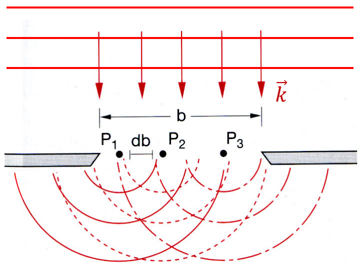
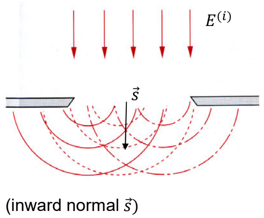
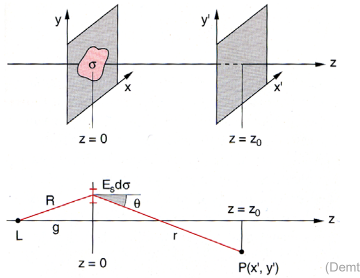
Diffraction and Huygens' Principle



Kirchhoff-Fresnel diffraction integral





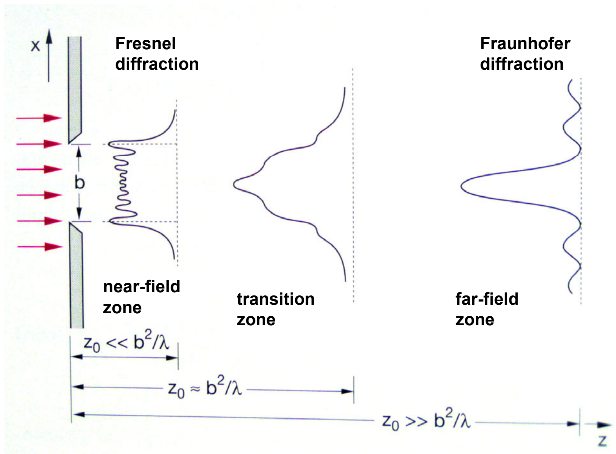
(Demtröder)

Approximations for disturbance $\vec{E}$:

$$\left.\begin{array}{lll} \text{In aperture:} & E = E^{(i)} \quad ; & \dfrac{\partial E}{\partial s} = \dfrac{\partial E^{(i)}}{\partial s} \\ \text{On screen:} & E = 0 \quad ; & \dfrac{\partial E}{\partial s} = 0 \end{array}\right\} \quad E_P(x', y') = \iint_\sigma E_S(x, y)\, A(\theta)\, \frac{e^{-ikr}}{r}\, dx\, dy$$

(Kirchhoff (1883); Born & Wolf, Principles of Optics, p. 380)

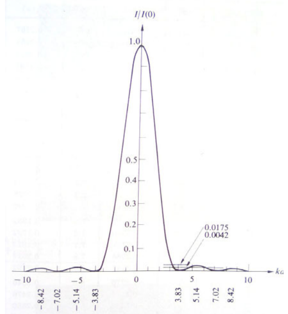
Diffraction at a circular aperture

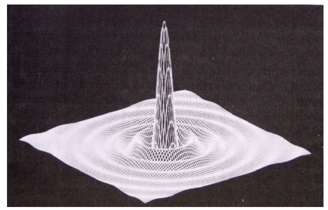


Demtröder, Elektrodynamik

Airy function

Fraunhofer diffraction at a circular aperture of radius R





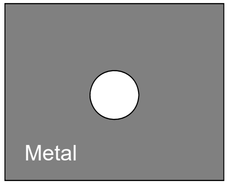
$$I(R,k,\varphi) = I(0) \cdot \left\{ \frac{2\, J_1(R\,k \sin\varphi)}{R\,k \sin\varphi} \right\}^2$$

(G.B. Airy, 1835)

(J_1 : Bessel function of the first kind and first order)

E. Hecht, Optik

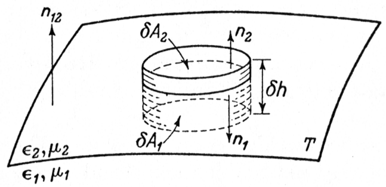
Diffraction at Nano-Apertures



Aperture diameter D

Kirchhoff's diffraction theory can not be applied to small apertures (D < λ) because the approximations are no longer valid.

Boundary conditions at a surface

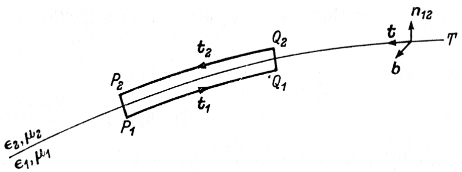


Illustrating the derivation of the boundary conditions for the normal components of **B** and **D**.

$$\operatorname{div} \vec{D} = 0 \quad \Rightarrow \quad \int \operatorname{div} \vec{D}\, dV = \oint \vec{D}\, d\vec{A} = 0$$

M. Born, Principles of Optics

Boundary conditions at a surface



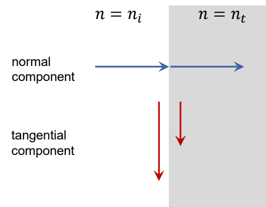
Illustrating the derivation of the boundary conditions für the normal components of **H** and **E**.

$$\int \operatorname{curl} \vec{E}\, d\vec{S} = \oint \vec{E}\, d\vec{r} = -\int \dot{\vec{B}}\, d\vec{S}$$

M. Born, Principles of Optics

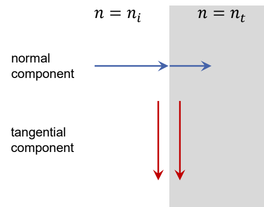
Boundary conditions

$\vec{D}$ and $\vec{B}$



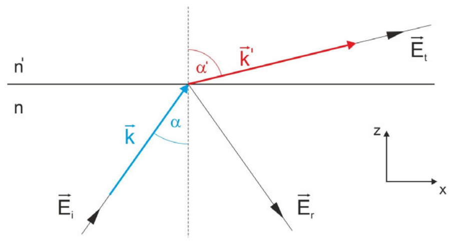
The normal components of $\vec{D}$ and $\vec{B}$ are continuous at the interface of two media.

$\vec{E}$ and $\vec{H}$



The tangential components of $\vec{E}$ und $\vec{H}$ are continuous at the interface of two media.

Example: Optical Refraction at an Interface



$$\frac{\sin\alpha}{\sin\alpha'} = \frac{n'}{n}$$

The law of Snellius is an exact solution of Maxwell's equations based on the boundary conditions.