# Note Booklet #3:

# Dynamics

**Force**

A force is simply any _____

The unit of force is _____

It is believed there are only 4 fundamental forces:

| | |
|---|---|
| 1. | 2. |
| 3. | 4. |

For example, if I push a chair this is really _____ force at a fundamental level. In practice, it is useful to differentiate forces as we experience them.

Some forces we will deal with in this course:

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

**Free body diagrams**

Free body diagrams show the _____ which affect an object. Arrows point in the direction the force acts; length of the arrows reflects the magnitude of the force.

| | |
|---|---|
| A box is pushed along a rough floor. | A sky diver is falling towards to Earth. |
| A ball which has just been thrown is travelling upwards | The thrown ball falls back downwards. |
| A very strong person pushes a desk East while a weaker person pushes the desk North. | A ball rolls down an incline. |

**Newton's First Law**

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

This is also called the _____

Inertia:

Another way of stating Newton's 1st law is that if an object has _____forces acting upon it, it will have constant velocity (if it is not moving it has constant velocity of 0)

Consider a book sitting on a desk, since it is not accelerating the normal force must be _____ to the force of gravity.

Consider a box being pushed at constant velocity, since it is not accelerating, the applied force must be _____ to the force of friction.

Consider a book sitting on the seat of a car, you hit the breaks and the book flies forward, why?

**Newton's Second Law**

Newton's second law deals with what happens when forces are unbalanced. It states that an object's acceleration will be in the direction of the net force and will depend on the mass of the object.

Heavier objects require _____ force to accelerate them.

Lighter objects require _____ force to accelerate them.

The key equation is:

This equation gives us the definition of the Newton:

A 5.0 kg block is pushed to the left with a force of 10.0 N. What is its acceleration?

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

Two people push a 50.0 kg block, one pushes to the left with a force of 56 N, the other pushes to the right with a force of 89 N. What is the net force acting on the block? What is the acceleration of the block?

Two people push a 750 kg truck, one pushes with a force of 65 N right, the other with a force of 79 N left. What is the net force acting on the truck? What is the acceleration of the truck?

**Newton's Third Law**

Every action has an _____and _____ reaction

**OR**

Forces come in _____, alike in type and magnitude but opposite in direction

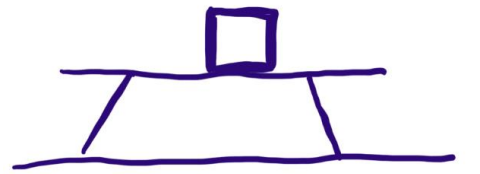
**OR**

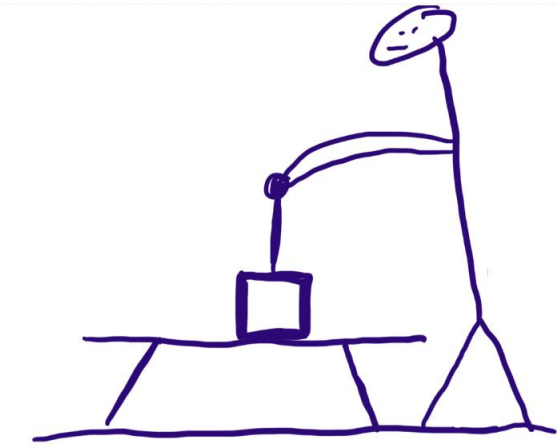
If you push something it pushes back with _____ force

**OR**

**What are the force pairs in each of the following situations?**

| A nail is hit with a hammer: | A book rests on a table: |
|---|---|
| | |

| **Situation:** *A block sits on a table supported by the floor*  | **Interaction Diagram** |
|---|---|
| **FBD:** *Block* | **FBD:** *Table* |

| | |
|---|---|
| **Situation:** *A block sits on a table supported by the floor, a person uses a rope to pull upwards on the block but it does not lift.*<br>  | **Interaction Diagram** |
| **FBD:** *Block* | **FBD:** *Table* |

**Inertial Mass**

The more mass an object has the greater its resistance to change in velocity. For example, to decrease the velocity of a 500 kg object 1 m/s requires 100 times more force than to decrease the velocity of a 5kg object the same amount.

How much force is required to change the velocity of a 2.0 kg object from rest to 5.0 m/s in 1.0 second?

How much force is required to change the velocity of a 2.0 kg object from 45.0 m/s to 50.0 m/s in 1.0 second?

How much force is required to change the velocity of a 2.0 kg from 5.0 m/s to rest in 1.0 second?

How much force is required to accelerate a 20.0 kg object at 5.0 $m/s^2$?

How much force is required to accelerate a 200.0 kg object 5.0 $m/s^2$?

**Force of Gravity**

The force of gravity attracts all _____ to _____

The more mass the more the force of gravity acts on the object. This is called _____ mass and is the same as inertial mass.

Mass is

Weight is

Mass is _____ but weight _____ depending where in the universe something is.

Force of gravity is determined using the equation:

Where m =

g =

On Earth g= on the moon it is g= on Jupiter g =

Determine the force of gravity acting on each of the following on Earth, then use Newton's second law to determine the acceleration due to gravity of each object.

A 86 kg man

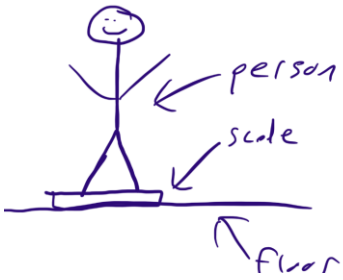
A 0.25 kg coffee cup

A 5800 kg elephant

Draw a FBD with magnitude of forces labelled for a 2.5 kg block which is sitting on a table.

