

Chapter 13. Light

Contents:

- 13.1 Reflection of light
- 13.2 Refraction of light
- 13.3 Total internal reflection
- 13.5 Dispersion of light

New word list:

3.2 Light

3.2.1 Reflection of light

Core

- 1 Define and use the terms normal, angle of incidence and angle of reflection
- 2 Describe the formation of an optical image by a plane mirror, and give its characteristics, i.e. same size, same distance from mirror, virtual
- 3 State that for reflection, the angle of incidence is equal to the angle of reflection; recall and use this relationship

Supplement

- 4 Use simple constructions, measurements and calculations for reflection by plane mirrors

3.2 Light continued

3.2.2 Refraction of light

Core

- 1 Define and use the terms normal, angle of incidence and angle of refraction
- 2 Describe an experiment to show refraction of light by transparent blocks of different shapes
- 3 Describe the passage of light through a transparent material (limited to the boundaries between two media only)
- 4 State the meaning of critical angle
- 5 Describe internal reflection and total internal reflection using both experimental and everyday examples

Supplement

- 6 Define refractive index, n , as the ratio of the speeds of a wave in two different regions
- 7 Recall and use the equation
$$n = \frac{\sin i}{\sin r}$$
- 8 Recall and use the equation
$$n = \frac{1}{\sin c}$$
- 9 Describe the use of optical fibres, particularly in telecommunications

3.2.3 Thin lenses

Core

- 1 Describe the action of thin converging and thin diverging lenses on a parallel beam of light
- 2 Define and use the terms focal length, principal axis and principal focus (focal point)
- 3 Draw and use ray diagrams for the formation of a real image by a converging lens
- 4 Describe the characteristics of an image using the terms enlarged/same size/diminished, upright/inverted and real/virtual
- 5 Know that a virtual image is formed when diverging rays are extrapolated backwards and does not form a visible projection on a screen

Supplement

- 6 Draw and use ray diagrams for the formation of a virtual image by a converging lens
- 7 Describe the use of a single lens as a magnifying glass
- 8 Describe the use of converging and diverging lenses to correct long-sightedness and short-sightedness

3.2.4 Dispersion of light

Core

- 1 Describe the dispersion of light as illustrated by the refraction of white light by a glass prism
- 2 Know the traditional seven colours of the visible spectrum in order of frequency and in order of wavelength

Supplement

- 3 Recall that visible light of a single frequency is described as monochromatic

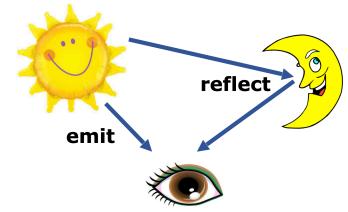
13.0 Nature of light

Wave-particle duality

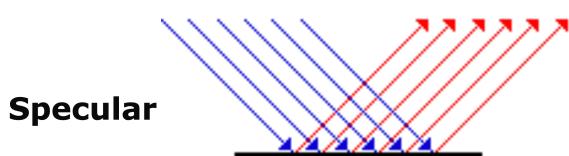
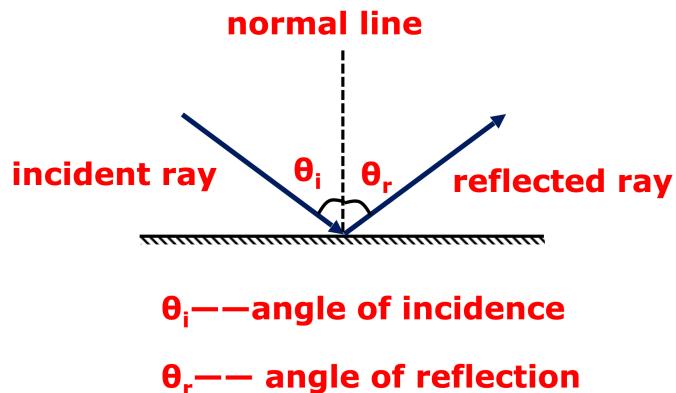
13.1 Reflection of light

