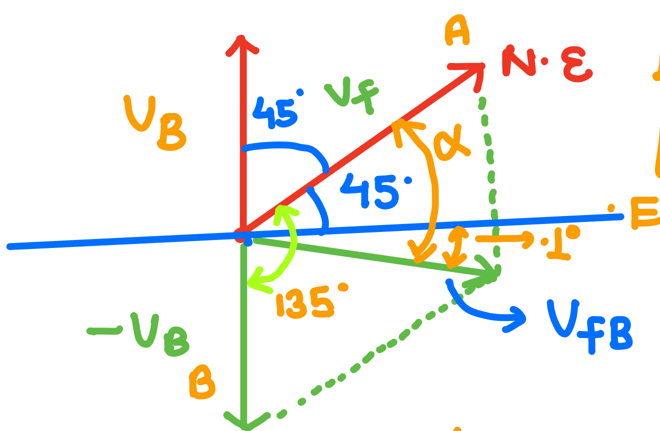
$v_w = 72 \text{ km/h}$

flag $\rightarrow$ N·E

$V_B = 51 \text{ km/h} \longrightarrow$ North

direction of flag,



$$\left\{ \tan\alpha = \frac{B\sin\theta}{A + B\cos\theta} \right\}$$

$\theta \rightarrow 135°$

$$\tan\alpha = \left\{ \frac{51 \sin 135°}{72 + 51 \cos 135°} \right\}$$

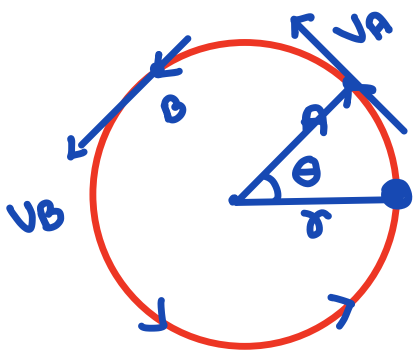
$$= \frac{51\left(1/\sqrt{2}\right)}{72 + 51\left(-1/\sqrt{2}\right)}$$

$$= 1.0039$$

$$\alpha = \tan^{-1}(1.0039)$$

$$= 45.1°$$

CIRCULAR MOTION :



Angular velocity / Angular freq. $= \omega = \left(\frac{d\theta}{dt}\right)$

$\theta = \frac{\text{arc}}{\text{radius}}$

$\lim_{\Delta t \to 0}\left(\frac{\Delta\theta}{\Delta t}\right) = \frac{d\theta}{dt}$

Time period : {1 Revolution to cover.}

↓

time = T

freq $= \nu = \frac{1}{T} =$ No of time particle is vibrating / rotating in 1 sec.

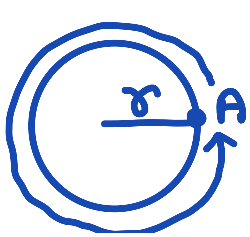
freq, Angular freq.

$\omega = \frac{d\theta}{dt} = \frac{2\pi}{T}$

$\omega = \frac{2\pi}{T}$

$\omega = 2\pi\left(\frac{1}{T}\right)$

freq.



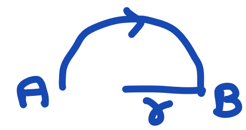
$$\boxed{\omega = 2\pi\nu}$$

ω → Angular freq → unit: radians/s

ν → freq. → sec^{-1}

$d\theta \rightarrow \pi$

$dt \rightarrow T/2$



$$\frac{d\theta}{dt} = \frac{\pi}{T/2} = \frac{2\pi}{T}$$

90 rev.

1 min = 60 seconds.

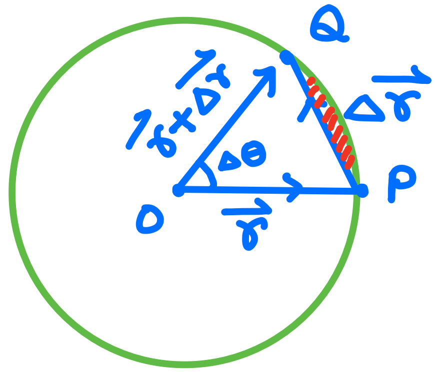
$\frac{90}{60}$ rev/s $= 3/2$ rev/s $= \nu$

$\omega = 2\pi\nu = 2\pi\left(\frac{3}{2}\right) = 3\pi$ radians/Sec

1. Relation b/w Angular velocity & linear velocity. (ω & v)

2. Angular Acceleration (a_c)

Relation b/w ω & v



Δt, Δ law of vector addition.

$$\vec{OQ} = \vec{r} + \vec{\Delta r}$$

$$\left.\begin{array}{lll} t & \rightarrow & t+\Delta t \\ \vec{r} & \rightarrow & \vec{r}+\vec{\Delta r} \end{array}\right\}$$ angle covered $\Delta\theta$.

