INSTRUCTIONS FOR USE

DO106041 - Premium ø80 Optical bench - Determination of focal lengths

DO106043 - BO PREMIUM complementary kit - Decomposition of white light

DO106042 - BO PREMIUM complementary kit - Diffraction & interference

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Description

This Premium ø80 optical bench enables pupils to discover and understand optics. It is simple to use and thanks to the size of the lenses (ø80), ideal for demonstrations by the teacher of the determination of the focal lengths

Its two complementary kits (decomposition of white light and diffraction & interference) allow the teacher to demonstrate diffraction and the decomposition of white light.

The two kits can be stored in the BO Premium Ø80 case in two specially provided spaces.

BO Premium ø80 - Determining focal lengths:

- 1 hollow prismatic aluminium track 1950 mm long with a 1900 mm scale and adjustable feet
- 1 x 100 mm Premium aluminium rider
- 3 x 50 mm Premium aluminium riders
- 2 x lens holders ø80 with clips on an aluminium stem
- 1 squared frosted glass screen 200x200mm on an aluminium stem
- 1 HEXAPOWER 10W light source with condenser, +100 mm (distance between ø10 stem and position of diaphragm: 110 mm)
- 1 power supply for light source, 18V
- 1 set of 4 hooped mineral glass lenses, ø80 (F-100/+100/+200/+500)
- 1 plane mirror, ø80
- 1 diaphragm with letter D, ø80
- 1 slide adapter for ø80 lens holder
- 1 red TRIO laser
- 1 optical axis adjustment diaphragm

BO Premium ø80 case

BO Premium ø80 complementary kit – Diffraction and interference:

- 1 lateral displacement rider
- 1 hooped token with 7 slits & 7 lines
- 1 hooped token with Young's slits
- 1 hooped token with diffraction holes and Young's slits
- 1 green TRIO laser

BO Premium ø80 case
with diffraction and interference kit

BO Premium ø80 complementary kit – Decomposition of white light:

- 1 PREMIUM angle joint
- 1 hollow prismatic aluminium track 500mm long with a 450mm scale and adjustable feet
- 1 PREMIUM prism mount
- 1 x 300 line glass grating
- 1 x 600 line glass grating
- 3 dichroic filters, primary colours (red, green and blue)
- 1 adjustable slot
- 1 glass prism

BO Premium ø80 case
with Decomposition of white light kit

and diffraction and interference kit

Use and adjustment of the optical axis

- Place the screen on a 50 mm rider on the bench.
- Place the red TRIO laser on the 100 mm rider on the bench.
- Adjust the TRIO laser height so that the laser beam hits the centre of the screen.

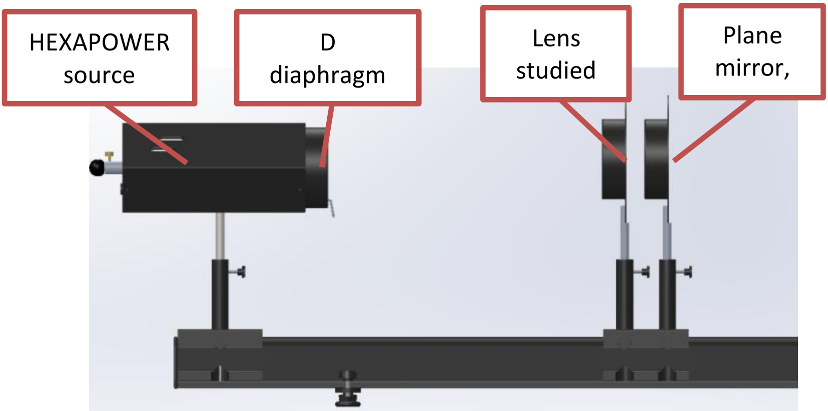
- Place a lens holder on a 50 mm rider on the bench.
- Place the optical axis adjustment diaphragm on the lens holder.
- Adjust the lens holder height so that the laser beam passes through the diaphragm.
- Do the same for the second lens holder.

- Replace the red TRIO laser with the HEXAPOWER source.
- Adjust the height of the source lining up the source lens supports and a lens holder.