- Def: the change of direction of a ray when it strikes a surface without passing through it

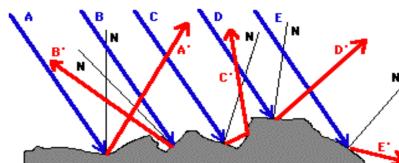
Reflection law:



A ray of light strikes a plane mirror

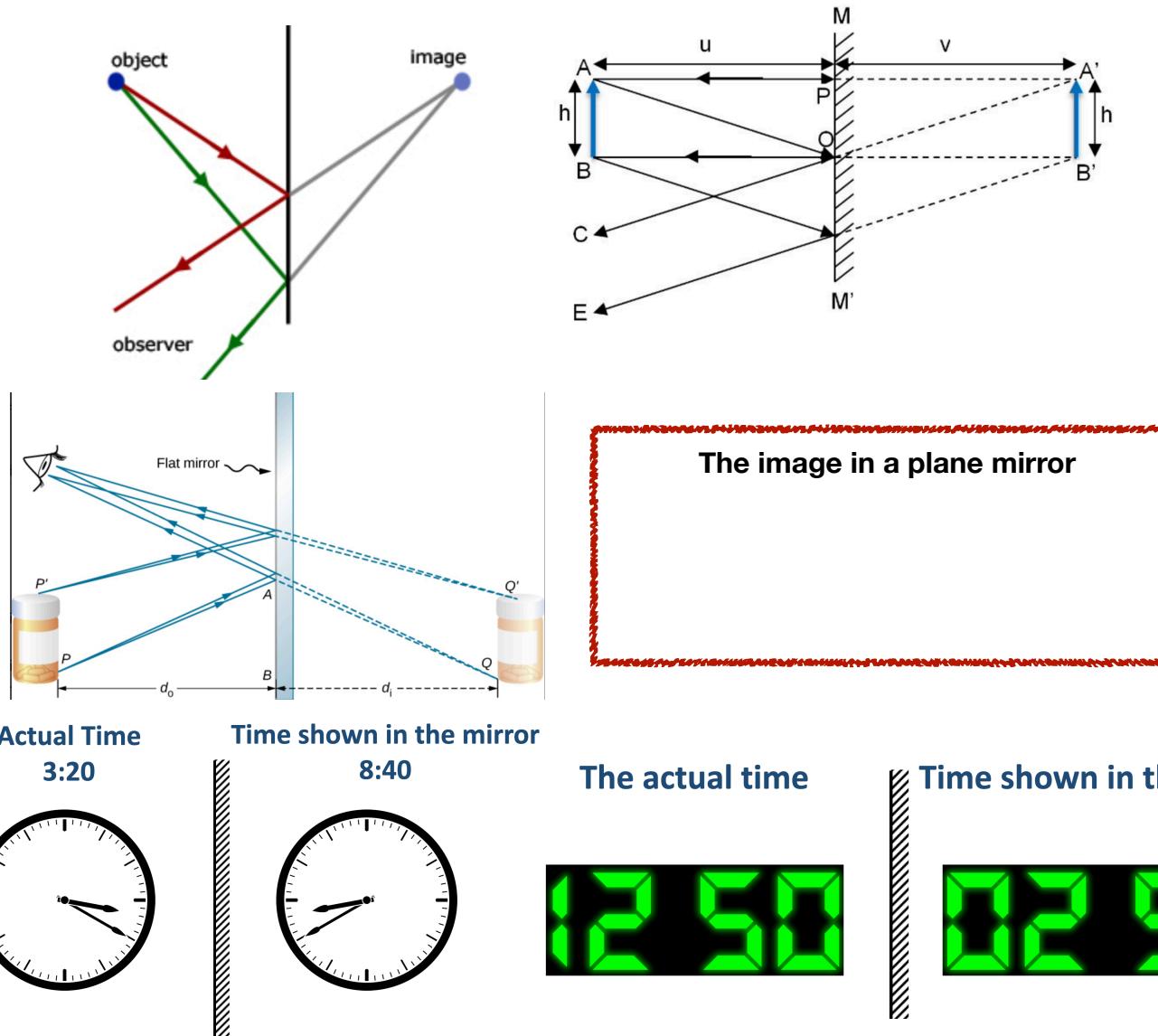


