UNIQUE NOTES | PHYSICS - 10

Chapter 11

TRANSFER OF THERMAL ENERGY

Key concepts:

- Conduction
- Convection in liquids and gases
- Heat transfer through radiation
- Greenhouse effect

Q.1 Define and explain thermal conduction in solids.

Key points: Thermal conduction in solids (Definition, Explanation)

Thermal Conduction

Definition: *"Conduction is the process by which heat is transferred through direct contact between particles in a material, without any actual movement of the material."*

1. Explanation

- It happens when fast-moving (hotter) particles collide with slow-moving (cooler) particles, transferring their kinetic energy.
- This method of heat transfer is most efficient in solids, especially in metals, as their particles are densely packed, and freely moving electrons facilitate the quick transfer of energy.

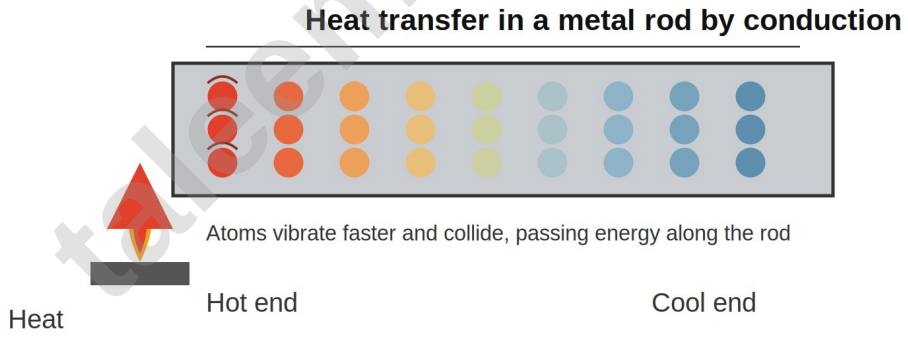


Fig. 11.1: Heat transfer in metals through conduction

2. Thermal Conduction in Solids

- When the handle of a metal spoon is placed in hot water, it quickly becomes warm, whereas the handle of a wooden spoon does not heat up. This difference highlights how materials transfer heat in different ways. Both metals and non-metals can conduct heat, but metals are typically much better at it.
- In solids, the atoms and molecules are tightly packed and constantly vibrate around their mean positions. When one end of the solid is heated, the particles at that end begin to vibrate more vigorously. These vibrating particles collide with nearby atoms or molecules, transferring some of their energy.
- This process causes the neighbouring particles to vibrate more rapidly and, in turn, pass some of their energy to other surrounding particles. Gradually, heat spreads throughout the solid, but the transfer is slow, with only a small amount of heat moving from the hotter to the cooler parts.

- In conduction, heat transfers through a solid medium due to a temperature difference.

3. Role of Free Electrons in Metals

Metals have free electrons that can move freely within the material. These fast-moving electrons carry energy quickly from the hot areas to the cooler areas of the metal. This is why heat moves more rapidly through metals than non-metals.

Tidbit: Diamonds are the best heat conductors, far better than metals. A high quality diamond can conduct heat 4-5 times better than copper.

Do You Know? Q. What is the difference between heat and temperature? Ans. Heat is the energy transferred to an object, like how a stove heats a pot through conduction. Temperature measures how hot or cold an object is, based on the average kinetic energy of its particles.

Q.2 What is convection? Explain the process of convection in liquids and gases in detail. Give practical applications of convection in daily life. (OR) What is convection? Explain convection in liquids and gases. Discuss the role of convection in coastal climates, marine life, domestic/commercial purpose, sustained flight in birds and gliders.

Key points: Convection in liquids and gases, Convection currents in air, Applications of convection currents, Convection in Seawater and Marine Life, Heating and cooling of Room by Convection

Convection

1. Convection in liquids and gases

Definition: *"Convection is the transfer of heat through the actual movement of molecules from a hot area to a cooler area."*

a. Mechanism of Convection

- Liquids and gases are not very efficient in conducting heat. However, heat can still be transferred through these fluids by a process called convection. When a liquid or gas is heated, it becomes less dense (lighter) and expands. The heated liquid or gas rises above the heat source, and cooler fluid from the surrounding area moves in to take its place.
- This cooler fluid then gets heated as well. In this way, heat is transferred through fluids by the movement of heated molecules from the hotter parts to the cooler parts of the fluid.

b. Experiment (for liquid convection)

- Fill a beaker two-thirds with water and heat it by placing a burner underneath.
- Now drop two or three potassium permanganate crystals into the water.
- We will notice coloured streaks moving upward above the flame, then flowing downward along the sides. These coloured streaks reveal the movement of currents within the liquid.
- As the water at the bottom of the beaker heats up, it expands, becoming lighter and rising. Meanwhile, the cooler, denser water sinks to replace it.

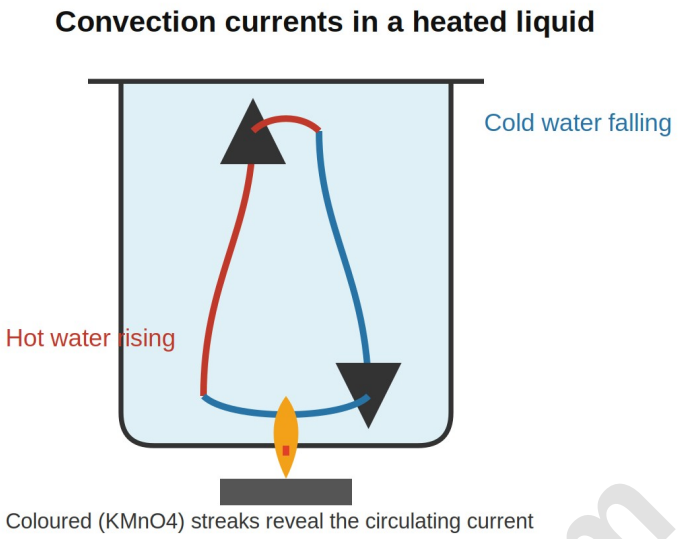


Fig. 11.2: Convection currents circulate heat as hot water rises and cold water sinks

2. Convection Currents in Air

- When gases get heated, they expand, and this creates convection currents due to the differences in air density at various points in the atmosphere.
- This process begins when the Sun heats the Earth's surface, warming the air close to the ground. As the air warms up, it becomes lighter and less dense, causing it to rise.
- As it rises, it cools down, becomes denser, and sinks back toward the surface.
- The cooler air then gets heated, and the cycle repeats. This movement of air creates convection currents, which are responsible for various natural phenomena such as winds, sea breezes, and weather patterns.
- These currents help to distribute heat throughout the atmosphere, playing a vital role in regulating Earth's climate and weather.

