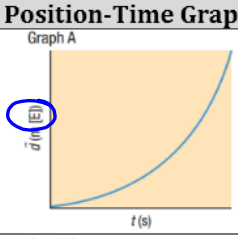
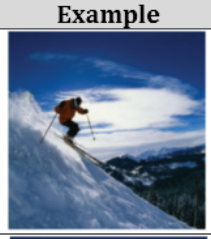
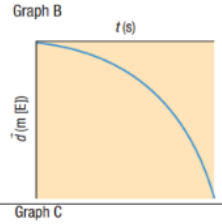
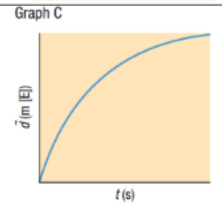
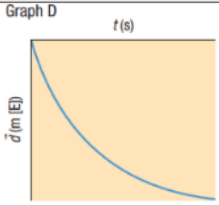
SPH3U: 1.3 Acceleration

1. Acceleration and graphs

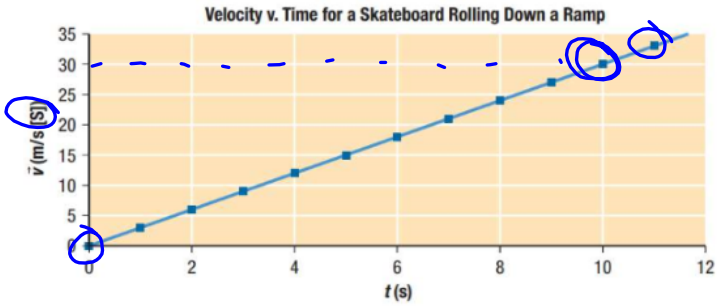
Acceleration:	rate of change of velocity.
velocity-time graph	x-axis: time y-axis: velocity.
position-time graph	is curved if we are accelerating.

Position-Time Graph	Type of Motion	Example
Graph A 	- $\vec{d}$ and $\vec{v}$ are increasing. - speeding up. - moving East.	
Graph B 	- $\vec{d}$ and $\vec{v}$ are decreasing. - speeding up. - moving West.	
Graph C 	- moving East - slowing down.	
Graph D 	- moving West - slowing down.	

2. Determining acceleration from a velocity-time graph

Average acceleration: $\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$

- in this course, $\vec{a} = \vec{a}_{av}$ because $\vec{a}$ is always constant.



What is the acceleration of the skateboard in the figure above? Consider the motion between 0 s and 10 s.

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{30 - 0}{10} = 3.0 \text{ m/s}^2 \text{ [S]}.$

When a rifle is fired, the rifle bullet accelerates from rest to 120 m/s [E] in 1.3 x 10^{-2} s as it travels down the rifle's barrel. What is the bullet's average acceleration?

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{120 - 0}{1.3 \times 10^{-2}} = 9231 \text{ m/s}^2 \text{ [E]}.$

$= 9.2 \times 10^3 \text{ m/s}^2 \text{ [E]}.$

When a hockey player hits a hockey puck with his stick, the velocity of the puck changes from 8.0 m/s [N] to 10.0 m/s [S] over a time interval of 0.050 s. What is the acceleration of the puck?

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{10 \text{ [S]} - 8 \text{ [N]}}{0.05} = \frac{10 \text{ [S]} + 8 \text{ [S]}}{0.05}$

$= \frac{18}{0.05} = 360 \text{ m/s}^2 \text{ [S]}$

A racehorse takes 2.70 s to accelerate from a trot to a gallop. If the horse's initial velocity is 3.61 m/s [W] and it experiences an acceleration of 2.77 m/s² [W], what is the racehorse's velocity when it gallops?

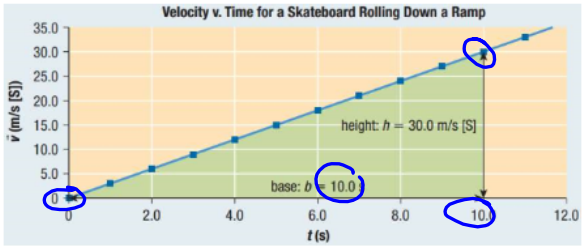
$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} \rightarrow \vec{v}_f = \vec{a}\Delta t + \vec{v}_i$

$\vec{v}_f = (2.77)(2.70) + 3.61 = 11.089 \text{ m/s [W]}$

$= 11.1 \text{ m/s [W]}.$

3. Motion with uniform and non-uniform velocity

Area under a v-t graph:	$\vec{\Delta d} = \frac{1}{2}(\vec{v}_f + \vec{v}_i)\Delta t$ - area is equal to displacement.

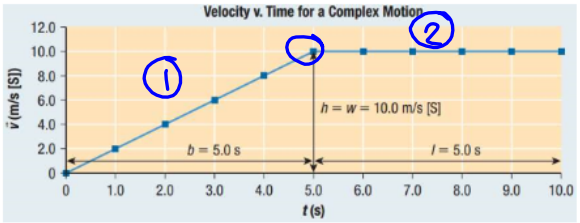


What is the displacement represented by the graph above?

$\Delta d = \frac{1}{2}(v_f + v_i)\Delta t = \frac{1}{2}(30 + 0)(10)$

$= 150 \text{ m [S]}.$

What is the displacement represented by the graph below over the time interval from 0 s to 10.0 s?



① $\vec{\Delta d} = \frac{1}{2}(v_f + v_i)\Delta t$

$= \frac{1}{2}(10 + 0)(5)$

$= 25 \text{ m [S]}.$

② $\vec{\Delta d} = \frac{1}{2}(v_f + v_i)\Delta t$

$= \frac{1}{2}(10 + 10)(5)$

$= 50 \text{ m [S]}.$

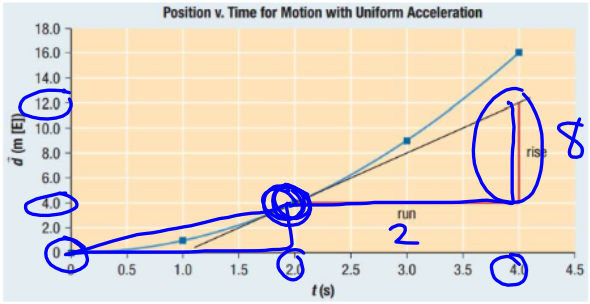
Total: $\vec{\Delta d}_T = \vec{\Delta d}_1 + \vec{\Delta d}_2$

$= 25 + 50$

$= 75 \text{ m [S]}.$

4. Instantaneous velocity and average velocity

Uniform acceleration:	motion where the velocity changes at a constant rate (straight line).
average velocity	average over a time interval.
instantaneous velocity	velocity at a specific instant in time. slope of a tangent on a position-time graph.
tangent	a line that touches a graph at one point.



Consider the point on the curve in the figure above at 2.0 s on the *x*-axis. What is the instantaneous velocity of the object at this time?

$\vec{v}$ = slope of the tangent

$= \frac{rise}{run}$

$= \frac{8.0\,m\,[E]}{2.0\,s} = 4.0\,m/s\,[E]$.

What is the average velocity of the object in the figure above over the time interval from 0.0 s to 2.0 s?

$\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t} = \frac{4.0-0}{2.0\,s} = 2.0\,m/s\,[E]$

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