INSTRUCTIONS FOR USE

INITIAL optical bench

DO106009

TWINSE

School Equipment for Science Education

Description

This INITIAL optical bench enables pupils to discover and understand optics in complete autonomy. It comes in a practical case for easy checking and storage of the bench. Simple to use, it is suitable for handling by pupils so that they can carry out their own experiments.
Features:

- 1 1125 mm long rail graduated over 1100 mm in three sections that clip together
- 5 riders
- 4 lens and slide holders (lens ø40) with clips
- 1 prism mount
- 1 squared white screen
- 1 3W LED light source with its power supply
- 1 set of 6 PMMA lenses (F +50/+100/+150/+250/-100/-200)
- 1 set of 8 plastic diaphragms (5 diaphragms with holes ø1/2/5/10/20, 1 number "1", 1 slit and 3 slits)

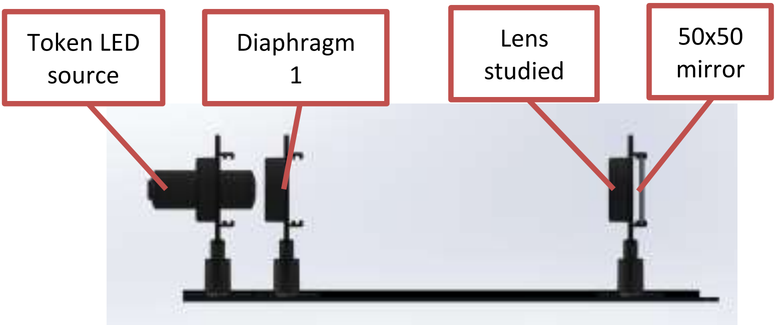
Use

- Place the 3 rail sections on a flat surface and clip them together.
- Place the lens holders and the screen on the riders.
- On one of the riders, place the token LED in a lens holder and block with a clip.
- Connect the 6V power cable to the back of the light source and plug into the mains.
- The bench is now ready for use for a variety of experiments to measure focal length and observe diffraction.

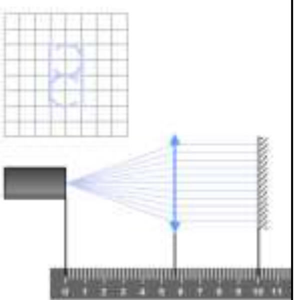
Focal length of thin lenses

The aim is to demonstrate the different methods of determining the focal length of thin lenses.

1. <u>Autocollimation</u>

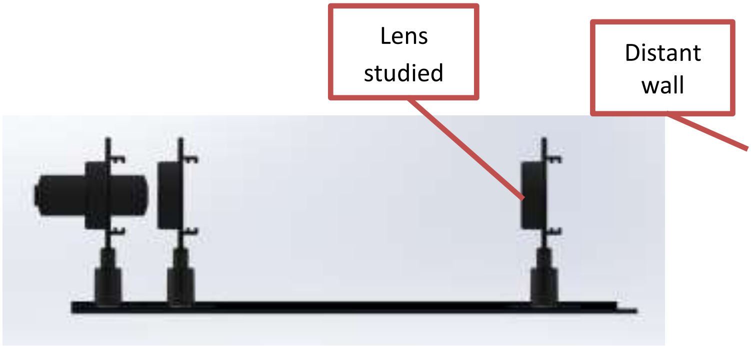


- Place the light source on the 0 mark.
- Place the diaphragm with the number "1" in a lens holder and position it on the 5 cm mark.
- Place a converging lens in a lens holder.
- Place a 50x50 mirror on the same lens holder.
- Move the assembly along the bench until you obtain a sharp inverted image of the same size on the on the diaphragm.
- The distance between the diaphragm and the lens then corresponds to the focal length of the lens.

