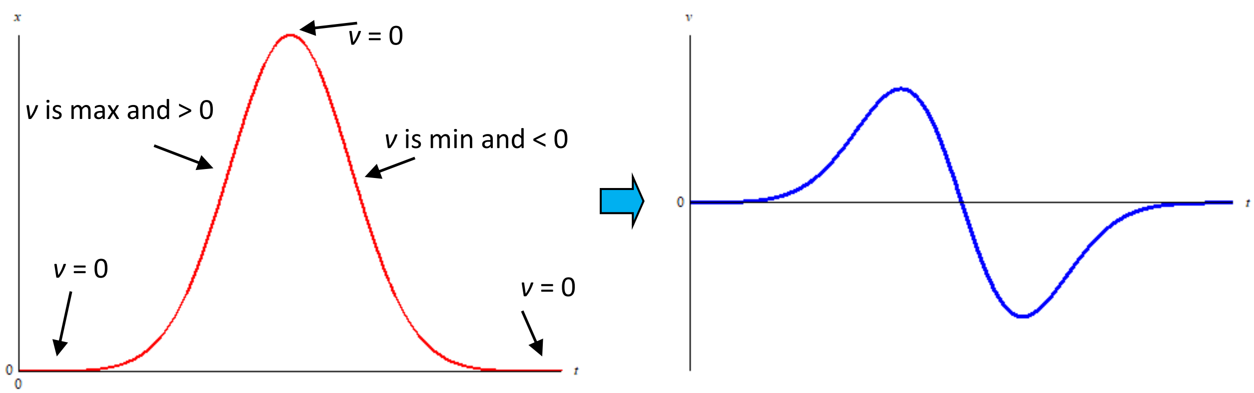
Teacher notes
Topic A

Graphs for kinematics

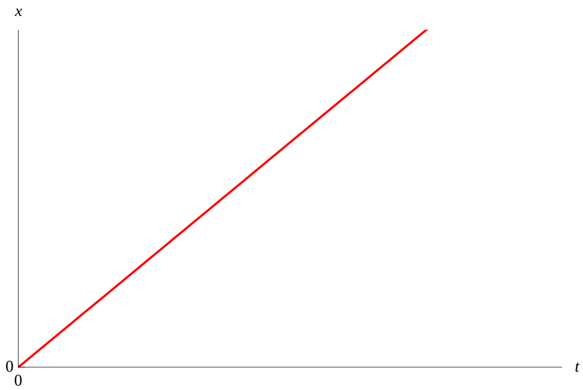
A basic skill in Physics.

Getting velocity from position graphs: the *v* vs *t* graph is the gradient of the *x* vs *t* graph.

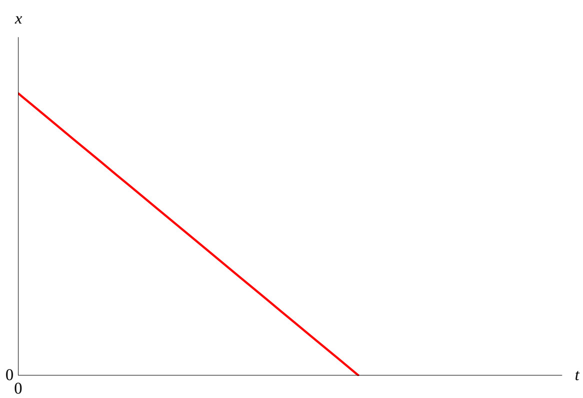


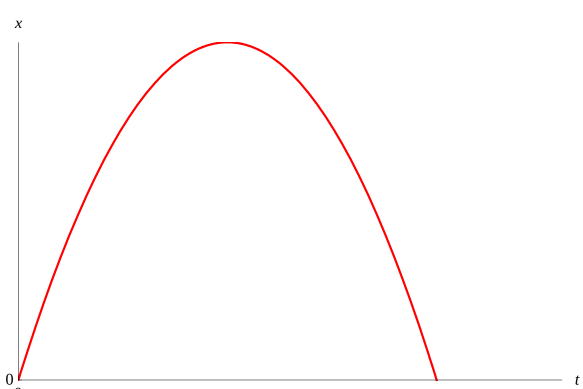
Gradient starts and ends at zero. It increases, gradient reaches a maximum and then becomes zero. Before reaching zero it becomes a positive maximum and after becoming zero it becomes a negative minimum.

