Hindbookcenter

GET IT ON Google Play

ALL NOTES BOOKS AVAILABLEALL STUDY MATERIAL AVAILABLE
COURIERS SERVICE AVAILABLE

MADE EASY , IES MASTER , ACE ACADEMY , KREATRYX

ESE , GATE, PSUs BEST QUALITY TOPPER HAND WRITTEN NOTES
MINIMUM PRICE AVAILABLE @ OUR WEBSITE

1. ELECTRONICS ENGINEERING
2. ELECTRICAL ENGINEERING
3. MECHANICAL ENGINEERING
4. CIVIL ENGINEERING
5. INSTRUMENTION ENGINEERING
6. COMPUTER SCIENCE

IES ,GATE , PSU TEST SERIES AVAILABLE @ OUR WEBSITE

- IES –PRELIMS & MAINS
- GATE

➢ **NOTE;- ALL ENGINEERING BRANCHS**

➢ **ALL PSUs PREVIOUS YEAR QUESTION PAPER @ OUR WEBSITE**

PUBLICATIONS BOOKS -

MADE EASY , IES MASTER ,ACE ACADEMY ,KREATRYX ,GATE ACADEMY, ARIHANT ,GK

RAKESH YADAV, KD CAMPUS , FOUNDATION , MC –GRAW HILL (TMH) ,PEARSON…OTHERS

HEAVY DISCOUNTS BOOKS AVAILABLE @ OUR WEBSITE

Shop No.7/8 Saidulajab Market Neb Sarai More, Saket, New Delhi-30	Shop No: 46 100 Futa M.G. Rd Near Made Easy Ghitorni, New Delhi-30	F518 Near Kali Maa Mandir Lado Sarai New Delhi-110030	

Website: www.hindbookcenter.com
Contact Us: 9711475393

Basics

Thermodynamics deals with the quantity of heat transfer or work transfer b/w system and surrounding.

$Q \rightarrow$ Joule OR KJ

Heat Transfer deals with the rate of heat transfer.

$\dot{Q} = \frac{dQ}{dt} \rightarrow$ Joule/sec OR watt

Thermodynamics $\rightleftharpoons$ Heat transfer

Q (J) $\quad$ $\dot{Q}$ (J/sec)

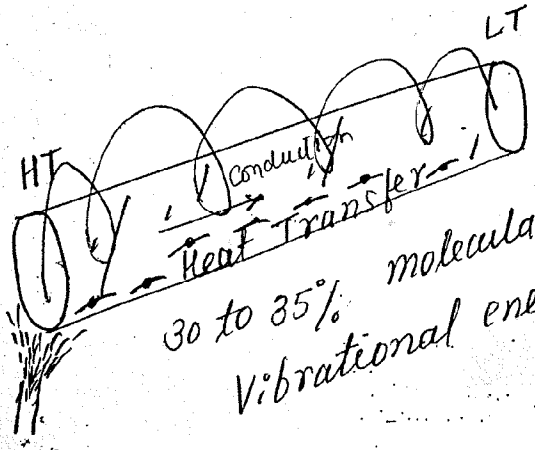
The direction of heat transfer is prescribed by the Clausius statement of second law of thermodynamics.

Modes of Heat Transfer

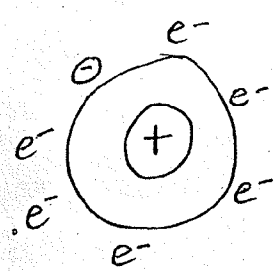
1. Conduction
2. Convection
3. Radiation

