

OPTICS:

CURVED MIRRORS

DIAGRAM QUESTIONS

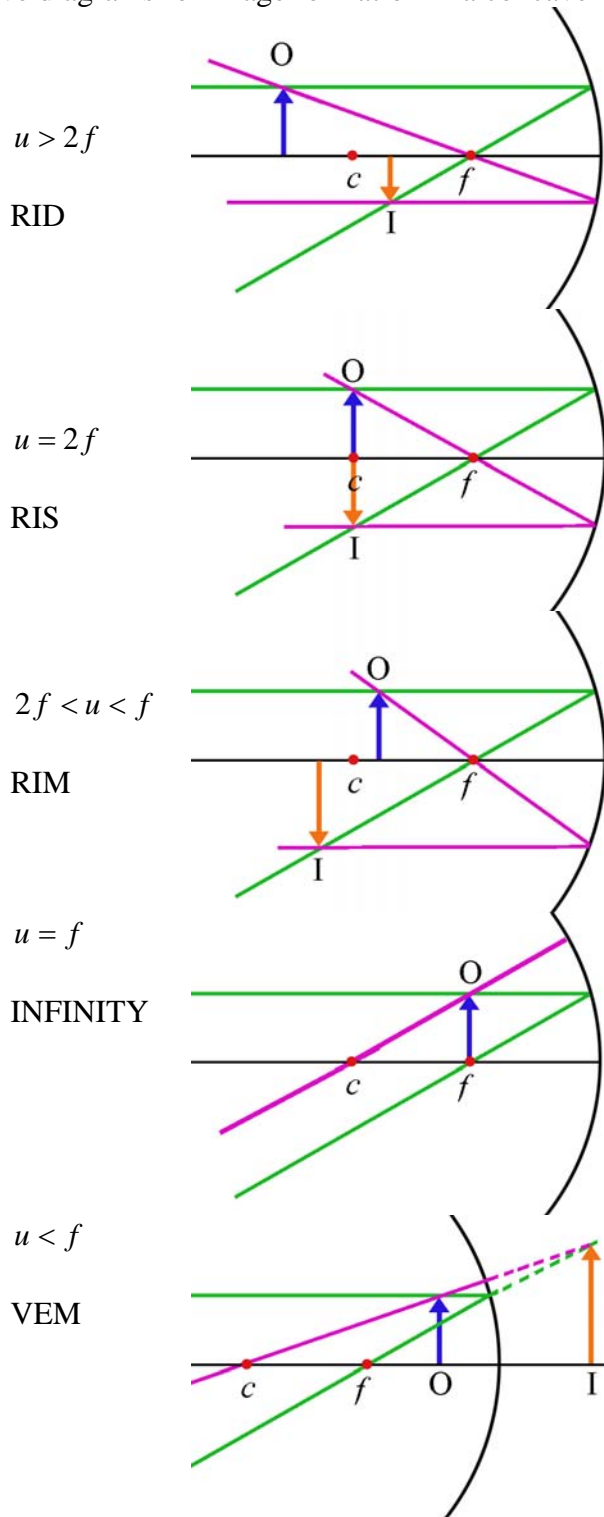
Concave Mirror

The focus is the midpoint between the centre of curvature and the pole.

How Rays Reflect:

- Rays parallel to the principal axis reflect through the focus, and vice versa.
- Rays touching the pole obey the law  $i = r$ .
- Rays through the centre of curvature reflect back on their own path.

Learn the five diagrams for image formation in a concave mirror:



RID, RIS, RIM, INFINITY, VEM.

## MIRROR EQUATIONS

$f$  = focal length,  $u$  = object distance,  $v$  = image distance,  $m$  = magnification,  $h_i$  = height of image,  $h_o$  = height of object.

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad m = \frac{v}{u} \quad m = \frac{h_i}{h_o}$$

NB Learn *easy* examples using these.

## EXAMPLE

An object is placed 24 cm in front of a concave mirror.

A real image is formed 40 cm from the mirror.

Calculate (i) the focal length of the mirror,

(ii) the magnification of the image.

## ANSWER

$$(i) \frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{24} + \frac{1}{40} = 0.066666666$$

$$f = 1 \div \text{ANS} = 15 \text{ cm.}$$

$$(ii) m = \frac{v}{u} = \frac{40}{24} = 1.7$$

## MANDATORY EXPERIMENT

To find the focal length of a concave mirror.

