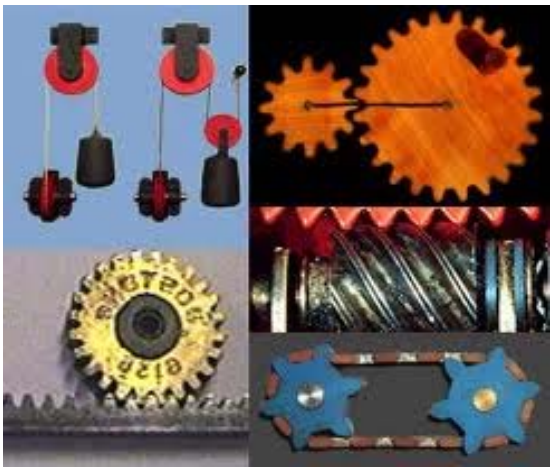
ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

Technology Exploration-I

Module 4: Pulleys and Gears



PREPARED BY

Academic Services

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Module 4: Pulleys and Gears

Module Objectives

After the completion of this module, the student should be able to:

- Identify pulleys.
- Describe some important applications of pulleys.
- Explain the advantages of using pulleys.
- Classify pulleys according to their types.
- Identify gears.
- Describe some important applications of gears.
- Explain the advantages of using the gears.
- Calculate the gear ratio and explain how it affects the speed.
- Evaluate the usage of gears or pulleys for certain applications.
- Conduct practical tasks to demonstrate the function of pulleys and gears.

Module Contents

Pulleys

4.1 Introduction to Pulleys

In addition to levers, and wheel and axle, pulleys are also another type of simple machines. **Definition**: Pulleys are wheels that are moved by ropes, cables, chains or belts around their rims.

4.1.1 Belt-Driven Pulleys

In the belt-driven pulley shown in figure 4.1, **Definition**: a belt joins two pulleys. The wheel to which an external force (effort) is applied is called the **drive** wheel, and the other is called the **driven** wheel. The belt transfers the motion from the drive to the driven pulley.

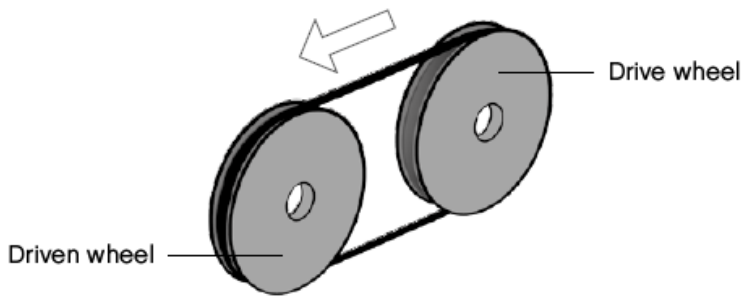


Figure 4.1: Belt-driven pulley.

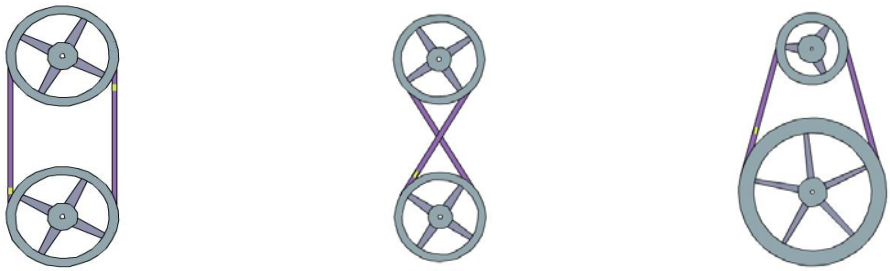
Figure 4.2 shows some examples of real life applications of belt-driven pulleys.

(a) (b) (c)

Figure 4.2: (a) A setup used in research. (b) Air compressor. (c) Car Engine.

4.1.2 Belt-Driven Pulleys Direction of Rotation and Speed

- The **direction of motion** of the pulley systems depends on the way the belt is fixed in the system.
- The **speed of rotation** of the pulleys depends on the size of the drive and driven pulley. Discuss the three cases shown in figure 4.3.

