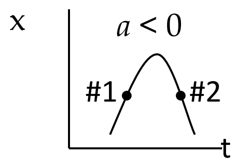
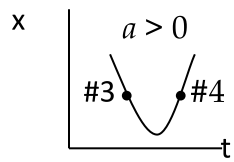
1-D Kinematics

(1) Consider the graphs below. Fill in the table whether v is positive or negative and whether the object is speeding up or slowing down.





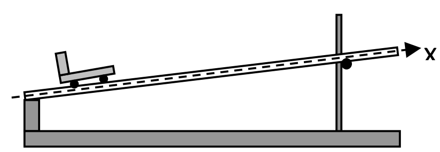
Point	Sign of a	Sign of v	Speeding up or slowing down?
#1	-	+	Slowin' Down
#2	-	-	Speedin' Up
#3	+	-	Slowin' Down
#4	+	+	Speedin' Up

(2) You can't use the sign of the acceleration alone to determine if a particle is speeding up or slowing down. Using the table that you just filled out, develop a rule to determine if a particle is speeding up?

If the signs match, the item is speeding up.

If the signs don't match, the item is slowing down.

(3) In front of you are a rail sloping upwards and a cart. Let's use the coordinate system shown in the figure. Tap the car so that it rolls most of the way up before rolling back down.



To answer these next two questions, use what you see before you but, also, use the rule that you established above.

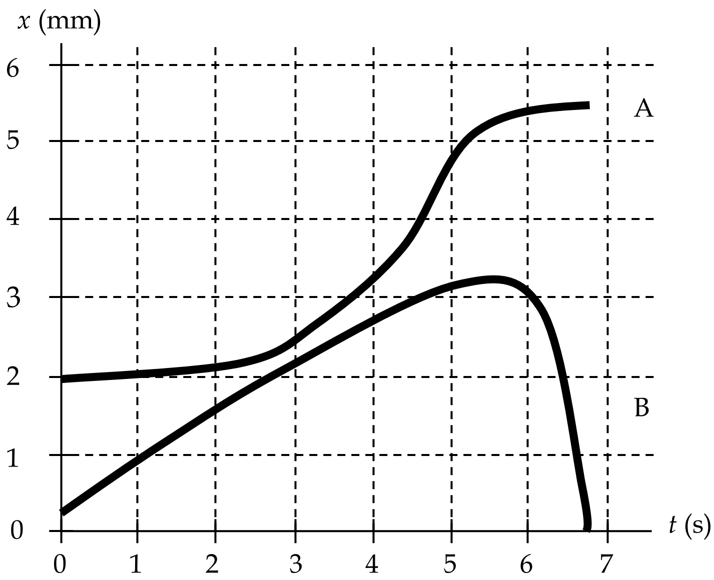
During the upward journey, what is the sign of the velocity and the acceleration?

v __+__ a __–__

How about the downward journey?

v __–__ a __–__

(4) The position-versus-time graph shows the motion of objects A and B moving along the same axis.



a) At t = 1s is the speed of A greater than, less than or equal to the speed of B?

$V_A < V_B$

At t = 5s?

$V_A > V_B$

b) At t = 4s is the acceleration of B negative, zero or positive? Zero at 4s

At t = 6 s?

