Lego Challenge

2. Energy and Work

Pupil Booklet

Name
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What is the OPITO Lego Challenge?  
What is in the box?  

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- Gears: Extension Tasks  

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- My Wonderful Wind Turbine  
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Have you ever played with Lego?
Almost all of you will have come across Lego before now.

You may have already completed Course 1: Mechanics In Practice.

During this course ‘Energy and Work’ you will build on all that you learnt in ‘Mechanics In Practice’ and continue to:

• Involve yourself in real world investigations
• Problem solve
• Make assumptions & predictions
• Design and make models and then see how these work
• Reflect (think about) and then perhaps re-design your model
• Record and present your findings.
There are 396 different Lego pieces in the box, including a motor.

**Buddy Building System**

All the models you build for the Activities are designed so two pupils can build at the same time. Each buddy builds his or her own subsystem using either the A or B instructions booklet. These subsystems are then put together to become one complete model.

**Principle Models**

You will start by building some of the Principle Models. These are mechanical and structural principles that are normally hidden away in inside everyday machines and structures e.g. gears and cams under a car bonnet.

**Activities**

You will quickly move on to Activities which use some of the Principle Models. These Activities follow LEGO Education's 4C approach: Connect, Construct, Contemplate and Continue.

### Connect

You add to your brain's knowledge when you connect a new learning experience to those you already have. What everyday examples can you think of that use the models?

### Construct

Learning is best when hands and minds are engaged

### Contemplate (Think)

When you take time to think about what you've done, you have the chance to make connections between previous knowledge and new experiences. Questions in this booklet will help you to make connections

### Continue

The core tasks aren't the end of the story. There are extension ideas: you are encouraged to change or add features to your models and to investigate further
Mechanisms: Gears

Gears are wheels with teeth that mesh with each other. Because the teeth lock together, they can efficiently transfer force and motion.

The drive gear is the gear that is turned by an outside effort, for instance your hand or an engine. Any gear that is turned by another gear is called a driven gear. The drive gear provides the input force and the driven gear delivers the output force.

Using a gear system can create change in speed, direction and force. But there are always advantages and disadvantages. For example, you cannot have both have more output force and an increase in speed at the same time.

To predict the ratio of which two meshed gears will move relative to each other, divide the number of teeth on the driven gear by the number of teeth on the drive gear. This is called the gear ratio.

Gear ratio = (number of teeth on drive gear) : (number of teeth on driven gear) For example: a drive a gear of 48 teeth is meshed with a driven gear of 24 teeth the Gear ratio = 48 : 24 which can be simplified to Gear ratio = 2:1 (drive gear : driven gear).This means that for every 2 turns of the drive gear the driven gear turns just 1 time.

Gears are found in many machines, where there is the need to control the speed of rotary movement and turning force. Common examples include power tools, cars and egg beaters!
CORE TASKS

G1: Build G1 book III, page 2
Turn the handle and describe the speeds of the drive and the driven gears. Label the drive and driven gears. Use a circle to show exactly where each one is.

The drive gear and the driven gear are ___

______________________________

______________________________

Turn the handle and describe the speeds of the drive and driven gears. Label the drive and driven gears. Use a circle to show exactly where each one is.

The drive gear is ___ than the driven gear

______________________________

______________________________

G3: Build G3 book III, page 4
Turn the handle and describe the speeds of the drive and driven gears. Label the drive and driven gears. Use a circle to show exactly where each one is.

______________________________

______________________________

______________________________

Some words to use are:

<table>
<thead>
<tr>
<th>faster</th>
<th>direction</th>
<th>teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>slower</td>
<td>larger</td>
<td>opposite</td>
</tr>
</tbody>
</table>
CORE TASKS

G7: Build G7 book III, pages 11 to 14

Turn the handle and describe what happens.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

G8: Build G8 book III, pages 15 to 18

Turn the handle and describe what happens. What happens if you stop one of the output pointers? What happens if you stop both output pointers?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Some words to use are:

<table>
<thead>
<tr>
<th>bevel gears</th>
<th>90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>direction</td>
<td></td>
</tr>
<tr>
<td>input force</td>
<td>output</td>
</tr>
</tbody>
</table>

How do you think you did?

________________________________________________________________________

What could you improve on?

________________________________________________________________________
Gears – An Industry Example

The draw-works is the main machinery on a drilling rig to raise and lower the travelling block, the drill line and the drill bit.

In the draw-works (part 7) wire rope winds round a drum and goes up to the crown block (13) and down to the travelling block (11).

