Preview of Period 7: Simple Machines and Mechanical Advantage

7.1 Levers

How do machines, such as levers, reduce the force needed to lift heavy objects?

7.2 Examples of Levers

How does the use of levers make our lives easier?

7.3 Lever Arm Length and Distance Moved

How does the length of the lever arm relate to the distance the ends of the arm move?

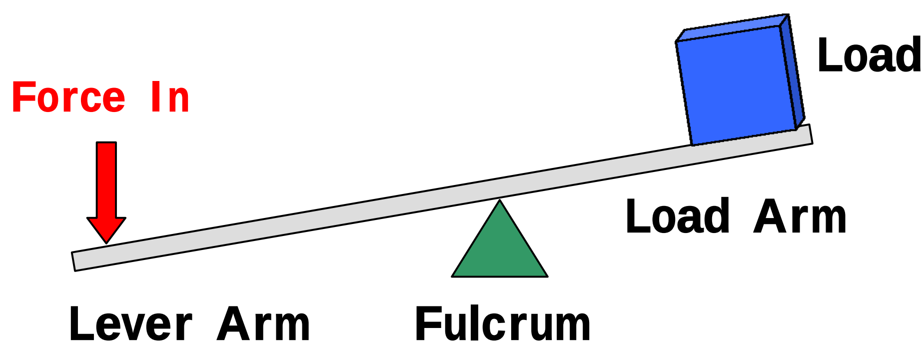
7.4 How Do Levers Work?

Why can we use the length of the lever and load arms to find the forces on the lever?

7.5 Mechanical Advantage

What is the theoretical and actual mechanical advantage of a simple machine?

Act. 7.1: Levers – Fulcrums and Forces

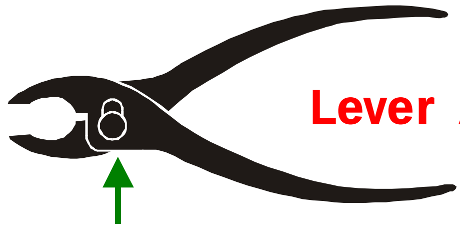


Machines allow you to lift heavy objects easily.

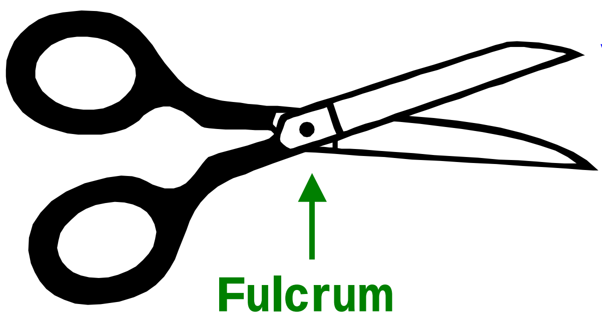
You can apply a small force in over a long lever arm to produce a large force out over a short load arm.

Examples of Levers

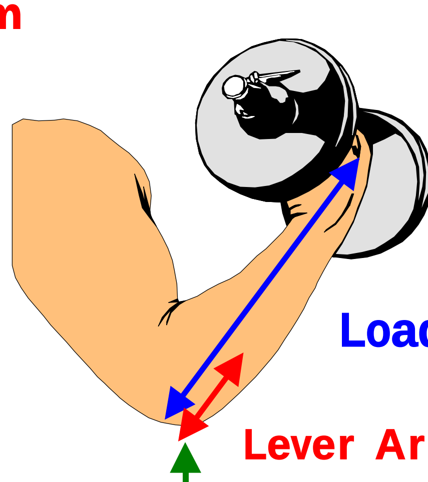
Pliers



Scissors



Human Arm



Act 7.3: Lever Arm Length and Distance Moved

What is the relationship between

- **the length of a lever arm and the distance the end of the lever arm moves?**
- **the length of the load arm and the distance the end of the load arm moves?**

With your measurements, you can form two ratios:

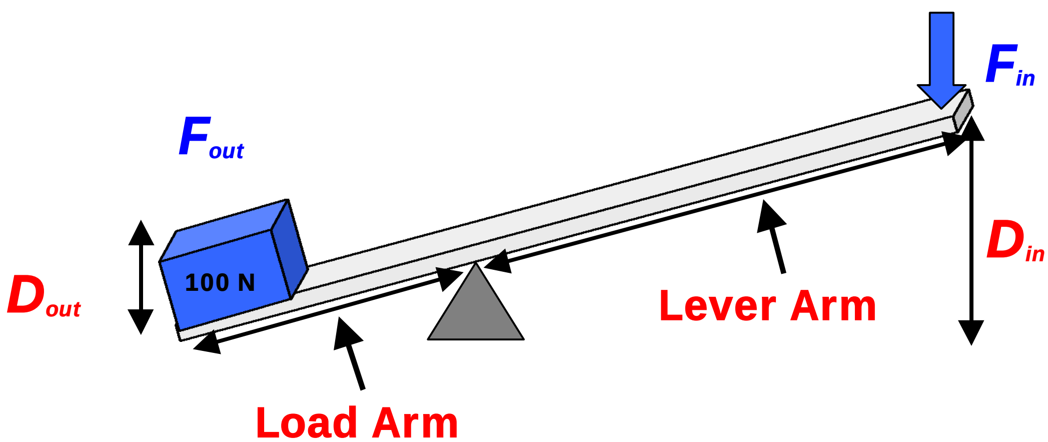
$$\frac{D_{in}}{D_{out}} \quad \text{and} \quad \frac{\text{lever arm}}{\text{load arm}}$$

What is the relationship between these ratios?

Act 7.4: Another Way to Describe Levers

What is the relationship between

- **the forces in and out and**
- **the distance the ends of the lever arms move?**



$$F_{in}\ D_{in} = F_{out}\ D_{out}$$

Calculations with Force and Distance

(Example 7.1)

Using a lever, you lift a 20 kg box a distance of 0.5 meters. If you apply a force of 50 newtons to the lever, over what distance must the lever move?

$$F_{in}\ D_{in} = F_{out}\ D_{out}$$

Solve the equation for D_{in} by dividing both sides by F_{in}

$$\frac{\cancel{F_{in}}\ D_{in}}{\cancel{F_{in}}} = \frac{F_{out}\ D_{out}}{F_{in}} =$$

$$\frac{20\ \cancel{kg} \times 9.8\ \cancel{m/s^2} \times 0.5\ m}{50\ \cancel{kg}\ \cancel{m/s^2}} = 2.0\ m$$

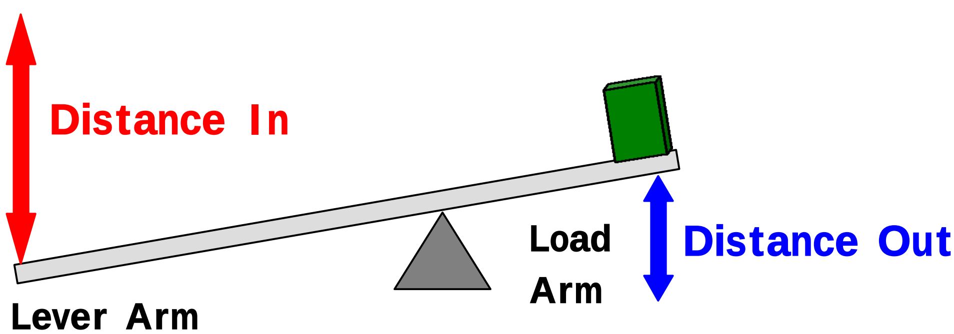
Act 7.5: Theoretical Mechanical Advantage

Theoretical mechanical advantage assumes no energy is wasted by frictional forces.

