OPTICS: LENSES

Converging lens – behaves like a concave mirror.

FIVE TYPES OF IMAGE: RID, RIS, RIM, INFINITY, VEM.
(five diagrams page 45.)

Click on this link to try an applet which will show this. (Requires Java, drag the object and see what happens.)
http://www.physics.uoguelph.ca/applets/Intro_physics/kisalev/java/clens/index.html

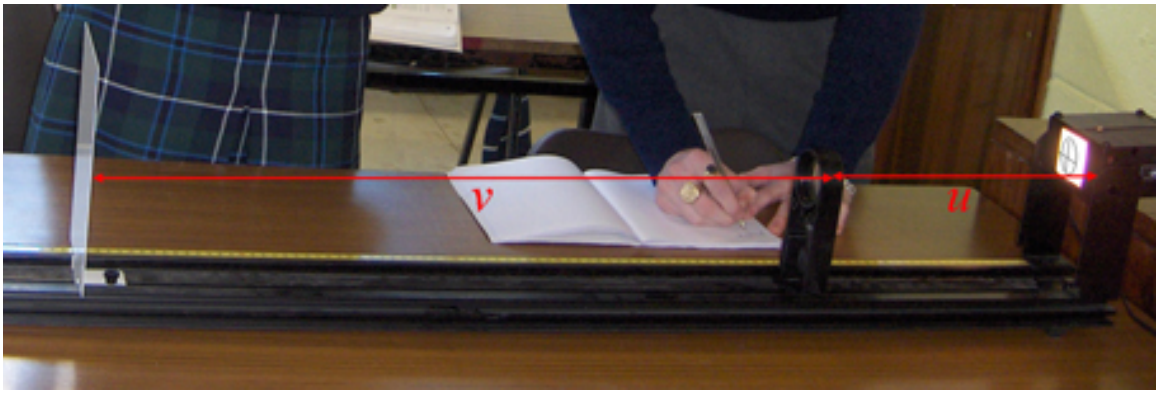
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \qquad\qquad m = \frac{v}{u}$$

MANDATORY EXPERIMENT: TO MEASURE THE FOCAL LENGTH OF A CONVERGING LENS.

Apparatus

Convex lens, raybox with cross-threads, screen, metre-stick or optical bench.

Method



Set up apparatus as in diagram.

Adjust the positions of the lens and the screen until the image of the cross threads is in sharp focus on the screen.

Measure *u*, the distance from the cross-threads to the centre of the lens.
Measure *v*, the distance from the screen to the centre of the lens.

Repeat for different values of *u* and *v*.

Graph 1/*u* against 1/*v*. Draw the best straight line.
Use this to obtain a single value for 1/*u* and for 1/*v*.

Calculate a value for the focal length of the lens, *f*, using the formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Sources of Error

- The error of parallax when reading *u* and *v*.
- The image may not be in sharp focus.

Solutions

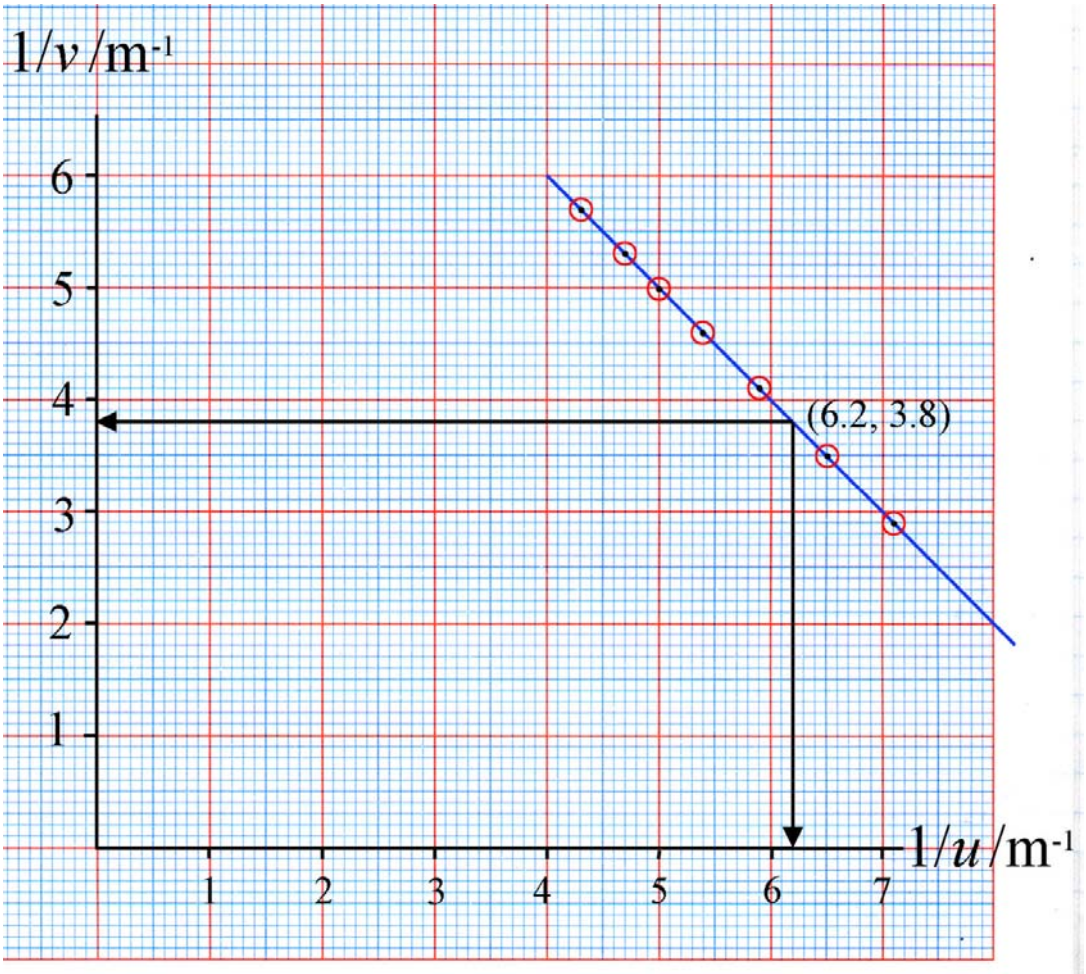
- Ensure your line of sight is at right angles to the metre stick.
- Perform the experiment in a dark room.

