GEARS

Name: ……

Date: ……

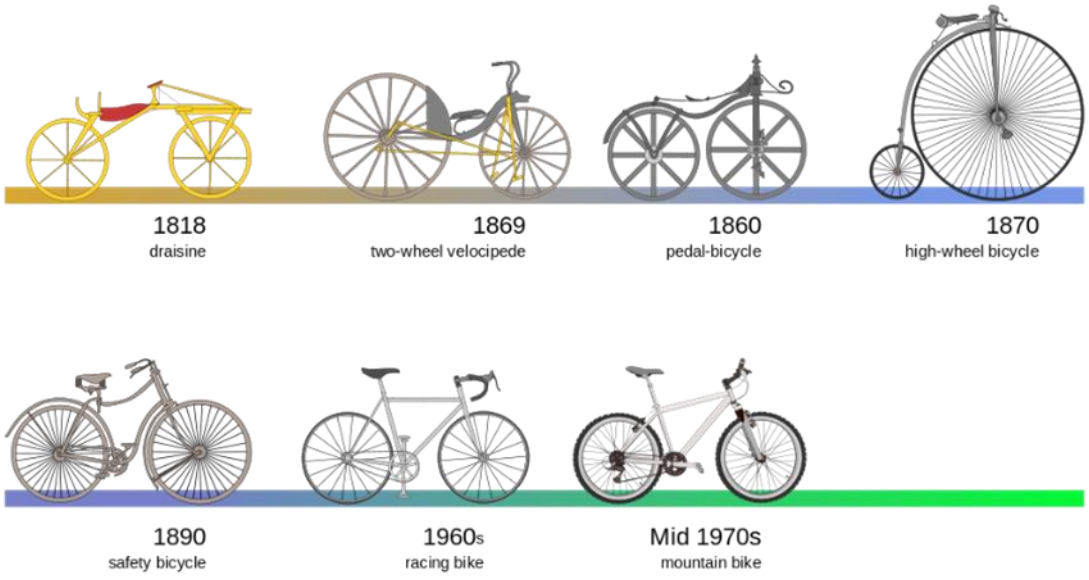
School: …… Class: ……

Before the experiments

QUESTIONS BEFORE THE EXPERIMENTS

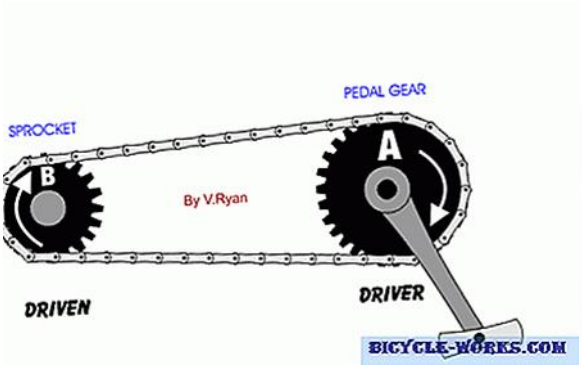
Answer the questions related to the Gears:

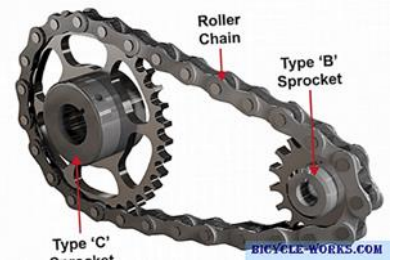
I. What is a spur gear?
II. Why does a bike have gears of different sizes?
III. Gears are all around us. Give examples of where you might see Gears working.
IV. Explain what the advantage of using a Gear is!
V. Whether is there any condition for the two gears to fit gearing?
VI. Which is the driver gear if you need to slow down motion?
VII. What can you say about linear velocity of the tooth if the 2 gears in a system are different size?
VIII. What can you say about number of revolution of the 2 meshing gears if they are different size?
IX. What directions do the two gears in a system rotate? How can you make the driver gear and driven gear rotate both clockwise?
X. Exploring bikes



It is possible to travel three times faster by bike than walk, besides consuming the same amount of energy.

