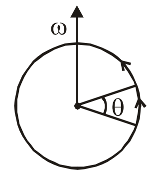
8. CIRCULAR MOTION

1. Average angular velocity

$$\omega = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t}$$

2. Instantaneous angular velocity

$$\omega = \frac{d\theta}{dt}$$



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

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

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

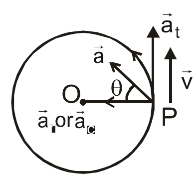
7. Tangential acceleration (rate of change of speed) $a_t = \frac{dV}{dt} = r\frac{d\omega}{dt} = \omega\frac{dr}{dt}$

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

9. Total acceleration

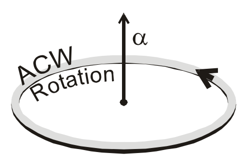
$a = a_t + a_r \qquad a = (a_t^2 + a_r^2)^{1/2}$

Where $a_t = \alpha \;\; r$ and $a_r = \omega \;\; v$



10. Angular acceleration

$$\alpha = \frac{d\omega}{dt} \text{ (Non-uniform circular motion)}$$



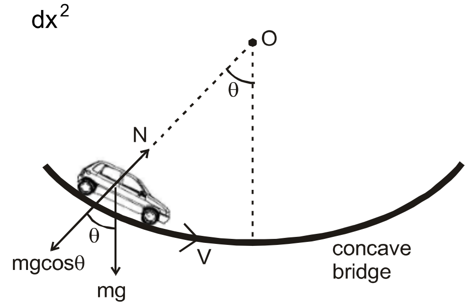
12. Radius of curvature $R = \frac{v^2}{a_\perp} = \frac{mv^2}{F_\perp}$

If y is a function of x. i.e. y = f(x)

$$R = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}{\frac{d^2y}{dx^2}}$$

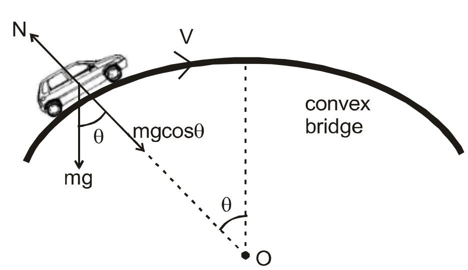
13. Normal reaction of road on a concave bridge

$$N = mg\cos\theta + \frac{mv^2}{r}$$



14. Normal reaction on a convex bridge

$$N = mg\cos\theta \quad \frac{mv^2}{r}$$



15. Skidding of vehicle on a level road

$v_{safe} \quad \sqrt{\mu g r}$

16. Skidding of an object on a rotating platform

$\omega_{max} = \sqrt{\mu g / r}$

17. Bending of cyclist $\quad \tan\theta = \dfrac{v^2}{rg}$

18. Banking of road without friction $\quad \tan\theta = \dfrac{v^2}{rg}$

19. Banking of road with friction $\quad \dfrac{v^2}{rg} = \dfrac{\mu + \tan\theta}{1 - \mu\tan\theta}$

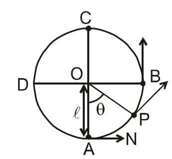
20. Maximum also minimum safe speed on a banked frictional road $\quad V_{max} = \left[\dfrac{rg(\mu + \tan\theta)}{(1 - \mu\tan\theta)}\right]^{1/2}$

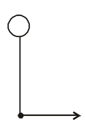
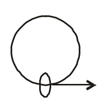
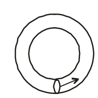
$$V_{min} = \left[\dfrac{rg(\mu - \tan\theta)}{(1 + \mu\tan\theta)}\right]^{1/2}$$

21. Centrifugal force (pseudo force) $\quad f = m\omega^2 r$, acts outwards when the particle itself is taken as a frame.

22. Effect of earths rotation on apparent weight $\quad N = mg \quad mR\omega^2 \cos^2\theta$;
where θ latitude at a place

23. Various quantities for a critical condition in a vertical loop at different positions
(True for a string or on a smooth track.)



(1)  (2)  (3) 

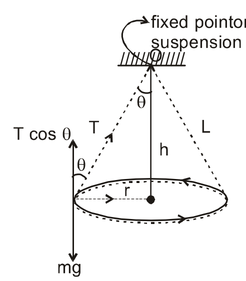
(1)	(2)	(3)
$V_{min} = \sqrt{4gL}$	$V_{min} = \sqrt{4gL}$	$V_{min} = \sqrt{4gL}$
(for completing the circle)	(for completing the circle)	(for completing the circle)

24. **Conical pendulum :**

$T\cos\theta = mg$

$T\sin\theta = m\omega^2 r$

$\therefore$ Time period = $2\pi\sqrt{\dfrac{L\cos\theta}{g}}$



25. **Relations amoung angular variables :**

ω_0 Initial ang. velocity	$\omega = \omega_0 + \alpha t$
ω Find angular velocity	$\theta = \omega_0 t + \dfrac{1}{2}\alpha t^2$
ω Const. angular acceleration	$\omega^2 = \omega_0^2 + 2\alpha\theta$
θ Angular displacement