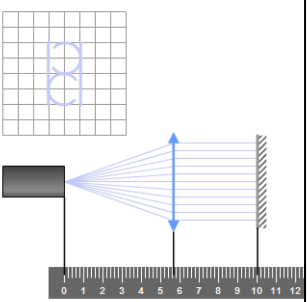
Focal lengths of thin lenses

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 letter D diaphragm in front of the HEXAPOWER source.
- Place a converging lens in a lens holder.
- Place a ø80 plane mirror on a second lens holder placed just afterwards.
- 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.



<u>**THEORETICAL EXPLANATION**</u>:

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.

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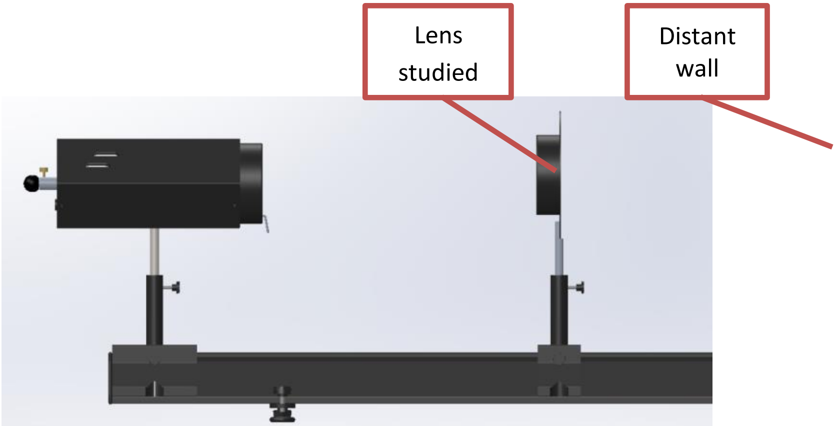
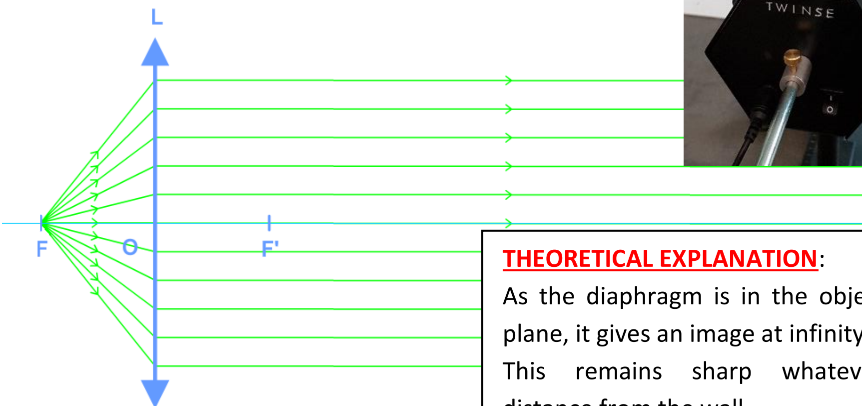
2. <u>Image at infinity method</u>

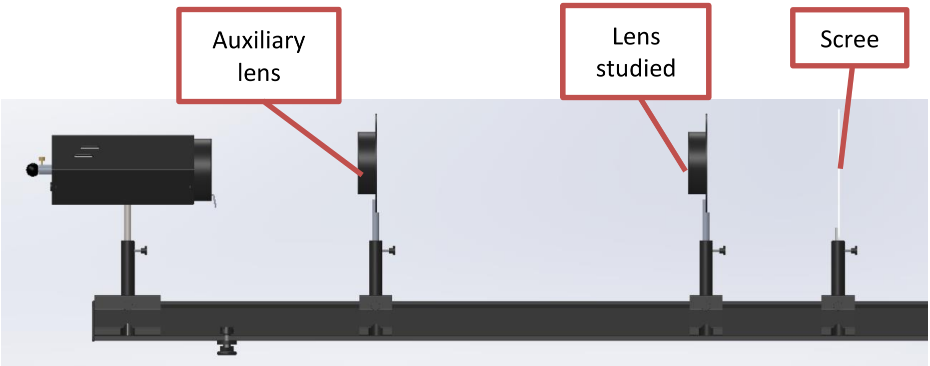


- The configuration is the same as before, but without the lens holder with the mirror.
- Move the rider with the lens to be studied until you obtain a sharp inverted image on the wall.
- The distance between the object and the lens then corresponds to the focal length of the lens.

