SIMPLE MACHINES, MECANISMS, AND TECHNIQUES

This document is intended for adults.

2010-2011
# Mechanics – Some definitions…

<table>
<thead>
<tr>
<th>Mechanics</th>
<th>The science of construction and of the operation of machines</th>
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</thead>
<tbody>
<tr>
<td>A mechanism</td>
<td>An arrangement of parts assembled to work as a whole</td>
</tr>
<tr>
<td>What is a mechanism used for?</td>
<td>The mechanism transmits or transforms the outside force that activates it.</td>
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<tr>
<td>How is a mechanism activated?</td>
<td>All mechanisms are activated by a force that comes from an energy source (outside the object or a part of the object).</td>
</tr>
<tr>
<td>Force</td>
<td>Action able to produce an effect (put into motion, slow down, stop or distort an object).</td>
</tr>
<tr>
<td>Energy source</td>
<td>The energy source may be muscular (animal, human), natural (water, wind, air, sun), chemical (gasoline) or mechanical (spring).</td>
</tr>
<tr>
<td>Types of motion</td>
<td>• Rotation: around an axle&lt;br&gt;• Rectilinear translation: constant direction without rotation&lt;br&gt;• Helical: combination of a translation and rotation around an axle.</td>
</tr>
<tr>
<td>Elementary mechanical function of an organ</td>
<td>• Guidance: Function of an organ that directs another organ along a precise trajectory&lt;br&gt;• Linkage: Function of an assembly organ (links two organs together).</td>
</tr>
<tr>
<td>Transmission of motion</td>
<td>Communication of the same movement from one organ to another</td>
</tr>
<tr>
<td>Transformation of motion</td>
<td>Mechanical action that changes the nature of the movement. (Example: the handle of a top makes a translation movement and the body of the top makes a rotary movement).</td>
</tr>
<tr>
<td>*Drive (or leading) gear</td>
<td>The drive gear is the gear upon which the force is applied. It transfers the effort to the next gear.</td>
</tr>
<tr>
<td>*Driven gear (receptor)</td>
<td>The gear that moves the load.</td>
</tr>
<tr>
<td>*Intermediary gear</td>
<td>This gear ensures that the gears on either side of it turn in the same direction.</td>
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</tbody>
</table>

These definitions are drawn from:<br>http://www2.cslaval.qc.ca/cdp/UserFiles/File/previews/mechanisms/<br>*http://versantnord.nbed.nb.ca/module%C3%A9olienne.htm
Simple machines

Simple machines allow a task (moving objects) to be accomplished more easily by optimising the force that is used. It is all a question of compromise, since from a scientific point of view, all work implies a force and a distance.

\[ \text{Work} = \text{force} \times \text{distance} \]

Using a simple machine, the force used will be reduced, but the distance will be greater. There's the compromise!

You most certainly know some types of simple machines, without even realising it, because they are a part of everyday life.

### Simple machines

<table>
<thead>
<tr>
<th>Simple machines</th>
<th>Description</th>
<th>Work accomplished</th>
<th>Examples</th>
<th>Image</th>
</tr>
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<tbody>
<tr>
<td>Lever</td>
<td>A solid bar that rests on a fulcrum or pivot point.</td>
<td>Lifts or moves loads. May also modify the direction of the force to be applied.</td>
<td>Teeter-totter, shovel, hammer, scissors, tweezers, wheelbarrow.</td>
<td><img src="image" alt="Lever" /></td>
</tr>
<tr>
<td>Inclined plane</td>
<td>A flat surface placed at an angle to the horizon.</td>
<td>To raise, lower or lift loads.</td>
<td>Wheelchair ramp, ramp at the rear of a delivery truck, ski hill.</td>
<td><img src="image" alt="Inclined plane" /></td>
</tr>
<tr>
<td>Screw</td>
<td>An inclined plane rolled around an axis.</td>
<td>Lift masses (liquids or solids), tighten or affix objects</td>
<td>Cork screw, adjustable height chair, nut and bolt, worm gear.</td>
<td><img src="image" alt="Screw" /></td>
</tr>
<tr>
<td>Pulley</td>
<td>A wheel with a concave outer edge, that makes a cable or belt turn.</td>
<td>Change the direction of the force. When there are several pulleys, the force to be applied is reduced.</td>
<td>Elevator mechanism, crane, horizontal blinds, clothes line.</td>
<td><img src="image" alt="Pulley" /></td>
</tr>
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1The six machines presented are those indicated by the QEP. Those in bold character are to be emphasised depending on the learning progression.
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<td><strong>Winch</strong></td>
<td>A rope or cable wound around a cylinder, activated by a handle.</td>
<td>To raise or lower loads.</td>
<td>Bucket in a well, mechanism to tighten a tennis net, winch for cars.</td>
<td><img src="http://office.microsoft.com/fr-fr/clipart/default.aspx" alt="Winch Image" /></td>
</tr>
<tr>
<td><strong>Wheel</strong></td>
<td>A gear affixed to a central axis (axles).</td>
<td>To lift or move loads.</td>
<td>Bicycle, door handle, steering wheel.</td>
<td><img src="http://office.microsoft.com/fr-fr/clipart/default.aspx" alt="Wheel Image" /></td>
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Questions relating to the "rotary gear systems" panel

