Scenario of the lesson on:

Witelo's studies on rectilinear propagation of light.

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General aims:

— cognition of assumptions that determine the light description in geometrical optics,

Specific aims

Student:

— knows historical reasons motivating to search the answers to the questions connected to human's perception, vision of the world,
— understands potrzebę the need to create and refine the new physical concepts and to formulate and prove the theorems,
— understands the weight of proving the theorems empirically,
— recognizes, by studying the certain fragments of Witelo work, the evolution of the ideas,
— knows the basic assumptions of geometrical optics,
— is able to decribe the course and explain the result of the historical Witelo's experiment,
— explains the formation of shadow and penumbra,
— knows under which conditions we observe the Sun and Moon eclipse,
— indicates the areas of everyday life, in which we use the shadow and penumbra phenomena.

Educational methods:

- *based on words,*
  talk – clear and transparent presentation of the need to conduct optics studies by Witelo, also quotation of some definitions, postulates and theorems that he formulated,
- *based on observation and measurement,*
  demonstration and measurement – detailed repetition of Witelo experiment by two pairs of students, deriving the results and proper conclusions.

Educational tools:

- copy of Witelo's device for demonstrating the rectilinear propagation of light,
- multimedia projector, computer,
- overhead projector, sample transparent and opaque objects,
- three sources of light (candles, bulbs),

- three balls of different size or spherical fruits,
- table, chalk.

Forms of work:

- individual,
- 5-person groups,
- homework.

1) Teacher's welcome, write of the lesson's subject and short information about the meeting's aims.

INTRODUCTION

Witelo was one of the most famous Polish scientists. He stretched his research on almost each science segment, that is why his susequent works created the unity with everyday life elements. His work „*Perspective”* which might seem devoted to optics, one of physics' branch, is also the basic geometry work. It also deals with human physiology, one chapter is an eye description with its mechanisms. Witelo took into account the subconscious action of mind, its influence on „seeing”. There were many interests in Witelo's activities, he was not only the naturalist, but also mathematician and philosopher.

During our physics lessons, we will limit ourselves to tracing Witelo's way of thinking, which lead him to formulate subsequent theorems and some experiments fundamental for geometrical optics (slide no.2 from the presentation - Fig.1.).

Fig.1. Slide no. 2 of the presentation.

	Teacher's activities	**Student's activities**
	1. Teacher questions: What is the light?	- The light is the visible range of electromagnetic spectrum (electromagnetic wave), - collection of particles – photons, each carrying his own energy
	2. Teacher shows the definition of light by Witelo as the next slide of the presentation (Fig.2.).	- students notice the archaic way of formulating the definition,

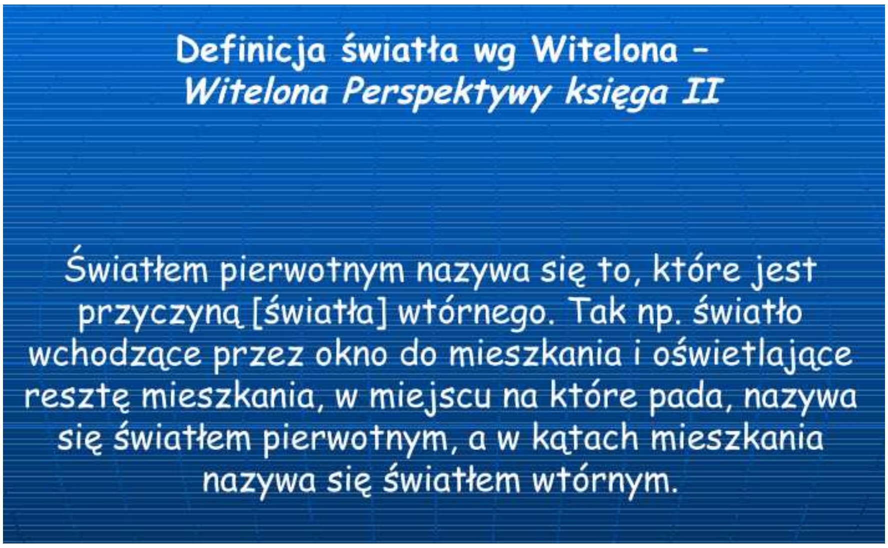

Fig.2. The definition of light by Witelo.

