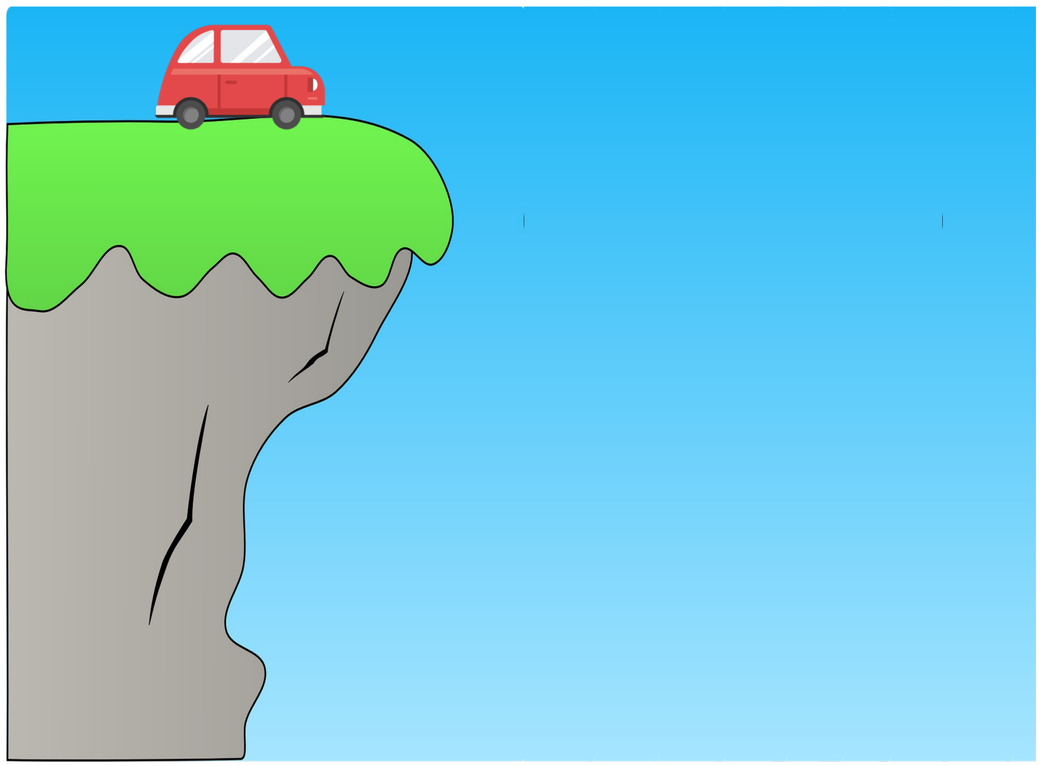
Raul Barrea
@PhysicsSensei

Projectile Motion with Horizontal Launch

Find how far the object goes



A red car is driving at 10.0 m/s directly to a cliff that is 20.0 m high, as shown in the picture. The car cannot stop and falls over the cliff.

1. Calculate how long it takes for the car to touch ground.
2. Calculate the maximum horizontal distance the car will go,
3. Calculate the final velocity of the car right before hitting ground.

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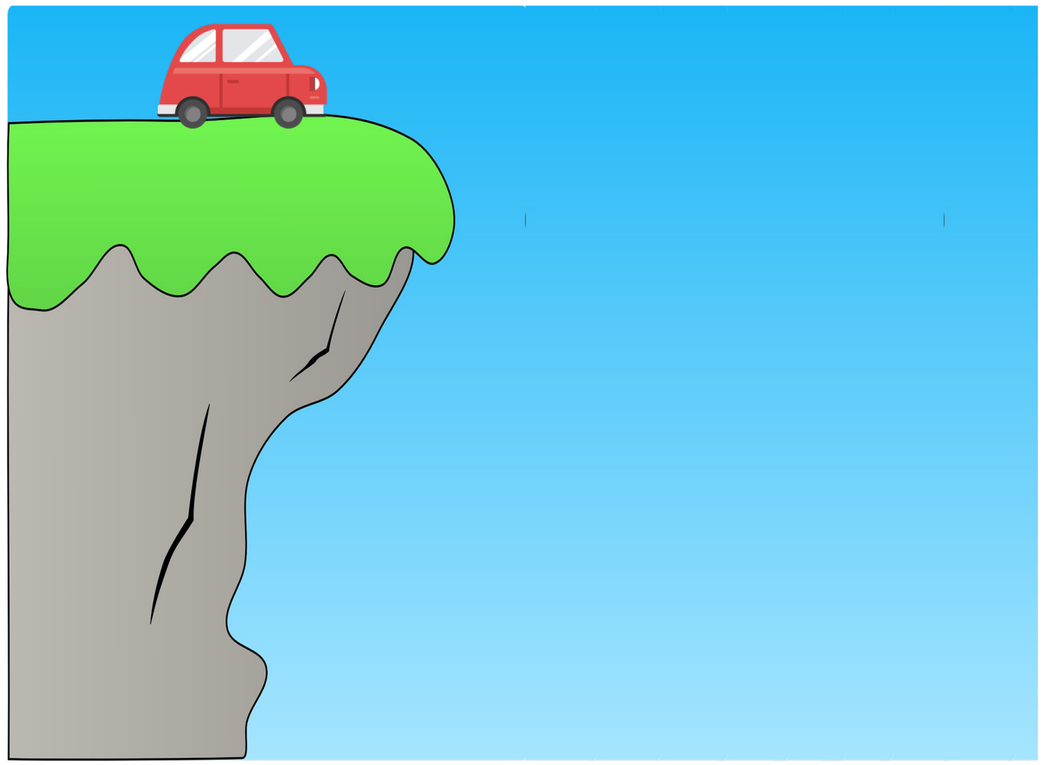
Find how far the object goes

