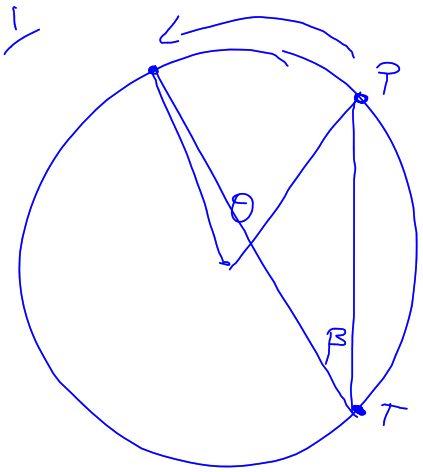
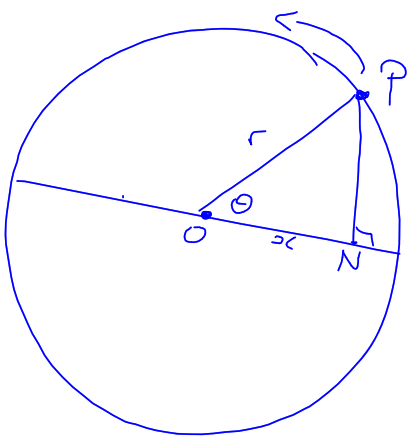


