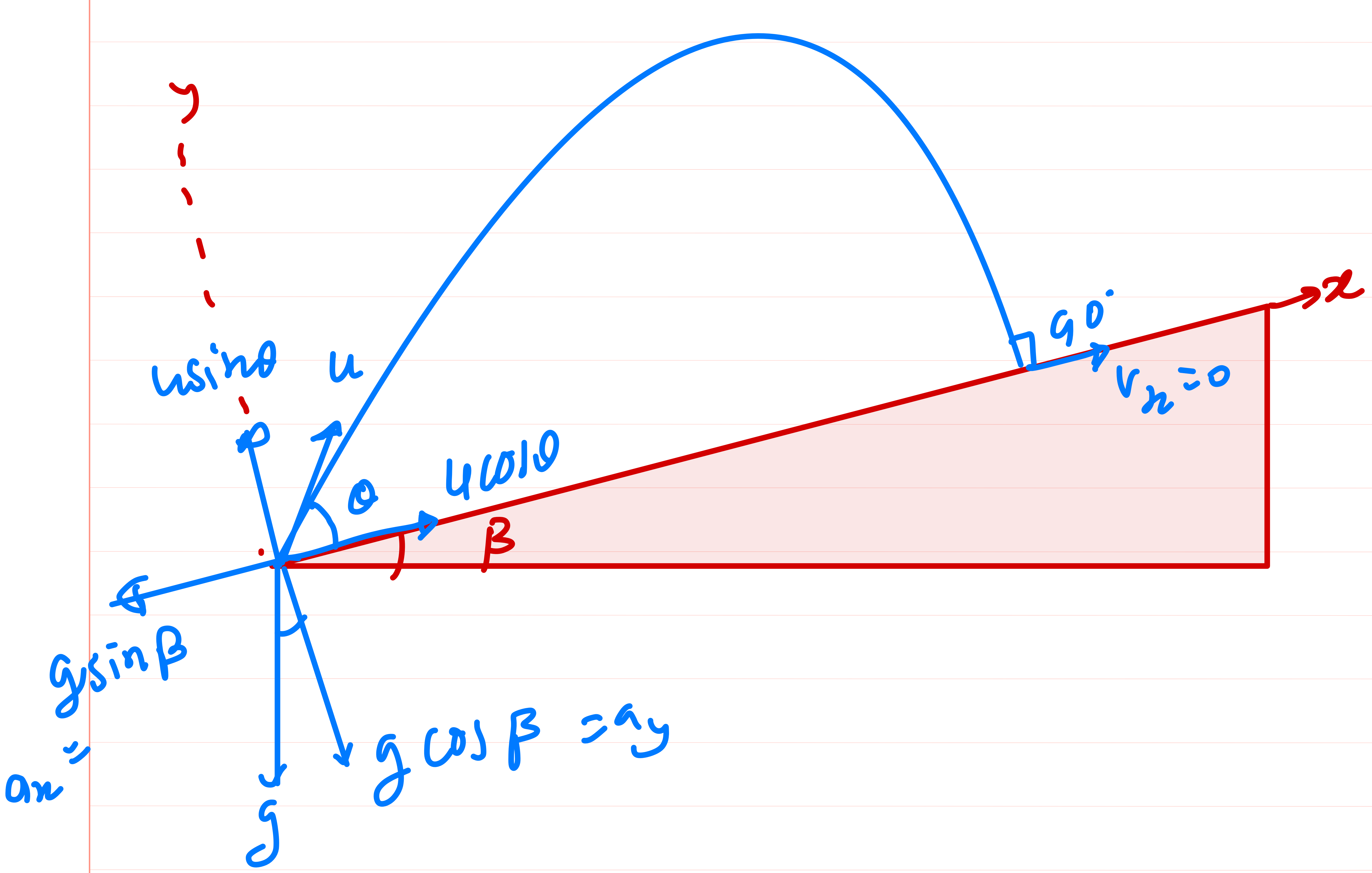
$\left(\frac{u}{2\cos\theta}\right)^2 = u^2 + 2gh$

$\frac{u^2}{4\cos^2\theta} = u^2 + 2gh \Rightarrow \frac{\cancel{4}g\cancel{h}}{\cancel{4}\cos^2\theta} = 6g\cancel{h} \Rightarrow \cos^2\theta = \frac{1}{6} \Rightarrow \cos\theta = \frac{1}{\sqrt{6}}$



**19.** A projectile is thrown with a speed u, at an angle $\theta$ to an inclined plane of inclination $\beta$. The angle $\theta$ at which the projectile is thrown such that it strikes the inclined plane normally is

