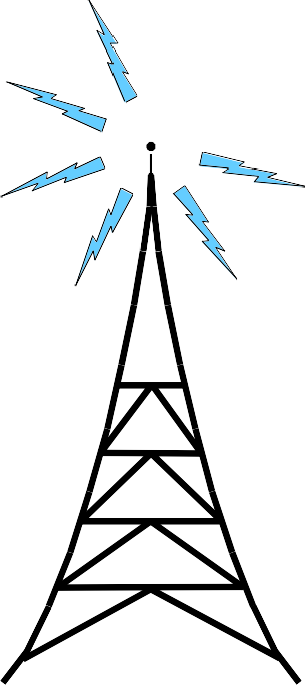
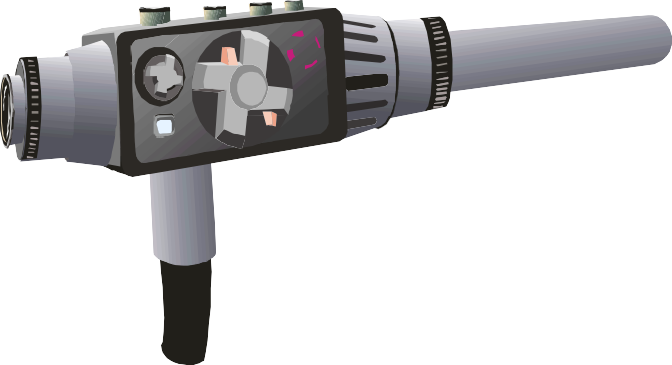
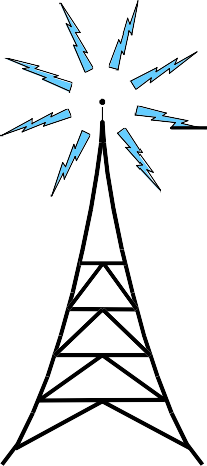
WAVES and OPTICS





# Name:

**Class:**

**Teacher:**

### Waves and Energy

All waves **transfer** (**carry**)

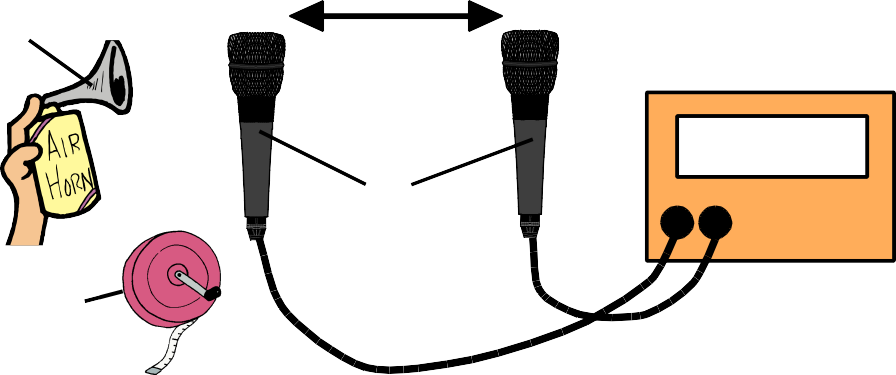
**e** from one place to another - A tsunami sea wave

**Experiment to Measure the Speed of Sound in Air**

We can perform an experiment to measure the

**speed of sound in air**.

measured

transfers an enormous amount of

sound

distance

**e** which can cause

extensive damage when the wave reaches land.

**Waves and Signal Transmission**

source

**2.0 m**

microphones

electronic timer

* 1. s

**Sound** and **light signals** are **transmitted** (**sent**) from one place to another by **w \_ \_ \_ \_**.

!!Remember!!

distance = speed x time

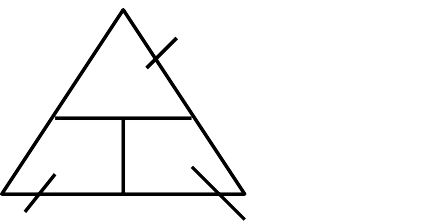
tape measure

* We use a **t \_ \_ \_ m** to measure the

**d \_ \_ \_ \_ \_ \_ \_** between the 2 **m \_** .

* We make a sharp **s** next to the left hand

**m \_** .



d \_ \_ \_ \_ \_ \_ \_

d unit:

v t

* + - The **s \_ \_ \_ \_** travels through the **a \_ \_** between the

2 **m \_ \_ \_ \_ \_ \_ \_ \_ \_ \_** . The **t** this takes is

recorded on the electronic **t \_ \_ \_ \_** .

* We calculate the speed of sound in air using the formula:

speed =

distance between microphones

time for sound to pass between microphones

s \_ \_ \_ \_ of s \_ \_ \_ \_ t \_ \_ \_ unit: unit:

**1)** (a) What value

(b) How could you improve

You can use this equation to calculate the speed of sound in air..............

2

for the speed of sound in air do you obtain using the values shown on the apparatus above?

this experiment?

### Comparing the Speed of Sound and Light in Air

In air, speed of sound = \_ \_ \_ m/s

In air, speed of light =\_ \_ \_ \_ \_ \_ \_ \_ \_ m/s ( \_ x 10 \_ m/s )

}

In air, light travels almost

times faster

than sound.

Light travels so quickly that we see an event happening at the instant it happens - light from the event reaches our eyes instantly (even when we are far away).

Use the word bank to complete the passage below.

hear

less

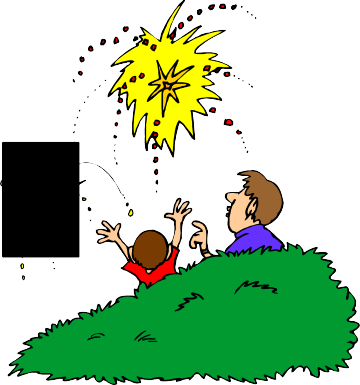
sound sound thunder

light

light

lightning

see



**2)** At a fireworks display, a rocket explodes high above your head, producing a loud explosion and a bright flash of light at the same time.

(a) What will reach you first? - the sound of the explosion or the flash of light:

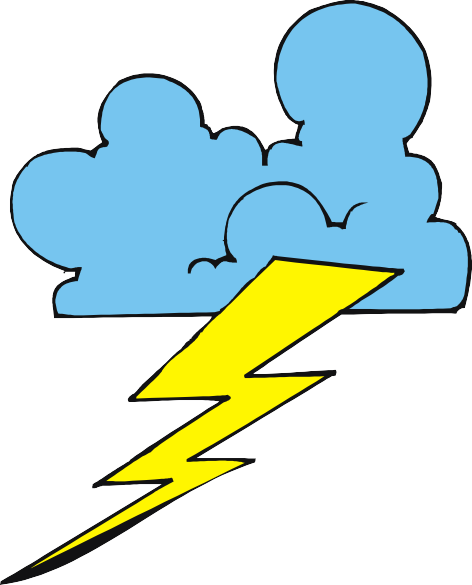
(b) Explain why:

1. On a golf course, you observe a golfer in the distance hitting a golf ball with her club.
   1. What will you observe first? - the ball moving through the air or the sound of the club hitting the ball:

(b) Explain why:

3

During a storm, **thunder** and **lightning** are produced at exactly the same time.



