18MEO103T – Energy systems for Buildings

Unit – IV Heat control & ventilation

Course Code	18MEO103T	Course Name	ENERGY SYSTEMS FOR BUILDINGS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NiL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the energy transfer in buildings*
CLR-2 :	*Study the solar passive heating and cooling systems*
CLR-3 :	*Be familiar with the lighting systems of buildings*
CLR-4 :	*Study the Heat control and ventilation methods in buildings*
CLR-5 :	*Be familiar with the Green buildings*
CLR-6 :	*Be familiar with the design and energy management of buildings*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning: Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire knowledge on heating and cooling load calculations on energy efficient buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*										*H*	
CLO-2 :	*Understand the concept of solar passive heating and cooling*	*1,2*	*90*	*80*	*H*	*M*					*M*							*H*	
CLO-3 :	*Understand the concept of Day lighting and electrical lighting systems*	*1&2*	*90*	*80*	*H*					*L*	*M*							*H*	
CLO-4 :	*Recognize the design parameters influencing thermal design of buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*			*M*							*H*	
CLO-5 :	*Understand the concept of green buildings and certifications*	*1 &2*	*90*	*80*	*H*		*M*			*L*	*M*							*H*	
CLO-6 :	*Acquire knowledge on design and energy management of buildings*	*1,2 & 3*	*90*	*80*	*H*	*M*	*M*	*M*		*L*	*M*							*H*	

		Energy transfer in buildings	Passive solar heating & Cooling	Lighting systems of buildings	Heat control & ventilation	Green buildings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concepts of energy efficient buildings*	*General principles of passive solar heating*	*Introduction to lighting systems of buildings*	*Introduction to heat control and ventilation*	*Introduction to green building*
S-2	SLO-1	*Conventional versus Energy Efficient buildings*	*Key design elements of passive heating*	*Glazing materials: Sources and concepts of optical materials*	*Design parameters influencing thermal design of buildings*	*Green building features and green construction materials*
S-3	SLO-1	*Climate and its influence in building design for energy requirement, Thermal properties of building materials*	*Direct solar heat gain by Trombe mass walls*	*Concepts of day lighting*	*Heat transmission through building sections*	*Green building rating tools*
S-4	SLO-1	*Codes and standards for the energy efficient buildings-ECBC codes*	*Passive cooling and its Key design elements, ventilation*	*Components of daylight factors and Recommended daylight factors*	*Effect of heating with orientation of buildings*	*Integrated ecological design, Sustainable site and landscaping*
S-5	SLO-1	*Energy balance for cooling and heating of buildings*	*Water walls, evaporative cooling*	*Day lighting analysis*	*Ventilation requirements for heat control in buildings*	*Indoor air quality, Water and waste management systems*
S-6	SLO-1	*Calculation of heating load, Heat losses and Internal heat sources*	*Convective air loops and solar chimney effects*	*Electrical lighting and Illumination requirement*	*Standards for ventilation*	*Green Globe, LEED, GRIHA, IGBC codes & certifications*
S-7	SLO-1	*Calculation of cooling loads of the building*	*Predicting ventilation in buildings, window ventilation calculations*	*Selection of luminaries and performance parameters*	*Ventilation designs, Energy conservation measurement*	*Standards for green building certifications*
S-8	SLO-1	*Low and zero energy buildings*	*Thermal insulation, load control, air filtration,*	*Electric lighting control for day lighted buildings*	*Natural ventilation methods*	*Economics, managing initial costs of green buildings*
S-9	SLO-1	*Future building design aspects*	*Odor removal and heat recovery in large buildings*	*Comparison of day and electrical lighting*	*Forced ventilation methods*	*Environment benefits of green buildings*

Design parameters influencing the thermal design of buildings

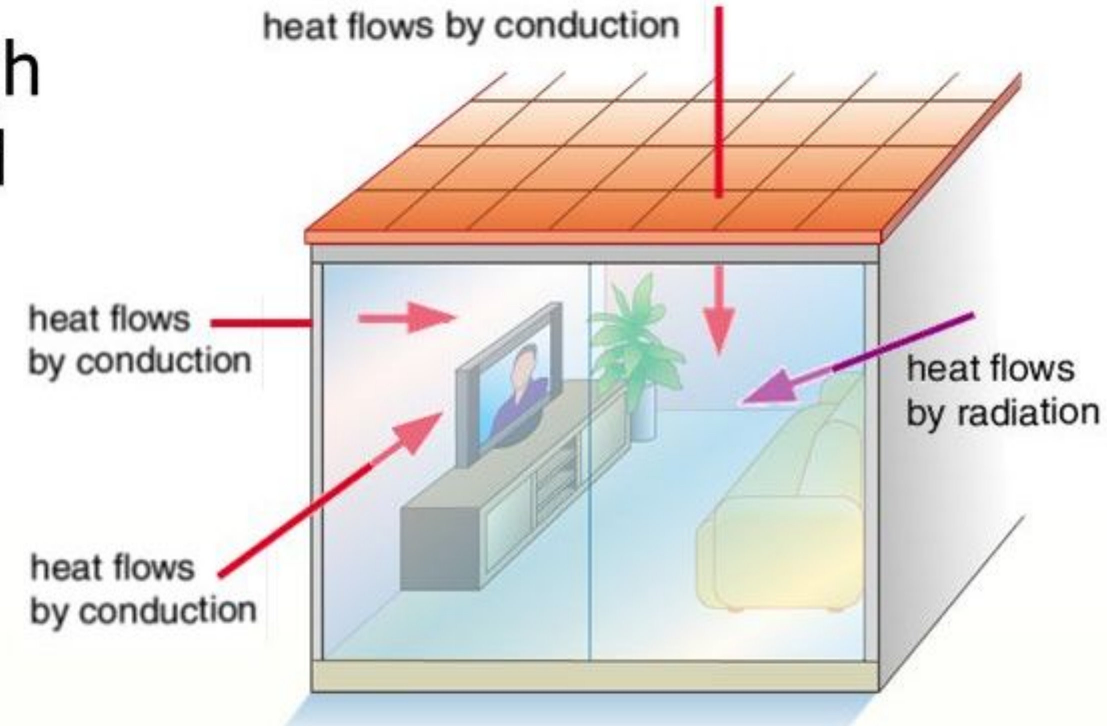
Building design Parameters	Climatic Parameters	Local Parameters
• Building Orientation • Walling material • Roofing Material • Envelope color • Type of Glass • Shading of walls • Shading of Windows	• Latitude • Solar Radiation • Air temperature • Wind Speeds • Humidity • Precipitation	• Indoor comfort conditions

Design parameters influencing the thermal design of buildings

Factors affecting the energy performance of buildings

Two ways of heat transfer through building envelope:

- Conduction through the walls, roof and glass windows
- Radiation through glass windows



Heat transfer & Modes of heat transfer

- Heat transfer can be defined as the transmission of energy from one region to another region due to temperature difference

- **Modes of heat transfer**
  - **Conduction**
  - **Convection**
  - **Radiation**

Conduction

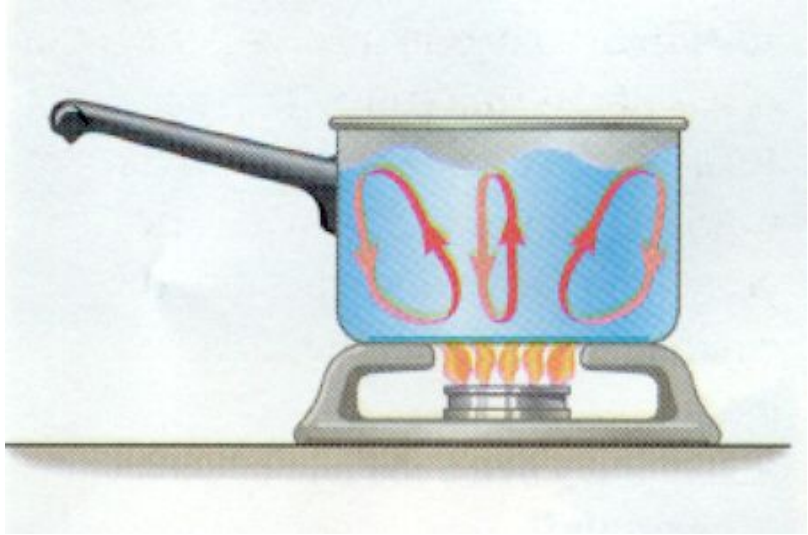
- Heat conduction is a mechanism of the heat transfer takes place high temperature region to low temperature region

- Example-This is how heat transferred to your finger if you touch the hot stove!

