The Sky-Diving Trainhopper

February 27, 2025

Om is a skydiving trainhopper. A freighter steam locomotive is going downhill on a straight track that makes an angle of elevation with the ground of $\theta = 37.13°$. Unfortunately, the train's engine has failed and the wheels are sliding down the frictionless tracks. Luckily, the train has a backup jet propulsion engine. The horizontal distance the hill comprises is 300 meters.

1 How fast is Om dying?

Om falls from 500 meters above and 300 meters from the mountain, which rises at an incline of 37.13°. The force of gravity on Om is 620N. The steam engine failed at the summit of the mountain, but luckily they had jet propulsion engines at the back which allowed the train to continue. The train weighs 550,000 kg. **Solve for the amount of time it takes for Om to reach the base of the mountain.**

2 How fast is that engine going?

Given the mass of the train is $m = 550000$ kg and the time t you found from the previous problem. You are finding the Work that the jet propulsion engine needs to do on the train for it to reach the bottom of the hill just in time to catch Om at the front of the engine.

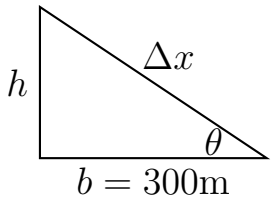
3 How much faster does the train go after Om dies?

4 Answer

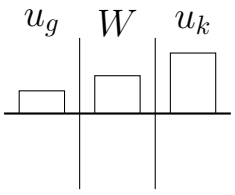
4.1 How fast is Om dying?

1. Find Om's mass.
   $F = ma\ m = \frac{F}{a}\ \frac{620N}{9.8} = 63.26kg$
2. Find the height of Om above the Earth.
   $90 - 37.13° = 52.87°$
   $300m \cdot \tan 52.87° = 396.24m$
   $396.24m + 500m = 896.24m$
3. Find the final velocity of Om.
   $mgh = \frac{1}{2}mv^2$
   $63.26(9.8)(896.24) = \frac{1}{2}63.26v^2$
   $555622.20 = 31.63v^2$
   $17566.30 = v^2$
   $132.54\frac{m}{s}^2 = v$
4. Find the time it takes Om to reach the base of the mountain.
   $t = \frac{d}{v}$
   $t = \frac{896.24}{132.54}$
   $t = 6.76s$

4.2 How fast is that engine going?



$$h = b\tan\theta \Longrightarrow h = (300\text{m})\tan(37.13°) \approx 227.135\text{m}$$
$$\Delta x = b\sec\theta \Longrightarrow \Delta x = (300\text{m})\sec(37.13°) \approx 376.285\text{m}$$



$$u_k = \frac{1}{2}mv^2 \quad u_g = mgh$$
$$\implies W = \frac{1}{2}mv^2 - mgh$$
$$v_f = v_0 + at \quad x_f = x_0 + v_0 t + at^2 \implies x_f = \frac{1}{2}at^2 \implies \frac{2x_f}{t} = at$$
$$v_f = \frac{2x_f}{t}$$
$$\implies W = m(\frac{1}{2}\left(\frac{2x_f}{t}\right)^2 - gh)$$
$$\implies W = m(2\left(\frac{x_f}{t}\right)^2 - gh) \implies W = (550000\text{kg})(2\left(\frac{376.285\text{m}}{6.76\text{s}}\right)^2 - \left(9.8\frac{\text{m}}{\text{s}^2}\right)(227.135\text{m}))$$
$$\implies 2184004499\text{J}$$

4.3 How fast is that engine going?