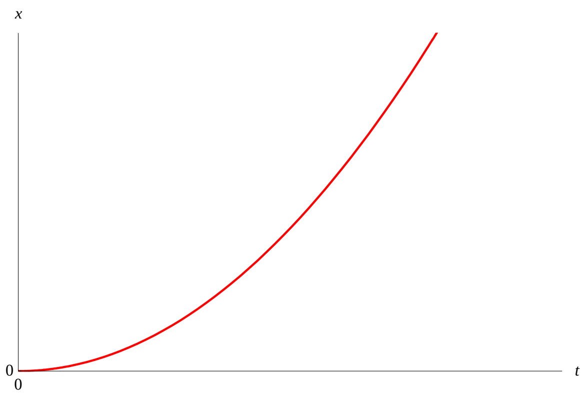
Now try these (answers at the end):

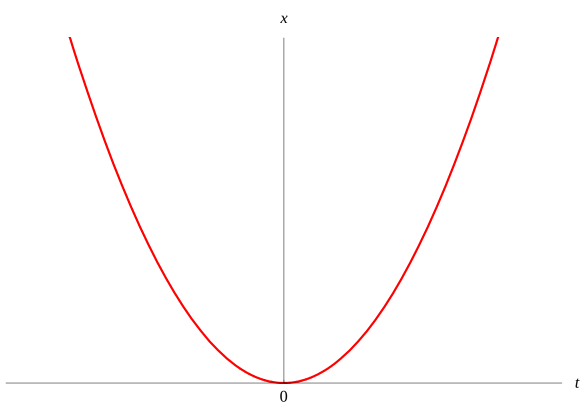

x
0
0
t

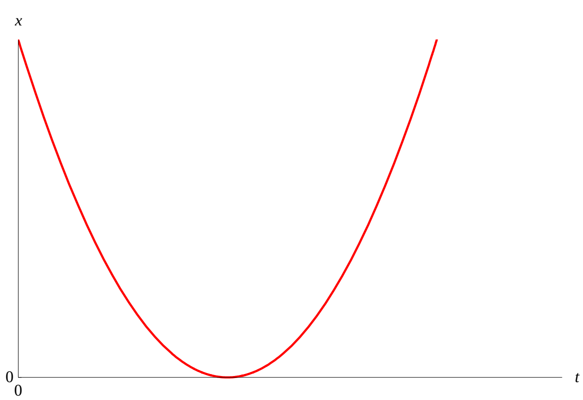

x
0
0
t

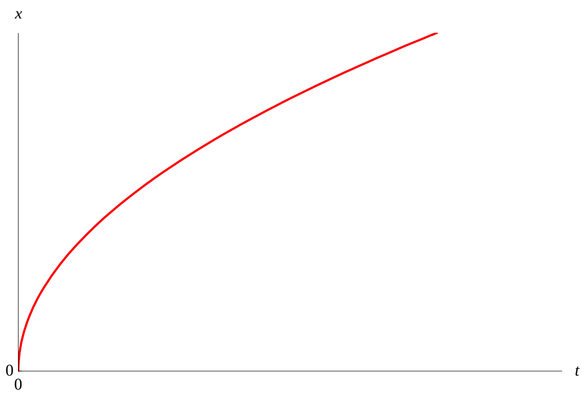

x
0
0
t

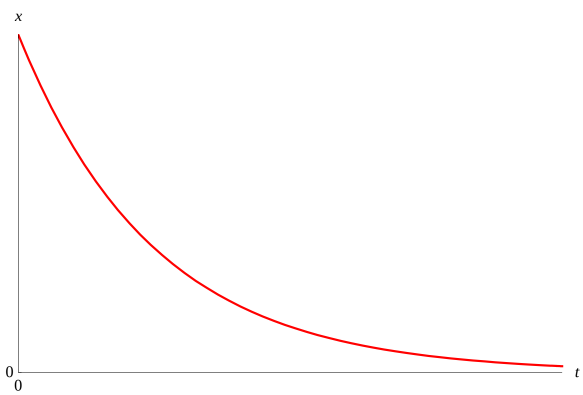

x
0
0
t

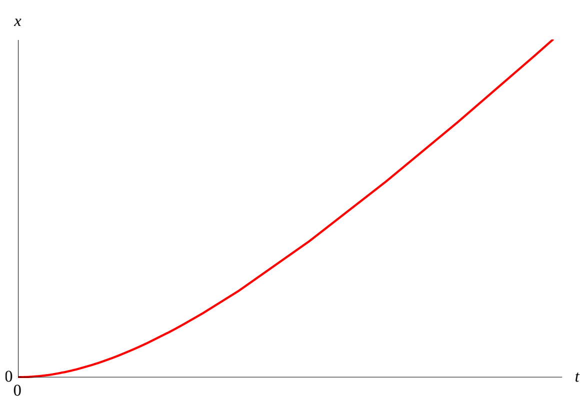

x
0
0
t

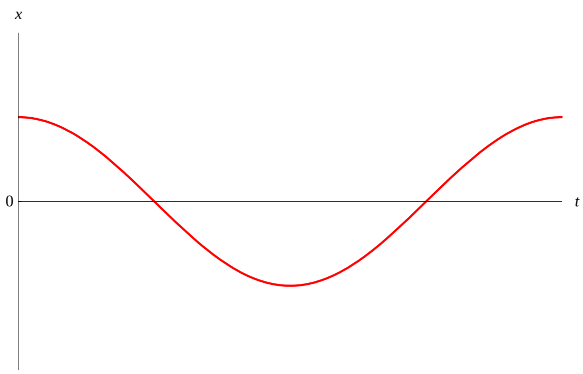

x
0
t

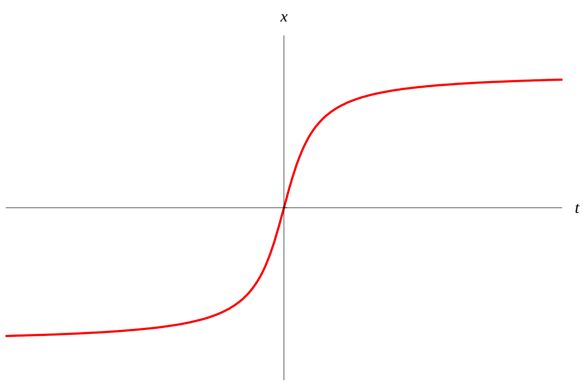

x
0
0
t

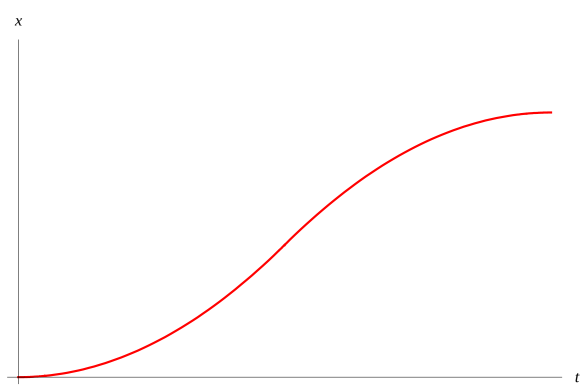

x
0
0
t

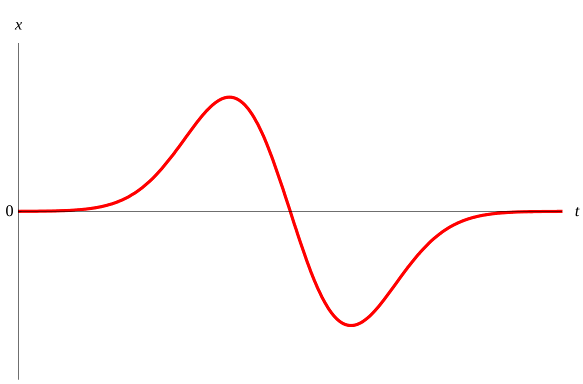

x
0
0
t


x
0
0
t


x
0
t


x
t


x
t

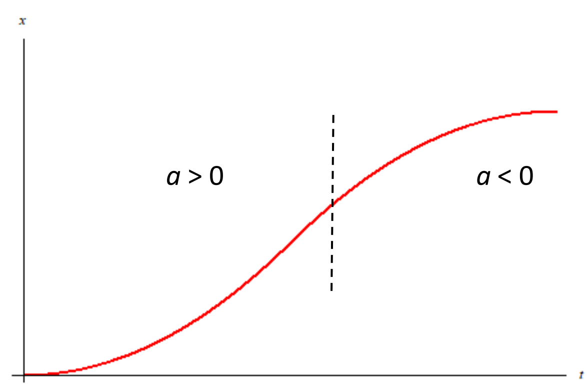

x
0
t

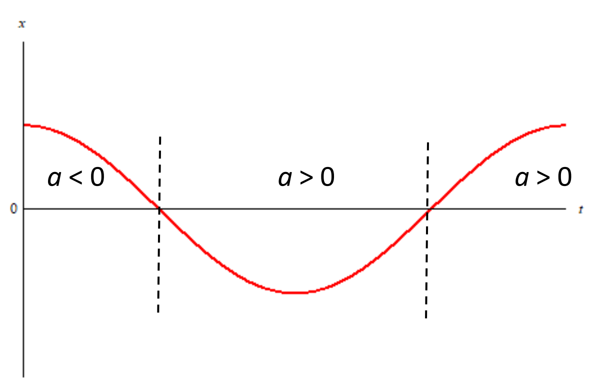
You can also do this in reverse, start from the velocity graphs and guess the position graphs. (You need to know the initial position.)

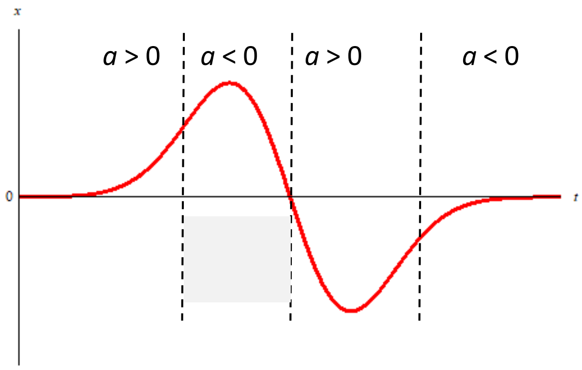
Acceleration

Acceleration is determined from the gradient of the velocity vs time graph so what we learned from the exercise above is used here as well. In some cases, it is useful to be able to tell whether the acceleration is positive (velocity, not speed, is increasing) or negative (velocity, not speed, is decreasing) from a position vs time graph.

We need to know that acceleration is positive if the position vs time graph is concave up and negative if concave down.