① $\Delta\theta = \dfrac{\text{arc}}{\text{radius}} = \dfrac{PQ}{r} = \dfrac{\Delta r}{r}$

② $\omega = \dfrac{d\theta}{dt} \Rightarrow \Delta\theta = \omega\Delta t$

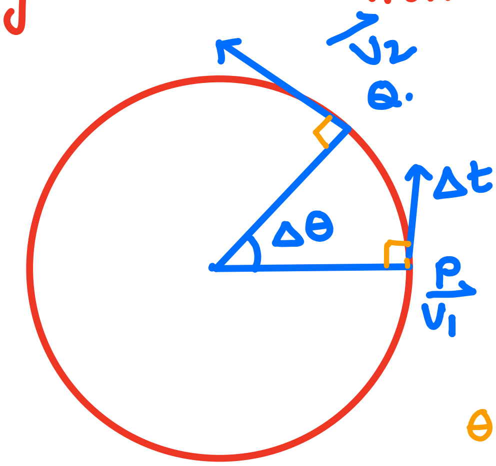
$$\frac{\Delta r}{r} = \omega\Delta t \Rightarrow \frac{\Delta r}{\Delta t} = \omega r$$

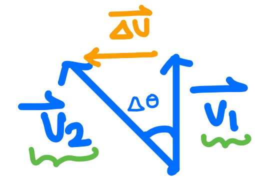
$$t \rightarrow 0$$

$$\Rightarrow \frac{dr}{dt} = \omega r$$

$$\Rightarrow \boxed{v = \omega r}$$ Reqd Relation

2). Angular acceleration





$\vec{V_1} + \vec{\Delta V} = \vec{V_2}$

$$\boxed{\vec{V_2} - \vec{V_1} = \vec{\Delta V}}$$

$\theta = \frac{arc}{rad} \Rightarrow \boxed{\Delta\theta = \frac{\Delta V}{V}}$ — ①

$\boxed{\frac{\Delta\theta}{\Delta t} = \omega}$ — ②

$\Delta\theta = \omega\Delta t$

$\omega\Delta t = \frac{\Delta V}{V}$

$\Rightarrow \left(\frac{\Delta V}{\Delta t}\right)_{t\to 0} = V\omega$

$V = r\omega$ (from previous derivation)

$$\boxed{a_c = \frac{dV}{dt} = V\omega}$$

$a_c = V\omega = (r\omega)\omega$

$\boxed{a_c = r\omega^2}$ $\underbrace{\text{Centripetal Acceleration}}$

$\left(\frac{dV}{dt}\right)$

$a = r\alpha$ → $\frac{d^2\theta}{dt^2}$ or $\frac{d\omega}{dt}$

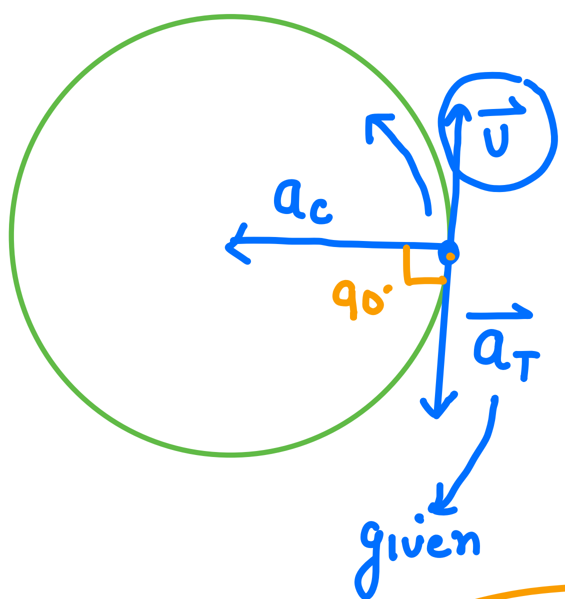
α → $\underbrace{\text{Angular acceleration}}$

Centripetal force $= m a_c = m r \omega^2$

$= m\omega(\omega r) = m\omega V = \frac{mV(\omega r)}{r}$

$$= \frac{mv(v)}{r} = \frac{mv^2}{r}$$

$$\boxed{\text{Centripetal force} = f_c = m\omega^2 r = \frac{mv^2}{r}.}$$



$$a_c = \omega^2 r$$
$$= \frac{\omega^2 r^2}{r}$$
$$a_c = \frac{v^2}{r}$$

v is given.

$$a = \sqrt{a_c^2 + a_T^2 + \underbrace{2a_c a_T \cos 90^\circ}_{\to 0}}$$
$$= \sqrt{a_c^2 + a_T^2}$$