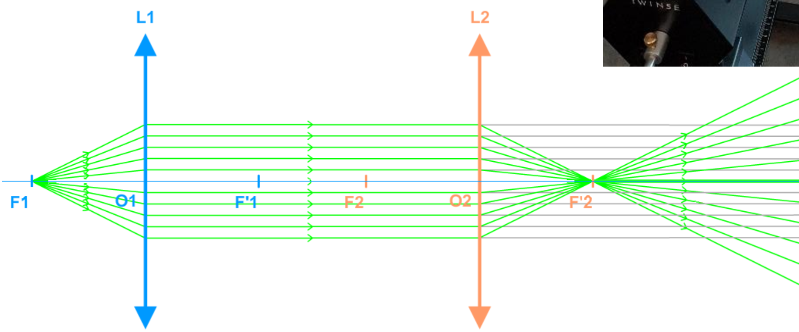


THEORETICAL EXPLANATION:
As the diaphragm is in the object focal plane, it gives an image at infinity.
This remains sharp whatever the distance from the wall.

3. Object at infinity method

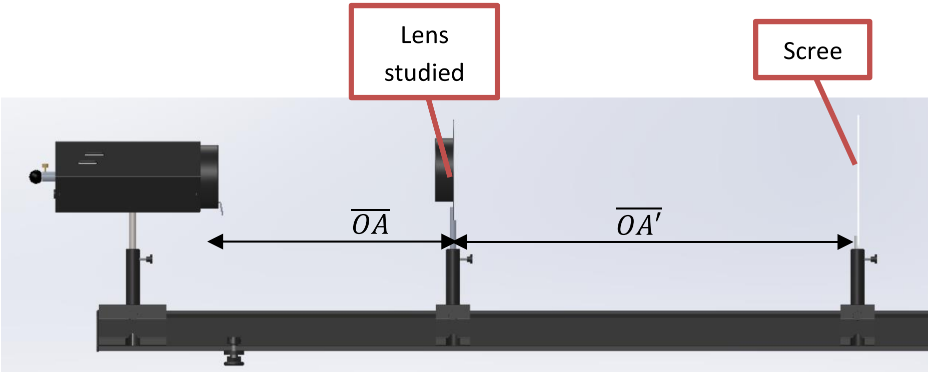


- This time an auxiliary lens is used, placed so as to obtain a sharp image at infinity (cf. image at infinity method).
- Then place the lens to be studied and the screen on the bench.
- Move the screen in relation to the lens until you obtain a sharp image.
- The focal length of the lens is then the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



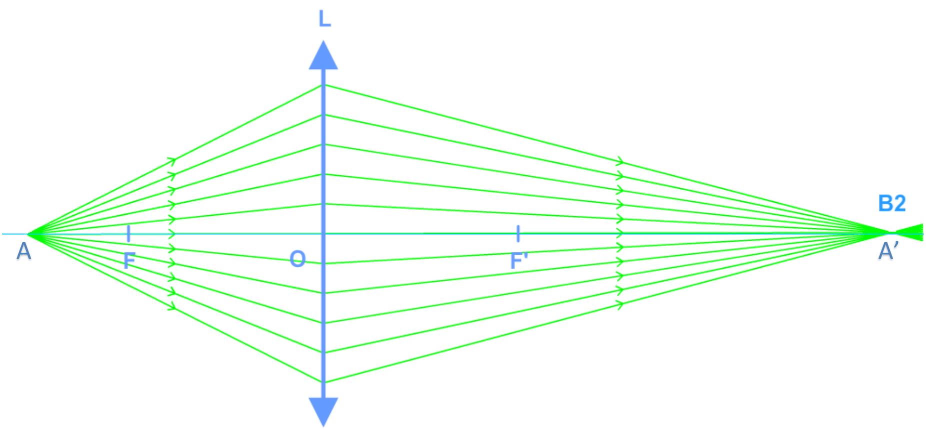
THEORETICAL EXPLANATION:
The first lens allows you to obtain an image at infinity which will serve as the object at infinity for the lens to be studied.
Thus by placing the screen in the image focal plane of the lens to be studied you obtain a sharp image.