Gears or friction wheels

- When the drive wheel turns clockwise, in which direction do the other wheels turn? Using arrows, indicate the direction of rotation of the wheels on the drawing.

- Count the number of teeth of the drive and driven gears. How many times does the driven gear turn for every time the drive gear turns? ________________

  ➢ Drive gear = ________ teeth.
  ➢ Driven gear = _________ teeth.

- If I want to retain the same direction of rotation for the drive and driven gears, what do I have to do? _______________________________________________________________________

Pulleys

- What difference do you notice in terms of the direction of rotation of the various elements, as compared to the two previous systems?

- What could you do to reverse the direction of the rotation of one of the pulleys?

_________________________________________________________________________________________________________
Questions relating to the "Two mechanisms of transformation of motion" panel

### Cam and excentric cam

**Cam**: Mechanical part whose function it is to push an element moving it in rotation or in translation. Possible shapes: truncated cylinder, oval, curve of some kind.

**Excentric**: Wheel whose rotation is off center. Synonym of round cam.

### Possible combinaisons

**Cam and rod in translation**

![Diagram of cam and rod in translation]

**Study of the cam and rod in translation combination:**

1. Place the cam in such a way that the center of rotation is positioned upwards.
2. Trace a line at the upper extremity of the rod.
3. Turn the cam to position it with the center of rotation downwards.
4. Trace another line at the upper extremity of the rod.
5. Measure the distance between these lines. Note this distance.
6. Measure the greatest distance between the center of rotation and the edge of the cam. Note this distance.
7. Measure the smallest distance between the center of rotation and the outside of the circle. Note this distance.

What do you notice?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Questions relating to the "Two mechanisms of transformation of motion" panel

### Crank and shaft

**Shaft:** Rigid bar or rod of a mechanical system that is used to produce motion and that is generally linked to a crank.

**Crank:** Mechanical part by which a force can transmit a rotary motion around an axle. This part presents an exocentric part called the crankpin.

![Simple crank diagram](image)

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### Study of the rod and crank combination

1. Place the model so that the crankpin is positioned toward the bottom.
2. Trace a line at the upper end of the rod.
3. Turn the mechanism to position the crankpin upwards.
4. Trace another line at the upper end of the rod.
5. Measure the distance between these two lines. Note this distance.
6. Measure the distance between the center of the crankpin and the center of rotation of the crank. Note this distance.

What do you notice?

________________________
Questions relating to the "Rotary transmission of motion mechanism" panel

<table>
<thead>
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<th>Cam and lever</th>
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</table>
| **Cam**: Mechanical part whose function it is to push an element moving it in rotation or in translation. Possible shapes: truncated cylinder, oval, curve of some kind.  

**Lever**: A lever is a rigid solid, used to lift objects or manoeuvre a mechanism with reduced effort. The distance between the command point of the lever and the axis of rotation is called the *lever arm.* |

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**Cam and lever in rotation**

![Diagram of cam and lever in rotation]

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**Study of the cam and lever in rotation combination:**

1. Place the cam in position A. Make it turn. Maintain the position of the lever.
2. Trace a line under the lever.
3. Do the same thing at the other two positions.

What do you notice?

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TO GO A LITTLE FURTHER

Connecting rod and crankshaft

**Crankshaft**: A "U" shaped axle with at least one rod that transforms the rectilinear motion of the rod into a rotary motion.

Contrary to using a single crank, the crankshaft allows for a guided rotation axis on each side.

**Crank slide**

**Slide**: Part with a groove in which a mobile part like a crank can slide.