① Conduction

70% by free electrons OR electron gas



30 to 35% molecular lattice Vibrational energy transfer



$e^- \rightarrow$ free electron OR Valence electron

Silver → $K = 410\ W/mK$

copper → $K = 385\ W/mK$

Aluminium → $K = 200\ W/mK$

Steel (alloy) → $K = 17$ to $45\ W/mK$

Gold = 319 W/mK

$K_{pure\ metal} > K_{its\ alloy}$

like $K_{iron} > K_{steel}$ and $K_{copper} > K_{brass}$

Insulators :- Asbestos → $K = 0.2\ W/mK$

Refractory Brick → $K = 0.9\ W/mK$

Glass wool → $K = 0.035\ W/mK$

polyurethene foam and styro foam → $K = 0.02\ W/mK$

↓

used in Refrigerator walls

Thermal conductivity is a thermophysical property which can change with variation of temp

$K = f(T)$ (may be)

Basics

mass transfer is taken care by chemical engineers, although in convection mass is been transfered but we are only interested in energy which it is taking with it.
so our subject is heat transfer.

Heat

when ever there is a temp difference in any body or body and surrounding the energy start getting transfer is called as heat.

Heat, spontaneously transfers from higher temp to lower temp only. it can also transfer from LT to HT by giving some external work input.

Relation to thermodynamics

Although heat is related to thermodynamics, but there are some fandamental differences in both subjects

TD	HT
→ TD deals with change of state → process	it deals with speed of process (KW or watt)
it requires energy (joules)	
→ Aim of subject Heat → work	Aim of subject (i) To find temp. distribution (ii) Rate of heat transfer.

→ it deals with thermo equilibrium states

it deals with TD Non equilibrium states

Modes in Heat Transfer

Conduction → In a stationary medium

Convection → Due to relative motion of molecules

Radiation → medium not required

General Simbols we will follow in intire subject

q → Rate of HT (watt)

q'' → Rate of Heat flux (w/m^2)

q'''_g → Rate of Heat generation per Unit Volume (W/m^3)

T → Temp (K or °C)

τ → time (sec) $\forall$ → Volume (m^3)

A_s → Surface area (m^2) A_c → crosssection area (m^2)

Introduction to Heat Transfer mechanism and Rate Laws

① Conduction :- it is transfer of energy from more energetic partical of a substance to the adjacent less energetic once. as a result of interaction b/w the particals. it can take place

in solid, liquid or gas.

Rate law of Conduction is given by Fourier

$$\left[q_{cond} = -KA \frac{dT}{dx} \right] \text{ watt}$$

$K \rightarrow$ Thermal Conductivity (W/mK OR W/m°C)
it is property of medium

$A \rightarrow$ Normal Area in direction of HT

$\frac{dT}{dx} \rightarrow$ temp gradient [K/m or °C/m]

