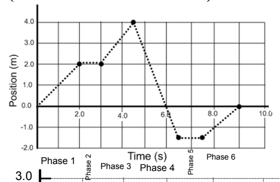
2.2 Acceleration

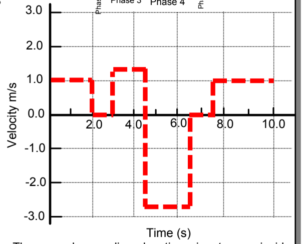
Graphing Velocity (Move to 2.1 Next Year)

From position vs. time graph, velocity vs. time graph can be derived: (Slope position. vs. time = m/s : velocity)

Phase 1: Velocity = +1.0 m/s
Phase 2: Velocity = 0.0 m/s
Phase 3: Velocity = +1.33 m/s
Phase 4: Velocity = -2.75 m/s
Phase 5: Velocity = 0.0 m/s
Phase 6: Velocity = + 1.0 m/s



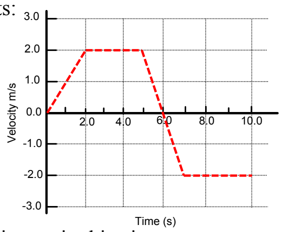
Do you find it disturbing that there are abrupt changes from one phase of motion to another on this graph?
You should - they indicate that there is no transition time from one velocity to another.



Note: These graphs are aligned so time signatures coincide.

Graphing Velocity

Velocity vs. Time graphs should show gradual transitions between horizontal segments:



Describe what's going on in this picture.

What do the sloped parts of the line represent?

Acceleration!

Acceleration

Rate of change of velocity.
Acceleration:

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} \quad or: \quad \frac{v - v_0}{t - t_0}$$

Unit analysis:

$$a = \frac{\Delta v}{\Delta t} = \frac{\frac{m}{s}}{s} = \frac{\frac{m}{s}}{\frac{s}{1}} = \frac{m}{s} \bullet \frac{1}{s} = \frac{m}{s^2}$$

Acceleration

A vector quantity: a change in speed, direction, or both will make Δa.

Case A. Change in speed only.
Motorcycle starts at 20 m/s, ends at 30 m/s.

Case B. Change in direction only.
Car going 20 m/s steers around a curve.

Case C. Change in speed and direction.
Car starts uphill at 60 km/hr, and slows to 40 km/hr at the top.

Ex. 1.

A car traveling at 90. km/hr slows to 40. km/hr in 5.0 seconds. What is the average acceleration in m/s²?

$$v_0 = \frac{90\,km}{h} \bullet \frac{1000\,m}{1\,km} \bullet \frac{1\,h}{3600\,s} = 25\,m/s$$

$$v = \frac{40\,km}{h} \bullet \frac{1000\,m}{1\,km} \bullet \frac{1\,h}{3600\,s} = 11\,m/s$$

$$t = 5.0\,s$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0} = \frac{11\,m/s - 25\,m/s}{5.0\,s} = -2.8\,m/s^2$$

Constant Acceleration → Velocity

For simplicity, this course will deal with only constant acceleration.

Resultant velocity equation (AP Equation - Resources P. 8):

$$v = v_0 + at$$

v = final velocity
v_0 = initial velocity
a = acceleration
t = time of acceleration

Important Equation!

Ex. 2 A

A car accelerates linearly at a rate of 5.5 m/s² for 6.0 seconds. Assume it starts from rest.

A. List all explicit and implicit information given.

B. What's the car's velocity after 6.0 seconds?

A. Information:
a = 5.5 m/s²
t_0 = 0.0 s
v_0 = 0.0 m/s
t = 6.0 s
v = ?

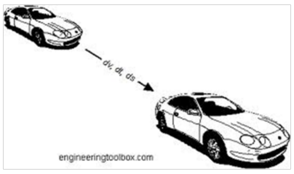
$$v = v_0 + at$$

$$v = 0.0\,m/s + 5.5\,m/s^2 \cdot 6.0\,s = 33\,m/s$$

Ex. 2 B

If a parachute deployed after 6.0 seconds and the car's acceleration changed to -2.4 m/s², how long would it take to stop?