Convection

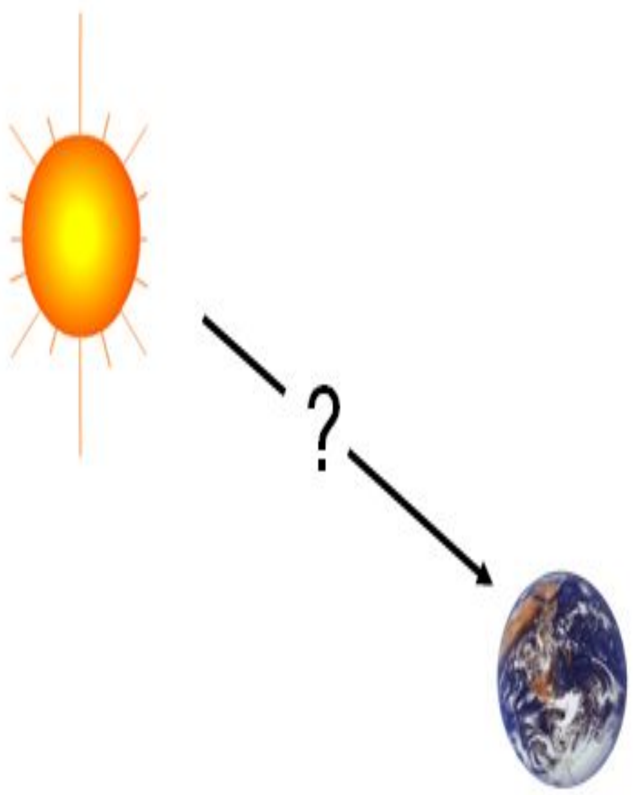
- Heat transfer occur b/w a solid surface and fluid medium when they are at different temperature

- It is possible only presence of fluid medium



Radiation

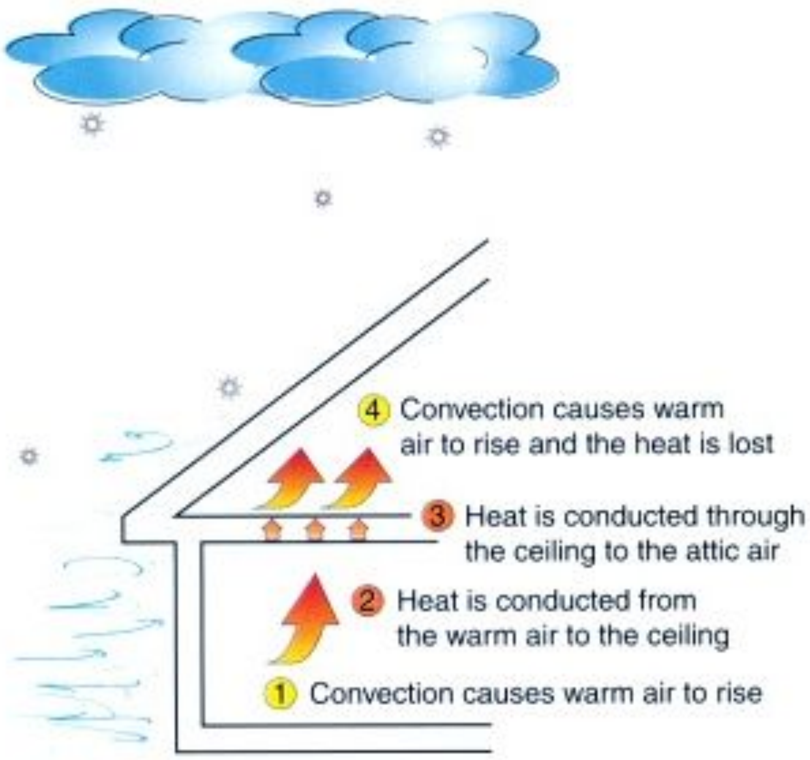
- The heat transfer takes place from one body to another body without any transmitting medium.
- Example-There are no particles between the Sun and the Earth so it is called as Radiation
- The radiation energy emitted by a body is transmitted in a space in the form of electromagnetic waves.

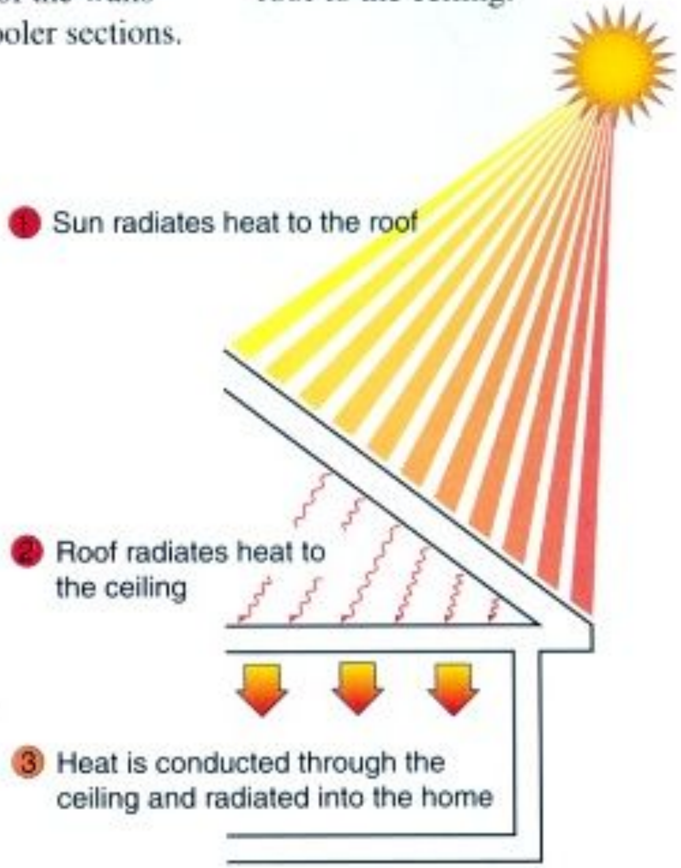


Electromagnetic (EM) radiation is a form of energy that is all around us and takes many forms, such as radio waves, microwaves, X-rays and gamma rays.

Heat transmission through building sections

	Convection	**Conduction**	**Radiation**
Definition:	The transfer of heat by moving air.	The transfer of heat through a solid material.	The transfer of heat in the form of electromagnetic waves.
Example:	Warm air rises and transfers heat to the ceiling	Heat is transferred from warmer sections of the walls and ceilings to cooler sections.	Heat is transferred from the roof to the ceiling.





Effect of heating with orientation of building

Orientation:

•Building will have to be **opened up** and **oriented to catch whatever** air movement there it is as this is the only available relief from climatic stress.

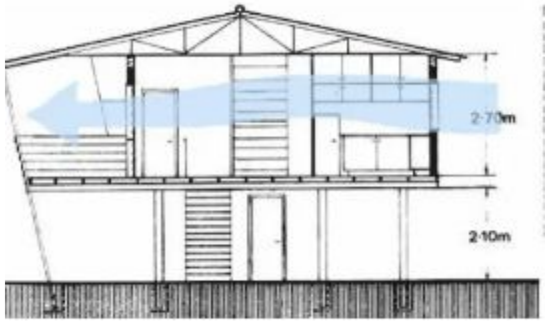
•Failure to do this would produce indoor conditions always warmer than the shaded external spaces.

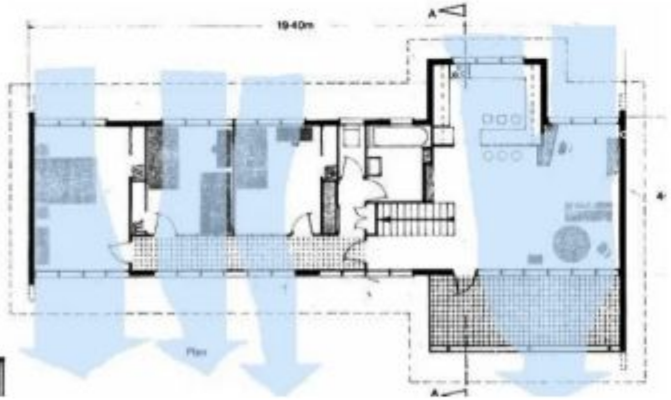
Open up Plan for Cross Ventilation:

•Buildings tend to have **open elongated plan shapes**, with a single row of rooms to allow **cross ventilation**.

•Such rooms can be accessible from **verandahs or galleries** , which also provides **shading**.

•**Door & window** openings should be as **large** as possible to allow free passage of air.





