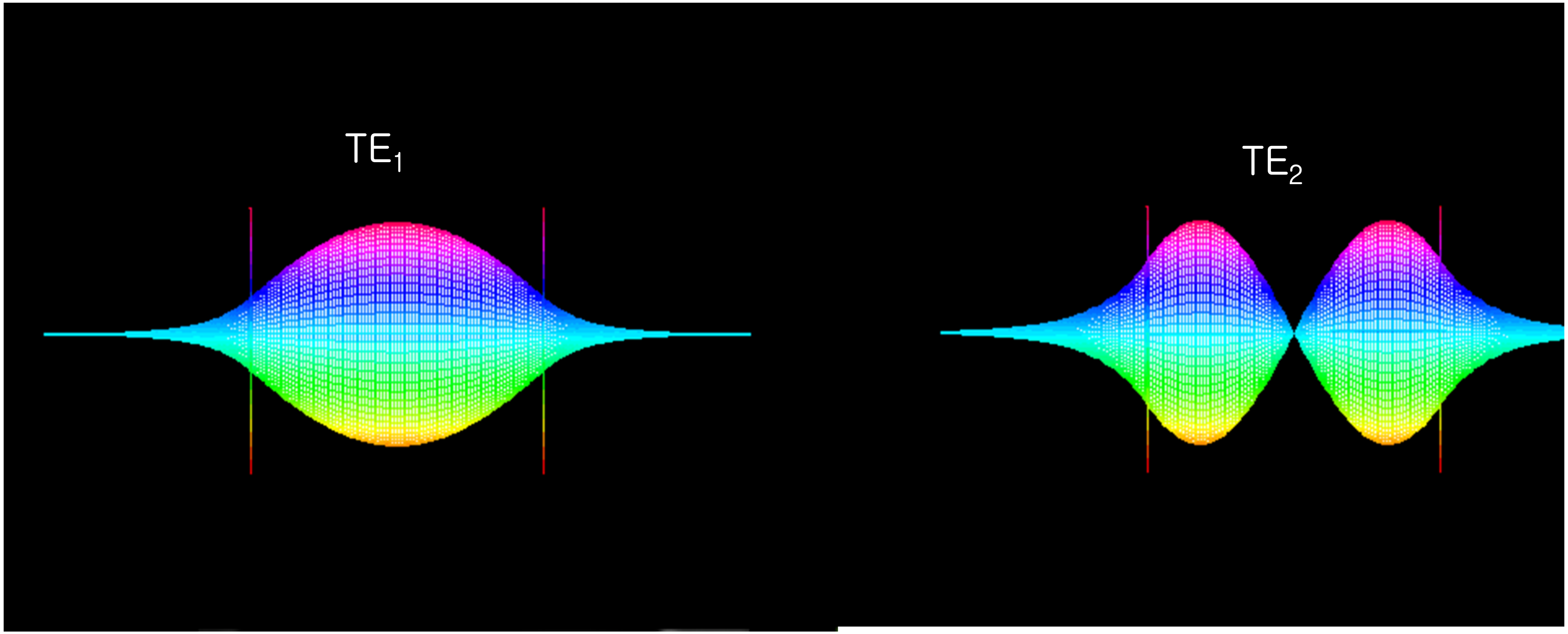
Lect. 13: Dielectric Waveguides (2)