Diffuse
Reflection

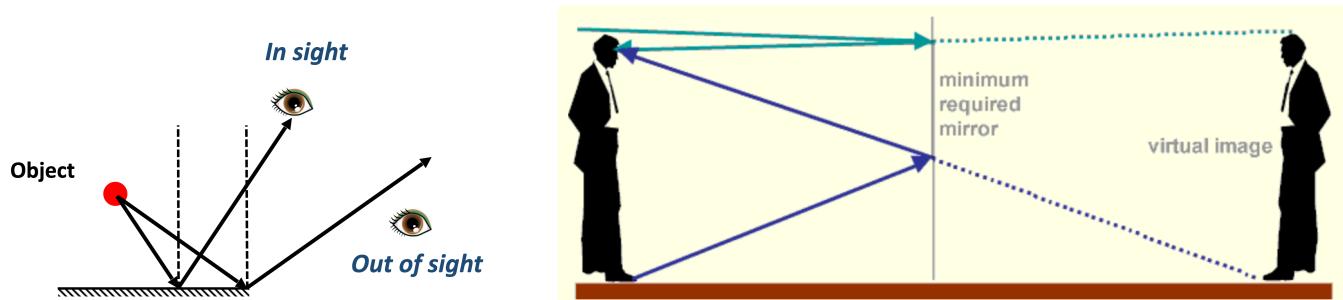


The Law of Reflection is Always Observed
(regardless of the orientation of the surface)

The image in a plane mirror



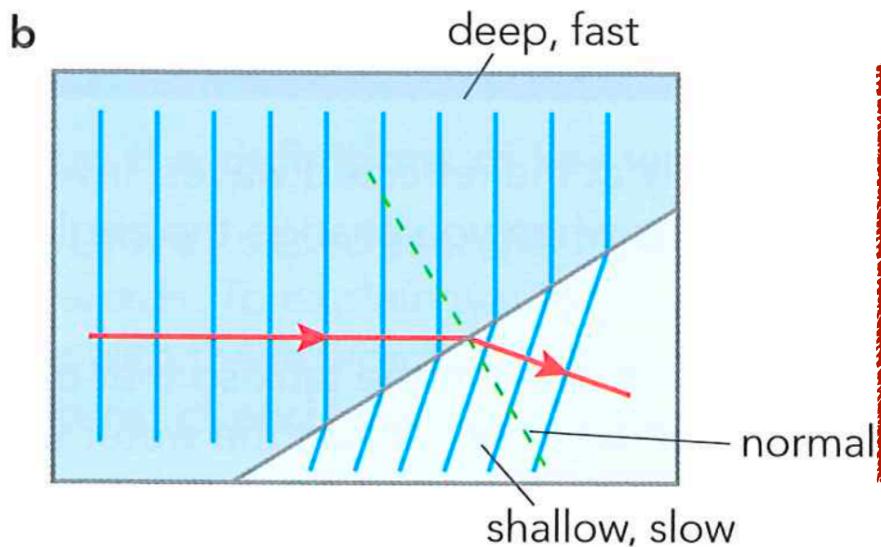
In/out of sight:



13.2 Refraction of light

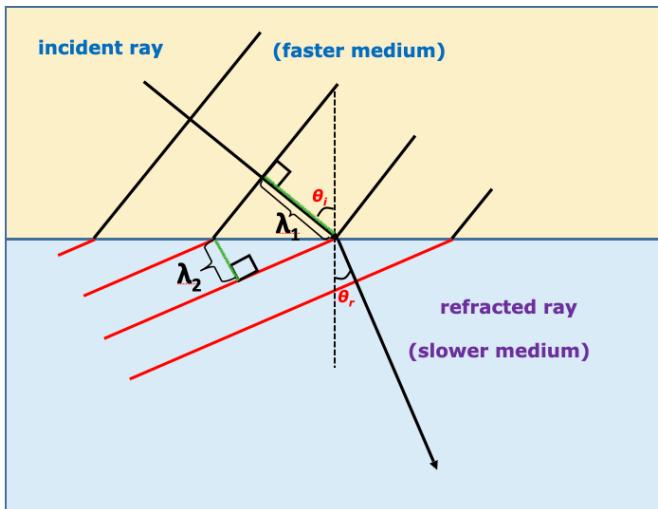


def:



Law of refraction:

Derivation of law of refraction:



$$\lambda_1 = L \times \sin \theta_i$$

$$\lambda_2 = L \times \sin \theta_r$$

$$\lambda_1 / \lambda_2 = \sin \theta_i / \sin \theta_r$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\sin \theta_i}{\sin \theta_r}$$

$$\frac{v_1}{v_2} = \frac{\lambda_1 f}{\lambda_2 f}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{\sin \theta_i}{\sin \theta_r}$$

refractive index of medium (n) —

$$n = \frac{c}{v} = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$$

$$n_1 = \frac{c}{v_1} \quad n_2 = \frac{c}{v_2}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{\sin \theta_i}{\sin \theta_r}$$

