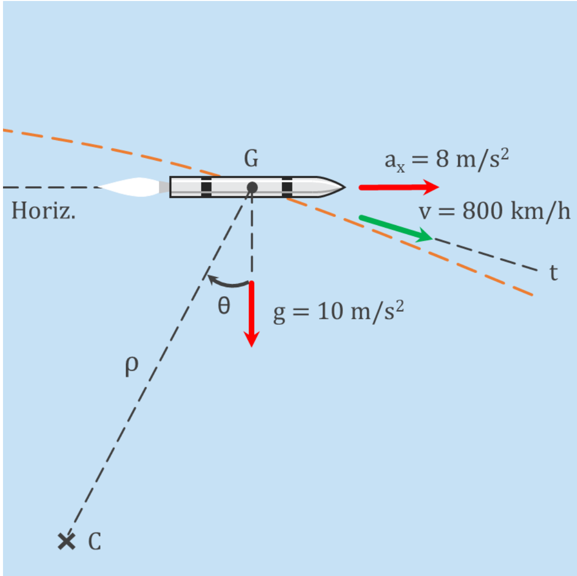
Rocket Accelerates



A rocket maintains at horizontal attitude of its axis during the powered phase of its flight. The acceleration due to horizontal thrust is 8 m/s^2, and the downward acceleration due to gravity is g = 10 m/s^2. At the instant represented, the velocity of the mass centre G of the rocket along the (θ) 15° direction of its trajectory is 800 km/h. Determine the radius of curvature ρ in meters of the flight trajectory. Round to the nearest hundred (e.g. 8700 m).

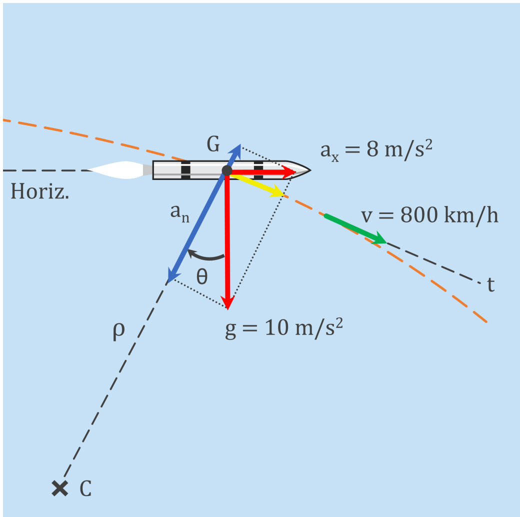


Figure 1: Rocket Accelerates

The normal acceleration a_n points towards the centre of curvature C. Figure 1 shows the acceleration vectors a_x and g deconstructed in the normal direction (blue) and the tangential direction (yellow). It can be easily seen that g and a_x deconstructed in the normal-direction are equal to $g \cdot \cos(\theta)$ and $a_x \cdot \sin(\theta)$ respectively. However, in this case $a_x \cdot \sin(\theta)$ points in the opposite way of a_n (points ↗ instead of ↙). This means that to determine the final value of a_n, the term $a_x \cdot \sin(\theta)$ should be subtracted. Resulting in the final answer:

$$a_n = g \cdot \cos(\theta) - a_x \cdot \sin(\theta) \qquad (1)$$

Given:
Angle: $\theta = 15^{\circ}$
Gravitational acceleration: $g = 10m/s^2$
Horizontal acceleration: $a_x = 8m/s^2$
Velocity: $v = 800km/h = 222.22m/s$

Inserting θ, g and a_x into Equation 1 results in:

$$a_n = g \cdot \cos(\theta) – a_x \cdot \sin(\theta) \quad \Rightarrow \quad a_n = 10 \cdot \cos(15) – 8 \cdot \sin(15) = 7.59m/s^2 \tag{2}$$

This results in:

$$\rho = \frac{v^2}{a_n} \quad \Rightarrow \quad \rho = \frac{222.22^2}{7.59} = 6507.40m \approx 6500m \tag{3}$$