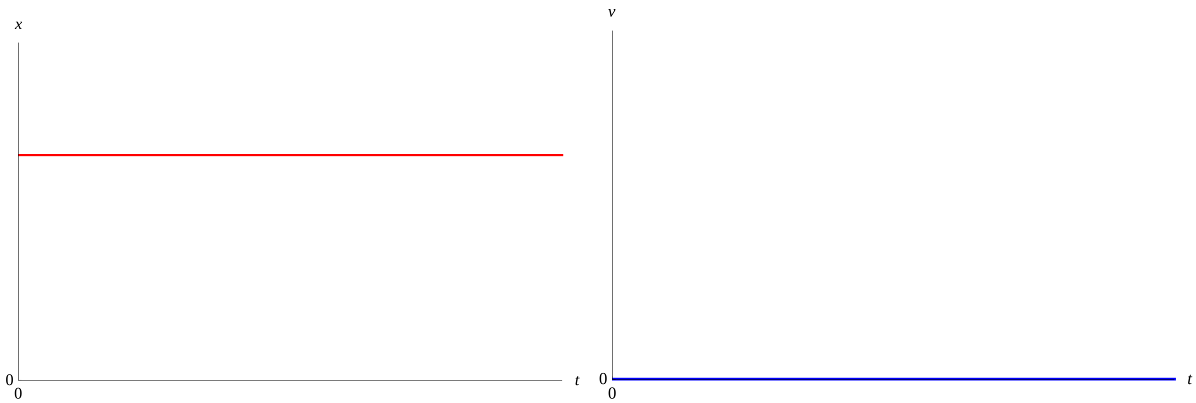
It is very instructive to ask students to justify explicitly why $a < 0$ in the shaded region above: the gradient is decreasing reaching zero at the peak. Hence velocity is decreasing. From the peak on, the gradient is still decreasing (it is getting more and more negative) hence the velocity is decreasing (even though the speed is increasing). Hence in the entire shaded region, velocity is decreasing. Hence $a < 0$. It is important to be thinking in terms of velocity and **not speed** when discussing acceleration.

(Interested students may want to know that:

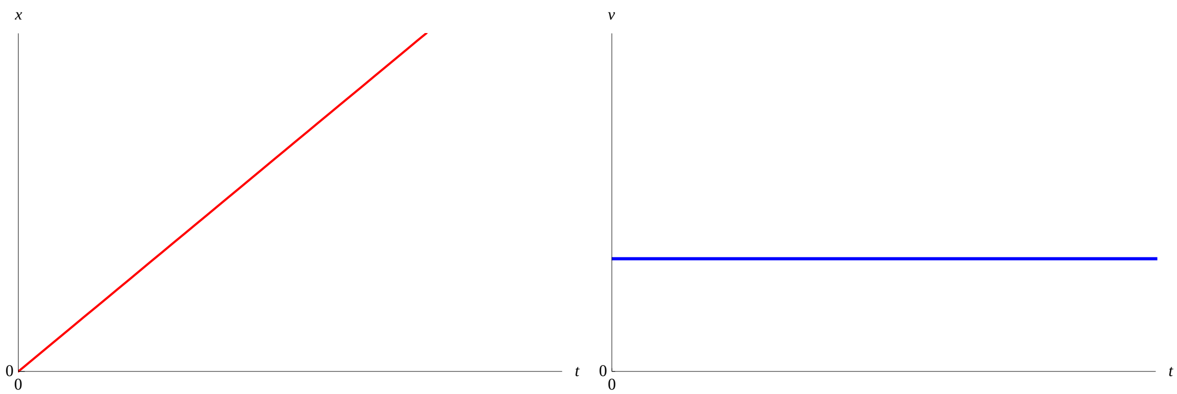
If *velocity* and *acceleration* have **the same sign** speed increases.

If *velocity* and *acceleration* have **opposite signs** speed decreases.)

