PHYSICS

ACCELERATION DUE TO GRAVITY

Learning Goals

B2.3 - Use a v-t graph to derive the equation for average velocity and the equations for displacement.

B2.7 - Solve problems involving non-uniform linear motion.

B3.2 - Distinguish between scalar and vector quantities as they relate to uniform and non-uniform motion.

Success Criteria

- [ ] Understand the empirical nature of gravity
- [ ] Know the acceleration due to gravity on Earth is 9.81m/s/s
- [ ] Be able to solve problems involving gravity using various equations

PHYSICS

ACCELERATION DUE TO GRAVITY

ACCELERATION DUE TO GRAVITY

Why do objects fall? The simple answer is because of ***GRAVITY***. Gravity is something we can observe. We can see an object fall to Earth and measure the time it takes to do so. Due to this, we can classify this knowledge of gravity as ***EMPIRICAL***.

Empirical:

Theoretical:

There are many aspects pertaining to the laws of gravity that are theoretical, however, in this course we will stick to the empirical measurements.

The consequence of gravity is that objects close to the Earth are pulled in by a force towards the center of the planet. After many experiments, Galileo (1604) noticed that this force acts on all objects equally and is therefore a ***constant***.

This constant is called the ***ACCELERATION DUE TO GRAVITY*** and describes the motion of falling objects towards a large body (such as a planet).

On planet Earth, this gravitational constant is 9.81 m/s^2. This means, if we ignore air resistance, all objects (regardless of mass) accelerate towards the Earth at a rate of 9.81 m/s^2.

PHYSICS

ACCELERATION DUE TO GRAVITY

FORMULAE	
$a = \frac{v_2 - v_1}{t}$	$d = v_1 t + \frac{1}{2} a t^2$

Video Example:

a) *What is his acceleration to the first data point (at t = 21s) in m/s²? Does it match the Earth's constant (9.81m/s²)? Thoughts?*

b) *Calculate acceleration again using data points from later in his jump (t = 30s and t = 40s). Same/Different? Thoughts?*

c) *Are we able to determine how far he has fallen to this point?*

d) *Eventually, during his free fall, he stops accelerating and begins to decelerate (t = 60s to t = 63s). Thoughts?*

PHYSICS

ACCELERATION DUE TO GRAVITY

Ex. 2 a)*Fire!!! We have to jump out the back window to escape. The ground is 5 m below us. If we jump up in the air with an initial velocity of 3 m/s [up], how long will it take us to hit the ground?*

b) *How fast do we hit the ground below (convert to km/h)?*

c) *Once you crash into the ground, it takes you 0.1 s to stop. What is your deceleration?*

d) *For fun only !!! - Calculate the g-force experienced*

PHYSICS

ACCELERATION DUE TO GRAVITY

Ex: *A professional football player can kick a ball with an initial velocity of 30 m/s [up].*

a) *When will the ball reach its max height?*

b) *How far up in the air will the ball be at its max height?*

c) *What is the total flight-time of the ball?*

PHYSICS

HOMEWORK

The equations of kinematics for uniform acceleration also apply to the special case of an object that is accelerating near the earth's surface. The gravitational pull of the earth on any object will cause it to accelerate towards the centre of the earth at a rate of 9.80 m/s^2, assuming air resistance is negligible. Thus, for any equations involving a body in free fall (something that is dropped or thrown) we can use the same problem solving skills we already have. There are a few unique features to solving freefall problems.

a) acceleration is always constant at $g = -9.80\ m/s^2$ (the negative is very important)

b) at the top of its flight, an object has $v = 0$. (since it must stop before starting to come down again)

c) keeping your sign conventions for direction is very important...all velocity directed down must be negative, and all velocity directed up must be positive.

1. A tourist drops a rock from rest from a guard rail overlooking a valley. What is the velocity of the rock at 4.0 s? What is the displacement of the rock at 4.0 s?

2. Suppose the tourist in question #1 instead threw the rock with an initial velocity of 8.0 m/s [down]. Determine the velocity and displacement of the rock at 4.0 s (Remember the v_i is down and must become a -8.0 m/s)

3. Suppose the tourist in question #1 instead threw the rock with an initial velocity of 8.0 m/s [up]. Determine the velocity and displacement of the rock at 4.0 s (Remember the v_i is up and must become a +8.0 m/s)

4. A college student wants to toss a textbook to his roommate who is leaning out of a window directly above him. He throws the book upwards with an initial velocity of 8.0 m/s. The roommate catches it while it is travelling at 3.0 m/s [up].
   a) How long was the book in the air?
   b) How far vertically did the book travel?
   c) Redo the problem, and have the roommate catch the book as it is travelling 3.0 m/s [down]. What is the time and displacement now? Do you notice anything?

5. A man is standing on the edge of a 20.0 m high cliff. He throws a rock vertically with an initial velocity of 10.0 m/s.
   a) How high does the rock go? (Remember that at its max height $v = 0$ m/s)
   b) How long does it take to reach its max height?