Two stage kinematics example

A sprinter can accelerate with constant acceleration for 4.0 s before reaching top speed. He can run the 100-meter dash in 10.0 s. What is his speed as he crosses the finish line? (Answer: 12.5 m/s)

\[ \begin{align*}
\text{Stage 1} & \quad \text{Stage 2} \\
\Delta v_1 &= 0 \\
\Delta v_2 &= 4 \text{ m/s} \\
\Delta x_1 &= \frac{1}{2} a \Delta t^2 \\
\Delta x_2 &= 100 \text{ m} \\
\frac{1}{2} a \Delta t^2 + v_f \Delta t &= 100 \\
\frac{1}{2} (v_f \Delta t)^2 + v_f \Delta t &= 100
\end{align*} \]

Kinematics in 2D

- Decompose motion into \( x \) and \( y \) components and treat each separately.
A daredevil is attempting to jump a gorge above a river. If their takeoff ramp is inclined upward 53.0° with respect to the horizontal, the gorge is 40.0 m wide, and the landing spot is 15.0 m below the takeoff location, (a) Find the velocity at \( t = 2 \) s. (b) Find the magnitude and direction of the position vector at \( t = 4 \) s. (Answers: (a) \( <9, 1> \) m/s, (b) 44.9 m, 32.2°)

A particle moves in the \( xy \) plane with constant acceleration. At time zero, the particle is at \( r = <2,3> \) m and has velocity \( v = <3,-7> \) m/s. The acceleration is a constant and is given by \( a = <3,4> \) m/s². (a) Find the velocity at \( t = 2 \) s. (b) Find the magnitude and direction of the position vector at \( t = 4 \) s. (Answers: (a) \( <9, 1> \) m/s, (b) 44.9 m, 32.2°)

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A daredevil is attempting to jump a gorge above a river. If their takeoff ramp is inclined upward 53.0° with respect to the horizontal, the gorge is 40.0 m wide, and the landing spot is 15.0 m below the takeoff location, (a) what speed do they need to accomplish the jump? (b) What is their final velocity, magnitude and direction? (c) If their speed is 2/3 the value found in part (a), where will they land?

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Projectile Motion: only under influence of gravity, \( \theta = \text{constant} \)
\[ \Delta x = 0 \text{ m/s}^2 \]
\[ \Delta x = 40 \text{ m} \]
\[ v_{x0} = v_{x} = \frac{u_{x}}{\cos 53}\]
\[ a_y = -9.8 \text{ m/s}^2 \]
\[ \Delta y = -15 \text{ m} \]

\[ \begin{align*}
\text{Eq. 1:} & \quad \Delta x = v_{x0} \Delta t + \frac{1}{2} a_x \Delta t^2 \\
\text{Eq. 2:} & \quad -15 = |v_{x0}| \sin 53 \Delta t - 4.9 \Delta t^2 \\
\end{align*} \]

\[ 2 \text{ eqs} \]
\[ 2 \text{ unknowns} \]
\[ \Delta t = 3.73 \text{ s} \]
\[ |v_{x0}| = 17.8 \text{ m/s} \]