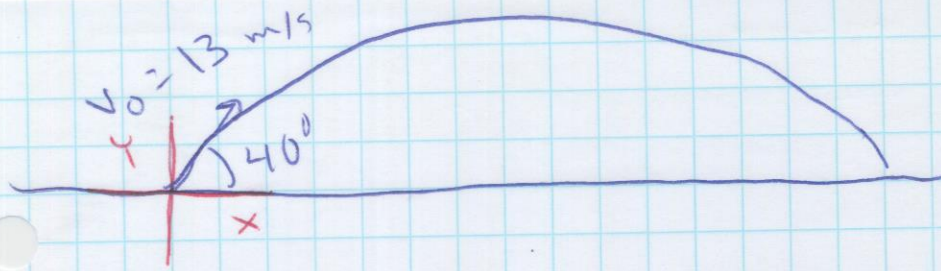


### Group Problem

A projectile is shot at an angle of 40 degrees above the horizontal over level ground. The initial speed of the projectile is 13.0 m/s.

1. What is the highest point this projectile reaches?
2. What is the total time of flight ?
3. What is the range?
4. At what time or times is the projectile at a height of 2.0 m?
5. What is the total velocity when the projectile is at a height of 2.0 m?



$$v_{0x} = v_0 \cos \theta = 13 \cos 40^\circ = 9.96 \text{ m/s}$$

$$v_{0y} = v_0 \sin \theta = 13 \sin 40^\circ = 8.36 \text{ m/s}$$

Start to Apex:	X	Y
	$9.96 = v_0$	$v_0 = 8.36$
	$9.96 = v_f$	$v_f = 0$
	$0 = a$	$a = -9.8$
	$\Delta x$	$\Delta y$
	$\Delta t$	$\Delta t$

$\Delta t$  to Apex:

$$v_f = v_0 + a \Delta t$$

$$0 = 8.36 + (-9.8) \Delta t$$

$$\Delta t = 0.853 \text{ s}$$

Height at Apex:

$$\Delta y = v_{0y} \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = 8.36(0.853) + \frac{1}{2}(-9.8)(0.853)^2$$

$$\Delta y = 3.57 \text{ m}$$

Max. Height

Total time in air: level ground, so

$$\Delta t = 2 \times \Delta t_{\text{Apex}}$$

$$\Delta t = 1.71 \text{ s}$$

Range

$$\Delta x = v_{0x} \Delta t + \frac{1}{2} a_x \Delta t^2$$

$$\Delta x = (9.96)(1.71) + 0$$

$$\Delta x = 17.0 \text{ m}$$

At what times is it at height of 2.0 m?

$$\Delta y = v_0 \Delta t + \frac{1}{2} g \Delta t^2$$

$$(2.0 - 0 \text{ m}) = (8.36 \text{ m/s}) \Delta t + \frac{1}{2} (-9.8 \text{ m/s}^2) \Delta t^2$$

$$4.9 \Delta t^2 + 8.36 \Delta t + 2.0 = 0$$

$$\Delta t = \frac{-8.36 \pm \sqrt{(-8.36)^2 - 4(4.9)(2)}}{2(4.9)}$$

$$\Delta t = 0.29 \text{ s} \quad \text{and} \quad 1.42 \text{ s}$$

Still going up

Coming down on other side

Vel when at  $h = 2.0 \text{ m}$ ?

Symmetry: same speed on both sides. One +, one -



$$v_y = v_{0y} + g \Delta t$$

$$v_y = 8.36 \text{ m/s} + (-9.8)(1.42 \text{ s})$$

$$v_y = -5.56 \text{ m/s}$$

$$\langle +5.56 \text{ m/s at } \Delta t = 0.29 \text{ s} \rangle$$

$$\text{Total } \vec{v} = \vec{v}_x + \vec{v}_y$$