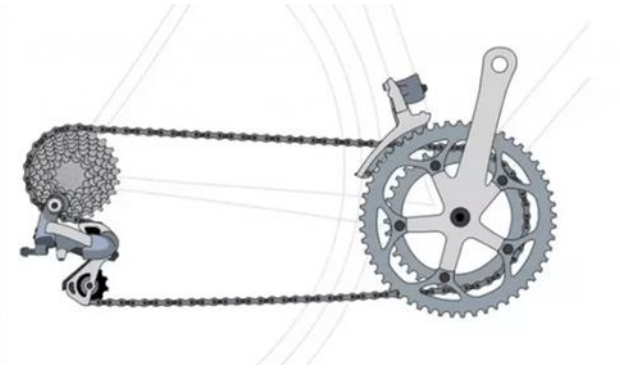
For the simplest bicycles, two gears connected by a chain provide movement.





1. Why do you need two gears?
2. How does such a gear system work?
3. Where is it comfortable to ride on this type of bike? / Which road is comfortable to ride on this type of bike?

Most bikes are equipped with a shifting gear system. It works by a system of gears and mechanisms that move the chain between gears with different numbers of teeth.



4. What is the purpose of variable gear?
5. What effect does the cyclist feel when switching?
6. How the choice of gear (lower or higher) is influenced by weather conditions:

• headwind,

• type of road surface (e.g. sand),

• terrain changes (mountain ride)

• terrain changes (downhill)

7. One of the most popular bikes MTB (Mountain Terrain Bike) is equipped with a large number of gear changes (21 - 30). Explain why?

Experiment 1

TITLE: Zobrata soļa noteikšana GEAR PITCH

FOR THE TEACHER

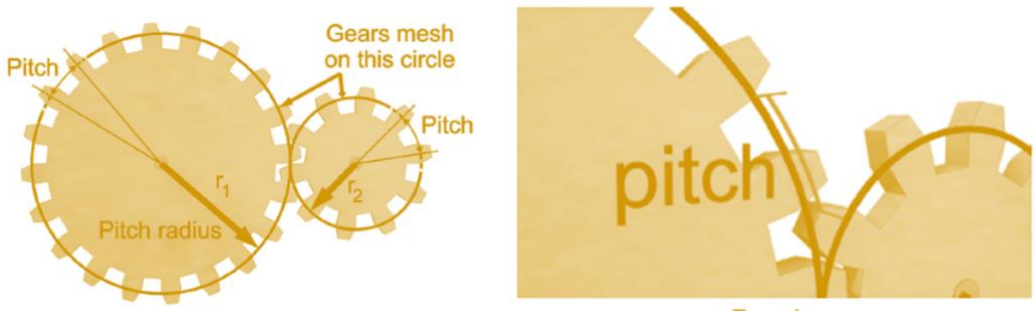
Before the experiments students must be taught the information provided below.

The gear set is characterized by 3 values:

Number of teeth, n

Pitch radius, r: The pitch radius is the radius that passes through the points where two gears mesh. This circle is called the pitch circle and the pitch circles of two connected gears meet at a single point.

Pitch, p: the pitch is the distance around the pitch circle between the same two points on two adjacent teeth.



During laboratory work, students conclude that a pair of gears may have different radii to gearing, but must have the same tooth pitch.

Formulas for calculating circumference $c = 2\pi r$ and number of teeth

$p = \frac{2\pi R}{n}$ should be applied.

LAB SHEET

Introduction

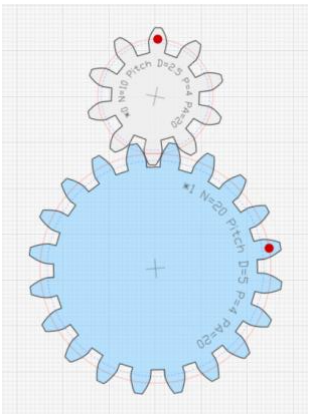
The aim of the laboratory work is to find out what is the regularity between the distances between the two tooth centers of the teeth. *Laboratorijas darba mērķis ir noskaidrot, kāda likumsakarība pastāv starp sazobē esošu divu zobratu zobu centru attālumiem.*

