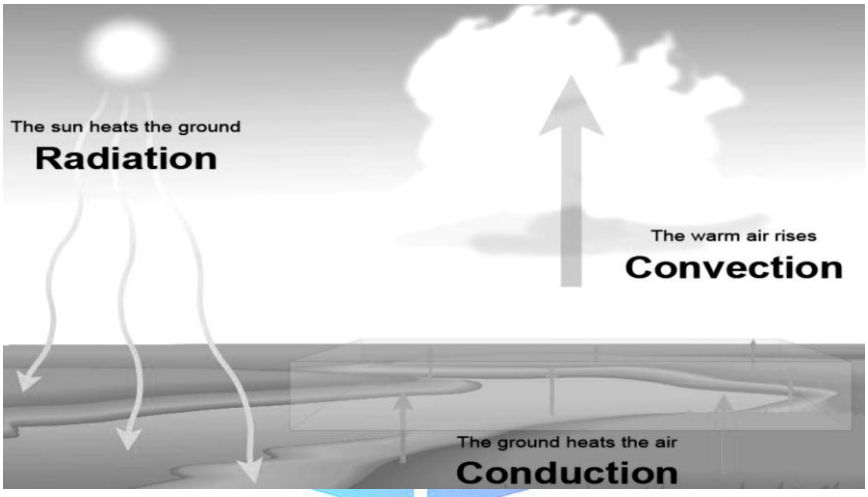
Unit 5
Building Physics, Ergonomics, and Comfort

THERMAL ASPECTS

Heat Flow in Buildings

Heat flow in buildings refers to the movement of thermal energy through building elements such as walls, roofs, windows, and floors. It affects thermal comfort, energy efficiency, and structural integrity.

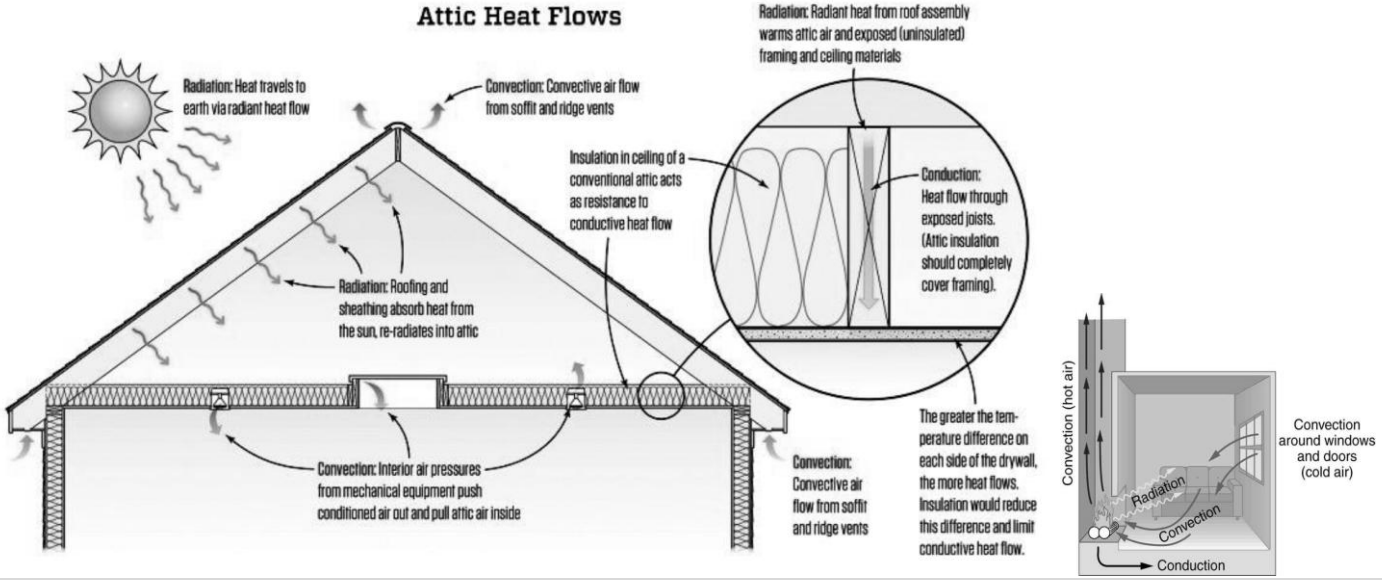


Modes of Heat Transfer

- Conduction: Through solids (e.g., walls, slabs)

$$Q = \frac{kA(T_1 - T_2)}{d}$$

- Convection: Air movement around surfaces
  - Influenced by indoor airflow, ceiling fans, AC
- Radiation: Transfer by electromagnetic waves
  - Infrared rays from sunlight warming interiors



Design Implications

- Use of reflective surfaces
- Thermal breaks in walls
- Orientation of windows (N-S vs E-W)

Humidity in Buildings

Humidity is the concentration of water vapor in the air.

- Absolute humidity - grams of water per m^3
- Relative humidity (RH) - % of moisture compared to maximum possible

Effects

- RH > 70%: Mold, bacterial growth
- RH < 30%: Dry eyes, skin discomfort

Sources

- Respiration, cooking, bathing, water seepage

Control Methods

- Dehumidifiers, fans, breathable materials
- Vapor barriers in walls (polyethylene sheets)

Thermal Control Techniques

Objective: Maintain indoor temperature between 20°C–28°C depending on activity, season, and clothing.

