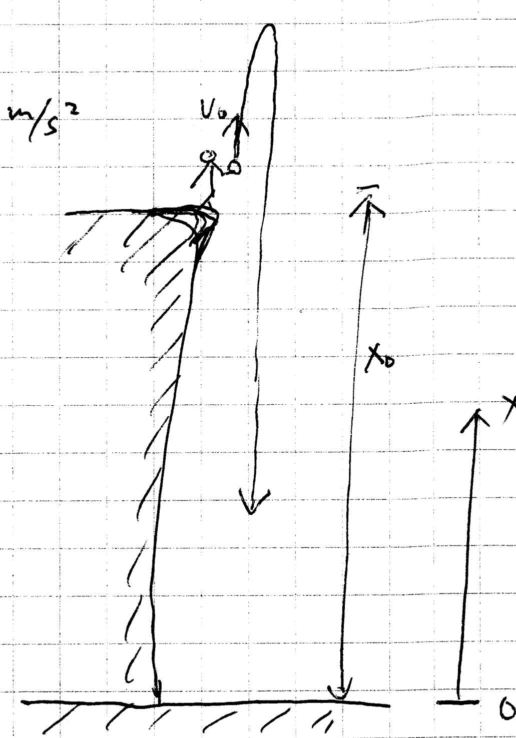
Problem 2.47

$v_0 = 12.0 \text{ m/s}$ $a = -g = -9.8 \text{ m/s}^2$

$x_0 = 70.0 \text{ m}$



a) $t = ?$ if $x = 0$

$x = x_0 + v_0 t - \frac{1}{2} g t^2$

$0 = 70 + 12t - \frac{1}{2}(9.8)t^2$

$4.9t^2 - 12t - 70 = 0$

$b^2 - 4ac = (-12)^2 - 4(4.9)(-70) = 1516$

$t = \frac{12 \pm \sqrt{1516}}{2 \times 4.9} = \frac{12 \pm 38.9}{9.8}$

$\boxed{t = 5.20 \text{ s}}$

b) $v = v_0 + at = v_0 - gt = 12 - (9.8)(5.20) = -39.0 \text{ m/s}$

$\boxed{|v| = 39.0 \text{ m/s}}$

c) at maximum height: $v_1 = 0$ $v_0 - g t_1 = 0$

$t_1 = \frac{v_0}{g} = \frac{12}{9.8} = 1.22 \text{ s}$

$x_1 = v_0 t_1 - \frac{1}{2} g t_1^2$

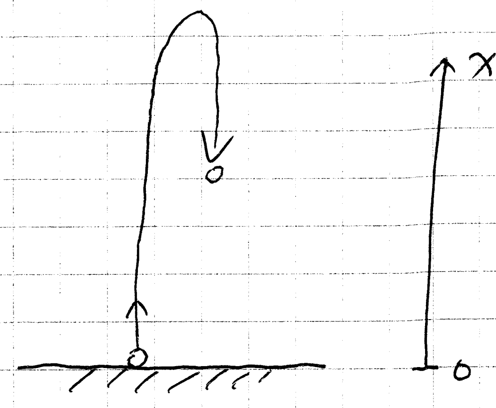
$= 12(1.22) - 4.9(1.22)^2$

$= 7.29 \text{ m}$

$D = x_1 + (x_1 + x_0) = 7.29 + 7.29 + 70 = 84.6 \text{ m}$

Problem 2.42.

$x_0 = 0$, $v_0 = 18$ m/s. $a = -g = -9.8$ m/s^2



a). $v = ?$ when $x = 11$ m.

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$= 18^2 - 2 \times 9.8\,(11 - 0)$$

$$= 108.4$$

$$v = \sqrt{108.4} = 10.4 \text{ m/s}.$$

b). $t = ?$ if $x = 11$ m.

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2 = x_0 + v_0 t - 4.9 t^2.$$

$$11 = 18t - 4.9t^2.$$

$$4.9t^2 - 18t + 11 = 0.$$

Solve for t: $b^2 - 4ac = (-18)^2 - 4(11)(4.9) = 108.4$

$$t = \frac{18 \pm \sqrt{108.4}}{2 \times 4.9}$$

$t_1 = 0.776$ s, $t_2 = 2.898$ s.

≈ 0.78 s ≈ 2.90 s.

