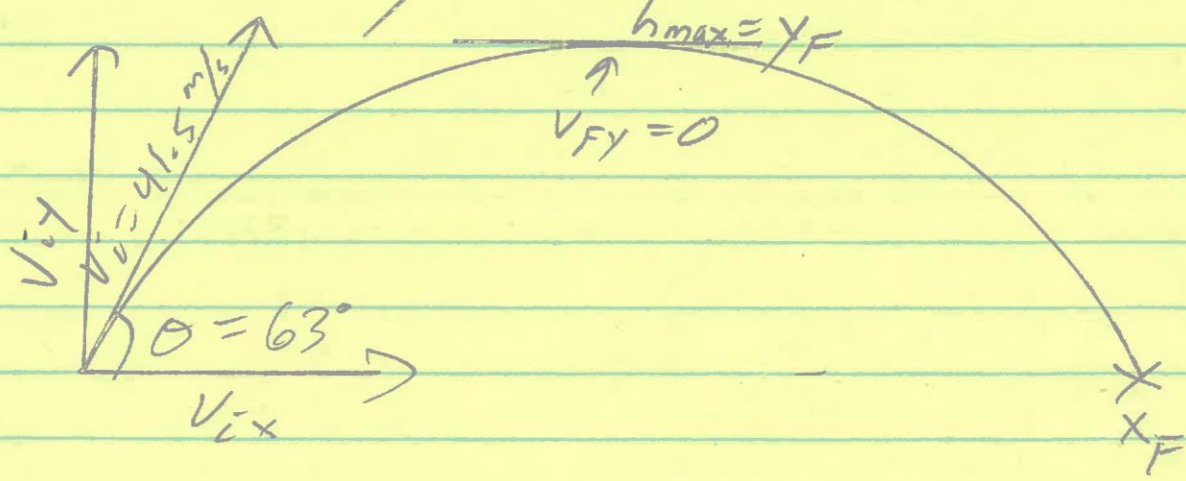
Projectile Motion Test

1) You are lying on your back with a slingshot loaded with a frozen grape.

You launch the grape with an initial velocity of 41.5 m/s @ an angle of 63 degrees to the horizontal.

) How high does it go?
) How long is it in the air?
) How far away does it land?

Do either one of these first



Sketch w/ initial conditions

PHYSICS - 11/17/2023 TEST

1) shoot w/ $v_i = 41.5\ m/s$ @ $63°$

a) $v_{iy} = v_i \sin\theta = 36.97\ m/s$ +2
$v_{ix} = v_i \cos\theta = 18.84\ m/s$

How high does it go? +4

$v_{fy}^2 - v_{iy}^2 = 2a\Delta y \Rightarrow -v_{iy}^2/2a = \Delta y = \frac{(36.97\ m/s)^2}{(2)(9.81\ m/s^2)}$

$= 69.66\ m$
$= 70.\ m$ S.F. +4

b) How long is it in the air? +4

$v_{fy} = v_{iy} + at \Rightarrow -v_{iy}/a = t$

$\frac{-36.97\ m/s}{-9.81\ m/s^2} = (3.765\ s)(2)$

$= 7.537\ s$
$= 7.5\ s$ S.F.

c) How far away does it land? +4

$x_f = x_i + v_{ix} t + \frac{1}{2} a t^2$

$x_f = (v_{ix})(t) \Rightarrow (v_i \cos\theta)(t)$

$= (18.84\ m/s)(7.537\ s) = 142\ m$
$= 140\ m$ S.F.