Passive Measures

- Building orientation: East-West exposure minimized
- Shading: Overhangs, louvers, pergolas
- Thermal mass: Thick walls to absorb/release heat
- Natural ventilation: Cross-ventilation, stack effect
- Cool roofs: White coatings reduce heat absorption

Active Measures

- HVAC (Heating, Ventilation, Air Conditioning)
- Smart thermostats
- Radiant floor heating

Condensation and Its Effects

Condensation occurs when warm moist air contacts cold surfaces, turning vapor into liquid.

Problems

- Damp patches
- Mould/fungus
- Rotting of wooden elements
- Reduced insulation efficiency

Prevention

- Warm surface temperatures (insulation)
- Airtightness control
- Mechanical ventilation with heat recovery (MVHR)
- Hygroscopic materials (lime plaster)

Thermal Insulation

Used to reduce heat transfer, save energy, and improve comfort.

Materials

- Glass wool, Rock wool
- Polystyrene (EPS/XPS)
- Polyurethane foam
- Reflective foil insulation

- Cellulose fiber

U-Value

$$U = \frac{1}{\sum\left(\frac{d}{k}\right)}$$

Lower U-value = better insulation

Application Areas

- Roof: Insulation boards or batts
- Walls: Cavity wall insulation
- Floors: Underfloor insulation
- Windows: Double-glazing, low-E glass

LIGHTING ASPECTS

Photometry and Light Measurement

Photometry is the science of measuring visible light.

Term	Unit	Description
Luminous Flux	Lumen (lm)	Total output
Illuminance	Lux (lx)	Light falling on surface
Luminous Intensity	Candela (cd)	Brightness in a direction
Luminance	cd/m²	Brightness perceived

Recommended Lux Levels

- Home: 100–300 lux
- Offices: 300–500 lux
- Labs: 500–750 lux
- Hospitals: 1000+ lux

Types of Lighting

A) Natural Lighting:

- Daylight via windows, skylights
- Depends on:
  - Orientation (N-light is diffuse, S-light intense)
  - Glazing materials
  - Shading elements

Benefits:

- Energy saving
- Boosts productivity
- Human circadian rhythm support

B) Artificial Lighting:

Type	Description
Incandescent	High heat, warm light
Fluorescent	Tubes, energy efficient
LED	Long life, cool options
Halogen	Spot lighting
CFL	Curly tubes, older tech

Lighting Schemes

- General (ambient)
- Task lighting (focused)

- Accent lighting (decorative)

Visual Comfort and Glare

Visual Comfort - Ability to perform visual tasks without strain or distraction.

Types of Glares

- Direct Glare: From luminaires
- Reflected Glare: From polished surfaces
- Discomfort Glare: Causes eye pain
- Disability Glare: Reduces visibility

Control Methods

- Louvered fittings
- Matte finishes
- Anti-glare films
- Zoned lighting design

Color Temperature and Visual Effect

Range	Appearance	Uses
2700–3000K	Warm White	Living areas
3500–4500K	Neutral White	Offices, study rooms
5000–6500K	Cool Daylight	Industrial, retail

High CRI (Color Rendering Index) values give more natural lighting.

Energy-Efficient Lighting

- Use LED bulbs with high lumen/watt
- Install motion sensors
- Daylight-linked dimming
- Design with reflectivity and daylight factor

Daylight Factor: Ratio of indoor to outdoor illumination

- Target: 2–5% in homes, >5% in studios

ACOUSTIC ASPECTS

What is Building Acoustics?

Acoustics in architecture ensures:

- Clarity of speech
- Noise isolation
- Comfortable listening experience

Acoustic Design Criteria

- Reverberation time (RT): Ideal 0.5–1.5 sec
- Background noise: < 40 dB for bedrooms
- Sound Transmission Class (STC): > 50 for party walls

Noise Insulation Techniques

Soundproofing - Preventing unwanted noise between or within spaces.

Materials

- Mass-loaded vinyl (MLV)
- Gypsum boards
- Mineral wool insulation
- Resilient channels
- Acoustic sealants

Construction Measures

- Staggered stud walls
- Floating floors
- Acoustic underlays
- Double-glazed windows

Room Acoustics

Objective: Balance sound absorption, diffusion, and reflection.

Key Terms

- Absorption Coefficient (α): 0 (reflective) to 1 (fully absorbent)
- RT60: Time for sound to decay 60 dB
- Flutter Echo: Echo between parallel walls

Treatments

- Acoustic panels
- Ceiling clouds
- Carpeting and soft furnishing
- Perforated gypsum boards

Construction Impacts on Acoustics

Factors

- Wall thickness and material
- Floor slab type
- Type of ceiling (suspended or solid)
- Type of doors and seals

Best Practices

- Avoid continuous rigid paths
- Use damping layers
- Decouple surfaces using clips and spacers

Specialized Acoustic Zones

Zone	Design Tip
Libraries	High absorption ceilings, carpeted floors
Auditoriums	Curved walls, diffusers
Hospitals	Sound absorbing wall panels
Homes	Bedroom near quiet zones, kitchen near active zones