Engineering Optics

Lecture 32

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by

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Problem-1

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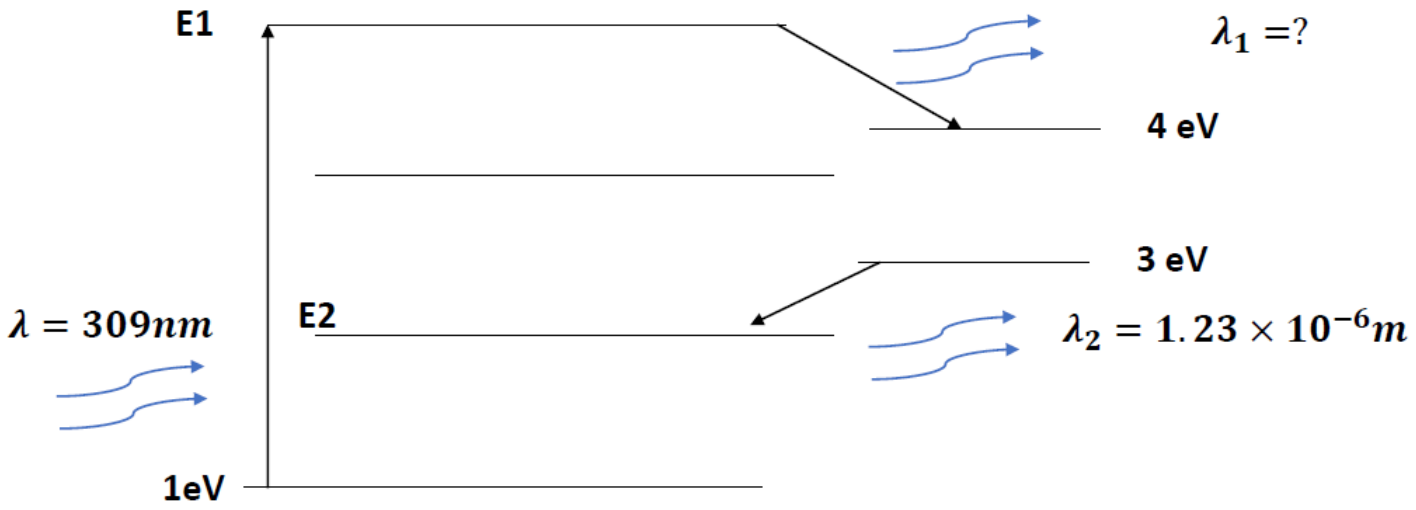
$$\frac{N_j}{N_i} = e^{-\frac{hc}{\lambda_{ji} k_B T}}$$

$$\frac{N_j}{N_i} = e^{-\frac{1.98\times10^{-25}}{694.3\times10^{-9}\times1.38\times10^{-23}\times300}} = 1.21 \times 10^{-30}$$