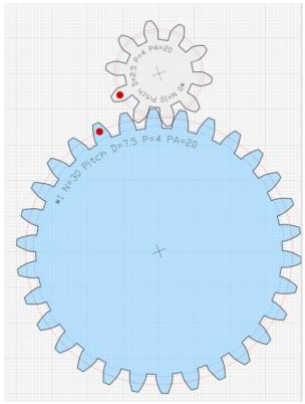
Equipment

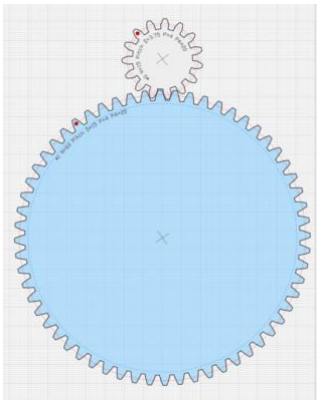
3 or more different sets of gears, ruler, caliper.

Procedure:

There are given three different gear sets.







1. 2. 3.

For each gear set:

- Measure the radius of each gear R1 and R2.
- Calculate the circumference of each gear C1 and C2.

- Count the number (n) of teeth and calculate the length of arch between the centers of two adjacent teeth p1 and p2.

Table of results:

Gear set	R1	R2	C1	C2	P1	P2
1.						
2.						
3.						

Calculations:

What regularities did you see?

FIX CONCEPTS AND REFLECTIONS

Check your answers to the question V before the experiments. What are your conclusions?

Experiment 2

TITLE: Zobratu sistēmas zobu skaita un apgrieziena skaita attiecības RELATION OF TEETH AND REVOLUTION OF GEAR SET

FOR THE TEACHER

During the experiment, students have to come to conclusion that there is inversely proportion between the numbers of teeth of the gears to their number of revolution.

LAB SHEET

Introduction

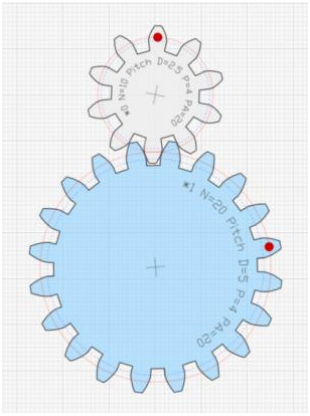
In each gear system, there are certain regularities between gear sizes, number of teeth and revolution.

Equipment

3 or more different sets of gears, ruler, caliper.

Procedure:

There are given three different gear sets.



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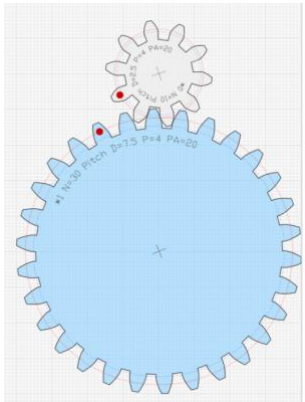

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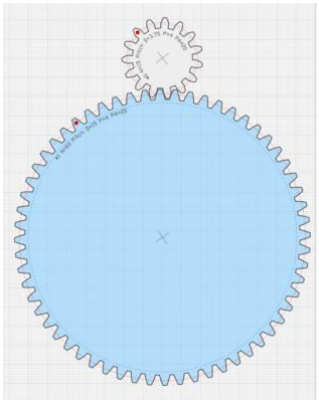


1.

Investigate how these systems work. What regularities can you see?

Take dimension measurements of each gear pair and record them in the table: D1 – diameter of the smallest gear and D2 - the largest gear.

Calculate the gear diameter ratio D1: D2 and record them in the table.

In each system, for each of the gears, determine the number of teeth: N1 - the smallest gear and N2 - the largest gear, and record them in the table.

Calculate the ratio of the teeth number of gears N1: N2.

In each system, determine the mutual gear ratio n1: n2 (small gear revolutions: large gear revolutions), record in the table.

GEAR SET	Diameter of small gear (D_1)	Diameter og largs gear (D_2)	$D_1 : D_2$	Number of teeth (small gear) (N_1)	Number of teeth (large gear) (N_2)	$N_1 : N_2$	$n_1 : n_2$
1.							
2.							
3.							

