Simple Machines

Definitions to know:

Work – *done when an applied force causes an object to move in the direction of the force*

Energy – *ability to cause change; can change the speed, direction, shape, or temperature of an object*

Load – *the weight being lifted by the simple machine*

Effort – *effort is the force placed on the simple machine to move the load. Also called* ***applied force*** *or* ***input force***

What are simple machines?

- Simple machines are tools that **make work easier**
- They have few or no moving parts
- These machines use energy to work
- Do work with one movement
- Make our work easier by letting us use less mechanical effort to move an object
- Simple machines make work easier for us by allowing us to **push or pull over increased distances**
- Use the idea of spreading force over distance: if you push further, you can use less force
  - You are doing the same amount of work — it just seems easier
  - You move an object a greater distance to accomplish the same amount of work.
- There's a trade–off of energy when using simple machines.
- Simple machines give us an advantage by **changing the amount, speed, or direction of forces**
- They allow us to use a smaller force to overcome a larger force
- The amount of effort saved when using machines is called **mechanical advantage** or **MA**

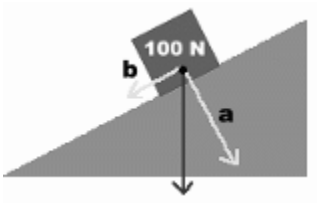
What are Compound or Complex machines?

- Two or more simple machines working together
- Most of the machines we use today are compound machines

Types of Simple Machines

- Two groups:
  - Inclined planes
    - Ramp
    - Wedge
    - Screw
  - Levers
    - Lever
    - Wheel & Axle
    - Pulley

Ramp or Inclined Plane

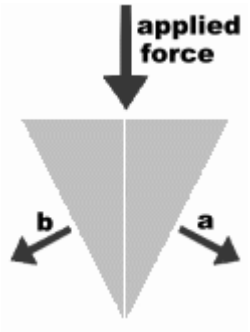


- Both terms are used
- A flat surface that is higher on one end - slanting surface connecting a lower level to a higher level.
- You can use this machine to move an object to a lower or higher place.
- Inclined planes make the work of moving things easier - allows us to raise an object with less effort than if we lifted it directly upward.
- You would need less energy and force to move objects with an inclined plane.
- **Trade-off**: The way an inclined plane works is that to save effort, you must move things a greater distance
  - The longer the distance of the ramp, the easier it is to do the work
  - It will take a much longer time to do the work
- The shallower the ramp, the easier it is to move the object
- The **trade-off** is that you must move the object farther to lift it to the same height

Examples of Inclined Planes:

- Ramp
- Slanted Road
- Path up a Hill
- Slide

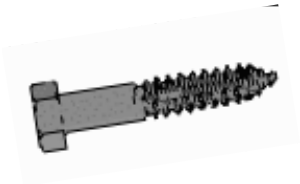
Wedge



- A wedge is a simple machine used to **push two objects apart**
- A wedge is usually made up of two inclined planes
- These planes meet and form a sharp edge. This edge can split or push objects apart
- A wedge is an inclined plane which moves
- A wedge can also be used as a lifting device, by forcing it under an object
- Most wedges (but not all) are combinations of two inclined planes.
- Can also be round, like the tip of a nail
- The narrower the wedge (or the sharper the point of a wedge), the easier it is drive it in and push things apart
- **Trade-off**: To split something apart really wide, you have to push the wedge a long distance.
- Generally it can be anything that splits, cuts, or divides another object including air and water

Examples of Wedges:

- Knife
- Axe
- Teeth
- Forks
- Nails



Screw

- An inclined plane that winds around itself

    - a wedge at the tip
- A screw has ridges and is not smooth like a nail
- Some screws are used to lower and raise things
- They are also used to hold objects together
- A screw is like the ramp —the width of the thread is like the angle of an inclined plane
    - The wider the thread of a screw, the harder it is to turn it.
    - **Trade-off**: The distance between the threads depends on the slope of the inclined plane - the steeper the slope, the wider the thread
    - Screws with less distance between the threads are easier to turn