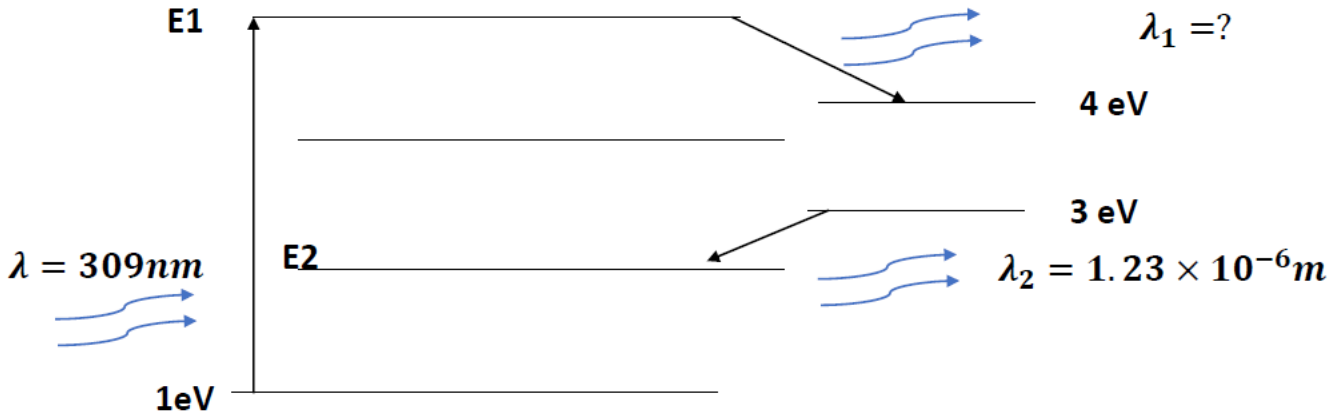
Problem-2

From the given energy spectra of the 4 level laser find out the unknown energy levels E_1, E_2 and λ_1.



Problem-2

Answer:



E_1 calculation

$$E_1 - 1eV = \mathrm{hc}/\boldsymbol{\lambda}(\boldsymbol{eV})$$

$$\frac{\mathrm{hc}}{\boldsymbol{\lambda}}(\boldsymbol{eV}) = \frac{1.98644582 \times 10^{-25}}{309 \times 10^{-9} \times 1.62 \times 10^{-19}} = 4eV$$

$$E_1 = 5eV$$

Problem-2

λ_1 calculation

$$5eV - 4eV = hc/\lambda_1\ (eV)$$

$$1.62\times10^{-19} = hc/\lambda_1$$

$$\lambda_1 = 1.98644582\times10^{-25}/1.62\times10^{-19}$$

$$\lambda_1 = 1.23\times10^{-6}m$$

$$\Rightarrow E_2 = 2eV$$

Introduction to Fiber optics

- The need to stay always connected → has set the demand rolling for high internet speeds with high quality and consistency.
- Further, innovations in the telecom sector have increased the deployment of broadband-based network architectures.
- This all has given a huge growth opportunity for the *fiber optic cable industry*.

https://www.stl.tech/blog/optical-fibre-cable-working-applications-real-life-usage/

Fiber optics

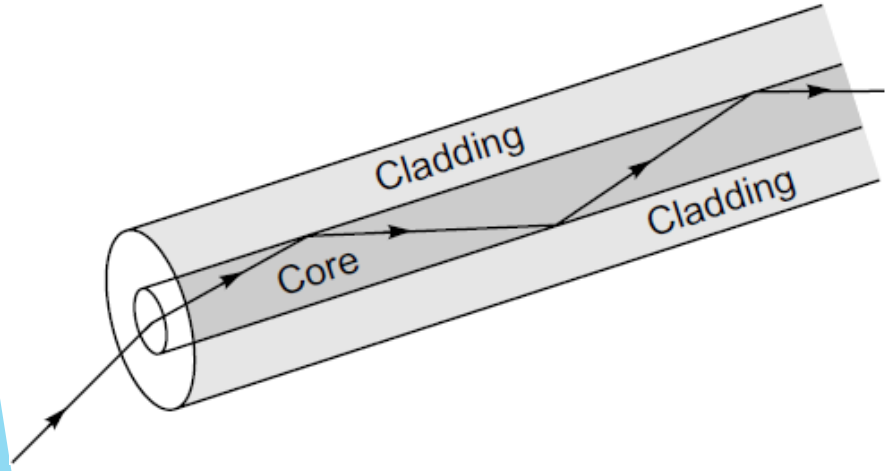
- Fiber optics → the technology associated with the transmission of information (in terms of light pulses) along a glass or plastic strand or fiber.
- Optical fiber → is a flexible, transparent fiber made by glass (silica) or plastic diameter slightly thicker than that of a human hair
- used for long-distance and high-performance data networking
- commonly used in telecommunication services such as internet, television and telephones.
- better than metal (copper) cables → higher bandwidth and transmit speeds.

