FAULKES TELESCOPE

Light and Optics

The Nature of Light

Student Question Sheet (Advanced)

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Introduction

This worksheet contains questions and activities which will test your knowledge and understanding of the project, ‘Light and Optics’. It is assumed that you have carried out the project as given in the document, ‘Light and Optics- Activity Instructions’ before completing this worksheet.

What is light?

Light is a type of energy which travels as a wave. It travels from a luminous source (such as the Sun, or a flame, or a torch), in a straight line. Not everything is a source of light however - this piece of paper which you are looking at now, does not emit light. So how can you see it? The paper is reflecting light from the room towards your eyes, making you able to see it. This is how we can see all objects, and we shall investigate the path that light takes, later in this module.

1. Arrange the following objects in the table below according to whether they are sources or reflectors of light:

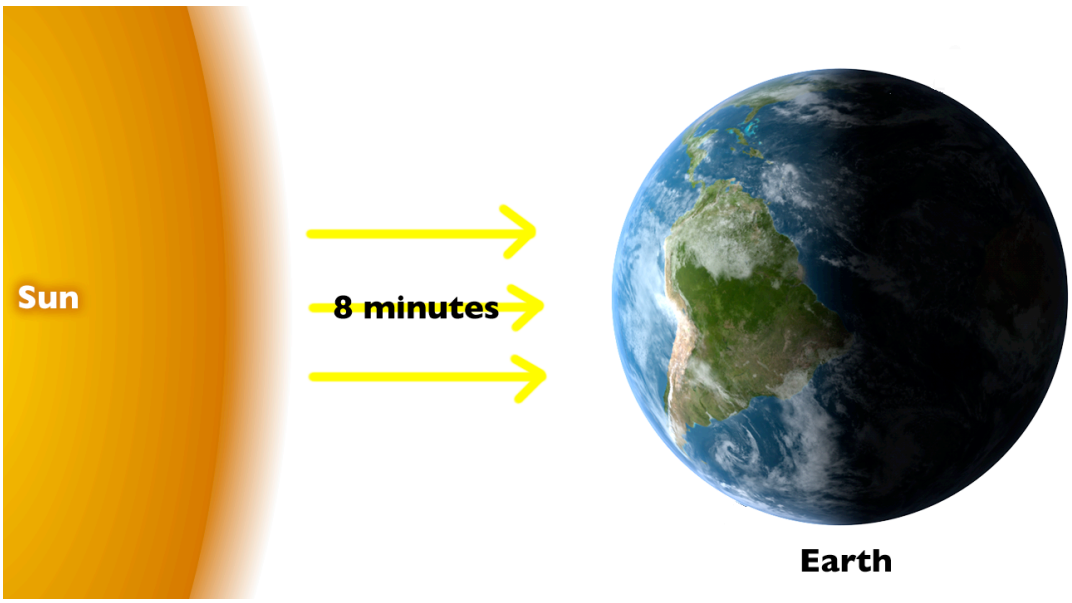
The Sun	Candle flame	Asteroids
Planets	Torch	
Stars	The Moon	

Source of light	Reflects light

The Speed of Light

It would be very easy to assume that light travels instantaneously - when you switch a light on in a dark room, the light seems to come on straight away. However, light is not instantaneous - it travels at a speed of $3x10^8$m/s. Obviously this is very, very fast, so it appears instantaneous to us if it is only travelling short distances (as it would be from a light bulb to a room). Light travels faster than sound - this is why, in a storm, you see the flash of lightning before you hear the thunder!

If we consider the distances in the Universe, the time it takes for light to reach us on Earth, does not appear to be instant. It takes 8 minutes for light from the Sun to reach Earth, so actually, the sunlight on Earth is 8 minutes old.



In a similar way, light from our nearest galaxy neighbour, called the Canis Major dwarf galaxy, takes about 25,000 years to reach us! This means that when we look at this galaxy, we are seeing it as it looked 25,000 years ago, so we are looking back in time!