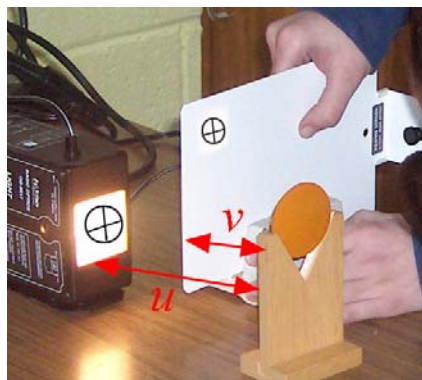
**Approximate Method**

First find an approximate value for the focal length.

This is done by projecting the image of a distant object, e.g. a cloud, onto a screen, e.g. a sheet of white paper. The distance between the screen and the back of the mirror is approximately equal to the focal length.

**Precise Method****Apparatus**

Raybox with cross threads, screen, concave mirror, mirror holder, metre stick.

**Method**

Set up apparatus as in diagram.

Move the mirror until there is a sharp image of the cross threads on the screen.

Record  $u$ , the distance from the cross threads to the back of the mirror, and  $v$ , the distance from the screen to the back of the mirror.

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

Graph  $1/u$  against  $1/v$ .

Draw the best straight line.

From this line choose a single value for  $1/u$  and for  $1/v$ .

Calculate a value for  $f$  using the formula  $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

### Sources of Error

- The image of the cross-threads may not be sharp enough.
- The error of parallax when reading the metre stick.
- Measurements may have been taken from the front rather than the back of the mirror.

### Solutions

- Perform the experiment in a dark room.
- Ensure that your line of sight is at right angles to the metre stick.
- Take measurements from the back of the mirror.

### Results

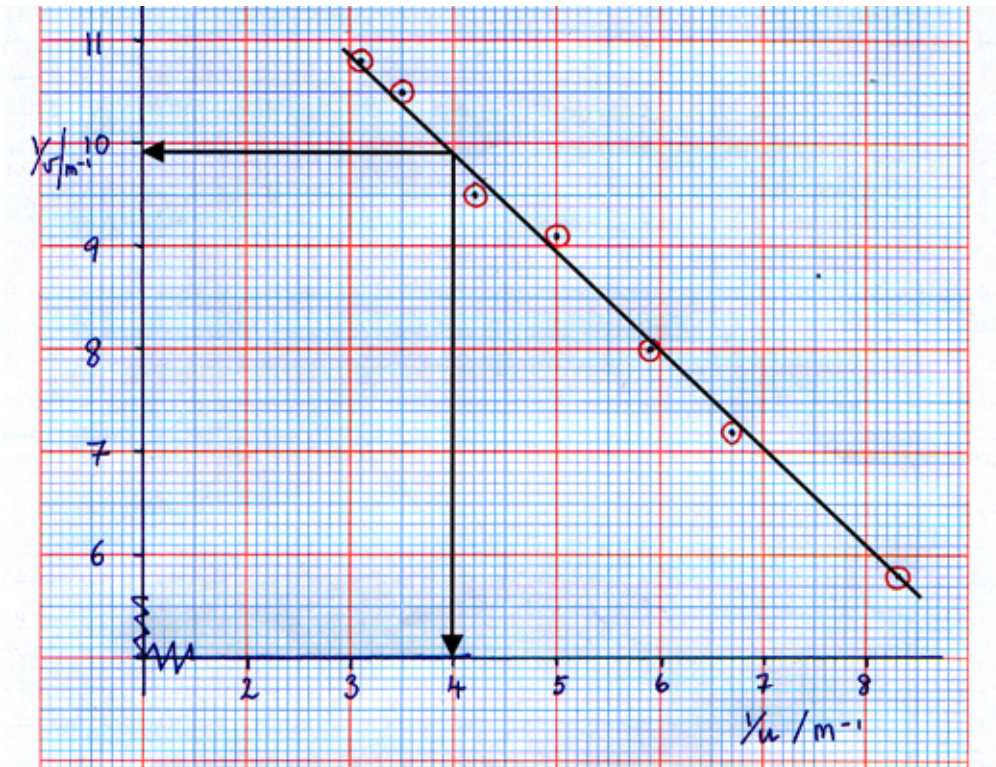
u/m	0.12	0.15	0.17	0.2	0.24	0.285	0.326
v/m	0.172	0.138	0.125	0.11	0.105	0.095	0.093

Graph  $1/u$  against  $1/v$ .