Fiber optic cables

- **A fiber-optic cable** → composed of as few as two strands or as many as several hundreds of them.
- These optical fiber cables carry information in the form of data between two places using optical or light-based technology.
- Once the light beams travel down the optical fiber cable (OFC), they would emerge at the other end.
- A photoelectric cell will be required to turn the pulses of light back into electrical information the computer could understand.

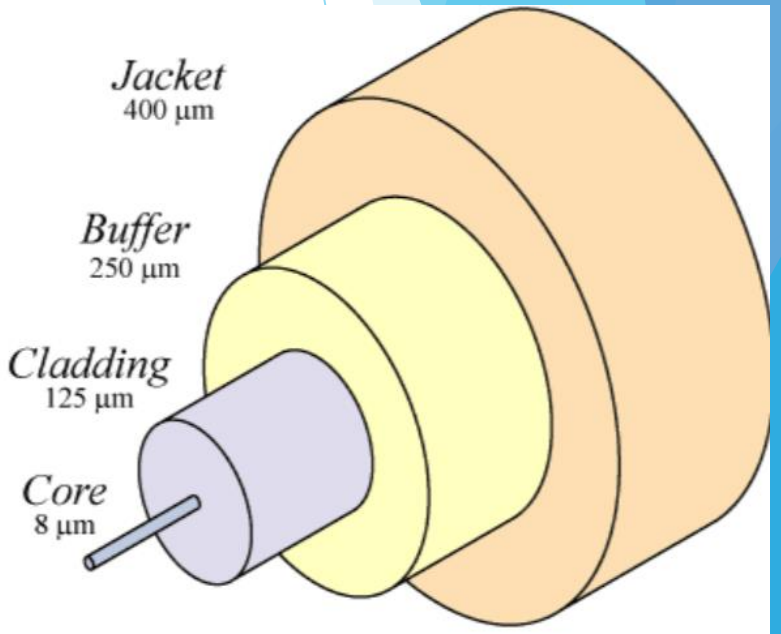
https://www.indiamart.com/proddetail/optic-fibre-cables-4342495091.html

