

Grade 10 Science

Light and Geometric Optics
Class 9

Overall Expectations

- Evaluate the effectiveness of technological devices and procedures designed to make use of light, and assess their social benefits
- Investigate, through inquiry, the properties of light, and predict its behavior, particularly with respect to reflection in plane and curved mirrors and refraction in converging lenses
- Demonstrate an understanding of various characteristics and properties of light, particularly with respect to reflection in mirrors and reflection and refraction in lenses

Light

- Light is an electromagnetic wave – has both electric and magnetic parts and does not require a medium
 - Medium – any physical substance through which energy can be transferred

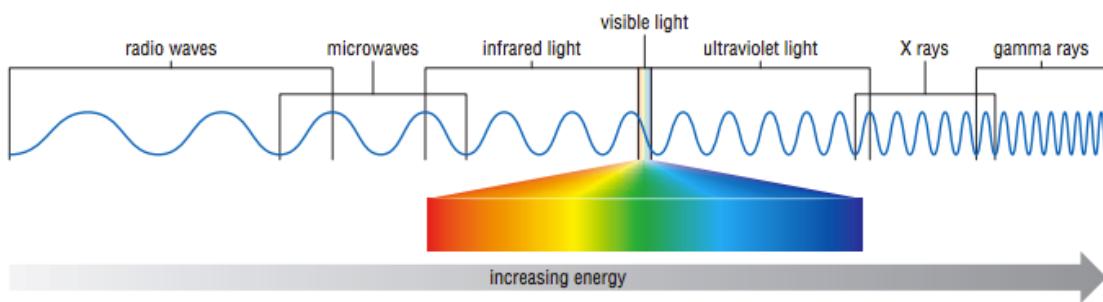


Figure 5 The electromagnetic spectrum. Note the different categories as the energy of the electromagnetic wave increases.

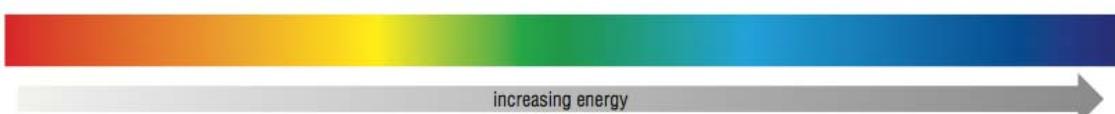
Table 1 The Many Uses of Electromagnetic Waves

Type of electromagnetic wave	Use/phenomena
radio waves 	<ul style="list-style-type: none">• AM/FM radio• TV signals• cellphone communication• radar• astronomy (for example, discovery of pulsars)
microwaves 	<ul style="list-style-type: none">• telecommunications• microwave ovens• astronomy (for example, background radiation associated with the Big Bang)
infrared light 	<ul style="list-style-type: none">• remote controls (for example, DVD players and game controllers)• lasers• heat detection (for example, leakage from windows, roofs) and remote sensing• keeps food warm (in fast-food restaurants)• astronomy (for example, discovering the chemical composition of celestial bodies)• physical therapy

visible light 	<ul style="list-style-type: none"> • human vision • theatre/concert lighting • rainbows • visible lasers • astronomy (for example, optical telescopes, discovering the chemical composition of celestial bodies)
ultraviolet light 	<ul style="list-style-type: none"> • causes skin to tan and sunburn • increases risk of developing skin cancer • stimulates production of vitamin D • kills bacteria in food and water (sterilization) • "black" lights • ultraviolet lasers • astronomy (for example, discovering the chemical composition of celestial bodies)
X-rays 	<ul style="list-style-type: none"> • medical imaging (for example, of teeth and broken bones) • security equipment (for example, scanning of luggage at airports) • cancer treatment • astronomy (for example, study of binary star systems, black holes, the centres of galaxies)
gamma rays 	<ul style="list-style-type: none"> • cancer treatment • astronomy (for example, study of nuclear processes in the universe) • product of some nuclear decay

Visible Light

- White visible light is composed of a continuous sequence of colours called the visible spectrum (ROYGBIV)
- Visible spectrum was discovered by Sir Isaac Newton who used a prism to separate the colours



Luminous/Non-Luminous

- **Luminous** – produces its own light (ex: Sun, lightbulb, lit match, flashlight, etc.)
- **Non-luminous** – does not produce its own light and can only be seen by using reflected light (ex: tree, moon, pencil, etc.)