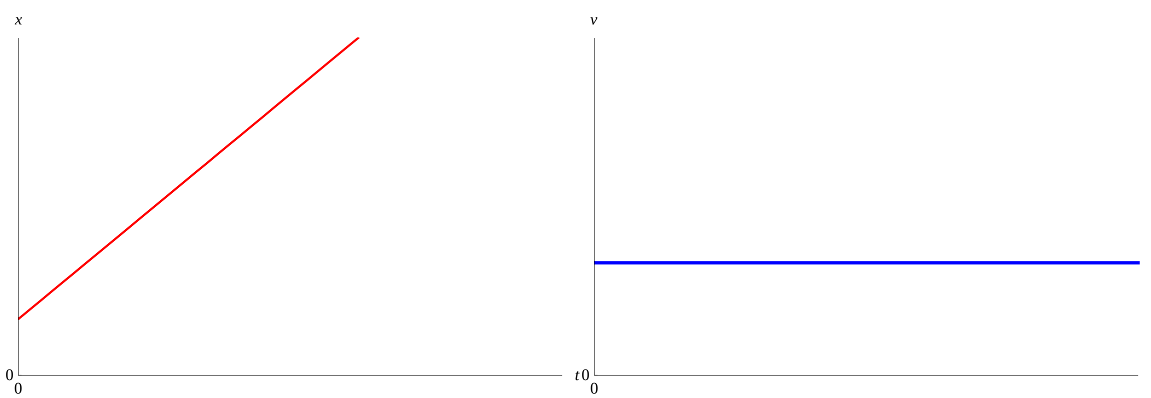
Answers



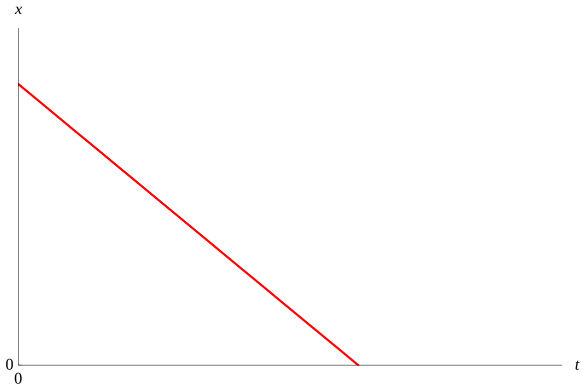
Zero gradient so zero velocity.

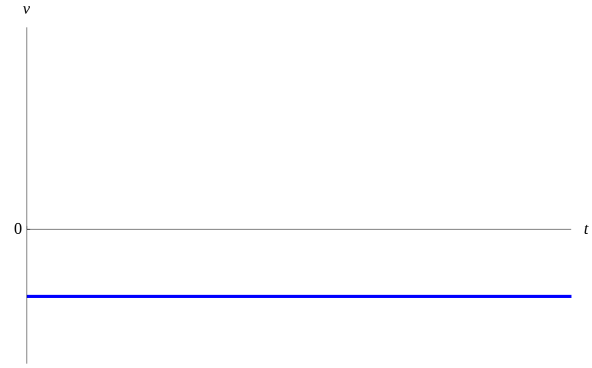


Constant positive gradient.

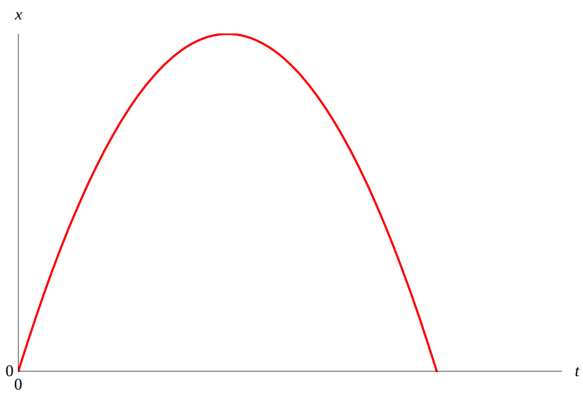


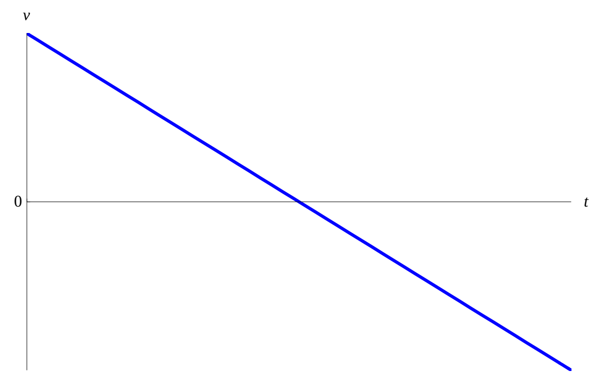
Constant positive gradient.



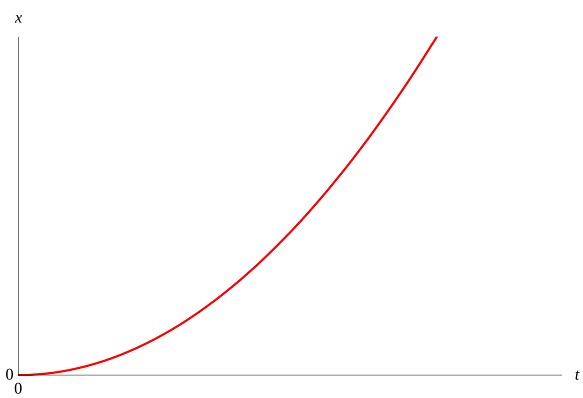


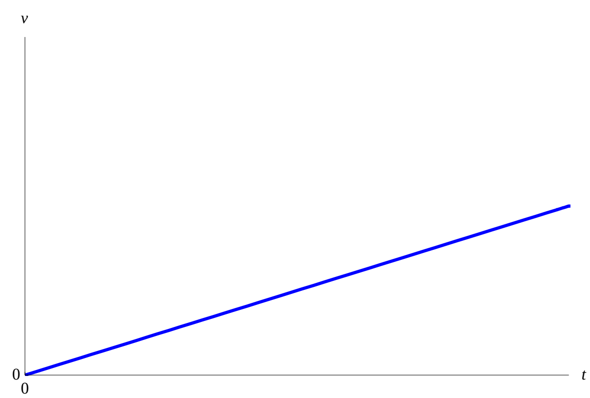
Constant negative gradient.