Basic steps to solve this problem

1) Read the problem
2) Draw a diagram
3) Write down info
4) Choose equation
5) Solve for the unknowns
6) Check your answers



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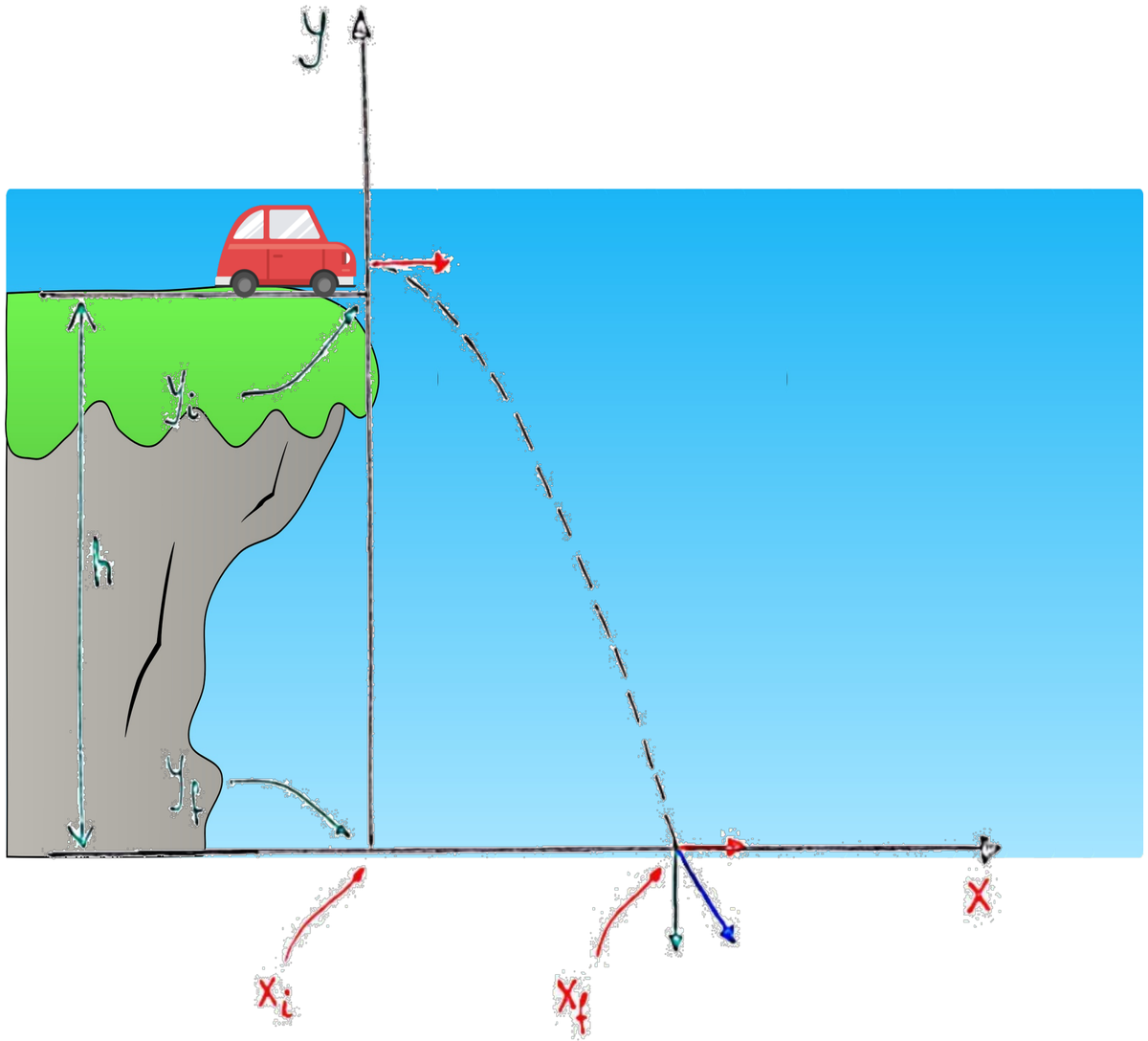