Data given:
t_0 = 0.0 s
t = ? s
a = -2.4 m/s²
v_0 = 33 m/s
v = 0.0 m/s



Ex. 2 B

B. Rearrange the equation to isolate for t and solve:

$$v = v_0 + at$$

$$t = \frac{v - v_0}{a} = \frac{0.0\,m/s - 33\,m/s}{-2.4\,m/s^2} = 13.75\,s \rightarrow 14\,s\,(sig\ figs)$$

Ex. 2 C

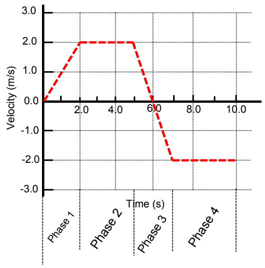
C. What's the car's velocity 10. s after the parachute is deployed?

$$v = v_0 + at = 33\,m/s + (-2.4\,m/s^2) \cdot 10.\,s = 9.0\,m/s$$

Graphing Acceleration.

A velocity vs. time graph yields an acceleration vs. time graph the slope of the velocity graph is velocity/time (m/s/s) = acceleratio (m/s²).

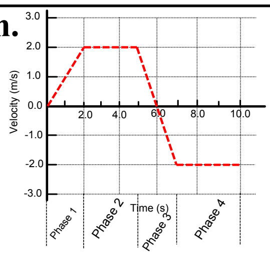
You do!
Determine acceleration for each phase of motion, then graph it with a table partner.



Graphing Acceleration.

Acceleration:

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$



Data:

Phase 1: $a = \frac{2.0\,m/s}{2.0\,s} = 1.0\,m/s^2$

Phase 2: $a = \frac{0.0\,m/s}{3.0\,s} = 0.0\,m/s^2$

Phase 3: $a = \frac{-4.0\,m/s}{2.0\,s} = -2.0\,m/s^2$

Phase 4: $a = \frac{0.0\,m/s}{3.0\,s} = 0.0\,m/s^2$

Graphing Acceleration.

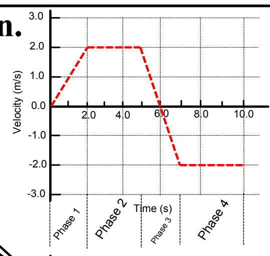
The Graph: Random students, come try it!

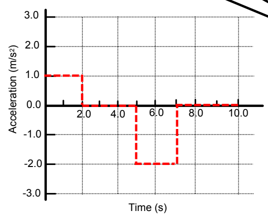
Phase 1: 1.0 m/s^2

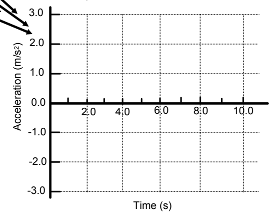
Phase 2: 0.0 m/s^2

Phase 3: -2.0 m/s^2

Phase 4: 0.0 m/s^2

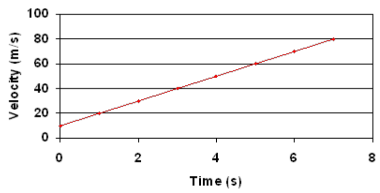






Graphing Acceleration Factoid 1.

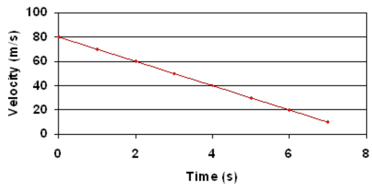
With a partner, describe the motion portrayed in this graph:



A positive slope in the first quadrant shows positive acceleratio (going faster in a positive direction).

Graphing Acceleration Factoid 2.

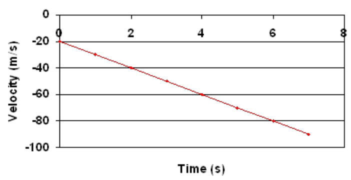
What does this graph show?



Slowing down in a positive direction (deceleration).

Graphing Acceleration Factoid 3.

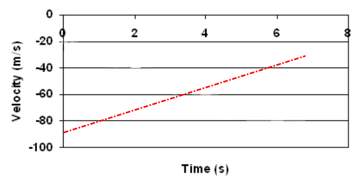
What will speeding up in a negative direction look like?



A negative slope in the 4th quadrant.

Graphing Acceleration Factoid 4.