② Convection

fluid molecules have

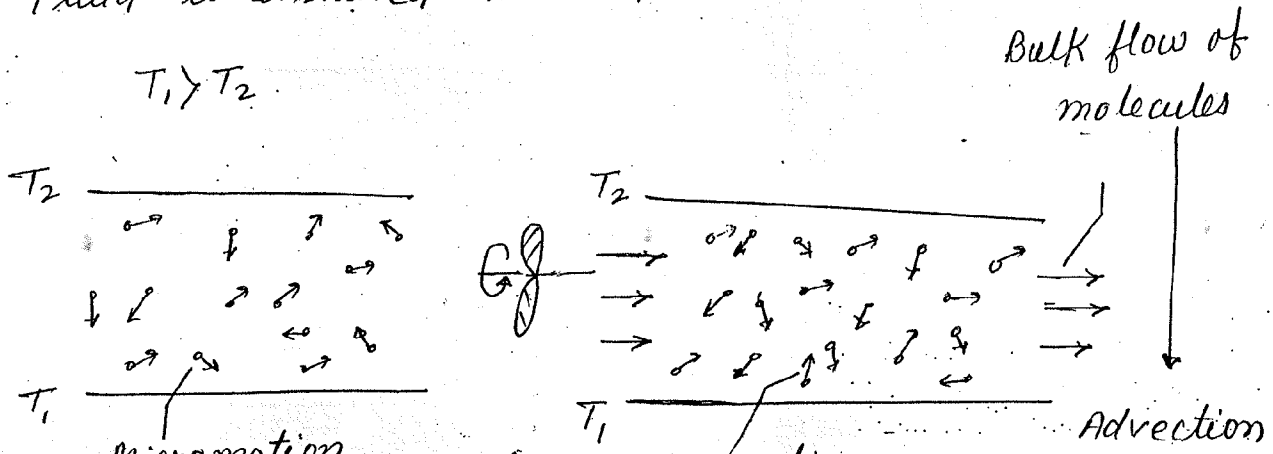
(1) Micro motion

motion of molecule associated with microscopic KE.

(2) Macro Motion

Bulk flow of molecules

Fluid is Considered b/w two plates



Convection is the mode of heat transfer which involves the combined effect of conduction and advection.

Rate law of Convection

it is given by Newton's law of cooling

$$\left[q_{conv} = hA_s(T_s - T_\infty)\right] \Rightarrow q_{conv} = hA_s(T_\infty - T_s)$$

$T_s > T_\infty$ $\qquad$ $T_\infty > T_s$

$T_s \rightarrow$ Temp of solid surface

$T_\infty \rightarrow$ Temp of fluid

$h \rightarrow$ convection Heat transfer coeff (W/m^2K) ~ it is always +Ve

Convective Heat Transfer Coeff

→ it is not property of fluid. it is an experimentaly determined parameter whose value depends upon

(i) surface geometry

(ii) surface roughness

(iii) Nature of fluid motion

(iv) property of fluid (ρ, μ, ν, c_p, K)

(v) Bulk fluid velocity

(vi) temp difference

(vii) acc due to gravity (g)

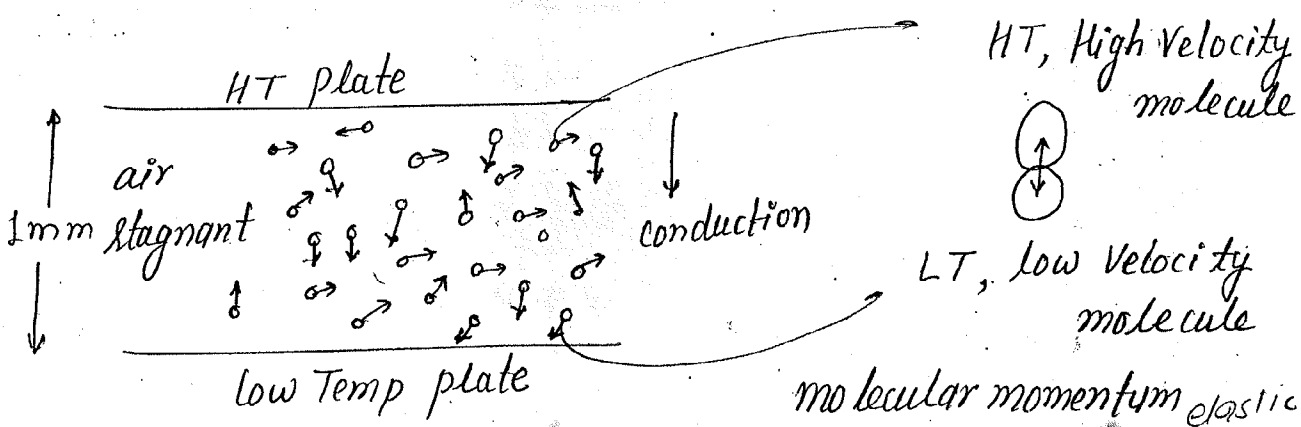
Type of Convection	h (W/m²K)
① Free Convection of gases	2 – 25
② Free convection of liquid	10 – 1000
③ Forced Convection of gases	25 – 250
④ forced convection of liquid	50 – 20000
⑤ Boiling and Condensation	2500 – 100000

③ Radiation

it is energy emitted by matter in the form of electromagnetic waves or photons, as a result of change in the electronic configuration of the atom or molecule.

it does not require any medium to occur so in vacuum radiation is only responsible for heat transfer.