We

the

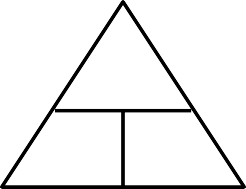
before we the

because, in air, the speed of is **less** than the speed of .

The reaches us before the .

We can use this **formula** to solve problems about sound travelling through the air (or other materials):

d \_ \_ \_ \_ \_ \_ \_



distance = speed x time

1. Susan shouts at a brick wall. After

0.8 seconds, she hears her "echo" - the sound of her shout reflected off the wall.

Calculate how far away from the wall

s \_ \_ \_ \_ of s \_ \_ \_ \_

unit:

d unit:

v t

t \_ \_ \_

unit:

Susan is. **BE CAREFUL !** - It might help if you draw the path taken by the sound on the diagram.

Susan

wall

* 1. Calculate the distance sound will travel through the air in



2 seconds.

* 1. How far will the sound of an explosion travel through the air

in 5 seconds?

Sound has a different speed in different materials. For example:

Speed of sound in steel = 5 200 m/s. Speed of sound in water = 1 500 m/s.

* 1. Calculate the time it will take sound to travel 1 020 metres

through the air.

* 1. How long will it take the sound of a bell to travel 850 metres through

the air?

1. A steel wire is 6 760 metres long. Calculate the time it will take sound to travel along the

wire.

1. Calculate the speed of sound in air if it takes 4 seconds for the

sound to travel 1 360 metres.

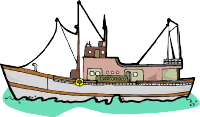
4

1. The sound of a car horn is heard 1 190 metres away,

3.5 seconds after it has been sounded. Calculate the speed of

the horn sound in air.

1. To find out the depth of water beneath its hull, a fishing boat sends a pulse of sound through the water from its hull to the sea bed.

After 1.2 seconds, the fishing boat detects the sound pulse reflected from the sea bed.

How deep is the sea?

sea bed

**Understanding Waves**

1. What is a wave?
2. Do all waves transfer energy?
3. Do all waves have certain things in common?

Use the word bank to label the wave diagram:

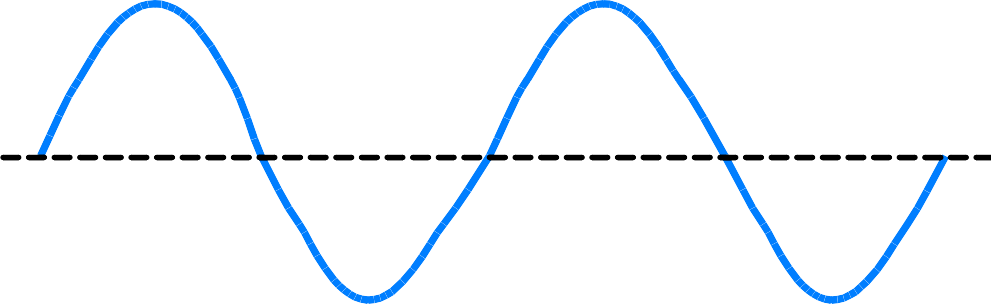
amplitude

wavelength wavelength

amplitude

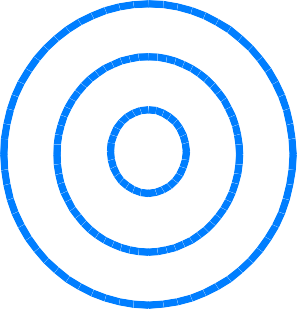
crest

trough



These diagrams represent **waves** viewed from above. The lines show the middle of **wave crests**.

No **wave troughs** are shown.