4. Descartes' thin lens formula

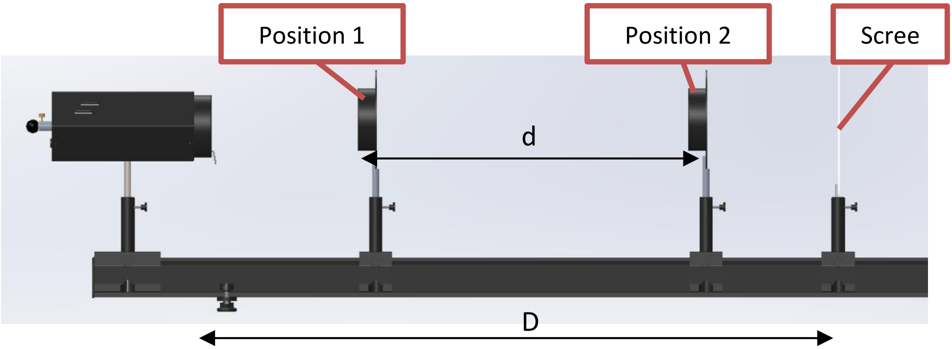


- Place the lens to be studied on the bench.
- Move the screen until you obtain a sharp image on it.
- $\overline{OA}$ is the the distance between the lens and the object (algebraic distance) and $\overline{OA'}$ the distance between the lens and the screen (algebraic distance).
- The focal length can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

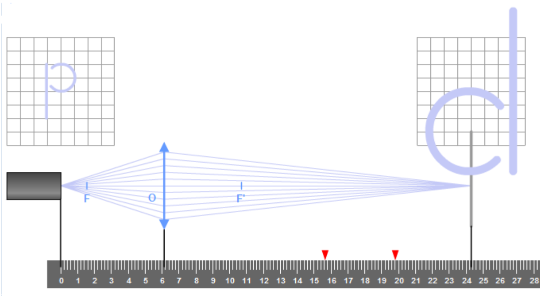
$$\frac{1}{f'} = \frac{1}{\overline{OA'}} - \frac{1}{\overline{OA}}$$

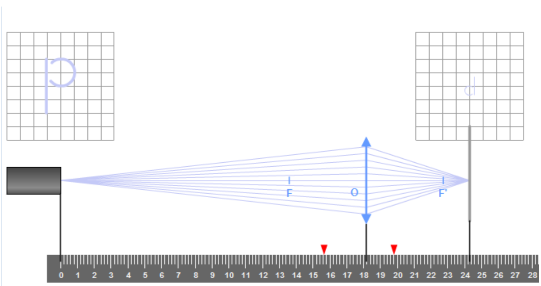


5. <u>Bessel's method</u>



- 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:

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

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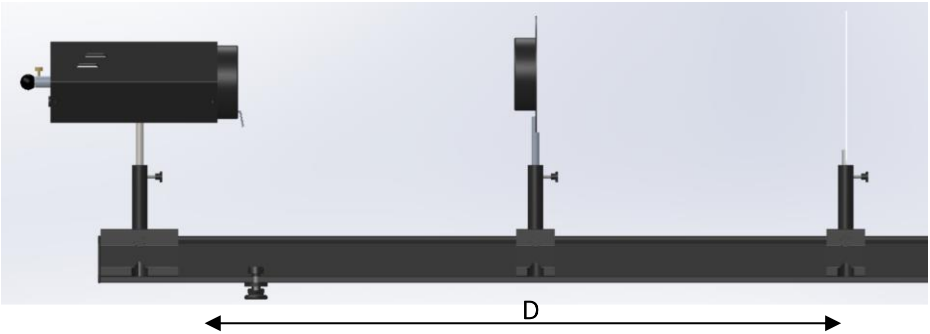
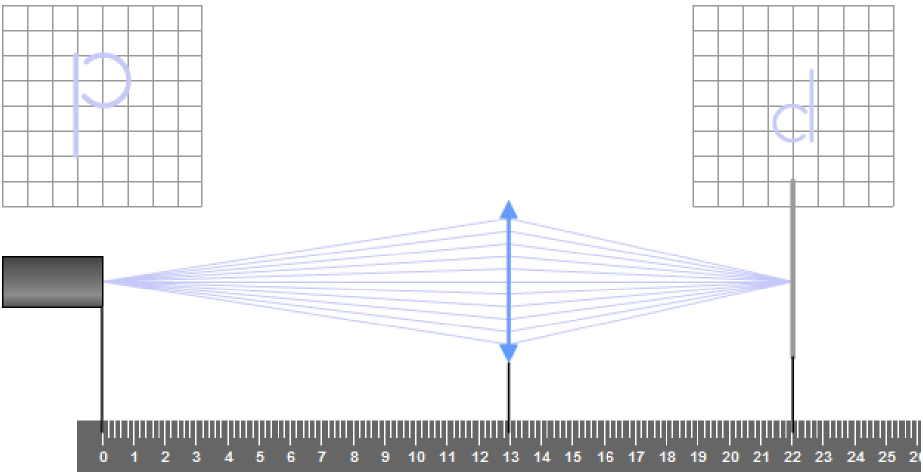
6. Silbermann's method