The optical fiber



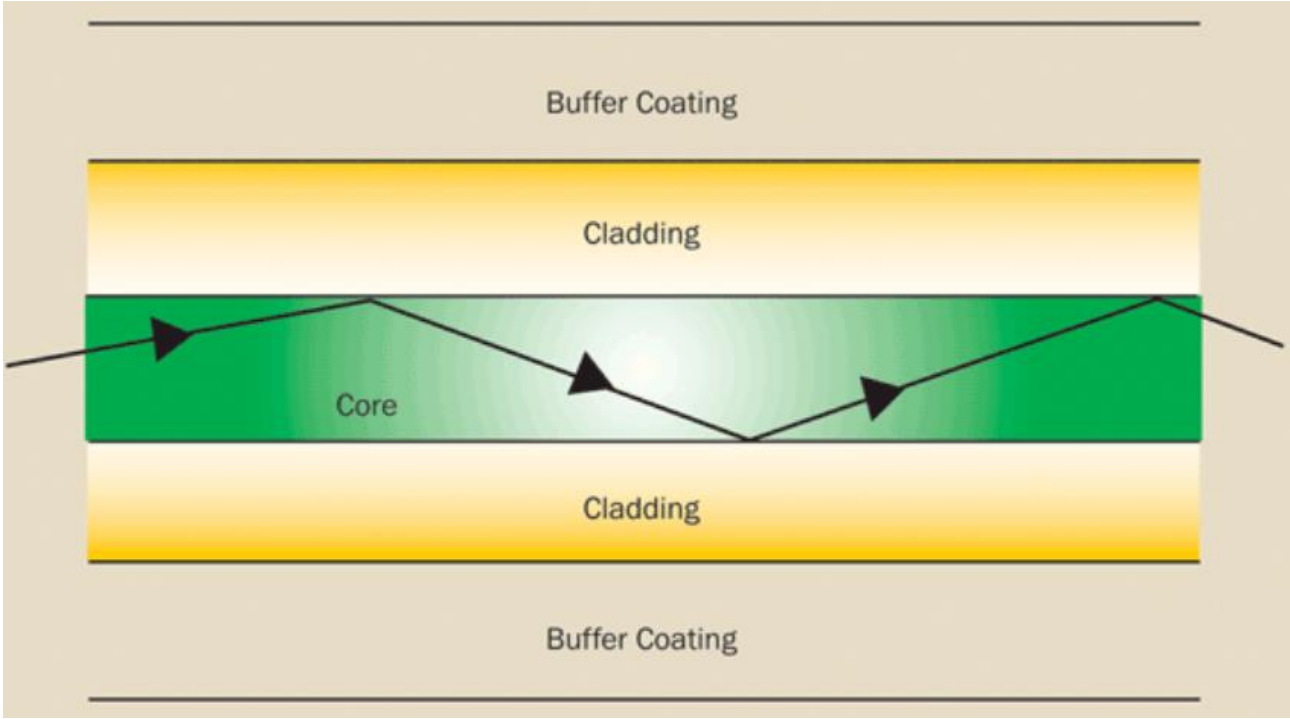
Optics, Hecht

- central dielectric core
- Core/cladding: low loss light propagation
- Buffer/jacket: protection against mechanical damage and the environment (UV radiation, humidity, etc.)



https://ocw.mit.edu/courses/materials-science-and-engineering/3-071-amorphous-materials-fall-2015/lecture-notes/MIT3_071F15_Lecture13.pdf

How Fiber optics works

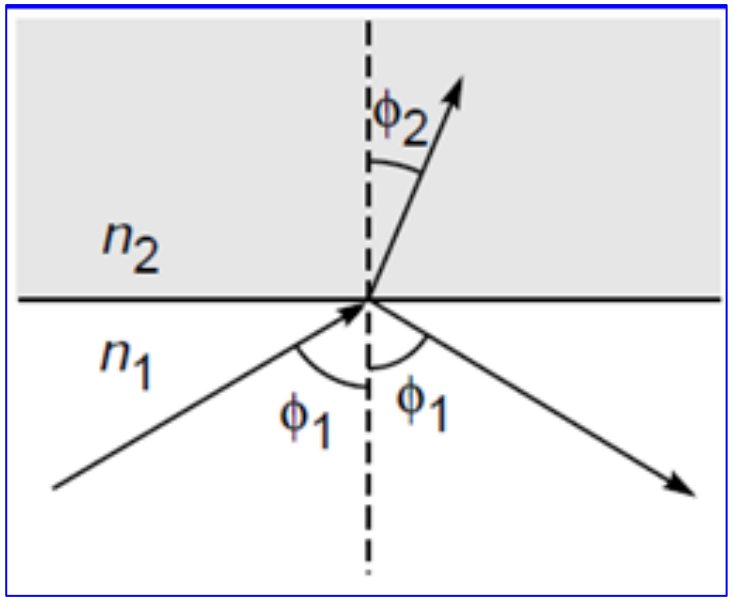


https://www.photonics.com/Articles/Fiber_Optics_Understanding_the_Basics/a25151

- Transmission of data in the form of light particles → or photons through a fiber optic cable.
- The glass fiber core and the cladding each have a different refractive index
- incoming light is bent at a certain angle.
- When light signals are sent through the fiber optic cable, they reflect off the core and cladding in a series of zig-zag bounces, adhering to a process called **total internal reflection.**