A system of gears in the draw-works can turn the drum at different speeds. This lengthens or shortens the wire rope and so raises or lowers the drill string and drill bit.

People who work in this area are part of the drill crew, include:

- Driller
- Roughneck

Skills at Work

Industry apprentices demonstrate a gear box with ratios 1:6 and 1:4

http://www.youtube.com/watch?v=JXK8ZTzIol4
Big Build 1: Sweeper

Watch the Lego video clip of the Sweeper
This is a building activity

The person building subsystem A is ____________________
The person building subsystem B is ____________________

How do you think you did?

________________________________________________________

What could you improve on?

________________________________________________________
Sweeper

How can you combine pushing a cart with cleaning a path? Let’s find out!

Build the Sweeper
(all of book 1A and book 1B to step 11)

• Try it
• If it does not spin smoothly loosen the axle bushings and make sure the bricks are firmly linked to one another

What makes a good Sweeper?

• Test your spin speeds with the gears shown below. Try them with only two Sweeper blades (a).

  1  2  3

• Now try these Sweeper blades with your FASTEST gears to see which one is best at sweeping crumbs

  a  b  c

• Test different Sweepers and compare them with your standard model

Tip: Choose from the words on the right to fill in the table above. You can use them more than once. Make up your own descriptions too.
EXTENSION TASKS

(After big build if time)

G4: Build G4 book III, pages 5 to 6

Turn the handle and describe the speed and direction of the drive and driven gears. Label the drive and driven gears. Use a circle to show exactly where each one is.

G5: Build G5 book III, pages 7 to 8

Turn the handle and describe the speed and direction of the drive and driven gears. Label the drive and driven gears. Use a circle to show exactly where each one is.

G6: Build G6 book III, pages 9 to 10

Turn the handle and describe the movement of the driven gear.
Mechanisms: Pawl and Ratchet

A ratchet mechanism is based on a gear wheel and a pawl that follows as the wheel turns.

When the gear is moving in one direction, the pawl slides up and over the gear teeth, sending the pawl into the notch before the next tooth. The pawl is then jammed against the depression between the gear teeth, preventing any backwards motion. Ratchet mechanisms are very useful devices for allowing linear or rotary motion in only one direction. Common examples of ratchets are clocks, jacks and hoists.
Mechanisms: Pawl and Ratchet

I1: Build I1 book III, pages 28 to 29

Turn the handle clockwise and describe what happens.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

12:

Turn the handle anticlockwise and describe what happens

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

How do you think you did?

________________________________________________________________________

What could you improve on?

________________________________________________________________________

Some words to use are:

- pawl
- gear
- teeth
- direction
- stops
Pawl and Ratchet -
An Industry Example

Pawl & Ratchet: Working Safely

1: In this video the industry apprentices use a ratchet system to raise a heavy metal table and keep it safely in place.

http://www.youtube.com/watch?v=EnMdpmsE_O4

2: To Move a ‘Christmas Tree’ on the deck floor

To control the flow of oil and gas from a reservoir a series of valves are used.
This piece of equipment looks like a decorated tree so is often called a “Christmas Tree”. It sits on the deck floor of the platform.

When the ‘Christmas Tree’ needs to be moved a pawl and ratchet system is used so the job can be done safely.
When the tree is raised to the right height the pawl fits in between the gears teeth and prevents it from falling to the deck floor.

3: Ratchet straps are used to keep cargo safely in place in a container.

People who do this in their job include:

-Derrickman
-Mechanical Technician
-Banksman
-Slinger
How can you use a wind turbine and a rope to lift a heavy load?
Big Build 2: Wind Turbine

Watch the Lego video clip of the Windmill.

For this big build activity you and your buddy should change roles from your last big build.

If you were A building the Sweeper, you will be B building the Wind Turbine.

The person building subsystem A is ________________

The person building subsystem B is ________________

Build the Wind turbine

(Building Instruction 8A and 8B to page 12, step 17)

How do you think you did?

_________________________________________________________

What could you improve on?

_________________________________________________________
Big Build 2: Wind Turbine

How can you use a Wind turbine and a rope to lift a heavy load?
Let's find out!

Build the Wind turbine (all of book 8A and book 8B to page 12, step 17).
• Make sure it turns smoothly
• If it feels stiff to turn, loosen the axle bushings and make sure all other elements fit tightly together

What difference does the number of sails make?