When astronomers talk about the very large distances in space, they use units of *light-years*. This is the distance that light takes to travel at a speed of $3x10^8$m/s in one year.

1. The Andromeda galaxy is 2.9 million light years from Earth.

    a) How long does it take for light from Andromeda to reach Earth?

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b) If we sent a message from Earth to the Andromeda galaxy, how long would it take for us to get a reply?

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2. Below is an image of the Eagle nebula, taken with the Faulkes Telescope. This nebula is a region in our Galaxy which contains lots of dust and gas. The columns of dust are illuminated by nearby stars, making them visible to our telescope. Inside these huge columns, it is thought that stars are being born.

a). It takes about 7000 years for light from the Eagle nebula to reach us on Earth. Using this information, and the speed of light given above, calculate how far the Eagle Nebula is from us in kilometres.

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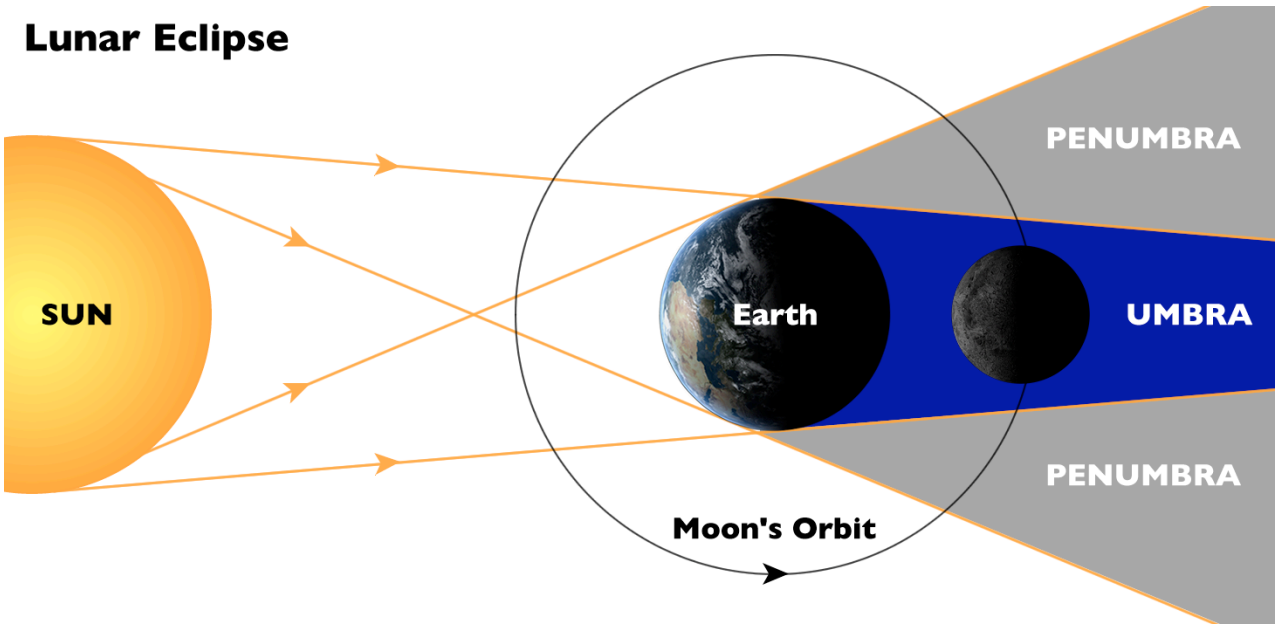
b). The length of the dust columns in the Horsehead Nebula are about one light year in size. How long would it take light to travel from the tip to the end of the column?

The Path of Light

Light travels in straight lines. It can't bend itself around objects if they are in its path, which is why we see shadows. Shadows occur where light has been blocked by an object, as shown in the diagram below. Here, the Earth is blocking the light from the Sun, from reaching the Moon, so the Moon is said to be in the Earth's shadow (or 'umbra'. The penumbra is the region on the edge of the umbra). When the Earth, Moon and Sun are all aligned so that all the light from the Sun is blocked from the Moon, this is a lunar eclipse.