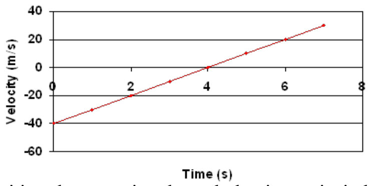
What will slowing down in a negative direction look like?



A positive slope in the 4th quadrant.

Graphing Acceleration Brain Teaser.

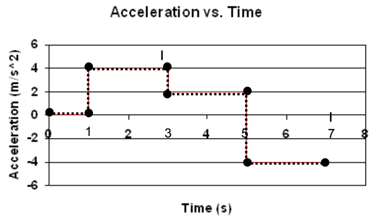
What would a positive change in direction look like?



A positive slope passing through the time axis, indicating a brief stop.

Interpreting Graphs

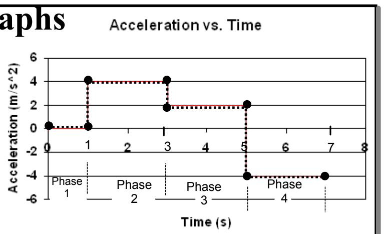
Describe the object's motion, assuming it starts from rest.



Interpreting Graphs

Calculate object's velocity at the end of each phase. Do this iteratively: carry velocity from previous phase to the next calculation. Use:

$$v = v_0 + at$$



Phase 1: a = 0 m/s²
t = 1 s
v_0 = 0 m/s

$$v = 0\,m/s + 0\,m/s^2 \bullet 1\,s = 0\,m/s$$

Phase 2: a = 4 m/s²
t = 2 s
v_0 = 0 m/s

$$v = 0\,m/s + 4\,m/s^2 \bullet 2\,s = 8\,m/s$$

Phase 3: a = 2 m/s²
t = 2 s
v_0 = 8 m/s

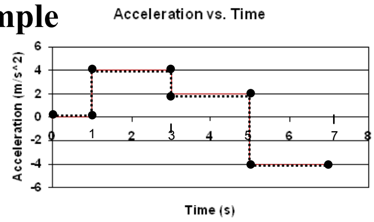
$$v = 8\,m/s + 2\,m/s^2 \bullet 2\,s = 12\,m/s$$

Phase 4: a = -4 m/s²
t = 2 s
v_0 = 12 m/s

$$v = 12\,m/s + (-4\,m/s^2) \bullet 2\,s = 4\,m/s$$

Graphing Example

Graph the velocity of the object, using the data from the previous example.

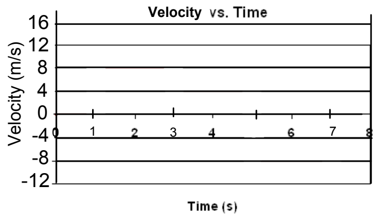


Phase 1: t = 1 s
v_0 = 0 m/s
v = 0 m/s

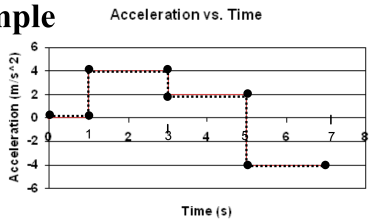
Phase 2: t = 2 s
v_0 = 0 m/s
v = 8 m/s

Phase 3: t = 2 s
v_0 = 8 m/s
v = 12 m/s

Phase 4: t = 2 s
v_0 = 12 m/s
v = 4 m/s



Graphing Example



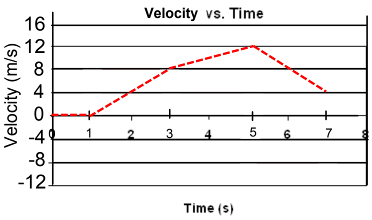
Answer:

Phase 1: t = 1 s
v_0 = 0 m/s
v = 0 m/s

Phase 2: t = 2 s
v_0 = 0 m/s
v = 8 m/s

Phase 3: t = 2 s
v_0 = 8 m/s
v = 12 m/s

Phase 4: t = 2 s
v_0 = 12 m/s
v = 4 m/s



Homework

Read 2.4 in your book
2.2 Problems in your Booklet
NOTE!! Problem 3: The graph's y-axis should read
'velocity m/s'

Due: Next Class