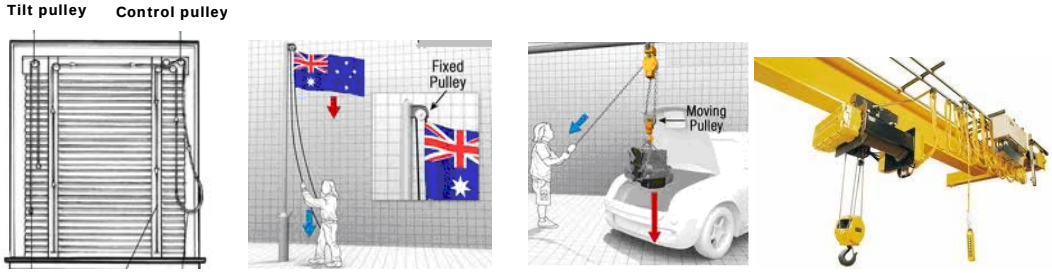


(a) (b) (c)

Figure 4.3: (a) Same direction and same speed. (b) Reverse direction and same speed. (c) Same direction and different speed.

4.1.3 Rope, Chain and Cable Driven Pulleys

In this type of pulleys the rotational motion and forces are transmitted by mains of ropes, chains or cables. Figure 4.4-a and 4.4-b shows two examples of rope driven pulley systems. Figure 4.4-c shows a chain driven pulley system while figure 4.4-d shows a cable driven pulley system.



(a) Window blinds. (b) Flagpole. (c) Chain driven pulley. (d) Overhead crane.

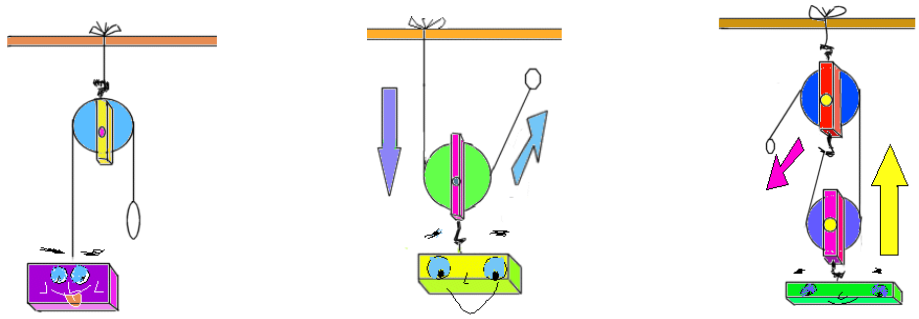
Figure 4.4: Examples of the pulley systems.

4.2 Types of Pulley Systems

There are three types of pulley systems which are:

- Fixed pulleys
- Movable pulleys
- Compound pulleys

Figure 4.5 shows the three types of pulley systems.



(a) (b) (c)

Figure 4.5: (a) Fixed pulley. (b) Movable pulley. (c) Compound pulleys.

4.2.1 Fixed pulley

The pulley shown in figure 4.6 is a fixed pulley.

- It does not move up or down with the load.
- It is often fixed to an overhead beam and will only be able to rotate around its own axle.
- It only allows you to lift a load up by pulling the rope.
- As the rope is pulled down the load moves up by the ***same distance***.
- Effort is equal to the load or more. Figure 4.6 shows that you need 100N effort to raise a 100 N load.

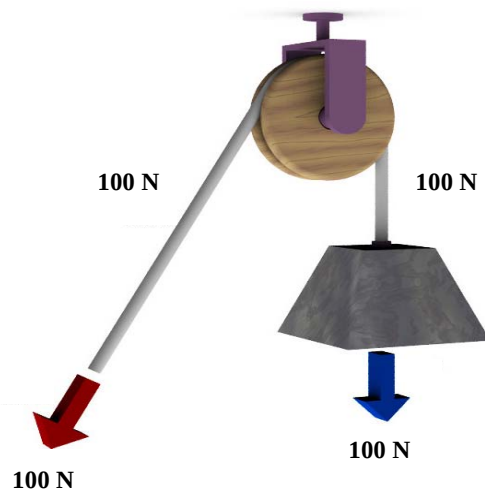


Figure 4.6: Fixed pulley.

