Gear mechanisms and belt drives

Physics | Mechanics | Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5fafddbada80e000035c24c0

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Teacher information

Application (1/2)

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Test setup of the single-stage gear transmission

In the case of gear drives, torque transmission is achieved by means of positive locking. Usually, gear wheels with different diameters and numbers of teeth are used. The transmission ratio i should be a decimal number if possible to prevent the same teeth from always meshing with each other and thus prevent periodic wear.

The transmission ratio i of the simple spur gear unit can be calculated by means of the number of teeth of input and output z_{An} and z_{Ab} or the torques of the input and output M_{An} and M_{Ab} as follows:

$$i = \frac{z_{Ab}}{z_{An}} = \frac{M_{Ab}}{M_{An}}$$

Gearboxes have the property of reversing the direction of rotation!

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Application (2/2)

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Test setup of the belt drive

The power transmission of a simple belt is by means of frictional locking. Due to this fact, a pretension must always be placed upon the belt. Exceptions are the so-called tooth belts.

The calculation of the transmission ratio i is different with a simple belt drive than with a gear drive.

The transmission ratio i of the belt drive can be determined by the diameters of the pulleys of the input and output d_{In} and d_{Out} as follows:

$$i = \frac{d_{Out}}{d_{In}}$$

Another difference to the gear drive is the fact that the belt drive does not reverse the direction of rotation!

Other teacher information (1/2)

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Prior

Students should have a basic understanding of forces and moments and how they work. It would be recommended that students have already completed the experiment "P1001600 - Power" before performing this experiment in order to have an understanding of power.

Scientific

By selecting the transmission ratio i of a gear or belt drive, the effective torque and the rotational frequency can be adjusted in a suitable way depending on each other, as required by the particular application.

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Other teacher information (2/2)

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Learning

The students should become familiar with the structure and function of a simple gear drive and a belt drive and understand the mechanical relationships behind them.

Tasks

1. The directions of rotation between the driving and driven wheel and the transmission ratios are to be determined on one single-stage gear and one single-stage belt drive.
2. The experimentally obtained ratios are then to be compared with the ratio of the number of teeth in the case of the gears or the ratio of the wheel diameters in the case of the belt drive.

Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

Motivation

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Gear wheels of a mechanical watch movement

Gear and belt drives are important components in a wide variety of mechanical applications. They are ideally suited for converting speeds and torques in specific ratios. Think, for example, of the gears in a classic clockwork, the V-belt on a car engine or your bicycle chain.

In this experiment you will learn the physical principle behind it and understand how speed and torque interact with each other.

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Tasks

First, investigate a simple spur gear consisting of two gears.

Afterwards you will examine a belt drive, which also consists of two (non-toothed) wheels.

Determine in each case:

1. The translation ratio.
2. The direction of rotation of the wheels.

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	1
3	Boss head	02043-00	2
4	Shaft, dia.12mm, l.45mm	02353-00	2
5	Gear wheel, 20 teeth	02350-13	1
6	Gear wheel, 40 teeth	02351-03	1
7	Wheel and axle	02360-00	1
8	Vernier calliper, plastic	03011-00	1
9	Fishing line, l. 20m	02089-00	1

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Additional equipment

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Position	Equipment	Quantity
1	Scissors	1

Set-up (1/2)

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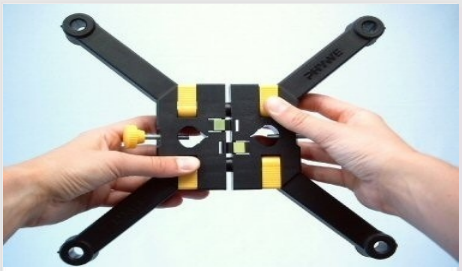
Plug the two halves of the tripod foot together.

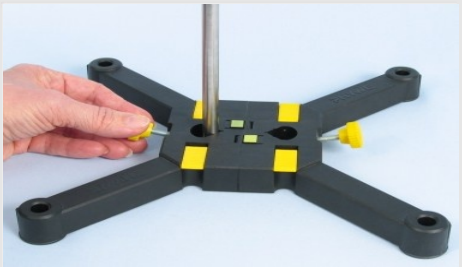
Then screw together the divided stand rod to a long one.

Fix the long stand rod vertically in the stand foot.