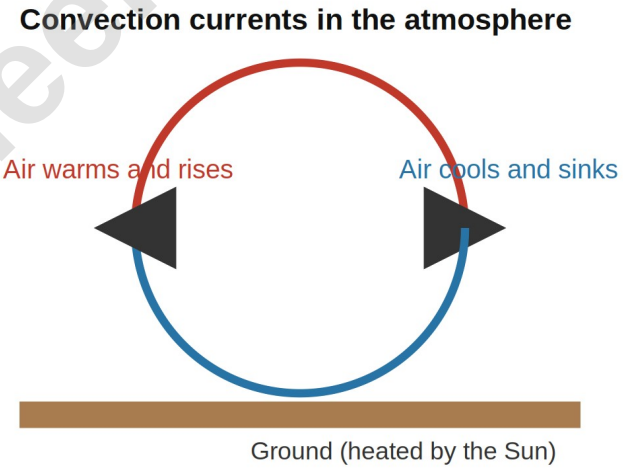


Fig. 11.3: Convection currents drive air circulation as warm air rises and cool air sinks

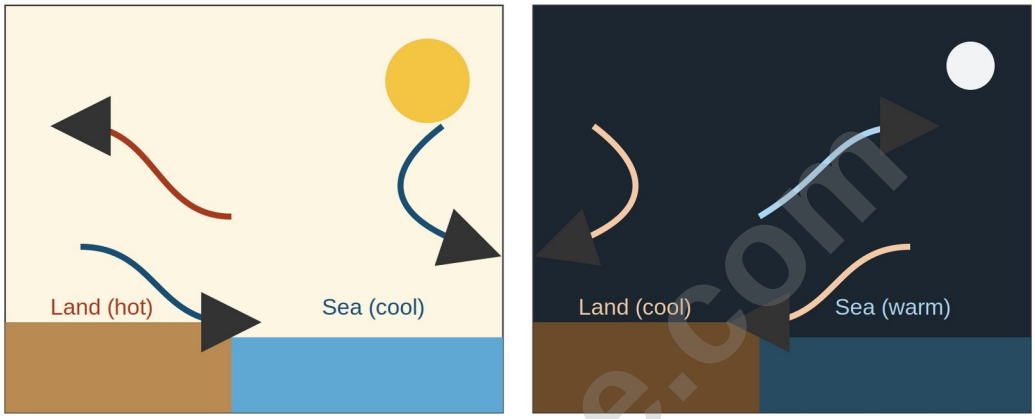
3. Applications of Convection Currents

- Convection currents created by electric, gas, or coal heaters are used to warm our homes and offices.
- Central heating systems also rely on convection to distribute heat throughout the buildings.
- On a larger scale, convection currents occur naturally in the environment.
- The daily changes in temperature in the atmosphere are caused by the movement of warm or cool air.

- Land and sea breezes are examples of convection currents in nature.

a. Land and Sea Breezes

- Land and sea breezes are caused by convection.
- During the day, the land heats up faster than the sea due to the land's lower specific heat capacity. The warm air above the land rises, and cooler air from the sea moves in to replace it, creating a sea breeze.
- At night, the land cools down more quickly than the sea. As a result, the air above the sea becomes warmer and rises, while cooler air from the land moves towards the sea, creating a land breeze.



Day: Sea Breeze (sea to land) **Night: Land Breeze (land to sea)**

Fig. 11.4 / 11.5: Sea breeze (day) blows from sea to land; land breeze (night) blows from land to sea

b. Gliding

- A glider, which is like a small plane without an engine, relies on the upward movement of warm air currents, or thermals, created by convection.
- Gliders take advantage of these rising currents of warm air to stay in the air for extended periods.

c. Bird Lift

- Similarly, birds use thermals to stay aloft for hours without flapping their wings. They stretch their wings and circle in the thermals, allowing them to gain altitude as the warm air rises.
- Birds such as eagles, hawks, and vultures are especially skilled at using thermals to glide over long distances with little effort, barely needing to flap their wings.

d. Convection in Seawater and Marine Life

- Convection plays an important role in seawater and is important for supporting marine life.
- When sunlight heats the surface of the ocean, the warm water becomes lighter and stays at the top, while the cooler, denser water sinks to the bottom. This difference in temperature causes convection currents in the ocean.
- These currents continuously move water up and down, helping to mix oxygen from the surface into deeper layers and bringing nutrients from the ocean floor to the surface.
- This process is very important for the survival of marine animals and plants because it ensures that there is enough oxygen and food available at different depths.
- Without convection, the deep ocean would lack oxygen, and surface waters would lack nutrients, making it difficult for marine ecosystems to thrive.

Brain Teaser — Q. Why do we feel a nice breeze coming from the sea during the day time at the beach? Ans. During the day, land heats up faster than the sea because land has a lower specific heat capacity. Warm air above

the land rises, creating a low-pressure area, and cooler air from the sea moves in to replace it, forming a sea breeze that feels nice at the beach.