$$\theta = 2\beta$$

$$\frac{d\theta}{dt} = 2\frac{d\beta}{dt}$$

$$\frac{d\beta}{dt} = \frac{1}{2}\frac{d\theta}{dt}$$

2/



$$ON = r\cos\theta$$

$$\dot{ON} = -r\sin\theta \cdot \frac{d\theta}{dt}$$

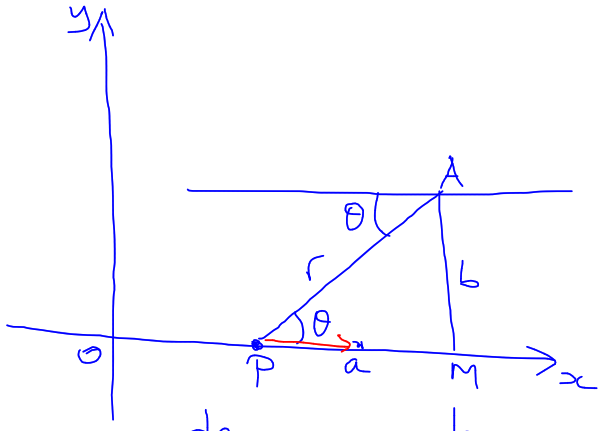
$$= -r\omega\sin\theta$$

$$\ddot{ON} = -r\omega\cos\theta \cdot \frac{d\theta}{dt}$$

$$= -r\omega^2\cos\theta$$

$$= -\omega^2 \cdot ON$$

3



$$\frac{da}{dt} = -u$$

$$\frac{b}{a} = \tan\theta$$

$$a = b\cot\theta$$

$$\frac{da}{d\theta} = -b\,\mathrm{cosec}^2\theta$$

$$\frac{d\theta}{dt} = \frac{da}{dt} \times \frac{d\theta}{da}$$

$$= -u \times \frac{-\sin^2\theta}{b}$$

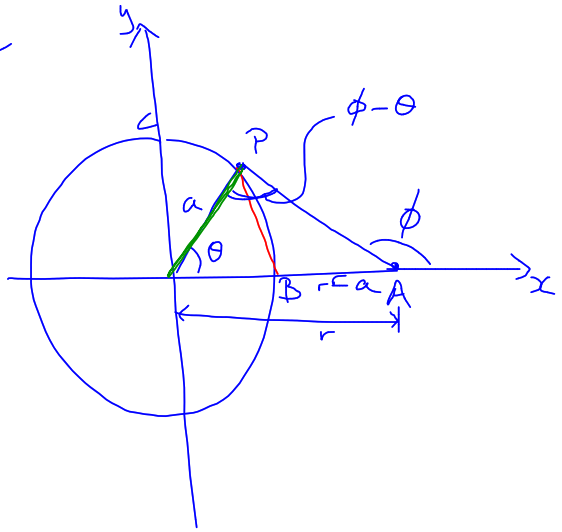
$$= \frac{u}{b}\sin^2\theta$$

$$= \frac{u}{b} \times \frac{b^2}{r^2}$$

$$= \frac{bu}{r^2}$$

$$=$$

4



In $\triangle POA$

$$\frac{r}{\sin(\phi-\theta)} = \frac{a}{\sin(180-\phi)}$$

$$= \frac{a}{\sin\phi}$$

$$r\sin\phi = a\sin(\phi-\theta)$$

$$r\sin\phi = a\sin(\phi-\theta)$$

$$r\cos\phi\cdot\frac{d\phi}{dt} = a\cos(\phi-\theta)\cdot\frac{d(\phi-\theta)}{dt}$$

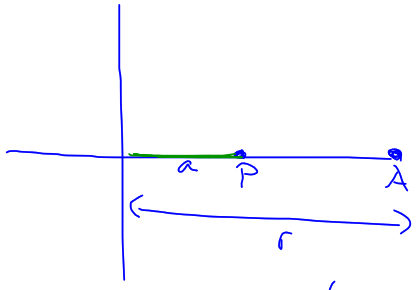
$$= a\cos(\phi-\theta)\left(\frac{d\phi}{dt}-\frac{d\theta}{dt}\right)$$

$$\frac{d\phi}{dt}\left(r\cos\phi - a\cos(\phi-\theta)\right) = -a\cos(\phi-\theta)\cdot\frac{d\theta}{dt}$$

$$\frac{d\phi}{dt}\left(a\cos(\phi-\theta)-r\cos\phi\right) = a\omega\cos(\phi-\theta)$$

$$\frac{d\phi}{dt} = \frac{a\omega\cos(\phi-\theta)}{a\cos(\phi-\theta)-r\cos\phi}$$

at $(B(a,0)$



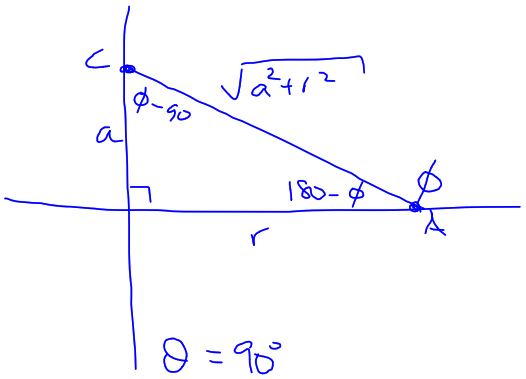
$\theta = 0, \quad \phi = 180^\circ$

$$\frac{d\phi}{dt} = \frac{a\omega \cos 180^\circ}{a\cos 180^\circ - r\cos 180^\circ}$$

$$= \frac{-a\omega}{-a+r}$$

$$= \frac{a\omega}{a-r}$$

at $C(0, a)$

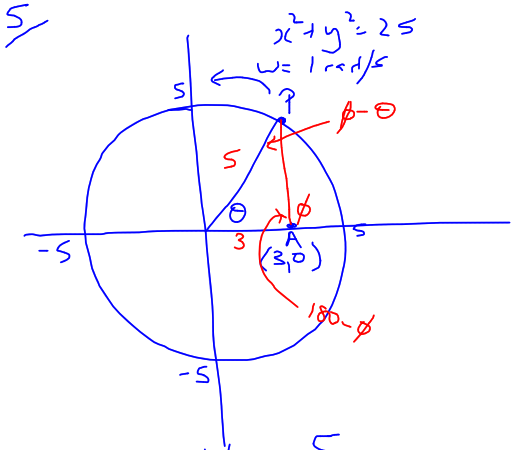


$$\frac{d\phi}{dt} = \frac{a\omega\cos(\phi-\theta)}{a\cos(\phi-\theta) - r\cos\phi}$$

