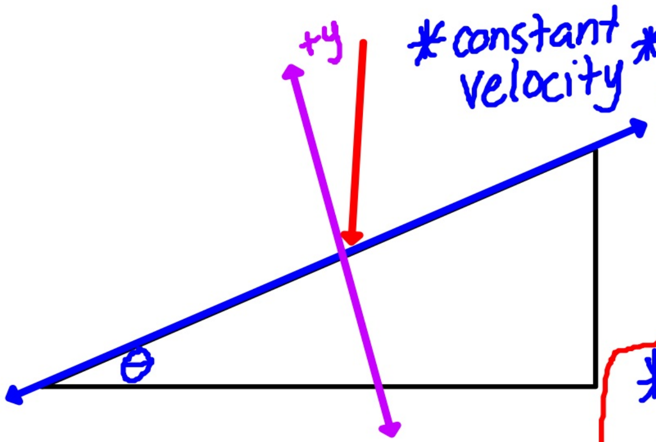
2D Motion - Motion on a Ramp (Inclined plane)



constant velocity

$$\Delta X = (V_x)t$$

$$\Delta X = (V_x)_i t + \frac{1}{2} a_x t^2$$

$$(V_x)_f = (V_x)_i + a_x t$$

$$(V_x)_f^2 = (V_x)_i^2 + 2a_x \Delta X$$

$$\Delta y = (V_y)t$$

$$\Delta y = (V_y)_i t + \frac{1}{2} a_y t^2$$

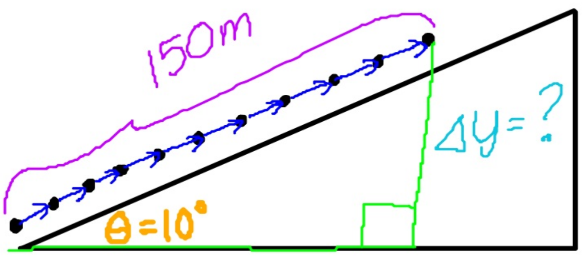
$$(V_y)_f = (V_y)_i + a_y t$$

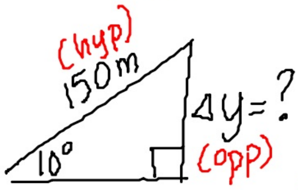
$$(V_y)_f^2 = (V_y)_i^2 + 2a\Delta y$$

$$a_x = \pm g\sin\theta$$

$$a_y = -g$$

A car drives up a steep 10° slope at constant speed of 15 m/s. After 10 s, how much height has the car gained?





$\sin\theta = \frac{opp}{hyp}$

$\sin 10° = \frac{\Delta y}{150m}$ *150m

Given:
$\theta = 10°$
$V_x = 15\frac{m}{s}$
$t = 10s$

Unknown:
Δy

Eqn.
$\Delta X = (V_x)t$
$\Delta X = (15\frac{m}{s})(10s)$
$\Delta X = 150m$

$\Delta y = 150\sin 10°$

$\Delta y = 26m$

1SF 30m

$(V_x)_i$

A skier starts from rest and accelerates down a stretch of a mountain with a contant slope. If the skier travels 360 m while dropping a vertical distance of 170 m, what is the fastest speed a skier can achieve at the end of the run? How much time would this run take?

$(V_x)_f = \_\_\_\_ \text{ m/s}$

use $(V_x)_f^2 = (V_x)_i^2 + 2a\Delta x$

Find θ:

$\sin\theta = \frac{opp}{hyp}$

$\therefore \theta = \sin^{-1}\left(\frac{opp}{hyp}\right)$

$\theta = \sin\left(\frac{|-170|}{360}\right)$

$\theta = 28^\circ$

$\Delta X = 360\text{m}$

$\Delta y = -170\text{ m}$

$(V_x)_f = \sqrt{(0)^2 + 2(4.6)(360)}$

$(V_x)_f = 58 \text{ m/s}$

$a_x = g\sin\theta = 9.8\sin(28)$

$a_x = 4.6 \text{ m/s}^2$

$(V_x)_f = (V_x)_i + at$

$(58) = (0) + (4.6)t$

$\frac{58}{4.6} = \frac{\cancel{4.6}t}{\cancel{4.6}}$

$12.6087 = t$

$t = 13\text{s}$

$\Delta X = (V_x)_i t + \frac{1}{2}a_x t^2$

$(360) = (0)t + \frac{1}{2}(4.6)t^2$

$\frac{360}{2.3} = \frac{\cancel{2.3}t^2}{\cancel{2.3}}$

$\sqrt{156.5217} = \sqrt{t^2}$

$12.5109 = t$

$t = 13\text{ s}$

A wooden roller coaster has cars that go down a big hill first, gaining speed. The cars then ascend a second hill with a slope of 30°. If the cars are going 25 m/s at the bottom and it takes then 2.0 s to climb this hill, how fast are they moving going at the top?