E(y) profile: n_1=1.5, n_2=1.495, d=10μm, λ=1μm



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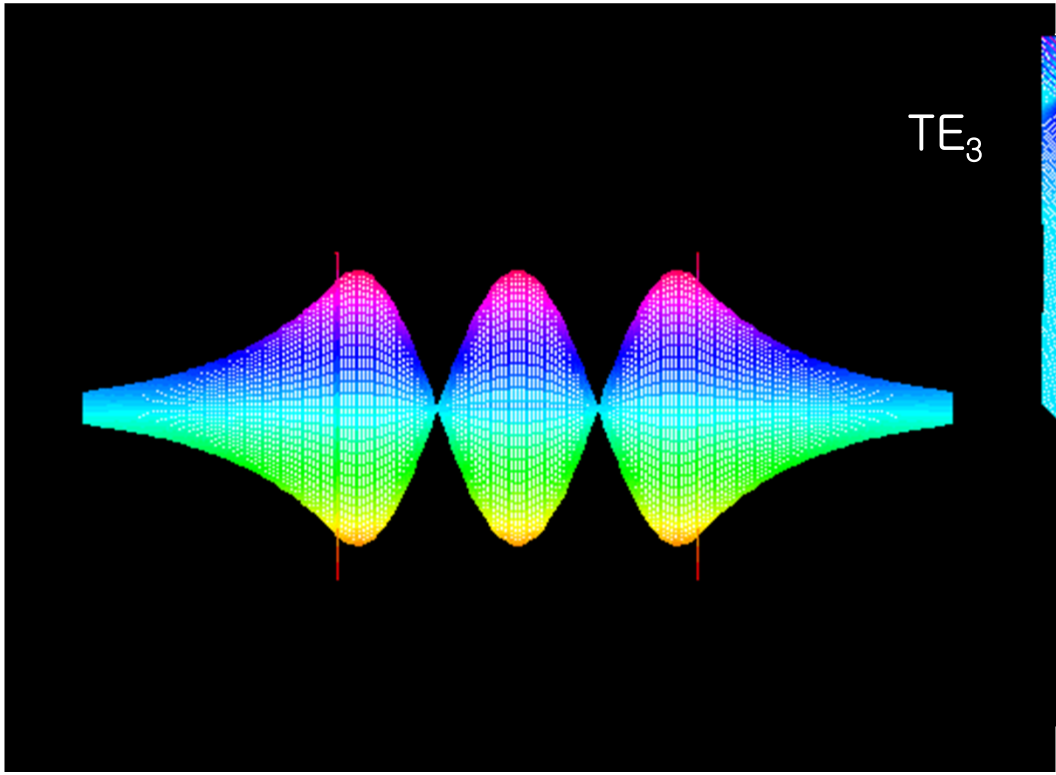
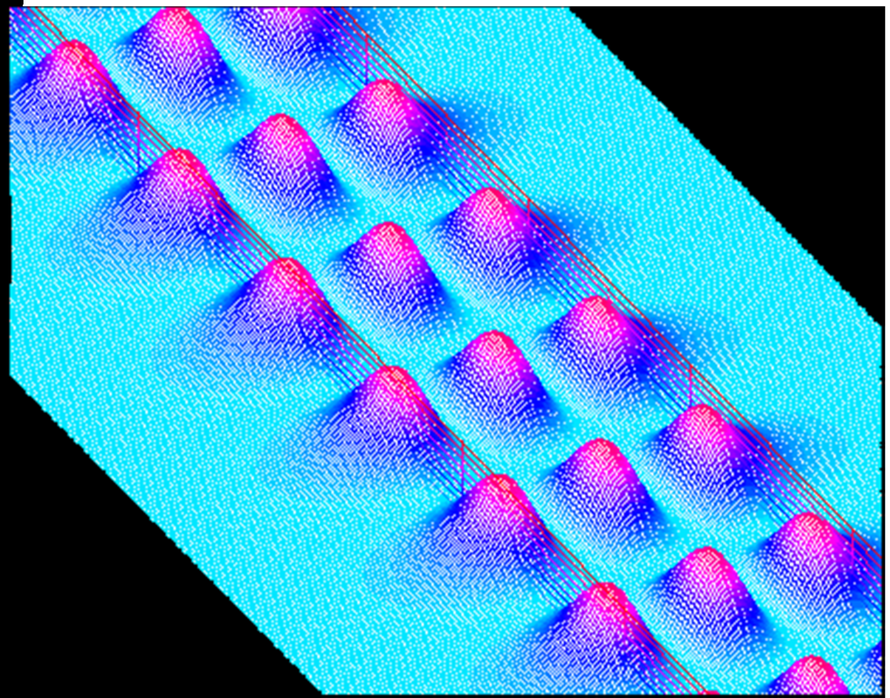
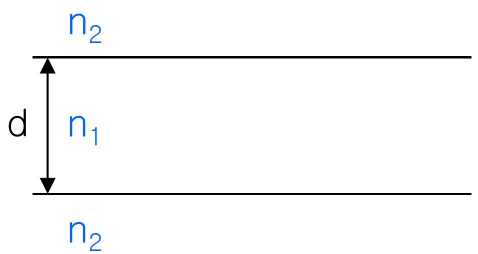




Lect. 13: Dielectric Waveguides (2)

- Effective index: $n_{eff} = \beta / k_0$



How does n_{eff} changes for different modes

- Confinement factor: Γ

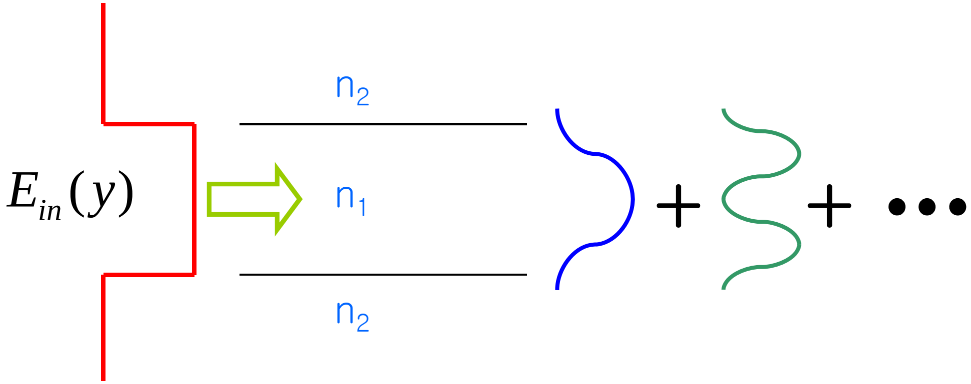
  How much power is confined within the core

