TIN CAN ROBOT

A. OVERVIEW

Subject	Physics
Age	6-10
Duration	60 Minutes
Content	Gears and cams
Goals	Students will: 1. Understand that gears are used to change the velocity or direction of rotation 2. Understand that gears can be used to increase the torque exerted on an object 3. Understand that cams are used to convert rotary motion into reciprocating motion
Objectives	After completing this section, students will relate their knowledge of gears and cams to machines around them.
Materials	Tin can robot kit and instruction sheet AA 1.5 volt battery, small crosshead screwdriver, one used, cleaned tin can (aluminium drink can is best)
Introduction	Background reading – Gears and cams Class discussion – Gears and cams in machines
Practical	Students will assemble Tin Can Robot.
Extensions	Open ended discussion/investigation.

B. BACKGROUND READING

Set the background reading as a homework assignment the day before the planned Tin Can Robot lesson. The reading covers gears and cams.

Review

Start the lesson by reviewing the reading.
Points to ensure are understood

- gears can change the direction or velocity of motion
- gears can exchange rotational velocity and torque
- cams are used to convert rotating motion to reciprocating motion

Reading material

Energy conversion – motors/batteries
Batteries allow chemical energy to be converted to electrical energy (see Green Science Potato Clock kit).
Motors convert electrical energy to mechanical energy via electromagnetic principles (see Green Science Dynamo Torch kit).
Gears
Gears work on the principle of mechanical advantage. By using different gear diameters, you can exchange between rotational velocity and torque. Torque is the force that causes an object to rotate. Gears are used to change the direction or velocity of motion or to increase the amount of torque (rotational force) exerted on an object by converting rotational velocity to rotational force (torque).
Gears consist of wheels with evenly sized and spaced teeth on their edges. The teeth of each gear wheel fit into the teeth of the next gear wheel allowing the transfer of rotary motion from one to the other.
The driving gear wheel is the gear wheel that initiates the rotation. The driven gear wheel rotates in the opposite direction of the driving gear wheel.
If the two gear wheels have the same number of teeth they will rotate at the same speed. If the driven gear wheel has fewer teeth than the driving gear wheel it will rotate faster and vice versa.
Gear trains are formed when multiple gear wheels are connected. The output rotation is the motion of the last gear in the train. If there are even numbers of gear wheels in the gear train, the output rotation will be in the opposite direction as the driving wheel. If there are odd numbers of gear wheels in the gear train, the output rotation will be in the same direction as the driving wheel.

Gear ratio = $\frac{\text{number of teeth on driven gear}}{\text{number of teeth on driving gear}}$

For example, if the driving gear has 40 teeth and the driven gear has 10 teeth, the gear ratio is 10/40 =1/4.
Types of gears

Spur gear
- disk with teeth projecting radially
- can be meshed together only if they are fitted to parallel axes

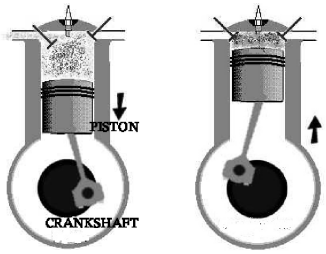
Rack and pinion gear
- used to convert between rotary and linear motion
- often the pinion rotates in a fixed position and the rack moves

Worm gear
- used when large gear reduction are needed
- used if a motor is able to produce fast rotation but not enough torque (rotational force) to rotate the desired object

Cams
Cams are used to convert rotary motion into reciprocating (up and down) motion. The motion created can be simple and regular or complex and irregular. As the cam turns, driven by the circular motion, the cam follower traces the surface of the cam transmitting its motion to the required mechanism.

The camshaft of an automobile takes the rotary motion of the engine and translates it into the reciprocating motion necessary to operate the valves of the cylinders.

The crankshaft of an automobile does the opposite. It takes the reciprocating motion of the pistons and translates it into the rotary motion necessary to operate the wheels.



C. Class discussion

What machines have the class used recently that contain gears?
How do the gears help the machine function?
Machine Function of gear
Funicular railway Convert rotary to linear motion (rack and pinion)
Rotation from motor transferred to pinion. Pinion rotation over free-moving rack 'pulls' the railcar uphill.
Bicycle Transfer rotation from pedals to wheels.
Low gears – preserve torque (rotational force) by decreasing rotational velocity – great for going uphill.
High gears – increase rotational velocity with favourable gear ratios. One turn of the pedals causes many turns of the wheels and so the rider travels a greater distance requiring less work.
Hand drill Transfer rotation at hand crank to rotation at drill bit.
Electric drill Transfer rotation from motor to rotation at drill bit.
Increase torque at drill bit by conversion of rotational velocity.
What other machines with gears can your class recall?

D. Practical

Each group of students requires 1 kit and 1 instruction sheet. Select the relevant information from the instructions if necessary.
Each group will also need 1xAA 1.5V battery, 1 used, cleaned, tin can and 1 small cross headed screwdriver.
Go through the safety warnings advised in the instructions with the class before assembly.
Check each group's finished model and supervise the class' test runs.
Races could be held if you have sufficient time and space.

E. Extension

Can you explain the functions of the gears and cams in your robot?
HINT – direction of force, velocity of rotation, torque
What cams/gears are necessary in the conversion of the chemical energy of petrol to the kinetic energy of the rotating wheels via a petrol combustion engine in an automobile?
TASK – research the mechanical structure of an automobile, identify the gears/cams/energy conversion steps, draw a schematic diagram

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