**Scales, Weight and Mass**

A person stands on a bathroom scale to determine their mass.




Draw a FBD for the scale.

Draw a FBD for the person

The scale does not measure the mass of the person, rather it will show

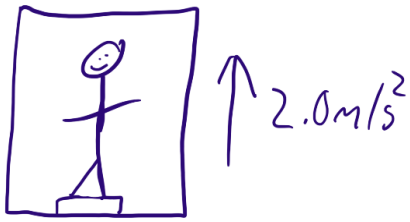
which will be equal to the

which is proportional to

Example: If the normal force between the person and the scale is 627 N

The normal force from the person onto the scale is called

A 50.0 kg person stands on a scale in an elevator which is accelerating upwards at 2.0 m/s$^2$. It could be speeding up going upwards, or slowing down going downwards, either is the same for our purposes.




What is the actual weight (force of gravity) of the person?

What is the net force acting on the person?

Draw a FBD for the person

What is the apparent weight of the person?

What will it appear that their mass is?

**Friction**

Friction is created whenever

On the microscopic level

Friction is given by the equation

Where $F_N$ = $\mu$ =

Static friction is

Kinetic friction is

| Static Friction | Kinetic Friction |
|---|---|
| $\mu_{static}$ | $\mu_{kinetic}$ |

**Example 1:** A 3.75kg block is on a tabletop. The coefficient of static friction is 0.65, the coefficient of kinetic friction is 0.53.

What force is required to start the block moving?

Once it has started moving what force is required to keep it moving at a constant velocity?

Draw a FBD of the block moving at a constant velocity with the magnitudes of all forces labelled.

**Example 2**: A 0.200 kg puck is pushed along a sheet of ice by an applied force of 0.240 N. If it moves at a constant velocity find the coefficient of kinetic friction.

**Example 3**: What is the maximum acceleration a 45 kg person can do if the coefficient of friction between them and the ground is 0.34?

**Example 4**: A 1.1 kg textbook is held against a wall by an applied force of 45 N. What is the minimum coefficient of static friction between the wall and book?

**Example 5**: A 0.200 kg puck with a coefficient of kinetic friction of 0.102 between it and the ice is shot a velocity of 26 m/s. How far will it travel before it stops?

**Tension**

Tension occurs _____ a material that is being pulled or stretched

It is an internal force at acts _____ along a rope (or string or chain) in _____

**Example 1:** Consider two carts, one 4.0 kg, the other 6.0 kg attached by a rope. The 6.0 kg mass is being pulled along a flat surface by a force of 60.0 N, friction is negligible.

a) What are the horizontal forces acting on the 6.0 kg cart?

b) What are the horizontal forces acting on the 4.0 kg cart?

c) What is the net force acting on the carts as a system?

d) What is the tension in the rope?

**Example 2**: A 6.0 kg and a 4.0 kg mass hang from a frictionless pully.

a) What will happen if the blocks are allowed to fall freely?

b) What is the net force acting on the system?

c) What will the acceleration of the blocks be?

d) Draw free body diagrams for the 6.0 kg block and the 4.0 kg block.

e) Determine the tension in the string connecting the blocks.

**Note: When solving for acceleration we consider the _____**

**When solving for tension we consider _____**

**Example 4:** An 8.0 kg mass is on a frictionless table and is connected with a rope to a 6.0 kg hanging mass. When the 6.0 kg mass is released determine the tension in the rope.

**Forces in 2D**

**EXAMPLE 1:** A block is pushed by two people, one towards the North, the other towards to East. The person pushing North pushes with a force of 65 N, the person pushing East pushes with a force of 45 N.

If we ignore friction what is the net force acting on the block?

What is the acceleration of the block if it has mass of 105 kg?

**EXAMPLE 2:** A 4.5 kg rocket is pointed perfectly horizontally, its engine outputs 25 N of force horizontally, gravity pulls the rocket downwards.

If we ignore air resistance what is the net force acting on the rocket?

What is the acceleration of the rocket?

**EXAMPLE 3:** A 25 kg block is pushed by two forces, a 62 N force at 38° N of E, and a 51 N force at 41° S of W.

What is the net force acting on the block?

What is the block's acceleration in the North/South direction?

How long will it take for the block to travel 35 m North?

**Inclines**

Draw an incline which makes an angle of $\theta$ with the horizontal.

Consider a block placed on the incline. Gravity pulls the block straight downwards while the Normal force acts perpendicular to the incline.

We can resolve the force of gravity into two perpendicular components:

Force parallel to the incline ( ) and the force perpendicular to the incline ( )

Key finding:

The parallel component of gravity will _____

The perpendicular component of gravity will _____

**Example 1:** A 8.0 kg block is placed on a frictionless 35° incline. What is the force acting to pull the block down the incline? What is the acceleration of the block?

**Example 2:** How much force is required to push a 24 kg block up a 52° incline at a constant velocity?

**Example 3:** How much force is required to push a 16 kg block up a 37° incline so that it accelerates at 1.2m/s$^2$?

**Example 4:** What is the normal force acting on a 29 kg block on a 26° incline?

**Inclines with friction**

**Example 1:** A 3.7 kg block is placed on a 21° incline with a coefficient of friction of 0.25. What will be the acceleration of the block down the incline?

**Example 2:** A 3.5 kg block is pulled upwards on a 36° incline by a force of 25 N. The coefficient of friction between the block and the incline is 0.23. What will be the acceleration of the block and in which direction?