Objects which block light and don't let any through are called **opaque**. Those which allow some light through are called **translucent**, whereas **transparent** objects allow all light through.

1. State whether the following objects are transparent, translucent or opaque.

a). A brick wall ----------

b). Eyeglasses ----------

c). Windows ----------

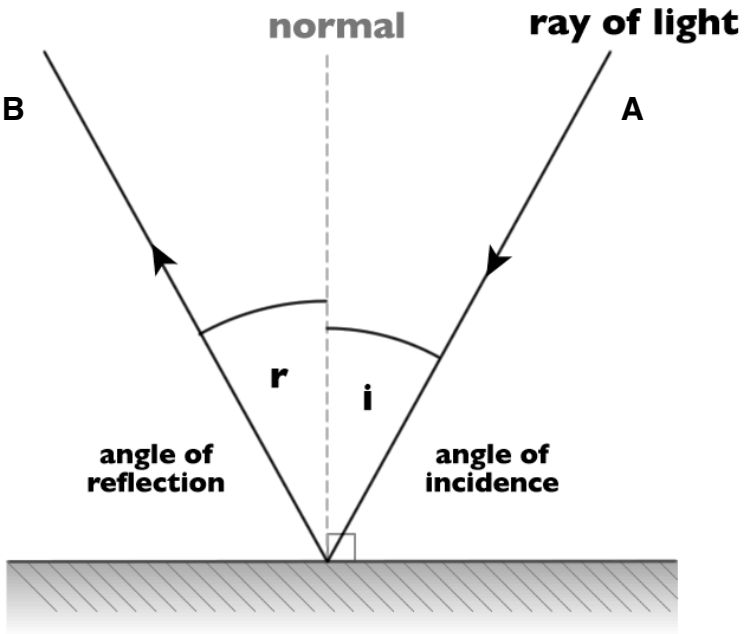
d). Frosted glass (like on a bathroom window) ----------

e). Cardboard ----------

2. What causes your shadow? Draw a ray diagram to illustrate what is happening.

Reflection

Although light cannot be bent around objects, it can be made to change direction with the use of mirrors - this is called reflection. When light is reflected off a mirror, the angle at which it hits the mirror (the angle of incidence) is the same as the angle at which it is reflected off the mirror (the angle of reflection). This is shown in the diagram below. The rays of light which hit the mirror and are reflected off the mirror are called the incident and reflected rays respectively. The normal is an imaginary line which lies at right angles to the mirror from where the ray hits it.



1. The light rays in the diagram above are labelled A and B.

    a). Which is the incident ray of light, A or B?

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    b). If the angle of reflection is 15 degrees, at what angle did the incident ray hit the mirror?

The main mirror on the Faulkes Telescope is 2 metres in diameter. The design of the telescope means that the light from an astronomical objects enters the telescope, hits the primary mirror, reflects onto the secondary mirror and then onto the CCD camera which records an image of the object.