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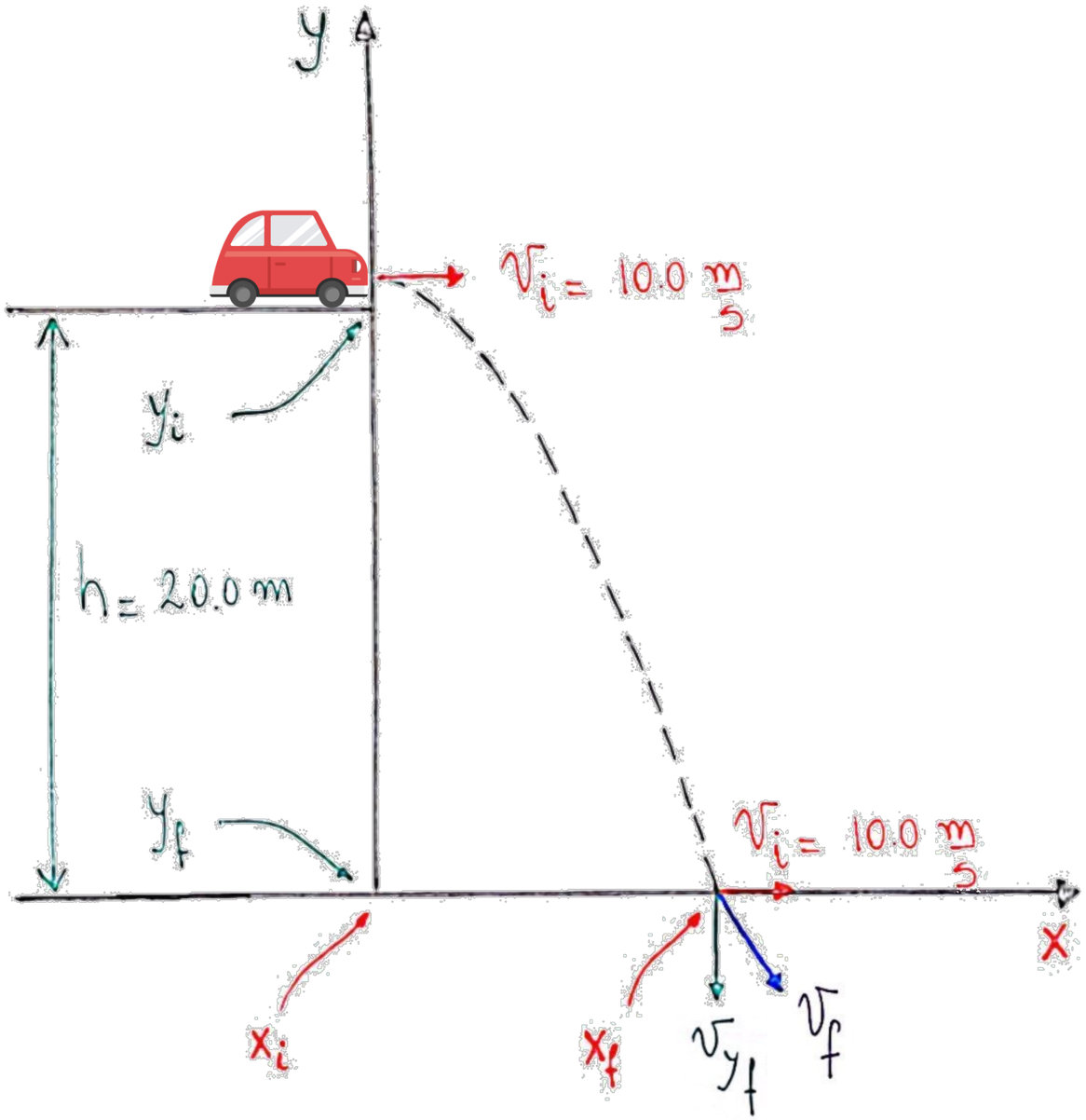
Never mix x and y variables