Incandescence



- Producing light as a result of high temperature
- Any object as it gets hotter and hotter will eventually produce light
- Ex: Incandescent lightbulbs contains a thin wire filament that glows as it gets hot
 - 5-10% of the electricity is converted into visible light
 - The rest of the energy is converted to infrared light that you feel as heat.

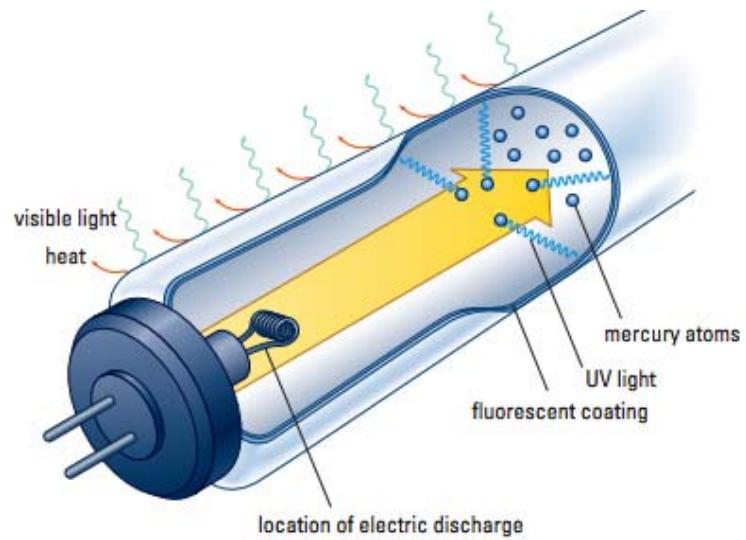
Electric Discharge

- Light that comes from an electric current passing through a gas (ex: Neon lights)
- Lightning is the light you see when an electric current passes through air



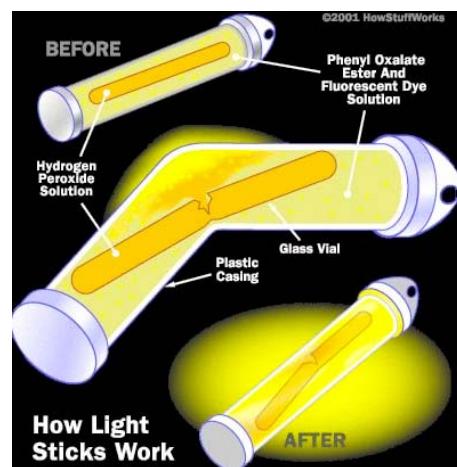
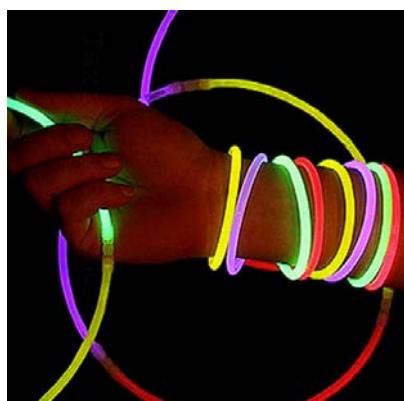
Phosphorescence/Fluorescence

- **Phosphorescence** – glow-in-the-dark objects are coated with phosphors, which absorb light and releases energy slowly
- **Fluorescence** – objects that absorb light and release the energy immediately
 - Highlighters contain a fluorescent dye that causes the ink to glow in the presence of UV light
 - Fluorescent lights – electric charge causes the mercury vapour to emit UV lights which strike the fluorescent material and emits light



