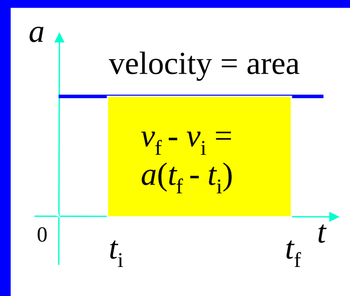
One Dimensional Motion with Constant Acceleration

Graphical Analysis -- Displacement, velocity and acceleration all in the same direction (but can have positive or negative signs)

- acceleration (a) vs time (t) graph
- get change in velocity from area under the curve
- To simplify, choose $t_i = 0$, call $t_f = t$, $v_f = v$, $v_i = v_0$

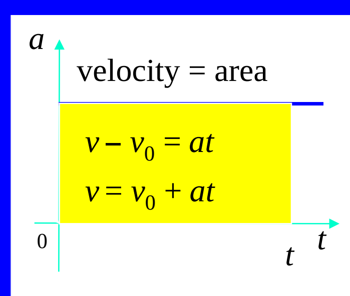


PHYS401 5/27/04

One Dimensional Motion with Constant Acceleration

Graphical Analysis -- Displacement, velocity and acceleration all in the same direction (but can have positive or negative signs)

- acceleration (a) vs time (t) graph
- get change in velocity from area under the curve
- To simplify, choose $t_i = 0$, call $t_f = t$, $v_f = v$, $v_i = v_0$
- first important formula for 1D constant a motion: $\boxed{v = v_0 + at}$

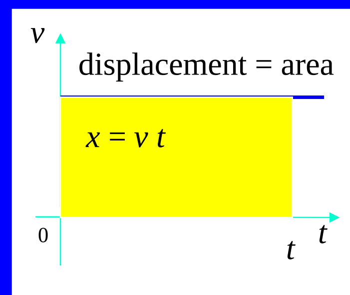


PHYS401 5/27/04

One Dimensional Motion with Constant Acceleration

Graphical Analysis -- Displacement, velocity and acceleration all in the same direction (but can have positive or negative signs)

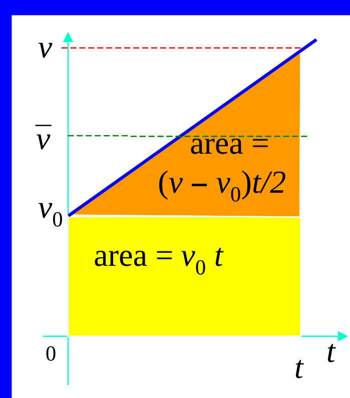
- velocity (v) vs time (t) graph: a straight line with a constant sloop acceleration
- get displacement x from area under the curve
- for $a = 0$, we have this graph:



One Dimensional Motion with Constant Acceleration

Graphical Analysis -- Displacement, velocity and acceleration all in the same direction (but can have position or negative signs)

- velocity (v) vs time (t) graph: a straight line with a constant sloop acceleration
- get displacement x from area under the curve
- for $a \neq 0$, we have this graph:



- x = displacement = area =

$v_0 t + (v - v_0)t/2 = (v + v_0)t/2$

- second important formula for 1D constant a motion:

$$x = (v + v_0)t/2$$

- i. e., $x = \bar{v}\, t$ ($x = (v + v_0)t/2$ only for motion with constant a, but area method and $x = \bar{v}\, t$ always works).

One Dimensional Motion with Constant Acceleration

Basic equations

- $v = v_0 + at$, $x = (v + v_0)t/2$
- two equations, five quantities: x, a, v_0, v, t
- can solve for the other two if three of them are given in a problem.
- it is convenient to derive two other equations:

  * $x = (v + v_0)t/2 = (v_0 + at + v_0)t/2 = v_0t + at^2/2$, or $x = v_0t + at^2/2$

  * $x = (v + v_0)t/2 = (v + v_0)(v - v_0)/a/2$, or $v^2 = v_0^2 + 2ax$

- most convenient to use the equation that has the three known quantities and the unknown quantity that is being asked for (see Table 2.1 of C & J).

Do CYU 2.3, Concept Simulation 2.1

One Dimensional Motion with Constant Acceleration

More explicit equations

- $v_f = v_i + a(t_f - t_i)$
- $x_f - x_i = (v_f + v_i)(t_f - t_i)/2$
- $x_f - x_i = v_i(t_f - t_i) + a(t_f - t_i)^2/2$
- $v_f^2 = v_i^2 + 2a(x_f - x_i)$
- need to know three of the five quantities: $x_f - x_i$, a, v_i, v_f, $t_f - t_i$

One Dimensional Motion with Constant Acceleration

Acceleration (speed up) or deceleration (slow down)?