Negative at 6s

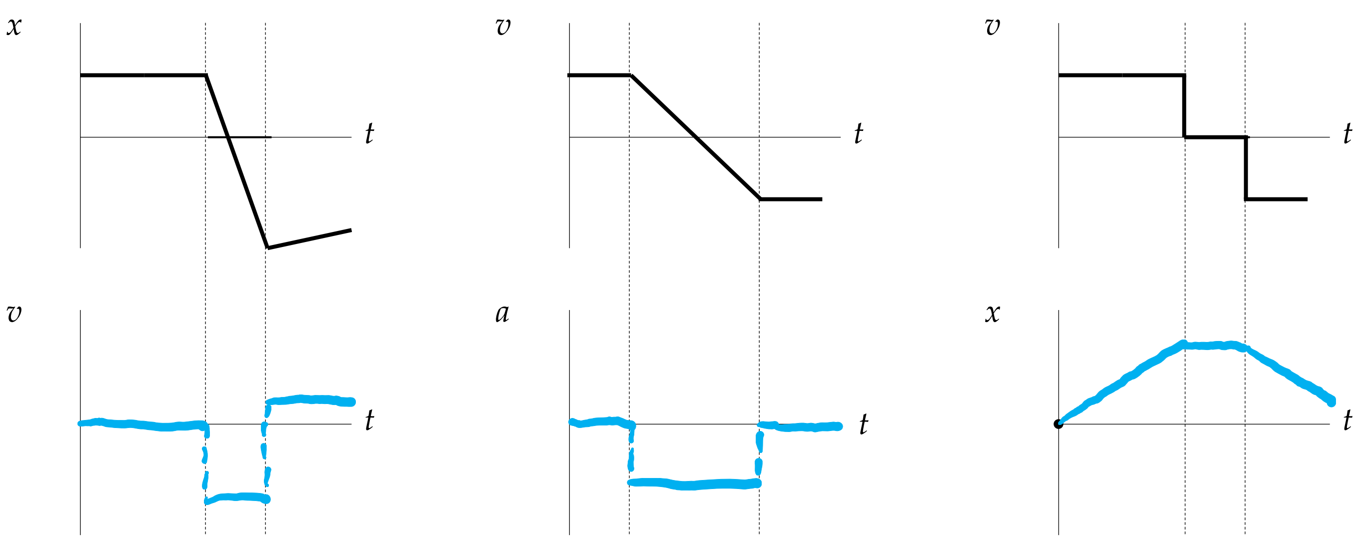
c) At what time (roughly) are they closest to each other?

At 3s

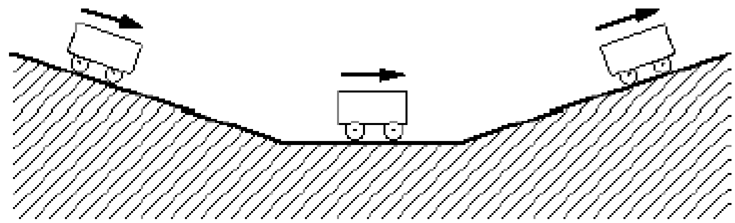
d) Does A ever turn around (reverse direction)? Does B?

A doesn't turn around but B does at about 5.7 seconds

(5) Each of the following pairs of graphs shows a kinematical quantity (x or v or a) versus time on the top graph. Sketch a plot of the indicated kinematical quantity versus time on the bottom graph. The dashed lines are given for your convenience to help you line up important features in the graphs.