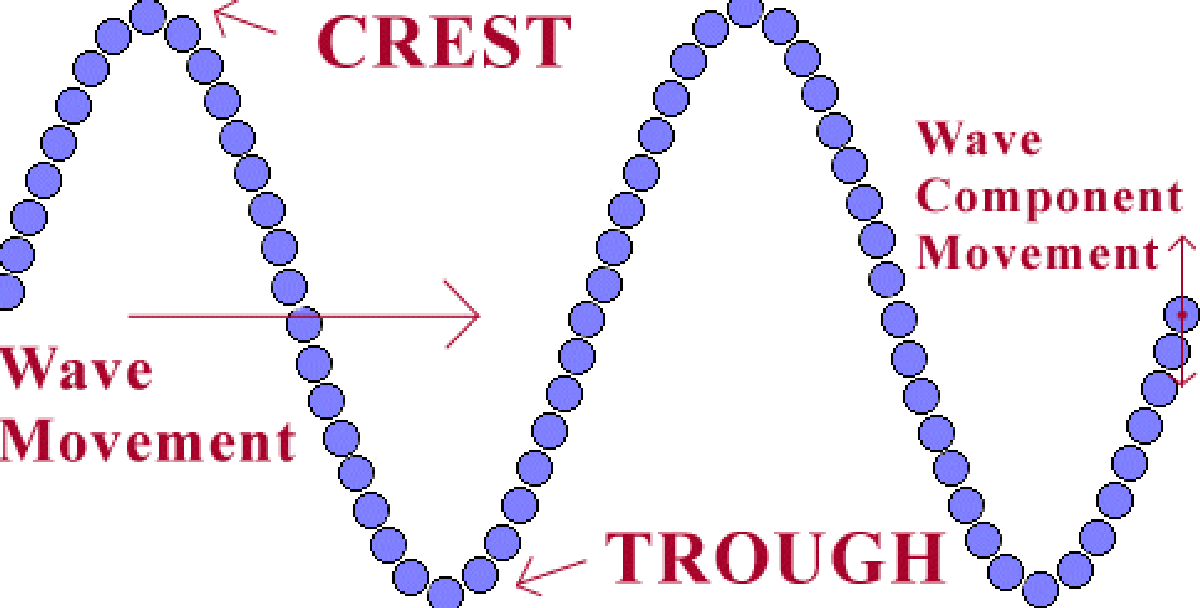


straight waves circular waves

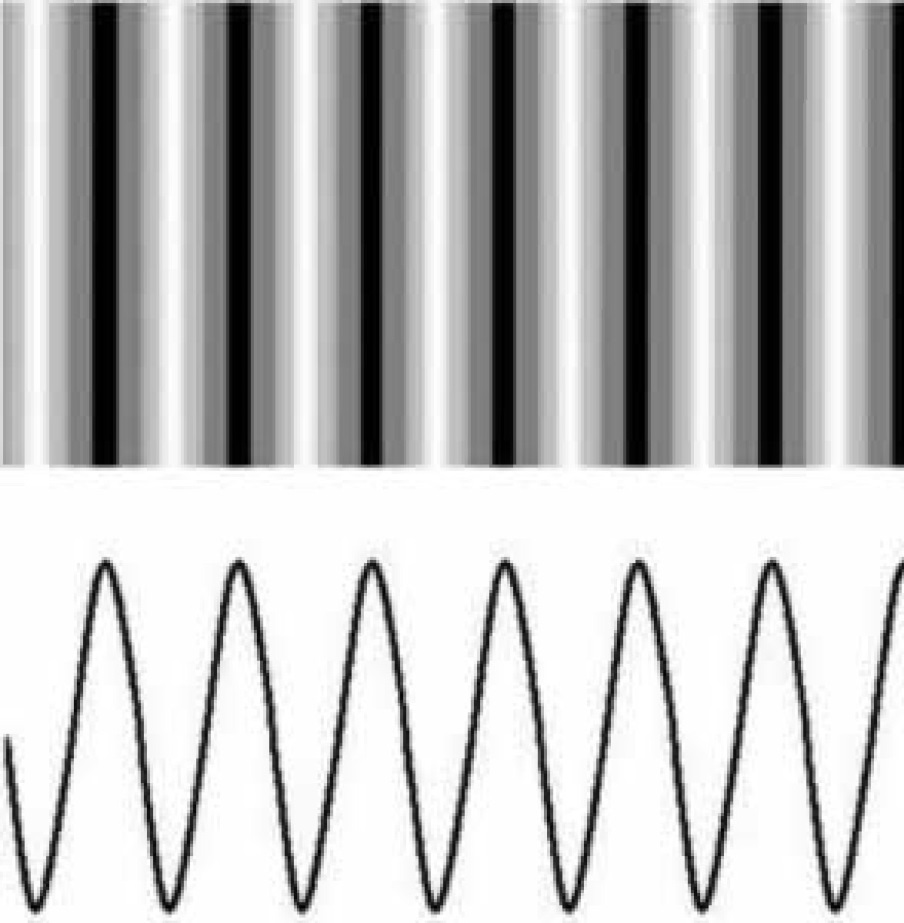
On each diagram, show the wavelength. 5

**Types of Waves**

**Transverse Longitudinal**



In a **transverse wave**, the particles vibrate up and down at **right-angles** (**90o**) to the direction in which **energy** is being carried.



In a **longitudinal wave**, the particles vibrate back and forward **along** the direction in which **energy** is being carried.

particles vibrate

movement of energy

particles



vibrate movement of energy

6

**Describing Waves**

Use the word bank to complete the table:

above

distance second wavelength

amplitude

amplitude

below

f Hz

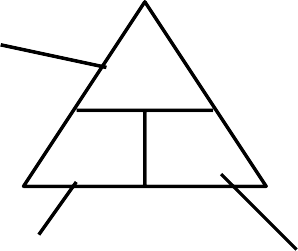
**** m m m/s v

The **frequency** of a wave is:

This can be represented by the formula:

number of wavelengths (or crests or troughs)

frequency = time in seconds

n of

N

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Symbol** | **Unit** | **Description** |
| wave crest |  |  | Part of wave  centre line. |
| wave trough |  |  | Part of wave  centre line. |
|  |  |  | Height of wave crest or wave trough measured from the centre line.  The higher the  of a wave, the more energy it carries. |
|  | lambda |  | Distance between 2 identical neighbouring points on a wave, e.g., distance between 2 neighbouring wave crests. |
| frequency |  | hertz | Number of wavelengths (or crests or troughs) every . |
| speed |  |  | wave travels every second. |

w \_ \_ \_ \_ \_ \_ \_ \_ \_ \_

or c or

f t

t \_ \_ \_ \_ \_ \_

f \_ \_ \_ \_ \_ \_ \_ \_

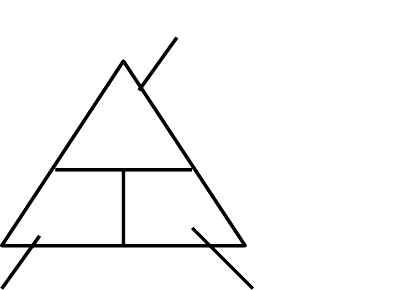
unit:

t \_ \_ \_ unit:

The **speed** of a wave is:

This can be represented by the formula:

distance = speed x time



d

v t

d \_ \_ \_ \_ \_ \_ \_

unit:

s \_ \_ \_ \_ of w \_ \_ \_

unit:

t \_ \_ \_

unit: 7

### Water Wave Problems/Calculations

1. (a) Which of these waves is carrying the most energy?
2. Explain you answer:

0.2 m

* 1. **B.**

**20)** 0.8 m

1. For this wave, state the value of:
   1. the amplitude
   2. the wavelength
2. The wave shown below is travelling to the right.
   * 1. As the wave travels, what happens to its amplitude?
     2. The wave was produced in 2 seconds. State the value for its frequency.
3. What must be happening to the wave's energy?
4. (a) Determine the wavelength of these water waves.

20 m

**18)** (a) State the value for this wave's:

* 1. amplitude:
  2. **m**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**0.2 m 0 m**

* 1. wavelength:

(b) These 5 wave crests were produced in 25 seconds. Determine the frequency of the waves.

**0.2 m 0.4 m 0.6 m 0.8 m 1.0 m 1.2 m 1.4 m 1.6 m**

(b) The wave was produced in 1 second.

State the value for its frequency: 6 m

**19)** Determine the frequency of the wave in each case:

1. (a) What is the wavelength of these

circular water

1. The 3 wave crests were produced in
   1. seconds. What is
      1. 5 wavelengths are produced every

second.

* + 1. 10 water waves pass the end of a pier

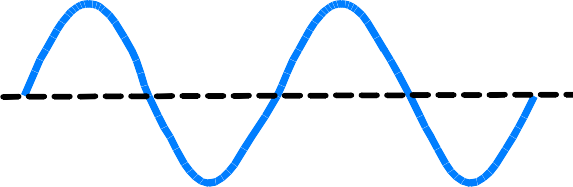
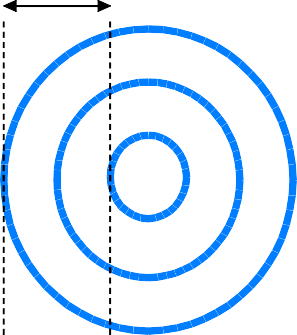
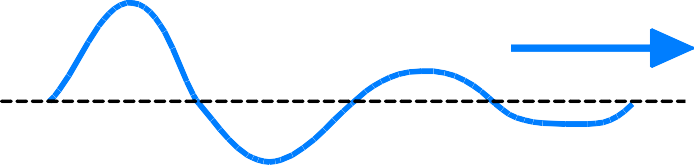
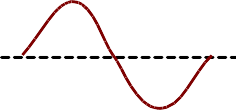
in 2 seconds.

* + 1. 12 circular waves spread across a pond

in 20 seconds

waves?

the wave frequency?



8

|  |  |
| --- | --- |
| **23)** A tsunami sea wave takes 6 seconds to travel up a beach  with a speed of  15 metres per second.  What distance does the wave travel up the beach? | **26)** Sid the surfer rides the crest of a sea wave travelling  at 6 metres per second for 8 seconds.    Calculate how far the wave carries Sid in this time. |
| **24)** When Sajidha threw a stone into a pond, circular waves travelled 7.5 metres  across the water in 2.5 seconds. | **27)** A drop of water from a leaking tap causes waves on the surface of Brenda's bath  water. |
| Calculate the speed of these water waves. | If these waves travel 0.4 metres in 1.6 seconds, at what speed are they travelling? |
| **25)** Sea waves approach a cliff at 4 metres per second.    What time will the waves take to travel 20 metres? |  |



**28)** As the tide goes out, sea waves travel 50 metres with a

speed of 2.5 metres per second.