	3. What do we call the source of light?	- the sources are all radiating objects,
	4. What is the way of light propagation? What is the way to observe it?	- rectilinear one - laser's beam, shadow
	5. Introduces the definition of light ray and light beam: while observing the Sun Witelo assumed, that the light propagates linearly as rays. Due to Witelo we can see the light only when it has the certain width (the lines along which the light propagates have a certain width). In the middle of the line there is a symbolic mathematical line, or the minimal visible portion of light. All the other light lines are parallel. The set of the parallel rays is the light beam. It is the first assumption of geometrical optics: The light stream	

	is a collection of separate, individual rays.	
	6. Shows the pictures on which you can notice, that the rays are rectilinear (Fig.3.).	- they notice, that the rays on the pictures are rectilinear,

Fig.3. The slide which shows the rectilinearity of light.

	7.Presents the Witelo's theorem about rectilinear propagation of light (Fig.4.).	- read the content „[Exiting of] the rays from any light source and propagating of the forms takes place linearly. The above statement can be proved not by evidence, but using a device."

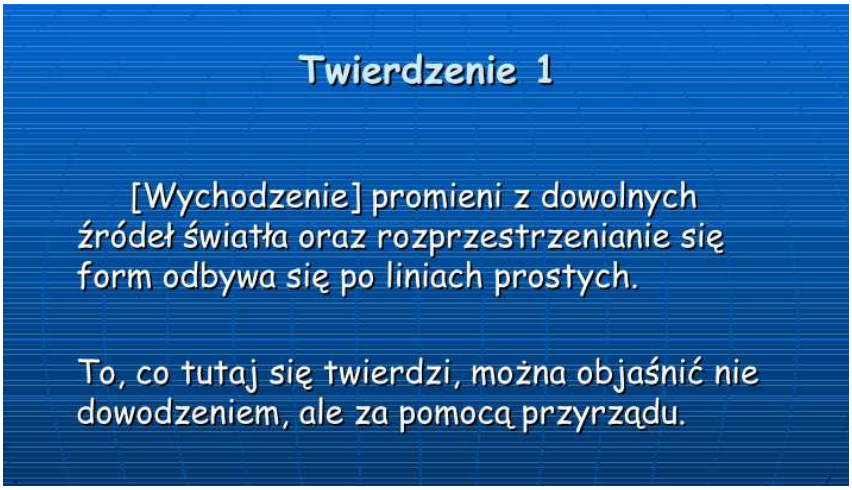

Fig.4. The slide presenting Witelo's theorem
on rectilinear propagation of light.

	8. Demonstrates the exact copy of the device, which was used to prove the rectilinear propagation of light. There is a scheme to redraw for the students (Fig.5.).	- the student describes the device: The device is an empty cylinder of concealed bottom. There is a degree scale on the inner side of the cylinder. There are two identical holes (2-3 mm wide) on opposite sides of the cylinder's wall. These holes are on the same height (2-3 mm) from the bottom of the device. Iside the dish there is a flat-plate parallel with the same hole as the ones drilled in cylinder's walls. The plate is attached to the bottom. This way all the holes are located on the same line, perpendicular to the cylinder's axis.

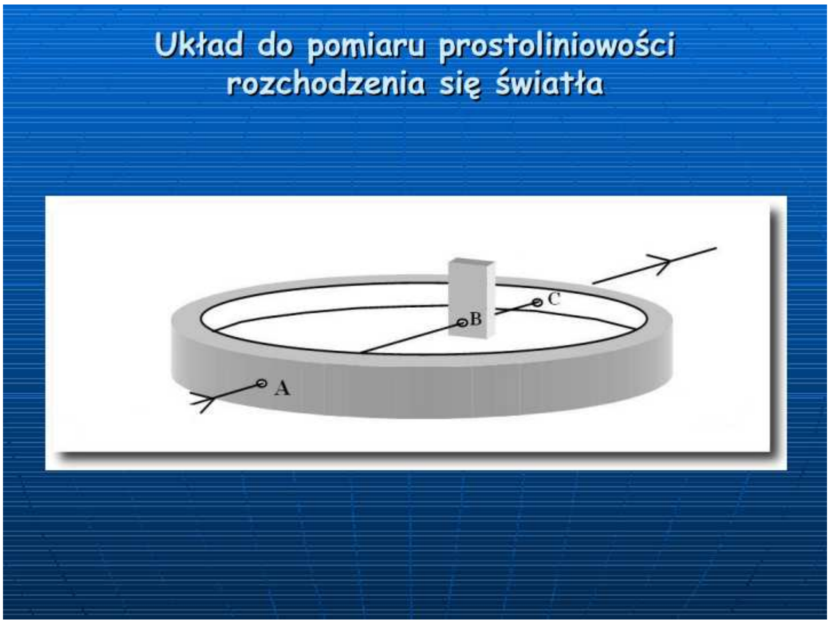

Fig.5. The slide with the scheme of the device for measuring the rectilinear propagation of light