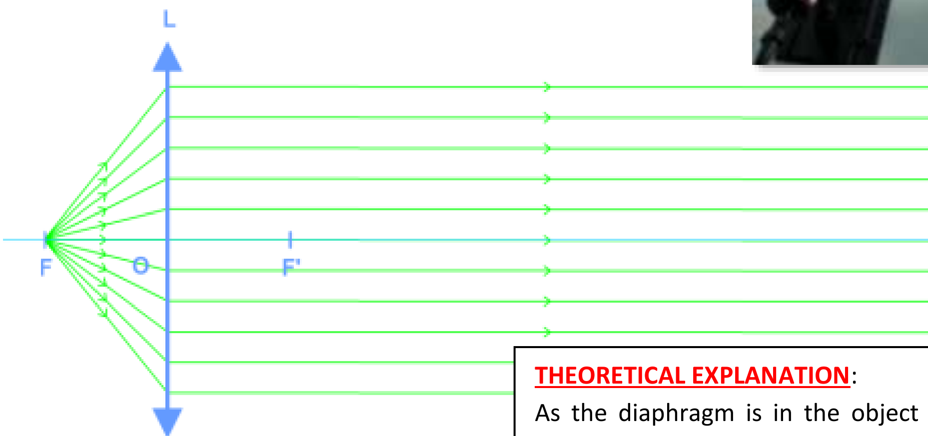


THEORETICAL EXPLANATION:
As the diaphragm is in the object focal plane of the lens, it gives an image at infinity.
Thanks to the mirror, on the return, this image at infinity becomes an object at infinity which gives a real image in the object focal plane or on the diaphragm.

2. <u>Image at infinity method</u>

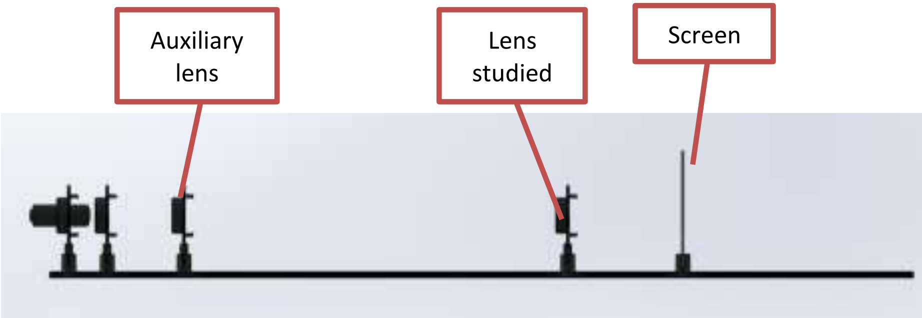


- The configuration is the same as before, but without the 50x50 mirror.
- Move the rider with the lens to be studied until you obtain a sharp inverted image on the wall.
- The distance between the object and the lens then corresponds to the focal length of the lens.

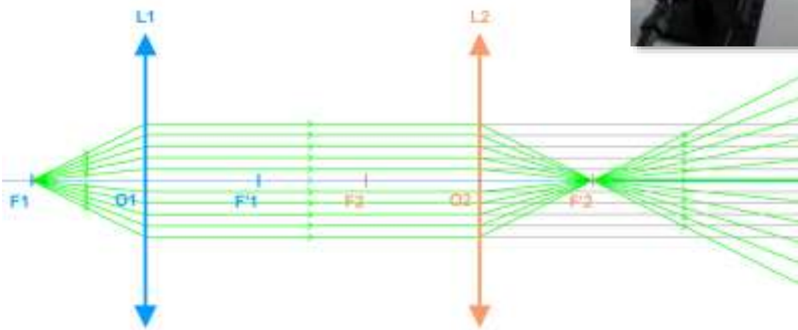


THEORETICAL EXPLANATION:
As the diaphragm is in the object focal plane, it gives an image at infinity.
This remains sharp whatever the distance from the wall.

3. Object at infinity method

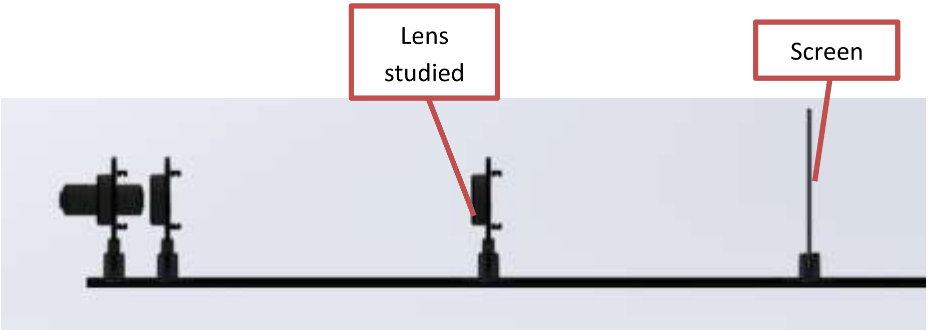


- This time an auxiliary lens is used, placed so as to obtain a sharp image at infinity (cf. image at infinity method).
- Then place the lens to be studied and the screen on the bench.
- Move the screen in relation to the lens until you obtain a sharp image.
- The focal length of the lens is then the distance between the lens and the screen.