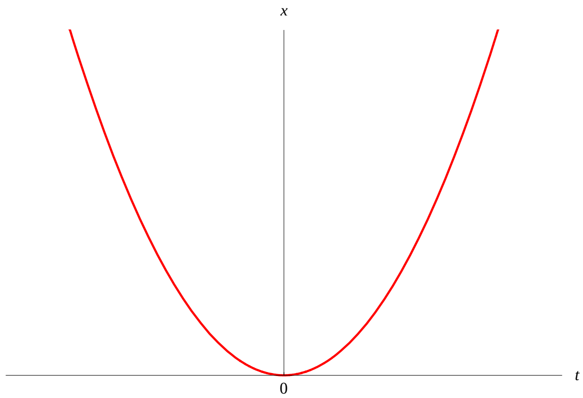


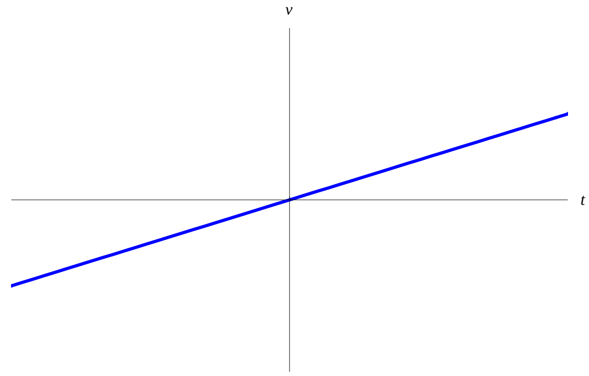
Gradient starts large and positive, becomes (increases to) zero and then becomes negative. Straight line if position graph is a parabola.



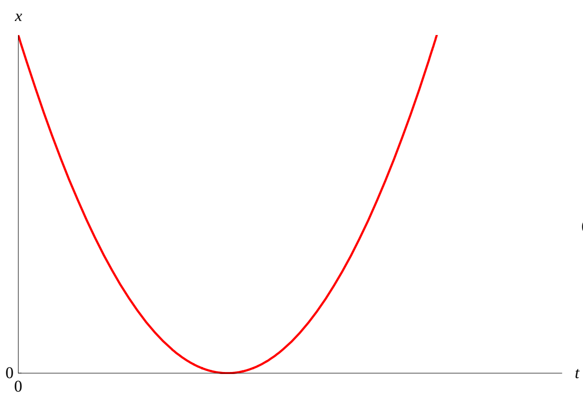


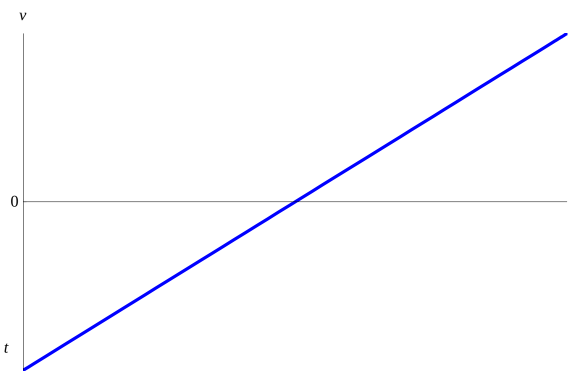
Gradient starts at zero and increases. Straight line if position graph is a parabola.



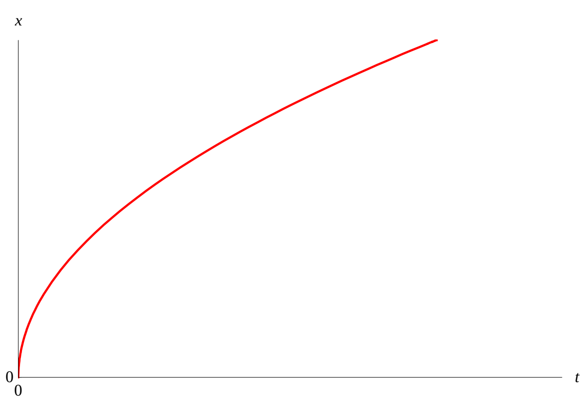


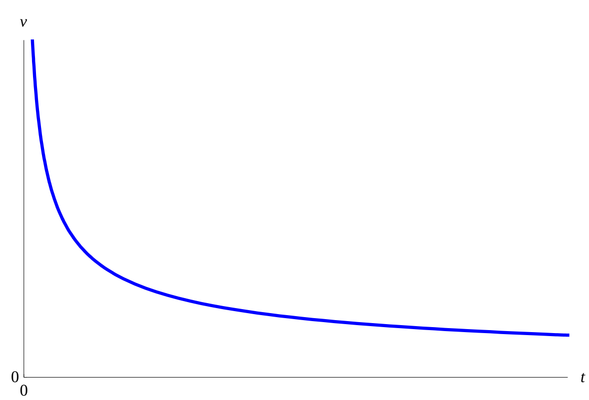
Gradient starts large and negative, increases to zero and then becomes positive. Straight line if position graph is a parabola.