Only Δt can be used

with both variables



x	y
$x_i = 0$	$y_i = h = 20.0\ m$
$x_f = ?$	$y_f = 0$
$v_i = v_x$	$v_{y_i} = 0$
$v_x = 10.0 \frac{m}{s}$	$v_{y_f} = ?$
$a_x = 0$	$a_y = -9.81 \frac{m}{s^2}$

$\Delta t = ?$

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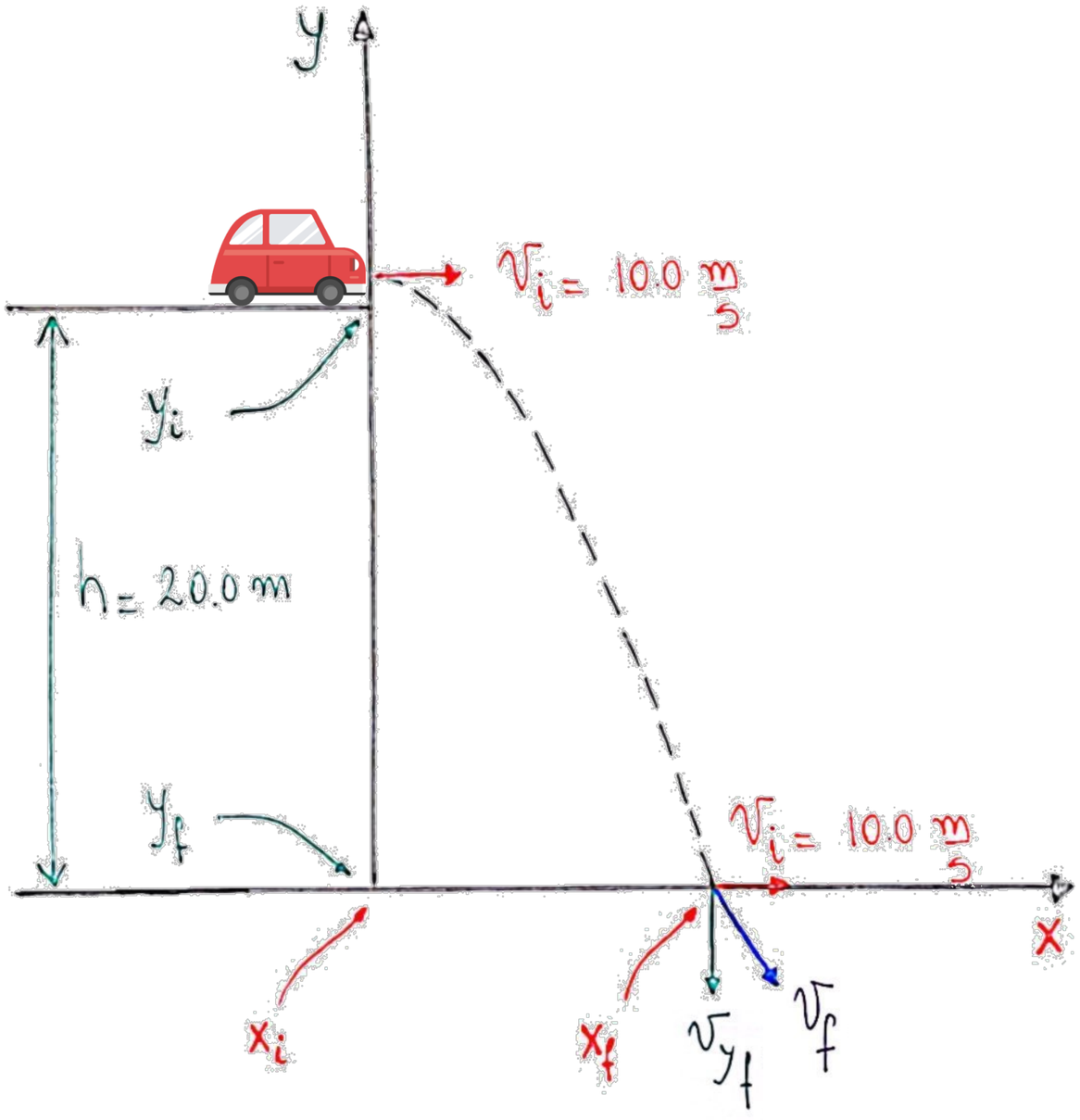