How long do the waves take to

travel this distance? 9

**Another Wave Formula**

For any wave, the **time** taken ( **T** ) to produce

**1 wavelength** ( **1 ** ) is related to the **frequency** ( **f** ) of the wave by the formula:

frequency = 1

time

f = 1

T

Explain the equivalence of the 2 wave formulae:

speed (v) = frequency (f) x wavelength (****)

If **1 wavelength** ( **1 ** ) is produced in **time** ( **T** ), a wave will travel a **distance** ( **d** ) of **1 wavelength** (**1 ** ) in **time** ( **T** ):

speed (v) =

and

distance (d) time (T)

speed (v) = distance (d) = 1 **** = 1 x ****

time (T) T T

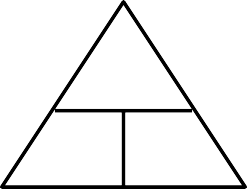
= f x ****

since f = 1

T

We have another **formula** which applies to **waves**:

s of



v

w \_ \_ \_

speed = frequency x wavelength

unit:

f ****

f \_ \_ \_ \_ \_ \_ \_ \_

unit:

10

w \_ \_ \_ \_ \_ \_ \_ \_ \_

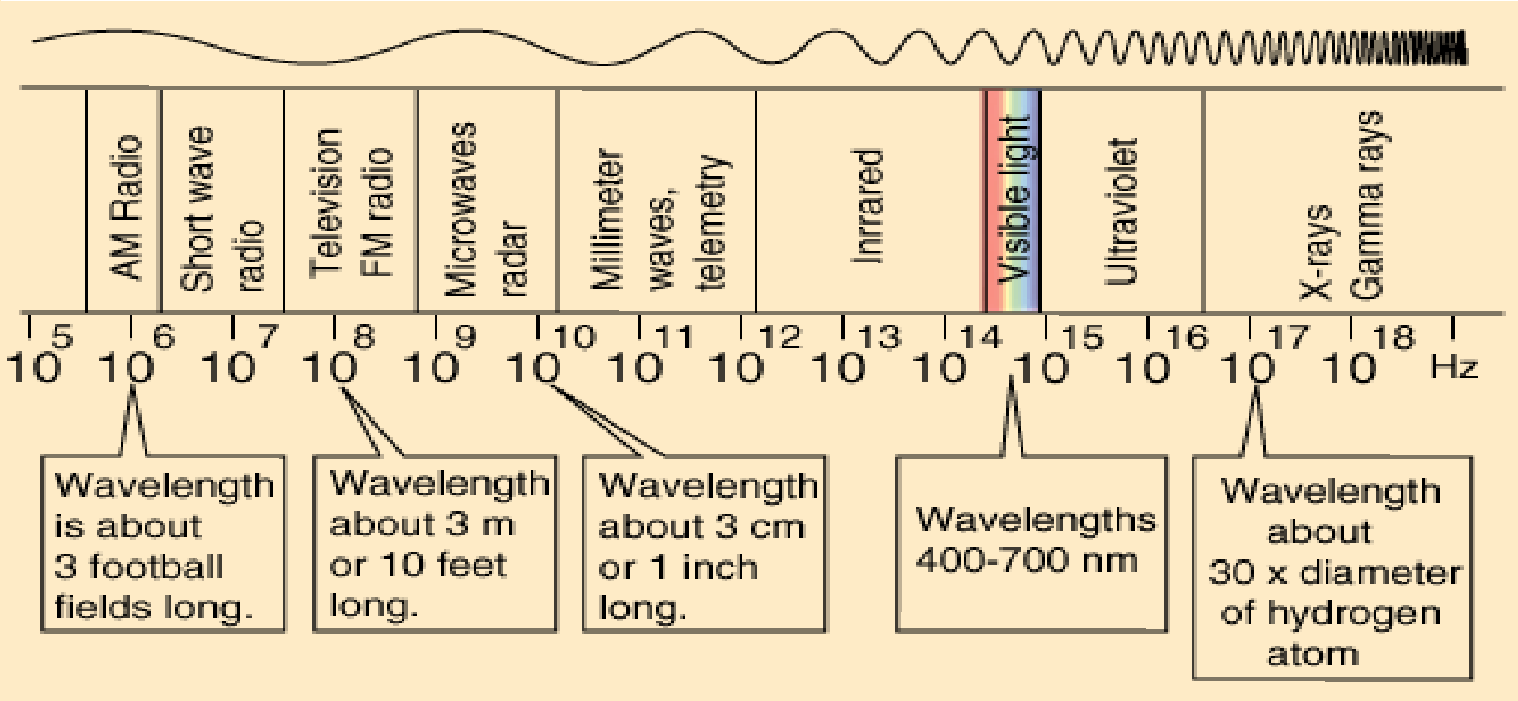
unit:

### Speed, Wavelength and Frequency Calculations for Water and Sound Waves

|  |  |  |  |
| --- | --- | --- | --- |
| **29)** Calculate the speed of  water waves which have a frequency of 2 hertz and a wavelength of 5 metres. | **32)** Every second, 2 waves are  produced on Alan's bath water by water dripping from a tap. If these waves have a wavelength of 0.05 metres, calculate their speed. | **35)** Calculate the speed of  sound waves in air which have a frequency of 500 hertz and a wavelength of 0.34 metres. | **38)** A submarine sends a pulse  of sound through the sea. Determine the speed of the sound pulse if it has a frequency of 7 500 hertz and a wavelength of 0.2 metres. |
| **30)** Calculate the frequency of water waves in a harbour if they travel at 3 metres per second  and have a wavelength of 4 metres. | **33)** The wind causes waves to travel across a puddle at  2.4 metres per second. If the waves have a wavelength of  0.6 metres, determine their frequency. | **36)** Calculate the frequency of sound waves in air which travel at 340 metres per second and have a wavelength of 1.7 metres. | **39)** Sound travels through steel at 5 200 metres per second. In the steel, sound waves have a  wavelength of 2 metres. Calculate their frequency. |
| **31)** Calculate the wavelength of water waves on a pond which  travel at 0.75 metres per second and have a frequency of 1.5 hertz. | **34)** A wave generator in a swimming pool produces  2.5 waves every second. The waves travel across the pool at  1.2 metres per second. Determine their wavelength. | **37)** Calculate the wavelength of sound waves in air if they travel at 340 metres per second and have a frequency of 6 800 hertz. | **40)** Ultrasound (frequency 21 000 hertz) travels through human muscle at 1 600 metres  per second. Calculate the wavelength of ultrasound in the muscle. |
|  |  |  | 11 |

**The Electromagnetic Spectrum**

The electromagnetic (EM) spectrum is a name that scientists give to groups of transverse waves which have different wavelengths/frequencies but all travel at the same speed in air (300 000 000 m/s, i.e., 3 x 108 m/s).

12 

**Light** travels in **straight lines**

called **light r \_ \_ \_**.

When a **light ray** hits a surface

### Optics

#### Reflection of Light

like a **plane mirror**, the **light ray**

**normal**

is **r** off the surface.

