OPTICAL FIBERS

HISTORY:

1966: KAO & Hockham (a) STANDARD TELECOM, UK PROPOSED THAT OPTICAL FIBERS CAN BE USED FOR TELECOMM. IF THE LOSS IS < 20 dB/km

1970: MAURER, KECK & SCHULTZ, CORNING INC, NY FABRICATED THE FIBER WITH LOSS < 20 dB/km
— REMOVED IMPURITIES FROM GLASS

1977: FIRST OPTICAL COMM. SYSTEM WAS INSTALLED IN CHICAGO. IT CARRIED 672 VOICE CHANNELS OVER 1.5 MILES.

1979: SINGLE-MODE FIBERS WERE MADE. FIBER LOSS ≅ 0.2 dB/km.

1980s → EFFICIENT SEMICONDUCTOR LASERS — INVENTED

1990s → OPTICAL AMP., NAMELY, EDFA — INVENTED

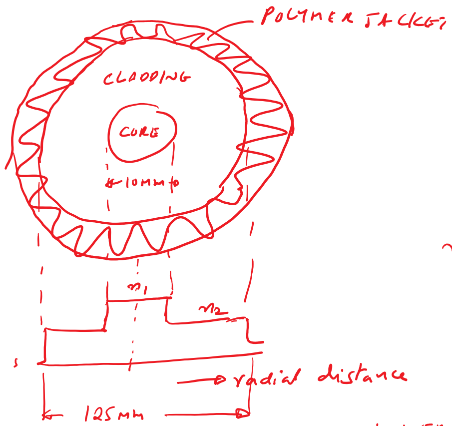
LOW LOSS FIBERS + SEMI. COND. LASERS + EDFA
— NEW ERA IN OPT. COMMUNICATION.

2009 — NOBEL PRIZE IN PHYSICS — KAO

TODAY — > 90% OF WORLD'S LONG DISTANCE IS CARRIED OVER OPTICAL FIBER CABLE

> 10 Tb/s DATA IS TRANSMITTED ~~OVER~~ PER FIBER OVER THOUSANDS OF km.
(MILLIONS OF VOICE & VIDEO CHANNELS)

OPTICAL FIBER STRUCTURE:



$n_1 > n_2$

CORE IS SURROUNDED BY CLADDING OF SLIGHTLY LOWER REFRACTIVE INDEX.

CLADDING — SILICA

CORE → SILICA + GeO_2 → R.I. BECOMES SLIGHTLY

CLADDING — SILICA

CORE → SILICA + GeO_2 → R.I. BECOMES SLIGHTLY HIGHER

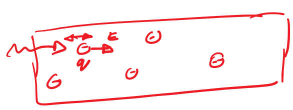
$n_1 = 1.46$, $n_2 = 1.45$

CLADDING DIAMETER = 125 μm ≅ SIZE OF THE HAIR.

ADVANTAGES OF FIBER OVER COPPER CABLE :

	FIBER	COPPER CABLE
(i) BANDWIDTH →	SEVERAL THz	~MHz to GHz
		MUCH LARGER
(ii) ATTENUATION →	~0.16 dB/km ⇒ LARGER REPEATER SPACING	⇒ SHORTER REPEATER SPACING
(iii) EMI → ELECTROMAGNETIC INTERFERENCE	FIBERS ARE NOT AFFECTED BY EXTERNAL EM NOISE FIELDS SUCH AS THAT COMING FROM ELECTRIC POWER LINES. BECAUSE — FIBER HAS NO METAL PART	EM NOISE FIELD SETS UP CONDUCTION CURRENT LEADING TO SIGNAL DISTORTION

LARGE BANDWIDTH ⇒ LARGE AMOUNT OF DATA CAN BE TRANSMITTED PER SECOND



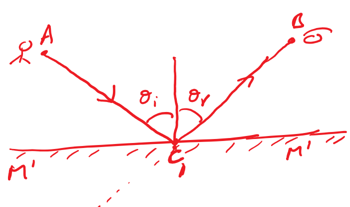
$F = qE$

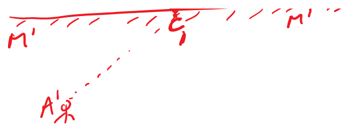
OPTICAL FIBERS ARE USED IN ELECTRIC POWER STATIONS BECAUSE THEY ARE IMMUNE TO EMI.

HIGH ELECT. POWER — KW or MW

BASIC OPTICS REVIEW

REFLECTION :





LAW OF REFLECTION: $\theta_i = \theta_r$

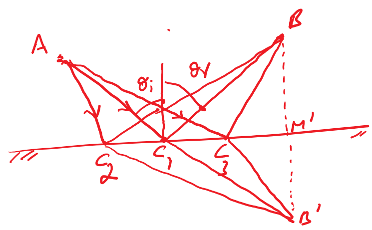
MAXWELL'S EQ. CAN BE USED TO PROVE.

FERMAT'S PRINCIPLE: THERE ARE MANY POSSIBLE PATHS FOR LIGHT TO GO FROM A TO B AFTER PASSING THROUGH THE MIRROR. OUT OF THESE INFINITE PATHS, LIGHT CHOOSES A PATH FOR WHICH THE TRANSIT TIME IS MINIMUM.

IN FREE SPACE, THE DISTANCE TRAVERSED BY LIGHT WAVE

$$z = ct$$ → TIME OF FLIGHT or TRANSIT TIME

SHORTEST PATH ⇒ SHORTEST TIME



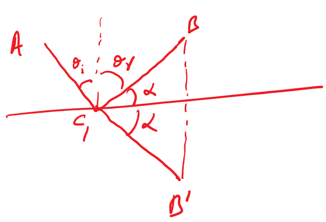
B' – IMAGE OF B, i.e. $BM' = B'M'$

$$C_1B = C_1B'$$
$$C_2B = C_2B' \text{ \& so on}$$

$$AC_1B = AC_1B', \quad AC_2B = AC_2B'$$

SUPPOSE AC_1B' IS A STRAIGHT LINE. ⇒ AC_1B IS THE SHORTEST PATH

ACCORDING TO FERMAT, LIGHT CHOOSES AC_1B.



$$C_1B = C_1B'$$

$$\theta_i + \theta_r + 2\alpha = 180^\circ$$

($\because AC_1B$ IS A STRAIGHT LINE)

$$\theta_r + \alpha = 90^\circ$$
$$\alpha = 90^\circ - \theta_r$$

$$\theta_i + \theta_r + 2(90^\circ - \theta_r) = 180^\circ$$

$$\theta_i + \theta_r + 180^\circ - 2\theta_r = 180^\circ$$

$$\boxed{\theta_i = \theta_r}$$