— Heat Conduction in Gases



molecular momentum elastic transfer during collision

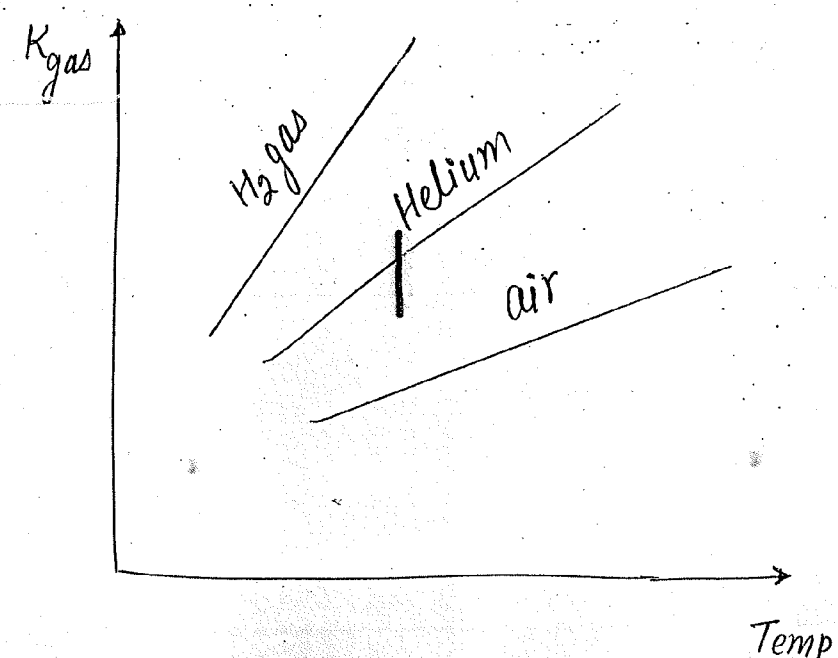
from Kinetic theory of gases

RMS Velocity of gas molecule $\bar{c} \propto \sqrt{T}$

Heat conducts from HT plate to LT plate through molecular momentum transfer during collision.

$K_{air} = 0.026\ W/mK$ at room temp

gases are very poor conductor of heat



as $T_{gas} \uparrow \Rightarrow K_{gas} \uparrow$

as $M_{gas} \uparrow \Rightarrow K_{gas} \downarrow$

For any gas

$$\text{as } T \uparrow \Rightarrow K \uparrow, C_p \uparrow, \nu \downarrow, \rho \downarrow$$

Liquids are better conductors of heat than gases

Ex:- $K_{water} = 0.63\ W/mK$

Among all the liquids, Hg has Highest K Value

$K_{Hg} = 8.54\ W/mK$

↓

Liquid metal

⇓

due to High K Value of Hg it is used for high cooling rate as in Nuclear reactor cooling

