Physics 161
Lecture 25 Summary
Reflection and Refraction

November 30, 2017

Lecture 25: learning objectives

You will be able to explain the dual nature of light and define the energy of a photon.

You will be able to apply the law of light reflection, define the index of refraction, the wavelength of light in media and apply Snell's law.

You will be able to define dispersion and describe prisms and rainbows.

You will be able to define total internal reflection and apply it to simple physical systems.

Particle-wave duality

Light has both a particle and a wave-like nature.

Photon energy:
Proportional to the frequency of light.

$$E = hf$$

h is Planck's constant $h = 6.63 \times 10^{-34}$ J s.

Ray approximation:
Light travels in a straight-line path in a homogeneous medium, until it encounters a boundary between two different materials.

Reflection and refraction

Law of reflection:
For light rays, the angle of incidence on a surface equals the angle of reflection from that surface.

$$\theta_1 = \theta_2$$

The incident and reflection angles are measured with respect to a normal to the surface of reflection.

1st Law of refraction:
For light rays, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant.

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} = \text{constant}$$

Laws of refraction

Index of refraction, n :
The index of refraction, n , for a given medium is the ratio of the speed of light in vacuum, c , to the speed of light, v , in that medium.

$$n = c / v$$

$$\lambda_1 n_1 = \lambda_2 n_2$$

2nd law of refraction:
As light travels from one medium to another, the light's frequency, f , is constant.

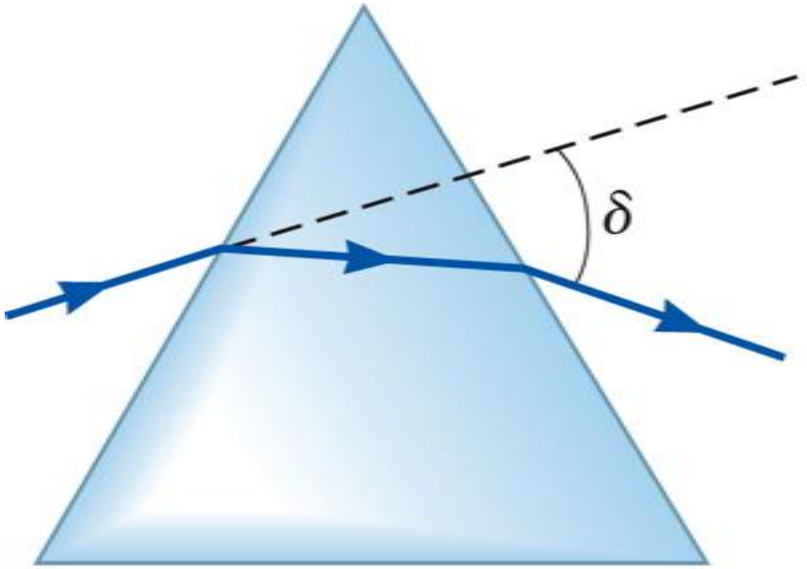
Snell's law of refraction:
The product of the index of refraction, n , and the sine of the angle of incidence, θ , is constant across a surface.

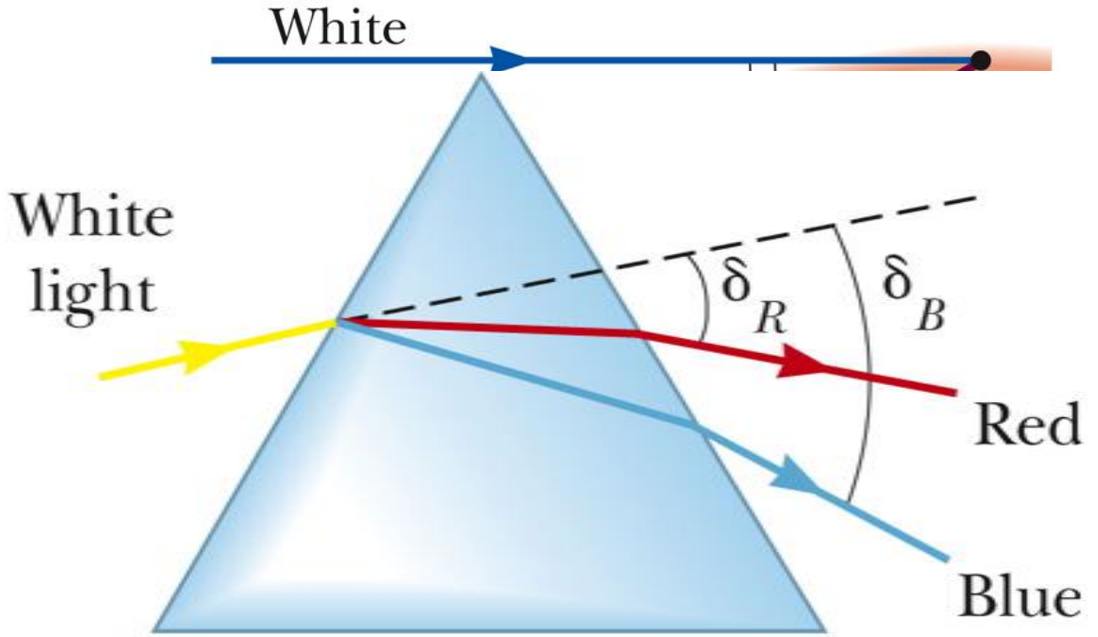
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Dispersion

The index of refraction actually depends on the wavelength of light.

Therefore (from Snell's law) the angle of refraction made when light enters a material depends on the wavelength of that light.





Total internal reflection

Total internal reflection:
Light rays are entirely reflected at a boundary.

Total internal reflection occurs when light travels from a medium with a higher index of refraction to a medium with a lower index of refraction.

Critical angle, θ_c :
Angle above which total internal reflection occurs.

$$\sin\theta_c = \frac{n_2}{n_1}$$

Note that $n_1 > n_2$ here.