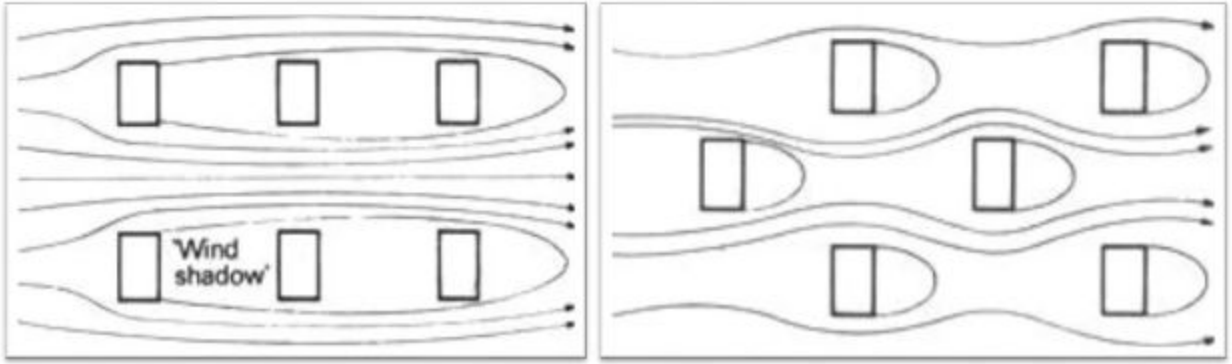
Effect of heating with orientation of building

Arrangements of Buildings:

•Groups of buildings tend to be **spread out**.

•**Extended plans** in a line across the prevailing wind direction, afford low resistance to air movement and is an ideal solution.

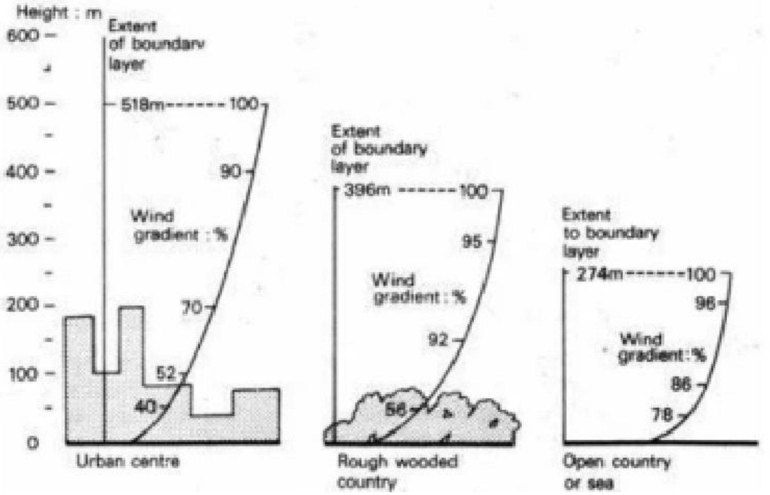
•If several rows of buildings follow, the air movement through buildings in the down-wind row will be substantially reduced by the first row.



Elevated Building & Plant cover:

•Plant cover of the ground creates **steeper wind gradient** than an open surface.

•The ground itself tends to be the same temperature as the air so no significant heat loss through conduction. So elevated building can **avoid the stagnant or slowly moving air** at the ground surface as well as **capture higher velocity of wind.**



Effect of heating with orientation of building

External Spaces:

• **Shading & free passage of air** are two basic requirements.

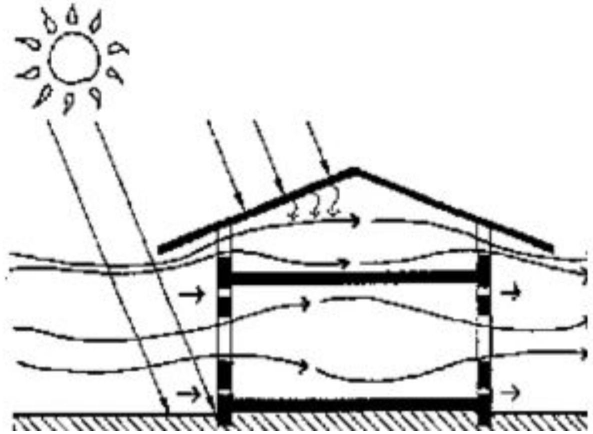
•**Trees and planting** can be used for shading, as plants carry full foliage all the year round.

Roofs & Walls:

•Buildings should be of **low thermal capacity materials**, using **lightweight** construction.

• As rainfall is higher in this regions, a **pitched roof** will most often be used covered by corrugated iron, asbestos cement or bright aluminium.

•Lower interior temperature can be achieved by a reflective upper surface, **double roof construction with roof space ventilated**, a ceiling with its upper surface highly reflective and having a good resistive insulation.



Ventilation:

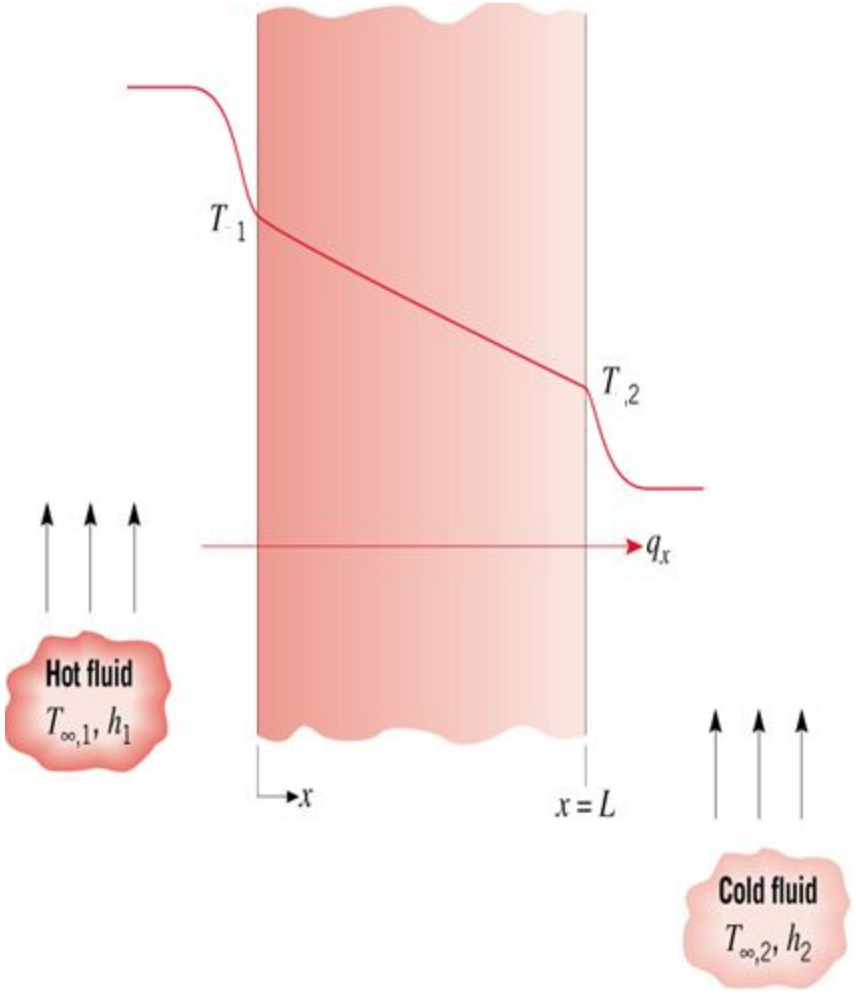
• Ventilation is necessary to reduce the **temperature and humidity of indoor**.

• Not only ventilation but also sensible **air movement across the body surface** is necessary.

• Space between **roof and ceiling** should be ventilated and care should be taken to avoid this **hot air across the living areas**.

Conduction of heat through slab or plane wall

- Consider slab of uniform ***thermal conductivity k, thickness L, with inner temp T_1 and outer temp T_2***
- Consider small ***elemental area thickness dx***



Fourier law of heat conduction

- The rate of heat conduction is proportional to the area measured normal to the direction of heat flow and to the temperature gradient in that direction

Heat transfer rate $Q = -kA\frac{dT}{dx}$

- A-Area in m^2
- dT/dx- Temperature gradient K/m
- k- Thermal conductivity, W/mk

- We know that
  - Fourier law of heat conduction

$$Q \propto -A\frac{dT}{dx}$$

$$Q = -kA\frac{dT}{dx}$$

- Integrating above eqn limits 0-L and T_1-T_2

$$Q * dx = -kAdT$$

$$Q\int_0^L dx = -kA\int_{T1}^{T2} dT$$

$$Q[L-0] = -kA[T_2 - T_1]$$

$$Q * L = kA[T_1 - T_2]$$

$$Q = \frac{kA}{L}[T_1 - T_2]$$

$$Q = \frac{T_1 - T_2}{\frac{L}{kA}}$$

$$Q = \frac{\Delta T}{R}$$

- R- Thermal resistance (K/W)