Results

u / m	0.140	0.155	0.170	0.185	0.200	0.215	0.230
v / m	0.350	0.282	0.243	0.218	0.200	0.187	0.177

We now wish to graph 1/*u* against 1/*v*.

$1/u$ / m^{-1}	7.1	6.5	5.9	5.4	5.0	4.7	4.3
$1/v$ / m^{-1}	2.9	3.5	4.1	4.6	5.0	5.3	5.7



$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}=6\cdot2+3\cdot8=10\Rightarrow f=1\div10=0\cdot1\text{ m}$$

OPTICS: LENSES

DIVERGING LENS
Behaves like a convex mirror, negative focus.
Only one kind of image: VED.

Click here for an applet which will show this. (Requires Java, drag the object and see what happens.)
http://www.physics.uoguelph.ca/applets/Intro_physics/kisalev/java/dlens/index.html

POWER OF A LENS
This measures how much a lens bends a ray towards the focus.
Converging lens: the thicker the lens, the smaller *f*, the more it bends the ray to the focus.

Thus P and *f* are reciprocal: $P = \frac{1}{f}$

Diverging lens: this bends light away from the focus, i.e. it has a negative power (cancels effect of a converging lens)

Two lenses in combination: $P = P_1 + P_2$

(Notice one or more of these may be negative.)
(NB. If a converging lens of f = 15 cm is put together with a diverging lens of f = -15 cm, then P = 0, no bending.)

The unit of P: m^{-1}.

(f must be converted to metres to use the formula $P = \frac{1}{f}$.)

THE EYE
Retina = light sensitive tissue at the back of the eye.
Cornea = transparent window at the front of the eye. (Most refraction occurs here.)
Iris = coloured part of the eye.

POWER OF ACCOMODATION
The ability of the eye to focus on objects at different distances.

Short Sight – Diverging Lens – Negative power / focus

Long Sight – Converging Lens – Positive power / focus.

EXAMS: 2006 H 7, 2003 H 3, 2002 H 12(b)

2006 H 6

What is meant by the refraction of light? (6)

A converging lens is used as a magnifying glass.
Draw a ray diagram to show how an erect image is formed by a magnifying glass. (12)

A diverging lens cannot be used as a magnifying glass. Explain why. (5)

The converging lens has a focal length of 8 cm. Determine the two positions that an object can be placed to produce an image that is four times the size of the object? (15)

The power of an eye when looking at a distant object should be 60 m^{-1}. A person with defective vision has a minimum power of 64 m^{-1}.
Calculate the focal length of the lens required to correct this defect. (12)

What type of lens is used? Name the defect. (6)

2003 H 3

The following is part of a student's report of an experiment to measure the focal length of a converging lens.

"I found the approximate focal length of the lens to be 15 cm. I then placed an object at different positions in front of the lens so that a real image was formed in each case."

The table shows the measurements recorded by the student for the object distance *u* and the image distance *v*.

u/cm	20.0	25.0	35.0	45.0
v/cm	66.4	40.6	27.6	23.2

How did the student find an approximate value for the focal length of the lens? (6)

Describe, with the aid of a labelled diagram, how the student found the position of the image.(10)

Using the data in the table, find an average value for the focal length of the lens. (15)

Give two sources of error in measuring the image distance and state how one of these errors can be reduced. (9)

2002 H 12(b)

State the laws of refraction of light. (6)

Draw a labelled diagram showing the optical structure of the eye. (9)

How does the eye bring objects at different distances into focus? (6)

The power of a normal eye is +60 m^{-1}. A short-sighted person's eye has a power of +65 m^{-1}.
Calculate (i) the power, (ii) the focal length, of the contact lens required to correct the person's short-sightedness. (7)