Assembling the tripod base

Screwing the stand rod



Assembling the tripod

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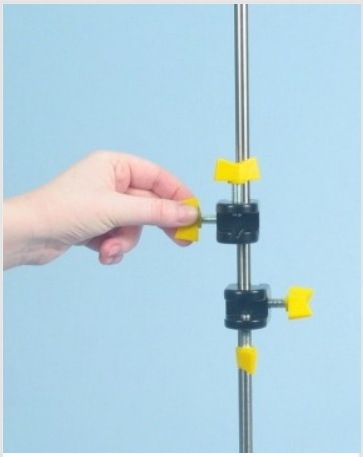
Set-up (2/2)



Installing the double sockets

Attach the two double sleeves to the stand rod.

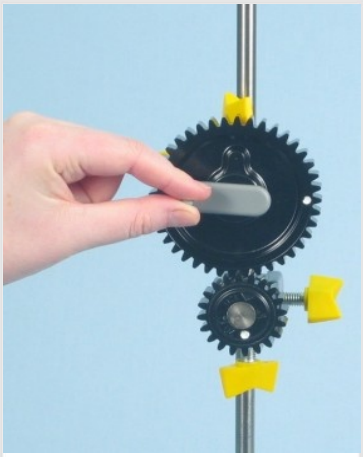
Put the two gear wheels on the shafts and clamp the shafts in the two sleeves.

Mount the crank on the large gear wheel.

Slide one double sleeve towards each other so that the two gear wheels mesh with each other, but run easily and without jamming.

Gearboxes

Procedure (1/6)



Turning the upper gear wheel

Count the teeth of both gears and note the number of teeth z_1 and z_2 in the minutes.

- Turn the upper (large) wheel alternately clockwise and counterclockwise and observe the direction of rotation of the smaller wheel. Use the marks on the wheels for this.
- Make 10 revolutions of the larger wheel ($R_1 = 10$), count the revolutions R_2 of the smaller wheel.
- Note your readings in the log.

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Procedure (2/6)

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Turning the lower gear wheel

- Now put the crank onto the lower, smaller gear wheel.
- Now make 10 turns on the smaller wheel ($R_2 = 10$), count the revolutions R_1 of the larger wheel
- Note your readings in the log.

Procedure (3/6)

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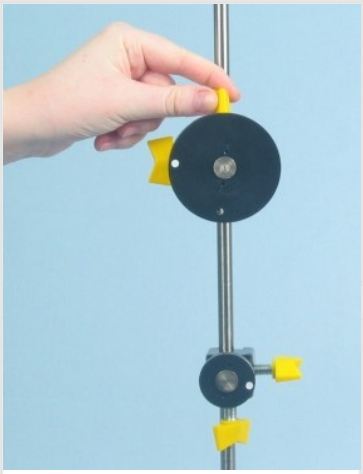

Divide the wheels and put them on the shafts

Replace the two gear wheels with the belt pulleys.

Bring the two double sockets to a distance of about 10 cm and clamp the shafts back into the double sockets.

Make a loop of fishing line of a suitable length and place it around the two wheels.

Now move the double sockets so that the line is taut.

Belt drive

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Procedure (4/6)

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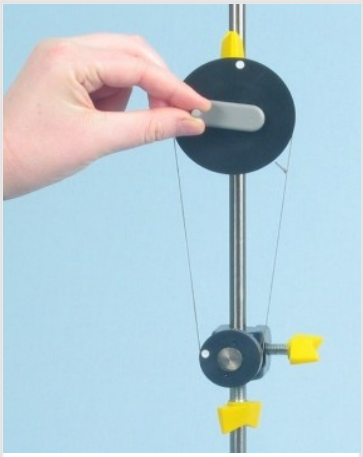

Turning the upper wheel

- Turn the upper (large) wheel alternately clockwise and counterclockwise and observe the smaller wheel. Use the marks on the wheels to do so.
- Make 10 revolutions of the larger wheel ($R_1 = 10$), count the revolutions R_2 of the smaller wheel.
- Note your readings in the log.