$V_{iy} = V_i \sin\theta = 46.7\ m/s$

$V_{ix} = V_i \cos\theta = 21.5\ m/s$

$V_F = V_i + At$

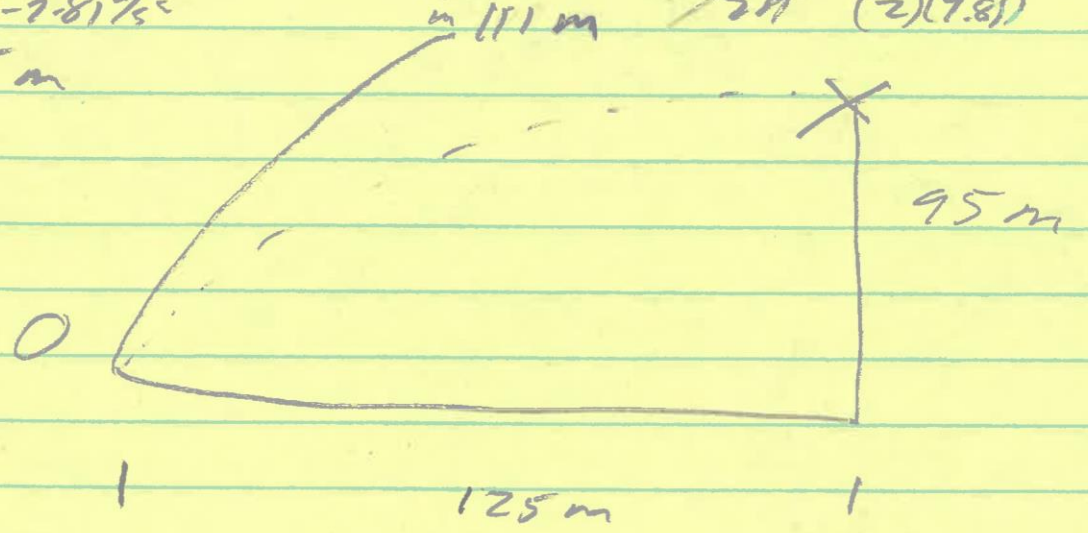
$-V_{iy}/A = t = 4.76$

$-46.7/-9.81\ m/s^2$

$135\ m$

$V_{Fy}^2 - V_{iy}^2 = 2A\Delta y$

$-V_{iy}^2/2A = (46.7\ m/s)^2/(2)(9.81) = 111\ m$



$t_{required} = 5.95\ sec$

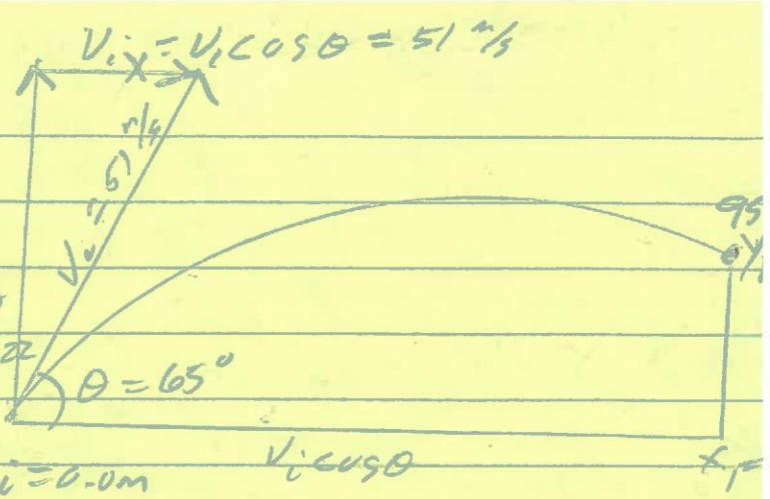
$Y_F = Y_i + V_i t + \frac{1}{2} A t^2$

$-4.905\ 46.7 - 95m$

$16.15 - 95 = 16.15\ m$

$Y_F = Y_i + V_i t + \frac{1}{2} A t^2$

$\sqrt{2Y_F/A} = t$ ~~2.855~~ 1.845



METHOD #2

Quadraticize the whole thing

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}A_y t^2 \Rightarrow \text{eq}$$

$$\tfrac{1}{2}A_y t^2 + (V_{iy})(t) + (y_i - y_f) = 0 \Rightarrow \text{Rewrite in quadratic form}$$