- the acceleration a can be negative
- a negative a does not necessarily mean deceleration
- it also depends on the sign of the velocity v_0 at that moment:

 * acceleration if $a > 0$, $v_0 > 0$, or $a < 0$, $v_0 < 0$, i. e., $av_0 > 0$

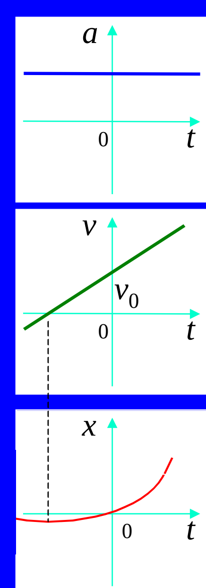
 * deceleration if $a > 0$, $v_0 < 0$, or $a < 0$, $v_0 > 0$, i. e., $av_0 < 0$

Do Concept Simulation 2.2

One Dimensional Motion with Constant Acceleration

Graphics for different cases

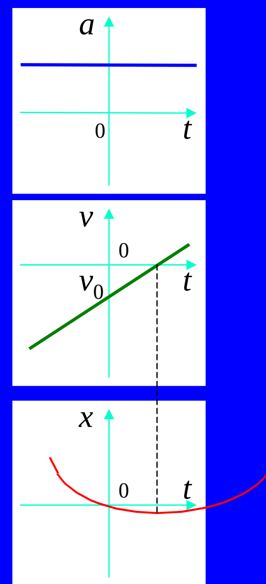
- $a > 0$
- $v_0 > 0$
- x vs t curve is a parabola with a minimum at $t < 0$ when $v = 0$.



One Dimensional Motion with Constant Acceleration

Graphics for different cases

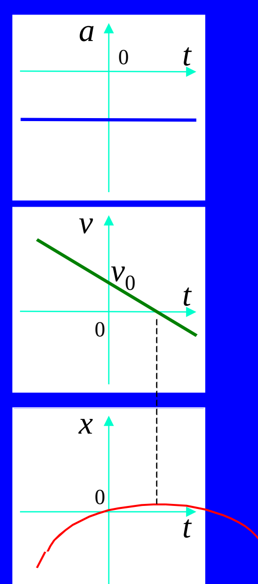
- $a > 0$
- $v_0 < 0$
- x vs t curve is a parabola with a minimum at $t > 0$ when $v = 0$.



One Dimensional Motion with Constant Acceleration

Graphics for different cases

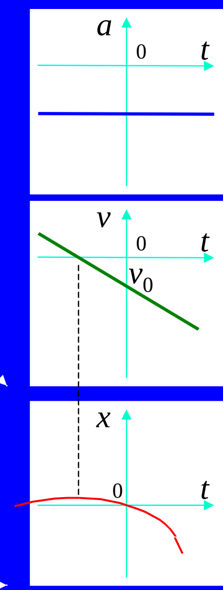
- $a < 0$
- $v_0 > 0$
- x vs t curve is a parabola with a maximum at $t > 0$ when $v = 0$.



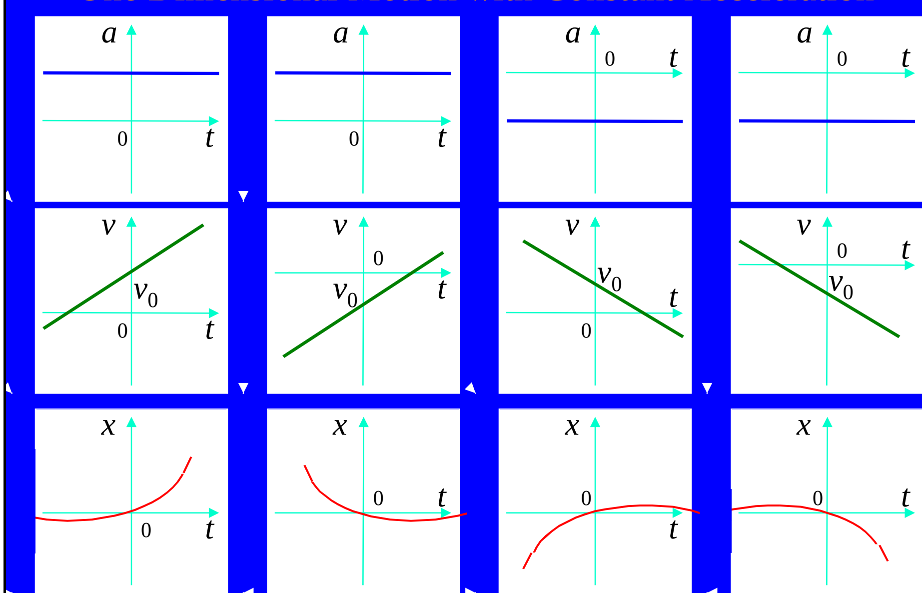
One Dimensional Motion with Constant Acceleration

Graphics for different cases

- $a < 0$
- $v_0 < 0$
- x vs t curve is a parabola with a maximum at $t < 0$ when $v = 0$.