Examples of Screws:

- Jar Lids
- Light Bulbs
- Stools
- Clamps
- Jacks
- Wrenches
- Spiral Staircase

Lever

- A lever is a board or bar that rests on a turning point
- This turning point is called the **fulcrum**
- An object that a lever moves is called the **load**
- The load is a force or object which must be overcome by the lever
- The **applied force** or **effort** or **input force** is the force you use to move the lever
- Lifts or moves loads
- By **changing the position of the fulcrum, you can gain extra power with less effort**
- The closer the object is to the fulcrum, the easier it is to move
- Most common simple machine because just about anything that has a handle on it has a lever attached
- The arm length of the lever is determined by the position of the fulcrum
- Used to transfer force
- It can be used to increase the force that is applied, or make something move in a different direction, or through a greater distance
- It can be used to lift something that is far away

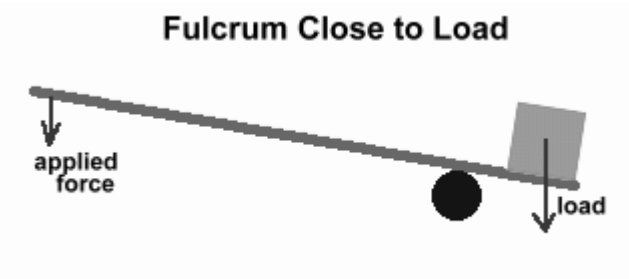
- It is the same principle as the inclined plane - the greater the distance over which the force must be applied, the smaller the force required to do the work (lift the load)
- Force moves over a longer distance
- Depending on where the fulcrum is located
- A lever can multiply either the force applied or
- The distance over which the force is applied

Three types of levers:

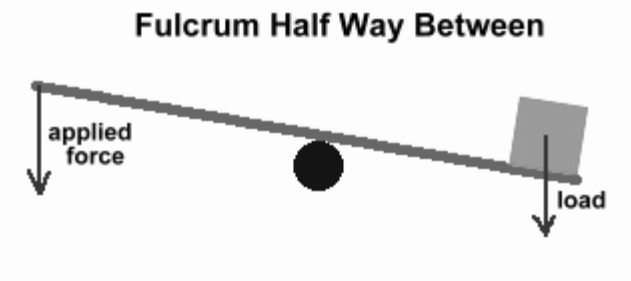
- 1st class
- 2nd class
- 3rd class

1st Class Levers

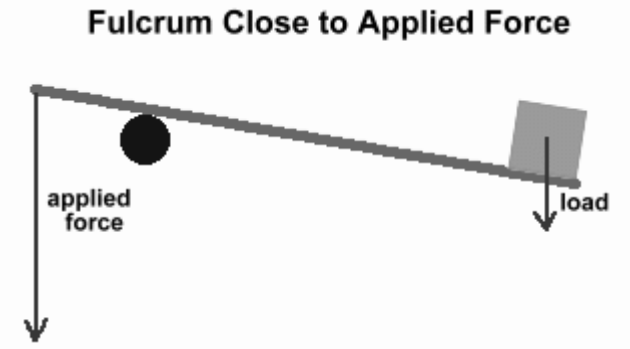
- ***Fulcrum in the center – between load & effort***
- The lever changes the direction of force



- The **fulcrum is placed close to the load**, and this will let you move the load with just a **small applied force (effort)**
- This type of lever system gives you a **mechanical advantage**, which means that the **force you apply gets multiplied**, so you can put a large force on the load.
- The **trade-off** of using a lever like this is that you have to apply a force over a *large distance*, and the load itself will move only a *short distance*



- The fulcrum is exactly **half way between the load and where you apply the force (effort)**
- This lever system has ***no*** mechanical advantage.
- Whatever force is necessary to move the load is the force you must apply
- This type of lever system takes advantage of another property of some levers: they **reverse the direction of the force**
- You can push in one direction, and the load moves the other way