Procedure (5/6)

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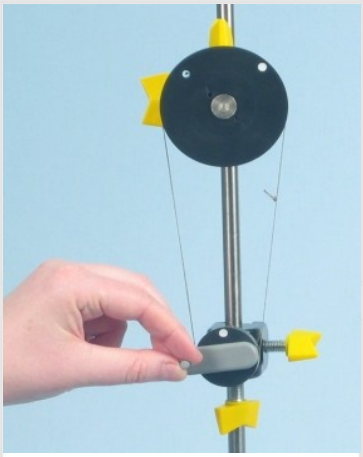

Turning the lower wheel

- Now put the crank into the smaller lower wheel.
- Now make 10 turns on the smaller wheel ($R_2 = 10$), count the revolutions R_1 of the larger wheel
- Finally, measure the diameter d_1 and d_2 the two pulleys of the belt drive with the caliper gauge.
- Note your readings in the log.

Measuring the wheels

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Procedure (6/6)

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Disassembling the tripod base

- To disassemble the tripod base, press the buttons in the middle and pull both halves apart.

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Report

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Table 1

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Enter your readings here.

R_1: big wheel / R_2: small wheel.

Calculate the transmission ratios i of the gear unit from the ratios of the number of teeth and the respective number of revolutions.

$Toothcount\ z_1 =$

$Toothcount\ z_2 =$

$R_1 = 10;\ R_2 =$

$R_2 = 10;\ R_1 =$

$i_{z1} = \frac{z_2}{z_1} =$

$i_{z2} = \frac{z_1}{z_2} =$

$i_1 = \frac{R_1}{R_2} =$

$i_2 = \frac{R_2}{R_1} =$

Table 2

PHYWE

Enter your readings here.

R_1: big wheel / R_2: small wheel.

Calculate the transmission ratios i of the belt drive from the ratios of the diameters and the respective numbers of revolutions.

$Diameter\ d_1 =$ cm

$Diameter\ d_2 =$ cm

$R_1 = 10;\ R_2 =$

$R_2 = 10;\ R_1 =$

$i_{d1} = \frac{d_2}{d_1} =$

$i_{d2} = \frac{d_1}{d_2} =$

$i_1 = \frac{R_1}{R_2} =$

$i_2 = \frac{R_2}{R_1} =$

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Task 1

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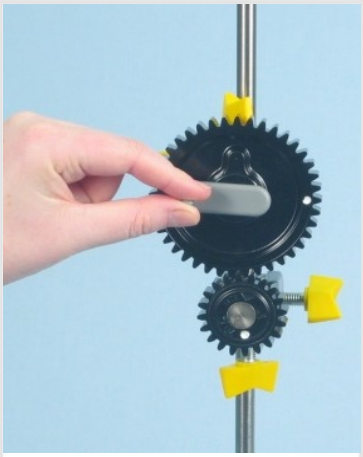


Gearboxes

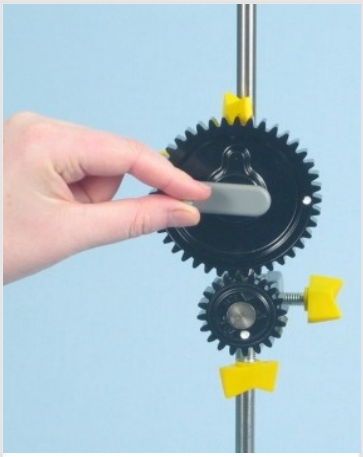
The wheels turn...

- ...both of them the same.
- ...opposed to each other.

Check

Task 2

PHYWE



Gearboxes

What is the relationship between the number of revolutions and the number of teeth of the gears?

- $z_2/z_1 = R_2/R_1$
- $z_2/z_1 = R_1/R_2$

Check

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Task 3

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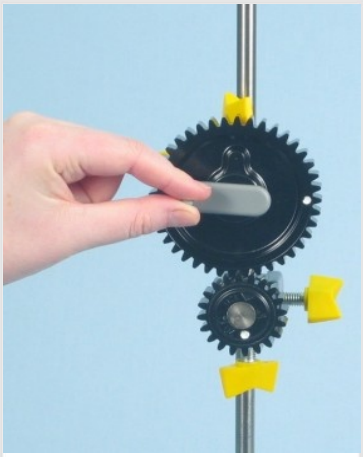


Gearboxes

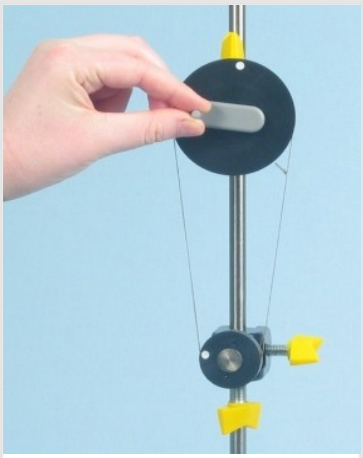
Do you see a possibility to change the direction of rotation of the driven gear in the gear drive

- [ ] You have to add a third gear.
- [ ] Reverse the direction of rotation of the driving wheel.
- [ ] You have to shift two more wheels behind it.