(A) $\cot^{-1}(2\tan\beta)$ (B) $\cot^{-1}(\tan\beta)$ (C) $\tan^{-1}\dfrac{(\cot\beta)}{2}$ (D) None of these




$$T = \frac{2u\sin\theta}{g\cos\beta}$$

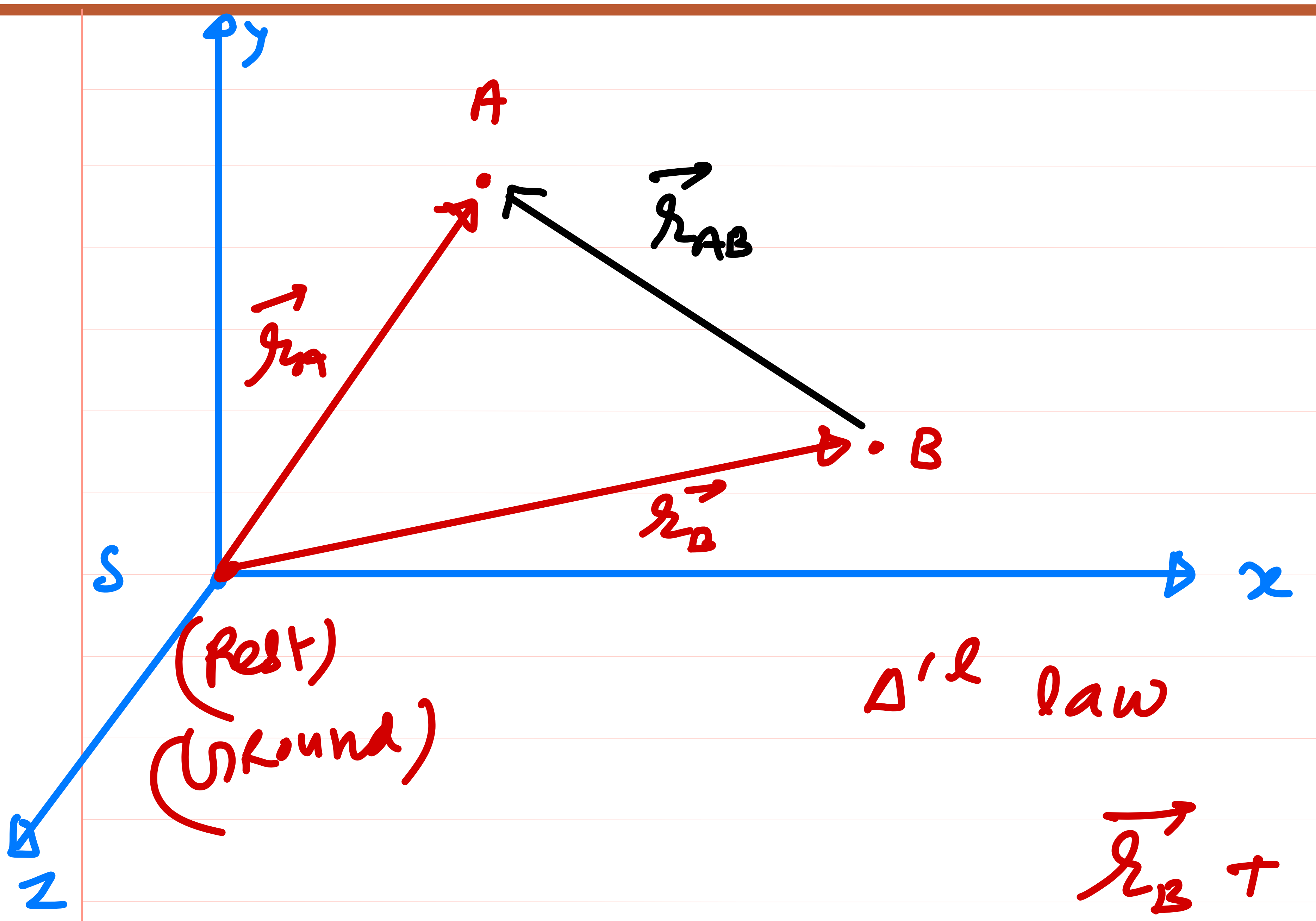
$$v_x = u_x - g\sin\beta\, T$$

$$0 = u\cos\theta - g\sin\beta\, T$$

$$\cancel{u}\cos\theta = \cancel{g}\sin\beta \times \frac{2\cancel{u}\sin\theta}{\cancel{g}\cos\beta}$$