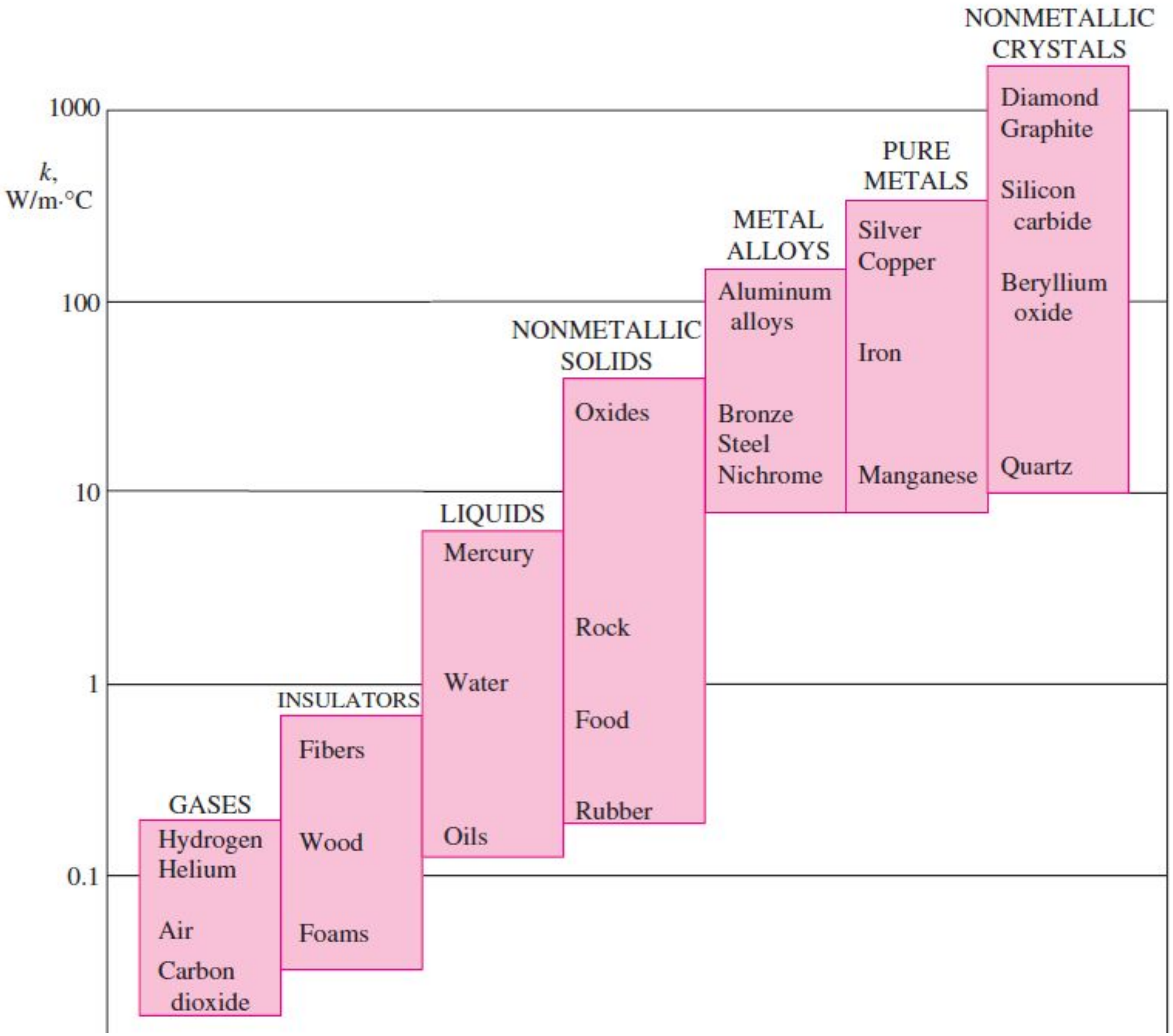
Thermal Conductivity

- The thermal conductivity of a material can be defined as the ***rate of heat transfer through a unit thickness of the material per unit temperature difference***. (W/m.K)

- The thermal conductivity of a material is a measure of the ***ability of the material to conduct heat***.

- A high value for thermal conductivity indicates that the material is a good heat conductor, and a low value indicates that the material is a poor heat conductor or insulator.

Material	k, W/m · °C*
Diamond	2300
Silver	429
Copper	401
Gold	317
Aluminum	237
Iron	80.2
Mercury (l)	8.54
Glass	0.78
Brick	0.72
Water (l)	0.613
Human skin	0.37
Wood (oak)	0.17
Helium (g)	0.152
Soft rubber	0.13
Glass fiber	0.043
Air (g)	0.026
Urethane, rigid foam	0.026


NONMETALLIC CRYSTALS
1000
k, W/m·°C
100
10
1
0.1
PURE METALS
METAL ALLOYS
NONMETALLIC SOLIDS
LIQUIDS
INSULATORS
GASES
Diamond
Graphite
Silicon carbide
Beryllium oxide
Quartz
Silver
Copper
Iron
Manganese
Aluminum alloys
Bronze
Steel
Nichrome
Oxides
Rock
Food
Rubber
Mercury
Water
Oils
Fibers
Wood
Foams
Hydrogen
Helium
Air
Carbon dioxide

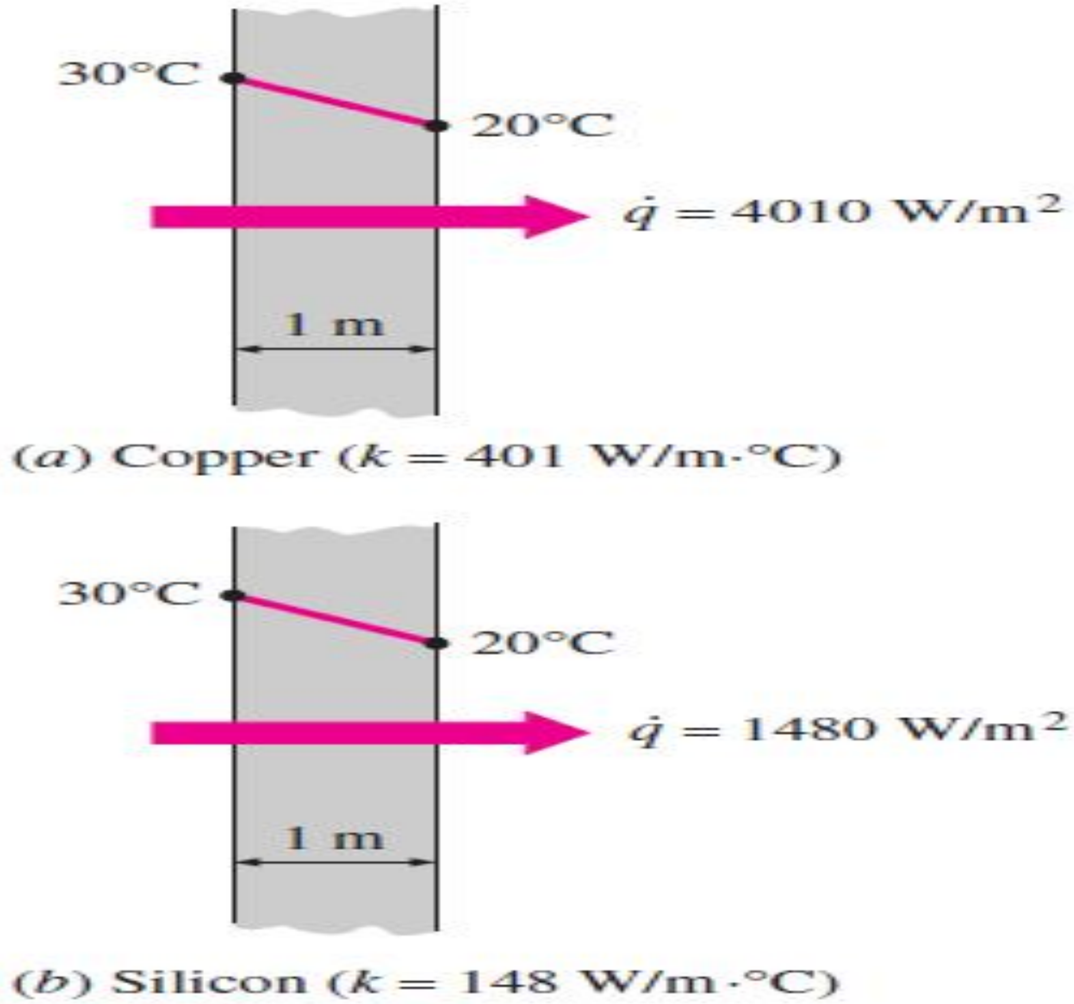


FIGURE 1–22

The rate of heat conduction through a solid is directly proportional to its thermal conductivity.

