

Chapter 6

Free Fall

You will learn

- The Principle of Free Fall Objects.
- Gravitational Force In Both Up And Down Ward Direction.

Free Fall

- ▶ All objects moving under the influence of only gravity are said to be in free fall.
- ▶ All objects falling near the earth's surface, falling with a constant acceleration.
- ▶ This acceleration is called the acceleration due to gravity, and indicated by “g”.
- ▶ *We will frequently* use the approximate value of g *at or near the earth's surface.*

Acceleration due to Gravity

- ▶ It is Symbolized by g .
- ▶ $g = - 9.8 \text{ m/s}^2$ always (because it is always directed downward).
- ▶ $g = - 10 \text{ m/s}^2$ can also be used for estimates.
- ▶ g is always directed downward.
 - toward the center of the earth
- ▶ once released, only gravity pulls on the object, just like in up-and-down motion.
- ▶ since gravity pulls on the object downwards:
 - ✓ vertical acceleration downwards
 - ✓ NO acceleration will be in horizontal direction

Free Fall

Case 1- an Object Dropped

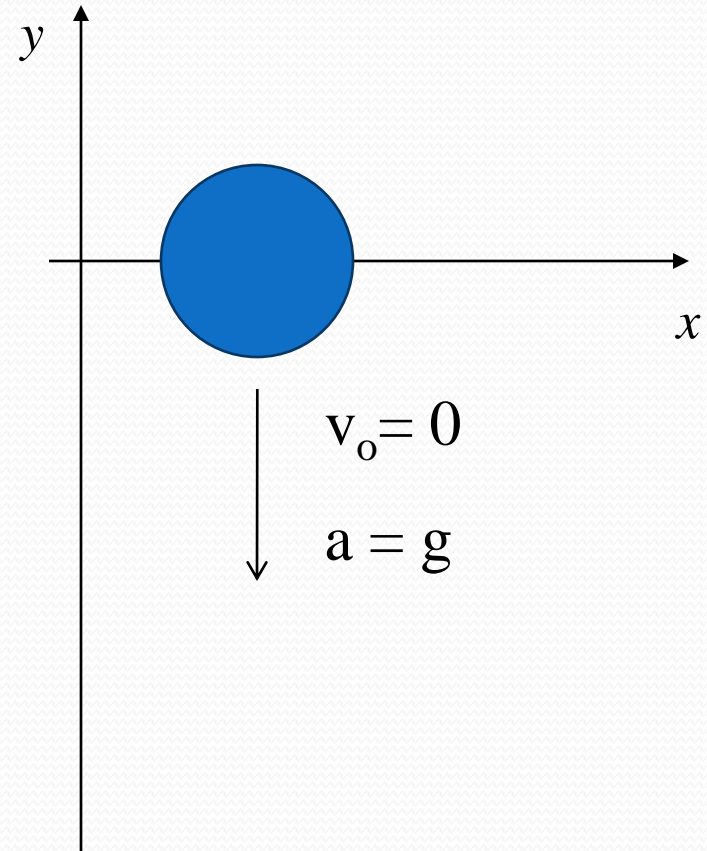
- ▶ Initial velocity is zero.
- ▶ Velocity and distance are negative after time , t, from initial point.
- ▶ Frame: let up be positive.
- ▶ Use the kinematic equations.

- Generally use y instead of x since vertical.