- 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: $f' = \frac{D}{4}$

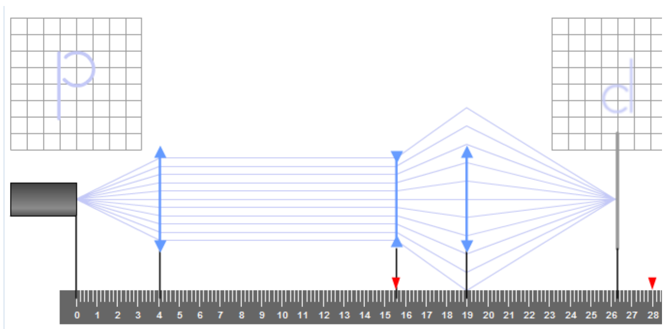


THEORETICAL EXPLANATION:
This is a special case of Bessel's method where d=0. Therefore if we apply Bessel's equation, we obtain: $f' = \frac{D}{4}$

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

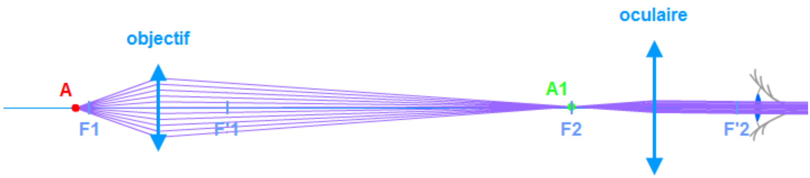
1. <u>Microscope</u>

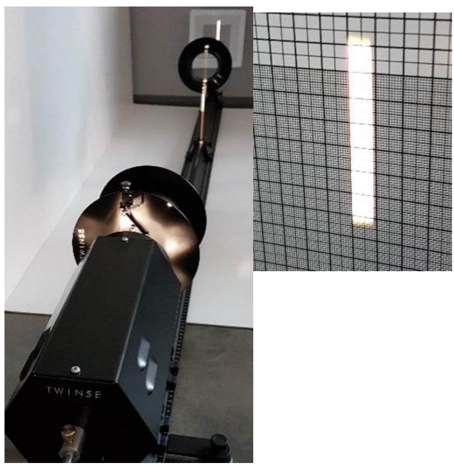
Supplementary accessories:

- 1 adjustable slot
- 1 x 50 mm PREMIUM rider

- Place the light source on the 0 mark.
- Place the adjustable slot near to the HEXAPOWER source.
- Place the F+100 lens near to the adjustable slot.
- Then place the F+500 lens 50cm away from the first lens.
- Move the pair of lenses to focus the image.
- Measure the width of the image obtained.
- Repeat the operation replacing the F+100 lens with the F+200 lens.
- Compare the image obtained with the one before.

lens eyepiece





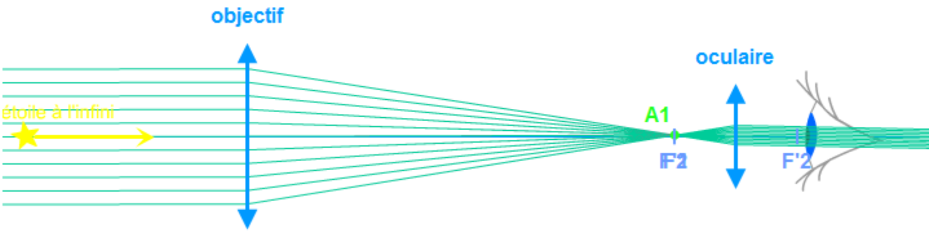
2. Keplerian telescope

Supplementary accessories:

- 1 adjustable slot
- 2 x 50 mm prismatic riders
- 1 x ø80 lens holder

- Place the light source on the 0 mark.
- Place the adjustable slot near to the HEXAPOWER source.
- Then place the F+100 lens 10cm away from the adjustable slot. This will enable you to simulate an object at infinity.
- Then place the F+500 lens 5cm on the bench.
- Finally place the F+200 lens about 70cm away from the previous lens

lens eyepiece



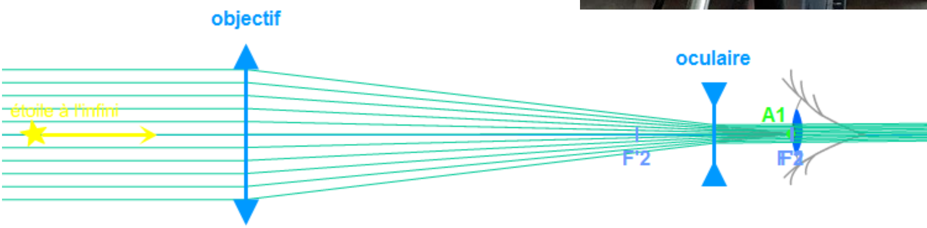
3. Galileo's telescope

Supplementary accessories:

- 1 adjustable slot
- 2 x 50 mm prismatic riders
- 1 x ø80 lens holder

- Place the light source on the 0 mark.
- Place the adjustable slot near to the HEXAPOWER source.
- Then place the F+100 lens 10cm away from the adjustable slot. This will enable you to simulate an object at infinity.
- Then place the F+500 lens 5cm on the bench.
- Finally place the F-100 lens about 40cm away from the previous lens

lens eyepiece



CONCLUSION:
With a Galilean telescope, we obtain a result similar to with a Keplerian telescope, but it is smaller because the 2 lenses are close to each other.

White light diffraction

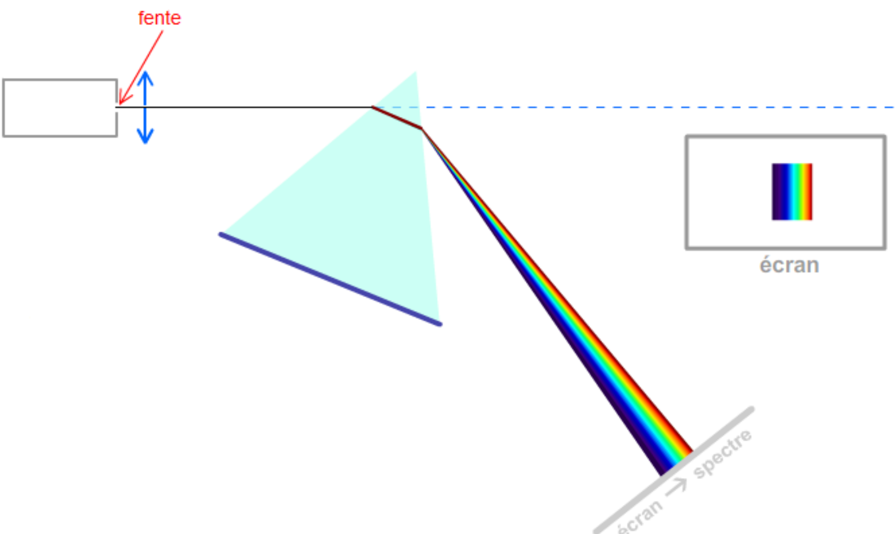
1. <u>Prism</u>

Supplementary accessories:

- BO Premium ø80 complementary kit – Decomposition of white light

- Place the light source on the 0 mark.
- Place the adjustable slot near the source.
- Then place the F+50 lens 5 cm away from the adjustable slot. This will enable you to simulate an object at infinity.
- Then place the prism mount with the prism on the BO prismatic joint.
- Place the screen on the 500 mm track linked to the joint.

