Projectile motion questions

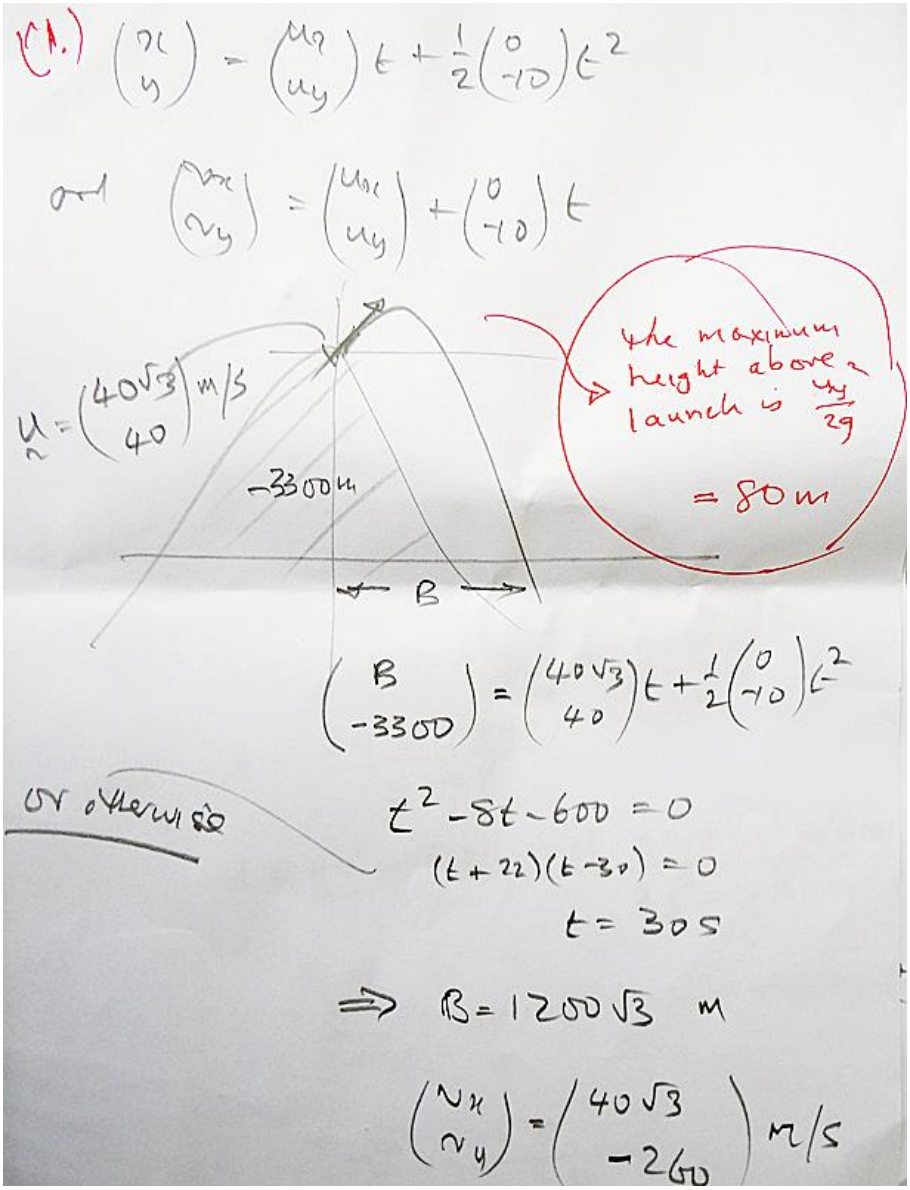
1 A volcanic eruption blasts a rock into the air with an initial velocity of 80.0 m/s at an angle of elevation of 30.0 degrees. (Take g to be -10m/s^2.)

a Find the time of fight.

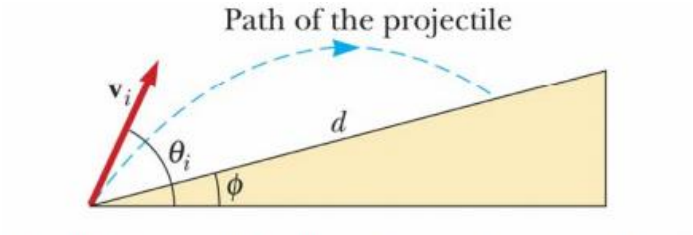
b What is the horizontal distance traveled by the rock?

c Determine the velocity of the rock just before impact.

d Calculate the maximum height of the rock above the ground.



2 A projectile is fired with an initial velocity $\mathbf{v}_i$ at an angle of elevation θ. It lands on an incline (angle ϕ) at a distance d as shown.

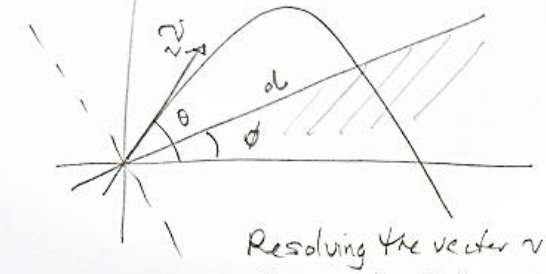


Show that the projectile travels a distance d up the incline, where

$$d = \frac{2v_i^2 \cos\theta_i \sin(\theta_i - \phi)}{g\cos^2\phi}.$$

(2)

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} u_x \\ u_y \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 0 \\ -10 \end{pmatrix} t^2$$



Resolving the vector velocity and acceleration along the incline and perpendicular to it...

$$\begin{pmatrix} d \\ 0 \end{pmatrix} = \begin{pmatrix} v\cos(\theta-\phi) \\ v\sin(\theta-\phi) \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} -g\sin\phi \\ -g\cos\phi \end{pmatrix} t^2$$

...and $$t = \frac{2v\sin(\theta-\phi)}{g\cos\phi}$$

$$d = \frac{2v^2\cos(\theta-\phi)\sin(\theta-\phi)}{g\cos\phi} - \frac{g\sin\phi\, 4v^2\sin^2(\theta-\phi)}{2g^2\cos^2\phi}$$

$$= \frac{2v^2}{g\cos^2\phi}\left[\cos\phi\cos(\theta-\phi) - \sin\phi\sin(\theta-\phi)\right]\sin(\theta-\phi$$

$$= \frac{2v^2\cos\theta\sin(\theta-\phi)}{g\cos^2\phi}$$

3 A Hydra base is located at the origin (0, 0). The Hydras plan to launch a projectile to hit a hospital directly to the East with a velocity of 50 km/h at an angle of elevation of 30°.

An Avenger base is located 50 km South and 100 km East of the origin. The Avengers have a canon aimed to the North.

Question: At what initial speed and angle of elevation should the Avengers fire to intercept the Hydras projectile if both projectiles are fired at the same time and g = 10m/s^2?