$$\Delta y = \frac{1}{2} at^2$$

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

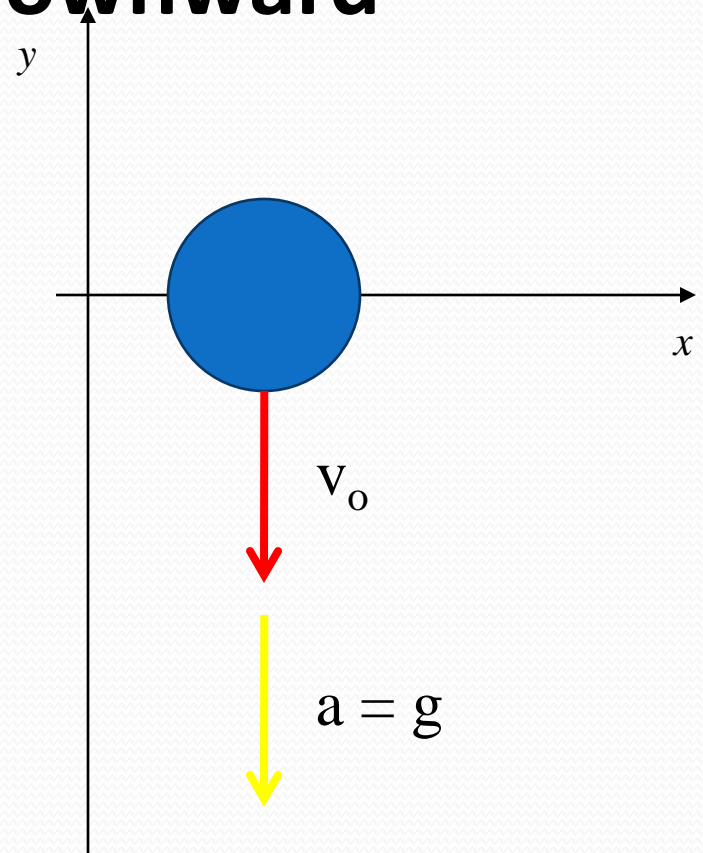
$$\text{thus : } g = -9.8 m/s^2$$



Free Fall

Case 2- an Object Thrown Downward

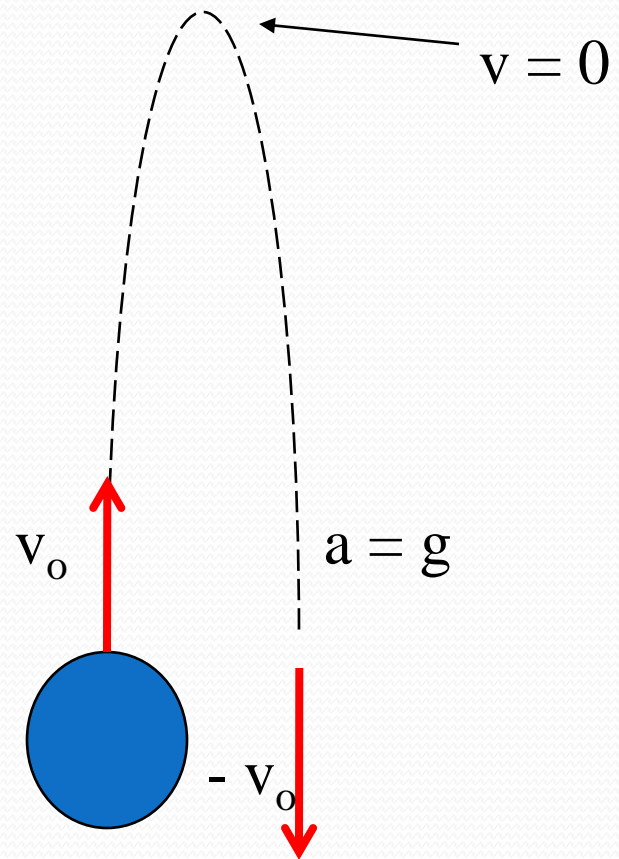
- ▶ $a = g$
 - With downward , y , acceleration will be negative,
thus: $g = -9.8 \text{ m/s}^2$
- ▶ **Initial velocity $\neq 0$**
- ▶ **initial velocity will be negative.**
- ▶ **Velocity and distance are negative after time , t , from initial point.**



