Tues: Discussion / quiz

Ex 112, 115, 116, 120, 122, 126, 129

Projectile motion

For projectile motion

$a_x = 0\,m/s^2$ $a_y = -g = -9.8\,m/s^2$

The kinematics equations are:

$$v_{fx} = v_{ix} + a_x \Delta t \qquad v_{fy} = v_{iy} + a_y \Delta t$$

$$x_f = x_i + v_{ix}\Delta t + \tfrac{1}{2} a_x \Delta t^2 \qquad y_f = y_i + v_{iy}\Delta t + \tfrac{1}{2} a_y \Delta t^2$$

$$v_{fx}^2 = v_{ix}^2 + 2a_x(x_f - x_i) \qquad v_{fy}^2 = v_{iy}^2 + 2a_y(y_f - y_i)$$

Warm Up!

DEMO: Track + cart launcher.

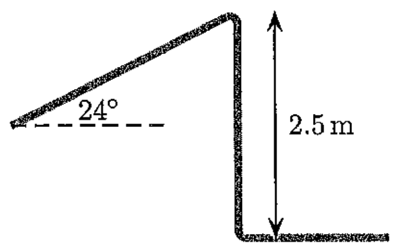
Fundamental Mechanics: Group Exercise 3

8 September 2025

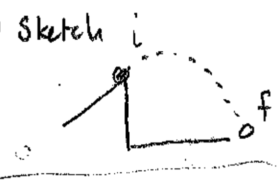
Names: ______________ ______________ ______________

______________ ______________

A ski ramp is arranged as illustrated. A skier launches off the top of the ramp (up and right) with a speed of 19 m/s. Determine the horizontal distance at which the skier lands from the bottom of the ramp.



Answer: ① Sketch



② Variables

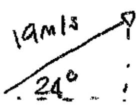
$x_i = 0\,m$ $\quad \Delta t =$ $\quad y_i = 2.5\,m$

$x_f =$ $\quad y_f = 0\,m$ $\quad a_x = 0\,m/s^2$

$v_{ix} = 17.4\,m/s$ $\quad v_{fx} =$ $\quad a_y = -9.8\,m/s^2$

$v_{iy} = 7.7\,m/s$ $\quad v_{fy} =$

③ v_i components



$v_{ix} = v_i \cos 24^\circ$
$= 19\,m/s \cos 24^\circ$
$= 17.4\,m/s$

$v_{iy} = v_i \sin 24^\circ = 19\,m/s \sin 24^\circ$
$= 7.7\,m/s$

④ Need $x_f = \cancel{x_i} + v_{ix}\Delta t + \frac{1}{2}\cancel{a_x}\Delta t^2$

$x_f = v_{ix}\Delta t = 17.4\,m/s\,\Delta t$

Get time from vertical

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

$0\,m = 2.5\,m + 7.7\,m/s\,\Delta t - \frac{1}{2}9.80\,m/s^2\,\Delta t^2$

$0\,m = 2.5\,m + 7.7\,m/s\,\Delta t - 4.90\,m/s^2\,\Delta t^2$

$$\Delta t = \frac{-7.7\,m/s \pm \sqrt{(7.7\,m/s)^2 - 4\cdot(-4.9\,m/s^2)\,2.5}}{2(-4.90\,m/s^2)}$$

$$= \frac{-7.7\,m/s \pm 10.4}{-9.80\,m/s^2}$$

$= 1.85\,s$ or negative

$x_f = 17.4\,m/s \times 1.85\,s$

$x_f = 32\,m$

Circular motion

We now consider situations where an object moves in a circle. Examples include:

1) object swinging in a circle on the end of a string
2) planets and moons orbiting

DEMO: TheSky 3D - show planets orbiting

We aim to determine the acceleration using the same basic rules for any kinematic situation

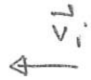
Warm Up 1

Quiz 1 ~~70%~~ $\approx$ 70% - 85%

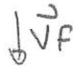
Exercise (for class) in steps

① $\vec{a}_{avg} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t}$

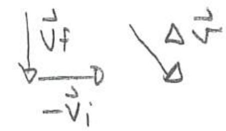
② sketch $\vec{v}_i$



③ sketch $\vec{v}_f$



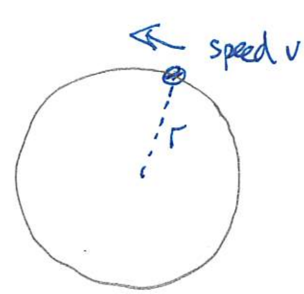
④ $\Delta\vec{v} = \vec{v}_f - \vec{v}_i =$



gives $\vec{a}_{avg}$

By taking the limit as $\Delta t \to 0$ we can get the acceleration. For uniform circular motion, where an object moves in a circle with constant speed

> The acceleration, called centripetal acceleration
>
> 1) points radially inward
> 2) has magnitude
>
> $$a_c = v^2/r$$
>
> where r = radius of orbit
> v = speed of object



136 Merry-go-round

A merry-go-round is a large flat disk that spins around a vertical axis through its center. A child is at the edge of a merry-go-round with radius 3.0 m. The merry-go-round spins so that the child's acceleration is $1.5g$. Determine the period and frequency of orbit for this to occur.

Answer: Strategy: (known acceleration) → (velocity) → (velocity → time)

$$a = \frac{v^2}{r} \Rightarrow v^2 = ar$$

$$\Rightarrow v = \sqrt{ar} = \sqrt{1.5 \times 9.8\,\text{m/s}^2 \times 3.0\,\text{m}}$$

$$= 6.6\,\text{m/s}$$

$$v = \frac{\text{distance one orbit}}{\text{time}}$$

$$= \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v} = \frac{2\pi \times 3.0\,\text{m}}{6.6\,\text{m/s}} = 2.8\,\text{s}$$

$$\text{frequency} = 1/T = 0.35\,\text{Hz}$$