4.2.2 Movable pulley

A movable pulley:

- It has a free axle that is free to move in space.
- A movable pulley has a **mechanical advantage of 2**. This means; if one end of the rope is anchored, pulling on the other end of the rope will apply a doubled force to the object attached to the pulley.
- Effort needed **equals half** the load which needs to be lifted Figure 4.7 shows that 50 N are needed to lift a weight of 100 N.

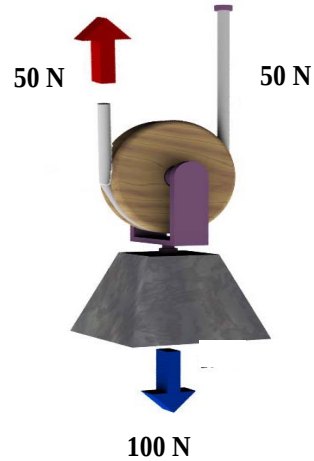


Figure 4.7: Movable pulley.

4.2.3 Compound Pulley

The pulleys shown in figure 4.8 called compound pulley system:

- They are a combination of fixed and movable ones. It is called compound because there is more than one pulley in the system (2 in this case).
- It will take a force (effort) equal to 1/2 the weight (load) or less to hold the weight steady.
- The main disadvantage is it travels a very long distance. Figure 4.8 shows that a 100 N load needs 50N effort to hold it steady.

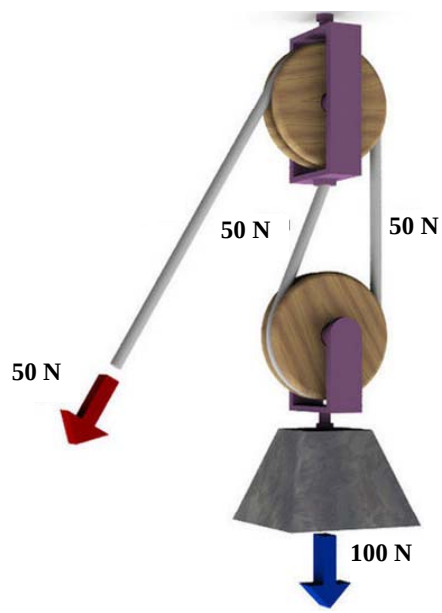


Figure 4.8: Compound pulley.

What do you think the advantage of using a compound pulley would be compared to a movable pulley?

_____

_____

4.3 Practical Tasks

4.3.1 Task 1

Refer to the building instructions booklet and build the C1 model of a pulley as shown in figure 4.9.

Turn the handle and describe the speed of the driver and driven wheels.

_____

_____

_____

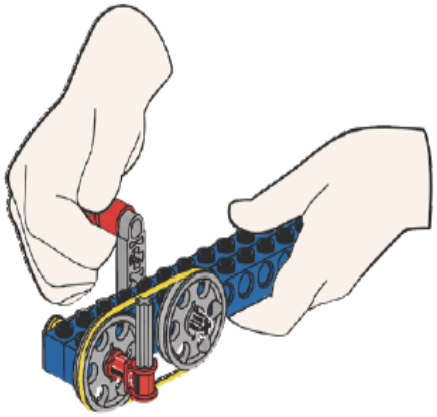


Figure 4.9: Pulley-C1 model.

5.3.2 Task 2

Now, build the C2 model as shown in figure 4.10.

Turn the handle and comment on the speed of both wheels and their direction of rotation.

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_____

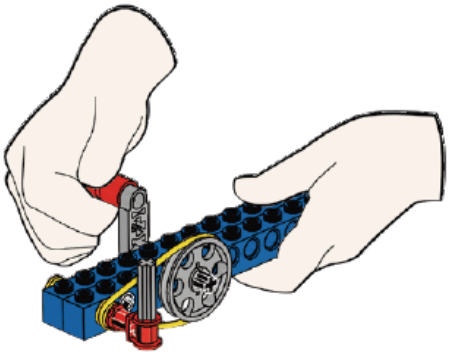


Figure 4.10: Pulley-C2 model.