- K_{High}
- low Vapour pressure
- More Volume expansion

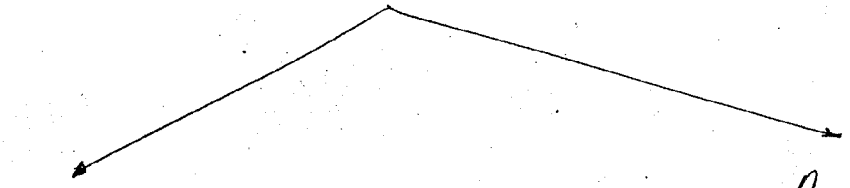
] thermometric fluid (Hg) properties

Diamond Has highest K Value among solids

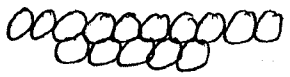
$K_{diamond} = 2300\ W/mK$

due to perfect crystalline lattice arrangement of molecules

Non Metals



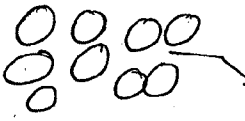
Crystalline



orderly arragement of molecules due to which K↑

like: Diamond
quartz
graphite

Amorphous



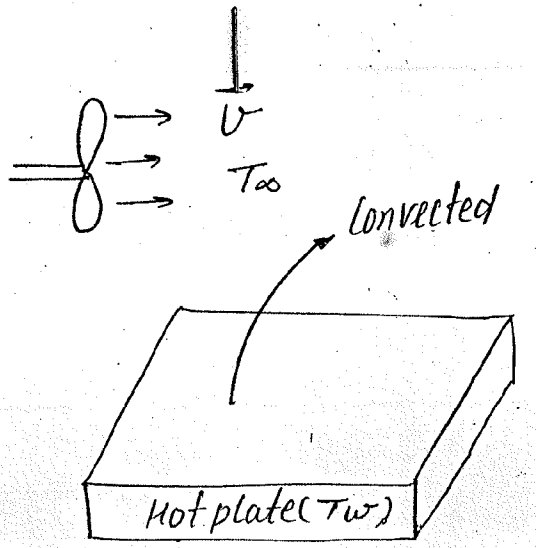
$K_{glass.} = 1.5\ W/mK$

K Value of diamond can be used to detect original diamond.

→ For non metallic liquids, K decreases with increase in temp (similar to viscosity)
exept:- water and gleseyrene.

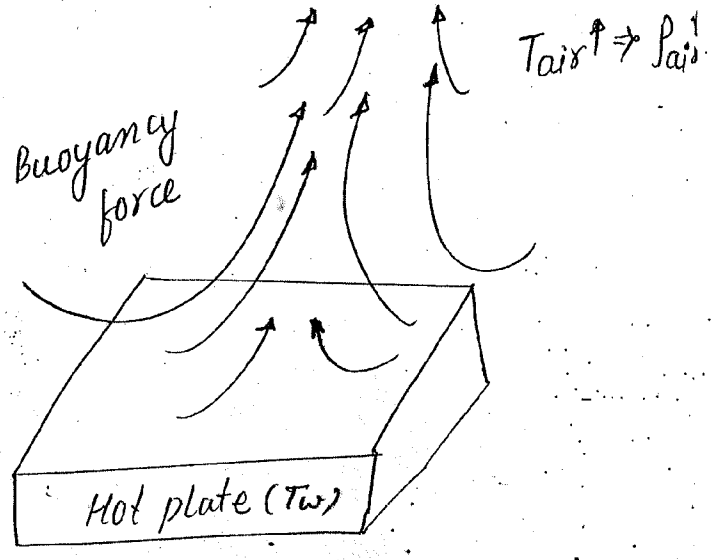
② Convection

Forced air



(Force Convection H.T)

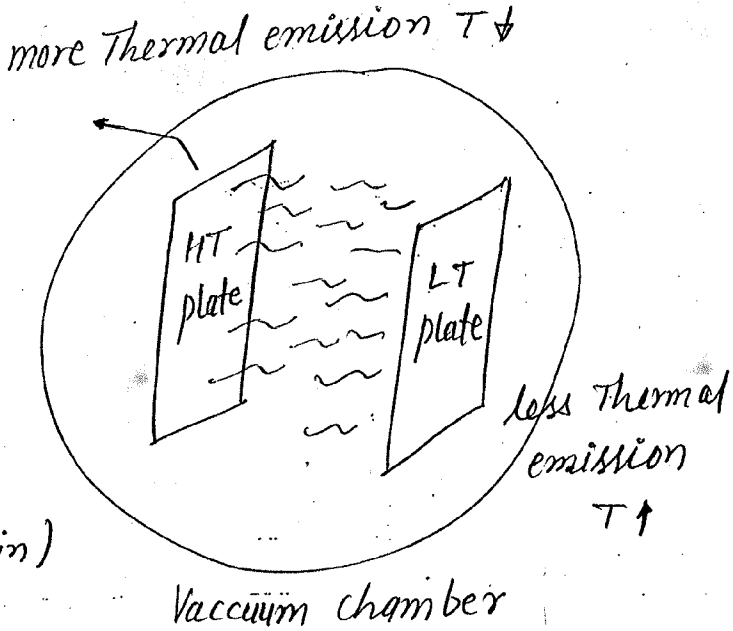
still air (T_∞)