$$\Gamma = \frac{\text{Power inside core}}{\text{Total Power}} = \frac{\displaystyle\int_{y=-\frac{d}{2}}^{y=\frac{d}{2}} |E(y)|^2 \, dy}{\displaystyle\int_{y=-\infty}^{y=\infty} |E(y)|^2 \, dy}$$

How does Γ change for different modes?

Lect. 13: Dielectric Waveguides (2)

Partitioning of input field into different guided modes.



$$E_{in}(y) \sim \sum_m a_m E_m(y)$$

For a_m, use the fact that $E_m(y)$'s are orthogonal: $\int E_m(y)E_n(y)dy = 0$ if $m \neq n$

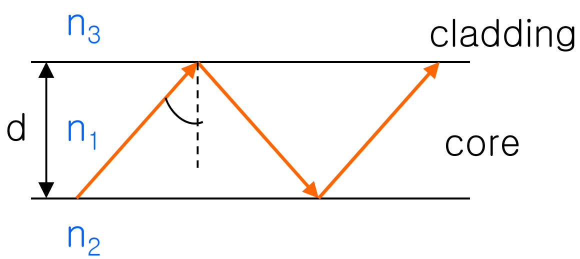
(Sturm-Liouville theory)

$$\int E_{in}(y)E_m(y)dy \sim \int \left[\sum_n a_n E_n(y)\right] E_m(y)dy = \sum_n \int a_n E_n(y)E_m(y)dy = \int a_m E_m{}^2(y)dy$$

$$\therefore a_m = \frac{\int E_{in}(y)E_m(y)dy}{\int E_m{}^2(y)dy}$$

Dot product between $E_{in}(y)$ and $E_m(y)$
Or projection of $E_{in}(y)$ into basis $E_m(y)$

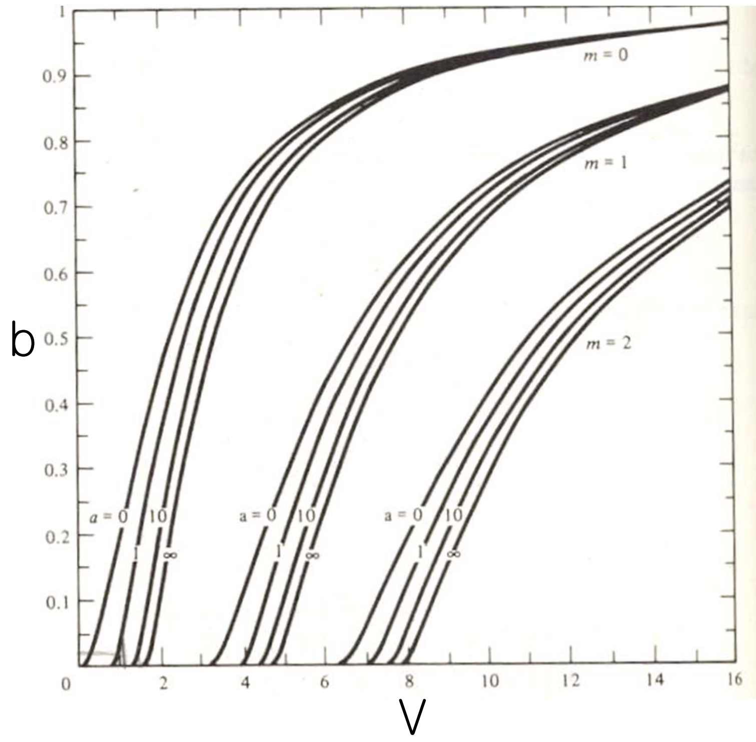
Lect. 13: Dielectric Waveguides (2)



Asymmetric waveguide?