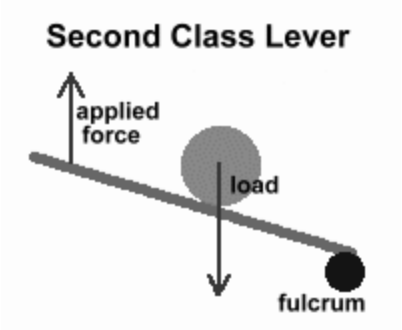


- The fulcrum is **nearer the applied force (effort)**
- Much more force than the force of the load itself must be applied
- If you're lifting something, it will require much more force than would be needed if you were to just lift the load by yourself – **this type lever system makes the work harder!!**
- This type of lever system usually uses a ***motor*** to lift the load
- The load is *far away*, and it moves a *long distance*
- We get a *small movement* where we applied the force

Examples of 1st Class Levers:

- See-saw
- Scissors
- Pliers

2nd Class Levers

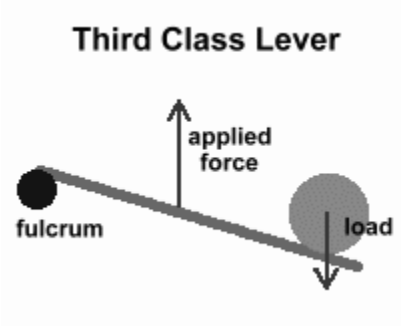


- ***The load is in the center – between the fulcrum and the applied force or effort***
- Causes the load to move in the **same direction** as the force you apply
- When the load is nearer to the fulcrum, the effort needed to lift the load will be less
    - If you want to move a very large load with a small effort, you must put the load very close to the fulcrum

Examples of 2nd Class Levers:

- Wheelbarrow
- Nutcracker

3rd Class Levers



- ***The applied force or effort is in the center – between the load and fulcrum***
- This lever system does **not give any mechanical advantage**
- No matter where you apply the force, the force you apply must always be greater than the force of a load
    - **No matter how close or how far the load is from the fulcrum, the effort used to lift the load, has to be greater than the load!**
- The load moves in the same direction as the force you apply
- A motor is usually used with this lever system to lift loads at a distance
- Speeds up movement

Examples of Third Class Levers:

- Your bent arm!
- Fishing rod

Wheel & Axle

- A wheel with a rod, called an axle, through its center lifts or moves loads
- The axle is a rod that goes through the wheel
- This lets the wheel turn
- The wheel & axle can be used as a tool to multiply the force you apply
- Or to multiply the distance traveled
- A lever that is able to rotate through a complete circle (360°)
- The circle turned by the wheel is much larger than the circle turned by the axle.
- The increased distance over which the force is applied as the wheel turns results in a more powerful force on the axle, which moves a shorter distance
- **Trade-off**: The larger the diameter of the wheel, the less effort you need to turn it, but you have to move the wheel a greater distance to get the same work done.

Examples of Wheels and Axles:

- Cars
- Roller skates
- Door knobs
- Gears

Pulleys

- Instead of an axle, the wheel could also rotate a rope or cord. This variation of the wheel and axle is the **pulley**
- In a pulley, a cord wraps around a wheel
  - As the wheel rotates, the cord moves in either direction
  - When a hook is attached to the rope you can use the wheel's rotation to raise and lower objects.
- The rope fits on the groove of the wheel
- One part of the rope is attached to the load
- When you pull on one side of the pulley, the wheel turns and the load will move
- Pulleys let you move loads up, down, or sideways

- Pulleys are good for moving objects to hard to reach places
- A pulley makes work seem easier because it changes the direction of motion to **work with gravity**
- A pulley saves the most effort when you have more than one pulley working together
- **Trade-off**: as you increase the number of pulleys, you also increase the distance you have to pull the rope
    - In other words, if you use two pulleys, it takes half the effort to lift something, but you have to pull the rope twice as far
    - Three pulleys will result in one-third the effort — but the distance you have to pull the rope is tripled!

