Mechanical

HEAT TRANSFER

B

Question 1

- **1. Transmission of heat by molecular collision is**
- A. Conduction
- B. Convection
- C. Radiation
- D. Scattering
- E. Transmission

Answer Question 1

- Ans: B
- Convection

Heat transferred

- **Heat** can be **transferred** from one place to another by three **methods**:
- 1- **Conduction** in solids,
- 2- Convection of fluids (liquids or gases), and
- 3- Radiation through anything that will allow radiation to pass.
- The **method** used to **transfer heat** is usually the one that is the most efficient.

Conduction and convection involve particles, but radiation involves electromagnetic waves.

Heat transferred (con.)

- <u>**How does insulation reduce heat loss by conduction?**</u>
- **Heat loss** through walls can be **reduced** using cavity wall **insulation**. This involves blowing **insulating** material into the gap between the brick and the inside wall, which **reduces** the **heat loss** by conduction. The material also prevents air circulating inside the cavity, therefore **reducing heat loss** by convection.
- <u>**What are some examples of convection?**</u>
- Everyday **Examples of Convection**. Boiling water - The heat passes from the burner into the pot, heating the water at the bottom. Then, this hot water rises and cooler water moves down to replace it, causing a circular motion.

Factor affect the rate of heat transfer

- **What can affect the rate of heat transfer?**
- **Factors** that **affect** rate of **heat** flow include the conductivity of the material:-
- 1- Temperature difference across the material,
- 2- Thickness of the material, and
- 3- Area of the material.
- Different materials have greater or lesser resistance to **heat transfer**,making them better insulators or better conductors.

Heat Flow Rate

- **What is heat flow rate?**
- The formula for **rate** of **heat flow** is :
- $\Delta Q/\Delta t = -K \times A \times \Delta T/x$,   Where:-
- 1- [$\Delta Q/\Delta t$] : is the **rate** of **heat flow**;
- 2- [-K] : is the thermal conductivity factor;
- 3- [A] : is the surface area;
- 4- [ΔT] : is the change in temperature and
- 5- [x] : is the thickness of the material
- [$\Delta T/x$] : is called the temperature gradient and is always negative because of the **heat** of **flow.**

Heat transferred (con.)

- **How do you explain convection?**
- Heat energy can transfer by convection when there is a significant difference in temperature between two parts of a fluid. When this temperature difference exists, hot fluids rise and cold fluids sink, and then currents, or movements, are created in the fluid.

Question 2

- **2. Metals are good conductors of heat because**
- A. They contain free electrons
- B. Their atoms are relatively far apart
- C. Their atoms collide frequently
- D. They have reflecting surfaces
- E. None of the above

Answer Question 2

- Ans: A
- They contain free electrons

Metals are good conductors of heat

- **Metals are good conductors of heat**. There are two reasons for this:
- 1- The close packing of the **metal** ions in the lattice.
- 2- The delocalised electrons can carry kinetic energy through the lattice.

- http://resources.schoolscience.co.uk/Corus/16plus/steelch1pg2.html

Question 3

- **3. Heat is shown to be closely related to**
- A. A fluid
- B. Energy
- C. Momentum
- D. Temperature
- E. Waveform

Answer Question 3

- Ans: D
- Temperature

Question 4

- **4. Body A is kept in contact with body B. Heat will flow from A to B, if**
- A. The heat content of A is greater than that of B
- B. The temperature of A is greater than that of B
- C. The specific heat of A is greater than that of B
- D. The specific heat of A is lower than that of B
- E. None of the above

Answer Question 4

- Ans: B
- The temperature of A is greater than that of B

Question 5

- **5. Cork is a good insulator because**
- A. Its density is low
- B. It is porous
- C. It can be powdered
- D. It can be cast into rolls
- E. It is flexible

Answer Question 5

- Ans: B
- It is porous

Cork

- <u>**Is Cork a conductor or insulator?**</u>
- These materials include plastic, **cork**, wood, Styrofoam, and rubber. Thermal insulators are thus **good** at maintaining a consistent level of **heat** — whether hot or cold. ... The thermos acts as an insulator, keeping **heat** out. As you may have guessed by now, insulators make poor **conductors**.
- It is the air which fills the cells in the **cork** that makes it an excellent thermal **insulator**. The same protective principle can also be found in other natural products, such as wool and feathers, and in industry, such as double glazed windows, for example.

Aluminum Foil

- <u>**Is aluminum foil a conductor or an insulator?**</u>
- It can be a good thermal **insulator** if it is applied in loose layers. The metal itself is a good **conductor**, but heat must cross each interface between layers. It is this interface that has poor conductance. The more layers, the better insulation.

Glass

- <u>**Why Glass does not conduct electricity?**</u>
- **No**. It is an **electric** insulator, one of the best actually and is used in very high voltage circuits to isolate the **electric** charge. ... **Glass** is a bad conductor of **electricity** because it **does not** allow electrons and **electric** charge to flow freely, where it thereby makes the flow of **electric** current even more difficult.