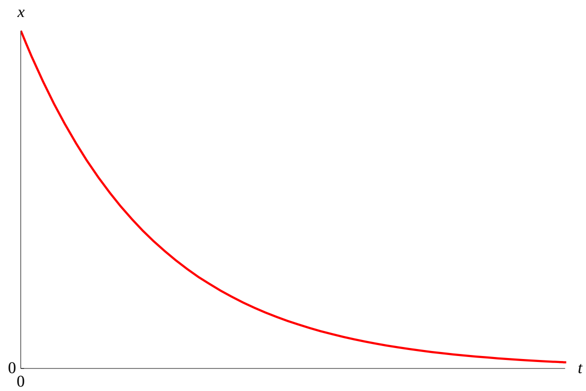


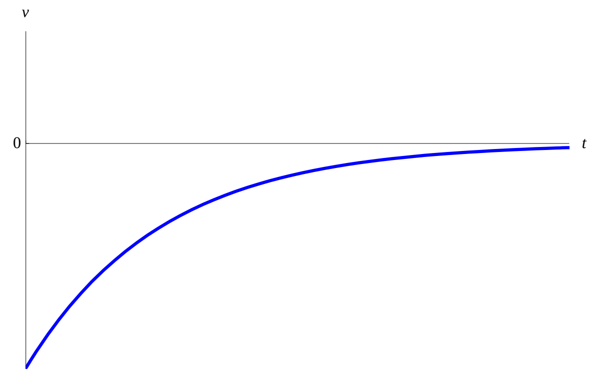
Gradient starts large and negative, decreases to zero and then becomes positive. Straight line if position graph is a parabola.



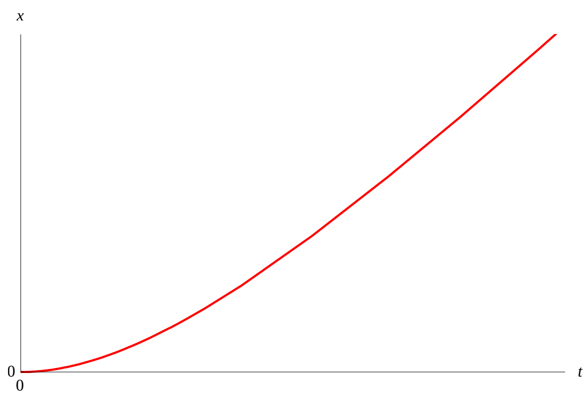


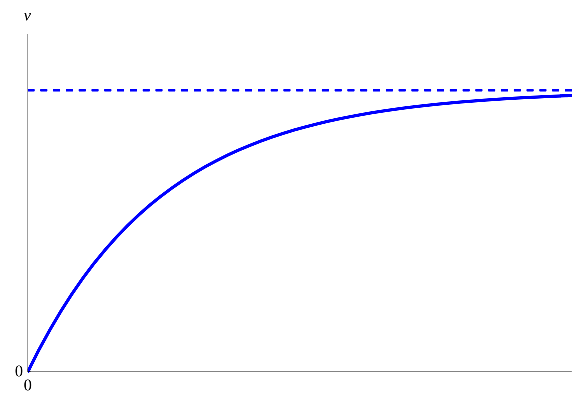
Gradient starts unrealistically large and positive; gradient decreases to zero.



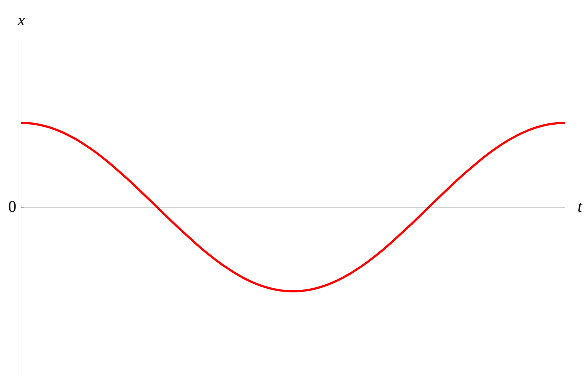


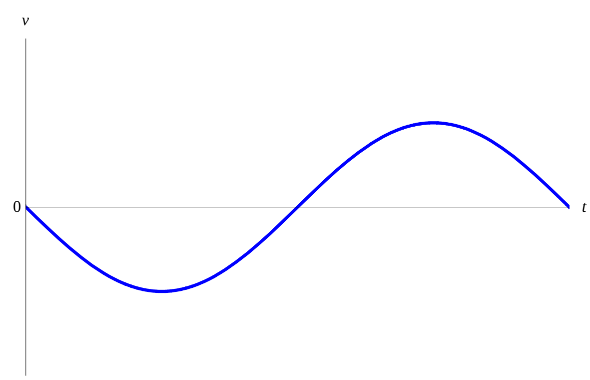
Gradient starts large and negative, decreases to zero.