**A normal is a dashed line drawn at 90o to a surface where a light ray hits the surface.**

During **r** ,



**i**

**r**

plane mirror

the **angle of i** (**i**) is always

**equal to** the **angle of r** (**r**).

**=**

### The Principle of Reversibility of Ray Paths

If a **light ray** is shone from **A** to **C** via **B** or from **C** to **A** via **B**,

it will follow **exactly the same path** but in the **reverse direction**.

This is the principle of r \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ of r \_ \_ p \_ \_ \_ \_.

**B**

plane mirror

**A C**

13

**Total Internal Reflection**

**Fibre optics** can be used as a transmission

This diagram shows parts of a

system for **c \_ \_ \_ light** - No **h \_ \_ \_ energy**

passes through the system.

**L \_ \_ \_ \_** passes along an **o \_ \_ \_ \_ f** by

##### t \_ \_ \_ \_ i \_ \_ \_ \_ \_ \_ \_ r \_.

* + - * What do the words "total" and "internal" tell you about the reflection?

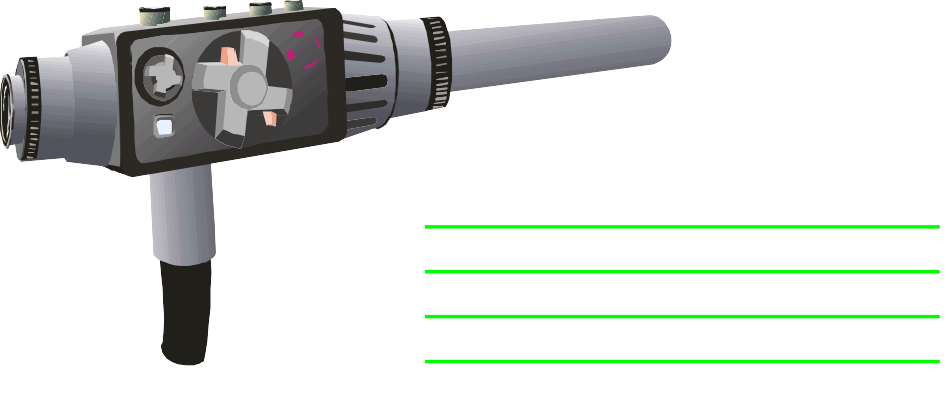
**f \_ \_ \_ \_ \_ \_ \_ \_ \_ (e )**



* + Complete this diagram to show light passing along an

optic fibre:

* + Describe and explain how it works:



* What is this device used for?



14

**Curved Reflectors**

Fitting a **c \_ \_ \_ \_ \_ r dish** to a **receiver aerial**

can make the **received signal s \_**.

When incoming signals hit the **c \_ \_ \_ \_ \_ r dish**,

the **dish f \_ \_ \_ \_ \_ \_** them all onto the **r \_ \_ \_ \_ \_ \_ \_ a \_ \_ \_ \_ \_**

* The **r \_ \_ \_ \_ \_ \_ \_ a \_ \_ \_ \_ \_** therefore receives a **s \_ \_ \_ \_ \_ \_ \_**

signal than it would if the **dish** was not fitted to it.

Show this by completing the diagram:

receiver aerial



curved reflector dish

### Curved Reflector Transmitter and Receiver Systems

Complete the diagram below to show signals being transmitted from the transmitter aerial to the receiver aerial:





curved reflector dish



curved reflector dish

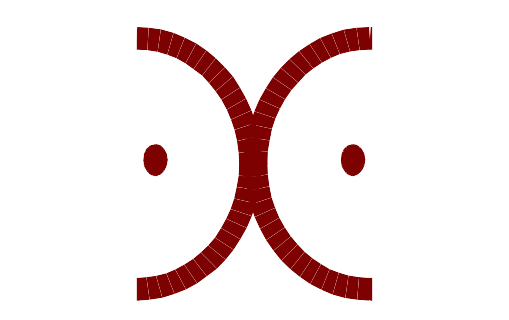
The above diagram could represent **signals** being passed from a **satellite** to the **Earth**, or a **TV link**

(e.g., television signals being sent from a sporting event to the television studio).

Sometimes, if **signals** have to travel a long distance over the Earth's surface, the **signals** get **w \_**.

We make the **signals s \_ \_ \_ \_ \_** again by giving them **e \_ \_ \_ \_ \_** at a **b station**.

Show this on the diagram below:

main transmitter booster receiver and transmitter station main receiver15



Refraction of Light

**Light** travels in **straight lines** called **light r \_ \_ \_**.

When **light** passes from one material into another of different **density**, its **s \_ \_ \_ \_** changes and so its **d \_ \_ \_ \_ \_ \_ \_ \_**

changes (unless the light hits the material at 90o to its surface) - This is known as **r \_**.

**A normal is a dashed line drawn at 90o to the surface of a material where a light ray hits the material.**

angle of



**normal**

i \_ \_ \_ \_ \_ \_ \_ \_

in air

When a light ray passes from air into glass/plastic/water, the ray bends t the normal

line.

i

angle of

r i \_ \_ \_ \_ \_ \_ \_ \_

in material

angle of

r \_ \_ \_ \_ \_ \_ \_ \_ \_

in material

i

r

**normal**

angle of

When a light ray passes from glass/plastic/water into air, the ray bends a \_ \_ \_ f \_ \_ \_ the

normal line.

r \_ \_ \_ \_ \_ \_ \_ \_ \_

16

in air

* + Using a ruler and protractor, complete each diagram below to show what happens to the

rays of light as they pass through the glass blocks. (Remember to draw normal lines).

TAKE YOUR TIME AND WORK VERY CAREFULLY.



17

Lenses

* + - Name each shape of lens shown below.
* Using a ruler, complete both diagrams to show what happens to the light rays.

**lens**

ruler

* On each diagram, show the focal length of the

lens.

* + Describe a simple experiment you could perform to find the

focal length of a

18 convex lens. far away window

convex lens

**lens**

screen

Focal Length and Power of Lenses

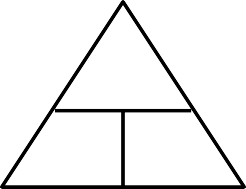
**T \_ \_ \_ \_** lenses refract (**b \_ \_ \_**) light more than **t \_ \_ \_** lenses - so **t \_ \_ \_ \_** lenses are more **p \_**.

A **powerful** lens has a **s** focal length.

Convex lenses have a **p \_ \_ \_ \_ \_ \_ \_** ( ) power. Concave lenses have a **n** ( ) power.