  slot screen screen →spectrum

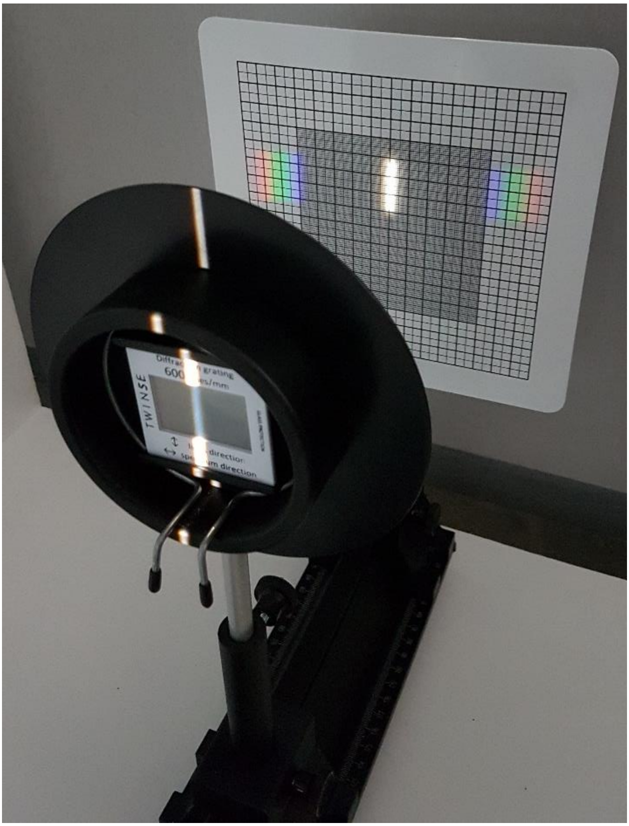


2. Grating

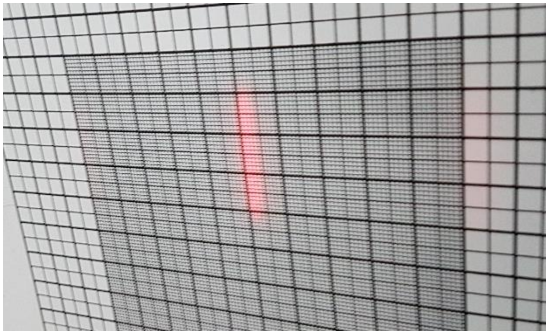
Supplementary accessories:

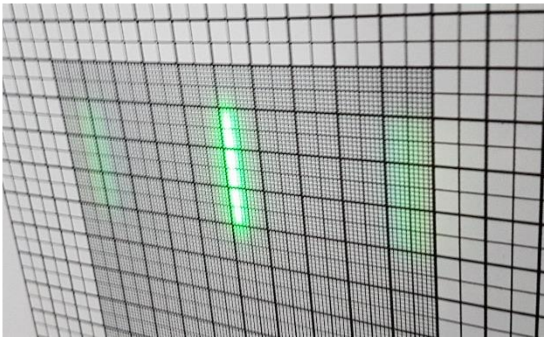
- BO Premium ø80 complementary kit – Decomposition of white light
- Component wheel

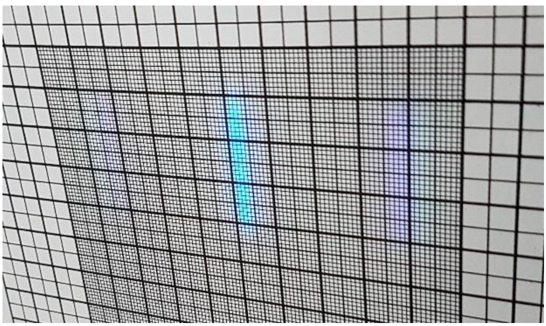
- Place the light source on the 0 mark.
- Place the adjustable slot near the HEXALU source
- Then place the F+100 lens 10cm away from the adjustable slot. This will enable you to simulate an object at infinity.
- Then place the 600 line grating (use the slide adapter).
- Observe the diffraction of the light.
- You can repeat the operation with a different grating.



- By placing the component wheel with the dichroic primary colour filters, the filtering of the rainbow obtained by the grating can be seen.







