13 - Convex and Concave lenses

- Level 4 - Show how lenses bend light using ray diagrams.
- Level 5 - Explain how a camera lens works.
- Level 6 - Relate the shape of a lens to the type of glasses needed for long and shortsightedness.

Lenses

Lenses REFRACT light and are usually used to form IMAGES.

2 types

- Convex
- Concave

<table>
<thead>
<tr>
<th>Actual</th>
<th>Draw as</th>
</tr>
</thead>
<tbody>
<tr>
<td>convex</td>
<td>concave</td>
</tr>
</tbody>
</table>

In practice, light is refracted at both surfaces of the lens but for simplicity we draw only one refraction as if it happened at the centre line.

Convex lenses bring the rays together ('converge') at a focus. Convex lenses are CONVERGING LENSES.

Concave lenses spread the rays out ('diverge'). The rays seem to come from a 'virtual focus' on the other side. Concave lenses are DIVERGING LENSES.
Ray diagrams

Light is reflected off all points of a non-luminous object in lots of different directions.

To work out what sort of image a lens will produce, we select 2 rays only from the top point of the object:
- one parallel to the axis
- one to the centre of the lens

RAY DIAGRAMS: RULES

1. A ray parallel to the axis is refracted through the focus.
2. A ray to the centre of the lens passes through undeflected.
3. A ray through the focus is refracted parallel to the axis.

Image – diagram gives position and size.

OBJECT (simplified)

RAY DIAGRAMS: IMAGES

If image larger than object: **MAGNIFIED**
If image smaller than object: **DIMINISHED**

MAGNIFICATION = IMAGE HEIGHT/OBJECT HEIGHT.

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If image same way up as object: **UPRIGHT**
If image upside down: **INVERTED**

If rays pass through object: **REAL**
If rays only seem to come from object (see diverging lens) **VIRTUAL**

IMAGE TYPES

**REAL** images can be projected on a screen.
**VIRTUAL** images cannot be projected.

1. Draw the following on graph paper
2. Draw an object outside 2F at the position shown and at the size shown
3. Apply the ray diagram rules and draw in the image.
4. Classify the image by filling in the table below. Repeat for other positions.

<table>
<thead>
<tr>
<th>Object pos.</th>
<th>Image pos.</th>
<th>mag/dim</th>
<th>upright/inverted</th>
<th>real/virtual</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>outside 2F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>between F &amp; 2F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inside F</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

6. CONCAVE (DIVERGING) LENS

Used in spectacles:
- **Short sight ‘Myopia’**
  - Eye lens too strong:
    - spectacle lens diverges light to bring back into focus

- **Long sight ‘Hyperopia’**
  - Eye lens too weak:
    - spectacle lens converges light to bring back into focus