Steady versus Unsteady (Transient) Heat Transfer

- Steady indicates no change with time at any point within the medium

- Transient indicates variation with time or time dependence

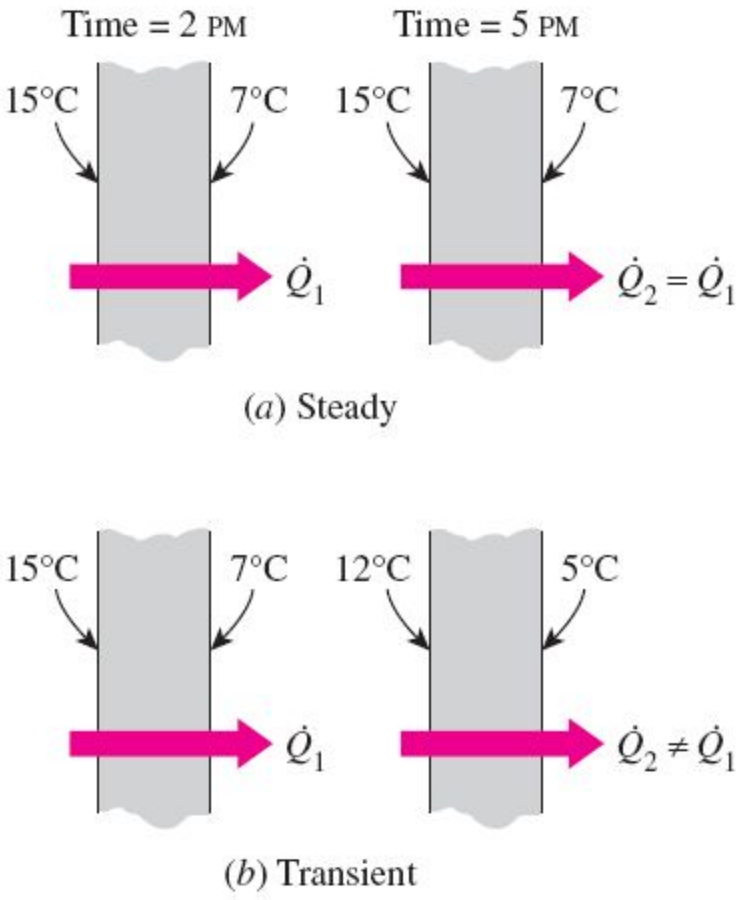
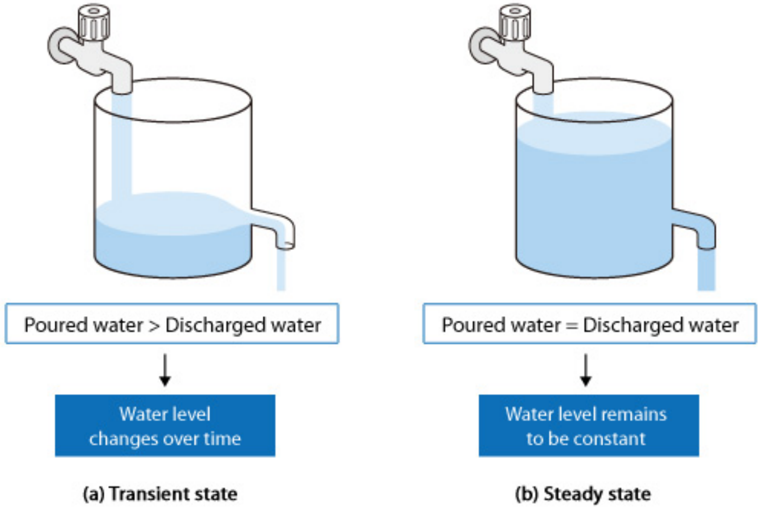


FIGURE 2–4

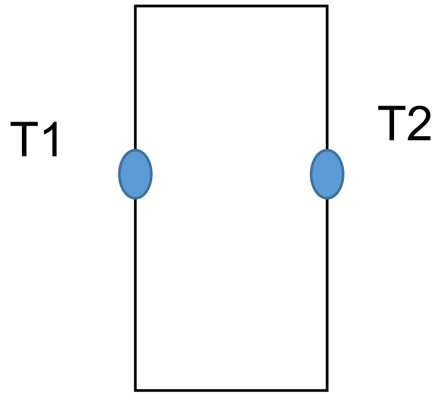
Transient and steady heat conduction in a plane wall.



PROBLEMS ON SLABS

- *1. Determine the heat transfer through the plane of length 6m, height 4 m and thickness 0.30 m. The temperature of inner and outer surfaces are 100°C and 40°C. Thermal conductivity of wall is 0.55 W/mK.*
- Given:

1. *Inner surface Temperature ,* $T_1 = 100°C + 273 = 373\ K$
2. *Outer surface Temperature,* $T_2 = 40°C + 273 = 313K$
3. *Thickness,* $L = 0.30\ m$
4. *Area,* $A = 6 \times 4 = 24m^2$
5. *Thermal conductivity,* $k = 0.55\ W/mK$



- **To find:**

 1. Heat transfer (Q)

Solution:

- **We know that, heat transfer through plane wall is**

$$Q = \frac{\Delta T \quad overall}{R}$$

where

$\Delta T = T_1 - T_2$

$R = L/kA$

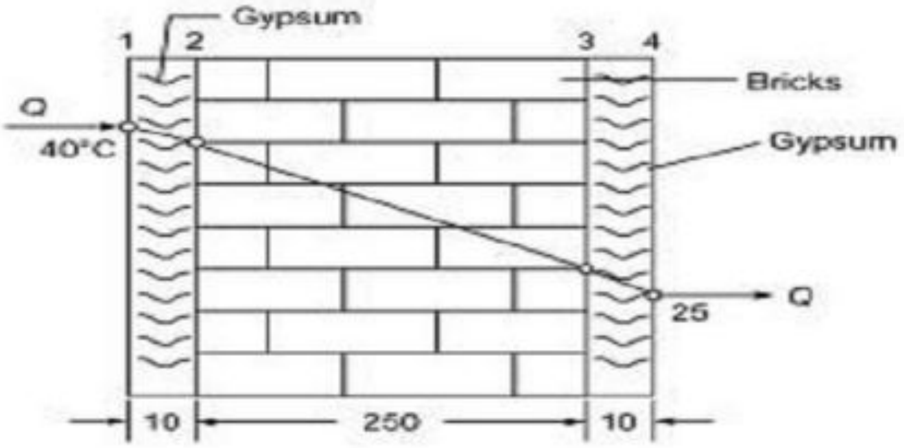
$$\Rightarrow Q = \frac{T_1 - T_2}{L / kA}$$

$$= \frac{373 - 313}{\frac{0.30}{0.55 \times 24}} = 2640 watts$$

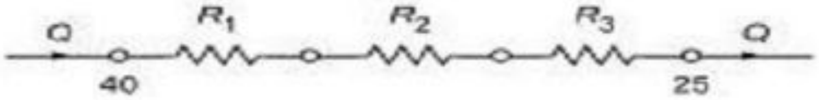
$$Q = 2640 watts$$

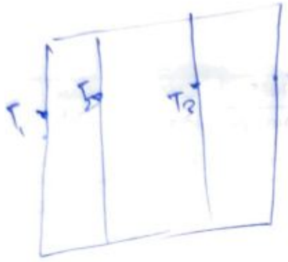
The wall of a building is a composite consisting of 250 mm layer of common brick ($k = 0.72$ W/mK) and 10 mm layers of Gypsum plaster ($k = 0.12$ W/mK) on both the sides of the bricks. During a hot day (at steady state), the temperature of outside plaster (exposed to ambient air) is 40°C and the temperature of inside plaster (exposed to inside air) is 25°C. Find (i) the heat flow rate through the wall per unit area of the wall (ii) the temperature of the interface of brick and outside plaster.