Check

Task 4

PHYWE



Belt drive

The wheels turn...

- ○ ...both of them the same.
- ○ ...opposed to each other.

Check

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Task 5

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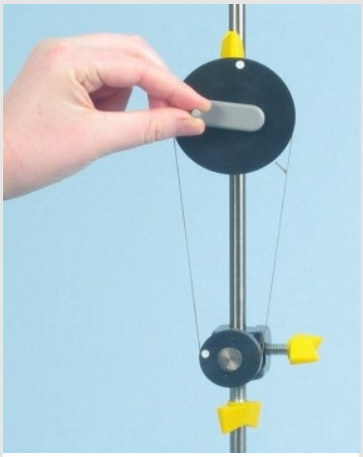


Belt drive

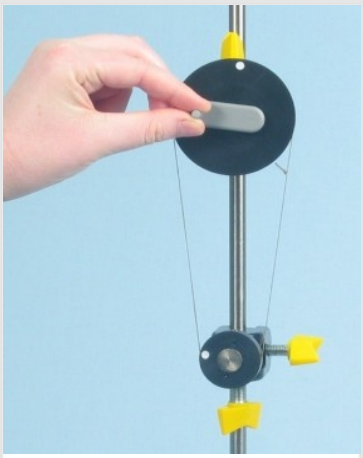
How do the diameter and number of revolutions of the belt drive relate to each other?

- ○ $d_2/d_1 = R_2/R_1$
- ○ $d_2/d_1 = R_1/R_2$

Check

Task 6

PHYWE



Belt drive

Can you specify a way to change the direction of rotation of the driven wheel in belt transmission?

(Try it experimentally if necessary)

- ○ There is no possibility to change the direction of rotation.
- ○ You have to tighten the belt crosswise.
- ○ You have to lengthen the belt considerably.

Check

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Task 7

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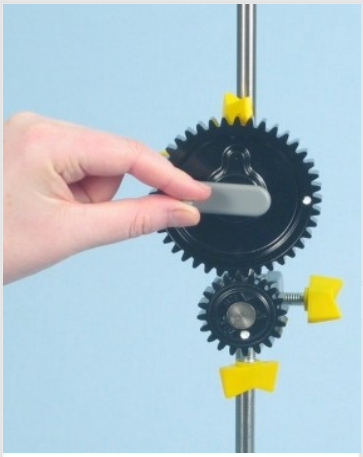
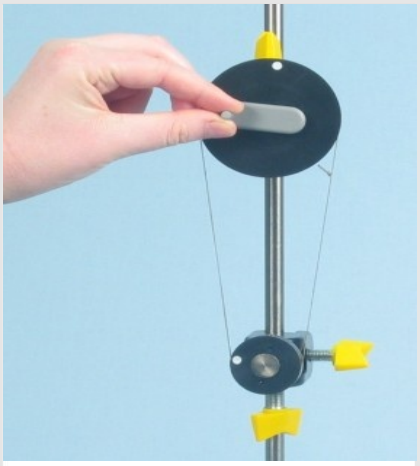


Gearboxes

What's right for a gearbox?

- [ ] You can convert the speed and torque.
- [ ] The direction of rotation can be reversed.
- [ ] It is possible to increase the generated power.

Check



Belt drive

Slide	Score / Total
Slide 23: Comparison of the directions of rotation	0/1
Slide 24: Relationship between number of revolutions and number of ...	0/1
Slide 25: Direction of rotation Gear drive	0/2
Slide 26: Comparison of the directions of rotation	0/1
Slide 27: Relationship between number of revolutions and diameter	0/1
Slide 28: Direction of rotation Belt drive	0/1
Slide 29: Features of a gear unit	0/2

Total amount 0 / 9

Solutions | Repeat | Exporting text

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