Brain Teaser — Q. How can birds fly for hours without moving their wings much in sunny weather? Ans. Birds like eagles, hawks, and vultures use rising convection currents called thermals, formed when the Sun heats the ground and warm air rises. They stretch their wings and circle in these thermals to gain altitude without flapping, allowing them to glide for hours.

e. Heating and Cooling of a Room by Convection

- In winter, gas heaters are often used to warm rooms. When the heater is turned on, it warms the air near it. This warm air becomes lighter (less dense) and rises toward the ceiling. As the hot air moves up, cooler, heavier air moves down to take its place near the heater. This process is called a convection current, that distributes heat throughout the room.
- A similar effect is applied during summer when air conditioning is used to cool the room. It keeps the air moving and helps in spreading the heat evenly throughout the room. That is why rooms gradually become cooler without needing fans.

f. The Mechanism of a Household Hot-Water System

- In most homes, hot water is provided using a storage tank water heater. The system works by bringing cold water into the house through pipes, where it splits into two lines: one for cold water use and one that goes into the water heater.
- Inside the water heater, the cold water is heated using an electric heating element or a gas burner, depending on the type of system.
- As the water heats up, it becomes less dense and rises naturally to the top of the tank, while the cooler, denser water stays at the bottom.
- When someone turns on a hot water tap, the hot water from the top of the tank flows out easily, and new cold water enters from below to be heated.
- A thermostat inside the tank controls the heating element or gas burner, ensuring that the water stays at a set temperature. This system ensures a steady supply of hot water.

Q.3 Describe the process of heat transfer by radiation. Discuss factors influencing the rate of heat transfer by radiation. Also discuss Leslie's cube experiment with its results.

Key points: Heat transfer through radiation, Factors, Leslie's cube experiment and its results

Heat Transfer through Radiation

Definition: *"In radiation, heat transfer occurs through electromagnetic waves without requiring a medium."*

1. Explanation

- The Sun serves as the main source of heat for our planet. However, this heat does not reach the Earth through conduction or convection, as there is no medium between the Sun and Earth's atmosphere. Instead, heat is transferred via radiation, a process in which energy travels across space in the form of electromagnetic waves.
- This is the mechanism through which the Sun's heat reaches the Earth.

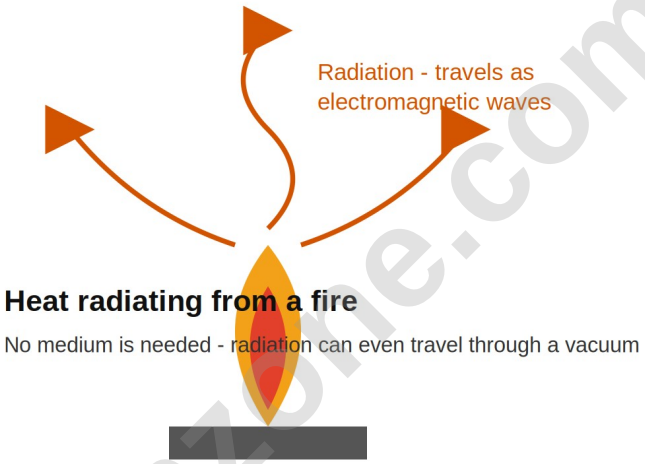


Fig. 11.10: Thermal radiations transform in the form of E.M waves

2. Radiation from a Fireplace

The heat travels from a fireplace to us. Heat does not reach us via conduction through the air because air neither conducts heat efficiently nor transfers heat well by that route.

3. Factors Affecting Radiation

Radiation emitted is influenced by various factors, including:

- the colour and texture of the surface
- the temperature of the surface
- the surface area

4. Why Objects Cool or Warm Over Time?

Why does a hot cup of tea cool down over time, and why does a cold glass of water warm up?

- All objects in a room, including the walls, ceiling, and floor, radiate heat while simultaneously absorbing it.
- If the temperature of an object is higher than that of its surroundings, it radiates more heat than it absorbs. Consequently, its temperature decreases until it matches the temperature of the surrounding environment.
- On the other hand, if the temperature of the object is lower than its surroundings, it absorbs more heat than it radiates, causing its temperature to rise until it reaches equilibrium with the environment.
- The rate at which different surfaces emit heat depends on their characteristics. This phenomenon can be illustrated with Leslie's cube.

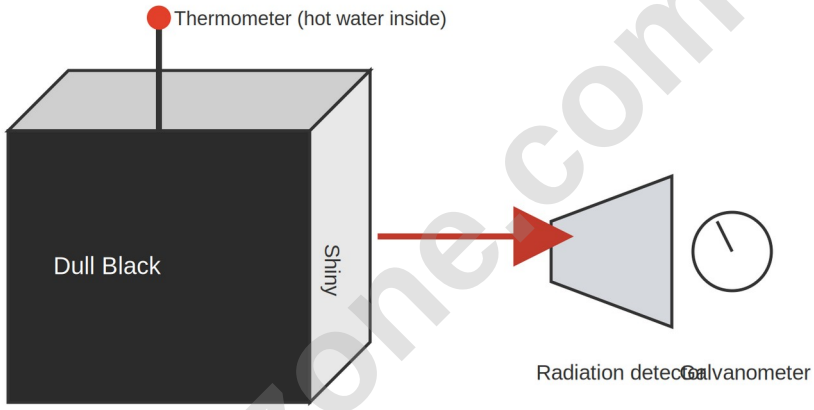
5. Leslie's Cube — Emission and Absorption of Radiation

Leslie's cube is a metal box with faces of different materials, such as:

- a shiny silver surface
- a dull black surface
- a white surface
- a coloured surface

When the cube is filled with hot water and one face is directed towards a radiation detector:

- It is found that the dull black surface is the most effective emitter of heat.
- The rate at which different surfaces absorb heat also varies based on their nature. When comparing a dull black surface with a polished silver one, the dull black surface absorbs heat more rapidly, causing its temperature to rise quickly, while the polished silver surface absorbs heat more slowly and warms up at a much slower rate.