Free Fall

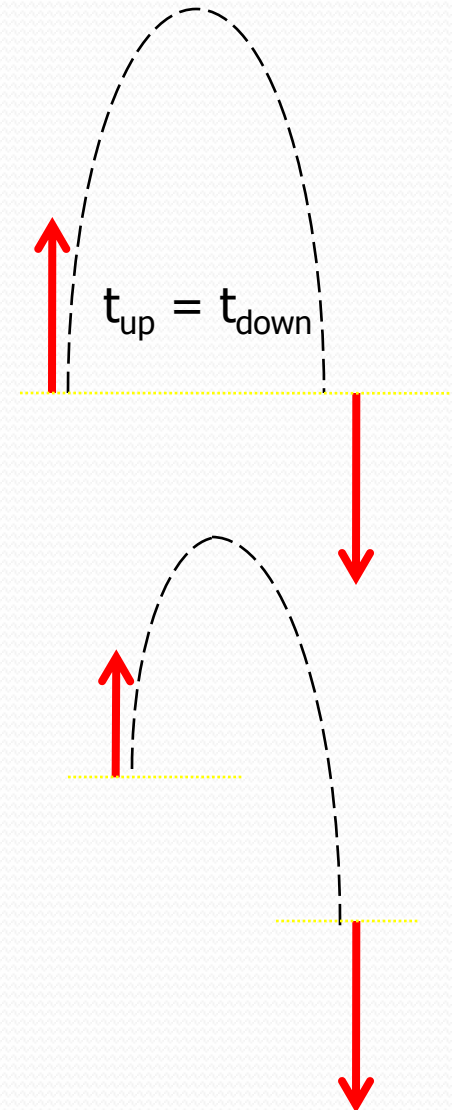
Case 3- object thrown upward

- ▶ Initial velocity is upward, so it is toward positive y axis.
- ▶ **The instantaneous velocity at the maximum height is zero**
- ▶ **Velocity and distance are positive after time , t, from initial point.**
- ▶ $a = g$ everywhere in the motion and $g = -9.8 \text{ m/s}^2$
 - g is always downward, negative



Thrown upward

- ▶ The motion may be symmetrical
 - then $t_{\text{up}} = t_{\text{down}}$
 - then $v_f = -v_o$
- ▶ The motion may not be symmetrical
 - Break the motion into various parts
 - ▶ generally up and down



Short Response Questions

Quick Quiz 2.6 A ball is thrown upward. While the ball is in free fall, does its acceleration (a) increase (b) decrease (c) increase and then decrease (d) decrease and then increase (e) remain constant?

Quick Quiz 2.7 After a ball is thrown upward and is in the air, its speed (a) increases (b) decreases (c) increases and then decreases (d) decreases and then increases (e) remains the same.

Free fall formula

kinematic equations

$$1) v_f^2 = v_i^2 + 2g\Delta s$$

$$2) \Delta x = v_i \Delta t + \frac{1}{2} g \Delta t^2$$

$$3) v_f = v_i + g \Delta t$$

$$4) \bar{v} = \frac{v_i + v_f}{2}$$

Comparison between kinematic motion and free fall motion

$$1) v_f^2 = v_i^2 + 2a\Delta s$$

$$2) \Delta s = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$3) v_f = v_i + a \Delta t$$

$$4) \bar{v} = \frac{v_i + v_f}{2}$$

$$1) v_f^2 = v_i^2 + 2g\Delta s$$

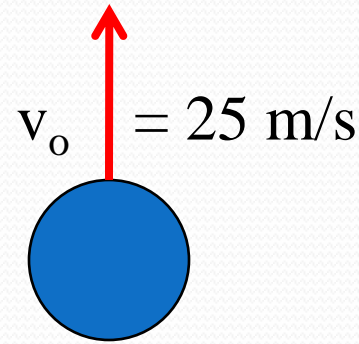
$$2) \Delta x = v_i \Delta t + \frac{1}{2} g \Delta t^2$$