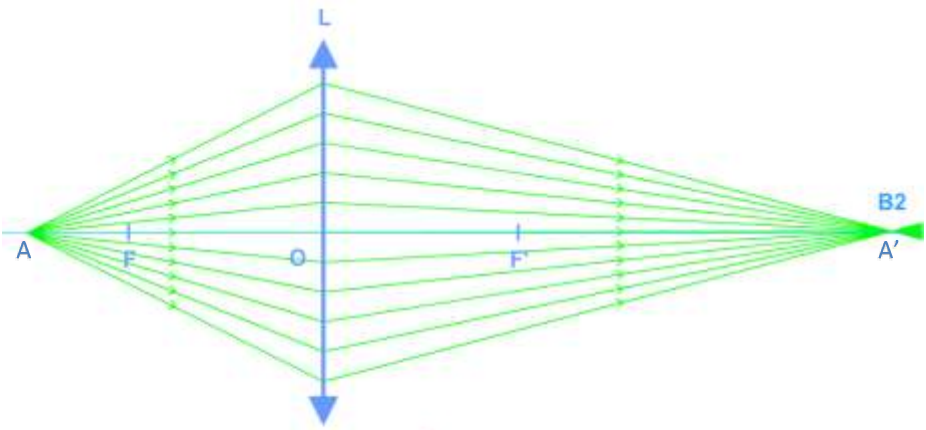
THEORETICAL EXPLANATION:
The first lens allows you to obtain an image at infinity which will serve as the object at infinity for the lens to be studied.
Thus by placing the screen in the image focal plane of the lens to be studied you obtain a sharp image.

4. Descartes' thin lens formula

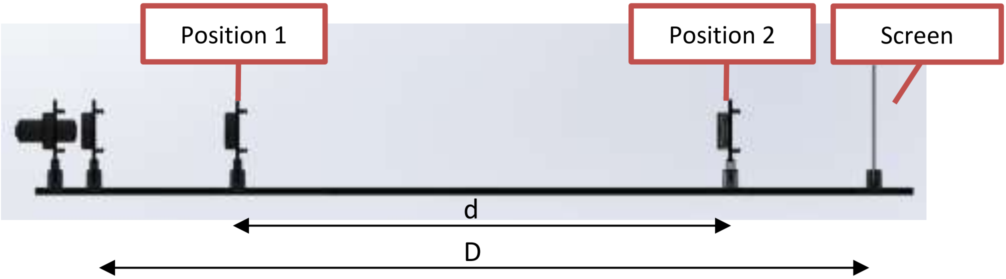


- Place the lens to be studied on the bench.
- Move the screen until you obtain a sharp image on it.
- $\overline{OA}$ is the distance between the lens and the object (algebraic distance) and $\overline{OA'}$ the distance between the lens and the screen (algebraic distance).
- The focal length can be calculated using Descartes' thin lens formula:

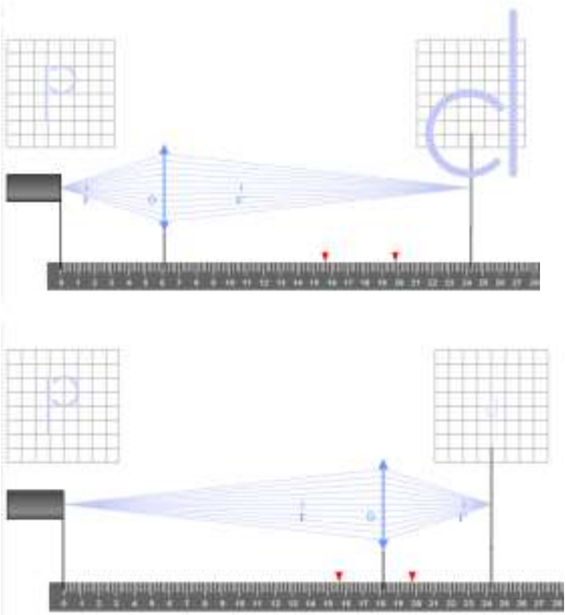
$$\frac{1}{f'} = \frac{1}{\overline{OA'}} - \frac{1}{\overline{OA}}$$



