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MADE EASY
MECHANICAL ENGINEERING
Heat And Mass Transfer
By-Kakkar SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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20-08-26

Thermodynamics

→ Dealing with energy transfer in the form of work and heat between two thermal equilibrium state of system

Ex:-

Present Room Temp = 30°C

Aim → To ↓ the temprature of Room temp 30°C to 20°C

For that

→ A/c is switched ON

→ After some time Room temprature is reached to 20°C

* What Thermodynamic is able to tell = ??

→ Information regarding the heat extracted from Room to bring down it's temp to 20°C

* What Thermodynamic is not able to tell = ??

→ Regarding the time consumption in the process = why

→ Because T.D is not dealing with mechanism of Heat transfer

When time is associated with the studies of energy transfer then, we say HEAT TRANSFER (ouse

HEAT TRANSFER

Symbol's

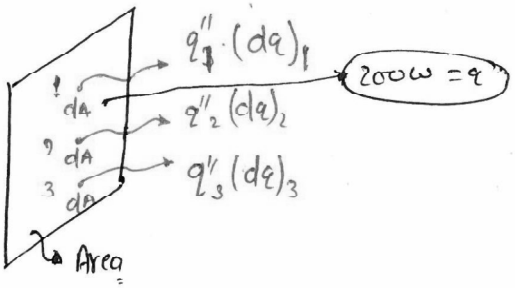
* $\forall$ = volume in only HT

Q = Energy transfer in form of heat unit = J

q = Rate of heat transfer [Total Rate of HT] unit = J/s = W (watt)

q'' = Rat of heat flux * [Local Rate of HT] unit = $\frac{W}{m^2}$

↳ More fundamental then the rate of Heat transfer.



At Point:1

$q''_1 = \frac{(dq)_1}{dA}$

$dq_1 = q''_1 dA$

At Point:2

$q''_2 = \frac{(dq_2)}{dA}$

$(dq_2) = q''_2 dA$

At Point:3

$q''_3 = \frac{(dq)_3}{dA}$

$(dq)_3 = q''_3 dA$

$(dq)_1 + (dq)_2 + dq_3 + \cdots + = q$

↳ Total Rate of Heat transfer.

Syllabus:-

1. Introduction to Heat transfer
2. Thermal Conduction.
   1. Basic of Thermal Conduction
   2. Steady state 1-D heat Conduction without heat generation
   3. Steady state 1-D heat Conduction with heat generation
   4. Heat transfer through extended Surface [FINS]
   5. Unsteady state heat Conduction.

② Thermal Radiation

① Basic of thermal Radiation
② Black Body Radiation
③ Real Body Radiation
④ Shape Factor
⑤ Radiative Heat transfer

⑥ Heat Exchanger

③ Thermal Convection

① Basics of Thermal Convection
② Forced Convection External Flow
③ Forced Convection Internal Flow
④ Natural Convection External Flow

Weightage

Gate = min 5 to 7 marks

ESE = pre = [13-16] question of HT = 150 Total question

main's = [55-65] marks = 300 Total marks of Paper-2

ESE = Incropera & Dewitt ✓

- Cengle
- Holman

Introduction to Heat transfer

→ Root cause of Heat transfer → Only Temperature difference.

→ When temp-Difference exists within the medium (or) between the media

→ Heat transfer takes place from High temp to Low temperature

* Mechanisms of Heat transfer

→ There are Three mechanisms
1. Thermal Conduction
2. Thermal Convection
3. Thermal Radiation

(1) Thermal Conduction

→ Heat transfer due to temperature difference through the stationary medium (or) between the media

* It is present in all states of matter i.e (1) in solids (2) in Liquids (3) in gases

* In gases

→ Molecules are in Random motion.

1. Random Translation energy
2. Random Rotational energy
3. Random vibration energy

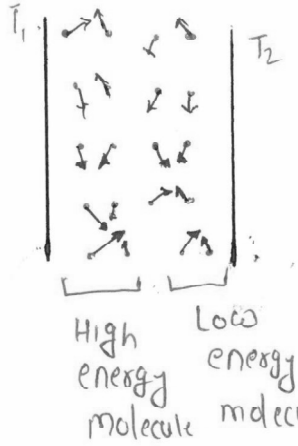
(+) (+)

Total Energy of molecule → Because of this molecules are in Random motion.

→ Because of this energy molecules are having Root mean Square speed

$V_{r.m.s} \propto \sqrt{T}$ → Temp

$(T_1 > T_2)$



* Root cause of Conduction in gases

→ By the collision between the molecules

* In Liquids

→ Root cause of Conduction in liquid

→ By Collision between the molecules.

* In solids.