4.3.3 Task 3

Build the model C3 as shown in figure 4.11. Turn the handle and describe the speed of the driver and driven wheels.

_____

_____

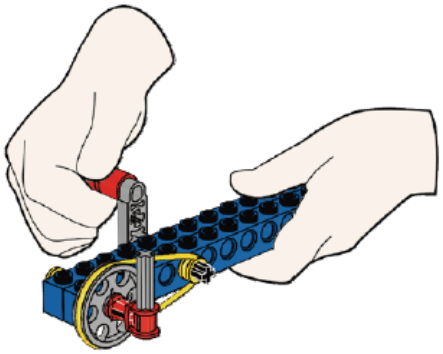


Figure 4.11: Pulley-C3 model.

4.3.4 Task 4

Refer to the building instructions booklet and build the C4 model of a pulley as shown in figure 4.12.

Is this a belt-driven pulley?

_____

_____

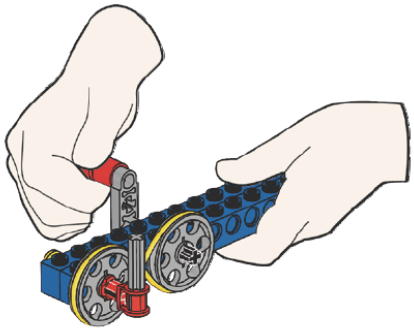


Figure 4.12: Pulley-C4 model.

Are the speed and direction of rotation of the driven and driver pulley wheels the same?

_____

_____

Gears

4.4 Introduction to Gears

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

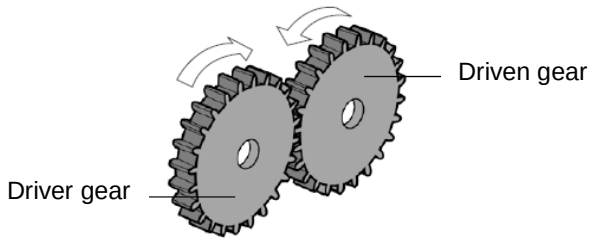


Figure 4.13: Driven gear and driver gear.

The driver (or **Drive gear**) gear is the gear that is turned by an outside effort, for example your hand or an engine. Any gear that is turned by another gear is called a **driven gear**.

- The **driver gear** provides the *input force* and the **driven gear** provides the *output force*.
- A gear system can be used to create a change in speed, direction or force.

Gears are found in many machines. Figure 4.14 shows some common examples that include hand drills, power tools and car gearboxes.

(a) Hand drill. (b)Electric hand drill. (c) Car gearbox.

Figure 4.14: Gears application examples.

4.5 Gear Ratio

Gear Ratio is the ratio of the number of teeth on the driven gear (N_2) to the number of teeth on the drive gear (N_1).

Gear Ratio = N_2 / N_1

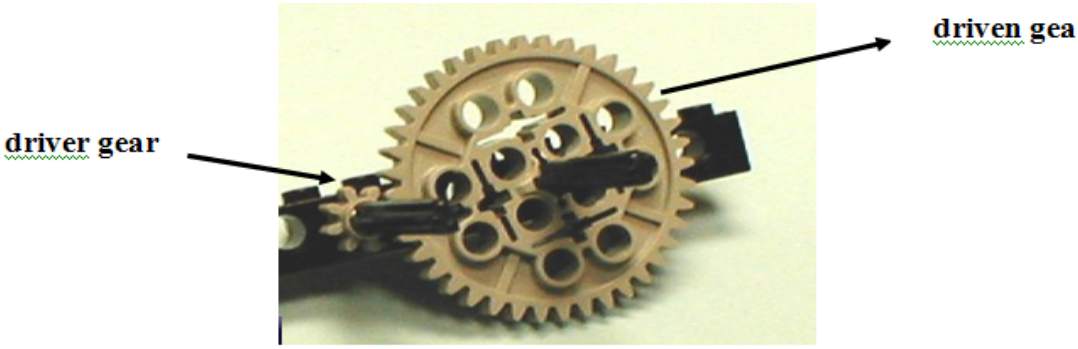


Figure 4.15: Gear ratio.