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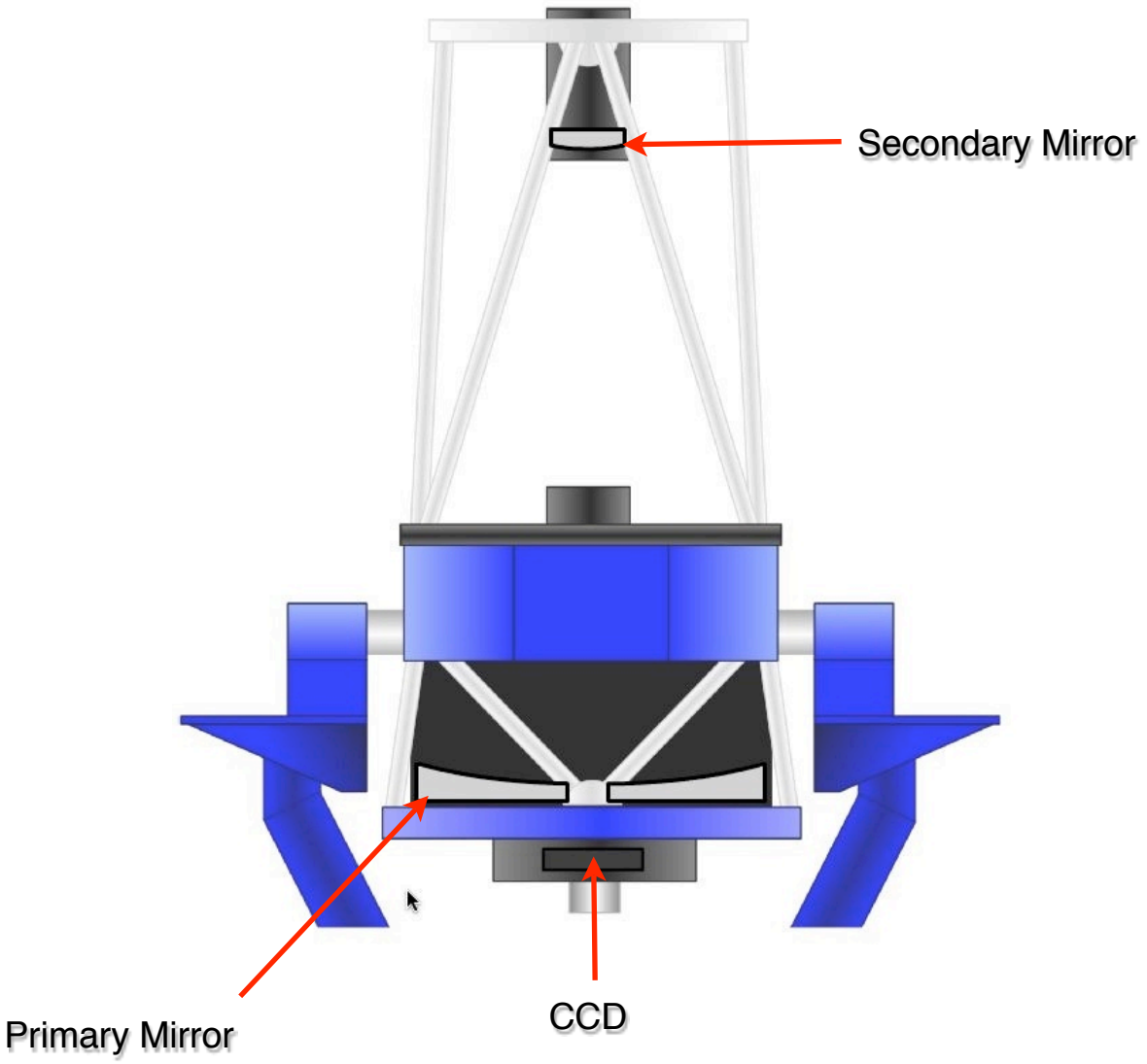
2. Run the flash animation of how the FT works. This can be found at:

Home>Education>Activities>Worksheets

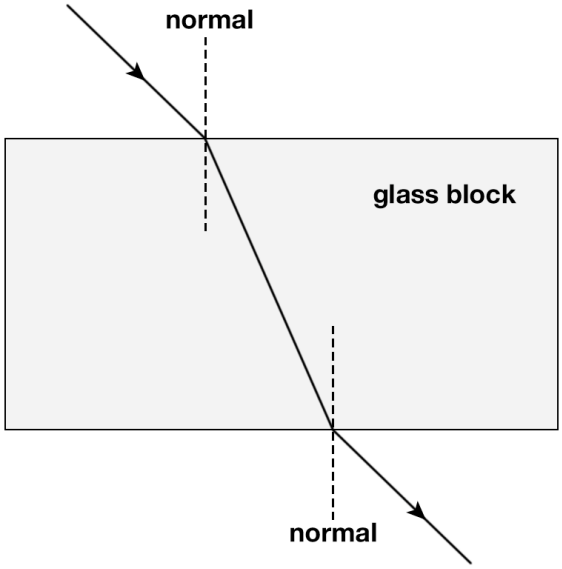
Pay attention to the path that the light takes to travel through the telescope.