→ Root Cause of Radition in solid

① By Lattice vibration

② By motion of free electrons] only in metals / Alloys

* Governing law

* → Fourier's Law

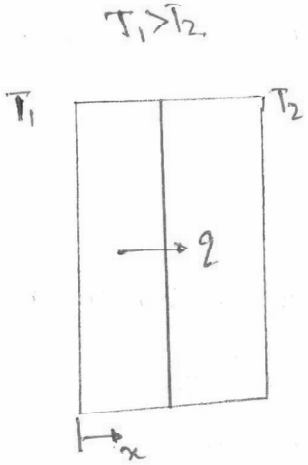
In +x direction

$$q = -KA \frac{dT}{dx} \quad \text{(unit: W)}$$

K = Thermal Conductivity

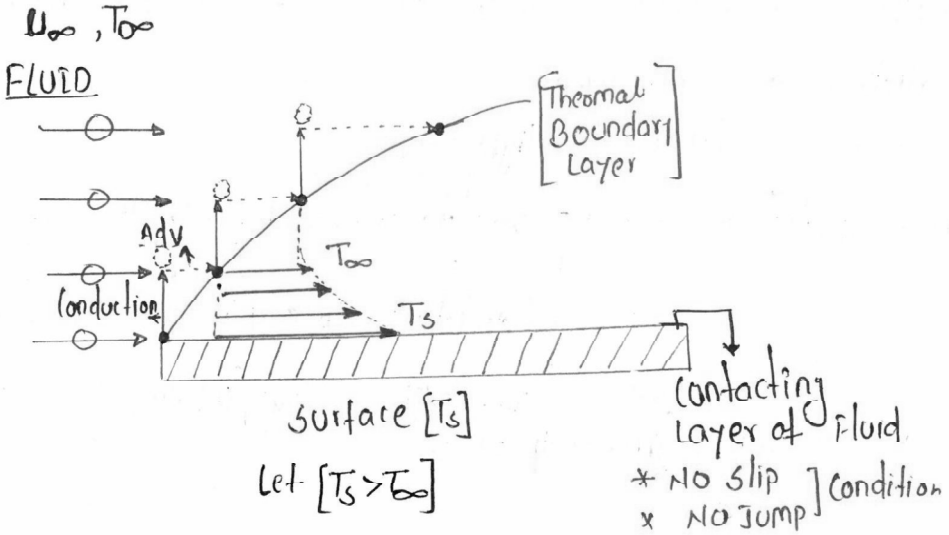
A = Area through which heat cut ies thare

$\frac{dT}{dx}$ = Temp Gradient



Thermal Convection

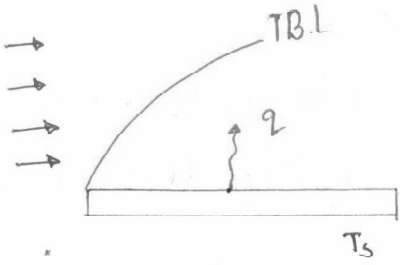
→ "Heat transfer due to temp difference because of the bulk motion (flow) of fluid particles over the surface"

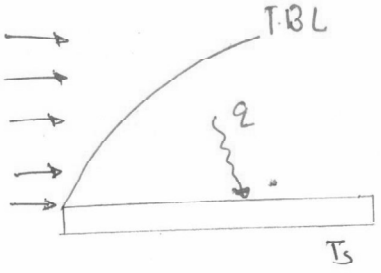


Thermal Conduction between the molecules of adjacent layers + Further this conductive heat is carried out by bulk flow of molecules [Advection] = Thermal Convective

Governing law

→ Newton's law of cooling / heating





$T_s > T_\infty$

$$q = hA[T_s - T_\infty]$$ unit Watt = $\frac{J}{m^2}$

$$q = hA[T_\infty - T_s]$$

A = Area through which heat flux it

h = Convection heat transfer coefficient.

21-08-26

Thermal Radiation

Presnce of Charge particle ⟶ Development of electric field

motion of charge particle ⟶ Develops Electric as well as magnetic field

Accelerated charge particle ⟶ e-m wave.

Radiation (light wave

* Some part of electro magnetic wave ⟶ Complete Infrared [0.78 μm – 100 μm
  + Complete visible [0.36 μm – 0.78 μm (V) (R)
  + Very little portion [0.1 μm – 0.36 μm] of U.V

* Thermal Radiation → wavelength (λ) [0.1 μm-100 μm]

Prevost Theory

⟶ Any body emits thermal Radiation at themprature above 0 K

① If Body Temp is more than surrounding temp

⟶ It emits → more

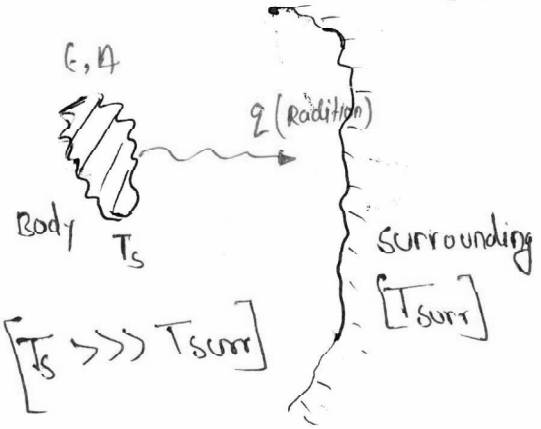
absorbs → Less

② If Body Temp is Less then Surrounding

⟶ It emits → Less

absorbs → more

* If a body is surrondedg by a very large enclosure of other body



** Rate of Radiative Heat transfer

$$Q = \epsilon \sigma A \left[T_s^4 - T_{surr}^4 \right] \quad \text{unit: } W$$

must be in Kelvin

ϵ → emissivity

σ → Stefan's constant (universal)
= 5.67×10^{-8}

A → Area through which heat cal is there