# ME 2580 Example #9: (2D Motion, Radial & Transverse Components)

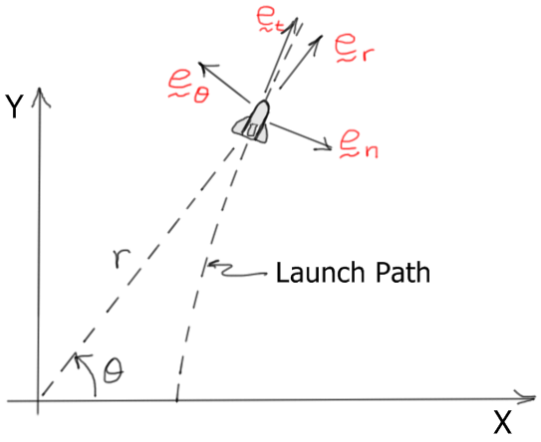
Given: $r = 5\ (\text{mi}) = 26{,}400\ (\text{ft})$, $\dot{r} = 1\ (\text{mi/s}) = 5280\ (\text{ft/s})$

$\ddot{r} = 0.01\ (\text{mi/s}^2) = 52.8\ (\text{ft/s}^2)$

$\dot{\theta} = 0.1\ (\text{deg/s}) = 0.1\pi/180\ (\text{rad/s})$

$\ddot{\theta} = -0.05\ (\text{deg/s}^2) = -0.05\pi/180\ (\text{rad/s}^2)$

Find: $\underset{\sim}{v}$ and $\underset{\sim}{a}$ in ft/s and ft/s$^2$ using ***radial*** and ***transverse*** components.

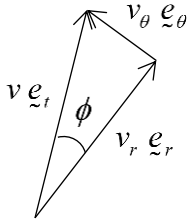



Solution:

***Velocity:***

$$\underset{\sim}{v} = \dot{r}\,\underset{\sim}{e}_r + r\dot{\theta}\,\underset{\sim}{e}_\theta = 5280\,\underset{\sim}{e}_r + 26400\left(0.1\pi/180\right)\underset{\sim}{e}_\theta \approx 5280\,\underset{\sim}{e}_r + 46.1\,\underset{\sim}{e}_\theta\ (\text{ft/s})$$

$$|\underset{\sim}{v}| = \sqrt{v_r^2 + v_\theta^2} \approx 5280\ (\text{ft/s})$$ (tangent to the launch path)




$$\phi = \tan^{-1}\left(\frac{v_\theta}{v_r}\right) = \tan^{-1}\left(\frac{46.1}{5280}\right) \approx 0.5\ (\text{deg})$$

***Acceleration:***

$$\underset{\sim}{a} = \left(\ddot{r} - r\dot{\theta}^2\right)\underset{\sim}{e}_r + \left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right)\underset{\sim}{e}_\theta$$

$$a_r = \ddot{r} - r\dot{\theta}^2 = 52.8 - 26400\left(0.1\pi/180\right)^2 \approx 52.7196 \approx 52.7\ (\text{ft/s}^2)$$

$$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 26400\left(-0.05\pi/180\right) + 2(5280)\left(0.1\pi/180\right) \approx -4.6076 \approx -4.61\ (\text{ft/s}^2)$$

$$|\underset{\sim}{a}| = \sqrt{a_r^2 + a_\theta^2} \approx 52.9206 \approx 52.9\ (\text{ft/s}^2) \approx 1.64\,\text{g's}$$