Draw the best straight line.

Use this line to obtain a single value for  $1/u$  and  $1/v$ .

$1/u / \text{m}^{-1}$	8.3	6.7	5.9	5.0	4.2	3.5	3.1
$1/v / \text{m}^{-1}$	5.8	7.2	8.0	9.1	9.5	10.5	10.8



From the graph, we get  $1/u = 4$  and  $1/v = 9.9$ .

This gives 
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = 4 + 9.9 = 13.9$$

i.e. 
$$f = 1 \div 13.9 = 0.072 \text{ m} = 7.2 \text{ cm}$$

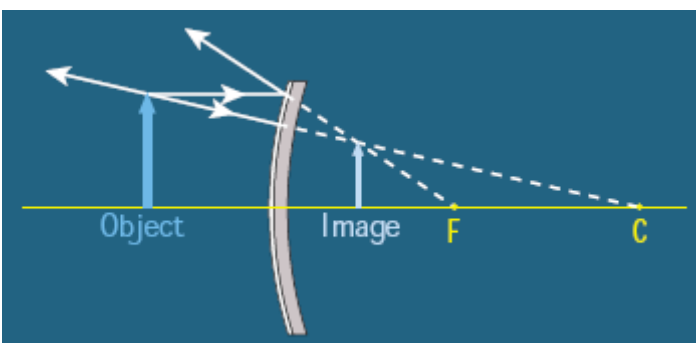
### USES OF A CONCAVE MIRROR

Shaving mirror.

Used in a torch to form a parallel beam. (Lamp must be at focus for this.)

### CONVEX MIRROR

NOTE: the focus and centre of curvature are both at the back of the mirror.



Only one type of image is formed: VED.

Click on this link to try an applet. (Requires Java, drag object and see what happens.)

[http://www.physics.uoguelph.ca/applets/Intro\\_physics/kisalev/java/dmirr/index.html](http://www.physics.uoguelph.ca/applets/Intro_physics/kisalev/java/dmirr/index.html)

USES: Rear view mirror in car, security mirror in shops.

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## EXAMPLE

An object is placed 18 cm in front of a convex mirror.

An image is formed 9 cm **behind** the mirror.

Find the focal length of the mirror.

## ANSWER

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{18} + \frac{1}{(-9)} = -0.0555555$$

$$f = 1 \div \text{ANS} = -18 \text{ cm}$$

NOTE:  $f$  is negative since it is **behind** the mirror.

## EXAM QUESTIONS

## 2007 H Q3

In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance  $v$  was then found for a range of values of the object distance  $u$ . The following data was recorded.

$u/\text{cm}$	15.0	20.0	25.0	30.0	35.0	40.0
$v/\text{cm}$	60.5	30.0	23.0	20.5	18.0	16.5

How was an approximate value for the focal length found?

What was the advantage of finding the approximate value for the focal length? (10)

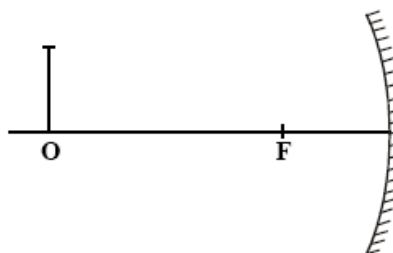
Describe, with the aid of a labelled diagram, how the position of the image was found. (12)

Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data. (18)

## 2005 H 5(d)

An object O is placed 30 cm in front of a concave mirror of focal length 10 cm.

How far from the mirror is the image formed? (7)



## 2002 Revised Sample Paper H 12(c)

A concave mirror can be used to form real or virtual images.

Draw a ray diagram to show the formation of a virtual image in a concave mirror. (9)

A dentist holds a concave mirror of focal length 25 mm at a distance of 20 mm from a cavity in a tooth. Find the position of the cavity. (9)

What is the magnification of this image? (4)

Explain why a dentist uses a concave mirror rather than a plane mirror.