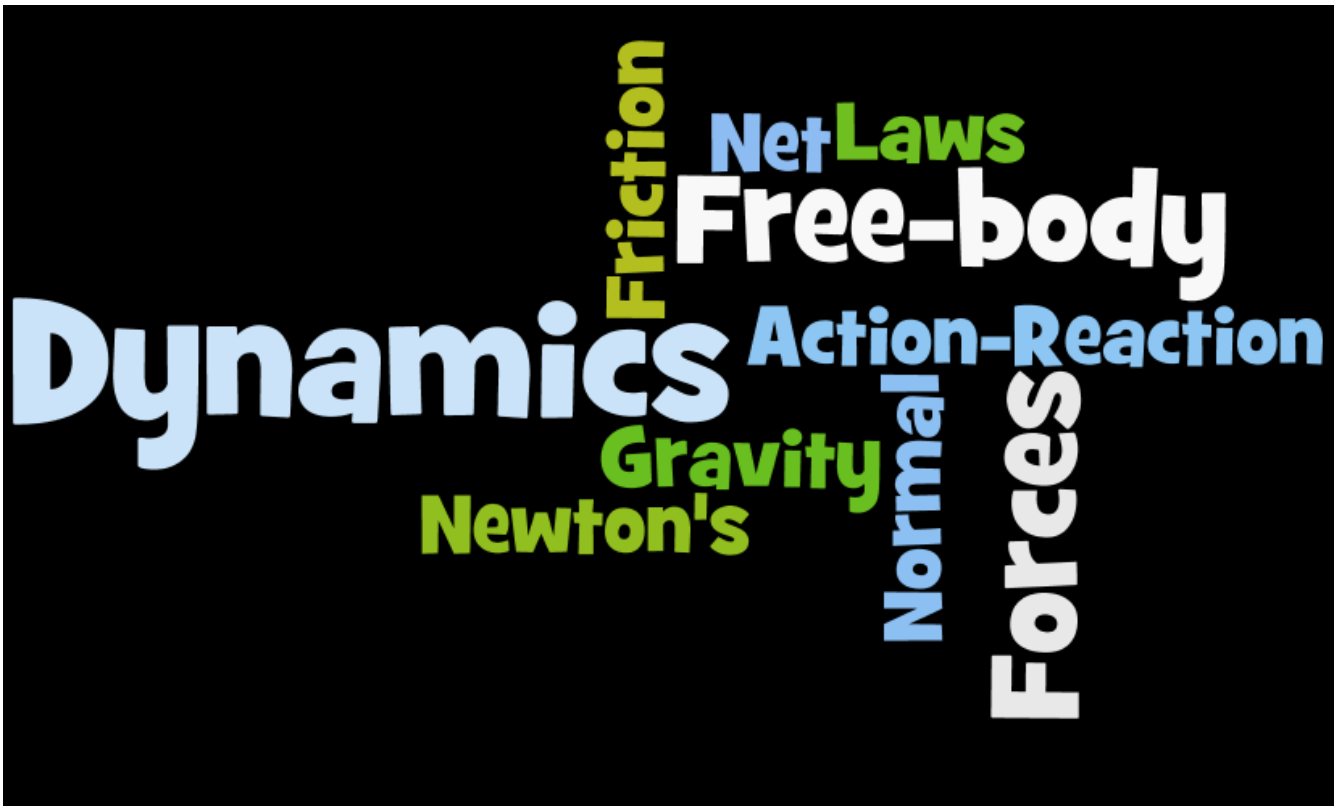
Friction
Net
Laws
Free-body
Dynamics
Action-Reaction
Gravity
Normal
Forces
Newton's

Dynamics

In our first unit, we examined both scalar and vector quantities. These physical quantities existed without any consideration to what caused them. Dynamics is a branch of physics that deals specifically with the causes of motion. For any motion to exist, there had to have been a cause.

Force

Force is defined as a push or a pull on an object. Each force has a magnitude (size), unit (Newton, N), and a direction.

ex. 8 N [For] 50 N [N 40° W]

The symbol for force is the Newton, N.

$1\ N = 1\ kg\ m/s^2$

1 N of force is equivalent to the force required to accelerate a 1 kg object at $1\ m/s^2$.

Types of Forces

1. Force of Gravity, $\vec{F_G}$
2. Normal Force, $\vec{F_N}$
3. Force of Friction, $\vec{F_F}$
4. Applied Force, $\vec{F_A}$
5. Force of Resistance, $\vec{F_R}$
6. Elastic Force, $\vec{F_E}$

Free Body Diagrams

A Free Body Diagram is a diagram of an object (at its center of gravity) removed from its surroundings, only showing the different forces acting on it.

A Free Body Diagram is a "tail to tail" diagram

For example, consider a 10000 N car with an applied force of 3000 N E and a frictional force of 1000 N W acting on it.

When the $\vec{F}_A$ and $\vec{F}_F$ are <u>collinear</u>

we can use the $\vec{F}_{NET}$ formula, however when these 2 forces are <u>non-collinear</u> we must use a "tip to tail" diagram to calculate F_{NET}. Will F_G and F_N always cancel each other out? Why?

Ex 5)

a) A tow truck starting to tow a damaged car exerts a force of 4000 N [E] on the car. A 1500 N [W] force of friction slows down the car's motion. The force of gravity on the car is 8000 N [Down]

Calculate the $\vec{F}_{NET}$ and draw a FBD.

Calculating F_{NET} with Non-Collinear Forces

b) Two football players tackle a rival player exerting forces on him/her at the same time. The forces are 300 N [N] and 300 N [W]. Draw a FBD and then calculate the net force.

c) Draw a FBD showing three forces, 40 N [W], 50 N [N 30° E], and 60 N [E]. Calculate the net force if those forces are acting on you.

Pull

Mass and the Force of Gravity, $\vec{F}_G$

- mass is defined as the amount of matter in an object at any given time.
- mass remains relatively constant
- mass is measured with an equal arm balance.
- any 2 objects in our universe have a certain amount of gravitational attraction between them.
- the force of gravity between any 2 objects may change depending on:
  - mass of individual objects
  - position of objects
    - earth?
    - moon?
  - distance between 2 objects.
- in general, the force of gravity between any 2 objects in the universe is directly proportional to the product of their masses and inversely proportional to the square of the distances between their centers. The relationship can be summarized as follows:

$$\vec{F}_G = \frac{G m_1 m_2}{(\Delta d)^2}$$

Gravitational Attraction Formula

m_1, m_2 } masses of objects in kg

Δd - distance between centers, in m

G - "universal gravitational constant" $= 6.67 \times 10^{-11}$

$\vec{F}_G$ - force of gravitational attraction, in N [toward each other]

eg) Calculate the $\vec{F}_G$ between an 80kg mass and 55kg mass that are 0.6m apart.

Gravitational Field Intensity (g.f.i.)

- every celestial body exerts a force of gravity on a mass at its surface.
- the greater the mass, the greater the "pull" down.
- the ratio of the mass and the force of gravity at a specific location is called the g.f.i., $\vec{g}$.

g.f.i. formula aka "weight" formula

$$\vec{g} = \frac{\vec{F}_G}{m} \quad \text{or} \quad \vec{F}_G = m\vec{g}$$

- on earth, we are all subject to the same g.f.i., that is the $\vec{F}_G$ affects us all the same. On earth, ...

$$\vec{g} = 9.8\ N/kg\ [Dn]$$

- on the moon, $\vec{g}$ is only 1.6N/kg [Dn]
- on the sun, $\vec{g}$ is 270 N/kg [Dn]
- on Jupiter, $\vec{g}$ is 24.6 N/kg [Dn]

Acceleration Due To Gravity

Since $\vec{g}$, gravitational field intensity at or near the earth's surface is $9.8\ N/kg$ [Down], all objects, in the absence of friction fall at the same rate. This rate is $9.8\ m/s^2$ [Down] G.F.I. and acceleration due to gravity are identical! This means that all kinematics formulas with an $\vec{a}$ in them can be written with a $\vec{g}$ instead. For example,

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$ becomes

$\vec{v}_2 = \vec{v}_1 + \vec{g}\Delta t$

* change all kinematics formulas

ex's)

a) The time the Demon Drop ride at Cedar Point, Ohio, is freely falling is 1.5 secs.
a) What is the coaster's final velocity?
b) How far does it fall?

b) A brick falls freely from a high scaffold.
a) What is the brick's velocity after 4 sec
b) How far does the brick fall during the 4 secs?

c) A tennis ball is thrown straight up with an initial velocity of 22.5 m/s [illegible]. It is caught at the same height above the ground from which it is thrown.
a) How high does the ball rise?
b) How long does the ball remain in the air?

Physics 2204 **Worksheet #5**

Freefall-Acceleration due to Gravity

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?

HIA

Practice Questions

1. A man falls 1 meter to the floor.
a) How long does the fall take?
b) How fast is he going when he hits the floor?
2. A pitcher throws a baseball straight up with an initial velocity of 27 m/s.
a) How long does it take for the ball to reach its highest point?
b) How long does the ball rise above its release point?
3. A stone falls freely from rest for 8 seconds.
a) Calculate the stone's velocity at the end of this time.
b) What is the stone's displacement during this time?
4. A student drops a rock from a bridge to the water 12 m below. With what speed does the rock hit the water?
5. Kyle is flying a helicopter when he drops a bag. When the bag has fallen for 2 seconds,
a) What is the bag's velocity?
b) How far has the bag fallen?
6. Kyle is flying the same helicopter and it rising at 5 m/s when he release the bag. After 2 seconds,
a) What is the bag's velocity?
b) How far has the bag fallen?
c) How far below the helicopter is the bag?
7. Kyle's helicopter now descends at 5 m/s as he releases the bag. After 2 seconds,
a) What is the bag's velocity?
b) How far has the bag fallen?
c) How far below the helicopter is the bag?
8. A weather balloon is floating at a constant height above the earth when it releases a pack of instruments.
a) If the pack hits the ground with a velocity of 73.5 m/s [Down], how far does the pack fall?
b) How long does the pack fall?