1

power (P) = focal length in metres (f)



1

P f

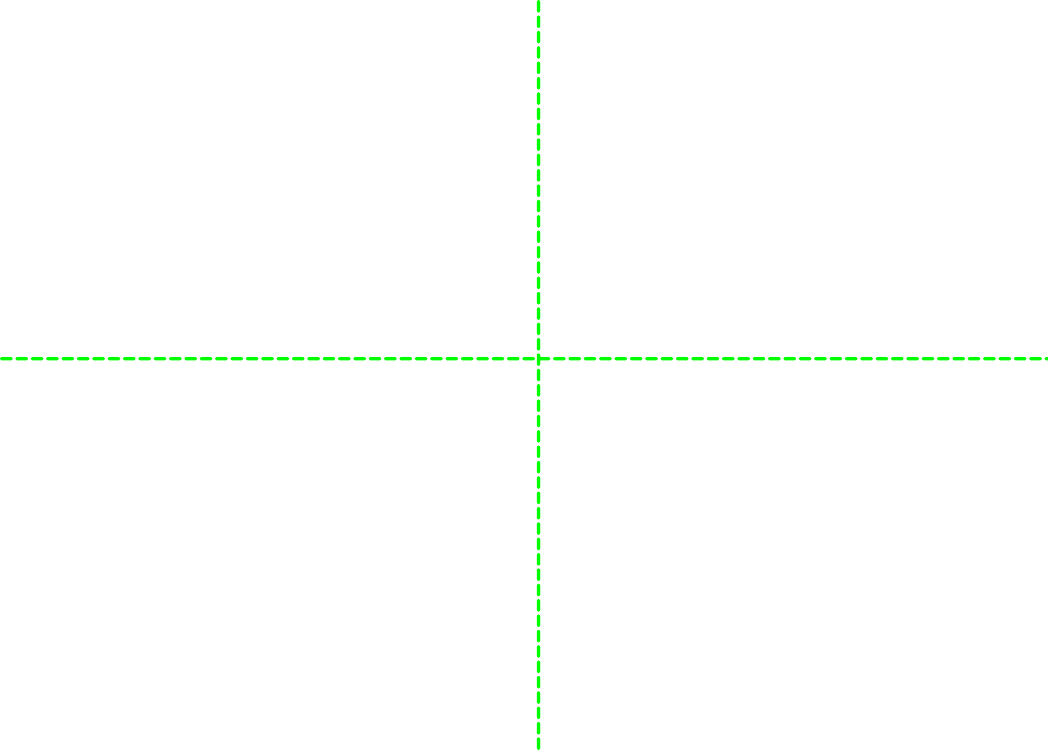
focal length in metres (f) = 1

power (P)

### Convex Lenses

##### dioptres (D)

**metres (m)**



A concave lens has a power of

-4 D

Calculate its focal length in metres

**Concave Lenses**

A concave lens has a focal length of

1.25 m. Calculate its power.

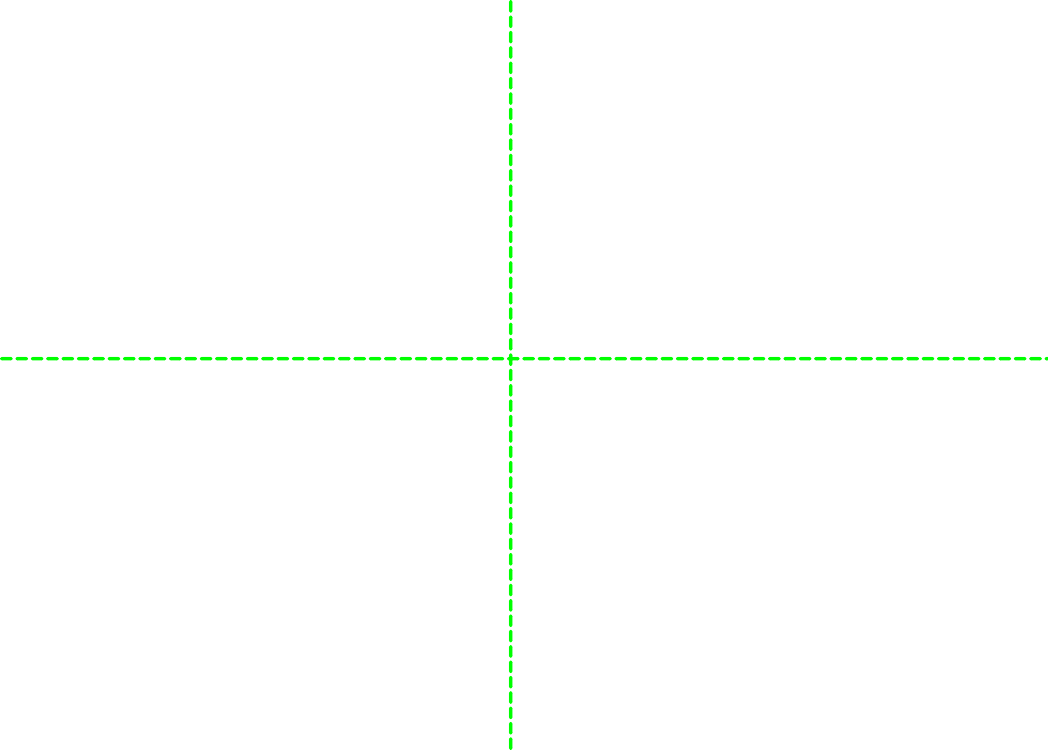
Calculate the focal length of a lens with power

-8 D.

Calculate the power of a concave lens of focal length

0.6 m

19



A convex lens has a power of

+ 5 D.

Calculate its focal length in metres.

A convex lens has a focal length of

0.5 m. Calculate its power.

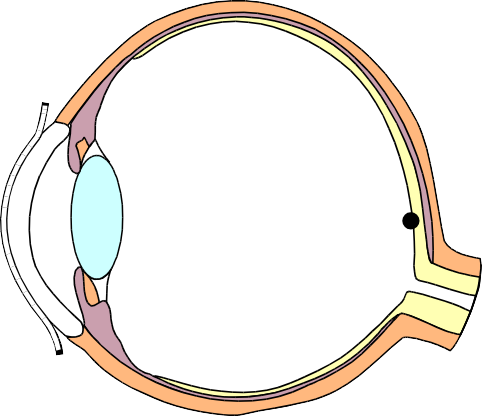
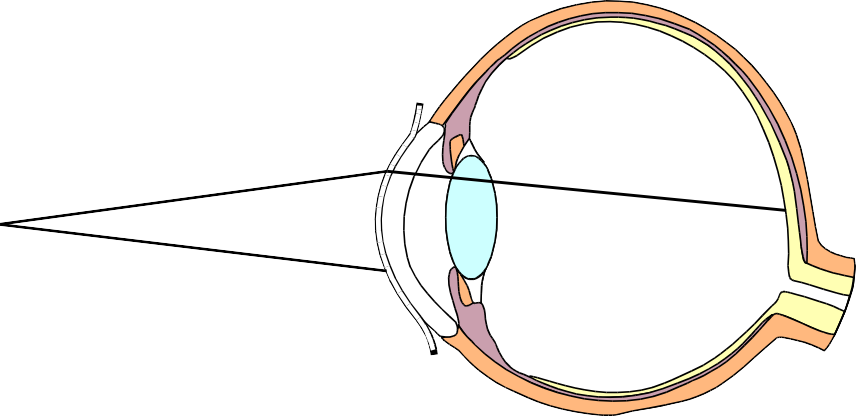
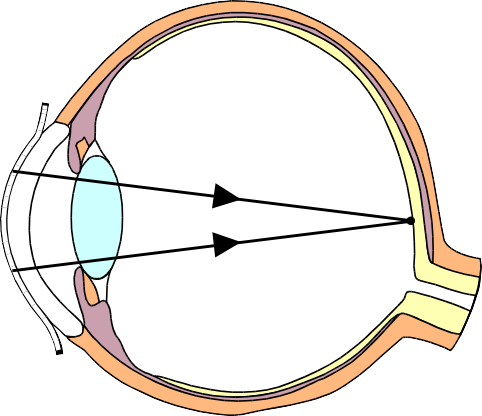
Calculate the focal length of a lens with power

+ 40 D.