https://searchnetworking.techtarget.com/definition/fiber-optics-optical-fiber

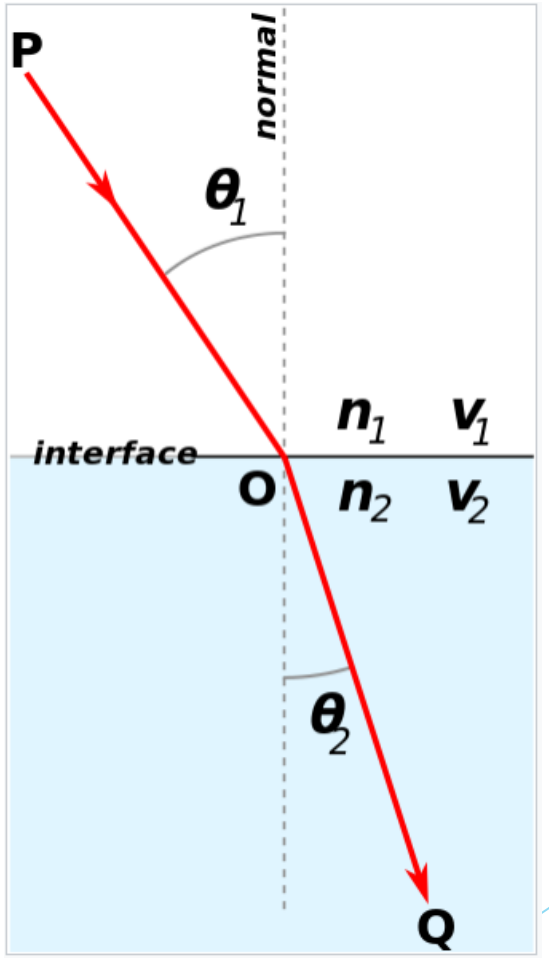
Refraction



- if a ray is incident at the interface of two media, what will happen?
- What is refraction?

Snell’s law of refraction

- Refraction of light?
- apparent --- of their legs that is observed when standing in water.
- The many facets of the cut diamond combined with a high index of refraction give diamonds the brilliance that they are known for.
- Snell's Law is especially important for optical devices, such as fiber optics.
- Snell's Law states that the ratio of the sine of the angles of incidence and transmission is equal to the ratio of the refractive index of the materials at the interface.



$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} = \frac{n_1}{n_2}$$

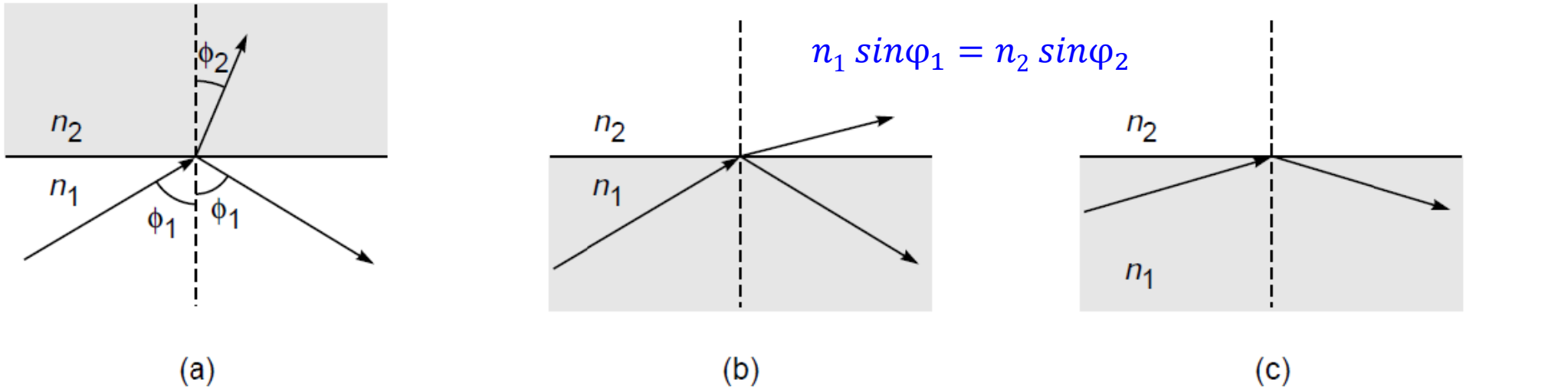
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Is the Figure correct?