For example, for the arrangement shown in Figure 4.15, the number of teeth on the driven gear (N_2) is 40 and the number of teeth on the driver gear (N_1) is 8. So the gear ratio = 40 / 8 = 5. This means that 5 revolutions of the driver gear will result in 1 revolution of the driven gear.

4.6 Idler Gears

Idler gears are used between the driver gear and the driven gear (sometimes called **follower**).

The function of idler gears is to:

- Add spacing
- Make both of them rotate in the same direction.

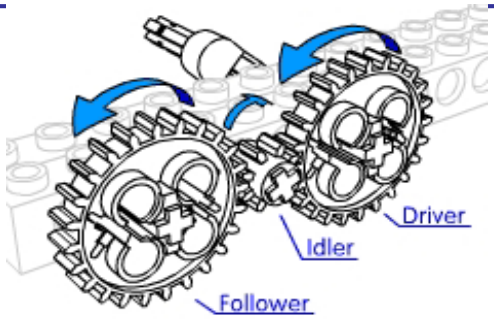


Figure 4.16: Idler gear.

4.7 Practical Tasks

4.7.1 Task 1

Refer to the building instructions booklet and build the G1 model of the gear as shown in figure 4.17. Calculate the gear ratio.

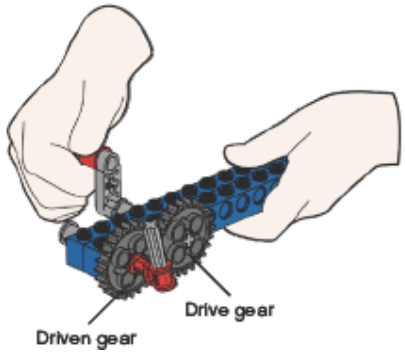


Figure 4.17: Gear-G1 model.

_____

_____

Turn the handle then comment on the speed and direction of rotation of the gears.

_____

_____

4.7.2 Task 2

Build the G2 model of the gear as shown in figure 4.18. Calculate the gear ratio.

_____

_____

Turn the handle then comment on the speed and output force of the gears.

_____

_____

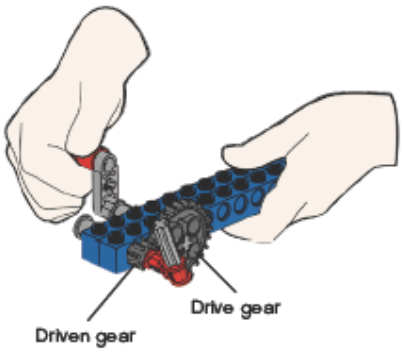


Figure 4.18: Gear-G2 model.

4.7.3 Task 3

Build the G3 model of the gear as shown in figure 4.19. Calculate the gear ratio.

_____

_____

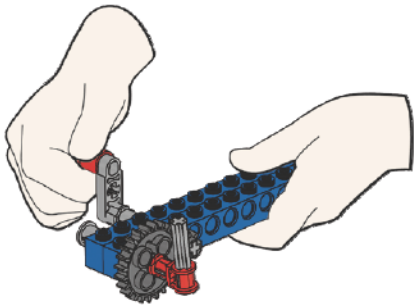


Figure 4.19: Gear-G3 model.

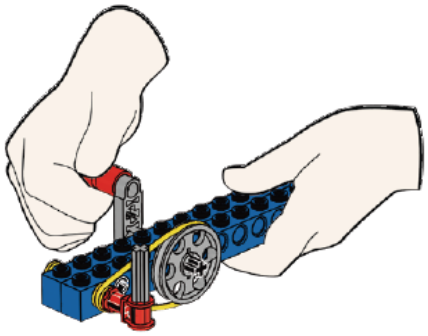
Turn the handle then comment on the speed and output force of the gears.