Question 6

- 6. Which one of the following cannot be unit of thermal conductivity?
- A. Watt / m2 K
- B. Kcal/m-hr?C
- C. BTU/ft-h?F
- D. cal/c,-sec?K
- E. CHU/ft-hr?C

Answer Question 6

- Ans: A
- Watt / m2 K

Question 7

- **7. Which one of the following will have least value of thermal conductivity?**
- A. Copper
- B. Silver
- C. Glass
- D. Water
- E. Air

Answer Question 7

- Ans: E
- Air

Question 8

- **8. Which one of the following materials will have highest value of thermal conductivity?**
- A.Steel
- B.Aluminium
- C.Brass
- D.Copper
- E.Lead

Answer Question 8

- Ans: E
- Lead

Question 9

- **9. Heat conduction does not occur**
- A. If a physical body is impermeable to any kind of rays
- B. If the parts of a body are not in motion relative to one another
- C. If the bodies are kept in vacuum
- D. If the bodies are immersed in water
- E. If the temperature difference between the bodies does not exist

Answer Question 9

- Ans: E
- If the temperature difference between the bodies does not exist

Question 10

- 10. Unsteady state of heat flow occurs in
- A .Flow of heat through furnace walls
- B. Flow of heat through insulated pipe with constant surface temperature
- C. Annealing of castings
- D. Flow of heat through refrigerator walls
- E. None of the above

Answer Question 10

- Ans: C
- Annealing of castings

- http://www.geekmcq.com/mechanical-engineering/HeatTransfer/discussion-40257

unsteady state

- Heat transfer is the transfer of thermal energy from a body, at a high temperature, to another at a lower temperature. This transfer of thermal energy may occur under steady or **unsteady state** conditions. ... Conversely, under **unsteady state** conditions the temperature within the system does vary with time.

The general gas equation

- The general gas equation is :
  - **PV = mRT**
- http://www.geekmcq.com/mechanical-engineering/methermodynamics/

Question 11

- **11. Heat is transferred by conduction, convection and radiation in**
- A.Insulated pipes carrying hot water
- B.Refrigerator freezer coils
- C.Melting of ice
- D.Boiler furnaces
- E.Condensation of steam in a condenser

Answer Question 11

- Ans: D.
- Boiler furnaces

Question 12

- **12. Transient heat flow occurs in**
- A. Electric conductors carrying current
- B. Insulated pipes carrying superheated steam
- C. Cooling of casting
- D. Heating and cooling of buildings due to sun
- E. Melting of ice

Answer Question 12

- Ans: D.
- Heating and cooling of buildings due to sun

Question 13

- **13. Molecular transmission of heat is smallest in case of**
- A. Gases
- B. Liquids
- C. Liquids with impurities
- D. Solids
- E. Alloys

Answer Question 13

- Ans: A
- Gases

Question 14

- **14. Essential requirement for the transfer of heat from one body to another is**
- A. Both bodies must be solids
- B. Both bodies must be in contact
- C. Temperatures of the two bodies must be different
- D.One of the bodies must have internal source of heat generation
- E.All of the above

Answer Question 14

- Ans: C.
- Temperatures of the two bodies must be different

Question 15

- 15. 40 C is equivalent to
- A. 172 R
- B. 273 K
- C. 500 R
- D. 104 F

Answer Question 15

- Ans: D
- 104 F

Question 16

- **16. The temperature inside a furnace is generally measured by**
- (A.Mercury thermometer
- B.Alcohol thermometer
- C.Gas thermometer
- D.Optical pyrometer
- E.Any of the above

Answer Question 16

- Ans: D
- Optical pyrometer

Question 17

- **17. The rate of heat flow from a 50 mm thick wall of material having thermal conductivity of 40 W/m.C for a temperature difference of 10 oC will be**
- A. 80 W/m2 – hr
- B. 800 W/m2 – hr
- C. 8000 W/m2 – hr
- D. 200 W/m2 – hr
- E. 2000 W/m2 - hr

Answer Question 17

- Ans: C
- 8000 W/m2 – hr

- Heat Flow/unit area = [40*1*(10/.05)]

Heat Loss through Wall

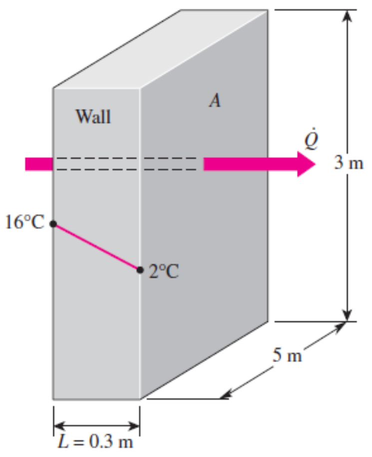

FIGURE 3–11
Schematic for Example 3–1.

The temperature drop across a layer is easily determined from Eq. 3–17 by multiplying $\dot{Q}$ by the thermal resistance of that layer.