Calculate the power of a convex lens of focal length

0.25 m.

A person who is **l \_ \_ \_ s \_ \_ \_ \_ \_ \_** can see **c \_ \_ \_ \_ \_ \_**



20

Long Sight

objects which are **f \_ \_ a \_ \_ \_** - This is because the eye

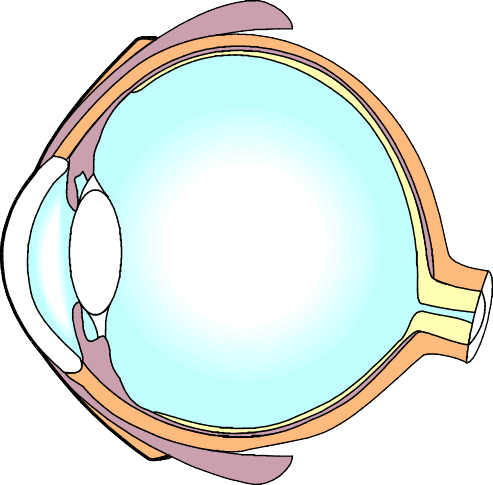
**c \_ \_** focus the **p** light rays coming from the object on the **r \_**.

However, the person cannot see **c** objects which

are **c \_ \_ \_ \_** to them - This is because the eye **c \_ \_ \_ \_ \_**

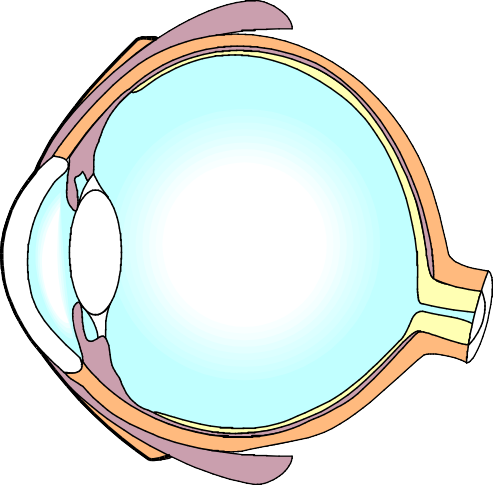
focus the **n \_ \_ - p** light rays coming from the

object on the **r \_**.

Complete this diagram to show how a "long-sighted eye" focuses light rays from a close object.

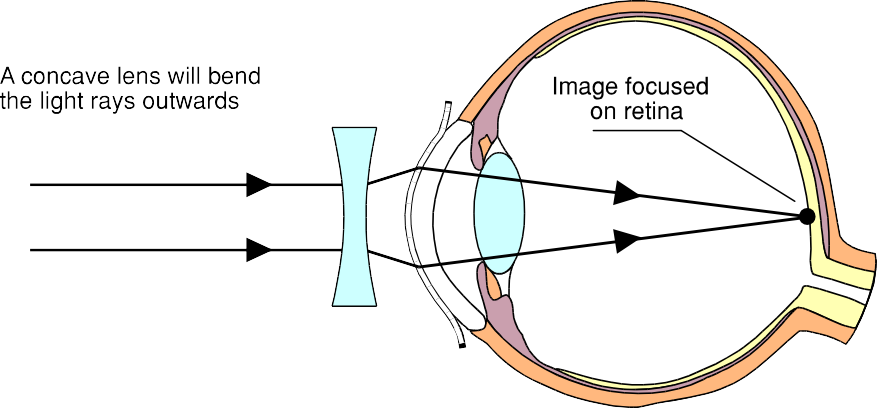
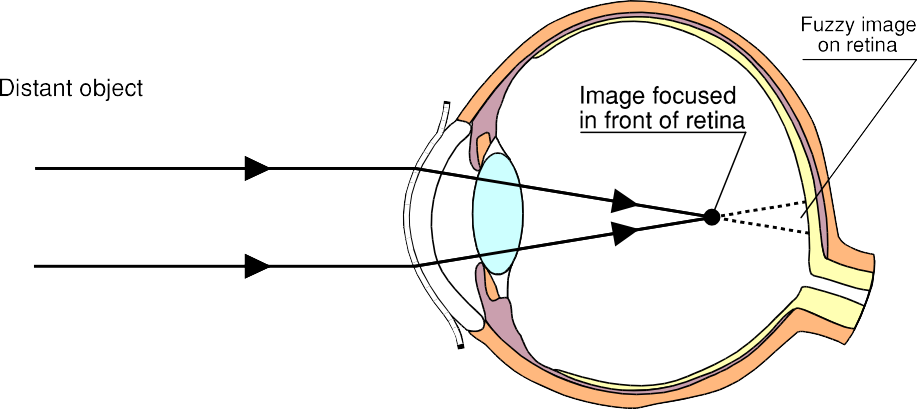
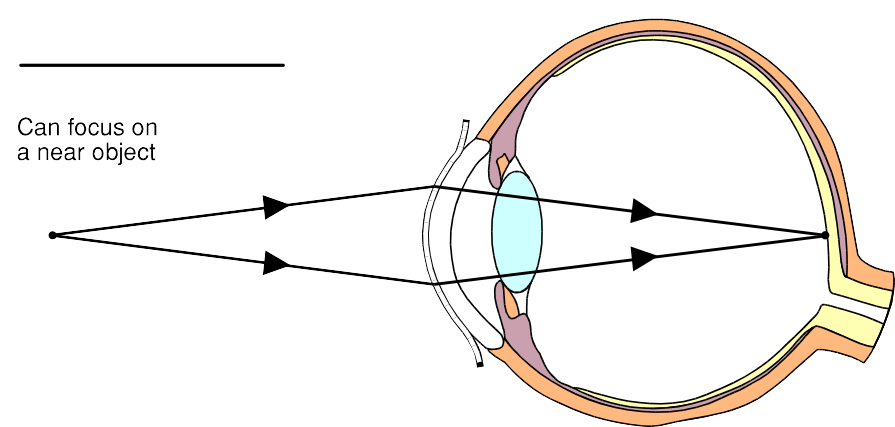
To correct long sight, a

**c \_ \_ \_ \_ \_ l** is placed in front of

the eye. Complete this diagram to show the affect the lens has on light rays from a

close object.

A person who is **s \_ \_ \_ \_ s \_ \_ \_ \_ \_ \_** can see **c \_ \_ \_ \_ \_ \_**



Short Sight

objects which are **c \_** - This is because the eye

**c \_ \_** focus the **n \_ \_ - p** light rays coming from

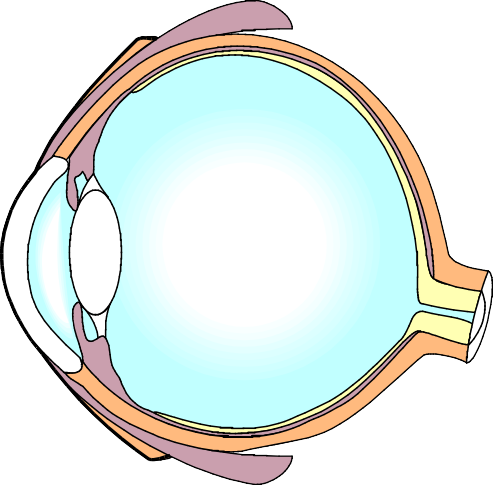
the object on the **r \_**.