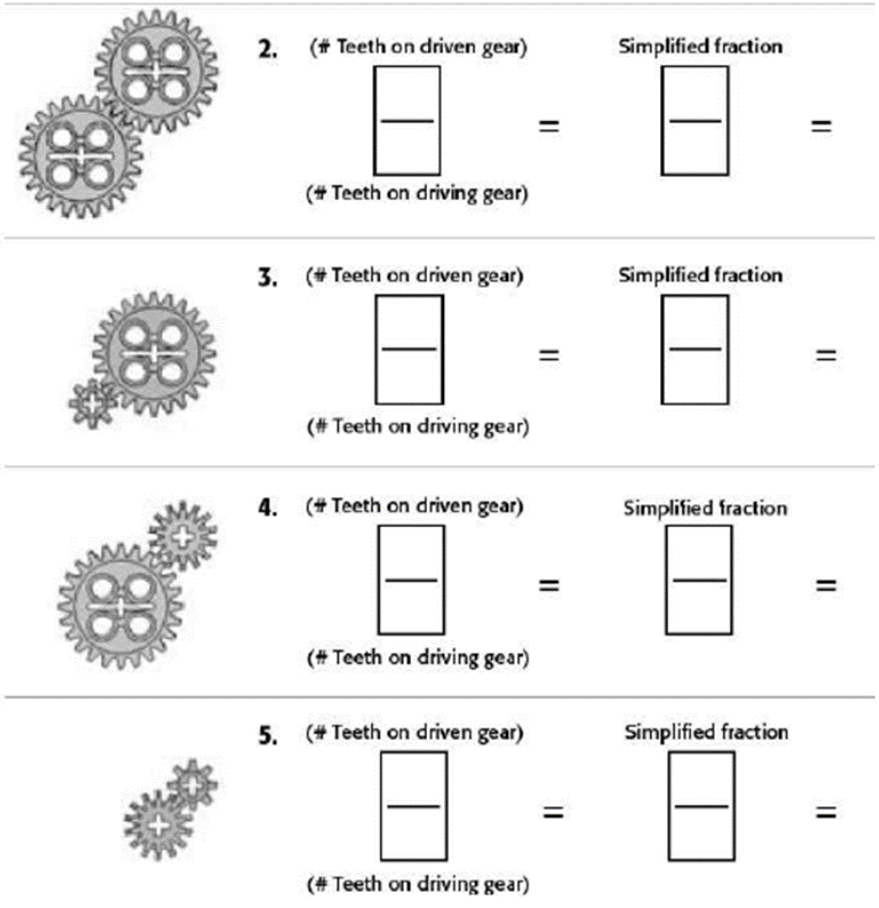
Calculations:

What regularities can you see? Think about the number of revolutions for each gear!

FIX CONCEPTS AND REFLECTIONS

Check your answers to the questions IV, VI-X before the experiments. What are your conclusions?

Activity:



Experiment 3

TITLE: THREE MESHED GEARS

FOR THE TEACHER

During the experiment, students have to come to conclusion that the idler gear does have impact on gear ratio, the idler gear ensures that the driver and follower rotate in the same direction.

LAB SHEET

Introduction

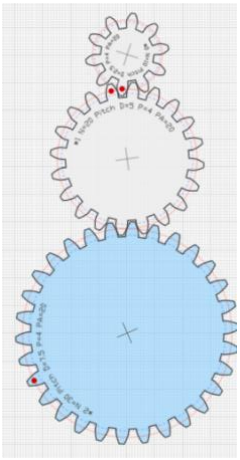
We have already found out that there are several relations between two meshing gears. It is time to find out what are the relations between 3 meshing gears.

Equipment

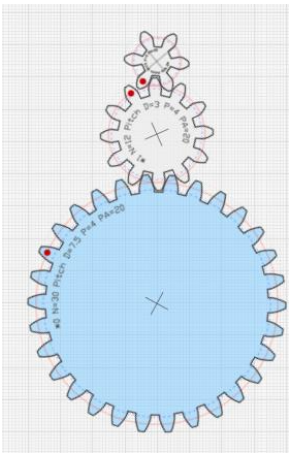
3 or more different sets of gears, ruler.

Procedure:

You have 3 different meshing gears systems. The upper gear is driver, and it rotates clockwise.



1.



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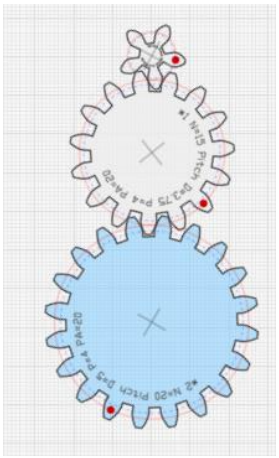


3.