	9. Explains how to perform the experiment.	- two pairs of students perform the experiment, derive the results (determine the beam's width), the other formulate the conclusions,

EXPERIMENT:

We put the light source next to one of the holes. The light is coming into the plate's hole and then on the cylinder's wall creating a circle spot there.

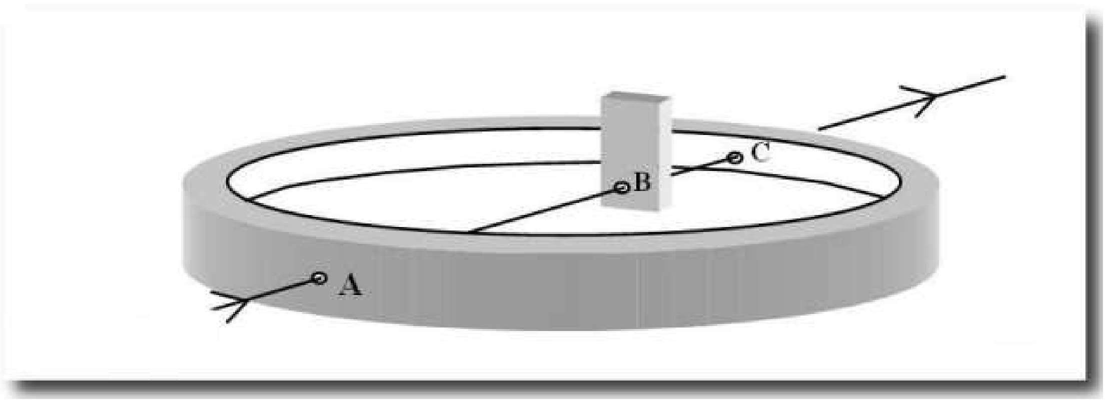

Fig.6. The scheme of the device, which was used to document the rectilinear propagation of light.

OBSERVATIONS:

There is a circle spot of light on the cylinder's wall, the middle of the light circle covers the next hole (marked *C*). We can determine the beam's width on the inner cylinder's wall and notice that the width is the same on both sides of the hole.

CONCLUSION:

The line along which the light ray goes crossing both holes A and B and then the middle of the light circle C is located on the plane and creates the circle's diameter. The circle's diameter is a straight line.

	10. Formulates the second assumption of geometrical optics: The light rays go rectilinearly from the source up to the moment when they meet the obstacle or there is a change of the environment in which they propagate (Fig.7.).	- writing,

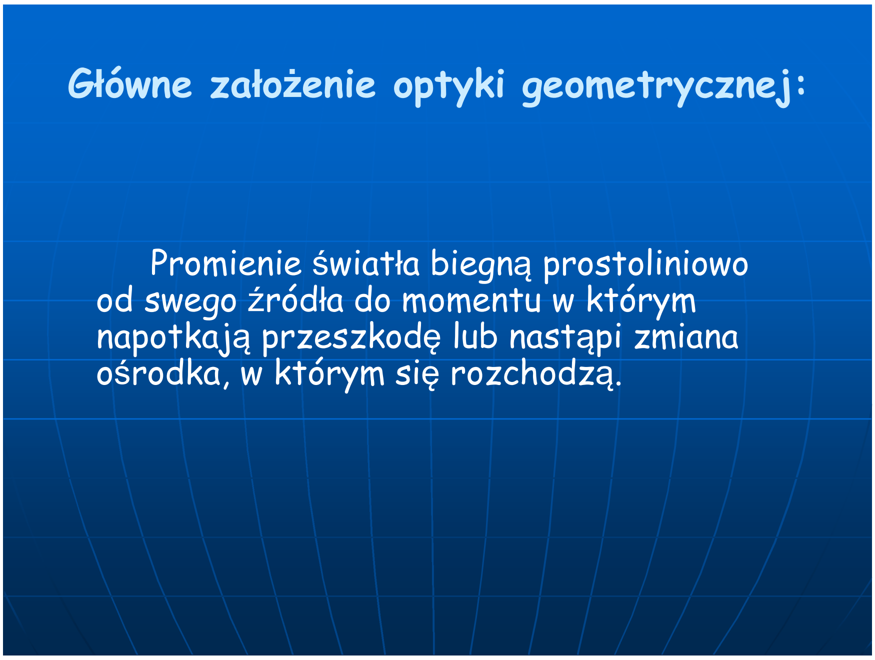

Fig.7. The slide describing the second assumption of geometrical optics.