The thermal resistance concept is widely used in practice because it is intuitively easy to understand and it has proven to be a powerful tool in the solution of a wide range of heat transfer problems. But its use is limited to systems through which the rate of heat transfer $\dot{Q}$ remains *constant*; that is, to systems involving *steady* heat transfer with *no heat generation* (such as resistance heating or chemical reactions) within the medium.

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·K (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.

Heat Loss through Wall (con.)

- PHOTO\EXAMPLE 3-1 SLOUTION.PNG

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 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·K.

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

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

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

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

Substituting, we get

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

Discussion This is the same result obtained earlier. Note that heat conduction through a plane wall with specified surface temperatures can be determined directly and easily without utilizing the thermal resistance concept. However, the thermal resistance concept serves as a valuable tool in more complex heat transfer problems, as you will see in the following examples. Also, the units W/m·°C and W/m·K for thermal conductivity are equivalent, and thus interchangeable. This is also the case for °C and K for temperature differences.

Question 18

- 18. Pipes are insulated so that
- A. They may not break under pressure
- B. There is minimum corrosion
- C. They can withstand higher fluid pressures
- D. Heat loss from the surface is minimized
- E. Vibrations resulting from fluid flow are minimized

Answer Question 18

- Ans: D
- Heat loss from the surface is minimized

Question 19

- **19. All heat transfer processes**
- A. Involve transfer of energy
- B .Involve temperature difference between the bodies
- C. Obey first law of thermodynamics
- D. Obey second law of thermodynamics
- E. Obey Newton's law

Answer Question 19

- Ans: B
- Involve temperature difference between the bodies

Question 20

- **20. Steady state heat transfer occurs when**
- A. The flow of heat is negligible
- B. The flow of heat is uniform
- C. The flow of heat is independent of time
- D. The flow of heat is uniformly increasing
- E. The flow of heat is uniformly decreasing

Answer Question 20

- Ans: E.
- The flow of heat is uniformly decreasing

Question 21

- **21. There metal walls of same cross-sectional area having thermal conductivity in the ratio 1 : 2 : 4 transfer heat at the rate of 15000 kcal/hr. For same thickness of wall, the temperature drop will be in the ratio**
- A.1 ; 2 ; 4
- B.4 ; 2 ; 1
- C.1 :
- E.1 ; 1 ; 1

Answer Question 21

- Ans: C
- 1 :

Thermal diffusivity

- Thermal diffusivity is a measure of the transient thermal response of a material to a change in temperature and the term thermal diffusivity (a) is defined as

- $$a = k/(\rho \times c_p)$$

- Where:
- a : is the thermal diffusivity (m^2/sec)
- k : is the thermal conductivity (W/m-K)
- ρ : is the density (kg/m^3)
- c_p : is the heat capacity (J/kg-K)

Question 22

22. Thermal diffusivity is

- A. A mathematical formula only
- B. A physical property of the material
- C. A configuration for heat conduction
- D. A dimensionless parameter
- E. A function of temperature

Answer Question 22

- Ans: B
- A physical property of the material

Question 23

- **The unit of thermal diffusivity is**
- A. m/hr
- B. m2/hr
- C. m/hr.C
- D. m2/hr.C
- E. kcal/m2-hr

Answer Question 23

- Ans: B
- m2/hr

Question 24

- **24. Non-isotropic conductivity is exhibited in case of**
- (A.Brass
- B.Steel
- C.Copper
- D.Lead
- E.Wood

Answer Question 24

- Ans: E
- Wood

Thermal conductivity

- Thermal **conductivity** (often denoted k, λ, or κ) is the property of a material to conduct heat.
- It is evaluated primarily in terms of Fourier's Law for heat conduction
- Heat transfer occurs at a lower rate across materials of low thermal conductivity than across materials of high thermal conductivity
- Correspondingly, materials of high thermal conductivity are widely used in heat sink applications and materials of low thermal conductivity are used as thermal insulation.
- The thermal conductivity of a material may depend on temperature
- The reciprocal of thermal conductivity is called thermal resistivity.

Thermal conductivity (CON.)

- In SI units, thermal conductivity is measured in watts per meter-kelvin (W/(m·K)). The dimension of thermal conductivity is $M^1L^1T^{-3}\Theta^{-1}$. These variables are mass (M), length (L), time (T), and temperature (Θ). In Imperial units, thermal conductivity is measured in BTU/(hr·ft·°F).
- Other units which are closely related to the thermal conductivity are in common use in the construction and textile industries.
- The construction industry makes use of units such as the R-value (resistance) and the U-value (transmittance). Although related to the thermal conductivity of a material used in an insulation product, R- and U-values are dependent on the thickness of the product.
- Likewise the textile industry has several units including the tog and the clo which express thermal resistance of a material in a way analogous to the R-values used in the construction industry

Question 25

- **25. For glass wool the thermal conductivity varies from sample to sample because of variations in**
- A. Structure
- B. Composition
- C. Density
- D. Porosity
- E. All of the above

Answer Question 25

- Ans: E
- All of the above