Chemiluminescence

- Production of light as a byproduct of a chemical reaction with little or no heat produced (ex: glowsticks)



Bioluminescence

- Production of light in living organisms as a result of a chemical reaction with little or no heat produced (ex: fireflies)



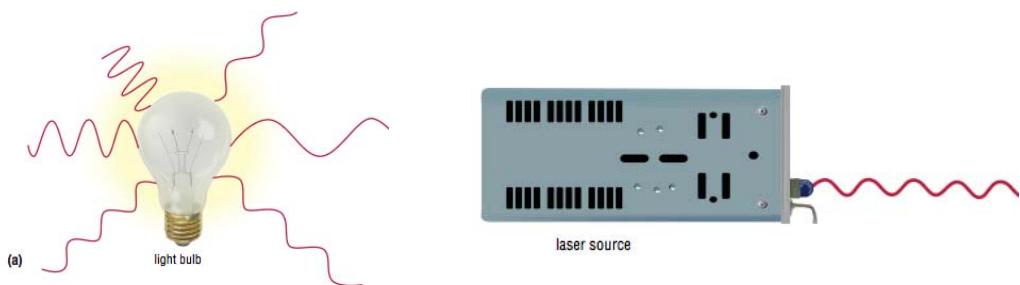
Triboluminescence

- Production of light from friction as a result of scratching, crushing or rubbing certain crystals



Lasers

- Emits electromagnetic waves of exactly the same energy level resulting in a pure colour
- Laser lights is also very intense and concentrated in one narrow beam because it travel is one direction

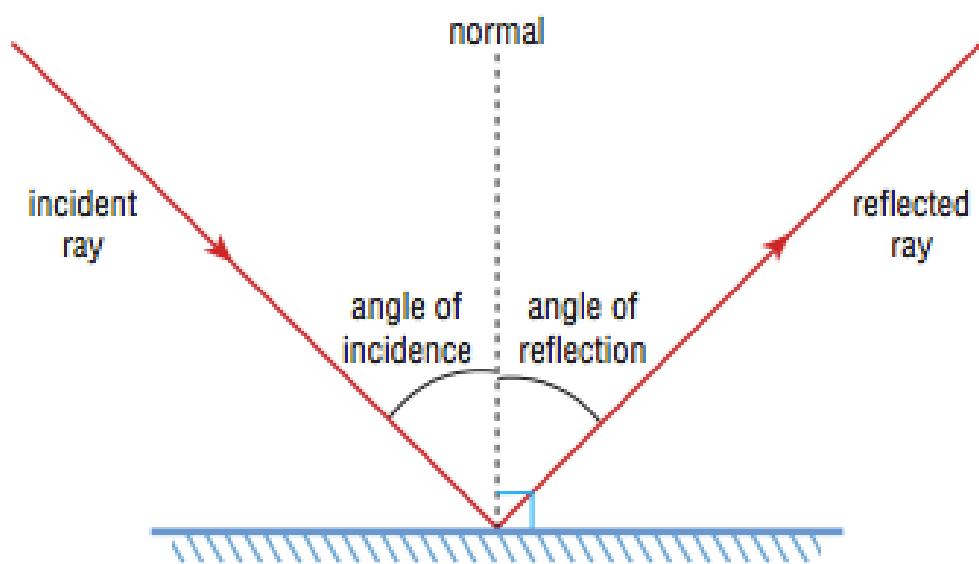


Ray Model of Light

- **Light Ray** – a line on a diagram representing the direction and path that light is traveling
- **Incident Ray** – Light emitted from a source that strikes an object
- Objects can be classified into 3 categories:
 - **Transparent** – lets light pass through easily
 - **Translucent** – allows some light to pass through
 - **Opaque** – allows no light to pass through