• Predict and test how fast each design will lift the treasure chest (weight brick).
Use some sort of timing device
• Use the same wind speed each time

<table>
<thead>
<tr>
<th>1: Wind</th>
<th>2: Nowind</th>
<th>3: Nowind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myprediction</td>
<td>Myprediction</td>
<td>Myprediction</td>
</tr>
<tr>
<td>Actualspeed</td>
<td>Actualspeed</td>
<td>Actualspeed</td>
</tr>
</tbody>
</table>

What difference does the ratchet make?

Predict and test what will happen to the treasure chest with each position of the ratchet with or without wind.

<table>
<thead>
<tr>
<th>1: Wind</th>
<th>2: Nowind</th>
<th>3: Nowind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myprediction</td>
<td>Myprediction</td>
<td>Myprediction</td>
</tr>
<tr>
<td>Whathappened?</td>
<td>Whathappened?</td>
<td>Whathappened?</td>
</tr>
</tbody>
</table>
My Wonderful Wind Turbine

Draw or photo, download and print your model.

Label your picture.

Explain how the 3 best bits work below.

Some words to use are:

- ratchet
- gears
- weight
- raise
- energy
- pawl
- safety
- work
All in a spin!

Build the wind-up spinner model book 8B, step 1 and the 3 different spinning tops on pages 14, 15 and 16.

- Use the energy from a falling weight brick to power these spinning tops
- How long will each top spin for?

<table>
<thead>
<tr>
<th>Myprediction</th>
<th>Myprediction</th>
<th>Myprediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual spintime</td>
<td>Actual spintime</td>
<td>Actual spintime</td>
</tr>
</tbody>
</table>

Make your own spinning top!

You could try...

- Coloured spirals on card spinners
- Gears as spinners
- Inventing your own Spinning Game and making a scoring system
Wind Turbine
An Industry Example
Beatrice Windfarm

A pioneering energy project to generate electricity for the Beatrice Platform using offshore wind-turbines

The Beatrice oil field is located in the Moray Firth, 22km off the North East Coast of Scotland. In 2006, the owners, Talisman, installed 2 wind-turbines nearby so they could reduce the costs of running the platform and extend the oil production from the field to 2025.

This Beatrice Windfarm project produces 10 million watts of electric power. A cable on the sea-bed takes the power from the turbines to the Beatrice Platform where it is used.

LOOKING AFTER THE ENVIRONMENT

Before any work could take place an environmental study was carried out. Amongst the topics considered were:

- Collision risk of birds with wind-turbines
- Noise effect on fish, whales and dolphins using the area
- The location of commercial fishing grounds
The different parts are constructed on shore. They are taken

1. The tower-shaped base or ‘jacket’ is placed horizontally on a crane-barge, taken out to sea and placed into position

2. The crane-barge then collects the wind-turbine from the shore and takes it out to meet the base

3. The crane raises the wind-turbine from the barge and places it on it’s base

You can view a video of this at:

http://www.beatricewind.co.uk/press/library.asp (start at 3mins 30secs)
OPITO Lego Challenge
Learner’s Questionnaire - Energy and Work

To help assess how this challenge has contributed to your learning please complete this final questionnaire. Thank you.

### 1. Successful Learner

Rate your confidence in each of the following Subjects:

<table>
<thead>
<tr>
<th>Subject</th>
<th>1 (No confidence)</th>
<th>2 (Not very confident)</th>
<th>3 (Confident)</th>
<th>4 (Very confident)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics (e.g. Forces or Electricity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maths</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Studies (e.g. Materials, Making models)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Confident Individual

Using a scale from 1 to 4, where 1 = No confidence and 4 = Very confident
Rate your confidence in each of the following Personal Skills:

<table>
<thead>
<tr>
<th>Skill</th>
<th>1 (No confidence)</th>
<th>2 (Not very confident)</th>
<th>3 (Confident)</th>
<th>4 (Very confident)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading and following technical instructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organising my work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working and Communicating with a partner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communicating to an audience</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3. Effective Contributor

Using a scale from 1 to 4, where 1 = No confidence and 4 = Very confident
Rate how effective you are working as a member of a Team:

<table>
<thead>
<tr>
<th>Task</th>
<th>1 (No confidence)</th>
<th>2 (Not very confident)</th>
<th>3 (Confident)</th>
<th>4 (Very confident)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicating my own ideas to others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listening to the ideas of others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributing to decision making</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Being reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Being responsible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4. Responsible Citizen

Looking ahead: Please tick √ any that apply

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>6th Year</th>
<th>College</th>
<th>University</th>
<th>Job</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 5 years time, I think I will be</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In 10 years time, I think I will be</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Job: Please name if you can
OPITO Lego Challenge

Your thoughts about this challenge will help us when we do it again with other pupils.