5. <u>Bessel's method</u>



- The configuration is the same as the previous one.
- Move the rider with the lens to be studied from the diaphragm towards the screen until you obtain a sharp enlarged inverted image on the screen. Note the value of this position 1 (X_1).
- Continue moving the rider towards the screen until you obtain on a second, but substantially smaller sharp inverted image. Note the value of this position 2 (X_2).
- D is the distance between the object and the screen and $d = X_2 - X_1$



THEORETICAL EXPLANATION:
The focal length of the lens is then given by Bessel's equation:

$$f' = \frac{D^2 - d^2}{4xD}$$

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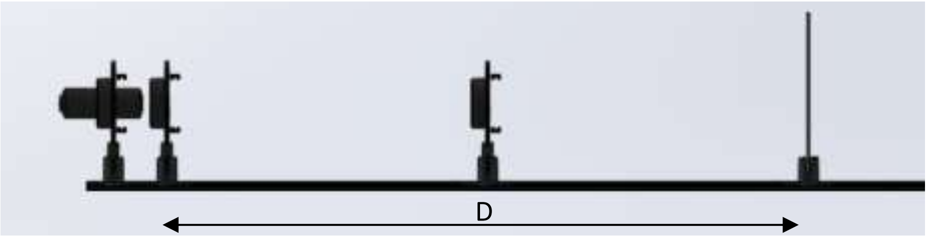
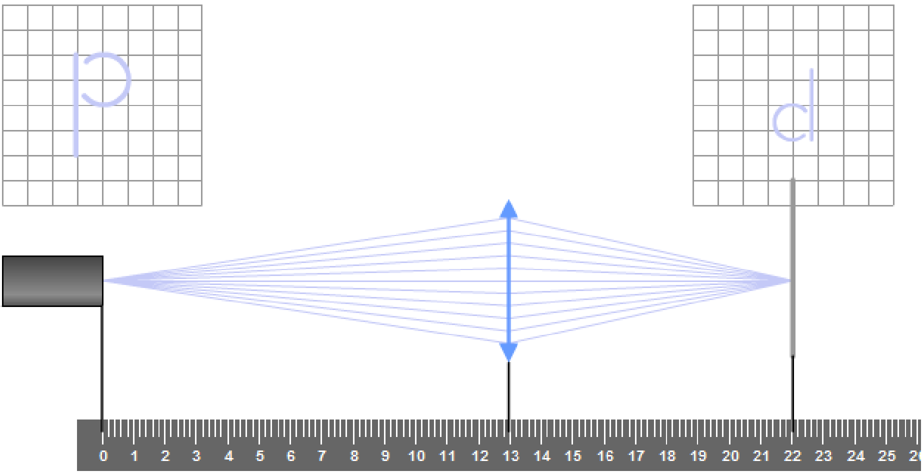
6. Silbermann's method



- This method is a special case of Bessel's method.
- This time we are looking for the position of the lens and the screen that gives an inverted image on the screen that is the same size as the object.
- In this case, the focal length of the lens is: $f' = \frac{D}{4}$

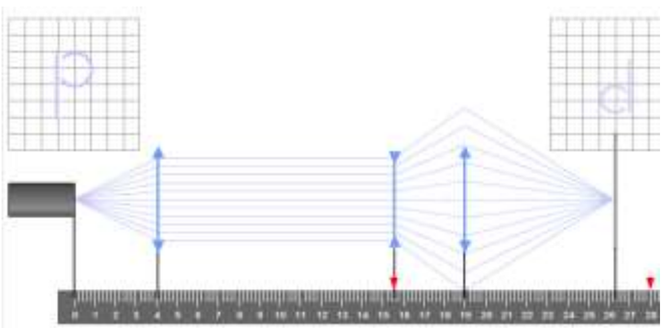


THEORETICAL EXPLANATION:
This is a special case of Bessel's method where d=0. Therefore if we apply Bessel's equation, we obtain: $f' = \frac{D}{4}$

7. Diverging lenses - Badal's method

In the case of diverging lenses, a real image cannot be produced by a real object.

- Use the configuration for the object at infinity method (page 7) with 2 converging lenses. Then deduce the focal length of the second lens f'_2 which is the distance between lens 2 and the screen.
- Then place the diverging lens to be studied in the object focal plane of the second converging lens (namely at a distance f'_2 before the second lens). Then move the screen until you obtain a sharp image. d is the distance between the 2 positions of the screen.
- $f_3' = \frac{f'_2}{\mathrm{d}}$



Representation of optical instruments

With this bench, it is also possible to represent different optical instruments in order to understand how they work.