https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials_Science)/Optical_Properties/Snell's_Law

https://en.wikipedia.org/wiki/Snell%27s_law

Total internal reflection



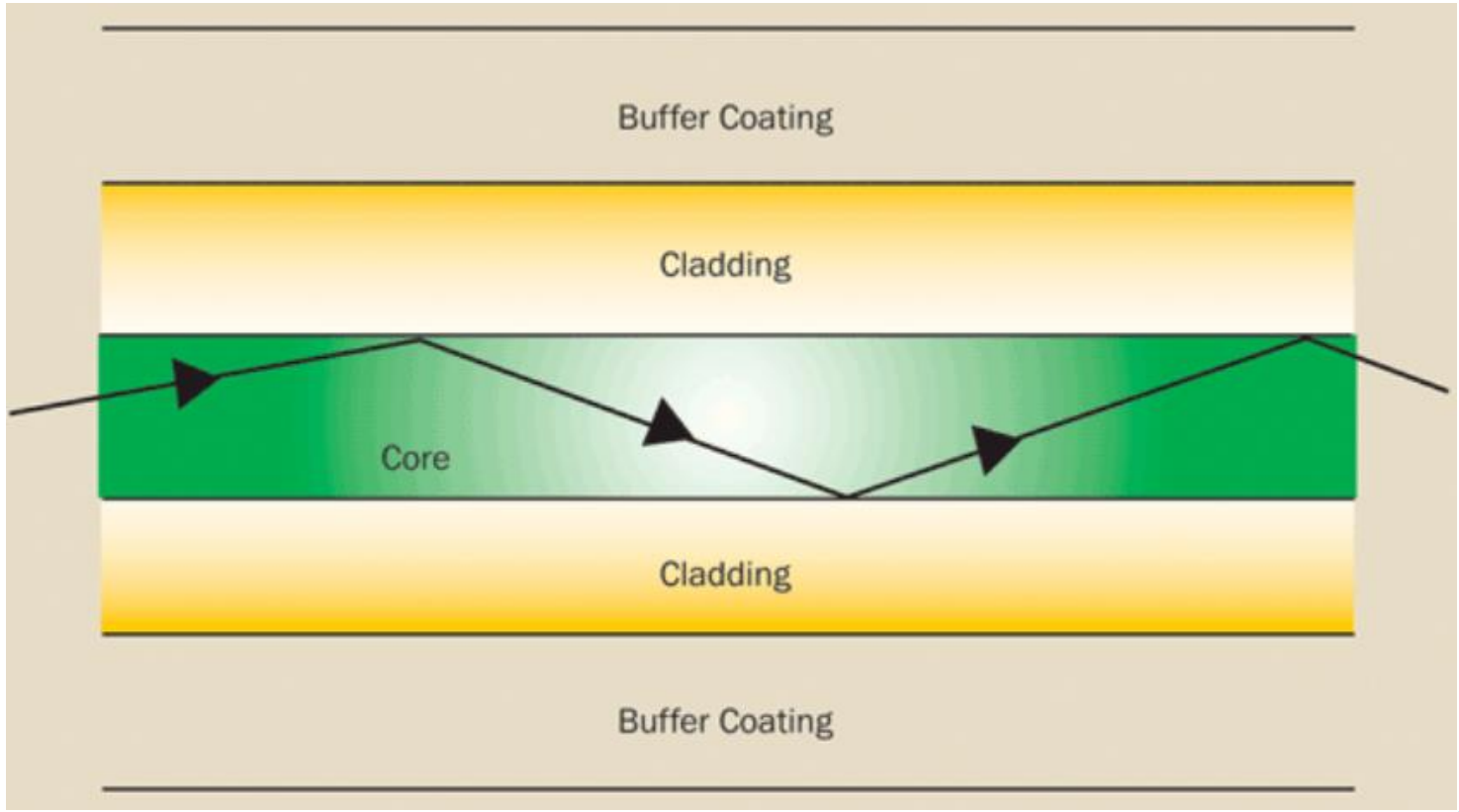
(a) For a ray incident on a denser medium ($n_2 > n_1$), the angle of refraction is less than the angle of incidence. (b) For a ray incident on a rarer medium ($n_2 < n_1$), the angle of refraction is greater than the angle of incidence. (c) If the angle of incidence is greater than critical angle, it will undergo total internal reflection.