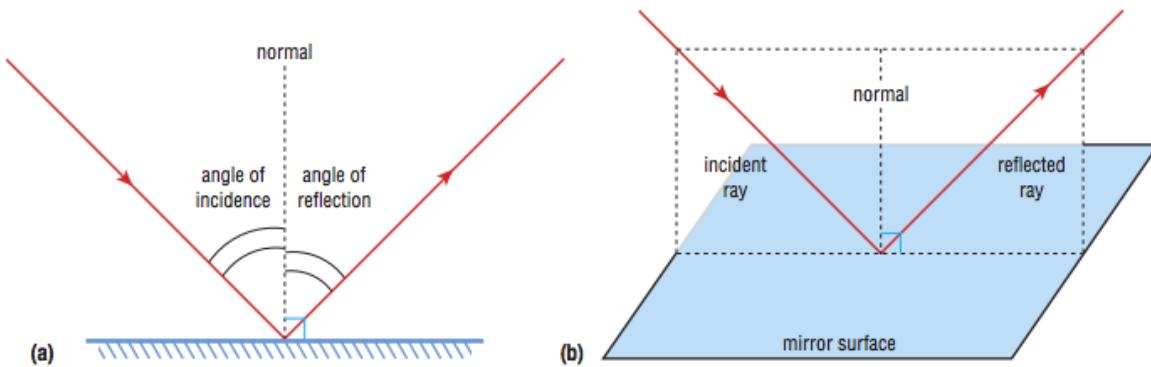
Mirrors

- **Mirror** – any polished surface that exhibits reflection
- **Image** – the reproduction of an original object that is produced through the use of light
- **Reflection** – the bouncing back of light from any surface



Laws of Reflection

- The angle of incidence equals the angle of reflection
- The incident ray, the reflected ray and the normal all lie in the same plane



Types of Reflection

- Specular Reflection – reflection off a smooth surface
- Diffuse Reflection – reflection off an irregular or dull surface



Writing Reflectively

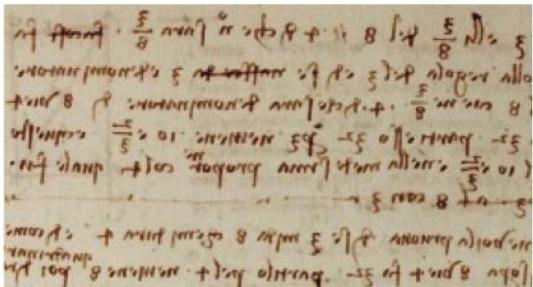


Figure 1 A section from one of Leonardo da Vinci's notebooks showing his backwards writing

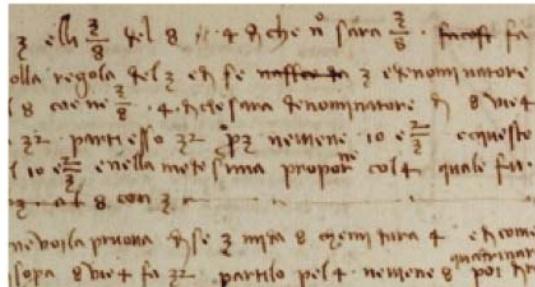
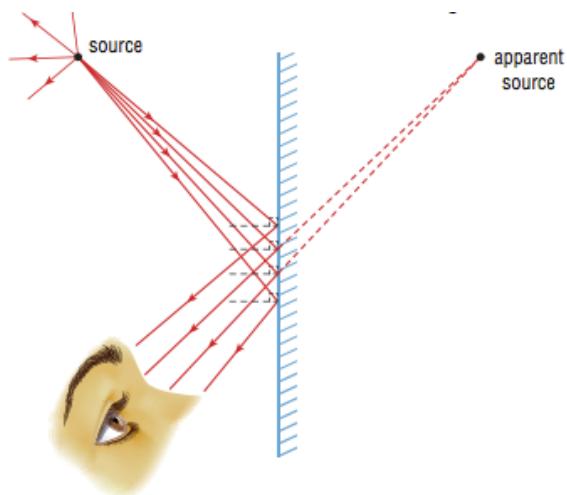


Figure 2 The same section from Figure 1 now reflected in a mirror. Note that the numbers are now readable.

