Section 3.3: Free Fall

- How would you define a free-falling object?
- What variables affect a free-falling object?
  - object that is dropped to the ground from a certain height; downward; gravity; surrounded by air; drag (air resistance); initial velocity

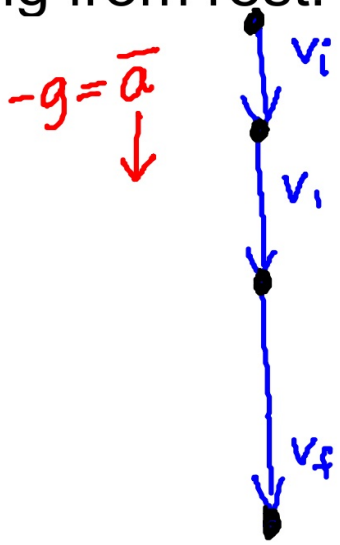
Section 3.3 Notes:

gravity (accerelation of gravity)

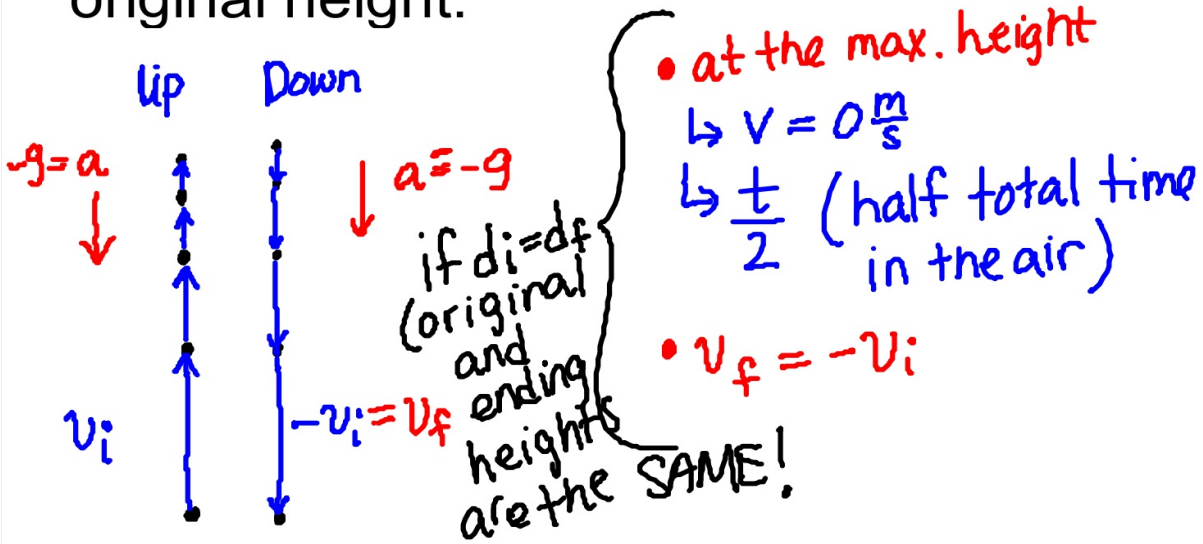
↳ $g = 9.80 \frac{m}{s^2}$, downward

↳ $-g = -9.80 \frac{m}{s^2}$

Draw a particle model to represent a ball dropping from rest.

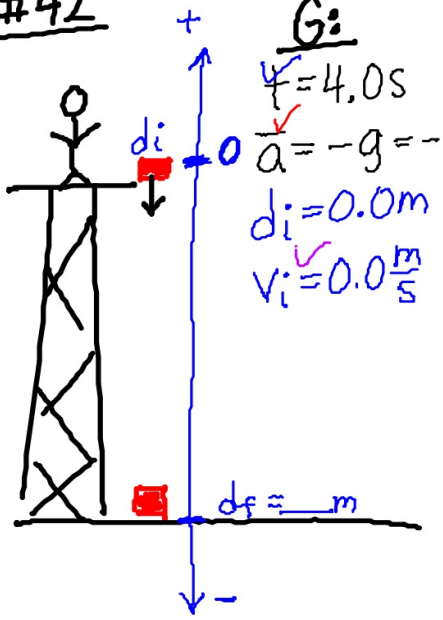


Draw a particle model of a ball being thrown up in the air and falling back down to its original height.