$$= \frac{a\omega \times \frac{a}{\sqrt{a^2+r^2}}}{a \times \frac{a}{\sqrt{a^2+r^2}} + r \times \frac{r}{\sqrt{a^2+r^2}}}$$

$$= \frac{a^2\omega}{a^2+r^2}$$

5/



$$\frac{\sin(180-\phi)}{5} = \frac{\sin(\phi-\theta)}{3}$$

$$3\sin\phi = 5\sin(\phi-\theta)$$

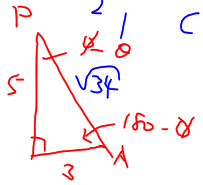
$$3\cos\phi \cdot \frac{d\phi}{dt} = 5\cos(\phi-\theta)\left(\frac{d\phi}{dt} - \frac{d\theta}{dt}\right)$$

$$3\cos\phi \frac{d\phi}{dt} = 5\cos(\phi-\theta)\frac{d\phi}{dt} - 5\cos(\phi-\theta)$$

$$\frac{d\phi}{dt} = \frac{5\cos(\phi-\theta)}{5\cos(\phi-\theta) - 3\cos\phi}$$

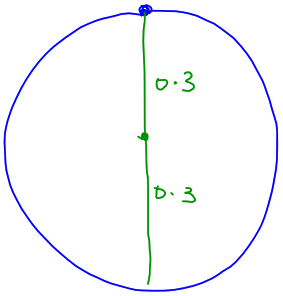
$\theta = 0$, $\frac{d\phi}{dt} = \frac{5}{2}$

$\theta = \frac{\pi}{2}$ $\frac{d\phi}{dt} = \frac{5\cos\left(\phi-\frac{\pi}{2}\right)}{5\cos\left(\phi-\frac{\pi}{2}\right) - 3\cos\phi}$



$$= \frac{5\left(\frac{5}{\sqrt{34}}\right)}{5\left(\frac{5}{\sqrt{34}}\right) + 3\left(\frac{3}{\sqrt{34}}\right)} = \frac{25}{34}$$

6



$v = r\omega$

$= 0.6 \times \frac{2000}{27}$

$= 160 \text{ km/h}$

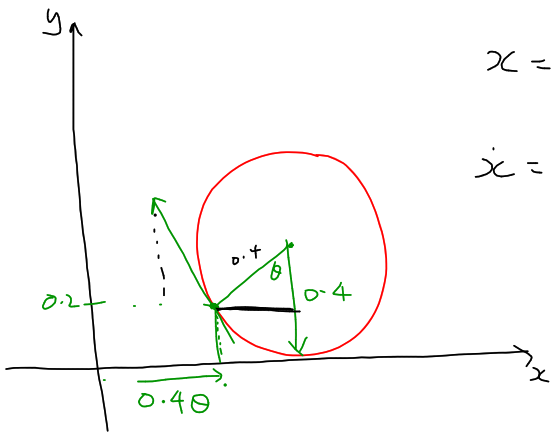
$v = 80 \text{ km/h}$

$= \frac{200}{9} \text{ m/s}$

$\omega = \frac{v}{r}$

$= \frac{2000}{27} \text{ rad/s}$

7/



$x = 0.4\theta - 0.4\sin\theta$ $\quad y = 0.4 - 0.4\cos\theta$

$\dot{x} = 0.4(1 - \cos\theta)\omega$ $\quad \dot{y} = 0.4(\sin\theta)\omega$

$$\tan\alpha = \frac{\dot{y}}{\dot{x}}$$

$$= \frac{\sin\theta}{1-\cos\theta}$$

$$= \frac{\frac{\sqrt{3}}{2}}{1-\frac{1}{2}}$$

$$= \sqrt{3}$$

$\alpha = 60^\circ$ $\quad V = 60\text{km/h}$