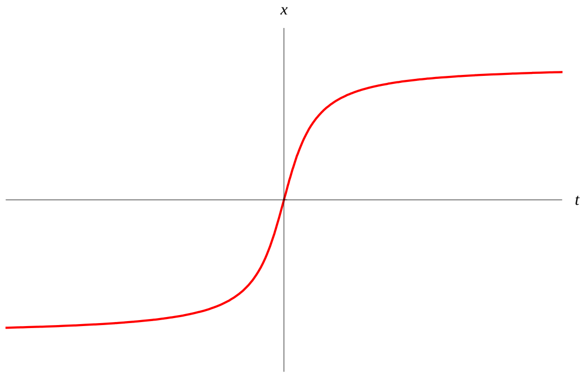


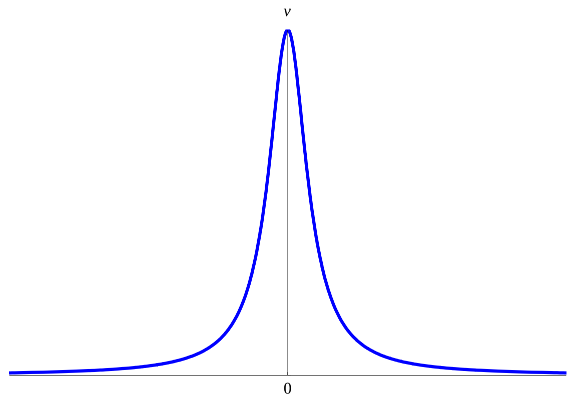
Gradient starts large at zero and increases. Position graph becomes straight so velocity approaches a constant value.



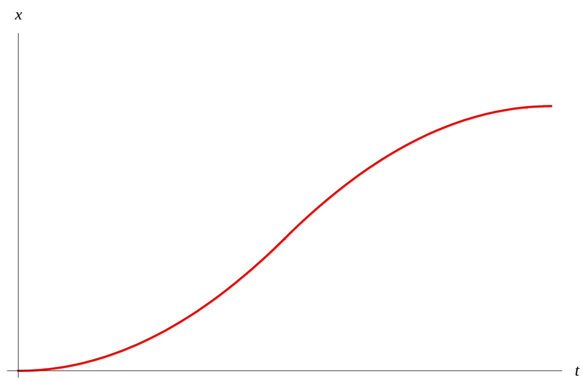


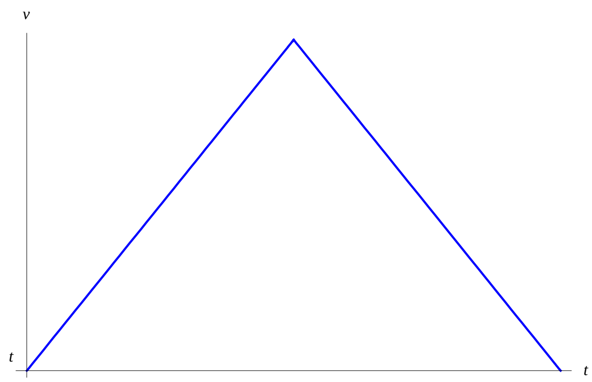
Gradient starts at zero, becomes negative, zero again, then positive and then zero.



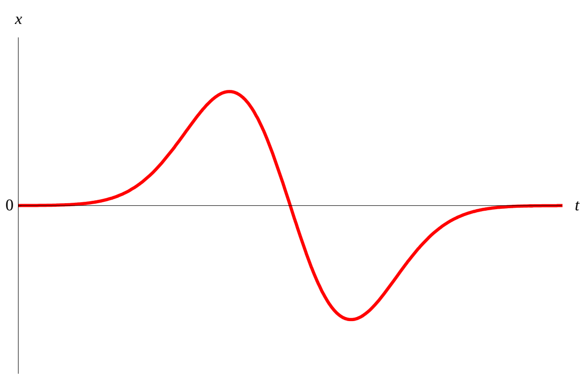


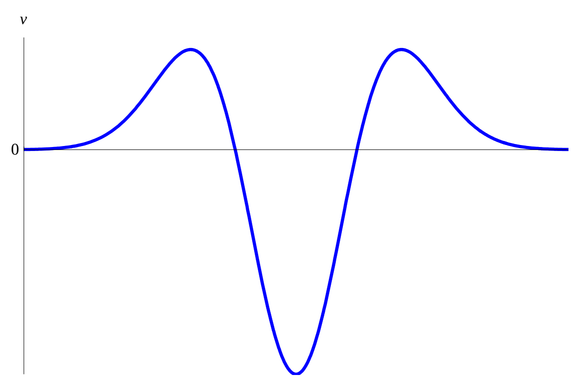
Gradient is never negative, so velocity is always positive. It starts at zero and ends at zero. It reaches a maximum at $t = 0$.





Gradient starts and ends at zero. It increases to a maximum and then decreases to zero.





Gradient is zero in the beginning and the end of the motion. It is also zero at two other times at the peak and trough of the position graph. The velocity is very large and negative where the position graph has a zero.