Equations

$$y_f = y_i + v_{y_i} \Delta t + \frac{1}{2} a_y \cdot \Delta t^2$$

$$x_f = x_i + v_x \cdot \Delta t$$

$$v_{y_f} = v_{y_i} + a_y \cdot \Delta t$$

$$v_f = \sqrt{v_x^2 + v_{y_f}^2}$$

$$\theta = \tan^{-1}\left(\frac{v_{y_f}}{v_x}\right)$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate how long it takes for the car to touch ground

$$y_f = y_i + v_{y_i}\Delta t + \frac{1}{2}a_y \cdot \Delta t^2$$

$$y_f = y_i + \cancel{v_{y_i}}^{\,0}\Delta t + \frac{1}{2}a_y \Delta t^2$$

Solve for Δt

Using the values from the y axis

$$0 = 20.0\,m - \frac{1}{2}\left(9.81\,\frac{m}{s^2}\right)\Delta t^2$$

$$\Delta t^2 = \frac{20.0\,m}{4.905\,\frac{m}{s^2}}$$

$$\Delta t = \sqrt{\frac{20.0\,m}{4.905\,\frac{m}{s^2}}}$$

$$\boxed{\Delta t = 2.02s}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the maximum horizontal distance the car will go

Solve for x_f

Using the value of Δt

$$x_f = x_i + v_x \cdot \Delta t$$

$$x_f = \cancel{x_i}^{\,0} + v_x \cdot \Delta t$$

$$x_f = \left(10.0 \frac{m}{s}\right)(2.025)$$

$$\boxed{x_f = 20.2\ m}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

Solve for v_{y_f}

Using the values from the y axis

$$v_{y_f} = v_{y_i} + a_y \cdot \Delta t$$

$$v_{y_f} = \cancel{v_{y_i}}^{0} + a_y \cdot \Delta t$$

$$v_{y_f} = a_y \cdot \Delta t$$

$$v_{y_f} = \left(-9.81 \frac{m}{s^2}\right)(2.02s)$$

$$\boxed{v_{y_f} = -19.8 \frac{m}{s}}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

$$v_f = \sqrt{v_x^2 + v_{y_f}^2}$$

Solve for v_f

Using the values from the x and y axis

$$v_f = \sqrt{\left(10.0 \frac{m}{s}\right)^2 + \left(-19.8 \frac{m}{s}\right)^2}$$

$$\boxed{v_f = 22.2 \frac{m}{s}}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

