Physics 100 Name: A1/2

Free-Fall, More Kinematics Formulas, and Kinematics Problems

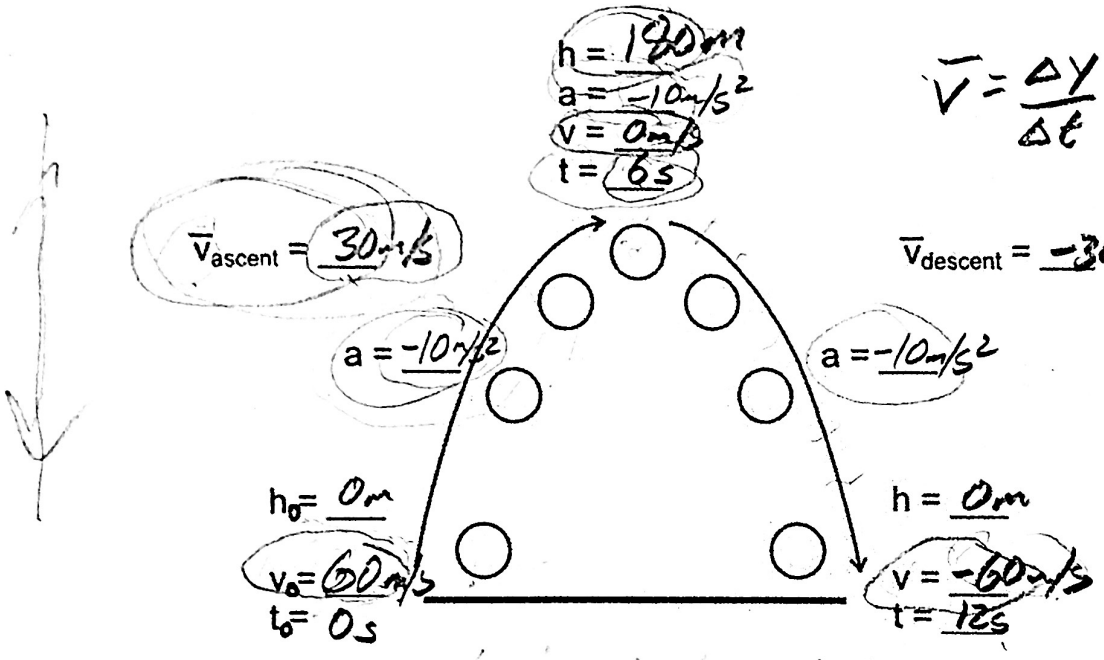
Free-fall: The state of being acted upon by only the force of gravity. Objects can be in free-fall if they are moving upward or downward – as long as there is no air resistance or any other force (other than gravity).

Free-fall acceleration: $-9.8 m/s^2$ or -g. But we will probably use $-10 m/s^2$ most of the time.

The diagram below is intended to represent an object that is launched vertically upward in the absence of air resistance (i.e. in free-fall). The diagram appears to show the ball moving sideways, but it isn't moving sideways. The apparent sideways motion is unavoidable if we're going to separate upward-moving objects from the downward-moving objects (as we need to do for clarity).

1. Fill in one of the blanks in the diagram with a made-up value. Based on that value, fill in the rest. Estimate by using $g=10 m/s^2$

$\bar{v} = \frac{\Delta y}{\Delta t}$ $\bar{v} = \frac{d}{t}$ $d = \bar{v}t$



2. Write the formula for acceleration (starting from rest), based on time and displacement:

$$a = \frac{2\Delta x}{t^2}$$

$v_0 = 0$

Example Problem: Starting from rest, a student travels a distance of 6m in a time of 2s, accelerating the entire time. What is the student's acceleration over this 2s time period?

$$a = \frac{2\Delta x}{t^2} = \frac{2(6m)}{(2s)^2} = \frac{12m}{4s^2} = \boxed{3 m/s^2}$$

3. Write the formula for displacement, based on acceleration (starting from rest) and time:

$\Delta x = \frac{1}{2} a t^2$

"x" means motion is horizontal.

Example Problem: If a ball is dropped in the absence of air resistance, how far does it fall during the first 3 seconds of its fall?

$\Delta y = \frac{1}{2} a t^2 = \frac{1}{2}(-10 m/s^2)(3s)^2 = -5 m/s^2 (9 s^2)$

because motion is vertical

$\Delta y = -45 m$

distance = $\boxed{45 m}$

Review and practice Problems:

4. Write the basic formulas for average velocity and acceleration.

$\bar{v} = \frac{\Delta x}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

5. Starting from rest, a rubber band car travels 5m in 2.82 seconds.

a. What is its average velocity?

$\bar{v} = \frac{5 m}{2.82 s} = \boxed{1.77 m/s}$

b. What is its acceleration?

$a = \frac{2\Delta x}{t^2} = \frac{2(5 m)}{(2.82 s)^2} = \frac{10 m}{7.95 s^2} = \boxed{1.26 m/s^2}$

6. The rubber band car travels over the last floor tile in a time of 0.076 seconds. If the distance across the floor tile is 0.305m, what is the rubber band car's average velocity during that time?

$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{0.305 m}{0.076 s} = \boxed{4.01 m/s}$

7. A runner stands motionless. Then she accelerates at a rate of $3 m/s^2$ for 3 seconds. How far has she traveled?

$\Delta x = \frac{1}{2} a t^2 = \frac{1}{2}(3 m/s^2)(3s)^2 = 1.5 m/s^2 (9 s^2) = \boxed{13.5 m}$

8. A car speeds up from 3m/s to 8m/s over a time of 2 seconds. What is its acceleration?

$a = \frac{\Delta v}{\Delta t} = \frac{5 m/s}{2 s} = \boxed{2.5 m/s^2}$

9. A ferrari SF90 can accelerate from 0-60mph in 2.0 seconds. If 60mph is 26.8 m/s...

a. What is the Ferrari's acceleration?

$a = \frac{\Delta v}{\Delta t} = \frac{26.8 m/s}{2 s} = \boxed{13.4 m/s^2}$

b. How far does the car travel in those 2 seconds?

$\Delta x = \frac{1}{2} a t^2 = \frac{1}{2}(13.4 m/s^2)(2s)^2$

$= 6.7 m/s^2 (4 s^2) = \boxed{26.8 m}$