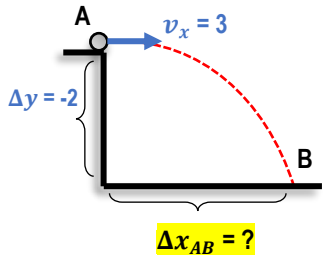
CONCEPT: SOLVING PROJECTILE MOTION USING EQUATION SUBSTITUTION

PREVIOUS EXAMPLE: A ball rolls off a 2m-tall table at a speed of 3m/s. Find the horizontal displacement of the ball.



X

$\Delta x_{AB} = v_x t_{AB}$

Δx_{AB} =(3)( )

Y

$a_y = -g = -9.8$

$v_{0y} = v_{Ay}$ = 0

$v_y = v_{By}$ =

Δy_{AB} = -2

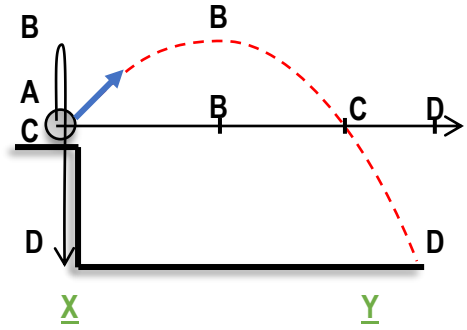
t_{AB} =

(3): $\Delta y_{AB} = \cancel{v_{Ay} t_{AB}} + \frac{1}{2} a_y t_{AB}^2$

$t_{AB} = 0.64s$

- You'll need to solve problems where 2 of these 3 $[v_0, \theta_0, t]$ are unknown, but may not be asked for.
  - When you write X & Y equations, you may end up with ___ equations with the SAME ___ unknown variables.
  - Use **Substitution:** (1) _____ expression for 1 variable in *simplest* equation. Never write expression for θ_A first!
    (2) _____ expression in *other* equation.
    (3) Solve for other unknown using *either* 1st or 2nd equation if necessary

EXAMPLE: A soccer ball is kicked upwards from a 5m-tall hill. It travels through the air for 4.5s and lands on the ground 45m away. Find the ball's initial velocity and the angle at which the soccer ball was kicked.



X

$\Delta x = v_x t$

Y

$a_y = -g = -9.8$

v_{0y} =

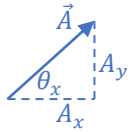
v_y =

Δy =

t =

PROJECTILE MOTION
1) Draw paths in X&Y and points of interest *(Points of Interest: initial, final, max height, etc.)*
2) Determine target variable
3) Determine interval and UAM equation
4) Solve

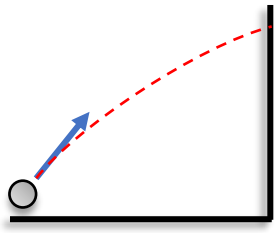
UAM EQUATIONS
X
$\Delta x = v_x t$
Y
(1) $v_y = v_{0y} + a_y t$
(2) $v_y^2 = v_{0y}^2 + 2a_y \Delta y$
(3) $\Delta y = v_{0y} t + \frac{1}{2} a_y t^2$
*(4) $\Delta y = \frac{1}{2}(v_{0y} + v_f) t$

VECTOR EQs

$A = \sqrt{A_x^2 + A_y^2}$
$\theta_x = \tan^{-1}\left(\frac{\lvert A_y \rvert}{\lvert A_x \rvert}\right)$
$A_x = A\cos(\theta_x)$
$A_y = A\sin(\theta_x)$

EQUATION SUBSTITUTION
1) Write expression for 1 variable in 1 equation
2) Plug expression into other equation to solve
3) Solve *other* variable in *either* equation

PROBLEM: A ball is kicked at a 45° angle from the ground. It hits the wall of a building 30m away, 10m up from the ground. What was the ball's initial velocity?

A) 17.7 m/s
B) 3.2 m/s
C) 21 m/s
D) 441 m/s



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1) Draw paths in X&Y and points of interest *(Points of Interest: initial, final, max height, etc.)*
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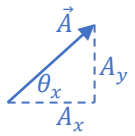
UAM EQUATIONS	
X	**Y**
$\Delta x = v_x t$	(1) $v_y = v_{0y} + a_y t$ (2) $v_y^2 = v_{0y}^2 + 2a_y \Delta y$ (3) $\Delta y = v_{0y} t + \frac{1}{2} a_y t^2$ *(4) $\Delta y = \frac{1}{2}(v_{0y} + v_f)t$

VECTOR EQs



$A = \sqrt{A_x^2 + A_y^2}$

$\theta_x = \tan^{-1}\left(\frac{|A_y|}{|A_x|}\right)$

$A_x = A\cos(\theta_x)$

$A_y = A\sin(\theta_x)$