(UPTU – 2003)



The equivalent electric circuit is–





$$R_{total} = R_1 + R_2 + R_3$$

$$= \frac{L_1}{K_1 A} + \frac{L_2}{k_2 A} + \frac{L_3}{K_3 A}$$

$$= \frac{1}{A}\left[\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}\right]$$

$$R_t = \frac{1}{A}\left[\frac{10}{0.12} + \frac{250}{0.72} + \frac{10}{0.12}\right] \times 10^{-3}$$

$$= 0.514\ °C/W$$

$T_1 - T_2$

$T_1 - T_4$

$(T_2 - T_3)$

$Q = \Delta T$

$(T_2 - T_3)$

$$Q = \frac{\Delta T}{R}$$

$$Q = \frac{T_1 - T_4}{R_{total}} = \frac{40-25}{0.514} = 29.18\ W$$

$$Q = Q_{12} = Q_{23} = Q_{34}$$

$$Q_{12} = \frac{+KA(T_1 - T_2)}{L_{12} \Rightarrow 10\times10^{-3}} = \frac{0.12\times1(T_1 - T_2)}{10\times10^{-3}}$$

$(T_1 - T_2)$ 40

$$29.18 = \frac{0.12(40-T_2)}{10\times10^{-3}}$$

$$= \frac{\cancel{0.12(T_2-40)}}{} = \frac{\cancel{4.8 - 4.8T_2}}{\cancel{10\times10^{-3}}}$$

$$2.43 = 40 - T_2$$

$$\cancel{4.8 = 4.8T_2}$$

$T_2 = 37.3$

$\boxed{T_2 = 37.3}$

$$T_2 - 40 = -2.43$$

$$\boxed{T_2 = 37.57^\circ C}$$

$$Q_{23} = \frac{+k_3 A(T_2 - T_3)}{L_{23}}$$

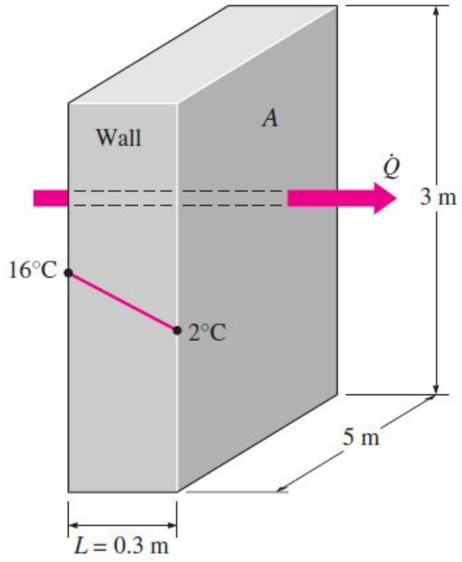
$$29.18 = 0.72(\cancel{37.57} - T_3) \quad \frac{(37.3 - T_3)}{250\times10^{-3}}$$

$$10.13 = 37.3 - T_3$$

$$\boxed{T_3 = 27.3}^\circ C.$$

EXAMPLE 3–1 Heat Loss through a Wall

Consider a 3-m-high, 5-m-wide, and 0.3-m-thick wall whose thermal conductivity is $k = 0.9$ W/m · °C (Fig. 3–11). On a certain day, the temperatures of the inner and the outer surfaces of the wall are measured to be 16°C and 2°C, respectively. Determine the rate of heat loss through the wall on that day.



SOLUTION The two surfaces of a wall are maintained at specified temperatures. The rate of heat loss through the wall is to be determined.

Assumptions **1** Heat transfer through the wall is steady since the surface temperatures remain constant at the specified values. **2** Heat transfer is one-dimensional since any significant temperature gradients will exist in the direction from the indoors to the outdoors. **3** Thermal conductivity is constant.

Properties The thermal conductivity is given to be $k = 0.9$ W/m · °C.

Analysis Noting that the heat transfer through the wall is by conduction and the area of the wall is $A = 3$ m $\times$ 5 m $= 15$ m^2, the steady rate of heat transfer through the wall can be determined from Eq. 3–3 to be

$$\dot{Q} = kA\frac{T_1 - T_2}{L} = (0.9 \text{ W/m} \cdot {}^\circ\text{C})(15 \text{ m}^2)\frac{(16 - 2)^\circ\text{C}}{0.3 \text{ m}} = \mathbf{630\ W}$$

We could also determine the steady rate of heat transfer through the wall by making use of the thermal resistance concept from

$$\dot{Q} = \frac{\Delta T_{\text{wall}}}{R_{\text{wall}}}$$

where

$$R_{\text{wall}} = \frac{L}{kA} = \frac{0.3 \text{ m}}{(0.9 \text{ W/m} \cdot {}^\circ\text{C})(15 \text{ m}^2)} = 0.02222^\circ\text{C/W}$$

Substituting, we get

$$\dot{Q} = \frac{(16 - 2)^\circ\text{C}}{0.02222^\circ\text{C/W}} = 630 \text{ W}$$

EXAMPLE 1–5 **The Cost of Heat Loss through a Roof**

The roof of an electrically heated home is 6 m long, 8 m wide, and 0.25 m thick, and is made of a flat layer of concrete whose thermal conductivity is $k = 0.8$ W/m · °C (Fig. 1–24). The temperatures of the inner and the outer surfaces of the roof one night are measured to be 15°C and 4°C, respectively, for a period of 10 hours. Determine (*a*) the rate of heat loss through the roof that night and (*b*) the cost of that heat loss to the home owner if the cost of electricity is \$0.08/kWh.

SOLUTION The inner and outer surfaces of the flat concrete roof of an electrically heated home are maintained at specified temperatures during a night. The heat loss through the roof and its cost that night are to be determined.

Assumptions **1** Steady operating conditions exist during the entire night since the surface temperatures of the roof remain constant at the specified values. **2** Constant properties can be used for the roof.

Properties The thermal conductivity of the roof is given to be $k = 0.8$ W/m · °C.

Analysis (*a*) Noting that heat transfer through the roof is by conduction and the area of the roof is $A = 6 \text{ m} \times 8 \text{ m} = 48 \text{ m}^2$, the steady rate of heat transfer through the roof is determined to be

$$\dot{Q} = kA\frac{T_1 - T_2}{L} = (0.8\ \text{W/m}\cdot{}^\circ\text{C})(48\ \text{m}^2)\frac{(15 - 4)^\circ\text{C}}{0.25\ \text{m}} = \mathbf{1690\ W = 1.69\ kW}$$

(*b*) The amount of heat lost through the roof during a 10-hour period and its cost are determined from

$$Q = \dot{Q}\,\Delta t = (1.69\ \text{kW})(10\ \text{h}) = 16.9\ \text{kWh}$$

$$\begin{aligned}\text{Cost} &= (\text{Amount of energy})(\text{Unit cost of energy})\\ &= (16.9\ \text{kWh})(\$0.08/\text{kWh}) = \mathbf{\$1.35}\end{aligned}$$

Discussion The cost to the home owner of the heat loss through the roof that night was $1.35. The total heating bill of the house will be much larger since the heat losses through the walls are not considered in these calculations.

Assumptions **1** Heat transfer through the window is steady since the surface temperatures remain constant at the specified values. **2** Heat transfer through the wall is one-dimensional since any significant temperature gradients will exist in the direction from the indoors to the outdoors. **3** Thermal conductivity is constant.

Properties The thermal conductivity is given to be $k = 0.78$ W/m · °C.

Analysis This problem involves conduction through the glass window and convection at its surfaces, and can best be handled by making use of the thermal resistance concept and drawing the thermal resistance network,

Noting that the area of the window is $A = 0.8 \text{ m} \times 1.5 \text{ m} = 1.2 \text{ m}^2$, the individual resistances are evaluated from their definitions to be

$$R_i = R_{\text{conv, 1}} = \frac{1}{h_1 A} = \frac{1}{(10 \text{ W/m}^2 \cdot {}^\circ\text{C})(1.2 \text{ m}^2)} = 0.08333{}^\circ\text{C/W}$$

$$R_{\text{glass}} = \frac{L}{kA} = \frac{0.008 \text{ m}}{(0.78 \text{ W/m} \cdot {}^\circ\text{C})(1.2 \text{ m}^2)} = 0.00855{}^\circ\text{C/W}$$

$$R_o = R_{\text{conv, 2}} = \frac{1}{h_2 A} = \frac{1}{(40 \text{ W/m}^2 \cdot {}^\circ\text{C})(1.2 \text{ m}^2)} = 0.02083{}^\circ\text{C/W}$$

Noting that all three resistances are in series, the total resistance is

$$R_{total} = R_{conv,\,1} + R_{glass} + R_{conv,\,2} = 0.08333 + 0.00855 + 0.02083$$
$$= 0.1127°C/W$$

Then the steady rate of heat transfer through the window becomes

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{[20 - (-10)]°C}{0.1127°C/W} = \mathbf{266\ W}$$

Knowing the rate of heat transfer, the inner surface temperature of the window glass can be determined from

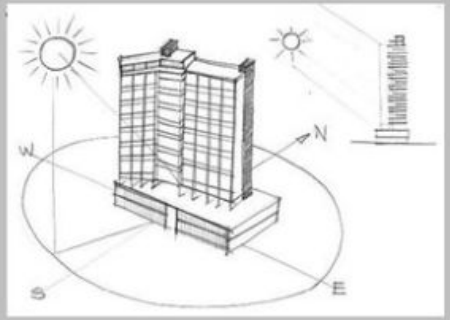
$$\dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv,\,1}} \longrightarrow T_1 = T_{\infty 1} - \dot{Q}R_{conv,\,1}$$
$$= 20°C - (266\ W)(0.08333°C/W)$$
$$= \mathbf{-2.2°C}$$

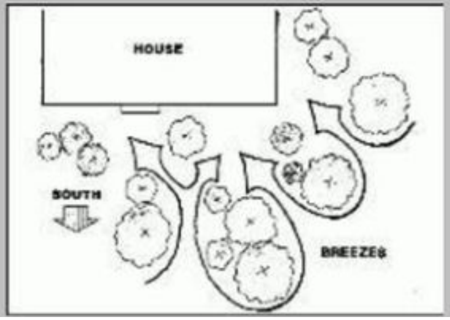
Requirements for Ventilation

- Heat removal: the human body has a thermal efficiency of up to 20%, remaining energy send to the atmosphere
- Supply of oxygen and removal of carbon dioxide
- Removal of body heat dissipated by the occupants
- Removal of moisture dissipated by the occupants
- To provide sufficient air movement and air distribution in occupied space
- To maintain the purity of air by removing odor and dust.