Investigate how these systems work. What regularities can you see?

In each system

Determine the directions of rotation of the gears.

Determine the ratio of driver to idler gear n_1: n_2.

Determine the ratio of the idler and driven (third) gear n_2: n_3.

Determine the ratio of the driver and driven (third) gear n_1: n_3.

Table

GEAR SET	Direction of rotation driver gear	Direction of rotation idler gear	Direction of rotation driven gear	n_1: n_2	n_2:n_3	n_1:n_3
1.	clockwise					
2.	clockwise					
3.	clockwise					

Calculations:

What are the regularities between the gear ratios?

What regularities can you observe between the directions of gear rotation?

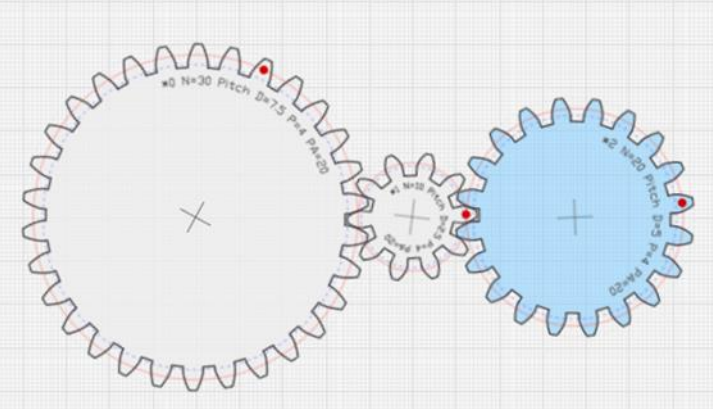
CONCEPTS AND REFLECTIONS

Check your answers to the questions IX before the experiments.

Can you find a general relationship between the ratio of the turns of the first and last gears when there are many connected gears?

Activity:

Consider the following set of gears. The largest gear turns clockwise through one full turn. How many times will gear 3 turn and which direction? How does this compare with the previous result?



Experiment 4

TITLE: TWO IDLER GEARS ON THE SAME AXLE

FOR THE TEACHER

Regarding direction of rotation students have to conclude that matters odd or even number of axles, not odd or even number of gears.

LAB SHEET

Introduction

We have previously found out that there are several relations between two meshed gears and three meshed gears rotating in one plane.

Now let us find out what the relations are between the four gears arranged in two planes, and in each plane there are two meshed gears, besides idler gears rotate on the same axle.

Equipment

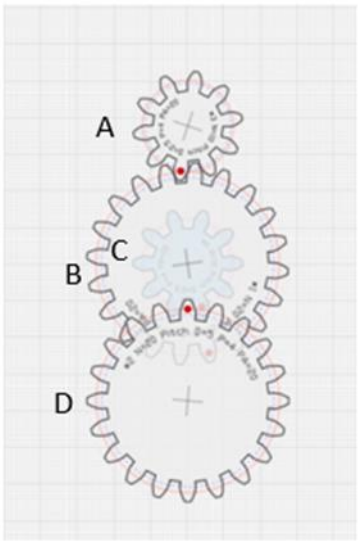
3 or more different four-gear systems in which gears B and C rotate on the same axle, at the same speed.

Procedure:

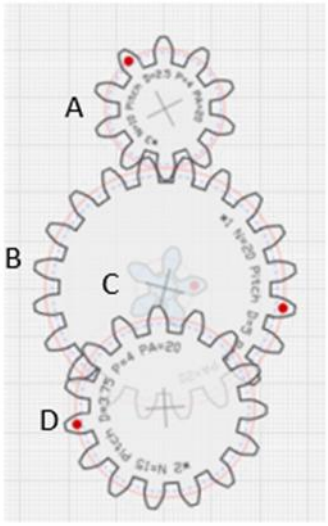
Investigate how these systems work. What regularities can you see?

For each system

- determine the gear ratio A and B of a gear in one plane N_A: N_B;
- determine the gear ratio C: D of the gear in the same plane N_C: N_D;
- determine the gear ratio of the side gears A and D of the system N_A: N_D.