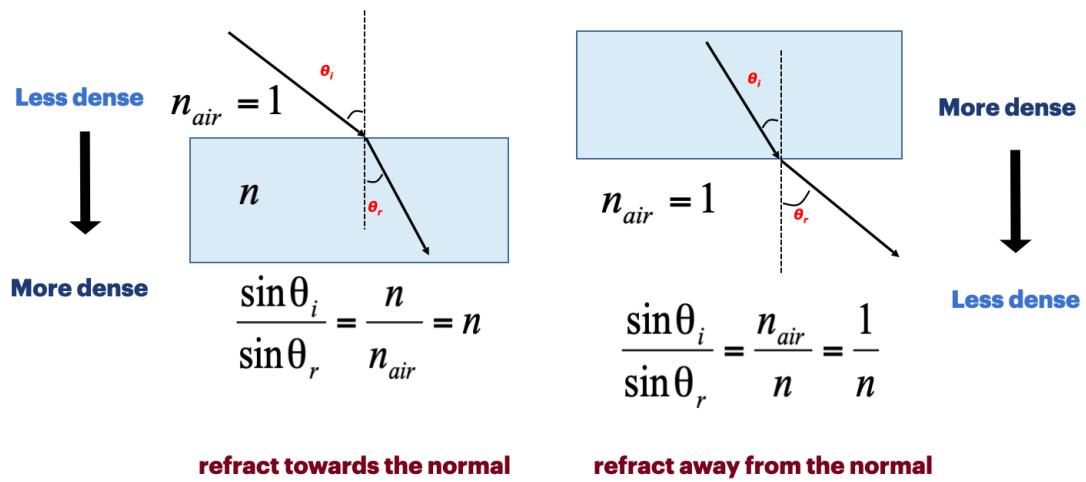


$$\frac{v_1}{v_2} = \frac{\sin \theta_i}{\sin \theta_r} = \frac{n_2}{n_1}$$

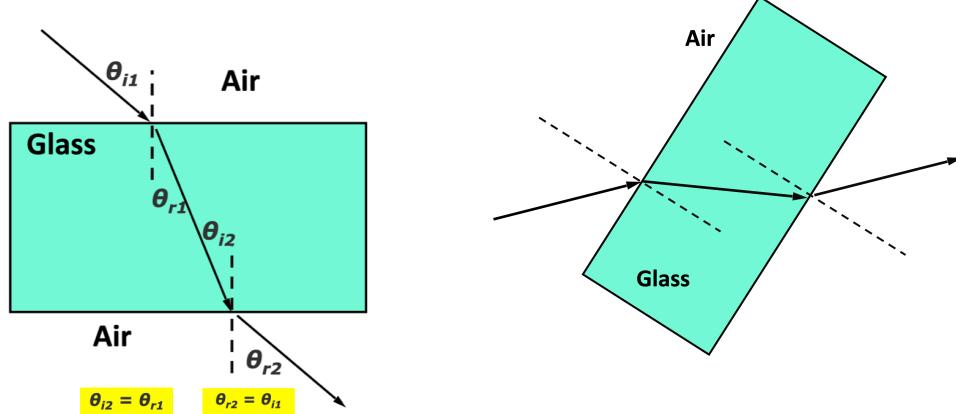
Refractive index of vacuum: $n_{vacuum} = c/c = 1$ $n_{air} \approx n_{vacuum} = 1$

n of all other materials > 1

Material	Speed of light/m/s	$\frac{\text{speed in vacuum}}{\text{speed in material}}$
vacuum	2.998×10^8	1 exactly
air	2.997×10^8	1.0003
water	2.308×10^8	1.33
Perspex®	2.000×10^8	1.5
glass	$(1.800-2.000) \times 10^8$	1.5–1.7
diamond	1.250×10^8	2.4

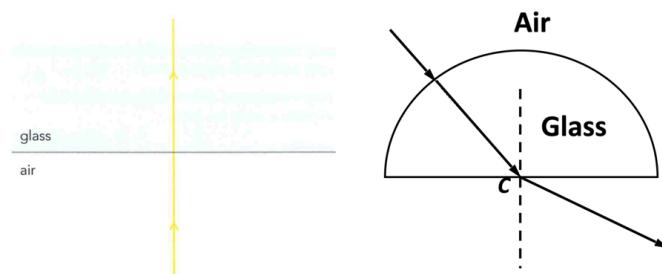


refraction through block



Refracted ray will return to its original direction, only **shifted**

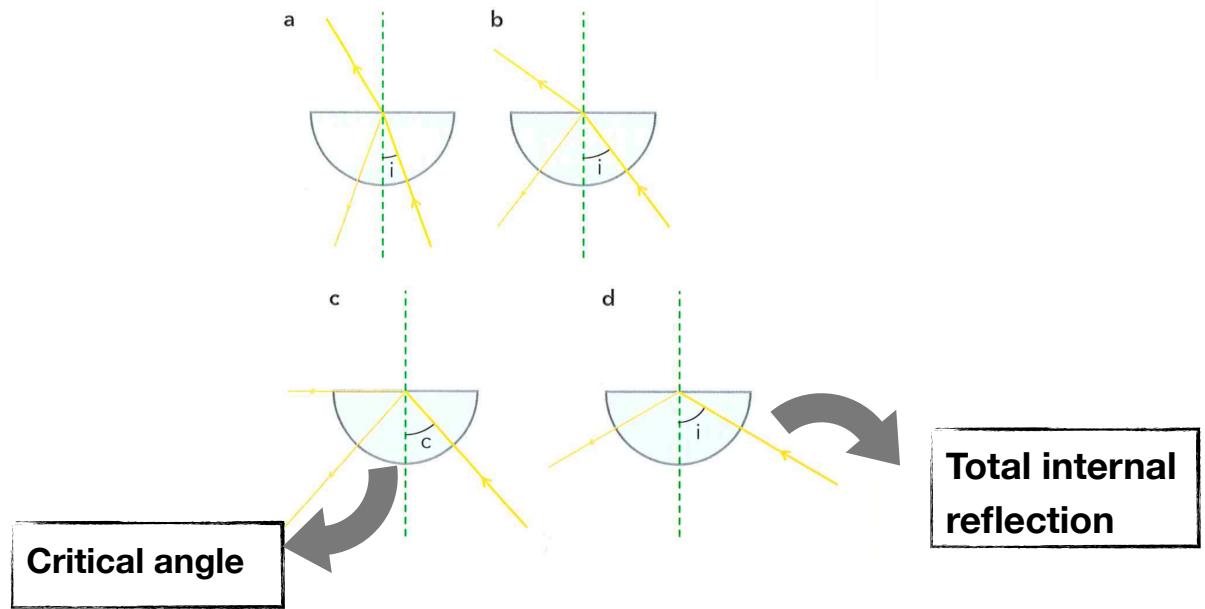
When incident angle = 0 ==> refracted angle = 0