Leslie's cube: the dull black face emits the most radiation

Fig. 11.11 / 11.12: Leslie's cube — comparison of emission and absorption of radiation

Conclusion

The experiment shows that a dull, black surface emits the most radiation, while the shiny surface emits the least, proving surface nature affects emission.

6. Effect of Surface Colour and Texture on Infrared Radiation

- The colour and texture of a surface have a strong effect on how it emits, absorbs, and reflects infrared radiation.
- Dull and dark-coloured surfaces are very good at absorbing and emitting infrared radiation. That is why a dull black surface heats up quickly and cools down faster by giving off more heat.
- On the other hand, shiny and light-coloured surfaces are poor absorbers and emitters of radiation. Instead, they reflect most of the infrared radiation away. This is why shiny surfaces, like polished metals, stay cooler under the Sun compared to dark surfaces.
- The texture also matters. Rough surfaces absorb and emit radiation better, while smooth surfaces tend to reflect more radiation.

Do You Know? Q. Why do dull black surfaces absorb and emit more heat than shiny surfaces? Ans. Dull black surfaces are good absorbers and emitters of infrared radiation due to their rough texture and dark colour, which trap and release heat effectively. Shiny surfaces reflect most radiation, absorbing and emitting less, which is why solar panels are painted black.

7. Impact of Surface Temperature and Surface Area on Heat Transfer

- The rate of radiation emitted by an object depends greatly on two important factors: the surface temperature and the surface area.
- When the surface temperature of an object increases, it radiates more energy because hotter objects emit more heat compared to cooler ones. For example, a hot iron rod glows and emits more heat than a warm one.
- Similarly, the surface area also plays a major role. If an object has a larger surface area, it can emit or absorb more heat at a faster rate. This is why radiators used for heating rooms are made with lots of thin slots or fins to increase the surface area without taking up too much space.
- A larger area means more radiation can happen at the same time, making heat transfer more efficient. Thus, both a higher surface temperature and a larger surface area help an object emit thermal energy more quickly through radiation.

Tidbit: Heat from the Sun reaches us through radiation, no air needed, just pure energy travelling across space.

8. Measuring Temperature Using an Infrared Thermometer (Application)

- An infrared thermometer measures the temperature of objects without touching them.
- It detects the heat (infrared radiation) emitted by the object.
- During the COVID-19 pandemic, these thermometers were used widely to check body temperatures safely.
- They are also useful for checking the heat of ovens, machines, or even dangerous radioactive materials.
- To use it, we point the thermometer at the object, press the trigger, and read the temperature on the screen.

Do You Know? Q. What is the basic difference between conduction, convection, and radiation? Ans. Conduction transfers heat through direct contact between particles in solids. Convection occurs when heated liquids or gases move, carrying heat with them. Radiation transfers heat through electromagnetic waves without needing a medium.

Q.4 Explain real life applications of conduction in heating objects and thermal insulation in thermos flask and building construction.

Key points: Applications of conduction, Thermal insulation

Applications of Conduction

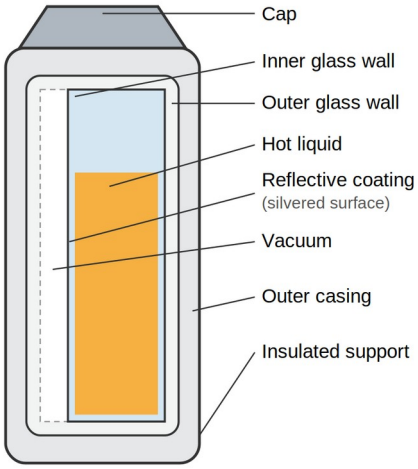
Heating Objects such as Kitchen Pans

- One everyday application of heat transfer is when we cook food using kitchen pans.
- When a pan is placed on a stove, heat from the flame or heating element transfers to the pan mainly by conduction.
- The metal of the pan, being a good conductor, quickly absorbs the heat and passes it through the surface.
- This causes the entire pan to become hot, allowing food placed inside to cook evenly.

Thermal Insulation

1. Using Thermal Insulation to Maintain the Temperature of a Liquid

- Thermal insulation helps to keep hot things hot and cold things cold. For example, a thermos flask (vacuum flask) has double walls with a vacuum between them.
- The vacuum stops heat transfer by conduction and convection because there is no air or material to move heat.
- The inside walls of the flask are coated with a reflective layer (silvered coating) that bounces back radiation to keep the liquid warm.
- The outer casing and lid are made of insulating materials like plastic or stainless steel to prevent heat loss.
- This smart design helps liquids like tea, coffee, or soup to stay at the right temperature for many hours.



A thermos (vacuum) flask

Fig. 11.15: Thermos flask

Tidbit: The handle of a cooking pan stays cool because it is made of poor conductors like wood or plastic.

2. Reducing Thermal Energy Transfer in Buildings

- Thermal insulation in buildings helps to keep them warm in winter and cool in summer.
- By adding things like thick curtains, foam in the walls, double-glazed windows, or false ceilings, we can reduce heat loss through conduction, convection, and radiation.
- In cold weather, insulation stops warm indoor air from escaping.
- In hot weather, it prevents heat from entering from outside.
- This reduces the need for heaters and air conditioners, saving energy and lowering costs.
- Even simple ideas like using proper shading outside the windows or ensuring good ventilation can make a big difference in controlling indoor temperature.

Q.5 Define and explain greenhouse effect in detail. (OR) What is a greenhouse effect? How is temperature controlled in greenhouse? Discuss the role of the greenhouse effect in regulating Earth's temperature. What are the potential consequences of an enhanced greenhouse effect due to human activities?

Key points: Greenhouse effect, Temperature regulation in a greenhouse, Greenhouse Effect on Earth

Greenhouse Effect

The greenhouse effect refers to the process by which the Earth's atmosphere traps some of the Sun's heat, maintaining a temperature that is suitable for life. Without this effect, the planet would be too cold to support life.

Tidbit: The public has been led to believe that increased carbon dioxide from human activities is causing a greenhouse effect that is heating the planet. But carbon dioxide comprises only 0.035% of our atmosphere and is a very weak greenhouse gas.