(Free OR Natural Convection HT)

Heat is transfered due to bulk motion of molecules

③ Radiation

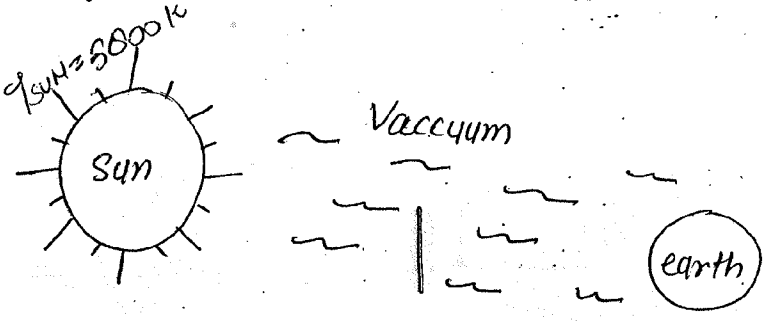


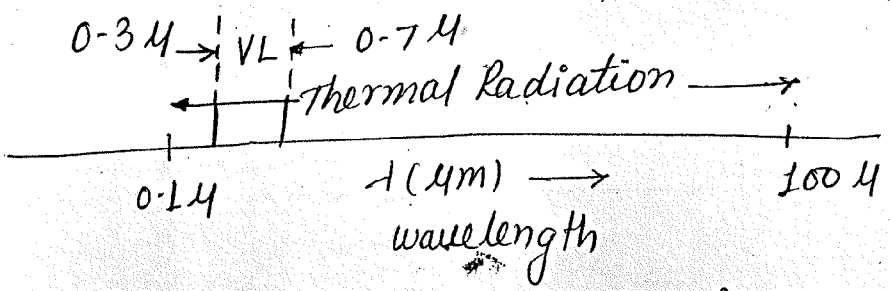
prevost's theory —
All bodies at all temp emits thermal Radiation except the body at 0K OR −273.16°C

$E \propto T^4$ (T in Kelvin)

Thermal Radiation is the mode of heat transfer which occurs in the form of electromagnetic waves and thus do not require any medium for their propagation.