Practice Problems (p. 74)

#42



G:
$t = 4.0\,s$
$a = -g = -9.80\,m/s^2$
$d_i = 0.0\,m$
$v_i = 0.0\,\frac{m}{s}$

U:
(a) $v_f = \_\_\_\,\frac{m}{s}$
(b) $d_f = \_\_\_\,m$

E:
(b) $d_f = d_i + v_i t + \frac{1}{2} a t^2$

S:
$d_f = 0.0\,m + (0.0\,\frac{m}{s})(4.0\,s) + \frac{1}{2}(-9.8\,\frac{m}{s^2})(4.0\,s)^2$

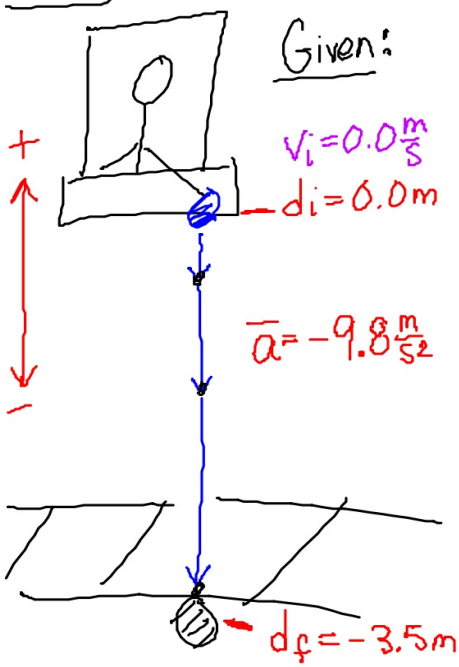
$d_f = -78\,m$

E:
(a) $v_f = v_i + a t$

S:
$v_f = 0.0\,\frac{m}{s} + (-9.8\,\frac{m}{s^2})(4.0\,s)$
$v_f = -39.2 = \boxed{-39\,\frac{m}{s}}$ (a)

(b) Brick fell 78 m

#44



Given:
$v_i = 0.0\,\frac{m}{s}$
$d_i = 0.0\,m$
$a = -9.8\,\frac{m}{s^2}$
$d_f = -3.5\,m$

Unknown:
$v_f = \_\_\_\,\frac{m}{s}$

Equation:
$v_f^2 = v_i^2 + 2a(d_f - d_i)$

$v_f = \sqrt{(0.0\,\frac{m}{s})^2 + 2(-9.8\,\frac{m}{s^2})(-3.5\,m)}$

$\boxed{v_f = 8.3\,\frac{m}{s}}$

How fast? (Speed) $8.3\,\frac{m}{s}$

If they asked for velocity the answer would be $-8.3\,\frac{m}{s}$

#44

G:

$\Delta d = -3.5$

$\bar{a} = -9.8 \frac{m}{s^2}$

$v_i = 0.0 \frac{m}{s}$

U:

$v_f = \_\_\_ \frac{m}{s}$

E:

$v_f^2 = v_i^2 + 2\bar{a}(d_f - d_i)$

$v_f = \sqrt{v_i^2 + 2\bar{a}(d_f - d_i)}$

$v_f = \sqrt{(0.0\frac{m}{s})^2 + 2(-9.8\frac{m}{s^2})(-3.5m)}$

$v_f = \sqrt{68.6}$

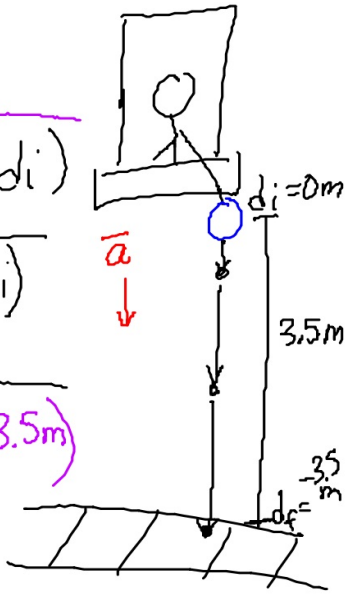
$v_f = 8.28 \frac{m}{s}$

$\rightarrow \Delta d = d_f - d_i$

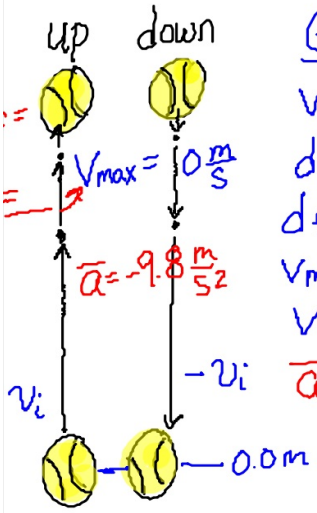
$v_f = 8.3 \frac{m}{s}$

2 SF!

How fast $\Rightarrow$ speed



#45



Given

$v_i = 22.5 \frac{m}{s}$

$d_i = 0m$

$d_f = 0m$

$v_{max} = 0 \frac{m}{s}$

$v_f = -22.5 \frac{m}{s}$

$\bar{a} = -9.8 \frac{m}{s^2}$

Unknown (only looking at trip up! $d_{max} = d_f$)

(a) $d_{max} = \_\_\_ m$

(b) $t = \_\_\_ s$

Equations

(b) $v_f = v_i + \bar{a}t$

$\therefore t = \frac{v_f - v_i}{\bar{a}}$

$t = 4.59s$

Equations

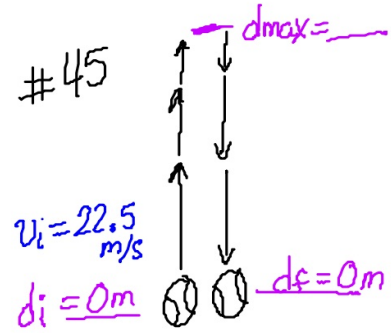
(a) $v_f^2 = v_i^2 + 2\bar{a}(d_f - d_i)$

$d_f = \frac{v_f^2 - v_i^2}{2\bar{a}} + d_i$

$d_f = \frac{(0\frac{m}{s})^2 - (22.5\frac{m}{s})^2}{2(-9.8\frac{m}{s^2})} + 0m$

(a) $d_f = 25.8m$

#45



G:
$d_i = 0m$
$d_f = 0m$
$v_i = 22.5 \frac{m}{s}$
$\bar{a} = -9.8 m/s^2$

U:
(a) $d_{max} =$ ___ m
(b) $t =$ ___ s

(b) E:
$d_f = d_i + v_i t + \frac{1}{2}\bar{a}t^2$
$0m = 0m + (22.5\frac{m}{s})t + \frac{1}{2}(-9.8\frac{m}{s^2})t^2$
$0 = 22.5t - 4.9t^2$
$-22.5t = -4.9t^2 \Rightarrow \frac{-22.5}{-4.9} = \frac{-4.9t}{-4.9}$
$t = 4.59s$

E:
(a) $v_f^2 = v_i^2 + 2\bar{a}(d_f - d_i)$
$v_{max}^2 = v_i^2 + 2\bar{a}(d_{max} - d_i)$
$-v_i^2 \quad -v_i^2$
$\frac{(v_{max})^2 - v_i^2}{2\bar{a}} = \frac{2\bar{a}}{2\bar{a}}(d_{max} - d_i)$ ($d_i = 0m$)
$d_{max} = \frac{v_{max}^2 - v_i^2}{2\bar{a}} = \frac{(0\frac{m}{s})^2 - (22.5\frac{m}{s})^2}{2(-9.8\frac{m}{s^2})}$

$d_{max} = 25.8 m$

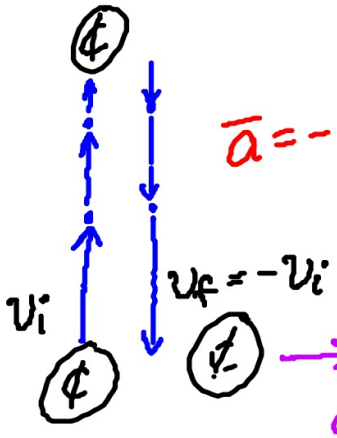
#46

$v_f = 0.0 \frac{m}{s}$
$d_f = 0.25m$ (2 SF!)
$\bar{a} = -g = -9.8\frac{m}{s^2}$

U: (a) $v_i =$ ___ $\frac{m}{s}$
E: $v_f^2 = v_i^2 + 2\bar{a}(d_f - d_i)$
S: $v_i = \sqrt{v_f^2 - 2\bar{a}(d_f - d_i)}$
$v_i = \sqrt{(0)^2 - 2(-9.8)(.25)}$
$v_i = 2.21 \frac{m}{s}$
(a) $v_i = 2.2 \frac{m}{s}$

