Name: ____________________

Period: ____________________

Freefall

1.6

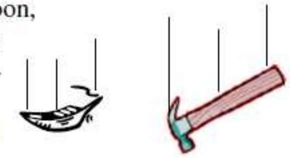
"Free-fall" is the expression we use for any object falling in our earth's gravitational field with only gravity acting on it: it is falling freely.

On the earth the **acceleration due to gravity ("g") is 9.8 m/s²**. Because we usually call "up" the positive direction, g is given a negative value.

For objects in freefall:
$a = g = -9.8\ m/s^2$

Not all falling objects are in freefall. Parachutes, balloons, and airplanes all have air resistance or buoyancy slowing them down: $a \neq -9.8\ m/s^2$.

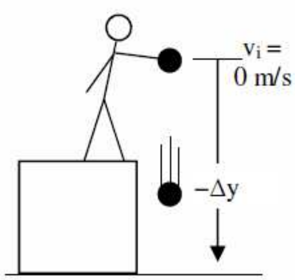
Without air resistance light and heavy objects fall at the same rate. This can be proven in a vacuum chamber when all of the air is removed. On the moon, Apollo 15 astronauts showed this by dropping a feather and a hammer at the same time. They hit the ground at the same time. The moon has no atmosphere so it is a vacuum. It has gravity, but no air resistance.



Special Situations

Because a = g, very little information is needed to be able to solve a freefall problem, but often you must use your everyday knowledge to pull additional information out of a problem.

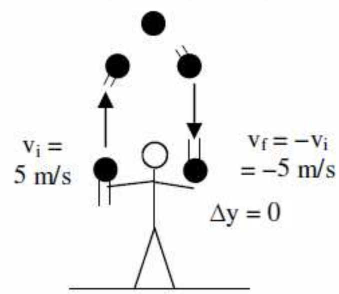
Dropped objects: Δy is $-$; $v_i = 0$ m/s.



Dropped objects begin at rest and go down, so **Δy is $-$** and **$v_i = 0$ m/s.**

Examples: "is dropped"; "pushed off a ledge"; "sitting on a cliff."

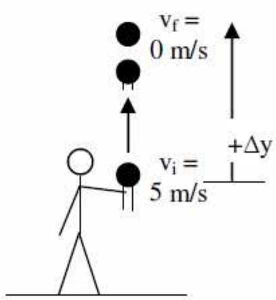
Returns to initial position: $\Delta y = 0$, and $v_f = -v_i$.



If an object comes back to its starting position then **$\Delta y = 0$ m and $v_f = -v_i$.**

Examples: *"Back to the ground"; "back to your hand"; "from ground to ground."*

Final position at top: $V_f = 0$ m/s.



If the object's final position is at the top, then **y is + and $v_f = 0$ m/s.**

Examples: "How high does it go?"; "find maximum height."

Vertical Kinematic Equations

The kinematic equations become the vertical kinematic equations just by putting Δy in for Δx.

Choose the correct equation by deciding which variable is not used in your problem.

$$\Delta y = \frac{1}{2}(v_i + v_f)t$$ ← "a" is not used

$$v_f = v_i + (at)$$ ← "Δy" is not used

$$\Delta y = (v_i t) + \left(\frac{1}{2}a(t)^2\right)$$ ← "v_f" is not used

$$\Delta y = (v_f t) - \left(\frac{1}{2}a(t)^2\right)$$ ← "v_i" is not used

$$v_f^2 = v_i^2 + (2a\Delta y)$$ ← "t" is not used

Example 1. An object is dropped from 40 m. How fast is it going at the bottom?

Variables:
Dropped so: $v_i = 0$ m/s
Falling so: $\Delta y = -40$ m
$a = -9.8\ m/s^2$
v_f = ______
(t is not used)

$$v_f^2 = v_i^2 + 2a\Delta y$$
$$v_f^2 = 0 + 2(-9.8)(-40)$$
$$v_f^2 = 784$$
$$v_f = \sqrt{784} = \pm 28$$

Because it is going down we choose the negative: $v_f = -28$ m/s

Example 2. An object is thrown up into the air going 8 m/s. How long does it take for it to get back to the ground?

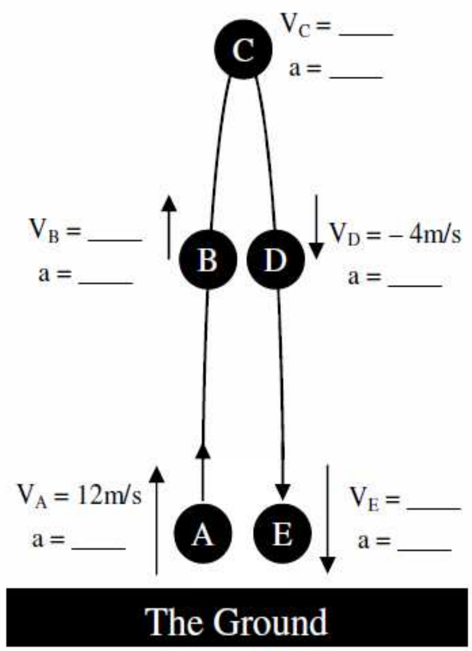
Variables:
$v_i = 8$ m/s
Because it comes back to its original position:
$\Delta y = 0$ m
$v_f = -8$ m/s
$a = -9.8\ m/s^2$
t = ______

Because we have all of the variables, we choose the easiest equation.

$$v_f = v_i + at$$
$$-8 = 8 + (-9.8t)$$
$$-16 = -9.8t$$
$$t = \frac{-16}{-9.8} = 1.63\ \text{sec}$$

Notice that mass is not in the equation, meaning two objects of different mass will hit the ground at the same time!

1. *Fill in the missing information.*



2. *Freefall? Yes or No?*

_____ Paper floating down.

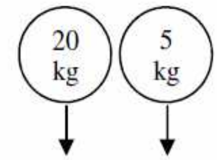
_____ An airplane.

_____ A ball rolling off a table.

_____ A volleyball hit over a net.

_____ A person jumping.

3. What do we call any space that has no air?



4. If the two objects at the right are dropped in a vacuum, which will hit the ground first?

5. What if there is air resistance?

6. "An object is thrown 3 m/s from the ground and it lands on the ground."

v_i = _______; v_f= _______; a = _______; Δy = _______.

7. "An object is thrown into the air going 80 m/s. How high does it go?"

v_i = _______; v_f= _______; a = _______;

8. An object is dropped from a 15 m ledge. How fast it is moving just before it hits the ground?

Variables: Equation and Solve:

9. A person throws tennis ball 6 m/s straight up. How long does it take for it to come back to their hand?

Variables: Equation and Solve:

10. A ball is thrown 24 m/s into the air. How high does it go?

Variables: Equation and Solve:

11. A rock falls off a cliff and falls for 3 secs. How high was the cliff?

Variables: Equation and Solve:

12. An object is thrown up into the air going 9 m/s. How fast is it going 2 seconds later?

13. An object is thrown 16 m/s straight up from a 7 m tall cliff. How much time does it take to hit the ground below?