However, the person cannot see **c** objects which

are **d \_ \_ \_ \_ \_ \_** (**f \_ \_ a** ) - This is because the eye

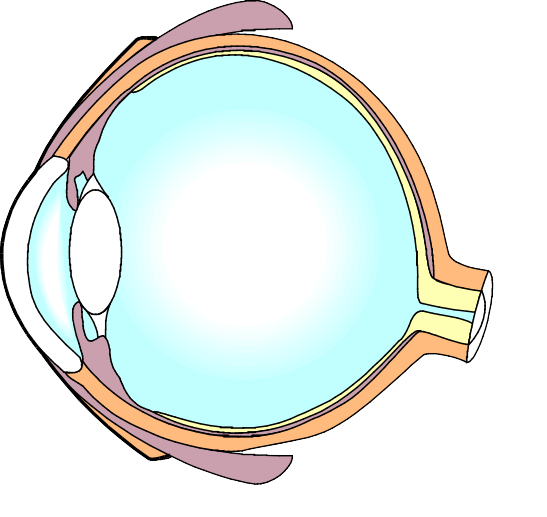
**c \_ \_ \_ \_ \_** focus the **p** light rays coming from the

object on the **r \_**.

Complete this diagram to show how a "short-sighted eye" focuses light rays from a distant object.

To correct short sight, a

**c \_ \_ \_ \_ \_ \_ l** is placed in front of

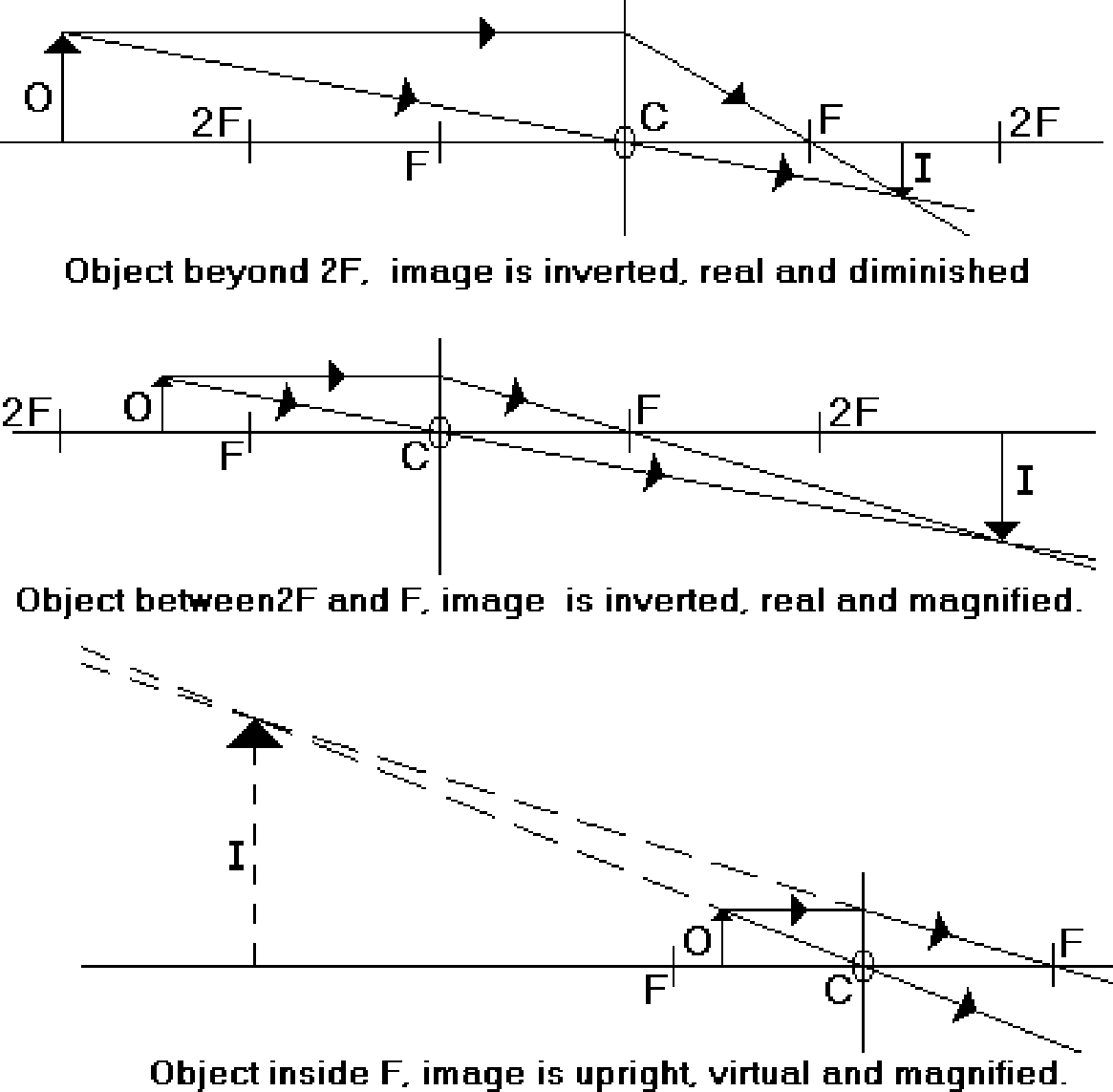
the eye. Complete this diagram to show the affect the lens has on light rays from a

distant object.

## 21

### Images Formed by Convex Lenses

22



###### Complete each diagram, to show the image formed by the convex lens.

**USE A PENCIL AND RULER. BE CAREFUL. TAKE YOUR TIME.**

**O 2F**



**F**

**F 2F**

###### Object beyond 2F: Image is i \_ \_ \_ \_ \_ \_ \_ , r \_ \_ \_ and d \_.

**2F O**

##### F

**F 2F**

###### Object between 2F and F: Image is i \_ \_ \_ \_ \_ \_ \_ , r \_ \_ \_ and m \_.



**O**

**F**

**F**

Object inside F: Image is u \_ \_ \_ \_ \_ \_ , v \_ \_ \_ \_ \_ \_ and m \_ \_ \_ \_ \_ \_ \_ \_. 23

* ONCE AGAIN, complete each diagram, to show the image formed by the convex lens.

**USE A PENCIL AND RULER. BE CAREFUL. TAKE YOUR TIME.**

**O 2F**



##### F

**F 2F**

###### Object beyond 2F: Image is i \_ \_ \_ \_ \_ \_ \_ , r \_ \_ \_ and d \_.

**2F O**

##### F

**F 2F**

###### Object between 2F and F: Image is i \_ \_ \_ \_ \_ \_ \_ , r \_ \_ \_ and m \_.



**O**

**F**

**F**

24 Object inside F: Image is u \_ \_ \_ \_ \_ \_ , v \_ \_ \_ \_ \_ \_ and m \_.