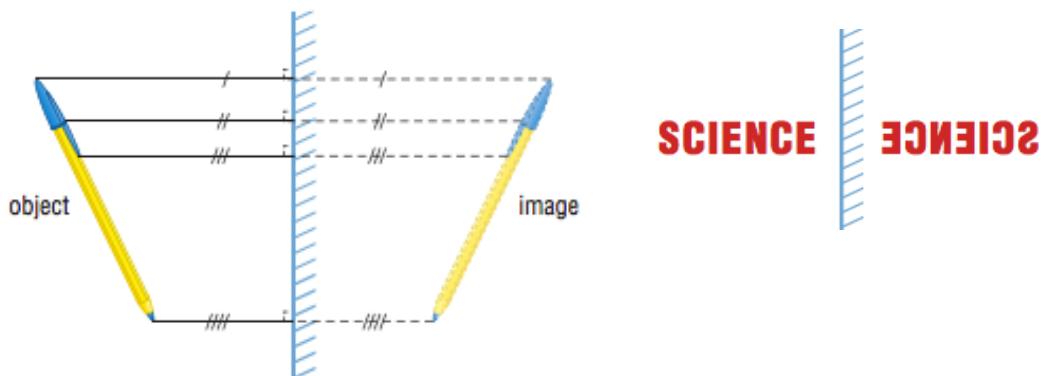
- Leonardo Da Vinci often mirror wrote in his notes unless it was intended for other people to read

Images in Plane Mirrors



- Virtual Image – an image formed by light coming from an apparent light source; light is not coming from the actual image location

- Distance from the object to the mirror is exactly the same as the image to the mirror
- The object-image line is perpendicular to the mirror surface
- Images are upright but flipped horizontally; lateral inversion



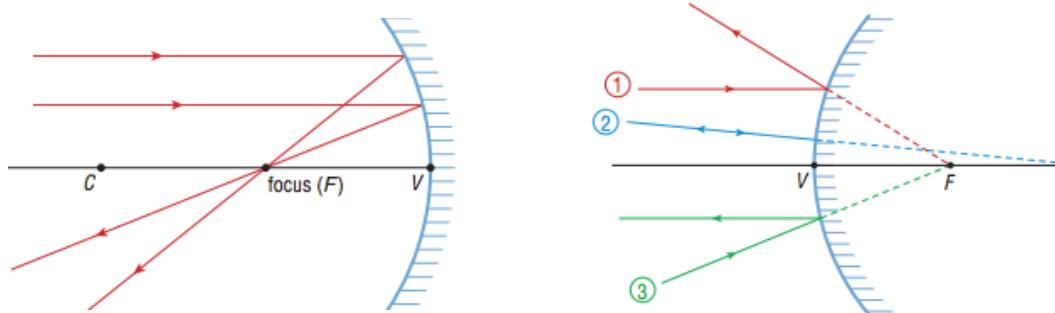
SALT

- S = size of image compared to the object
- A = attitude of image; upright/inverted
- L = location of image
- T = type of image; real or virtual

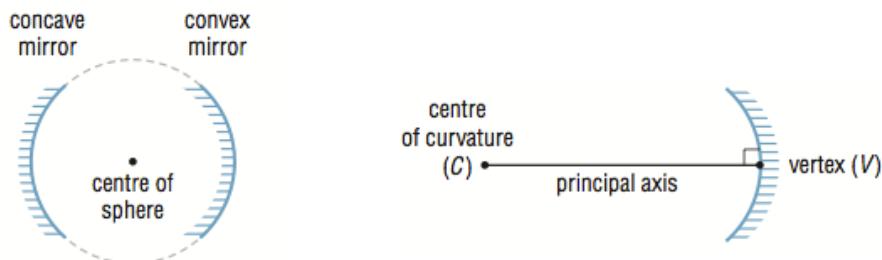
	Size	Attitude	Location	Type
Image	larger or same or smaller	upright or inverted	object ? image	virtual or real