Natural ventilation depends on 6 factors:

1. Building orientation and shape
   – opening and air movement.
2. External elements
   – house surrounding/tree.
3. Cross ventilation
   – allow the air movement from one opening one opening…window, wall….
4. Opening location
5. Opening size
   – high and width of window, double door…
6. Opening control
   – types of opening : sliding/ram window
   - full / half opening…

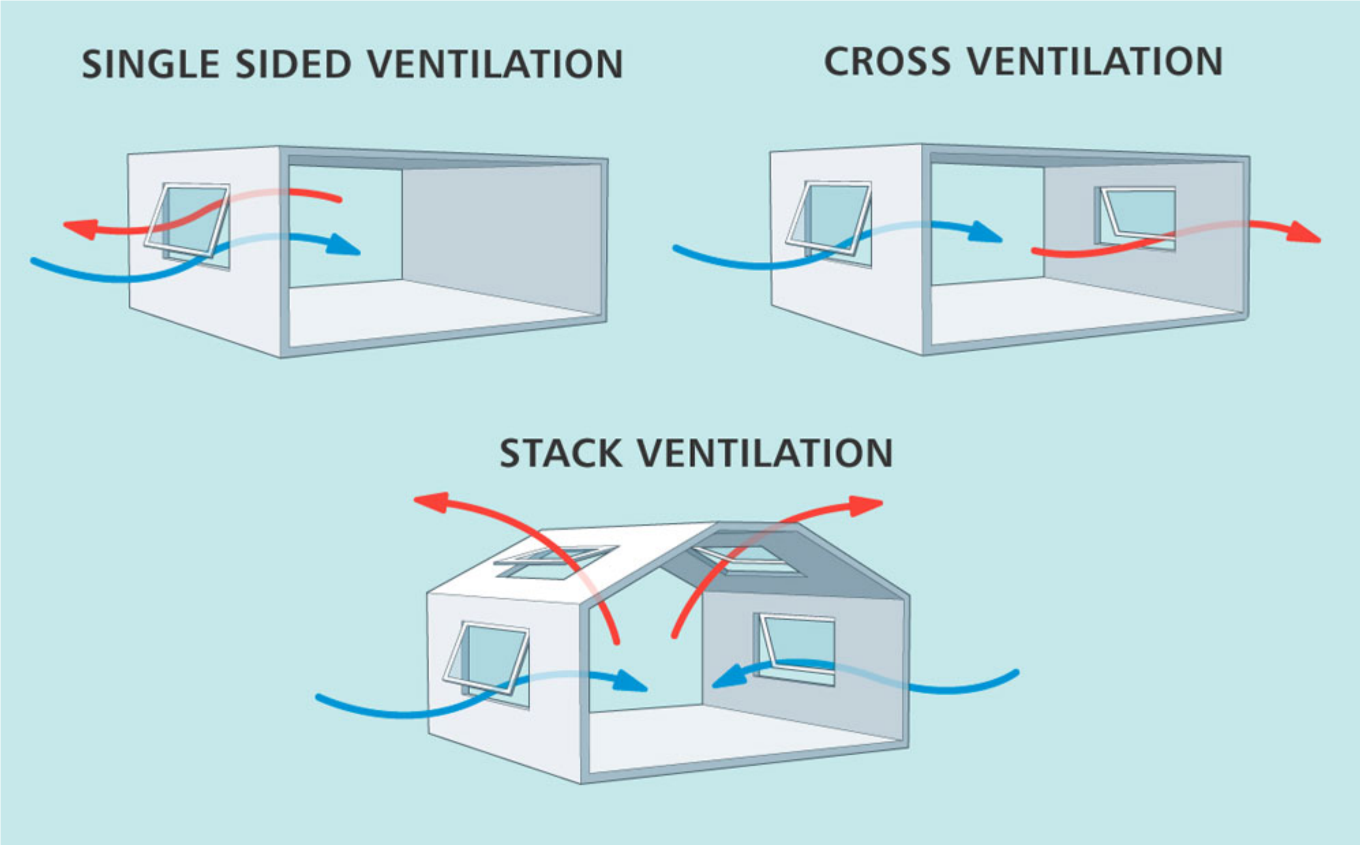




Natural ventilation is a method of supplying fresh air to a building or room by means of passive forces, typically by wind speed or differences in pressure internally and externally.
Natural ventilation relies on natural forces: wind from the surrounding environment as well as buoyancy forces that develop due to temperature gradients within the building.

The following points should be considered while providing natural ventilation in a room:

- Doors and windows should be so located that they provide maximum in-flow air.
- The height of the room should be sufficient to allow air movement.
- Inlet openings should not be obstructed.

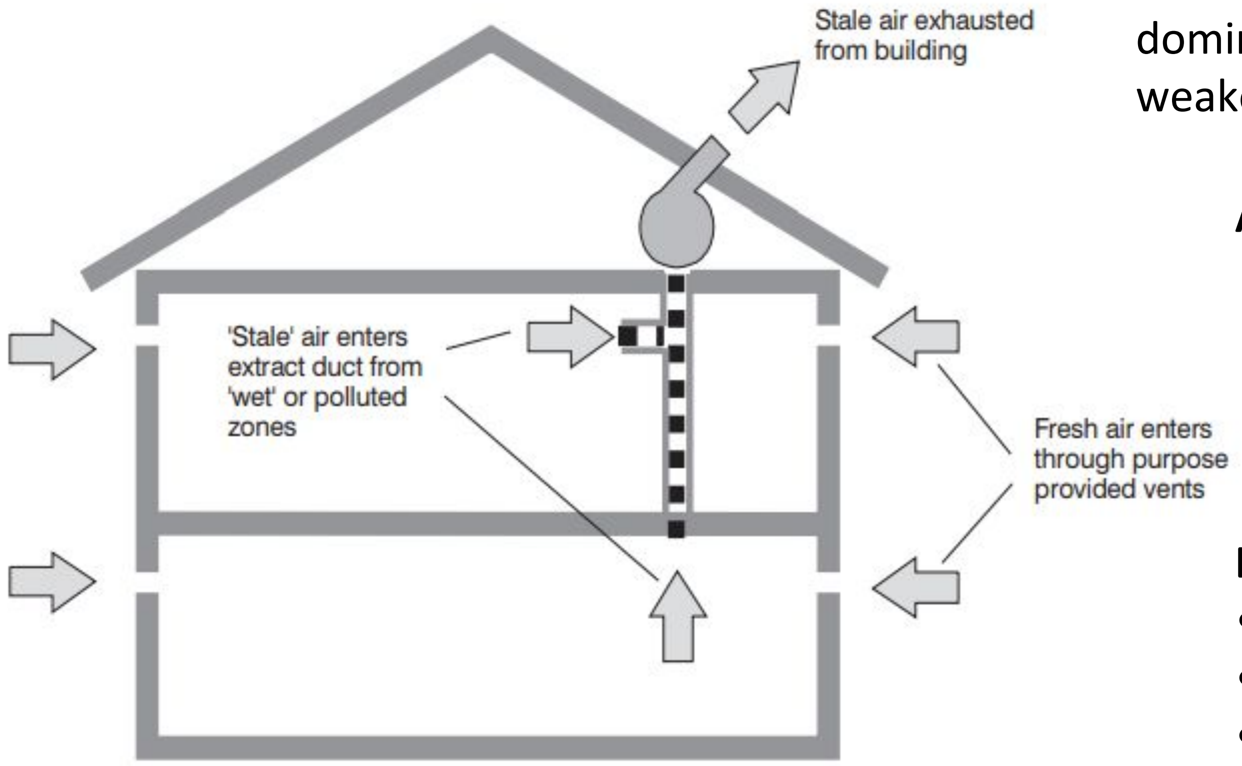


Single-side ventilation involves having openings only on one external wall and generally towards the wind direction. Air exchange happens through wind turbulence.

Cross ventilation, openings are located such that the ones at the receptive end allow maximum inflow of fresh air, and the outlet openings are placed such that the air gets circulated in the space efficiently and is pushed out with the inflow of fresh air.

Stack ventilation is based on the fact that cooler air is light in weight and hot and stale air is heavier. Receptive openings are given on the lower sides in the wind-ward directions and for an outlet, openings are given on the upper side.