$$MA_{theoretical} = \frac{D_{in}}{D_{out}}$$

D_{in} = **distance you move the machine**

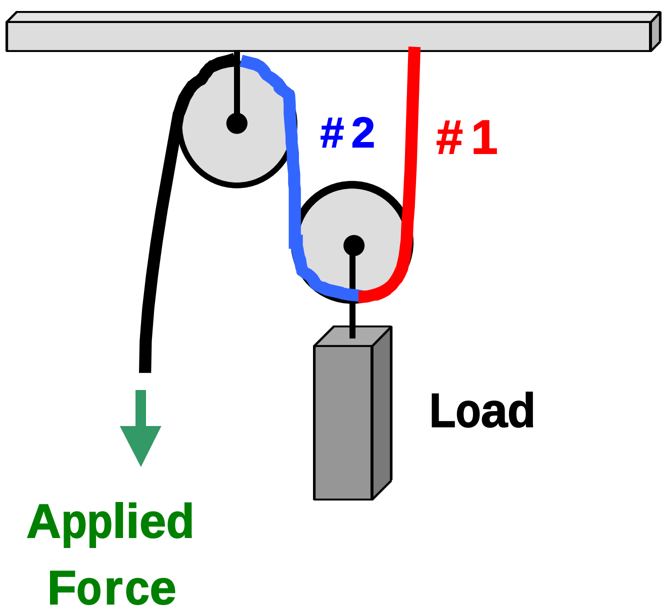
D_{out} = **distance the load moves**



Theoretical Mechanical Advantage of

Pulleys or Block and Tackles

The theoretical mechanical advantage of a pulley system equals the number of directly attached rope segments supporting the load. (The rope you pull on to apply force does not count.)



This pulley system has two attached ropes, so its theoretical mechanical advantage = 2

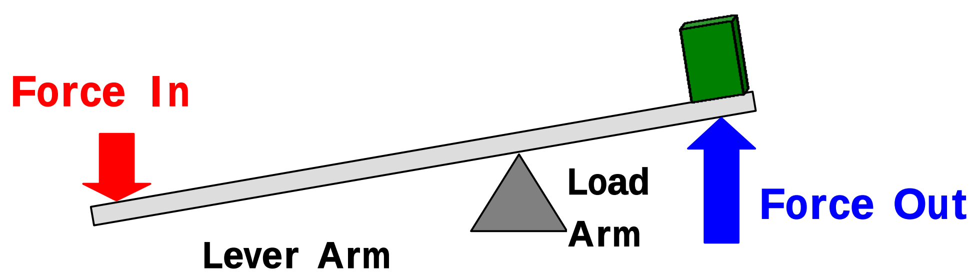
Act 7.6: Actual Mechanical Advantage

The actual mechanical advantage of a machine takes into account the energy wasted by frictional forces.

$$MA_{actual} = \frac{F_{out}}{F_{in}}$$

F_{in} = force you exert on the machine

F_{out} = force exerted on the load by the machine



Force Out = Weight of Load = Mg

Summary of Mechanical Advantage of Machines

Theoretical Mechanical Advantage

$$MA_{theoretical} = \frac{D_{in}}{D_{out}}$$

D_{in} = distance you move the machine

D_{out} = distance the load moves

Theoretical mechanical advantage is an ideal case with no energy wasted by frictional forces.

Actual Mechanical Advantage

$$MA_{actual} = \frac{F_{out}}{F_{in}}$$

F_{in} = the force you exert on the machine

F_{out} = the force exerted on the load by the machine

Actual mechanical advantage takes into account the energy wasted by frictional forces.

Period 7 Summary

7.1: Machines make tasks easier by exerting a smaller force over a larger distance.

The amount of work done is NOT reduced.

7.2-3: If the energy wasted by frictional forces is ignored, Work in = Work out, or

$$F_{in} \times D_{in} = F_{out} \times D_{out}.$$

Levers consist of load arms and lever arms. The lever pivots on a fulcrum.

The placement of the fulcrum determines the amount of force needed to move a load.

The ratio of the distance the ends of the lever arms move equals the ratio of the lengths of the arms.

$$\frac{D_{in}}{D_{out}} = \frac{L_{lever}}{L_{load}}$$

Therefore, $F_{in} \times L_{lever} = F_{out} \times L_{load}$

7.5: Theoretical mechanical advantage = D_{in}/D_{out}

Actual mechanical advantage = F_{out}/F_{in}

Actual MA takes into account the energy wasted by friction; theoretical MA does not.

Period 7 Review Questions

R.1 Why do grass clippers have long blades, but tin snips have short blades?

R.2 Can you lift someone heavier than yourself with a lever? Why or why not?

R.3 Why do we discuss simple machines in terms of the lever and load arm lengths instead of the relative distances in and out that the arms move?

R.4 Explain the difference between theoretical mechanical advantage and actual mechanical advantage.

R.5 How can you find the theoretical mechanical advantage of a lever? Of a pulley system?

R.6 How can you find the actual mechanical advantage of a lever or a pulley system?