FORMULAE SHEET

(a) Projectile Motion

Time of flight: $T = \frac{2u\sin\theta}{g}$

Horizontal range: $R = \frac{u^2 \sin 2\theta}{g}$

Maximum height: $H = \frac{u^2 \sin^2 \theta}{2g}$

Trajectory equation (equation of path):

$$y = x\tan\theta - \frac{gx^2}{2u^2 \cos^2 \theta} = x\tan\theta\left(1 - \frac{x}{R}\right)$$

Projection on an inclined plane

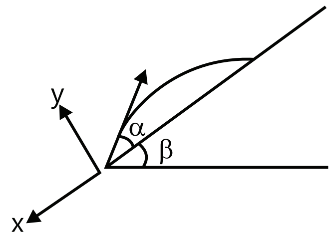

Figure 3.23

(b) Relative Motion

v_{AB} (velocity of A with respect to B) $= v_A - v_B$

a_{AB} (acceleration of A with respect to B) $= a_A - a_B$

Relative motion along straight line $= x_{BA} = x_B - x_A$

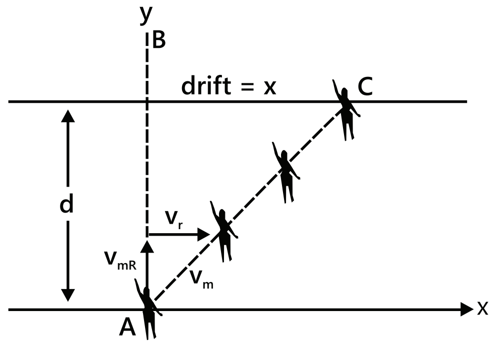

Figure 3.24

(c) Crossing River: A boat or man in a river always moves in the direction of resultant velocity of velocity of boat (or man) and velocity of the river flow.

(d) Shortest Time: Velocity along the river, $V_X = V_R$

Velocity perpendicular to the river, $V_f = V_{mR}$

The net speed is given by $V_m = \sqrt{V_{mR}^2 + V_R^2}$

(e) Shortest Path: Velocity along the river, $V_x = 0$

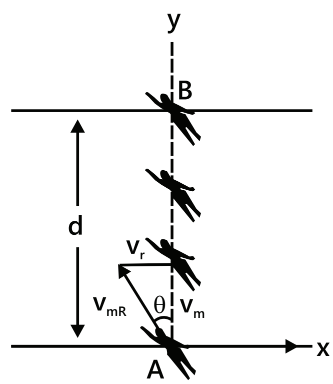

Figure 3.25

and velocity perpendicular to river $V_y = \sqrt{V_{mR}^2 - V_R^2}$

The net speed is given by $V_m = \sqrt{V_{mR}^2 - V_R^2}$

at an angle of $90°$ with the river direction.

velocity V_y is used only to cross the river, therefore time to cross the river,

$t = \frac{d}{v_y} = \frac{d}{\sqrt{v_{mR}^2 - v_R^2}}$ and velocity v_x is zero, therefore, in

this case the drift should be zero.

$v_R = v_{mR}\sin\theta = 0$ or $\quad v_R = v_{mR}\sin\theta \quad$ or $\quad \theta = \sin^{-1}\frac{v_R}{v_{mR}}$

(f) Rain Problems: $v_{Rm} = \vec{v}_R - \vec{v}_m \quad$ or $v_{Rm} = \sqrt{v_R^2 + v_m^2}$

(g) Circular Motion

i. Average angular velocity $\omega_{av} = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t}$

ii. Instantaneous angular velocity $\omega = \frac{d\theta}{dt}$

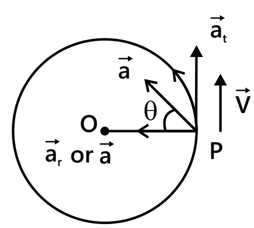

Figure 3.26

iii. Average angular acceleration $\alpha_{av} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t}$

iv. Instantaneous angular acceleration $\alpha = \frac{d\omega}{dt} = \omega\frac{d\omega}{d\theta}$

v. Relation between speed and angular velocity $v = r\omega$ and $v = \omega\ r$

vi. Tangential acceleration (rate of change of speed) $a_t = \frac{dV}{dt}$

vii. Radial or normal or centripetal acceleration $a_r = \frac{V^2}{r} = \omega^2 r$

viii. Total acceleration $\vec{a} = \vec{a}_t + \vec{a}_r$, $a = \left(a_t^2 + a_r^2\right)^{1/2}$

ix. Angular acceleration $\alpha = \frac{d\omega}{dt}$ (non-uniform circular motion)

x. Radius of curvature $R = \frac{v^2}{a_\perp} = \frac{mv^2}{F_\perp}$

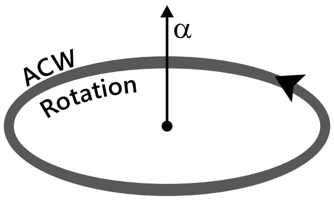

Figure 3.27

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