Freely Falling Bodies

Any object moving freely under the influence of gravity, regardless of its initial motion, is an object falling freely.

All freely falling objects experience a downward acceleration, called the free-fall acceleration

Objects experience the same free-fall acceleration regardless of whether they are thrown upward, downward, or released from rest

Neglecting external forces (air resistance, Earth's rotation, or any change in gravity due to elevation), the free-fall acceleration can be written as

$$a = -g = -9.8\ m/s^2$$

$$g = 9.8\ m/s^2$$

Example: A climber near the summit of a vertical cliff accidentally knocks loose a large rock. She sees it shatter at the bottom of the cliff 8 s later. Neglecting air resistance, what was the velocity of the rock just before impact?

Answer

$v = -78.4 \text{ m/s}$

Example: A ball is thrown vertically upward from the ground with an initial speed of 15 m/s.

(a) How long does it take the ball to reach its maximum altitude?

(b) What is its maximom altitude?

(c) Determine the velocity and acceleration of the ball at $t = 2s$.

Answers

(a) $t = 1.53\ s$

(b) $x_{max} = 11.5\ m$

(c) $v = -4.6\ m/s$

$a = -9.8\ m/s^2$

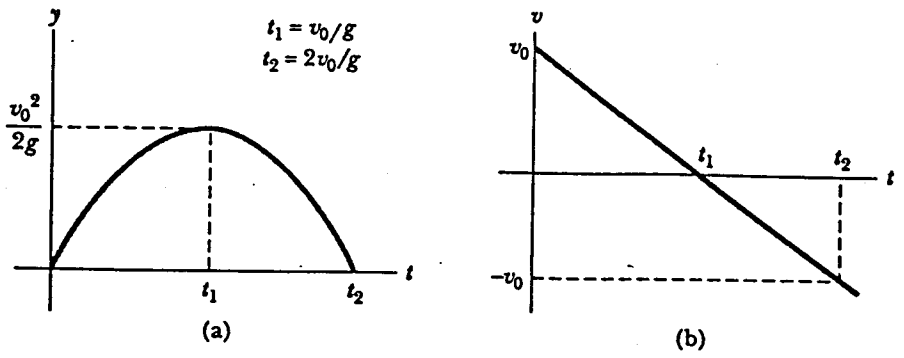
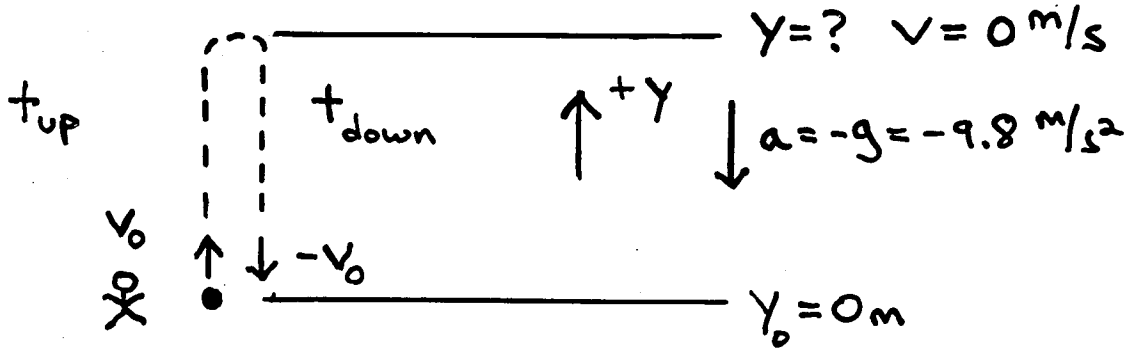


FIGURE 2.12 Graphs of (a) the displacement versus time and (b) the velocity versus time for a freely falling particle, where y and v are taken to be positive upward. Note the symmetry in (a) about $t = t_1$.

Physics For Scientists, R. A. Serway 4th ed.

-Consider a particle thrown vertically upward from the origin with velocity v_0.

The above graphs show y vs. t and v vs. t for this particle. Note its symmetry!



From symmetry we see that

$$t_{up} = t_{down}$$

and

The magnitude of the velocity when the ball is thrown and caught will be the same.

This type of symmetry will not exist if there is an external force (other than gravity) acting on the particle.

Ex. A rocket accelerates upward until its engines fail. At that point, the rocket is in free-fall as it drops back to Earth.

Example: A student throws a water balloon vertically downward from the top of a building. The balloon leaves the thrower's hand with an initial speed of 12 m/s.

(a) What is the velocity of the balloon after falling for 2 s?

(b) How far does the balloon fall in 2 s?

(c) What is the velocity of the balloon after dropping 10 m?

Answers

(a) $v = -31.6$ m/s

(b) $y = -43.6$ m

(c) $v = -18.4$ m/s