No bending when incident angle = 0

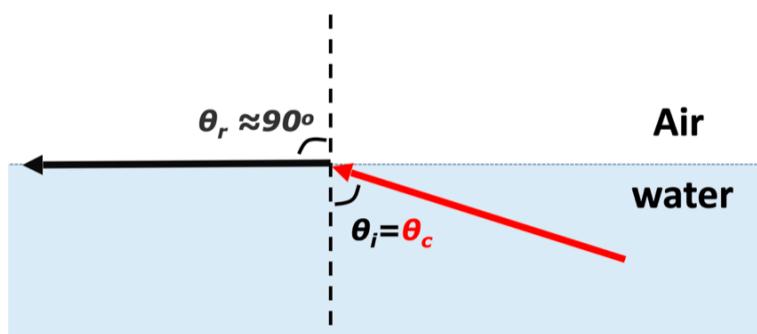
13.3 Total internal reflection

If we slowly increase incident angle, what would happen?



Critical angle:

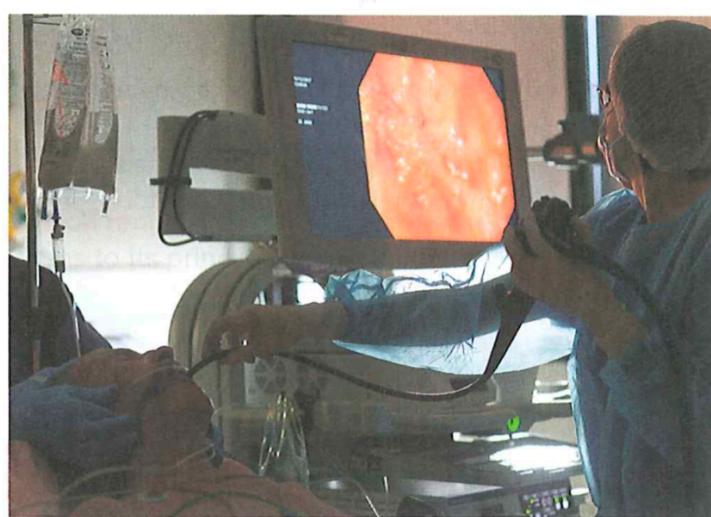
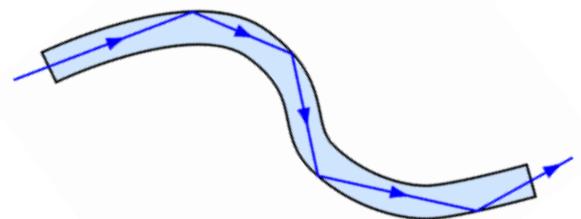
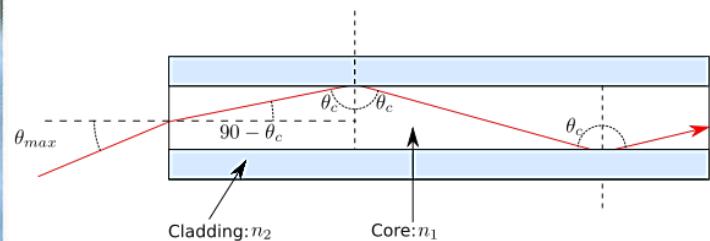
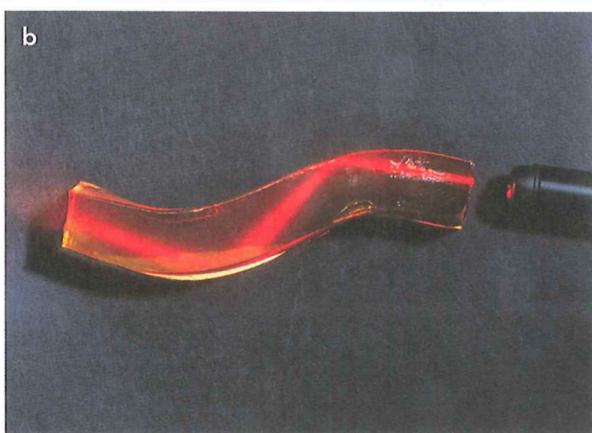
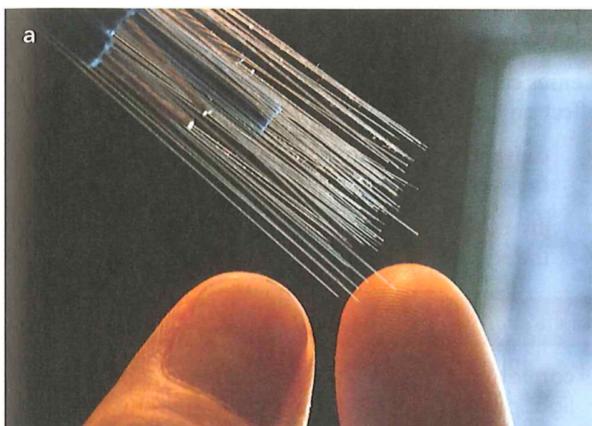
Total internal reflection (TIR):