1. Temperature Regulation in a Greenhouse

- The Sun emits both short-wavelength light and ultraviolet radiations and long-wavelength thermal radiations (infrared).
- Transparent materials such as glass and plastic allow short-wavelength radiations to pass through but block long-wavelength infrared radiation.

- This creates a heat trap inside the greenhouse. The rays from the Sun warm the objects inside the greenhouse, and these objects emit radiations with longer wavelengths. However, the glass or plastic sheets prevent this longer-wavelength radiation from escaping, reflecting it back into the greenhouse and maintaining a warm environment that benefits plant growth.

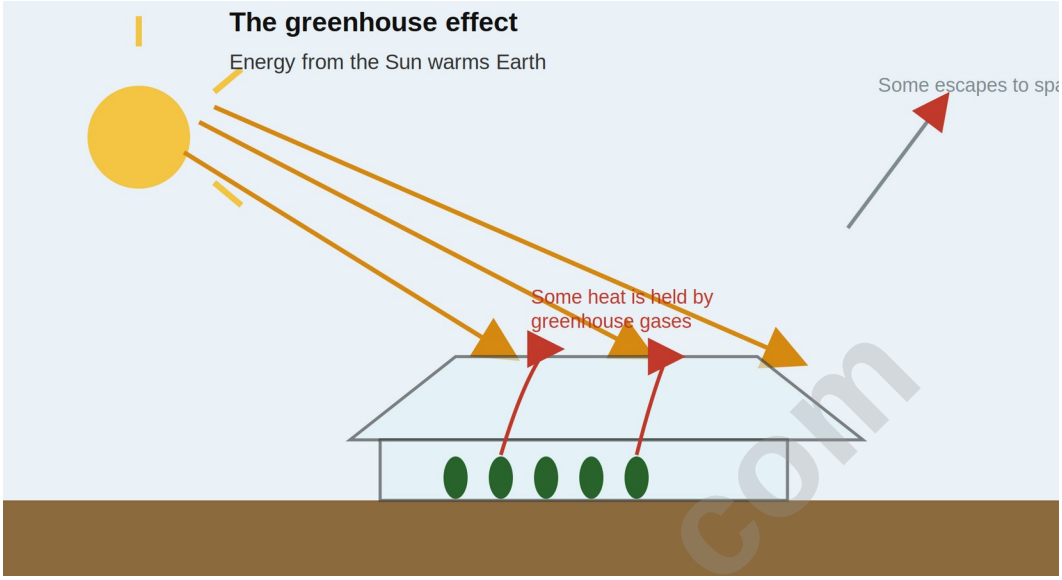


Fig. 11.17: Heat transfer mechanisms in a greenhouse (Earth is about 60°F; without the atmosphere it would be 0°F)

Do You Know? Q. How do greenhouse gases affect Earth's temperature? Ans. Greenhouse gases like carbon dioxide and water vapour absorb solar energy and trap it in the atmosphere through the greenhouse effect. Without this trapping, Earth would be too cold (about 0°F) for humans, but it keeps the planet warm enough (about 60°F) for life.

2. Greenhouse Effect on Earth

- The Earth's atmosphere functions in a similar way to a greenhouse, trapping heat from the Sun with gases such as carbon dioxide and water vapours. This helps to maintain the Earth's temperature.
- In recent years, the amount of carbon dioxide in the atmosphere has increased significantly, strengthening the greenhouse effect. As a result, more heat is trapped, leading to a rise in the Earth's average temperature, a phenomenon known as global warming.
- This increase in temperature has serious implications for global climate patterns.

Multiple Choice Questions Exercise

#	Question	Option A	Option B	Option C	Option D
1	Which method of heat transfer requires direct contact between particles?	(a) Convection	(b) Radiation	(c) Conduction	(d) Evaporation
2	What causes convection currents in liquids and gases?	(a) The continuous movement of particles in all directions	(b) The rising of warm regions and sinking of cooler regions	(c) The conduction of heat through the medium	(d) The reflection of heat waves
3	The natural phenomenon caused by convection currents is:	(a) earthquakes	(b) land and sea breezes	(c) magnetic fields	(d) solar eclipses
4	How does heat transfer occur through radiation?	(a) Through direct contact between objects	(b) Through the movement of heated fluid	(c) Through electromagnetic waves without needing a medium	(d) Through the absorption of water molecules
5	The surface which absorbs and emits the most radiation is:	(a) smooth and shiny surfaces	(b) dark and rough surfaces	(c) transparent and thin surfaces	(d) polished and white surfaces
6	What is the role of the greenhouse effect in Earth's temperature regulation?	(a) It allows all heat to escape into space	(b) It blocks heat from entering the atmosphere	(c) It traps heat to maintain a stable temperature	(d) It causes immediate cooling of Earth's surface
7	The Sun's heat reaches the Earth:	(a) through conduction between air particles	(b) through convection in space	(c) through radiation via electromagnetic waves	(d) through reflection by the moon

Answer Key

1	2	3	4	5	6	7	
c	b	b	c	b	c	c	

SLO Based Additional MCQs + Past Papers MCQs of Punjab Boards

Introduction to Heat Transfer

#	Question	Option A	Option B	Option C	Option D
1	The process of thermal energy flowing from a hotter object to a cooler one is known as:	(a) Thermal equilibrium	(b) Heat transfer	(c) Temperature	(d) Insulation
2	Thermal energy transfer between two objects continues until:	(a) One object is hotter	(b) Both are cold	(c) Thermal equilibrium is reached	(d) The source is removed
3	Conduction is most efficient in which state of matter?	(a) Liquids	(b) Gases	(c) Solids	(d) Plasma