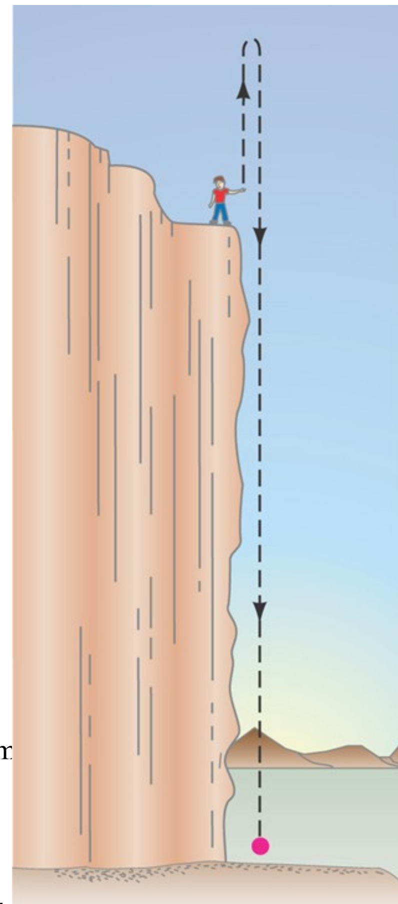
c).

t_1 — on its way up.

t_2 — on its way down.

Phys101 Tutorial #1

Written Assignment #1:



47. (III) A stone is thrown vertically upward with a speed of $12.0\,\mathrm{m/s}$ from the edge of a cliff 70.0 m high (Fig. 2–34).

(a) How much later does it reach the bottom of the cliff?

(b) What is its speed just before hitting?

(c) What total distance did it travel?

Solution:

$\boxed{47.}$ Choose downward to be the positive direction, and $y_0 = 0$ to be at the top of the cliff. The initial velocity is $v_0 = -12.0\,\mathrm{m/s}$, the acceleration is $a = 9.80\,\mathrm{m/s^2}$, and the final location is $y = 70.0$ m.

(a) Using Eq. 2-11b and substituting y for x, we have

$$y = y_0 + v_0 t + \tfrac{1}{2}at^2 \rightarrow \left(4.9\,\mathrm{m/s^2}\right)t^2 - \left(12.0\,\mathrm{m}\right.$$ s , 5.198 s

. The positive answer is the physical answer: $\boxed{t = 5.20\ \mathrm{s}}$.

(b) Using Eq. 2-11a, we have

$$v = v_0 + at = -12.0\,\mathrm{m/s} + \left(9.80\,\mathrm{m/s^2}\right)\left(5.198\ \mathrm{s}\right) = \boxed{38.9\,\mathrm{m/s}}$$

.

(c) The total distance traveled will be the distance up plus the distance down. The distance down will be 70 m more than the distance up. To find the distance up, use the fact that the speed at the top of the path will be 0. Then using Eq. 2-11c:

$$v^2 = v_0^2 + 2a\left(y - y_0\right) \rightarrow y = y_0 + \frac{v^2 - v_0^2}{2a} = 0 + \frac{0 - \left(-12.0\,\mathrm{m/s}\right)^2}{2\left(9.80\,\mathrm{m/s^2}\right)} = -7.35\ \mathrm{m}.$$

Thus the distance up is 7.35 m, the distance down is 77.35 m, and the total distance traveled is $\boxed{84.7\ \mathrm{m}}$.

Note: Students can choose different coordinate systems.

Quiz #1:

42. (II) A stone is thrown vertically upward with a speed of $18.0\,\mathrm{m/s}$. (*a*) How fast is it moving when it reaches a height of 11.0 m? (*b*) How long is required to reach this height? (*c*) Why are there two answers to (*b*)?

Solution:

42. Choose upward to be the positive direction, and $y_0 = 0$ to be the height from which the stone is thrown. We have $v_0 = 18.0\,\mathrm{m/s}$, $a = -9.80\,\mathrm{m/s^2}$, and $y - y_0 = 11.0\ \mathrm{m}$.

(*a*) The velocity can be found from Eq, 2-11c, with *x* replaced by *y*.

$$v^2 = v_0^2 + 2a\left(y - y_0\right) = 0 \quad \rightarrow$$

$$v = \pm\sqrt{v_0^2 + 2ay} = \pm\sqrt{\left(18.0\,\mathrm{m/s}\right)^2 + 2\left(-9.80\,\mathrm{m/s^2}\right)\left(11.0\ \mathrm{m}\right)} = \pm 10.4\,\mathrm{m/s}$$

Thus the speed is $\boxed{|v| = 10.4\,\mathrm{m/s}}$

(*b*) The time to reach that height can be found from equation (2-11b).

$$y = y_0 + v_0 t + \tfrac{1}{2}at^2 \quad \rightarrow \quad t^2 + \frac{2\left(18.0\,\mathrm{m/s}\right)}{-9.80\,\mathrm{m/s^2}}t + \frac{2\left(-11.0\ \mathrm{m}\right)}{-9.80\,\mathrm{m/s^2}} = 0 \quad \rightarrow$$

$$t^2 - 3.673t + 2.245 = 0 \quad \rightarrow \quad \boxed{t = 2.90\ \mathrm{s}\ ,\ 0.775\ \mathrm{s}}$$

(*c*) $\boxed{\text{There are two times at which the object reaches that height}}$ – once on the way up $\left(t = 0.775\ \mathrm{s}\right)$, and once on the way down $\left(t = 2.90\ \mathrm{s}\right)$.