Mechanical or Forced Ventilation



Central Mechanical Extract Ventilation (dwellings)

A fan is used to mechanically remove air from a space. This induces a 'suction' or 'under' pressure which promotes the flow of an equal mass of 'make-up' or 'fresh' air into the space through purpose-provided air inlets or infiltration openings. If the under-pressure created by the extract process is greater than that developed by wind and temperature, the flow process is dominated by the mechanical system. If the under-pressure is weaker, then the flow process is dominated by air infiltration.

Advantages

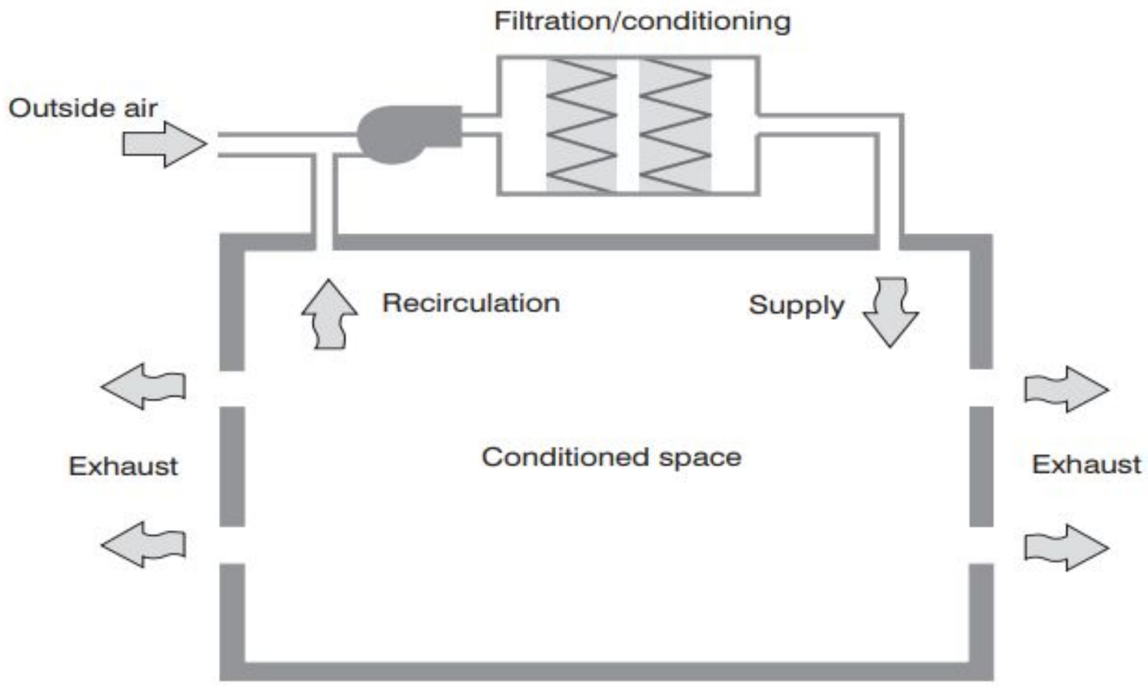
- Controlled ventilation rates are possible. •
- Extraction of pollutants at source reduces the risk of pollutant ingress into occupied spaces.
- The risk of moisture entering walls is reduced.
- Heat recovery from the exhaust air stream is possible.

Disadvantages

- Capital cost is greater than natural ventilation.
- Operational electrical energy is needed.
- System noise can be intrusive.
- Regular cleaning and maintenance are necessary.

Mechanical or Forced Ventilation

Supply (outdoor air) is mechanically introduced into the building where it mixes with the existing air. This process induces a positive (i.e. above atmospheric) pressure in the building. Indoor air is displaced through purpose provided and/or infiltration openings. If the system is well designed and good fabric air-tightness is achieved, supply ventilation inhibits the ingress of infiltrating air and therefore enables all the incoming air to be pre-cleaned and thermally conditioned.



Central Mechanical Supply Ventilation

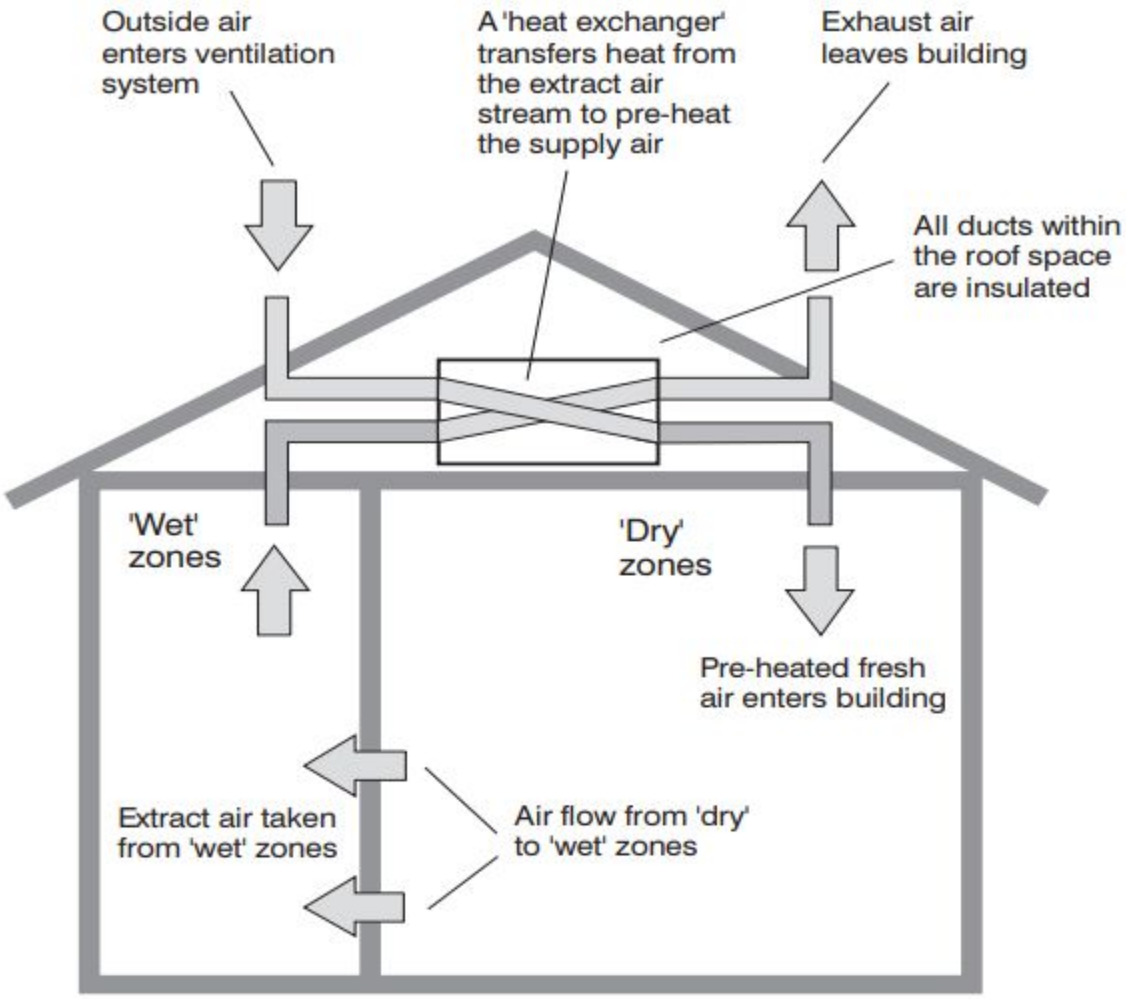
Advantages:

- Outdoor air can be pre-cleaned and conditioned.
- Good air control is possible.
- Entry of outside pollutants and soil gases is inhibited.
- Infiltration can be restricted, provided the structure is fairly airtight.

Disadvantages:

- Indoor moisture sources may be driven into the building.
- Heat recovery is not possible.
- Removal of pollutants at the source is not possible.

Mechanical or Forced Ventilation



Mechanical Balanced Ventilation (dwellings)

Balanced 'mixing' ventilation combines extract and supply systems as separately ducted networks. Typically, the air is supplied and mixed into occupied zones and is extracted from 'polluted' zones An airflow pattern is established between the supply to the extract areas which should be supported by air transfer grilles between rooms. Balanced systems almost always incorporate heat recovery using a plate heat recovery unit or similar air-to-air system. This enables 'free' pre-heating of the incoming air. It is this potential for heat recovery that is often used to justify the additional capital and operating costs. Sometimes an intentional flow imbalance may be introduced to put the building in a slight negative pressure (dwellings) or positive pressure (commercial buildings).

Advantages:

- Allows heat recovery and pre-heating of supply air.
- Supply air is targeted to occupied zones, while air is extracted from polluted zones.
- Filtration of the incoming air is possible.