$$\frac{\sin \theta_i}{\sin \theta_r} = \frac{\sin \theta_c}{\sin 90^\circ} = \sin \theta_c = \frac{1}{n}$$

Conditions for TIR to happen:

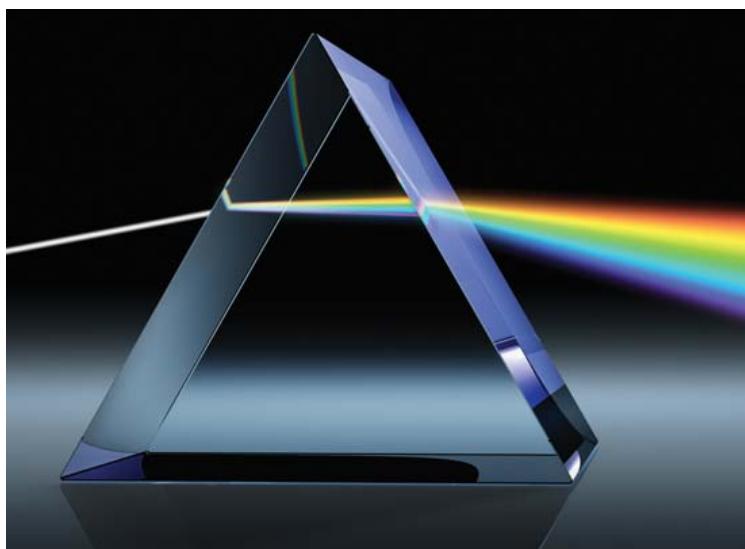
Applications of TIR: Optical fibres



13.5 Dispersion of light



White light passing through a prism, form a spectrum. => dispersion.
How does this happen? What determines color?



	Wavelength	Frequency
Red	~ 625 – 740 nm	~ 480 – 405 THz
Orange	~ 590 – 625 nm	~ 510 – 480 THz
Yellow	~ 565 – 590 nm	~ 530 – 510 THz
Green	~ 520 – 565 nm	~ 580 – 530 THz
Blue	~ 445 – 520 nm	~ 675 – 580 THz
Indigo	~ 425 – 445 nm	~ 700 – 675 THz
Violet	~ 380 – 425 nm	~ 790 – 700 THz

Def of dispersion:

Monochromatic light:

Explaining dispersion:

