Unit 2: Newton's Laws

Note 1 : Forces

Force:

The units of force are:

There are four fundamental forces that make up all of the forces in the universe:

1)
2)
3)
4)

Force of Gravity

Force of Gravity:

Mass (kg):

Weight (N):

Mass is_____throughout the universe but weight_____depending on where you are.

The formula for Force of Gravity is

Where

m =

g =

g varies depending on…

For Example:

- On Earth at sea level, g =
- On the moon, g =
- On Jupiter, g =
- On the sun, g =

Determine your weight on Earth, the moon and Jupiter (in Newtons)

Your Mass:_____kg (1 kg = 2.2 lbs) Weight on Earth:

$F_g = mg$

=

Weight on the Moon:

Weight on Jupiter:

Activity:

Jumping on the Moon

Purpose: To determine how high you could jump on the surfaces of the Moon and the Sun. Procedure:

1. Have your lab partner measure your best vertical on Earth.
2. Determine the initial velocity of your jump. We will assume that your initial jump velocity will be the same on the Moon and the Sun.
3. Find your vertical and hang time on the moon using an acceleration = -1.60 m/s^2.
4. Find your vertical and hang time on the Sun using an acceleration = -274 m/s^2.

Earth	Moon	Sun
Vertical:_____	Vertical:_____	Vertical:_____
Vo = _____	dmax = _____ t = _____	dmax = _____ t = _____

A Quick Aside on G-Forces

"G-forces" are actually a measurement of *acceleration* experienced by an object. It is related to the supporting reaction force that an object experiences due to acceleration. While at rest on Earth you are experiencing 1 *g*.

$$1\ g = 9.80\ m/s^2$$

For Example:

A car accelerates at 4.9 m/s^2, how many g's is that?

During lift-off a shuttle will accelerate at 28 m/s^2. How many g's are experienced by the astronaut?

A normal human can withstand 4.0 g's, while a fighter pilot can withstand up to 9.0 g's. What acceleration would cause each to pass out?

Unit 4: Newton's Laws

Newton's 1st Law

Newton's 1st Law:
An object in motion will…
and an object at rest will…
unless…

This is also referred to as the **Law of Inertia**.

Inertia:

Imagine that you are racing around a track on a go-kart. List *three* times when you notice your *inertia*.

1)

2)

3)

Another way of thinking of Newton's 1st Law is that if there is no net force on an object then it will stay at a constant velocity.

If it is not moving then it has a constant velocity of zero!!!

Ex. Imagine a book sitting on a table. There is a force of gravity pulling down on the book, but there is also a supporting (normal) force pushing up on the book.

Ex. If I drop the book from 2 m, there is only a downwards, gravitational force acting on it. Now that the forces on it are **unbalanced**, what does the book do?

Examples:

1) While riding a skateboard (or chuckwagon or unicycle, whatever), you fly forward off the board when hitting a curb or rock or other object which abruptly halts the motion of the skateboard.

2) The head of a hammer can be tightened onto the wooden handle by banging the **bottom** of the handle against a hard surface.

3) While you are sitting in the back seat of the car, it makes a hard right turn. You squish your sister against the side door (CORNERS!!!).

4) Headrests are placed in cars to prevent whiplash injuries during rear-end collisions.

Unit 4: Newton's Laws

Newton's 2nd Law

Newton's 2nd Law:

Stated as a formula:

Note that…

Ex. A 5.0 kg block is pushed to the right along a frictionless track with a force of 10.0 N. What is its acceleration?

Ex. A 650 kg car accelerates at 4.0 m/s^2 south. What is the net force acting on it?

Ex: A 1500 kg ice cream truck accelerates from rest to a top speed of 45 km/h in 8.0 s. What was the net force acting on the truck?

To find F_{net} when two forces work together …

Ex. Stan and Kyle are pushing a 75 kg sled along a frictionless ice rink. Stan pushes with 55 N and Kyle pushes with 45 N. Find the sled's acceleration.

To find F_{net} when many forces act on an object:

Ex: The Batmobile exerts a force of 8.50×10^3 N east, while friction pulls back on it with a force of 1500 N. If it has a mass of 1250 kg, what is its acceleration?

Unit 4: Newton's Laws **- FBDs**

Force	Description

Ex 1: A box is pushed across a rough floor at a constant velocity.

Ex 2: A hockey player glides on frictionless ice at a constant velocity.

1. A book is at rest on a table top.

2. A girl is suspended motionless from a bar which hangs from the ceiling by two ropes.

3. An egg is free-falling from a nest in a tree. Neglect air resistance.

4. A plane flies at a constant velocity (**Note**: there will be an applied force generated by the engines as well as a lift force provided by the wings).

5. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance.

6. A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance.

7. A college student rests a backpack upon his shoulder. The pack is suspended motionless by one strap from one shoulder.

8. A skydiver is descending with a constant velocity. Consider air resistance.

9. A force is applied to the right to drag a sled across loosely-packed snow with a rightward acceleration.

10. A football is moving upwards towards its peak after having been *booted* by the punter.

11. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.

Unit 4: Newton's Laws

Newton's 3rd Law

Newton's 3rd Law:

Any interaction involves two forces that we call…

1) You hit a baseball with a bat.

2) A sprinter starts running.

3) A fish swims through water.

Imagine a bug hitting the windshield of a semi trailer.

What force pair occurs?

Which force is bigger?

Which object has a greater acceleration?

Example 1: Recoil

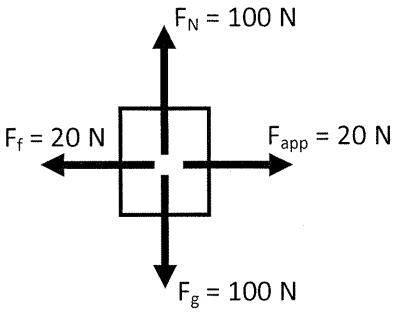
Example 2: Bricks

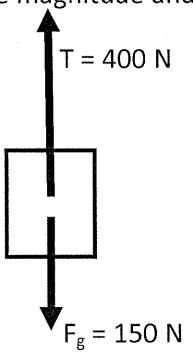
Example 3: Rockets

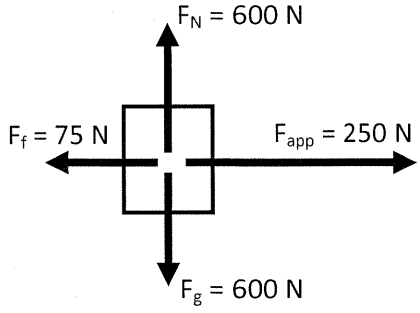
Worksheet 4.1

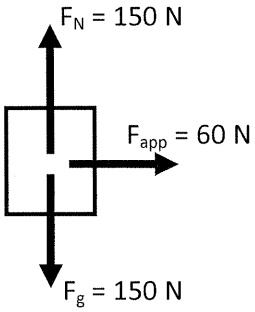
Newton's 2nd Law

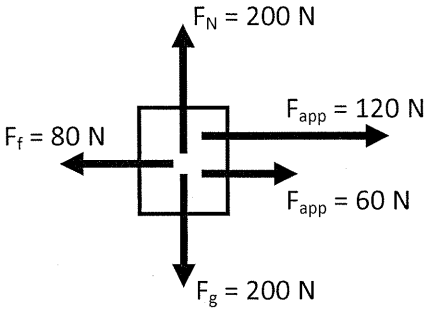
1) For each of the following diagrams determine the magnitude and direction of the net force.

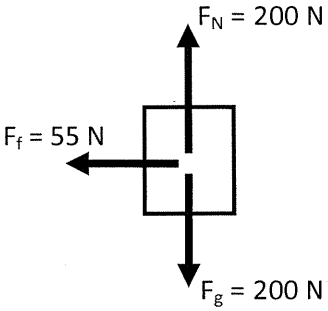




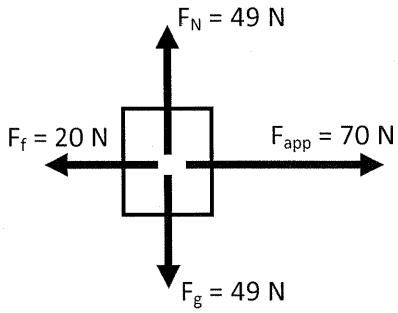






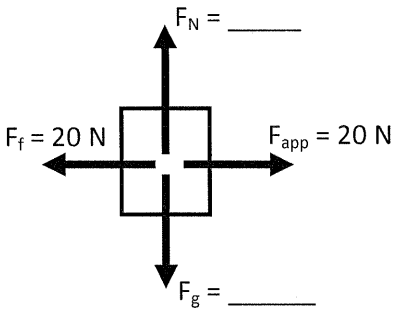


2) Use the information given for each diagram to fill in all missing blanks.



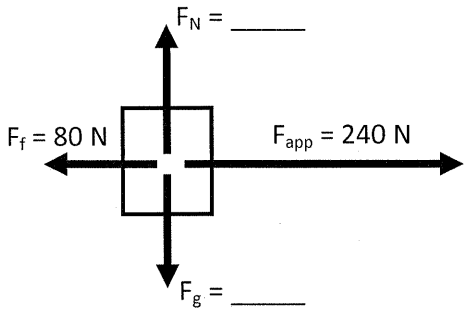
m = 5 kg

a = _____ m/s^2



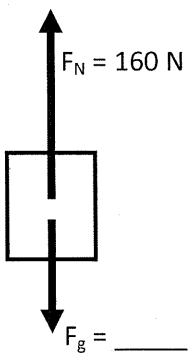
m = 12 kg

a = _____ m/s^2



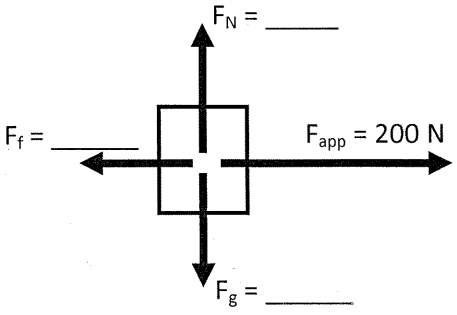
m = _____

a = 4 m/s^2 right



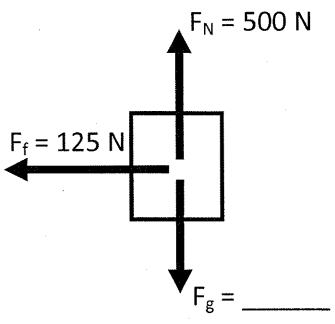
m = 8 kg

a = _____ m/s^2



m = 40 kg

a = 4 m/s^2 right



m = _____

a = _____ m/s^2

Worksheet 4.2: Newton's Second Law Worksheet #2

1) A 1100 kg car accelerates from rest to 60.0 km/h over a distance of 45 m. Find the net force acting on the car.

2) A 1400 kg car is traveling at 24 m/s when the driver takes his foot off of the gas. The car eventually rolls to a stop after 225 m. Find the force of friction acting on the car.

3) A 950 kg car travels at a constant speed of 35 m/s. If 350 N of friction act on the car, what is the applied force provided by the engine?

4) Ernie pushes Bert on a toboggan across some frictionless snow. Bert and the toboggan have a total mass of 85 kg and they are accelerating at 3.0 m/s^2.

a. Find Ernie's applied force (F_{Ernie})

b. If Ernie and Bert hit a bare patch of concrete that exerts a force of friction on the sled of 180 N, what will their acceleration be in this time?

5) A student raises their 15 kg backpack from the floor at a constant velocity of 5.0 m/s. How much force must the student apply?

6) A physics teacher attaches a 4.0 kg brick to a light string (boy do you need a new hobby!) and pulls straight up on it. The brick accelerates upwards at 3.2 m/s^2. How much force did the teacher apply to the brick?

7) A 75kg skydiver falls at terminal velocity (220 km/h) before pulling the chute. If she slows to 25 km/h in 3.8 s, determine the average force of air friction that acts on her during her deceleration.

8) A 45 kg chimpanzee on a skateboard accelerates from rest to 13.0 m/s over a distance of 8.0 m. A force of friction of 65 N acts on the board. What force must the chimp apply?

9) A 1350 kg crash test car strikes a cement wall at 24.0 m/s and bounces back at 8.0 m/s.
a. If it is in contact with the wall for 0.90 s, what force did the wall exert on the car?

b. If the same car had no crumple zones then it would only be in contact with the wall for 0.080 s. What force would the wall exert in this case?

1) 3400 N 2) 1800N 3) 350 N 4) a. 260 N b. 0.88 m/s^2 5) 150 N 6) 52 N 7) 1800N 8) 540 N 9)a. 4.3×10^4 N b. 5.4×10^5 N

Worksheet 3: Newton's 3rd Law
ACTION-REACTION FORCES

1. According to Newton's third law, each team in a tug of war pulls with equal force on the other team. What, then, determines which team will win?

2. According to Newton's third law, every force is accompanied by an equal and opposite *reaction* force. The reason that these forces do not cancel each other is ____.

a. the action force acts for a longer time period

b. the two forces are not always in the same direction

c. one of the two forces is greater than the other

d. the two forces act upon different objects; only forces on the same object can balance each other.

e. ... nonsense! They do cancel each other. Objects accelerate because of the 3 of a third force.

3. When a rifle shoots a bullet, Newton's Third Law says that the force that the rifle exerts on the bullet is exactly the same size as the force that the bullet exerts on the rifle - yet the bullet gets a **much** greater acceleration than the rifle. How can this be?

4. Tam Anh grabs Sarah by the hand and tries to pull her. She tries to remain standing without moving. A student analyzes the situation as follows. "If Tam Anh's force on Sarah is greater than her force on him, he can get her to move. Otherwise, she'll be able to stay where she is." What's wrong with this analysis?

5. When jumping from a boat to shore, it is always advisable to tie up the boat before jumping. Why?

6. When a small bug is splattered across a fast moving windshield what experiences more force- the bug or the windshield?

7. Why does the force have a greater effect on the bug?

8. If we find a body that we know to be acted on by a force, but that is not moving, what inference can we draw about its state of motion?

9. In a tug-of-war, what is the net force acting on the rope when the participants each pull with opposing forces of 500 N? _____ What is the tensional force within the rope? _____

10. Why can you exert greater force on the pedals of a bicycle if you pull up on the handlebars?