$(V_x)_f = (V_x)_i + at = (25) + (-4.9)(2)$

$\theta = 30^\circ$

$(V_x)_i = 25 m/s$

$t = 2.0 s$

$(V_x)_f = \_\_\_\_ m/s$

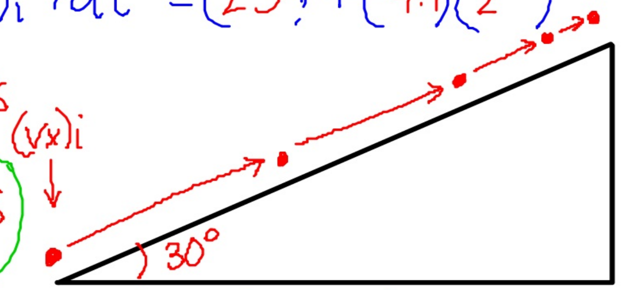
$a_x = -g \sin\theta$

$a_x = -(9.8) \sin(30^\circ)$

$a_x = \underline{-4.9} \ m/s^2$

$(V_x)_f = 15.2 m/s$

$(V_x)_f = 15 m/s$



+dir, slowing down

(−accel)

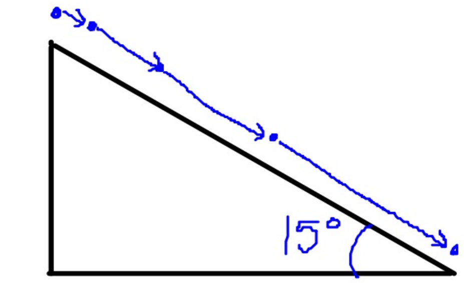
How far did the roller coaster car climb up the hill?

$$\Delta X = (V_x)_i t + \frac{1}{2} a t^2$$
$$= (25)(2) + \frac{1}{2}(-4.9)(2)^2$$
$$= 50 + -9.8$$
$$= 40.2 \ m$$
$$\Delta X = \underline{4.0 \times 10^1 \ m}$$

$$(V_x)_f^2 = (V_x)_i^2 + 2a\Delta X$$
$$(15)^2 = (25)^2 + 2(-4.9)\Delta X$$
$$225 = 625 - 9.8\Delta X$$
$$-625 \quad -625$$
$$\frac{-400}{-9.8} = \frac{-9.8\Delta X}{-9.8}$$
$$\Delta X = 40.8163$$
$$\Delta X = 41 m$$

Practice Problem #1:

You begin sliding down a 15° slope. Ignoring friction and air resistance, how fast will you be moving after 10 s?



+ dir, speeding up
(+ accel)

$\theta = 15°$

$t = 10\,s$

$(V_x)_i = 0\,m/s$

$(V_x)_f = \_\_\_\ m/s$

$a_x = \_\_\_\ m/s^2$

$a_x = g\sin\theta = (9.8)\sin(15°)$

$a_x = 2.536\ m/s^2$

$(V_x)_f = (V_x)_i + at$

$= (0) + (2.536)(10)$

$(V_x)_f = 25.36\ m/s$

25 m/s 2 SF

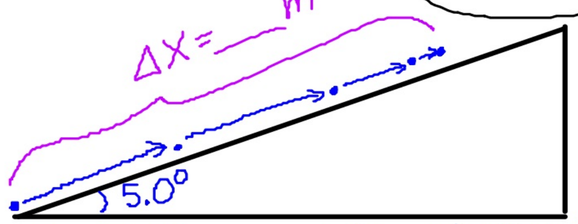
30 m/s 1 SF

Practice Problem #2:

A car traveling 30 m/s runs out of gas while traveling up a 5.0° slope. How far will the car coast before starting to roll back down?

$\Delta X = 530\,m$ (2SF)

$\Delta X = 500\,m$ (1SF)



$\theta = 5.0°$

$(V_x)_i = 30\,m/s$

$(V_x)_f = 0\,m/s$

+ dir, slowing down
(−accel)

$\Delta X = \_\_\_\ m$

$a_x = \_\_\_\ m/s^2$

$\Delta X = 526.85\,m$

$a_x = -g\sin\theta$

$= -(9.8)\sin(5.0)$

$a_x = -.8541\ m/s^2$

$(V_x)_f^2 = (V_x)_i^2 + 2a\Delta X$

$(0)^2 = (30)^2 + 2(-.8541)\Delta X$

$0 = 900 - 1.708\,\Delta X$

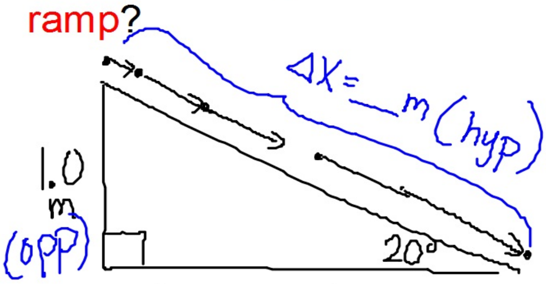
$-900 \quad -900$

$-900 = -1.708\,\Delta X$

$\frac{-900}{-1.708} = \frac{-1.708\,\Delta X}{-1.708}$

Practice Problem #3:

A piano begins to roll down a ramp on the back of a moving truck. If the truck is 1.0 m above the ground and the ramp is inclined at 20°. How long will it take for the piano to reach the bottom of the ramp?



+dir, speeding up (+accel)

$$a_x = g\sin\theta = (9.8)\sin(20) = \underline{3.352\ m/s^2}$$

$$\cancel{hyp} * \sin\theta = \frac{opp}{\cancel{hyp}} * \cancel{hyp}$$

$$\frac{hyp * \cancel{\sin\theta}}{\cancel{\sin\theta}} = \frac{opp}{\sin\theta}$$

$$hyp = \frac{opp}{\sin\theta}$$

$$\Delta X = \frac{\Delta y}{\sin\theta} = \frac{(1.0m)}{\sin(20)°} = \underline{2.924m}$$