- Graphical solution

b−V diagram for TE mode



$$V = k_0 d (n_1^2 - n_2^2)^{1/2}$$

(Normalized k)

$$a = \frac{n_2^2 - n_3^2}{n_1^2 - n_2^2}$$

(Asymmetry factor)

$$b = \frac{\left(\beta / k_0\right)^2 - n_2^2}{n_1^2 - n_2^2}$$

(Normalized β)

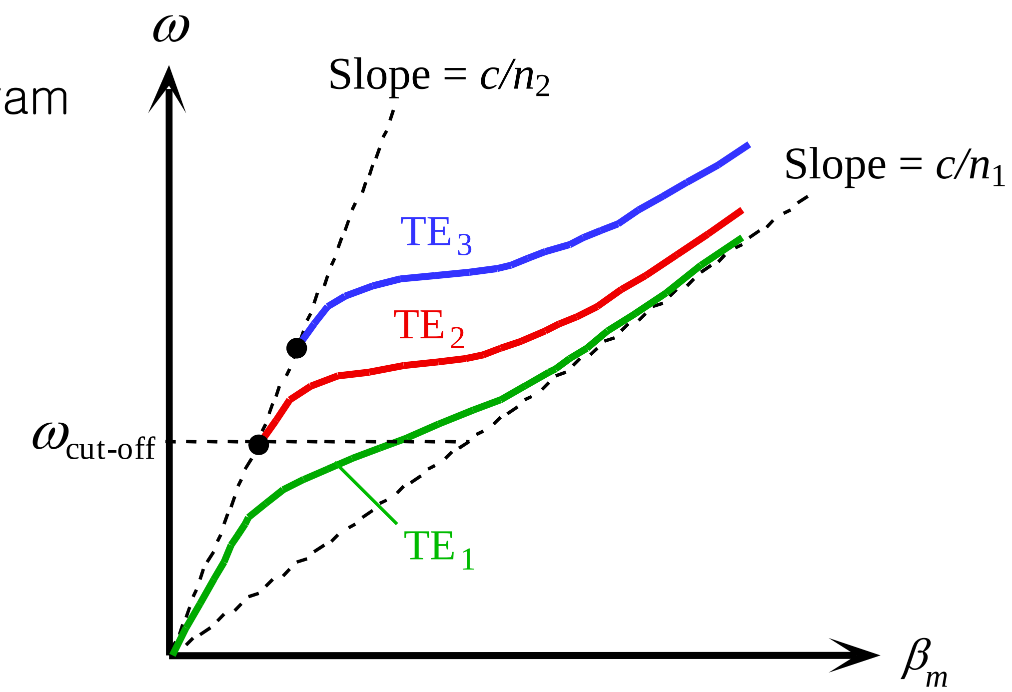
For a given waveguide: V,a ➔ b from the diagram

Then, determine β

- Numerical solution

Lect. 13: Dielectric Waveguides (2)

ω−β diagram



– For given ω, phase velocity (=ω/β) and group velocity (=dω/dβ) can be determined.

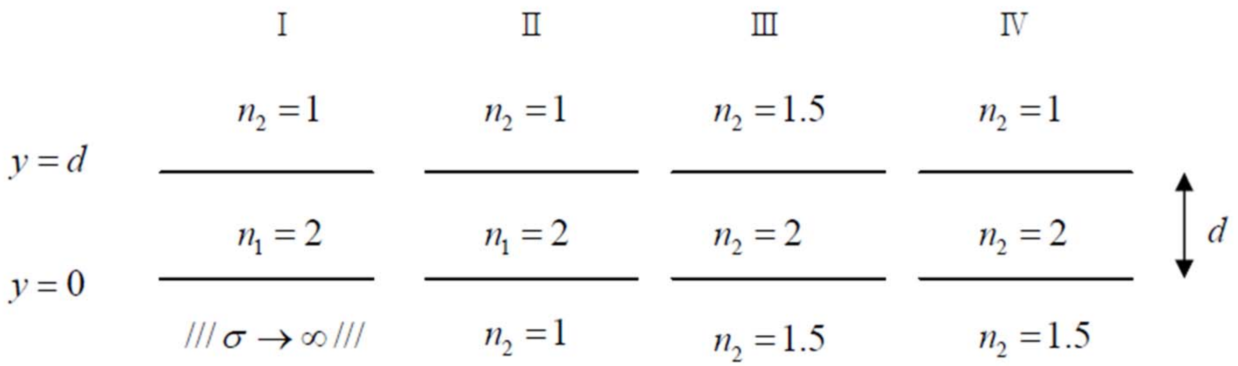
– Group velocity determines the speed of information transfer

– Multi-mode waveguides suffer from dispersion
since different modes have different group velocities

Lect. 13: Dielectric Waveguides (2)

Homework

Several different types of waveguides having the same core material and thickness are shown below.



(a) If we sketch the fundamental mode power distribution for each waveguide, which waveguide has the largest y value for the peak power position? Explain.

(b) Between Type II and III waveguides, which has the largest value for the fundamental mode effective index? Explain.

(c) Between Type II and III waveguides, which has the largest value for the fundamental mode confinement factor? Explain.