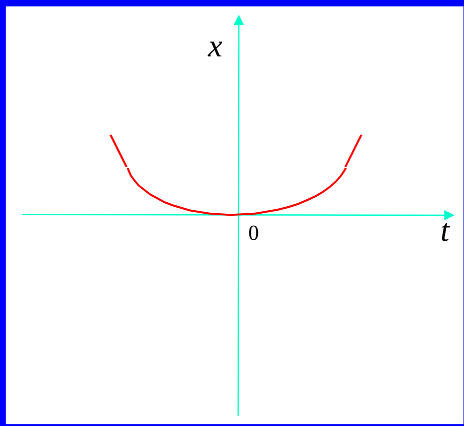
One Dimensional Motion with Constant Acceleration



One Dimensional Motion with Constant Acceleration

Graphics for different cases

- for the same a the shape of the x vs t parabola is the same

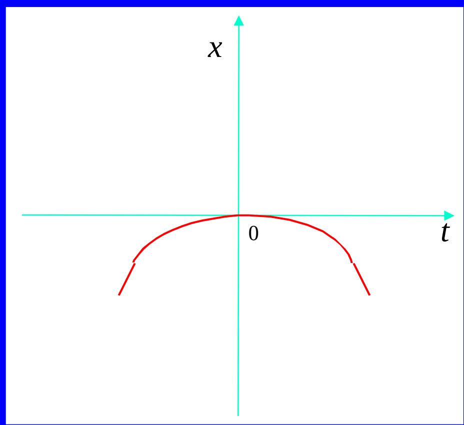


PHYS401 5/27/04

One Dimensional Motion with Constant Acceleration

Graphics for different cases

- for negative a the parabola turns upside down

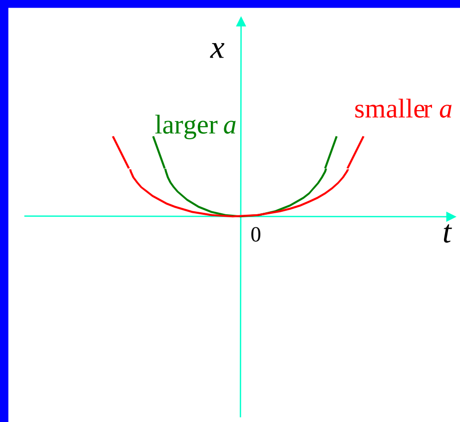


PHYS401 5/27/04

One Dimensional Motion with Constant Acceleration

Graphics for different cases

- for a larger a, the parabola becomes narrower (vice versa)



PHYS401 5/27/04

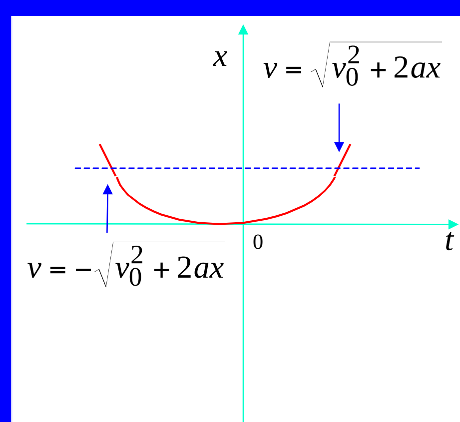
One Dimensional Motion with Constant Acceleration

Choose from two possible solutions

- when using the formula $v^2 = v_0^2 + 2ax$, there are two possible solutions:

$$v = \pm\sqrt{v_0^2 + 2ax}$$

- should draw a diagram to see which one to choose (see Example 8 of C & J).



PHYS401 5/27/04

Freely Falling Bodies

Downward acceleration due to gravity

- acceleration $a = -g$, $g = 9.8$ m/s^2
- usually use y for the displacement instead of x

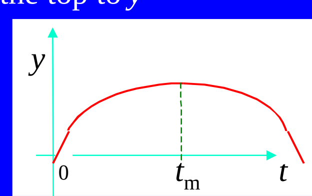
Equations become:

- $v = v_0 - gt$
- $y = (v + v_0)t/2$
- $y = v_0 t - gt^2/2$
- $v^2 = v_0^2 - 2gx$

Freely Falling Bodies

Symmetry in the motion of a upward moving object

- velocity = 0 at the highest point at time $t = t_m$
- the object is at the same position y at $t = t_m - \Delta t$ and $t = t_m + \Delta t$
- the velocity of the object has at the same magnitude at $t = t_m - \Delta t$ (positive) and $t = t_m + \Delta t$ (negative)
- it takes the same amount of time for the object to move from a y value to the top and for it to fall from the top to y



Do Concept Simulation 2.3 ,2CQ.011-014