$$3) v_f = v_i + g \Delta t$$

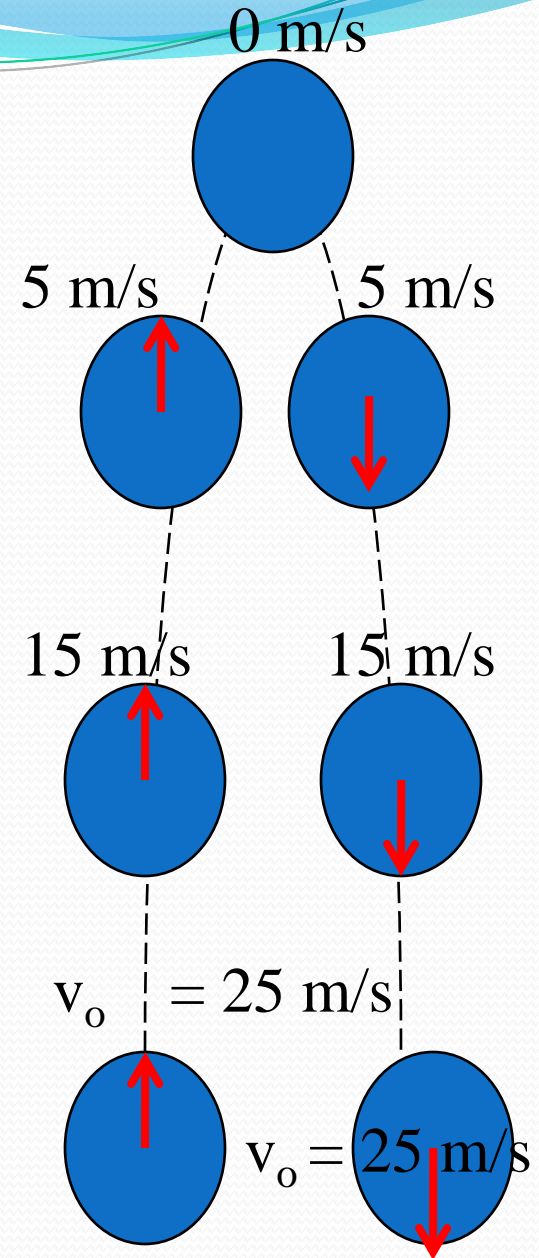
$$4) \bar{v} = \frac{v_i + v_f}{2}$$

Sample Problem

A ball is tossed straight up at 25 m/s. Estimate its velocity at 1-s intervals.



Solution Let us choose the upward direction to be positive. Regardless of whether the ball is moving upward or downward, its vertical velocity changes by approximately -10 m/s for every second it remains in the air. It starts out at 25 m/s . After 1 s has elapsed, it is still moving upward but at 15 m/s because its acceleration is downward (downward acceleration causes its velocity to decrease). After another second, its upward velocity has dropped to 5 m/s . Now comes the tricky part—after another half second, its velocity is zero. The ball has gone as high as it will go. After the last half of this 1-s interval, the ball is moving at -5 m/s . (The negative sign tells us that the ball is now moving in the negative direction, that is, *downward*. Its velocity has changed from $+5 \text{ m/s}$ to -5 m/s during that 1-s interval. The change in velocity is still $-5 \text{ m/s} - (+5 \text{ m/s}) = -10 \text{ m/s}$ in that second.) It continues downward, and after another 1 s has elapsed, it is falling at a velocity of -15 m/s . Finally, after another 1 s , it has reached its original starting point and is moving downward at -25 m/s .



QUESTION

A person standing at the edge of a cliff throws one ball straight up and another ball straight down at the same initial speed. Neglecting air resistance, the ball to hit ground below the cliff with greater speed is the one initially thrown.

1. upward
2. downward
3. neither – they both hit at the same speed

PROBLEMS

1. An object is shot upward at 30 m/s. How high does it go?
2. A ball thrown vertically upward with an initial velocity of 40 m/s, after 3 s what will be final velocity?
3. A stone falls off a tall building and hits the ground 4 seconds later. How high was the building?
4. A ball is dropped from a height of 30.0 m. After what time interval does the ball strike the ground?