Conduction

#	Question	Option A	Option B	Option C	Option D
4	In metals, heat transfer is faster than in non-metals due to the presence of:	(a) Tightly packed atoms	(b) Free electrons	(c) Air gaps	(d) Neutrons
5	Which material is mentioned as a better heat conductor than copper?	(a) Iron	(b) Diamond	(c) Wood	(d) Plastic
6	A vacuum flask reduces heat loss by conduction and convection primarily through its:	(a) Plastic cap	(b) Silvered coating	(c) Vacuum between double walls	(d) Outer casing
7	Why do cooking pans often have plastic or wood handles?	(a) To conduct heat better	(b) To look attractive	(c) To act as insulators	(d) To increase weight

Convection

#	Question	Option A	Option B	Option C	Option D
8	Convection is the transfer of heat involving the actual movement of:	(a) Electrons	(b) Molecules	(c) Photons	(d) Waves
9	In the experiment for liquid convection, what substance is used to visualize currents?	(a) Salt	(b) Sugar	(c) Potassium permanganate	(d) Ink
10	During the day, a sea breeze occurs because:	(a) Land heats up	(b) Sea heats up	(c) Air density is	(d) The sun sets

		faster than sea	faster than land	constant	early
11	Birds like eagles use rising warm air currents called _____ to glide.	(a) Thermals	(b) Breezes	(c) Cyclones	(d) Drafts
12	In a household water heater, hot water naturally moves to the:	(a) Bottom of the tank	(b) Center of the tank	(c) Top of the tank	(d) Outside of the tank
13	Convection currents in the ocean help support marine life by:	(a) Cooling the water only	(b) Mixing oxygen and nutrients	(c) Increasing salt content	(d) Reducing water pressure

Radiation

#	Question	Option A	Option B	Option C	Option D
14	Heat transfer by radiation travels in the form of:	(a) Sound waves	(b) Electromagnetic waves	(c) Water waves	(d) Seismic waves
15	Which device measures temperature by detecting infrared radiation?	(a) Mercury thermometer	(b) Barometer	(c) Infrared thermometer	(d) Anemometer
16	According to the Leslie's Cube experiment, which surface emits the most heat?	(a) Shiny silver	(b) White	(c) Dull black	(d) Polished metal
17	Radiators are designed with thin fins to increase their:	(a) Volume	(b) Surface area	(c) Density	(d) Weight
18	If an object is hotter than its surroundings, it will:	(a) Radiate more heat than it absorbs	(b) Absorb more heat than it radiates	(c) Maintain constant temperature	(d) Stop radiating heat

Greenhouse Effect

#	Question	Option A	Option B	Option C	Option D
19	Glass in a greenhouse allows short-wavelength radiation to enter but blocks:	(a) Ultraviolet light	(b) Visible light	(c) Long-wavelength infrared	(d) Radio waves
20	Which gas is primarily responsible for the enhanced greenhouse effect mentioned?	(a) Oxygen	(b) Nitrogen	(c) Carbon dioxide	(d) Helium
21	Without the natural greenhouse effect, Earth	(a) Too	(b) Too	(c) The	(d) A gas

	would be:	hot for life	cold for life	same temperature	giant
22	Global warming is defined as the rise in Earth's:	(a) Sea level only	(b) Average temperature	(c) Carbon emissions	(d) Oxygen levels

Answer Key

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
b	c	c	b	b	c	c	b
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
c	a	a	c	b	b	c	c
17	**18**	**19**	**20**	**21**	**22**		
b	a	c	c	b	b		

Exercise Short Questions

11.1 What are the three primary types of heat transfer?

The three primary types of heat transfer are conduction, convection, and radiation. Conduction is the transfer of heat through a material by direct contact between particles in solids. Convection is the transfer of heat through the actual movement of molecules (liquids and gases). Radiation occurs through electromagnetic waves without requiring a medium.

11.2 Why does heat travel faster in metals compared to non-metals?

Heat travels faster in metals compared to non-metals. Reason: Metals have free electrons that move freely and quickly transfer energy from hot to cold areas. Non-metals lack these free electrons and rely on slower lattice vibrations for heat transfer. This is why heat travels more rapidly through metals than non-metals.

11.3 How does convection transfer heat in liquids and gases?

When liquid or gas is heated, it becomes less dense and rises above the heat source. Cooler, denser fluid from the surrounding area moves downward to take its place. This cooler fluid then gets heated and rises again. This continuous circular movement of heated molecules from hot regions to cooler regions is called convection. The heat is transferred through the actual movement of the fluid molecules, not through direct contact.

11.4 What natural phenomenon causes land and sea breezes?

Land and sea breezes are caused by convection currents. During the day, land heats up faster than the sea because land has a lower specific heat capacity. The warm air above the land rises, and cooler air from the sea moves in to replace it, creating a sea breeze. At night, the land cools down more quickly than the sea, so the air above the sea becomes warmer and rises, while cooler air from the land moves towards the sea, creating a land breeze.

11.5 How do birds and gliders take advantage of convection currents?

Birds and gliders use rising warm air currents called thermals, which are created by convection. They stretch their wings and circle in these thermals to gain altitude. In this way they glide over long distances without flapping their wings, saving energy.

11.6 What is radiation, and how does it transfer heat?

Radiation is the transfer of heat through electromagnetic waves without needing a medium. Heat transfer occurs through radiation when energy travels across space in the form of electromagnetic waves. Example: Heat from the Sun reaches Earth by radiation through space.

11.7 Why does a dull black surface emit and absorb more radiation than a shiny silver surface?

A dull black surface emits and absorbs more radiation than a shiny silver surface. Reason: A dull black surface is rough and dark, making it a good absorber and emitter of infrared radiation. A shiny silver surface is smooth and reflective, so it reflects most radiation and absorbs/emits very little. This is why a dull black surface heats up quickly and cools down faster, while shiny surfaces like polished metals stay cooler under the same conditions.

11.8 How does the greenhouse effect help regulate Earth's temperature?

The greenhouse effect traps some of the Sun's heat in the atmosphere. Greenhouse gases such as carbon dioxide and water vapour trap the long-wavelength thermal radiations (infrared) emitted from the Earth's surface, reflecting them back into the atmosphere. This prevents excessive heat loss and maintains a warm, stable temperature on Earth.