$$-4.905\,t + 46.2\,\text{m/s} + (0 - 95\,\text{m}) = 0 \quad \text{Subst}$$

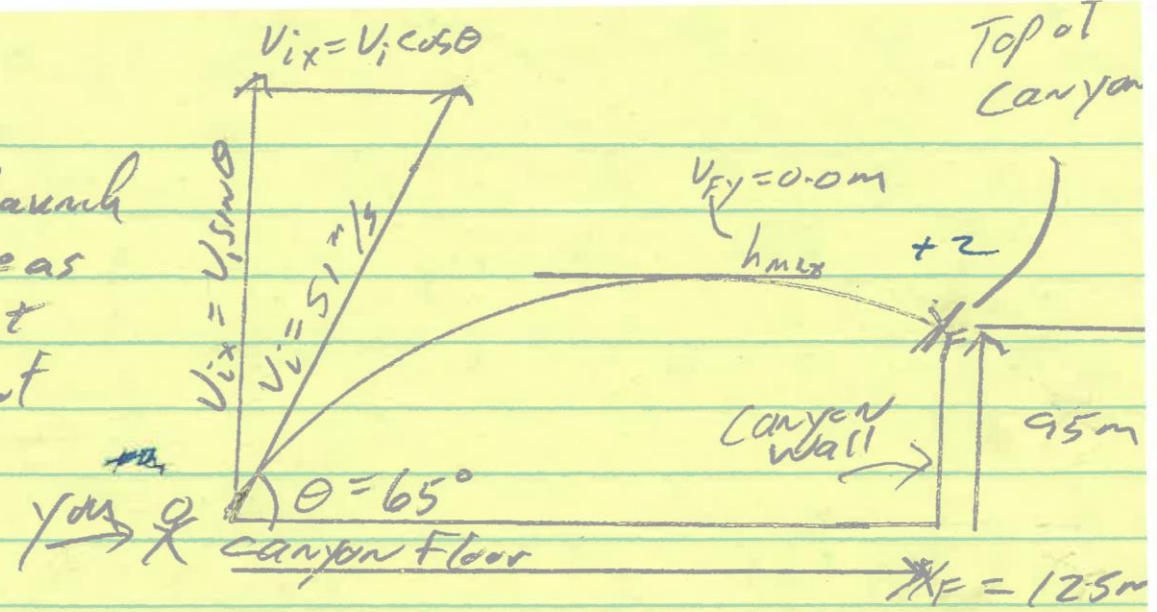
A B C identify quadratic terms

$t = 3.03$s AND (6.39s) time down

time up

This is a legit* time so yay, so the Eq makes it out of the canyon!

* $\Rightarrow$ not negative or imaginary!



...you launch ...zero grape as ...w. Does it ...e it out of ... canyon

$V_{iy} = V_i \sin\theta = 51\ m/s \sin 65° = 46.22\ m/s$

$V_{ix} = V_i \cos\theta = 51\ m/s \cos 65° = 21.55\ m/s$ +2

Method #1

a) - Find time to h_{max}

b) - Find h_{max}

c) - Find time to fall from h_{max} to Y_F

d) - Add times

Does the grape reach X_F? $(V_i \cos\theta)(t_{total})$ +7

a) Find time to h_{max}: +4

$V_{fy} = V_{iy} + At$ ⇒ List eq

$-V_{iy} = t$ ⇒ Isolate

A

$-46.22\ m/s = 4.712\ s$

$-9.81\ m/s$ ≈ 4.7 s S.F ⇒ Solve

b) Find h_{max} +y

$V_{fy}^2 - V_{iy}^2 = 2A\Delta y$ ⇒ List eq

$-V_{iy}^2 / 2A = \Delta y$ ⇒ Isolate

$-(46.22\ m/s)^2 / 2(-9.81\ m/s^2) = \Delta y$ ⇒ Subst

$\Delta y = 108.8\ m$

$= 110\ m$ S.F

$h_{max} = 108.8\ m$

+y

c) $y_f = 95\ m$ so $\Delta y = 13.8\ m$

0.0 m $V_{iy} = 0$ m/s

−13.8 m

Find time to fall 13.8 m

$y_f = y_i + v_{iy}t + \frac{1}{2}At^2$

$y_f = \frac{1}{2}At^2$ ⇒ eq

$\sqrt{2y_f/A} = t$ ⇒ Isolate

$\sqrt{(2)(-13.8\ m)/-9.81\ m/s} = 1.67\ s$

d) Total time = part a) + part c

+y $4.725 + 1.67\ s = 6.39\ s$

Does the grape go far enough in X:

$\vec{x}_f = \vec{x}_i + \vec{v}_{ix} t + \frac{1}{2} \vec{a} t^2$ ⇒ eq

$x_f = (v_{ix})(t_{total}) = (v_i \cos\theta)(t) = x_f$ ⇒ is d a/c

$(21.55\ m/s)(6.39\ s) = 137.7\ m = 140\ m$

So yes, it will go far enough (in X) +1

Does the grape go high enough?

From part B ⇒ 108.8 m = 110 m S.F.

yes! needs to go 95

So YES it makes it out! +1