1. <u>Microscope</u>

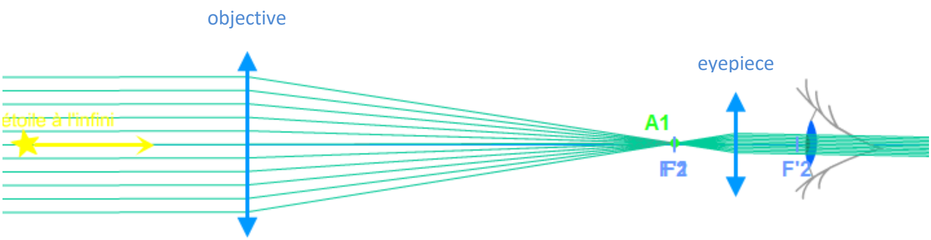
- Place the light source on the 0 mark.
- Place the diaphragm with 1 slit in a lens holder and place it just in front of the source.
- Place the F+50 lens near to the diaphragm.
- Then place the F+100 lens 30 cm away from the first lens.
- Move the pair of lenses to focus the image.
- Measure the width of the image obtained.
- Repeat the operation with the two lenses 40 cm apart.
- Compare the image obtained with the one before.

2. Keplerian telescope

Supplementary accessories:

- 1 INITIAL BO lens holder
- 1 INITIAL BO rider

- Place the light source on the 0 mark.
- Place the diaphragm with 1 slit just in front of the source.
- Then place the F+50 lens 5 cm from the diaphragm. This will enable you to simulate an object at infinity.
- Then place the F+250 lens 5 cm on the bench.
- Finally place the F+100 lens about 35 cm away from the previous lens.

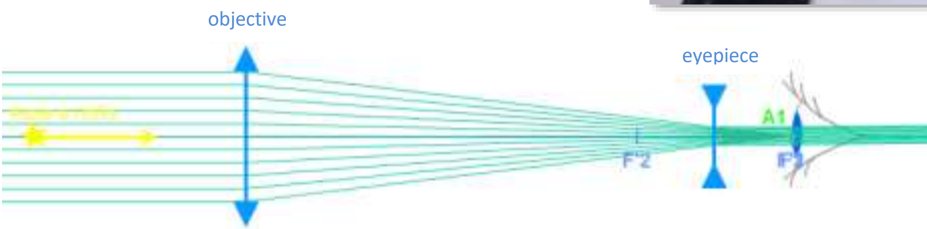


3. Galileo's telescope

Supplementary accessories:

- 1 BO INITIAL lens holder
- 1 INITIAL BO rider

- Place the light source on the 0 mark.
- Place the diaphragm with 1 slit just in front of the source.
- Then place the F+50 lens 5cm from the diaphragm. This will enable you to simulate an object at infinity.
- Then place the F+250 lens 5cm on the bench.
- Finally place the F-100 lens about 15 cm away from the previous lens.



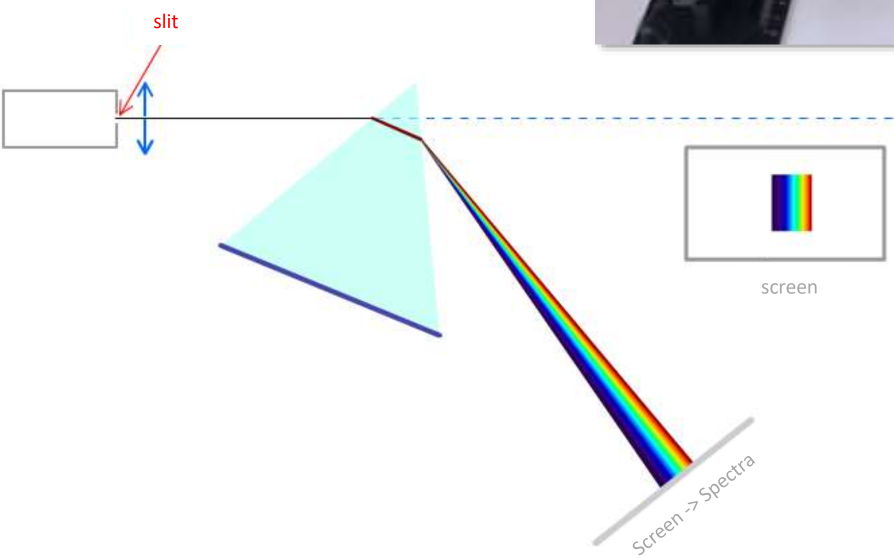
White light diffraction

1. Prism

Supplementary accessories:

- 1 prism

- Place the light source on the 0 mark.
- Place the diaphragm with 1 slit just in front of the source.
- Then place the F+250 lens 25cm from the diaphragm. This will enable you to simulate an object at infinity.
- Then place the prism mount with the prism on the bench.
- Place the screen next to the bench to observe what happens.