$$\frac{\cos\theta}{\sin\theta} = 2\,\frac{\sin\beta}{\cos\beta}$$

$$\cot\theta = 2\tan\beta$$




$\vec{r}_A$ = Position of Point A w.r.t to Reference - S

$\vec{r}_B$ = " " " " B " " " - S

$\vec{r}_{AB}$ = Position of - A w.r.t - B

$\Delta^{le}$ law

$$\vec{r}_B + \vec{r}_{AB} = \vec{r}_A$$

$$\vec{r}_{AB} = \vec{r}_A - \vec{r}_B$$

diff. w.r.t time

$$\frac{d\vec{r}_{AB}}{dt} = \frac{d\vec{r}_A}{dt} - \frac{d\vec{r}_B}{dt}$$

$$\boxed{\vec{V}_{AB} = \vec{V}_A - \vec{V}_B}$$

$\vec{V}_{AB}$ = velocity of A w.r.t B

$\vec{V}_A$ = velocity of A w.r.t - S (Ground

$\vec{V}_B$ = " " B " " "

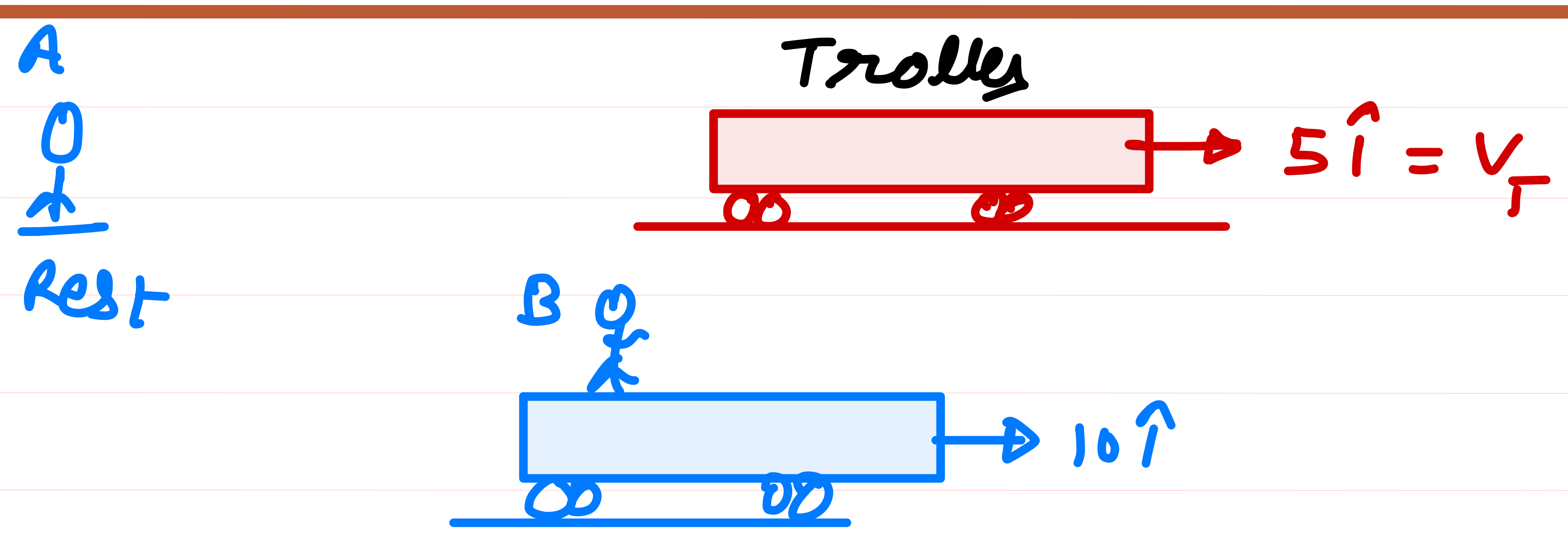
diff. w.r.t time

$$\boxed{\vec{a}_{AB} = \vec{a}_A - \vec{a}_B}$$

**Concept** = Ref. frame always assumed to be at rest (For Relative)



**Ex**




① Velocity of Trolley w.r.t – A