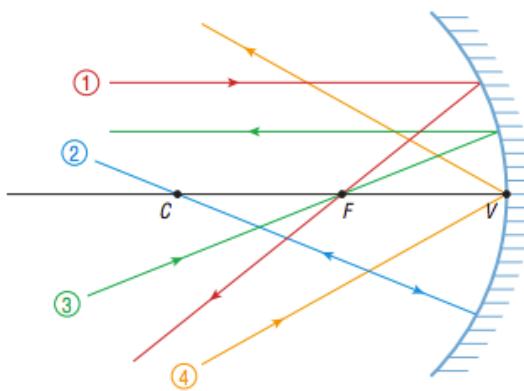
Images in Curved Mirrors

- Concave (converging) mirror – a mirror shaped like the inside of a spoon
- Convex (diverging) mirror – a mirror shaped like the outside of a spoon



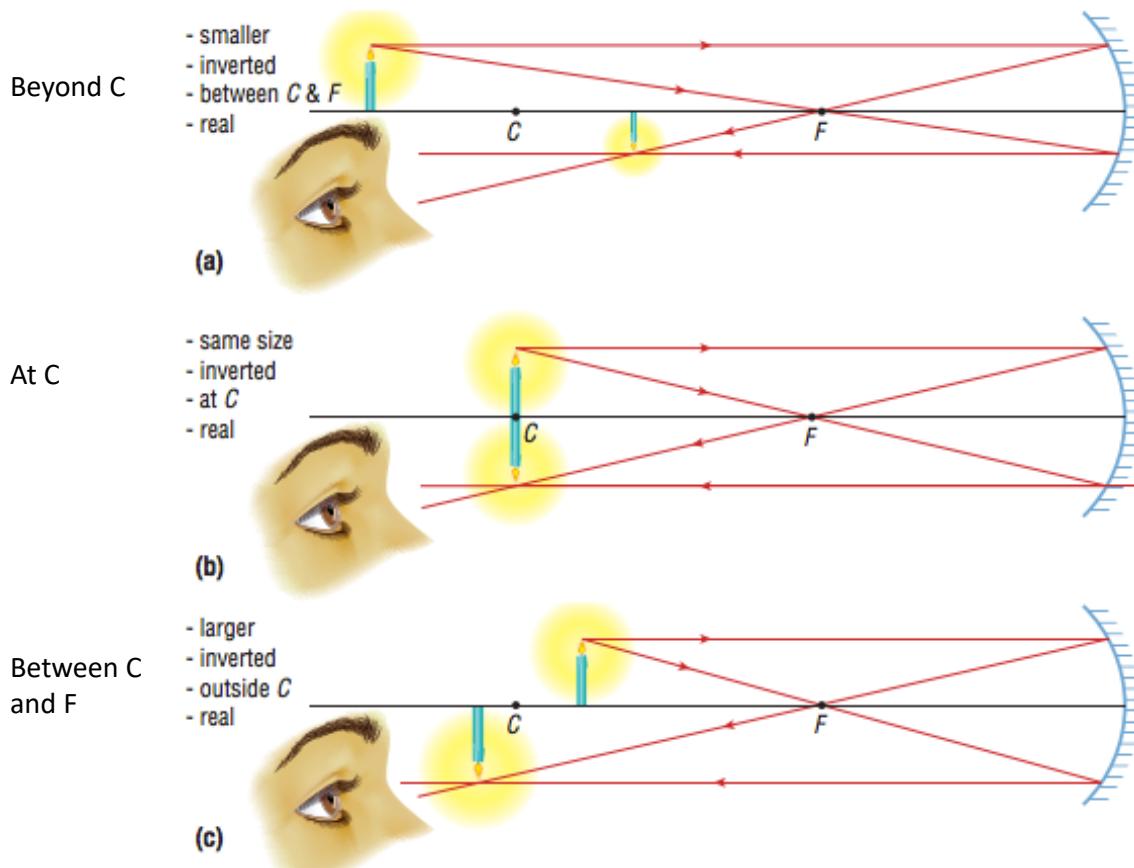
- **Centre of Curvature** – centre of the sphere, labeled as C
- **Principal axis** – the line going through the centre of curvature and the centre of the mirror
- **Vertex** – the point where the principal axis intersects the mirror, labeled V
- **Focus** – where parallel light rays converge





