

## Vertical Motion Worksheet

Answers on back.  
Worked-out solution key online.

Vertical Motion Formula:  $h = -16t^2 + vt + s$   
 $h = -4.9t^2 + vt + s$

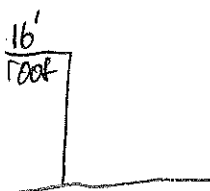
Formula if something is dropped instead of thrown:  $h = -16t^2 + s$   
 $h = -4.9t^2 + s$

Explain why the formula changes when an object is dropped and not thrown:  
 When an object is merely dropped, its initial velocity is 0 feet/sec.  
 When plugging  $v=0$  into the formula,  $vt=0$ , and the formula becomes  
 $h = -16t^2 + s$ .

Identify what the following variables represent in the formulas:

$h =$  height from ground     $t =$  time    (unit: seconds)  
 $s =$  starting height     $v =$  velocity    (unit: feet / second  
 or meters/second)

- 1) A measuring tape drops from a roof that is 16 feet above the ground. After how many seconds does the measuring tape land on the ground?



$h = -16t^2 + s$   
 $0 = -16t^2 + 16$   
 $16t^2 = 16$   
 $t^2 = 1$

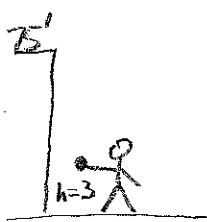
$t = \pm 1$   
 -1 is extraneous

1 second

After 1 second, it will hit the ground.

Dropping

- 2) Mrs. Wood forgot her car keys, so she called up to her friend to drop her keys out the window 75 feet above the ground. If Mrs. Wood's hand is 3 feet above the ground when she catches is, how long does it take for her to receive her keys?



$h = -16t^2 + s$   
 $3 = -16t^2 + 75$   
 $16t^2 = 72$   
 $t^2 = \frac{72}{16}$

$t^2 = \frac{9}{2}$   
 $t = \pm \sqrt{\frac{9}{2}}$   
 $t \approx \pm 2.12$   
 -2.12 is extraneous.

2.12 seconds

In about 2.12 seconds, Mrs. Wood will get her keys.

- 3) A frightened cat jumps straight into the air with an initial vertical velocity of 14 feet per second. How long will it take for the cat to reach the ground again?

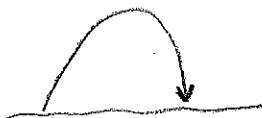
$v = 14$  ft/sec.  
 $h = 0$

$h = -16t^2 + vt + s$   
 $0 = -16t^2 + 14t$   
 $0 = -2t(8t - 7)$

$t = 0$      $t = \frac{7}{8}$

$\frac{7}{8}$  of a sec.

The cat will reach the ground in  $\frac{7}{8}$  of a second.



4) A cherry falls from a tree branch that is 9 feet above the ground.  $S=9$

A) What is the height of the cherry after 0.2 seconds?  $t=0.2$

$$h = -16t^2 + S \quad h(0.2) = -16(0.2)^2 + 9$$

Height of cherry

$$h = -16t^2 + 9 = 8.36$$

will be 8.36 feet above ground.

B) After how many seconds does the cherry hit the ground?  $\hookrightarrow h=0$

$$h=0 \quad 0 = -16t^2 + 9 \quad t = \pm \frac{3}{4}$$

$$16t^2 = 9 \\ t^2 = \frac{9}{16}$$

It will hit the ground in  $\frac{3}{4}$  of a second.  $\frac{3}{4}$  of a sec.

5) A red ball is kicked upward from the ground with an initial vertical velocity of 44 feet per second. A green ball is kicked upward from the ground with an initial vertical velocity at 40 feet per second.

A) Which ball is in the air for more time? B) How much more time is it in the air than the other?

use  $h = -16t^2 + vt + S$

Red:  $h = -16t^2 + 44t$

$$0 = -16t^2 + 44t$$

$$0 = -4t(4t - 11)$$

$$t=0 \quad 4t-11=0 \\ t = \frac{11}{4} = 2\frac{3}{4} \text{ sec.}$$

Green:  $h = -16t^2 + 40t$

$$0 = -16t^2 + 40t$$

$$0 = -4t(4t - 10)$$

$$t=0 \quad 4t-10=0 \\ t = \frac{10}{4} = 2\frac{1}{2} \text{ sec.}$$

started on ground

A) The red ball,

B)  $\frac{1}{4}$  of a second more

6) A man throws a ball into the air, releasing it from a height of exactly 7 feet with an initial velocity of 54 feet per second. How long will it take the ball to hit the ground?

$$S=7$$

$$V=54$$

$$h=0$$

use:  $h = -16t^2 + vt + S$

$$h = -16t^2 + 54t + 7$$

$$0 = -16t^2 + 54t + 7$$

$$t = \frac{-54 \pm \sqrt{54^2 - 4(-16)(7)}}{2(-16)}$$

$$t = \frac{-54 \pm \sqrt{3364}}{-32}$$

$$t = -\frac{4}{32} = -\frac{1}{8} \text{ extraneous}$$

$$t = \frac{-112}{-32} = 3\frac{1}{2}$$

Takes  $3\frac{1}{2}$  seconds to hit the ground.

7) While throwing a temper tantrum, an angry toddler standing on a chair screams and throws his ice cream cone into the air from 5 feet above the ground with an initial vertical velocity of 30 feet per second (he's pretty strong!). How long does it take before the cone hits his baby brother's head 1 foot above the ground?

Throws  $\rightarrow$  use  $h = -16t^2 + vt + S$

$$S=5$$

$$V=30$$

$$h=1$$

$$h = -16t^2 + 30t + 5$$

$$1 = -16t^2 + 30t + 5$$

$$(0 = -16t^2 + 30t + 4) \leftarrow \text{divide by } 2 \quad t = \frac{15 \pm 17}{-16}$$

$$0 = -8t^2 + 15t + 2$$

$$t = \frac{-15 \pm \sqrt{15^2 - 4(-8)(2)}}{2(-8)}$$

$$t = \frac{-15 \pm \sqrt{289}}{-16} \quad t = \frac{-15-17}{-16}$$

$$t = 2$$

extraneous } 2 seconds

ANSWERS: 1) 1 second 2) 2.1 seconds 3)  $\frac{7}{8}$  of a second 4) A) 8.4 feet B)  $\frac{3}{4}$  of a second  
5) A) the red ball B)  $\frac{1}{4}$  of a second longer 6)  $3\frac{1}{2}$  seconds 7) 2 seconds