PHYSICS

Free Fall

1. If a rock takes 0.750 s to hit the ground after being thrown down from a height of 4.80, determine the rock's initial velocity. **(2.7 m/s [down]).**

G: $t = 0.750\ s$

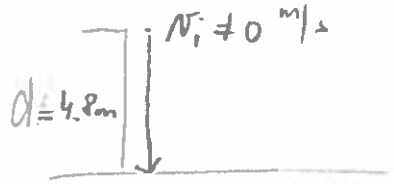
$\vec{a} = -9.8\ m/s^2$

$\vec{d} = -4.80\ m$

R: $\vec{v}_i = ?\ m/s\ [D]$

S: $v_i = -2.725\ m/s$

S: The initial velocity is 2.7 m/s [down].



A: $d = v_i t + \frac{1}{2} a t^2$

$v_i = \dfrac{d - \frac{1}{2} a t^2}{t}$

S: $v_i = \dfrac{-4.80 - \frac{1}{2}(-9.8)(0.750)^2}{0.750}$

2. Having scored a touchdown, a football player spikes the ball in the end zone. If the ball was thrown down with an initial velocity of 2.0 m/s from a height of 1.75m, determine how long until it hits the ground. **(0.43 s).**

G: $\vec{v}_i = -2.0\ m/s$

$\vec{d} = -1.75\ m$

$\vec{a} = -9.8\ m/s^2$

R: $t = ?\ [s]$

S: It takes 0.43 s before it hits the ground.

A: • $v_f = v_i + at \rightarrow t = \dfrac{v_f - v_i}{a}$

• $v_f^2 = v_i^2 + 2ad$

$= (-2.0)^2 + 2(-9.8)(-1.75)$

$v_f = \sqrt{38.3}$

$v_f = -6.188699279\ \frac{m}{s}$

S: $t = \dfrac{-\sqrt{38.3} - (-2.0)}{-9.8}$

$t \doteq 0.43\ s$

3. An elevator moving downward at 4.00 m/s experiences an upward acceleration of 2.00m/s^2 for 1.80 s. What is its velocity at the end of the acceleration interval and far has it travelled? **(0.40 m/s [down], 4.0 m).**

G: $\vec{v}_i = -4.00 \frac{m}{s}$

$\vec{a} = +2.00\ m/s^2$

$t = 1.80\ s$

R: $\vec{v}_f = ?\ [m/s]$ Down

$d = ?\ [m]$

A: • $\vec{v}_f = \vec{v}_i + at$ • $d = v_i t + \frac{1}{2} a t^2$

S: • $\vec{v}_f = (-4.00) + (2.00)(1.80) = -0.40\ m/s$ • $= (-4.00)(1.800) + \frac{1}{2}(2.00)(1.80)^2 = -3.96\ m$

S: Its final velocity is 0.400 m/s [down].

S: The elevator travelled 3.96 m ≐ 4.0m.

4. The Drop Zone drops riders 27.0 m from rest before slowing them down to a stop. How fast are they moving before they start slowing down? **(23 m/s).**

G: $\vec{d} = -27.0\ m$
$\vec{a} = -9.8\ m/s^2$
$\vec{v}_i = 0\ m/s\ [D]$

↑ +
↓ −

R: $v_f = ?\ [m/s]\ [D]$

A: $v_f^2 = v_i^2 + 2ad$

S: $= 0^2 + 2(-9.8)(-27.0)$
$\vec{v}_f = \pm\sqrt{529.2}$
$v_f = 23.0\ m/s$

S: They are moving with speed of 23.0 m/s.

5. A pebble falls from a ledge 20.0 m high.
   A) Find its velocity just before it hits the ground. **(2.0×10^1 m/s [down]).**
   B) Find the time it takes to hit the ground. **(2.0 s).**

G: $\vec{d} = -20.0\ m$
$\vec{a} = -9.8\ m/s^2$
$\vec{v}_i = 0\ m/s\ [D]$

↑ +
↓ −

R: • $\vec{v}_f = ?\ [m/s]\ [D]$
• $t = ?\ [s]$

A: • $v_f^2 = v_i^2 + 2ad$

S: $= 0^2 + 2(-9.8)(-20)$
$= \pm\sqrt{392}$
$= 2.0 \times 10^1\ m/s\ [D]$

• $v_f = v_i + at \rightarrow t = \frac{v_f - v_i}{a}$

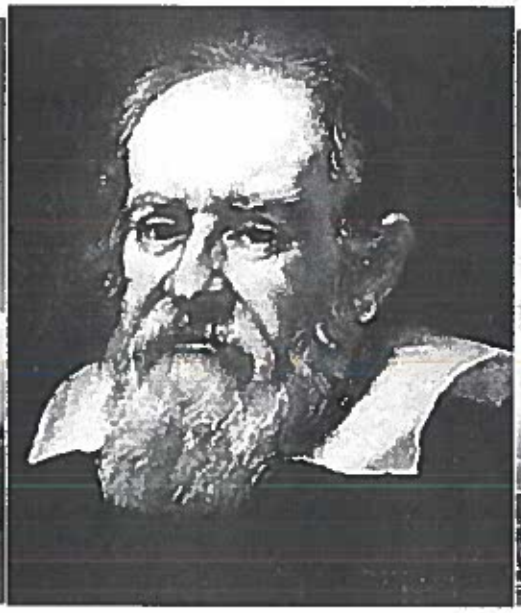
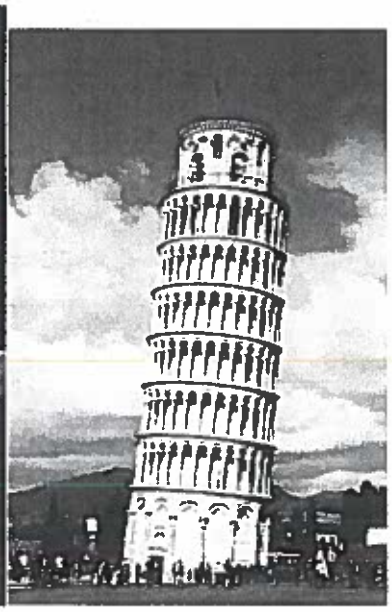
$t = \frac{-\sqrt{392} - 0}{-9.8}$

$t = 2.0203\ldots\ s$
$t = 2.0\ s$

S: Pebble's final velocity is 2.0×10^{-1} m/s [D] and it takes 2.0 s for it to hit the ground.

Acceleration due to gravity – summary

- Acceleration near the Earth's surface (unless specified otherwise).
- Vertical acceleration
- Does not depend on mass (you can read about the famous Galileo's experiment and the Tower of Pisa).

- The value of the acceleration due to gravity varies with geographic location.
- The acceleration due to gravity on Earth is approximately 9.8 m/s^2**[down]**.
- Symbol: $\overrightarrow{g}$
- Direction of the acceleration due to gravity is always towards the center of the Earth.
- When air resistance of a falling object can be neglected and no other forces except gravity act on an object the object is said to be falling in free fall.