② " " " " – B

③ Velocity of B w.r.t – A

④ Velocity of A w.r.t – B

**Sol** ① $\vec{V}_{TA} = \vec{V}_T - \vec{V}_A$

$= 5\hat{i} - 0$

$\boxed{\vec{V}_{TA} = 5\hat{i}}$ Ans

② $\vec{V}_{TB} = \vec{V}_T - \vec{V}_B$

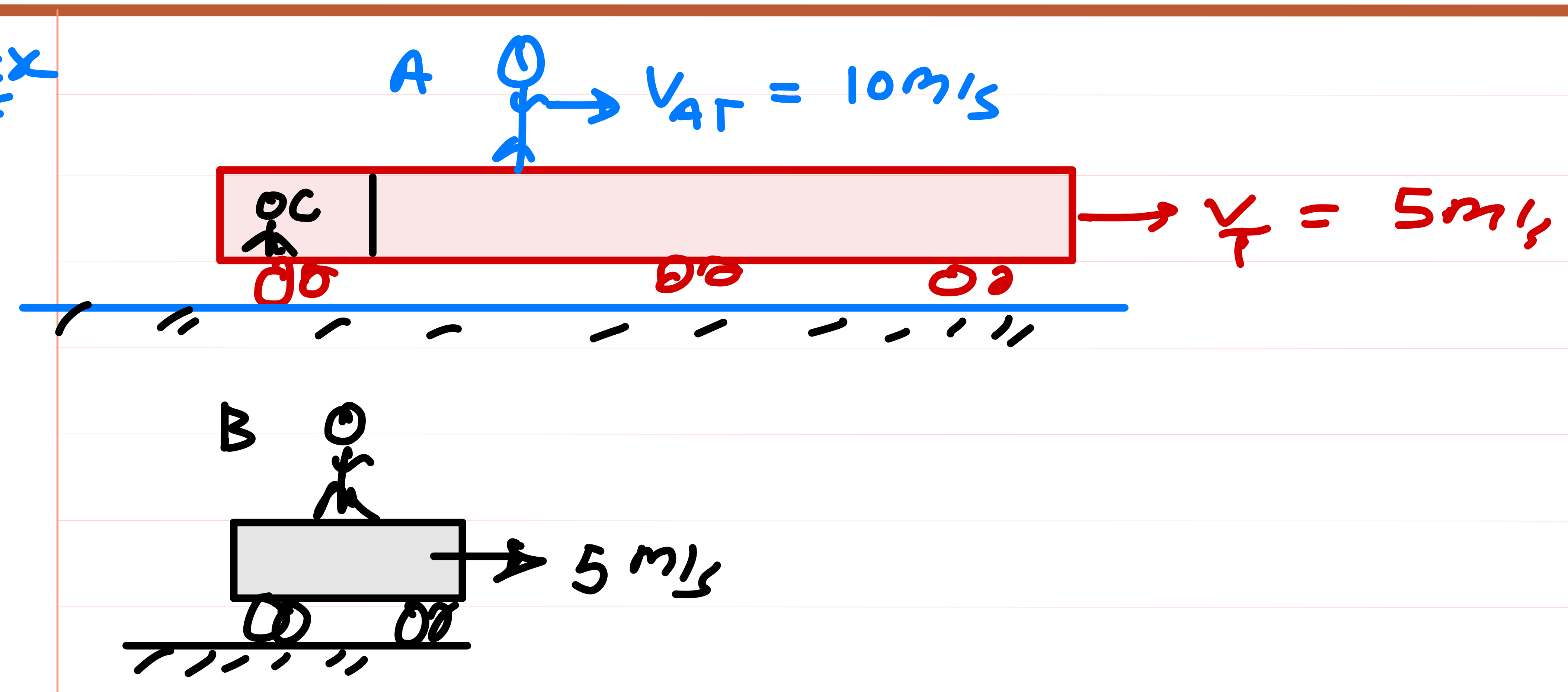
$= 5\hat{i} - 10\hat{i}$

$\boxed{\vec{V}_{TB} = -5\hat{i}\ m/s}$

③ $\vec{V}_{BA} = V_B - V_A = 10\hat{i} - 0$

④ $\vec{V}_{AB} = \vec{V}_A - \vec{V}_B = 0 - 10\hat{i}$

Ex




Find

① $V_{AB} = V_A - V_B = 15 - 5 = 10\,m/s$

② $V_{AC} = V_A - V_C = 15 - 5 = 10$

③ $V_{TB} = V_T - V_B = 5 - 5 = 0$

④ $V_{TC} = V_T - V_C = 5 - 5 = 0$

w.r.t to Ground

$V_{AT} = V_A - V_T \Rightarrow V_A = V_{AT} + V_T = 10 + 5 = 15\,m/s$

$V_C = V_T = 5$

⑤ $V_{CB} = V_C - V_B$

$= 5 - 5$

$V_{CB} = 0$