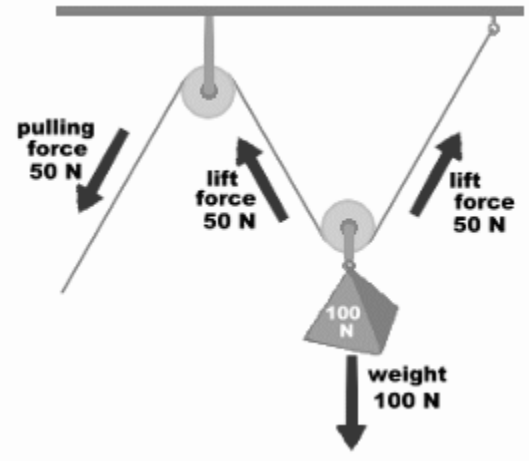
Types of Pulleys:

- Fixed pulleys
- Movable pulleys
- Single Pulleys
- Combination pulleys

Single Pulleys

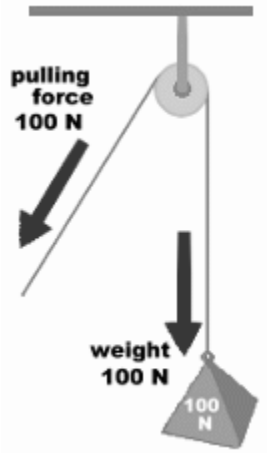
- A single pulley **reverses the direction of a force**
- With one pulley, the force you must pull with is the **same** as the weight of the object.
    - In order to raise the object a height of 1 meter, you must pull the rope 1 meter
- **Trade-off**: the end of the rope must move a greater distance than the load

Combination Pulley



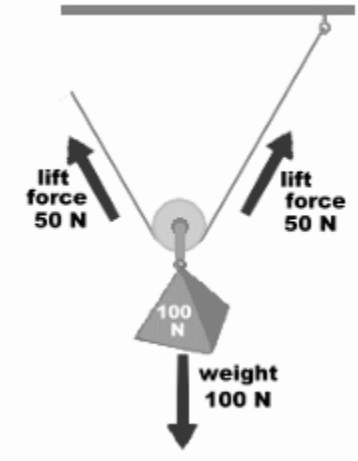
- Two or more pulleys connected together
- Allow a heavy load to be lifted with less force
  - Effort needed to lift the load is less than half the weight of the load
- The main advantage of this pulley is that the amount of effort is less than half of the load
- **Trade-off** - you need more rope and you need to pull more rope!

Fixed Pulleys



- May be single or combination
- Doesn't change position
- Makes work easier by changing the direction of the applied force
- The force required to lift the load remains the **same** as lifting it without the pulley
  - But it is much easier it is to raise a flag from the ground, instead of climbing up the pole
- If a force needs to be applied around a corner, a pulley allows us to overcome friction
- The only pulley that when used individually, **uses more effort** than the load to lift the load from the ground
- The fixed pulley is attached to an unmovable object like a ceiling or wall
  - Acts like a first class lever with the fulcrum being located at the axis
  - The bar or lever arm becomes a rope
- The advantage of the fixed pulley is that you do not have to pull or push the pulley up and down.
- The **trade-off** is that you have to apply more effort than the load

Movable Pulleys



- May be single or combination
- A pulley that moves with the load (both the load and the pulley move)
  - The load moves in the **same direction as the applied force**
- The movable pulley allows the effort to be less than the weight of the load
  - It takes less force to raise an object than if you used only your hands
  - The amount of **force required depends on the number of supporting ropes**
  - The greater the number of pulleys and supporting ropes, the smaller the force required.
  - **Trade-off:** the less force required, the greater the distance the rope must be pulled further than the load actually moves
- The movable pulley acts as a second class lever
  - The load is between the fulcrum and the effort
- The main advantage of a movable pulley is that you use less effort to pull the load

Examples of Pulleys:

- Flag Poles
- Sailboat
- Blinds
- Crane