- if a ray is incident at the interface of a rarer medium ($n_2 < n_1$), then the ray will bend away from the normal
- The angle of incidence, for which the angle of refraction is 90°, is known as the critical angle and is denoted by ϕ_c.
- When $\varphi_1 = \varphi_c = \sin^{-1}\frac{n_2}{n_1}$ → angle of refraction ϕ_2 = 90°
- If $\phi_1 > \phi_c$, there is no refracted ray and we have what is known as total internal reflection.

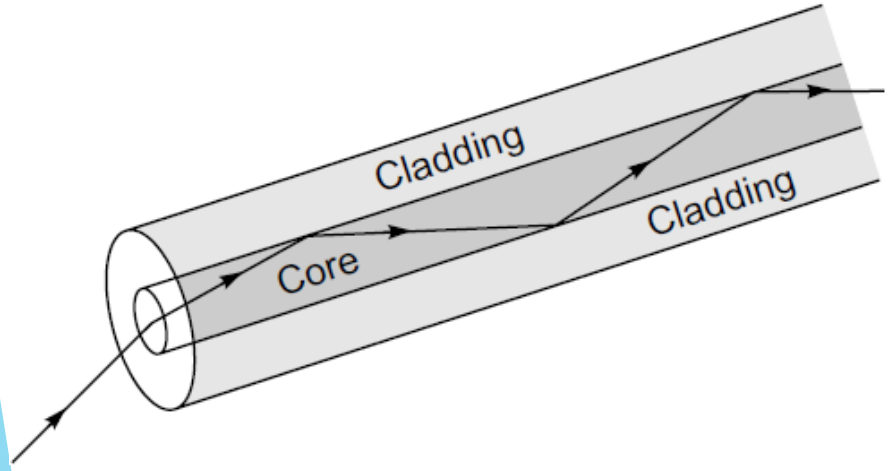
Optics, Ghatak

Which one is denser? Core or cladding?

$$n_1 \, sin\varphi_1 = n_2 \, sin\varphi_2$$

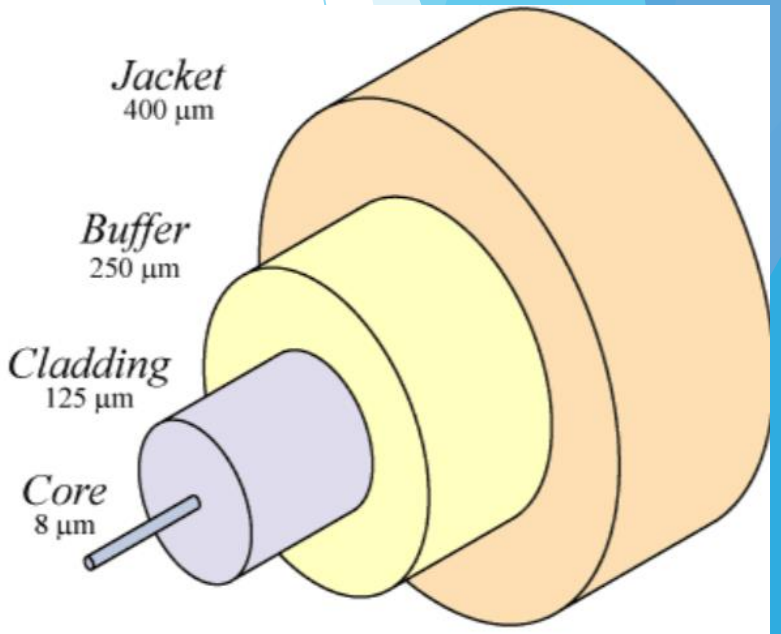


The optical fiber



Optics, Hecht

- central dielectric core **cladded by a material of slightly lower refractive index**
- Core/cladding: low loss light propagation
- Buffer/jacket: protection against mechanical damage and the environment (UV radiation, humidity, etc.)



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Thank You