Ex:-

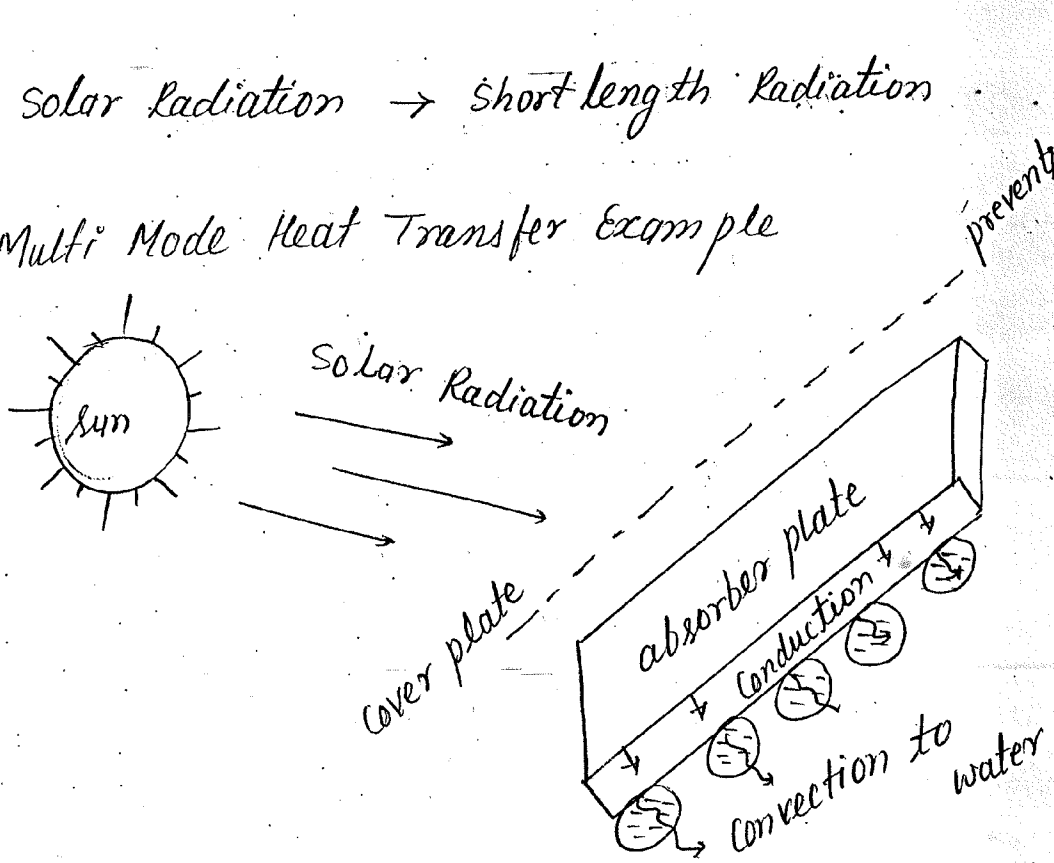




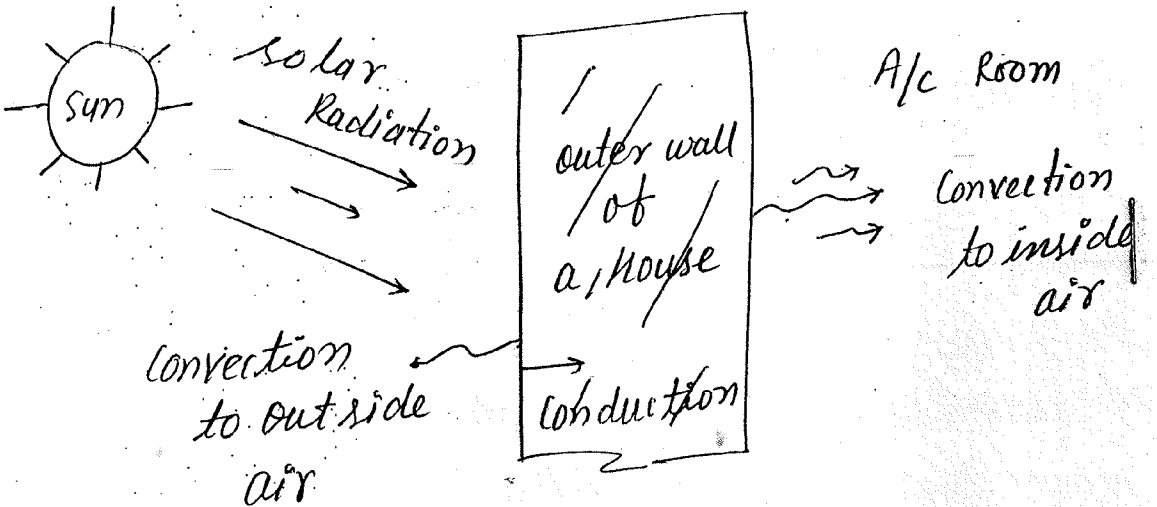
(Electromagnetic Spectrum)

Solar Radiation → Short length Radiation

Multi Mode Heat Transfer Example



(Solar Water Heating System)



(Room of a House)