Name: Tutor Group:

<table>
<thead>
<tr>
<th>ENJOY MOST</th>
<th>WHY?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
</tbody>
</table>

In the OPITO Lego Challenge, you have used elements of Physics, Maths and Engineering Science all connected to a real world industry.

Would you be interested in learning more about these subjects?

For each subject please □ YES □ NO □ MAYBE

<table>
<thead>
<tr>
<th>Subject</th>
<th>YES</th>
<th>NO</th>
<th>MAYBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Science</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you!
# Glossary

## A

**Acceleration:** The rate at which speed increases. If a car is accelerating it is moving faster.

**Advantage:** The ratio of the output force to the input force of a machine.

**Axle:** A rod through the centre of a wheel. It transmits force from an engine to the wheel in a car.

## B

**Balanced Force:** An object is balanced and does not move when all the forces acting on it are equal and opposite.

**Belt:** A continuous band stretched around two pulley wheels so one can turn the other. It is usually designed to slip if the follower pulley suddenly stops turning.

**Bevel gear:** A type of gear with at an angle. Can be used to change the direction of drive in a gear system by 90°.

## C

**Cams:** A none-circular wheel that rotates and moves a follower. It converts rotary movement of the cam into reciprocating or oscillating the movement of the follower.

**Counter balance:** A force often provided by the weight of an object you use to reduce or remove the effects of another force. A crane uses a large concrete block on the short arm of its jib to counter the unbalancing effect of the load on the other longer arm.

**Crank:** An arm or handle connected to a shaft or axle at right angles enabling the shaft to be easily turned.

## D

**Driven gear:** See follower

**Driver:** The part of a machine, usually a gear, pulley, lever, crank or axle, where the force first comes into the machine.

## E

**Effort:** The force or amount of force that you or something else puts into a machine.

**Efficiency:** A measure of how much of the force that goes into a machine comes out as useful work. Friction often wastes a lot of energy, reducing the efficiency of a machine.

**Energy:** The capacity to do work.
F
Fair testing  Measuring the performance of a machine by comparing its performance under different conditions.

Follower  Usually a gear, pulley or lever driven by another one.

Force  A push or a pull

Fulcrum  See Pivot

Friction  The resistance met when one surface sliding over another, e.g. when an axle is turning in a hole or when you rub your hands together

G
Gear  A toothed wheel or cog. The teeth of the gears mesh together to transmit movement.

Gearing down  A small driver turns a larger follower and amplifies the force from the effort. The follower turns more slowly.

Gearing up  A large driver turns a smaller follower and reduces the force from the effort. But the follower turns more quickly.

I
Inclined Plane  A slanted surface or ramp generally used to raise an object with less effort that is needed to lift it directly. A cam is a special sort of inclined plane.

L
Lever  A bar that pivots about a fixed point when an effort is applied to it.

Load  Any force a structure is opposing, such as a weight or mass. The amount of resistance placed on a machine.

M
Machine  A device that makes work easier or faster to do. It usually contains mechanisms.

Mass  Mass is the quantity of matter in an object

Mechanism  A simple arrangement of components that transforms the size or direction of a force, and the speed of its output.
P
Pivot The point around which something turns or rotates, such as the pivot of a lever.
Pulley A wheel with a grooved rim used with a belt, chain or rope.
Pulley wheel Changes the direction of the applied force. A pulley does not move with the load.
Pulley block One or more pulleys in a moveable frame with ropes or chains running around them to one or more fixed pulleys. The pulley block moves with the load and reduces the applied force needed to lift the load.

S
Slip A belt or rope slipping, usually on a pulley wheel as a safety feature.
Speed See Velocity
Strut A member of a structure that is in compression. Struts prevent parts of structures from moving towards each other.

T
Tensile forces Forces in a structure that pull in opposite directions trying to stretch the Structure.
Torque The turning force coming from an axle

U
Unbalanced force A force that is not opposed by an equal and opposite force. An object feeling an unbalanced force must begin to move in some way

W
Weight See Mass
Work We calculate the work done by multiplying the force needed to move an object by the distance it is moved.
Here are some roles within the industry that may interest you!

- IT Technician
- Environmental Advisor
- Mudlogger
- Geologist
- Production Technician
- Geophysicist
- Human Resources