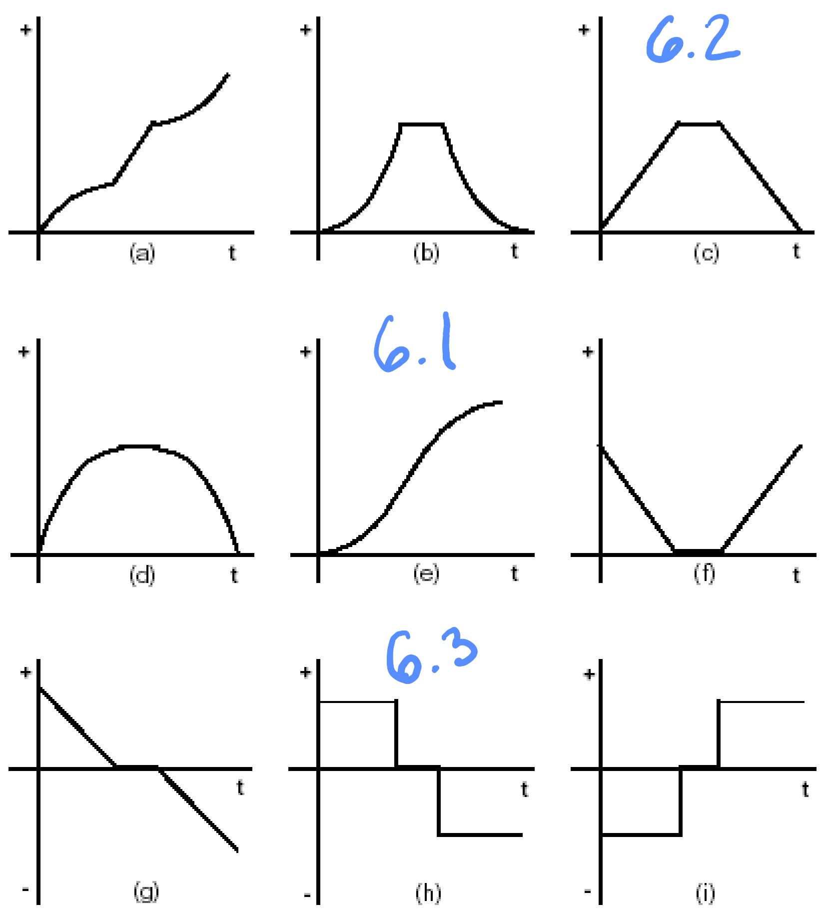
(6) A mining cart starts from rest at the top of a hill, rolls down the hill, over a short flat section, then back up another hill, as shown in the diagram. Assume that the friction between the wheels and the rails is negligible. Sign convention: For each section of track, let the direction shown in the figure above be taken as positive.



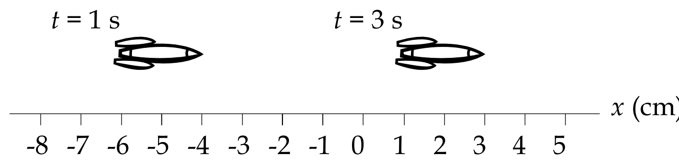
6.1) Which graph below best represents the position-versus-time graph? E

6.2) Which graph best represents the instantaneous velocity-versus-time graph? C

6.3) Which graph best represents the instantaneous acceleration-versus-time graph? H



(7) Imagine a rocket ship that moves in one dimension along the x-axis according to the equation:



$$x(t) = -6.0 + 1.5\,t + 0.50\,t^2$$

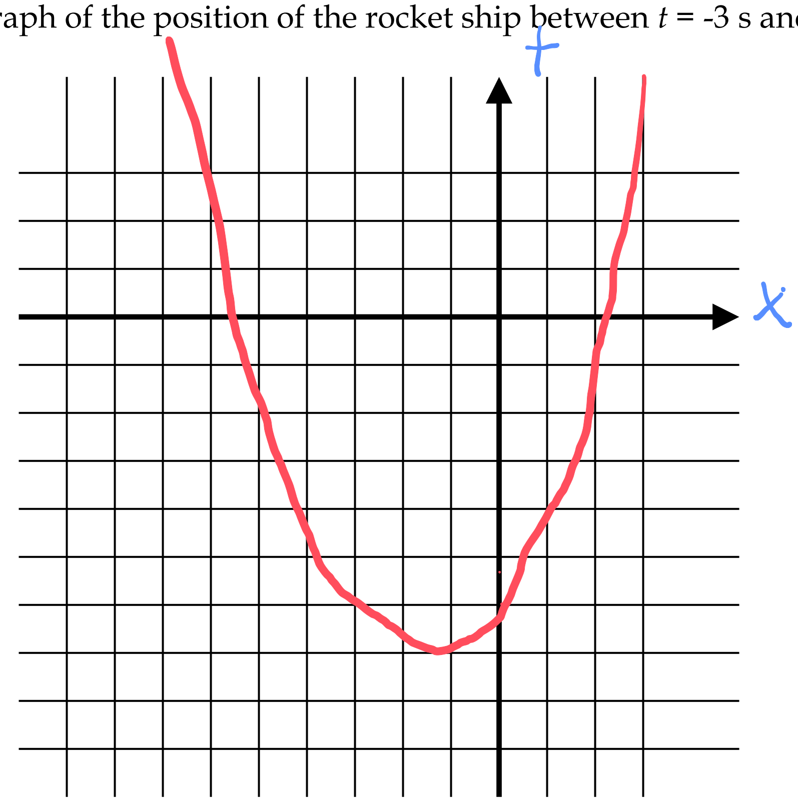
Here $x(t)$ is given in cm and t is in seconds. All equations must obey certain rules or they are meaningless. Two important rules regarding units are [1] both sides of an equation must have the same units (i*t makes no sense to say 2 meters = 4 seconds)* and [2] any two terms that are added together must have the same units (i*t makes no sense to evaluate 2 meters + 4 seconds)*.

