

SINDH TEXTBOOK BOARD • CHAPTER 9

Transfer of Heat

Detailed Lecture Notes on Thermal Energy, Conduction, Convection, Radiation, and Practical Engineering Applications.

Chapter 9 Core Objectives



Thermal Energy & Temp

Distinguish thermal energy from temperature and understand heat flow direction.



Three Methods of Transfer

Master Conduction, Convection currents, and electromagnetic Radiation physics.



Practical Applications

Explore land/sea breezes, vacuum flasks, home insulation, and greenhouse effects.

Thermal Energy and Temperature

Thermal Energy (\$Q\$)

The total kinetic and potential energy associated with the random motion of all atoms and molecules making up a substance.

Temperature (\$T\$)

A physical measure indicating the average kinetic energy of the particles within a physical system.
Determines direction of heat flow.

KEY PHYSICS PRINCIPLE

Heat spontaneously flows from a region of **higher temperature** to a region of **lower temperature** until thermal equilibrium is achieved.

SI Unit of Heat:

Joule (J)

SI Unit of Temp:

Kelvin (K) or °C

Thermal Conduction



Mechanism of Conduction

Transfer of thermal energy through matter by molecular collisions and free electron diffusion without actual bulk movement of the medium.

Primary Mediums:

Predominant in **solids** (especially metals due to mobile free electrons).



Conductors vs Insulators

Good Conductors (Thermal): Metals like Copper, Silver, Aluminum, Iron.

Bad Conductors / Insulators: Wood, cork, wool, glass, air, plastics, styrofoam.

Air is a very poor conductor of heat (excellent insulator when trapped).

Rate of Thermal Conduction



1. Cross-Sectional Area (A)

Larger surface area allows more free electrons and molecules to transfer heat simultaneously. Rate $\propto A$.



2. Length / Thickness (L)

Greater distance between hot and cold faces reduces rate. Thicker walls slow down heat loss. Rate $\propto 1/L$.



3. Temperature Difference (ΔT)

Higher temperature gradient between ends accelerates molecular vibration and heat transfer. Rate $\propto (T_1 - T_2)$.



4. Nature of Material (k)

Thermal conductivity constant (k) varies significantly across substances (copper vs. wood).

Thermal Convection

Definition of Convection

"Transfer of heat by actual physical movement of fluid (liquid or gas) molecules from a hot region to a cold region due to density differences."

Fluid Heating Mechanism

When heated, fluid expands, becomes less dense, and rises. Cooler, denser fluid sinks to take its place, forming **convection currents**.

Occurrence Domain

Occurs exclusively in **liquids and gases** (fluids). Cannot happen in solids because molecules are fixed in crystal lattices.

Applications of Convection



Land and Sea Breezes

≡ **Sea Breeze (Day):** Land heats faster than sea. Warm air rises over land; cool sea air blows inland.

▲ **Land Breeze (Night):** Sea retains heat longer than land. Warm air rises over sea; cool land air blows seaward.



Gliding & Central Heating

🦅 **Gliders (Thermal Currents):** Hawks and glider pilots soar upward on rising warm air columns (thermals).

🔥 **Central Heating Systems:** Hot water/air radiators warm rooms via natural convection loops.

Thermal Radiation



Electromagnetic Wave Transfer

Radiation is the transfer of thermal energy in the form of electromagnetic waves (infrared waves) traveling at the speed of light, requiring **no medium**.



Vacuum Transmission

Unlike conduction and convection, radiation can easily traverse absolute vacuum. This is how solar heat energy reaches Earth across 150 million kilometers of space.

Emission & Absorption Properties

Black & Dull Surfaces

Excellent absorbers and excellent emitters of thermal radiation. They reflect very little light.

Example: Solar water heaters are painted black inside to maximize heat absorption.

White & Shiny Surfaces

Poor absorbers and poor emitters (good reflectors) of thermal radiation.

Example: Tea pots and spacecraft are polished silver to reflect radiant heat and keep contents hot/cool.

The Vacuum Flask (Thermos)

Double-Walled Glass with Vacuum

The vacuum space between walls completely prevents heat transfer by **conduction and convection**.

Silvered Surfaces

Silver coating on inner walls reflects radiant heat back into the liquid, minimizing heat transfer by **radiation**.

Insulating Stopper & Support

Plastic/cork stopper prevents evaporation and conduction through the top opening.

Chapter 9 Review Summary

✓ Thermal Conduction

Solid heat transfer via molecular collisions and free electrons. Influenced by area, length, and material constant.

✓ Thermal Convection

Fluid movement driven by density variations. Powers land/sea breezes and atmospheric air currents.

✓ Thermal Radiation

Electromagnetic infrared waves requiring no medium. Black surfaces absorb/emit best; shiny surfaces reflect.

✓ Practical Gadgets

Vacuum flasks successfully block all three modes of thermal transfer.



Questions & Discussion

Prepare your review questions for Chapter 9 (Transfer of Heat) for the upcoming Karachi Edu Physics coaching test.

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