SLO Based Additional Short Questions + Past Papers Short Questions of Punjab Boards

Mechanism of Conduction

Q.1 Explain the process of thermal conduction in non-metal solids using the particle model.

In non-metal solids, atoms and molecules are tightly packed and vibrate around fixed positions. When one end is heated, the particles there vibrate more vigorously and collide with neighbouring particles. These collisions transfer kinetic energy to the neighbours, causing them to vibrate faster and pass energy further along, slowly spreading heat through the solid.

Applications of Conduction

Q.2 How does the design of a vacuum flask (thermos) minimize heat transfer? Explain.

A vacuum flask uses a double-walled structure with a vacuum in between to stop heat transfer by conduction and convection, as there is no medium for heat to travel. The inner walls are silvered to reflect heat radiation back into the liquid, while the plastic cap and outer casing act as insulators to prevent heat loss from the top and outside.

Q.3 How do thermal insulation measures, such as double-glazed windows, help regulate building temperature?

Double-glazed windows consist of two sheets of glass with an air gap or vacuum between them. Since air is a poor conductor and a vacuum prevents conduction and convection, this design stops warm air from escaping in winter and prevents outside heat from entering in summer, reducing the need for artificial heating or cooling.

Mechanism of Convection

Q.4 Describe the step-by-step mechanism of convection in liquids and gases.

When a fluid is heated, the molecules in the hot region expand and become less dense (lighter). These lighter molecules rise upward, while cooler, denser fluid from the surroundings sinks to take their place. This cooler fluid then gets heated and rises, creating a continuous circulation pattern known as a convection current that transfers heat.

Natural Convection Phenomena

Q.5 Explain the formation of a sea breeze during the day.

During the day, the land heats up faster than the sea because land has a lower specific heat capacity. The air above the land becomes hot, expands, and rises. Cooler, denser air from over the sea then flows inland to replace the rising warm air, creating a breeze that blows from the sea toward the land.

Q.6 Explain the formation of a land breeze at night.

At night, the land cools down much faster than the sea. As a result, the air above the relatively warmer sea remains warm and rises. The cooler, denser air from the land then flows out toward the sea to replace the rising air, creating a breeze that blows from the land to the sea.

Q.7 How does convection in seawater support the survival of marine life?

Sunlight heats the ocean surface, causing warm water to stay at the top while cold water sinks. This temperature difference drives convection currents that continuously mix the ocean water. This mixing process moves oxygen from the surface to deeper layers and brings essential nutrients from the ocean floor up to the surface, sustaining marine ecosystems.

Convection Applications

Q.8 Describe how a conventional heater warms an entire room through convection.

When a heater is turned on, it warms the air immediately adjacent to it. This warm air expands, becomes less dense, and rises toward the ceiling. Cooler, heavier air from other parts of the room sinks down to the floor to replace it near the heater. This cycle repeats, circulating warm air until the whole room is heated.

Q.9 Explain the operation of a household hot-water system.

In a storage tank system, cold water enters the bottom and is heated by a gas burner or electric element. As the water heats, it becomes less dense and naturally rises to the top of the tank. When a tap is turned on, hot water is drawn from the top, while fresh cold water enters at the bottom to continue the cycle.

Radiation

Q.10 Explain the concept of thermal equilibrium in the context of objects cooling or warming.

All objects constantly emit and absorb radiation. If an object is hotter than its surroundings, it emits more heat than it absorbs, causing it to cool down. Conversely, if it is cooler, it absorbs more than it emits, warming up. This process continues until the object and its surroundings reach the same temperature (thermal equilibrium).

Q.11 Discuss how surface colour and texture affect the absorption of infrared radiation?

The nature of a surface determines its ability to handle radiation. Dull, black, and rough surfaces are excellent absorbers of infrared radiation and heat up quickly. In contrast, shiny, white, and smooth surfaces are poor absorbers because they reflect most of the incident radiation, staying cooler for longer.

Q.12 Describe the “Leslie's Cube” experiment and its findings regarding emission.

A Leslie's cube is a metal box with different faces (dull black, shiny silver, white, etc.) filled with hot water. A radiation detector placed at equal distances from each face measures the heat emitted. The experiment shows that the dull black surface emits the most radiation, while the shiny silver surface emits the least, proving surface nature affects emission.

Q.13 List the factors that affect how much infrared radiation a surface emits or absorbs?

The factors are: (i) the colour of the surface, (ii) the texture of the surface, (iii) the surface temperature, (iv) the surface area. Dull, dark, and rough surfaces are better emitters and absorbers than shiny, light, and smooth ones.

Q.14 How do surface temperature and surface area influence the rate of radiation? Explain with example.

The rate of radiation is directly linked to these two factors. First, hotter objects emit significantly more energy than cooler ones. Second, a larger surface area allows more radiation to be emitted or absorbed simultaneously. For example, radiators use fins to maximize surface area for efficient heat transfer.

Greenhouse Effect

Q.15 Explain the mechanism of the greenhouse effect in a garden greenhouse.

The glass or plastic walls of a greenhouse are transparent to short-wavelength solar radiation (light), allowing it to enter and warm the interior. However, they are opaque to the long-wavelength infrared radiation (heat) emitted by the warmed objects inside. This traps the heat within the structure, keeping it warm even in cold weather.

Q.16 Describe the role of the atmosphere in the natural greenhouse effect.

The Earth's atmosphere acts like the glass of a greenhouse. Gases such as carbon dioxide and water vapour allow solar energy to reach the surface but absorb and trap the heat radiated back from the Earth. This natural process maintains the planet's temperature at a level suitable for life, preventing it from freezing.

Q.17 What is the relationship between human activities, CO2, and global warming?

Human activities have significantly increased the concentration of carbon dioxide in the atmosphere. Since CO2 is a greenhouse gas, higher concentrations trap more terrestrial radiation than normal. This “enhanced” greenhouse effect leads to a rise in the Earth's average temperature, a phenomenon known as global warming.