_____

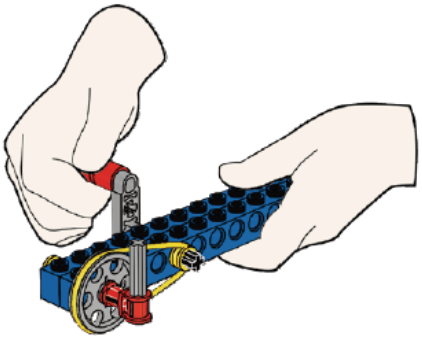
_____

4.8 Pulleys and Gears Worksheet

1. Observe the pulley systems in the figures given below and differentiate between the speeds of the driven pulley and the drive pulley wheels. Write your answers in the table below:



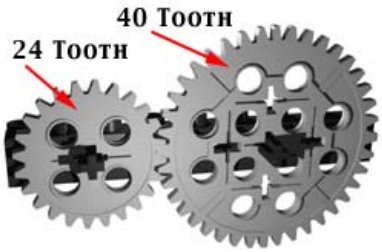
(a) Pulley setup-A



(b) Pulley setup-B

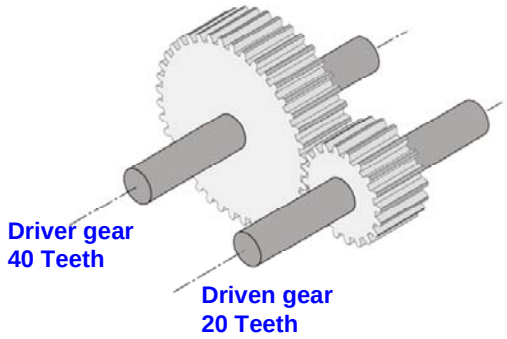
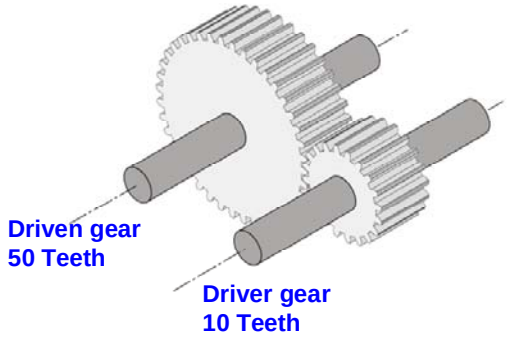
Pulley Setup-A	Pulley Setup-B
Speed _____.	Speed _____.
_____ Pulley wheel turns faster.	_____ Pulley wheel turns faster.

2. Calculate the gear ratio of the following:

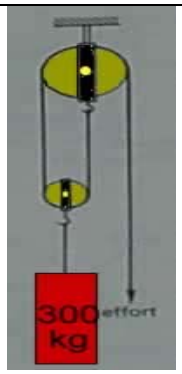
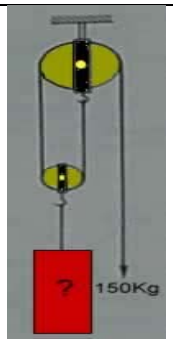


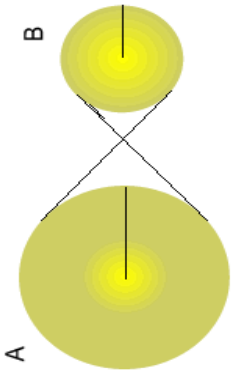
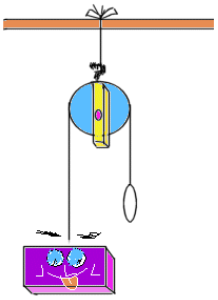
_____ _____

3. Calculate the Gear Ratio:

1		
2		

4. Answer the following questions

What is the minimum effort that must be applied to lift the load?	
What is the maximum load that can be lifted with this system?	

5. Draw arrows to indicate the direction of rotation	The radius of pulley A is 30 cm while pulley B has a radius of 10 cm. Pulley A is connected to a motor and used to drive pulley B. For every clockwise turn of pulley A pulley B will : Direction: Number of turns:	
	If the load is 200 N what is the effort needed?	
	If the load is 300 N what is the effort needed?