1.



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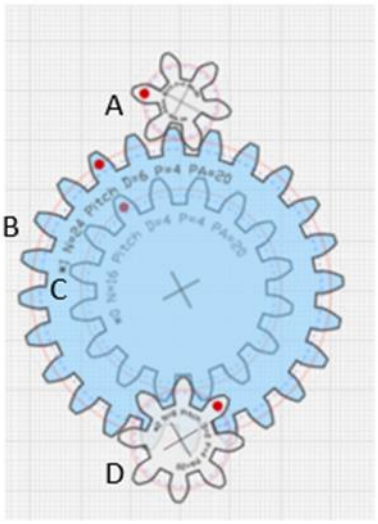


3.

Gear system	$N_A : N_B$	$N_C : N_D$	$N_A : N_D$
1.			
2.			
3.			

Calculations:

What are the regularities between the speed ratios?

Explain what the dimensions of the gears and their position in the four-gear system placed in two planes should be in order to maximize the ratio between the side gears?

FIX CONCEPTS AND REFLECTIONS

1) When determining gear direction is it the number of gear that matters or the number of gear axles?
2) How does the placement of two gears of different radii on the same axle relate to the movement of the bicycle? Look back at your answers to question II and X before experiments!

Experiment 5

TITLE: DETERMING CHARACTERISTICS OF HIDDEN GEAR

FOR THE TEACHER

Students have to think about the linear and radial velocity of a point on a circle and use expressions of linear velocity and radial velocity.

1. As the gears are meshed, they have the same linear velocity ($v_l = v_m$)

   $v = \omega R$ and $\omega = \frac{\varphi}{t}$

   $$\omega_l R_l = \omega_m R_m$$

   $\frac{\varphi_l}{t} R_l = \frac{\varphi_m}{t} R_m$ (1.formula)

   As the small gear has gone through one full turn, then $\varphi_m = 2\pi$

In turn, the large gear φ_l corresponds to n teeth. If there is a full revolution, then the angle 2π corresponds to N. A proportion can be drawn

$\frac{\varphi_l}{n} = \frac{2\pi}{N}$, where $\varphi_l = \frac{2\pi n}{N}$

By inserting the obtained relations (in formula 1)

$\frac{2\pi n R_l}{N} = 2\pi R_m$, from this we conclude $R_m = R_l \frac{n}{N}$

Since both gears have turned by the same number of teeth, counting n on the large gear gives the number of teeth of the small gear. ($n = n_m$)

LAB SHEET

Introduction

In this experiment, you have to think about the linear and radial velocity of a point on a circle. You have a set of meshed gears, where the smaller gear is hidden, you can see only few teeth of gear. One tooth is marked on each gear.

Tasks:

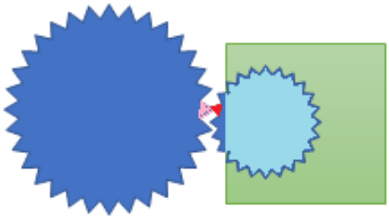
1. Determine the number of teeth of the small gear;

2. Determine the radius of the small gear.

Equipment

A set of meshed gears, ruler, caliper.

Procedure:



Picture 1

Picture 2

1. The large gear is rotated until the marked tooth of the small gear is in the start position again.

2. Count how many teeth the big gear has turned (n) while the small one has made a full turn.

3. Count the number of teeth of the large gear N.

4. Measure the radius of the large gear is R_l.

5. Determine the number of teeth of the small gear.

6. Determine the radius of the small gear R_m.

Table of results:

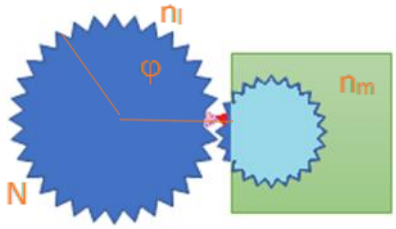
Nr.	**n**	**N**	**R_l**	**R_m**

Calculations:

Prove the result obtained using physics formulas!

FIX CONCEPTS AND REFLECTIONS

1) Explain how you got the number of small gear teeth!



2) What can you conclude about the linear speed of gears?

Reflection after all experiments:

What advantage do you gain from using gears? Check your answers to the question IV before the experiments.