3. Using the information above, and the flash animation (if you watched it), draw the path of the light rays as they journey through the telescope below. Make sure you mark the directions of the rays.

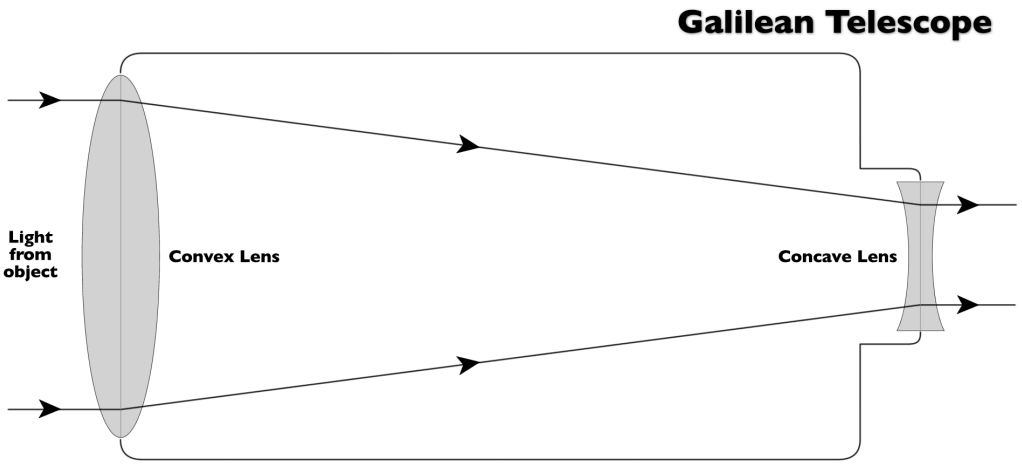


Refraction

Another way of changing the direction of light is to use lenses - this is called refraction. When light passes through different mediums, such as from air into glass, it is bent or refracted. In the diagram below, light passes through a glass block and back out again. When light passes into the glass block it is refracted towards the normal. When it passes back out of the glass into the air, it is refracted away from the normal.

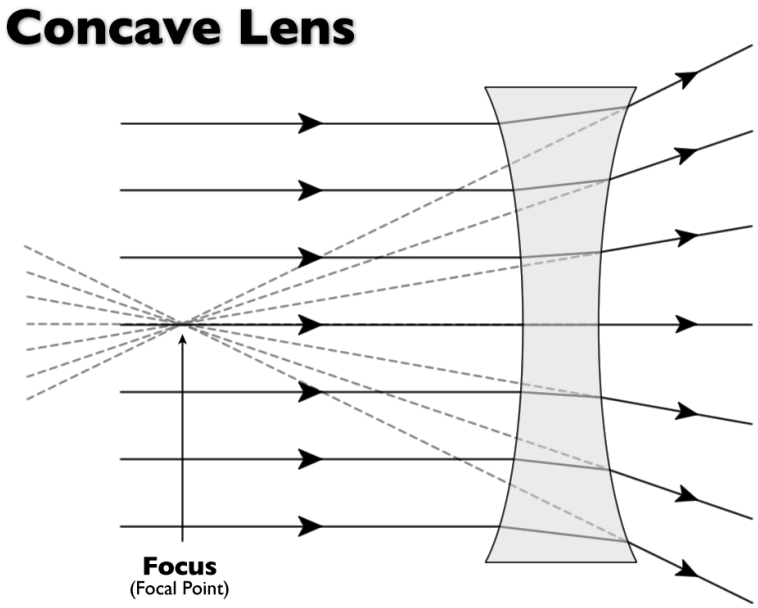


This refraction of the light when it passes through a medium means that if the medium is a particular shape, the light can be made to focus on a certain point - this type of object is called a lens. The first telescope, designed and built by Galileo, used lenses to focus light from astronomical objects, into Galileo's eye. Below is a simple diagram, showing how his telescope worked:



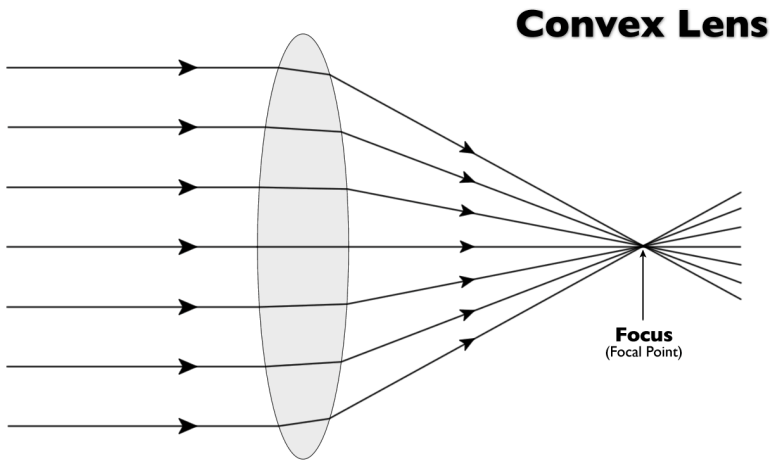
This telescope consists of two types of lense - concave and convex. Light rays will always be refracted towards the thickest part of the lens.

Concave lenses are thin in the middle and make light rays spread out, or diverge, as shown below.



If the rays of light are traced back (dotted line), they all intersect at the focus, or focal point, behind the lens.

Convex lenses however, are thicker in the middle, and focus light rays to a point in front of the lens (the rays ‘converge’). This point is called the focus or focal point.



The distance between the centre of the convex lens, and the point where the light rays are focussed, is called the focal length of the lens.

1. The human body contains a lens.

a). Where can this lens be found?

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b). Is this lens, convex or concave?

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2. a) Draw the path that light takes as it is refracted by a convex lens. On this diagram, mark the direction of the rays, and label the focus point, and the focal length of the lens.

b) Draw a diagram to show what you think would happen to the light rays if the lens in (a) above, was

(i) Thinner

(ii)Fatter

3. Select the true statements from the following by ticking the boxes:

a). When light bounces off a mirror, it is said to have been refracted ☐

b). When light bounces off a mirror, it is said to have been reflected ☐

c). The angle at which light comes off a mirror is equal to the angle at which it hits the mirror ☐

d). The angle at which light comes off a mirror is larger than the angle at which it hits the mirror ☐

e). The angle at which light comes off a mirror is smaller than the angle at which it hits the mirror ☐

4. a). Using the following words, fill in the blanks in the paragraph below:

Refracted	Reflected	Reflection	Incidence
Greater than	Telescope	Lenses	Less than
Equal to			

When light hits a mirror, it is _____. The angle at which it hits the mirror is called the angle of _____. The angle at which the light ray comes off the mirror is called the angle of _____. This angle is _____ the angle of incidence. Light can also be made to change direction with the use of _____.

b). Now find and circle the words which you used above, in the word-search below.

R	E	F	R	A	C	T	E	D	A
E	B	A	E	G	R	S	V	L	Q
F	E	K	F	Q	E	O	D	S	P
L	T	Y	L	C	U	P	H	E	Q
E	F	O	E	T	D	A	F	R	U
C	M	S	C	J	O	I	L	N	S
T	K	R	T	A	F	N	D	T	E
I	N	L	E	N	S	E	S	A	O
O	W	R	D	U	G	W	V	G	H
N	E	C	N	E	D	I	C	N	I