Diffraction and interference

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

1. <u>Grating</u>

Supplementary accessories:

- BO Premium ø80 complementary kit – Diffraction and interference:

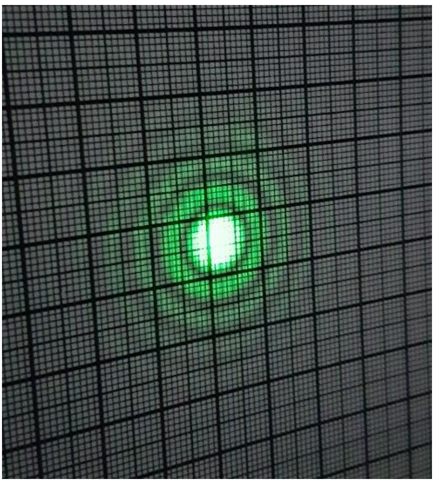
- Place the red TRIO laser on the 0 mark.
- Then place the 300 line/mm grating.
- Observe the diffraction of the light from the laser on the screen.
- d is the distance between the grating and the screen.
- x is the distance between the main mode and rank 1 mode.
- It is then possible to find the number of lines in the grating.
- You can repeat the operation with another grating and a green TRIO laser

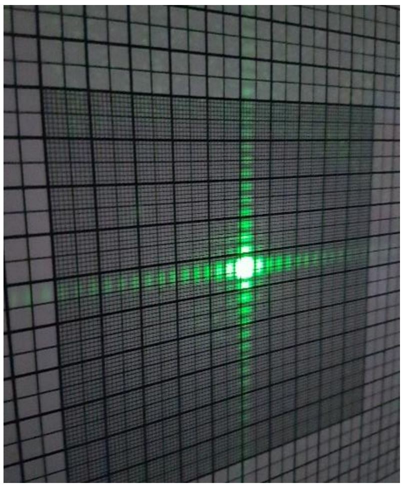
2. Diffraction holes

Supplementary accessories:

- BO Premium ø80 complementary kit – Diffraction and interference:

- Place the TRIO green on the 0 mark.
- Then place the token with the diffraction holes and Young's slits (use the ø40 lens adapter).
- Observe the diffraction of the laser light on the screen with a round hole and then a square hole.
- Either d the distance between the token 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.



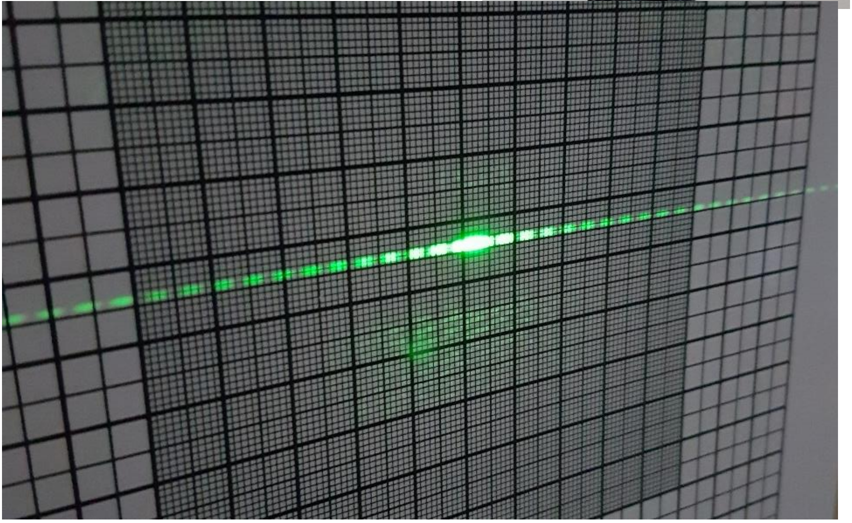


Diffraction slits

Supplementary accessories:

- BO Premium ø80 complementary kit – Diffraction and interference:

- Place the green TRIO laser on the 0 mark.
- Then place the token with 7 slits & 7 lines (use the ø40 lens adapter).
- Observe the diffraction of the light from the laser on the screen.
- Either d the distance between the token and the screen.
- Or x the distance between the main mode and rank 1 mode.
- It is then possible to find the width of the slit.



4. Holes and Young's slits

Supplementary accessories:

- BO Premium ø80 complementary kit – Diffraction and interference

- Place the green TRIO laser on the 0 mark.
- Then place the token with the diffraction holes and Young's slits (use the ø40 lens adapter).
- Observe the diffraction of the light from the laser on the screen.
- Do the same with the token with the Young's slits.