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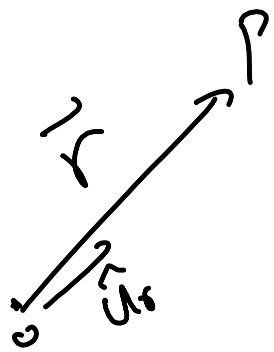
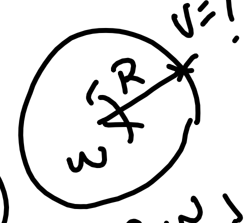


$$\vec{r} = r\hat{u}_r$$



$$\vec{V} = \frac{d\vec{r}}{dt} = \frac{d(r\hat{u}_r)}{dt}$$

$v = R\omega$

$$= \underbrace{\frac{dr}{dt}}_{V_{rel}}\hat{u}_r + r\underbrace{\frac{d\hat{u}_r}{dt}}_{\text{change in dxn}}$$

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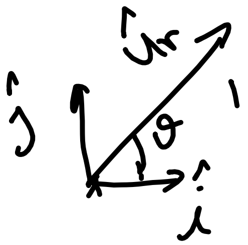

$$\hat{u}_r = \cos\theta\,\hat{i} + \sin\theta\,\hat{j}$$

$$\frac{d\hat{u}_r}{dt} = -\sin\theta\,\dot{\theta}\,\hat{i} + \cos\theta\,\dot{\theta}\,\hat{j}$$

$$= \dot{\theta}\left(\cos\theta\,\hat{j} - \sin\theta\,\hat{i}\right)$$

$$= \dot{\theta}\left(\cos\theta\,\hat{k}\times\hat{i} + \sin\theta\,\hat{k}\times\hat{j}\right)$$

$$= (\dot{\theta}\,\hat{k})\times\left(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}\right)$$

$\hat{i}\times\hat{j} = \hat{k}$

$\hat{j}\times\hat{k} = \hat{i}$

$\hat{k}\times\hat{i} = \hat{j}$

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$$\dot{\hat{u}}_r = \frac{d\hat{u}_r}{dt} = \vec{\omega} \times \hat{u}_r$$

$$\vec{v} = \frac{dr}{dt}\hat{u}_r + r\frac{d\hat{u}_r}{dt}$$

$$= \frac{dr}{dt}\hat{u}_r + r(\vec{\omega} \times \hat{u}_r)$$

$$\vec{V} = \underbrace{\frac{dr}{dt}\hat{u}_r}_{\text{Change in length}} + \underbrace{\vec{\omega}\times\vec{r}}_{\text{Change in dxn}}$$