a) These rules tell us that, for the above equation to make sense, the numbers in it are not pure numbers but are physical quantities with units. Find the units:

-6.0	cm
1.5	cm/s
0.50	cm/s²

Note that if, for example, $x = t$, then there is an implied "1" multiplying the t that has units.

b) Sketch the graph of the position of the rocket ship between t = -3 s and t = 3 s.



c) Find the displacement of the rocket ship between t = 1 s and t = 3 s.

7cm

d) Find the average velocity between $t = 1$ s and $t = 3$ s.

3.5 cm/s

We do not define $v_{ave} = (v_i + v_f)/2$. This equation might yield the same result for the average velocity as the one above, but in general it does not.

$x'(t) = 1.5 + t$

e) Find the velocity $v(t) = dx/dt$ at time $t = 1$ s.

$V(1) = 2.5$ cm/s

Physicists have a precise definition for the word "speed" that might be different from what you have in mind.

speed =	the magnitude (or absolute value) of the velocity
average speed =	total distance traveled divided by time interval

If you run to the left and then back to the right, stopping where you started, your average speed is non-zero and positive, but your average velocity is zero.

f) Find the speed at time $t = -1$ s.

$V(-1) = 0.5$ cm/s

g) Find the average velocity between $t = -3$ s and $t = 0$ s.

0 cm/s

h) Find the average speed between $t = -3$ s and $t = 0$ s.

0.75 cm/s

i) Find the acceleration at time $t = -1$ s.

$x''(t) = 1$

1 cm/s²

Constant Acceleration

(1) A car travels north for 10 km in 6.0 minutes. Then it returns south for 10 km at 200 km/h. What was its average speed (*not* velocity) for the total journey?

$\boxed{133 \text{ km/h}}$

$10 = 200t$

$\frac{1}{20}$ h → 3 min

Total 9 min

$v_f = v_i + a\,t$	$x_f - x_i = v_i\,t + ½\,a\,t^2$	$v_f^2 = v_i^2 + 2a\,(x_f - x_i)$	$x_f - x_i = ½\,(v_i + v_f)\,t$

20 km

9 min → $\frac{3}{20}$ h

$\frac{20}{1} \div \frac{3}{20} \rightarrow 20 \cdot \frac{20}{3} = \frac{400}{3} = 133 \text{ km/h}$

(2) A ball thrown straight up reaches a maximum height of 30 m above the point from which it was thrown. With what speed was it thrown? (The acceleration of gravity is g = 9.8 m/s^2.)

$\boxed{24.25 \text{ m/s}}$

(3) A hockey puck is sent sliding up an icy hill at 8.5 m/s. After 20 s, it comes back to the point from which it was launched with the same speed, but in the opposite direction. What was its acceleration?

$\boxed{-0.85 \text{ m/s}^2}$

(4) A ball is thrown upward and passes by a window. The window is 2.0 m top to bottom, and the ball takes 0.25 s to pass the height of the window. How long after passing the top of the window does it take for the ball to reach its peak height? How far above the top of the window does it rise?

$\boxed{0.642 \text{ s}}$ $\boxed{2.342 \text{ m}}$

(5) Rock #1 is dropped from a bridge and rock #2 is dropped 1.0 s later. What is the speed of rock #2 when rock #1 hits the river 50 m below? How far apart are the rocks?

$\boxed{21.5 \text{ m/s}}$