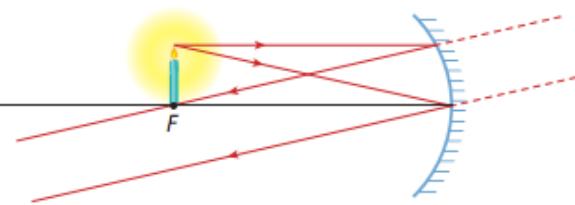
- ① A light ray parallel to the principal axis is reflected through the focus. This is how the focus is defined.
- ② A light ray through the centre of curvature is reflected back onto itself. This rule makes sense because any line through the centre of curvature is a radius of the circle formed by the mirror. A radius is always at 90° to the mirror. A ray along the normal has an angle of incidence of 0° . This means that the angle of reflection is also 0° . The reflected ray will return back on the same path.
- ③ A ray through F will reflect parallel to the principal axis. This rule uses the fact that the angle of incidence is always equal to the angle of reflection. Even if you switch the incident and reflected rays, the light will still follow the same path; only the direction will change. This principle is called the reversibility of light.
- ④ A ray aimed at the vertex will follow the law of reflection. Because the principal axis is perpendicular to the surface of the mirror, the angle of incidence can be easily measured.

- Real Image – an image that can be seen on a screen as a result of light rays actually arriving at the image location



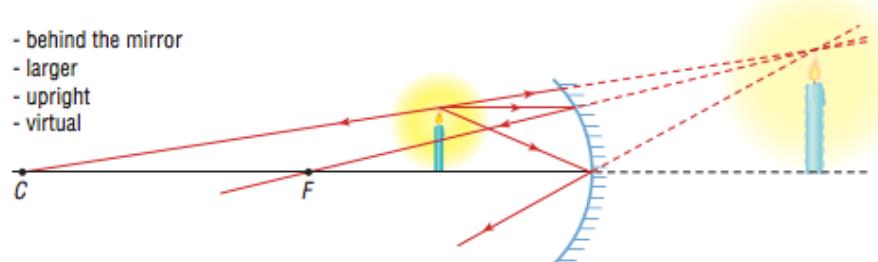
At F

no clear image formed
(reflected rays are parallel)

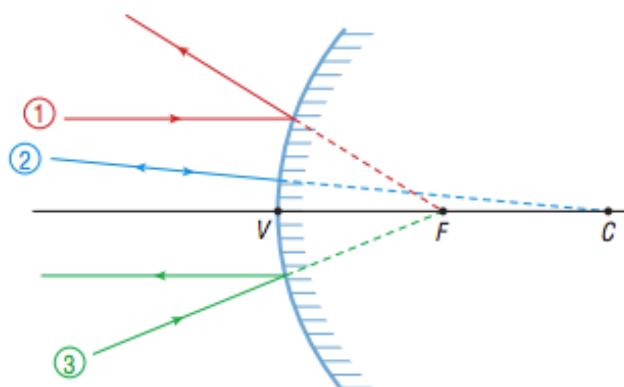


Inside F

- behind the mirror
- larger
- upright
- virtual



OBJECT	IMAGE				
	Location	Size	Attitude	Location	Type
beyond C	smaller	inverted		between C and F	real
at C	same size	inverted		at C	real
between C and F	larger	inverted		beyond C	real
at F	no clear image				
inside F	larger	upright		behind mirror	virtual



- ① A ray parallel to the principal axis is reflected as if it had come through the focus (F).
- ② A ray aimed at the centre of curvature (C) is reflected back upon itself.
- ③ A ray aimed at the focus (F) is reflected parallel to the principal axis.

- Smaller
- Upright
- Behind Mirror
- Virtual