	11. The formation of the shadow is one of the consequences of the rectilinear propagation of light.	
	12. Devides the students into 5 groups. Each group has its own set of props to demonstrate other phenomena. The teacher (T) asks the questions, the students (S) answer. Each conclusion derived from the experiment is displayed on slides as the theorem formulated by Witelo a long time ago. (Fig.8.).	

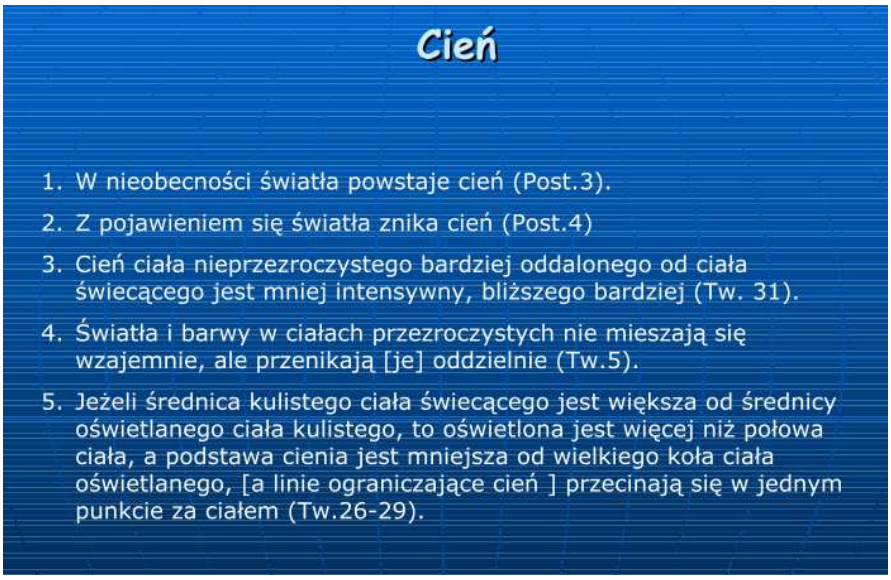

Fig.8. The slide containing the experiment's conclusions.

Experiment 1

Students demonstrate the shadows of different size and shape. They change the distance between the light source and the object.
T: What is the shadow? Where is it formed?
S: This is an area not available for the light.
T: Would it be possible to get the shadow if the propagation of light is not rectilinear?
S: No, because each area could be lighted.

T: When is the shadow more intensive, when is it weak?
S: The closer the object gets to the light source, the more intensive is the shadow.

Experiment 2

We point the light beam from the projector on the object:
a) transparent,
b) opaque.

T: What do you observe?

S: The shadow arise if we direct light on opaque object. We don't get the shadow if the light is directed towards the transparent object.

Experiment 3

We illuminate the same objects as in Experiment 1 with two light sources or one extended source.
T: What do we observe?
S: We observe the fuzzy shadow, that means stronger in the shadow of both sources and weaker around – in the area we call penumbra.

T: How does penumbra arise?
S: One light source illuminating an opaque object is causing its shadow. At the same time this area is lighted by the second source, hence the penumbra effect.

Experiment 4

We illuminate an object by three light sources.
T: How many shadows arise?
S: Three.
T: What does the number of shadows depend on?
S: On the number of light sources.
T: Are there any natural phenomena connected with the umbra and penumbra?
S: Yes, solar and lunar eclipse.

Experiment 5

Demonstration of solar and lunar eclipse by setting the balls or fruits of different size in the correct order.

2) The teacher summarizes the lesson, providing the homework: Is there „something” (person, animal, object) which under favorable conditions, does not have the shadow? Answer.

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2) A. Bielski, L. Bieganowski, *Studia i Materiały z Dziejów Nauki*,