Q.18 Why do shiny surfaces keep objects cooler under the Sun compared to dark surfaces?

Shiny and light-coloured surfaces are excellent reflectors of infrared radiation. When exposed to the Sun, they reflect a large portion of the incoming radiant heat rather than absorbing it. Dark surfaces, however, absorb most of the radiation, converting it to heat, which causes them to reach much higher temperatures.

Constructed Response Questions

11.1 During the Leslie's Cube experiment, why does the dull black surface radiate more heat than the shiny silver one, even though they are at the same temperature?

Ans. The dull black surface radiates more heat.

Reason: The emission of radiation depends on surface colour and texture. Dull and dark-coloured surfaces are naturally better emitters of thermal radiation. The shiny silver surface, being smooth and reflective, is a poor emitter of radiation and tends to reflect much of the heat back rather than emitting it. Therefore, when the Leslie's cube is filled with hot water at the same temperature, the dull black surface releases more thermal energy through radiation compared to the shiny silver surface.

11.2 How does the size (surface area) of a radiator affect the amount of heat it emits through radiation? Explain using a real-world example.

Ans. A larger surface area allows an object to emit more heat at a faster rate through radiation.

Explanation: If an object has a larger surface area, it can emit or absorb more heat simultaneously because more of the surface is exposed to radiate energy. Radiators used for heating rooms are designed with lots of thin slots or fins to increase the surface area. The large number of fins effectively increases the total surface area, which allows them to heat the room efficiently without occupying too much space.

11.3 Why is convection not possible in solids, and how do convection currents in liquids and gases compensate for their poor thermal conductivity?

Ans. Convection requires the actual movement of molecules. In solids, atoms and molecules are tightly packed and vibrate only around their mean positions; they cannot flow through the material. Therefore, convection is not possible in solids.

Convection currents in liquids and gases: Liquids and gases are poor heat conductors because their particles are loosely packed and not in direct contact as in solids. To compensate for this poor conductivity, convection currents form in liquids and gases. When heated, the fluid becomes less dense and rises, while cooler fluid sinks to replace it, creating a circular motion that distributes heat throughout the fluid much more effectively than conduction alone could achieve.

11.4 How do birds like eagles and gliders manage to stay aloft without flapping their wings for hours? Explain the scientific principle involved.

Ans. Birds like eagles and gliders stay aloft for hours without flapping their wings by riding on thermal currents. The scientific principle involved is convection.

Explanation: Birds and gliders use rising warm air currents called thermals, which are created by convection. They stretch their wings and circle in these thermals to gain altitude. In this way they glide over long distances without flapping their wings, saving energy.

11.5 Why does a hot metal object placed in a cooler room eventually cool down? Explain using the concepts of radiation and thermal equilibrium.

Ans. A hot metal object cools down because it radiates more heat than it absorbs from the cooler room.

Reason: All objects continuously emit and absorb thermal radiation. When hotter than its surroundings, the object radiates more heat energy than it absorbs, losing thermal energy through radiation. This continues until its temperature equals the room temperature, reaching thermal equilibrium where emission equals absorption.

Comprehensive Questions

10.1 Describe how convection occurs in fluids. How do convection currents contribute to natural phenomena such as sea breezes and wind patterns?

Ans. See Q.#2 of theory.

10.2 How does radiation differ from conduction and convection in terms of heat transfer? Give examples of radiation in everyday life and explain how different surfaces affect radiation absorption and emission.

Ans. See Q.#3 of theory.

10.3 Discuss the role of the greenhouse effect in regulating Earth's temperature. What are the potential consequences of an enhanced greenhouse effect due to human activities?

Ans. See Q.#5 of theory.

10.4 Compare the absorption and emission of heat by different surfaces. How does the colour and texture of a surface affect its ability to absorb and emit heat?

Ans. See Q.#3 of theory.

10.5 Analyze how uneven heating of Earth's surface leads to the formation of convection currents and influences wind patterns.

Ans. See Q.#2 of theory.

Important Questions of Board Examination

(i) Define conduction of heat. Explain the phenomenon of conduction of heat in the light of kinetic molecular model of matter.

(ii) What do you mean by convection? Describe an activity to show the transfer of heat by convection in liquids.

(iii) How convection currents are produced in air? Give some uses of convection currents in air.

(iv) Why does sea breeze blow during day?

(v) Explain why land breeze blows from land towards sea?

(vi) What causes a glider to remain in air. (OR) What are thermals? How gliders use thermals to stay in air?

(vii) Define radiation. On what factors the rate of radiation depends upon? Explain with examples.

(viii) Explain in detail the structure and use of Leslie's cube. (OR) How various surfaces can be compared by a Leslie's cube? Explain. (OR) What is a Leslie's cube? Describe its working principle and use.

Important Short Questions of Board Examination

(i). Define conduction of heat.

(ii). Define convection of heat.

(iii). Define radiation.

(iv). Define greenhouse effect.

(v). Define global warming.

(vi). Why does a large surface area result in a higher rate of emission of radiation? Provide an example.

(vii). How does increasing the temperature of an object affect the amount of infrared radiation it emits?

(viii). Why insulator materials like wood and plastic are poor conductor of heat?

(ix). Why metal feels colder than wood at the same temperature?

(x). Why do black, matt surfaces emit more infrared radiation than white, smooth surfaces?

(xi). How does the greenhouse affect leads to global warming?

(xii). Describe how surface colour affects the emission and absorption of radiation?

(xiii). Why a dark, rough surface is better at both absorption and emitting infrared radiation than a shinny, smooth surface?

(xiv). How land breeze and sea breeze contribute to moderate temperature along coastlines?

(xv). Describe role of convection current in heating a room through radiations.

(xvi). How do convection currents in sea water help to distribute nutrients and oxygen, benefits marine life?

(xvii). How do thermal insulators help to reduce energy loss in building?