

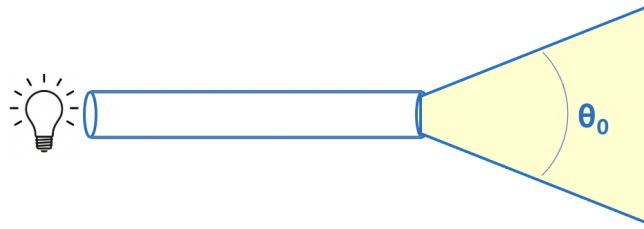
# Y2 Electromagnetism 2

## Non-assessed problem sheet 5 (weeks 9–11)

### EM waves in dielectrics, conductors and plasma

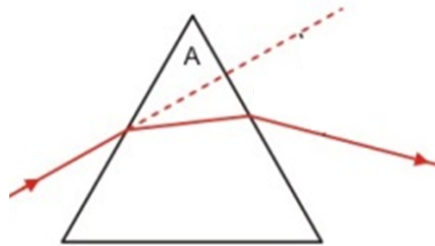


1) Consider a long thin cylindrical lightguide made of glass with a refractive index  $n$ . A point light source is located on the axis of symmetry of the lightguide close to the entrance. Find the opening angle  $\theta_0$  of the light cone at the exit of the lightguide. Plot the dependence  $\theta_0 = f(n)$ , and establish its properties.



2) Consider a plane electromagnetic wave traversing a boundary from a dielectric medium A into a dielectric medium B. The angle of incidence is equal to the Brewster's angle  $\alpha_B$ , and the angle of refraction is  $\alpha$ . Prove that for a wave traversing the boundary from the medium B into the medium A, the angle  $\alpha$  is the Brewster's angle.

3) Consider monochromatic light travelling in vacuum and traversing a right triangular prism with an apex angle  $A$  made of a dielectric material. Which conditions must be satisfied for all of the incoming energy to be transmitted, and none to be reflected? Find the refractive index of the prism for  $A = 60^\circ$  required for the absence of reflection.



4) The *degree of polarisation* of reflected and refracted natural light at a boundary of two dielectric media is defined in terms of the reflectances ( $R$ ) and transmittances ( $T$ ) of the  $s$ -polarised ( $\perp$ ) and  $p$ -polarised ( $\parallel$ ) light as follows:

$$\Delta_R = \frac{R_\perp - R_\parallel}{R_\perp + R_\parallel}, \quad \Delta_T = \frac{T_\perp - T_\parallel}{T_\perp + T_\parallel}.$$

Consider a ray of light incident on a vacuum/glass boundary at the Brewster's angle. The refractive index of glass is  $n$ . Using the Fresnel's equations and Brewster's angle properties, compute  $\Delta_R$  and  $\Delta_T$  as functions of  $n$ . Give a numerical answer for  $n = 1.5$ .

5) Show that the conductivity of plasma is purely imaginary:  $\sigma = -in_e e^2 / m_e \omega$ .