Unit 3: Dynamics - **Forces**

There are four fundamental forces that make up all of the forces in the universe:
1)
2)
3)
4)

Force:

The units of force are:

**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 =

 =

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

Your Mass: \_\_\_\_\_\_\_\_\_\_\_ kg (1 kg = 2.2 lbs)

Weight on Earth:
 Fg = mg
 =

Weight on the Moon:

Weight on Jupiter:

**g varies depending on…**

For Example:

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

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/s2.
4. Find your **vertical** and **hang time** on the Sun using an acceleration = -274 m/s2.

**Sun**

dmax: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

t = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Moon**

dmax: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

t = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Earth**

Vertical: \_\_\_\_\_\_\_\_\_\_\_\_

vo = \_\_\_\_\_\_\_\_\_\_\_\_\_

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/s2

For Example:
A car accelerates at 4.9 m/s2, how many g’s is that?

During lift-off a shuttle will accelerate at 28 m/s2. 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 3: Dynamics
**Newton’s 1st Law**

Unit 3: Dynamics - **Newton’s 1st Law**

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

1)

2)

3)

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:**

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. 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?

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.

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 3: Dynamics - **Newton’s 2nd Law**

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?

Newton’s 2nd Law:

Stated as a formula:

Note that…

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?

Ex. A 650 kg car accelerates at 4.0 m/s2 south. What is the net force acting on it?

**To find Fnet when many forces act on an object:**

**To find Fnet when two forces work together …**

Ex: The Batmobile exerts a force of 8.50x103 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?

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.

**Worksheet** - Newton’s 2nd Law

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

FN = 100 N

Ff = 20 N

Fg = 100 N

Fapp = 20 N

FN = 600 N

T = 400 N

Ff = 75 N

Fapp = 250 N

Fg = 600 N

Fg = 150 N

FN = 200 N

FN = 200 N

FN = 150 N

Ff = 55 N

Fapp = 120 N

Ff = 80 N

Fapp = 60 N

Fapp = 60 N

Fg = 200 N

Fg = 200 N

Fg = 150 N

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

FN = \_\_\_\_\_

FN = \_\_\_\_\_

FN = 49 N

Fapp = 240 N

Ff = 80 N

Fapp = 20 N

Ff = 20 N

Fapp = 70 N

Ff = 20 N

Fg = \_\_\_\_\_

Fg = \_\_\_\_\_\_ N

Fg = 49 N

m = 12 kg
a = \_\_\_\_\_\_\_ m/s2

m = \_\_\_\_\_\_\_\_\_
a = 4 m/s2 right

m = 5 kg
a = \_\_\_\_\_\_\_ m/s2

FN = 500 N

FN = \_\_\_\_\_

FN = 160 N

Ff = 125 N

Ff = \_\_\_\_\_\_

Fapp = 200 N

Fg = \_\_\_\_\_\_

Fg = \_\_\_\_\_\_

Fg = \_\_\_\_\_

m = \_\_\_\_\_\_
a = \_\_\_\_\_\_\_ m/s2

m = 40 kg
a = 4 m/s2 right

m = 8 kg
a = \_\_\_\_\_\_\_ m/s2

|  |  |
| --- | --- |
| Force | Description |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Unit 3: Dynamics **- FBDs**

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

2. A girl sleeps in a hammock which is attached to 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.

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.

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.

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.

Worksheet - Newton’s Second Law Worksheet

1. 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.
2. 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?
3. 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/s2.
a. Find Ernie’s applied force (FErnie)

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?

1. 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?
2. 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/s2. How much force did the teacher apply to the brick?
3. 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.
4. 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?
5. 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. 0.94 m/s2 5) 150 N 6) 52 N 7) 1800N 8) 540 N 9)a. 4.8x104 N b. 5.4x105 N

Unit 3: Dynamics - **Newton’s 3rd Law**

1) 3400 N 2) 1800N 3) 350 N 4) a. 260 N b. 0.94 m/s2 5) 150 N 6) 52 N 7) 1800N 8) 540 N 9)a. 4.8x104 N b. 5.4x105 N

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

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Unit 3: Dynamics - **Force of Friction**

Friction is created whenever…

On the microscopic level…

Friction is given by the equation:

 Where:
 FN =
 =
 µ =
 =
 =

Static Friction:

Kinetic Friction:

**Frictionstatic Frictionkinetic**

**μ static μkinetic**

Ex 2: A 0.200 kg puck is pushed along a sheet of ice with a force of 0.240 N. If it moves at a constant velocity, find the coefficient of friction.

Ex 1: A 3.75 kg block is pushed along a tabletop with a force of 45.0N. The coefficient of friction is 0.65.

a) Find the force of friction.

b) Find the acceleration.

Ex 3: A 1.1 kg textbook is held against a vertical wall with a force of 45 N. What is the coefficient of friction between the book and the wall?

1) A 7.6 kg object is resting on a horizontal surface. What is the normal force on the object?

Worksheet - Force of Friction

2) A 7.6 kg object is pulled along a horizontal surface. If the coefficient of friction is 0.20, what is the force of friction?

4) A 9.6 kg object is pulled along a horizontal surface. If the coefficient of friction is 0.11 what is the force of friction?

5) A 20.0 N object is pulled along a horizontal surface at a constant velocity by a 3.0 N force, what is the coefficient of friction?

6) A 16.2 kg object is pulled along a frictionless surface by an applied force of 10.2 N, what is the normal force acting on it?

7) A 6.2 kg object is pulled along a horizontal surface by a force of 22.0 N. If its acceleration is 1.1 m/s2, what is the coefficient of friction between the two surfaces?

8) A 1250 kg car traveling at 60.0 km/h comes to a sudden stop in 35 m. What is the coefficient of friction acting on the brakes?

9) A 950 kg car traveling at a constant velocity of 28 m/s, has a coefficient of friction of 0.125 acting on its axle. How much force is required by the engine to maintain its speed?

10) A 1425 kg dragster exerts 13900 N of force and accelerates from 0 to 100.0 km/h in 3.25 s. What is the coefficient of friction acting on the car?

1) 74 N 2) 15 N 3) 137 N 4) 10. N 5) 0.15 6) 159 N 7) 0.25 8) 0.40 9) 1200 N 10) 0.123