U: $t =$ ___ s
E: (b) $d_f = d_i + v_i t + \frac{1}{2}\bar{a}t^2$
$d_f = d_i + \bar{v}t$
$v_f = v_i + \bar{a}t$

#46 (b)



$\bar{a} = -g = -9.8 \frac{m}{s^2}$

$\rightarrow d_i = d_f$

or $d_f - d_i = 0m$

U: (b) $t =$ ___ s

E: (b) $v_f = v_i + \bar{a}t$

$v_f = -v_i = -2.2 \frac{m}{s}$

$v_i = 2.2 \frac{m}{s}$ (a)

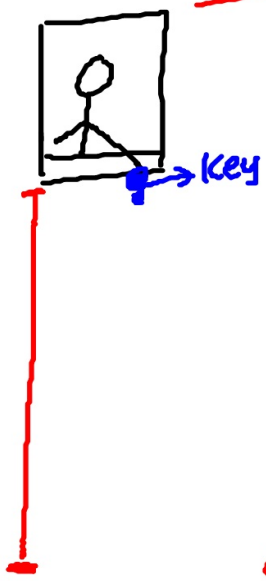
S: $t = \frac{v_f - v_i}{\bar{a}}$

$t = \frac{-2.2 \frac{m}{s} - 2.2 \frac{m}{s}}{-9.8 \frac{m}{s^2}}$

(b) $\boxed{t = .45 s}$

#49

Given:



$v_i = 0.0 \frac{m}{s}$

$d_i = 4.3$ m

$\bar{a} = -g = -9.8 \frac{m}{s}$

$d_f = 0.0$ m

Unknown:

$v_f =$ ___ $\frac{m}{s}$

E:

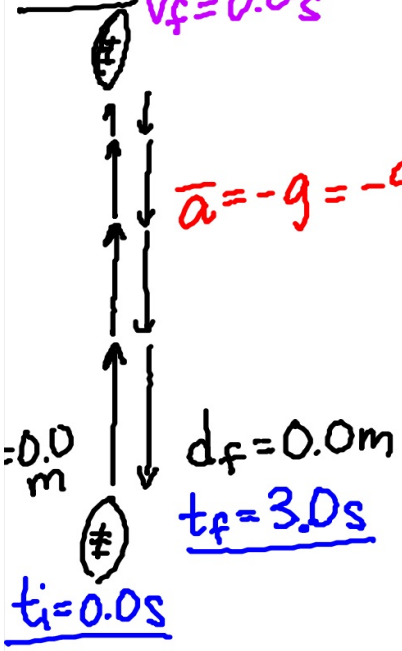
$v_f^2 = v_i^2 + 2\bar{a}(d_f - d_i)$ ✓ ✓ ✓ ✓

$v_f = \sqrt{(0.0 \frac{m}{s})^2 + 2(-9.8 \frac{m}{s^2})(-4.3 m)}$

$\boxed{v_f = -9.2 \frac{m}{s}}$ b/c keys are dropped downward

#50 @ max height (half of total time)

$V_f = 0.0 \frac{m}{s}$ $t = \frac{3.0s}{2} = 1.5s$



Given:

$v_f = 0.0 \frac{m}{s}$

$t_f = 1.5s$

$\bar{a} = -9.8 \frac{m}{s^2}$

Unknown:

$v_i = \_\_ \frac{m}{s}$

Equation:

$v_f = v_i + \bar{a}t$

Subst./solve:

$v_i = v_f - \bar{a}t$

$v_i = 0.0 \frac{m}{s} - \left(-9.8 \frac{m}{s^2}\right)(1.5s)$

$v_i = 15 \frac{m}{s}$

#51

G:

$v_i = 15 \frac{m}{s}$

$v_f = 0.0 \frac{m}{s}$

$\bar{a} = -9.8 \frac{m}{s^2}$

$t_f = 1.5s$

$d_i = 0.0m$

U:

$d_f = \_\_ m$

(max height)

E:

$d_f = d_i + v_i t + \frac{1}{2}\bar{a}t^2$

$d_f = 0.0m + \left(15 \frac{m}{s}\right)(1.5s) + \frac{1}{2}\left(-9.8 \frac{m}{s^2}\right)(1.5s)^2$

$d_f = 11 m$