Solve for θ

Using the values from the x and y axis

$$\theta = \tan^{-1}\left(\frac{v_{y_f}}{v_x}\right)$$

$$\theta = \tan^{-1}\left(\frac{-19.8\ m/s}{10.0\ m/s}\right)$$

$$\boxed{\theta = -63.2^\circ}$$

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Now it’s your turn

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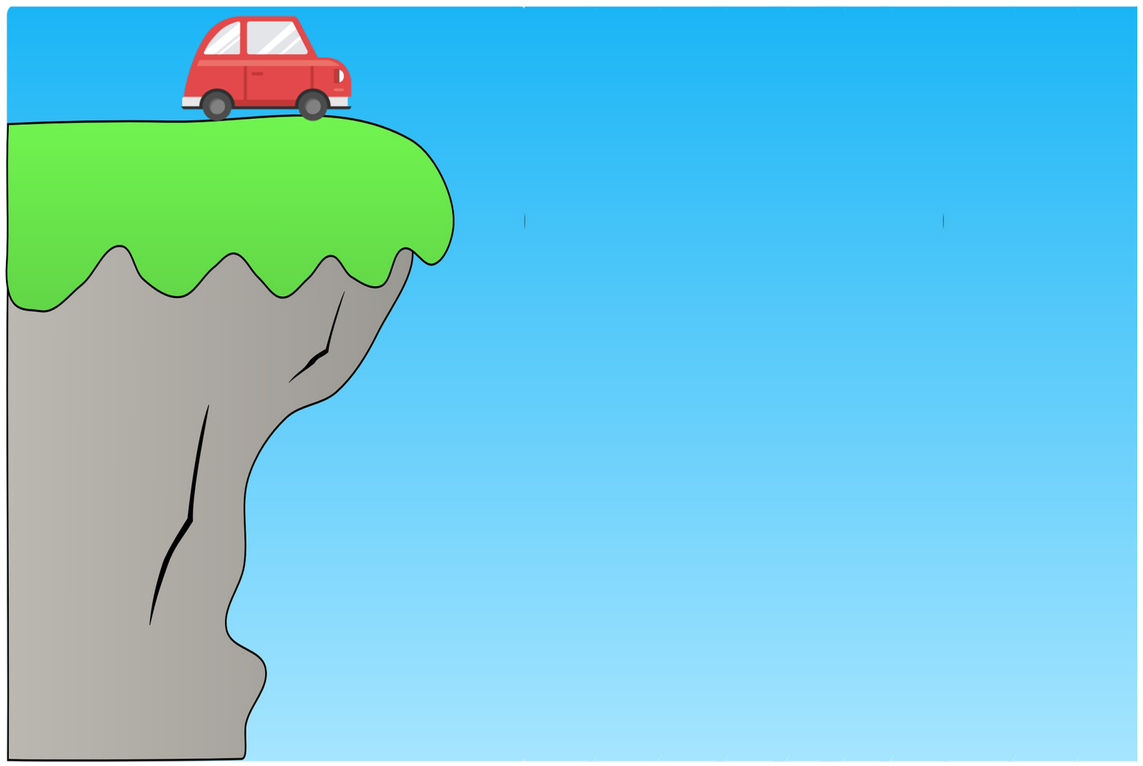

A red car is driving at 12.0 m/s directly to a cliff that is 23.0 m high, as shown in the picture. The car cannot stop and falls over the cliff.

1. Calculate how long it takes for the car to touch ground.
2. Calculate the maximum horizontal distance the car will go,
3. Calculate the final velocity of the car right before hitting ground.

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Take your time
Try without using your notes
Check your notes when you get stuck
Answers are next
Good Luck!!!!!!

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate how long it takes for the car to touch ground

$$y_f = y_i + v_{y_i}\Delta t + \frac{1}{2}a_y \cdot \Delta t^2$$

$$y_f = y_i + \cancel{v_{y_i}}^{0}\Delta t + \frac{1}{2}a_y \Delta t^2$$

$$0 = 23.0\,m - \frac{1}{2}\left(9.81\,\frac{m}{s^2}\right)\Delta t^2$$

$$\Delta t^2 = \frac{23.0\,m}{4.905\,\frac{m}{s^2}}$$

$$\Delta t = \sqrt{\frac{23.0\,m}{4.905\,\frac{m}{s^2}}}$$

$$\boxed{\Delta t = 2.16\,s}$$

Solve for Δt

Using the values from the y axis

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the maximum horizontal distance the car will go

Solve for x_f

Using the value of Δt

$$x_f = x_i + v_x \cdot \Delta t$$

$$x_f = \cancel{x_i}^{\,0} + v_x \cdot \Delta t$$

$$x_f = \left(12.0 \frac{m}{s}\right)(2.16\,s)$$

$$\boxed{x_f = 25.9\ m}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

Solve for v_{y_f}

Using the values from the y axis

$$v_{y_f} = v_{y_i} + a_y \cdot \Delta t$$

$$v_{y_f} = \cancel{v_{y_i}}^{0} + a_y \cdot \Delta t$$

$$v_{y_f} = a_y \cdot \Delta t$$

$$v_{y_f} = \left(-9.81 \frac{m}{s^2}\right)(2.16 s)$$

$$\boxed{v_{y_f} = -21.2 \frac{m}{s}}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

Solve for v_f

Using the values from the x and y axis

$$v_f = \sqrt{v_x^2 + v_{y_f}^2}$$

$$v_f = \sqrt{\left(12.0 \frac{m}{s}\right)^2 + \left(-21.2 \frac{m}{s}\right)^2}$$

$$\boxed{v_f = 24.4 \frac{m}{s}}$$

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Projectile Motion with Horizontal Launch

Find how far the object goes

Calculate the final velocity of the car right before hitting ground

$$\theta = \tan^{-1}\left(\frac{v_{yf}}{v_x}\right)$$

Solve for θ

Using the values from the x and y axis

$$\theta = \tan^{-1}\left(\frac{-21.2\ \frac{m}{s}}{12.0\ \frac{m}{s}}\right)$$

$$\boxed{\theta = -60.5^\circ}$$

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