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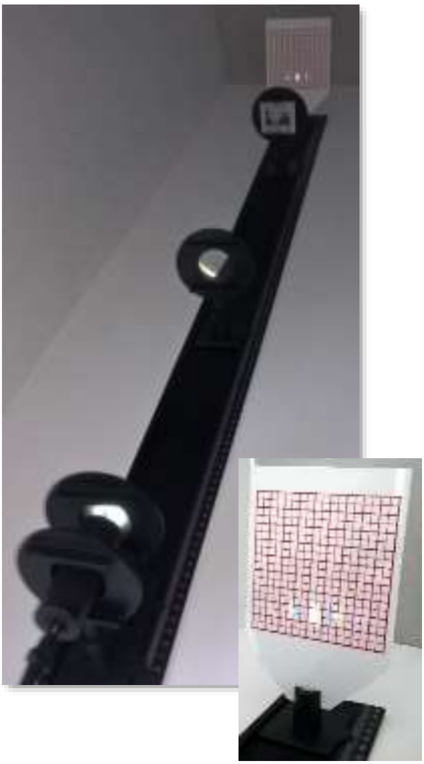
2. Grating

Supplementary accessories:

- 1 x 140 line/mm grating
- 1 x 530 line/mm grating

- Place the light source on the 0 mark.
- Place the diaphragm with 1 slit just in front of the source.
- Then place the F+250 lens 25cm from the diaphragm. This will enable you to simulate an object at infinity.
- Then place the 140 line/mm grating.
- Observe the diffraction of the light.
- Repeat the operation with a 530 line/mm grating.



Diffraction and interference

Using a token laser, it is also possible to do diffraction and interference experiments.

1. Network

Supplementary accessories:

- 1 token laser
- 1 x 140 line/mm grating
- 1 x 530 line/mm grating

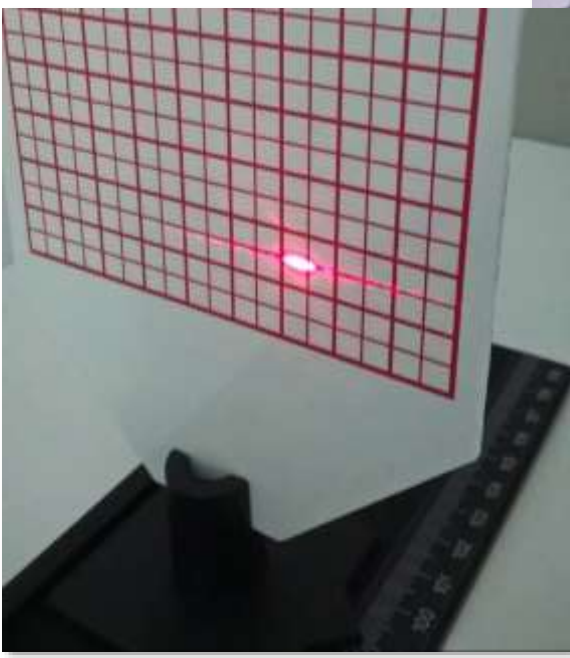
- Place the token laser on the 0 mark.
- Then place the 140 line/mm grating.
- Observe the diffraction of the light from the laser on the screen.
- d is the distance between the grating and the screen.
- x is the distance between the main mode and rank 1 mode.
- It is then possible to find the number of lines in the grating.
- Repeat the operation with a 530 line/mm grating.

2. <u>Diffraction slits</u>

Supplementary accessories:

- 1 token laser
- 1 slide with 7 slits & 7 lines

- Place the token laser on the 0 mark.
- Then place the slide.
- Observe the diffraction of the light from the laser on the screen.
- d is the distance between the grating and the screen.
- x is the distance between the main mode and rank 1 mode.
- It is then possible to find the width of the slit.



3. <u>Young's slits</u>

Supplementary accessories:

- 1 token laser
- 1 Young's slit side

- Place the token laser on the 0 mark.
- Then place the slide.
- Observe the diffraction of the light from the laser on the screen.