Chapter 22 Heat Transfer Exercises Answers

Name ________________ Class ____________ Date ________

Chapter 22 Heat Transfer

Exercises

22.1 Conduction (pages 431–432)

1. Define conduction.

2. What is a conductor?

3. ________________ are the best conductors.
4. In conduction, ________________ between particles transfer thermal energy.
5. Is the following sentence true or false? Conduction occurs without any overall transfer of matter. ________________
6. Is the following sentence true or false? Materials that are good conductors of heat are usually poor conductors of electricity. ________________
7. Imagine stepping with one bare foot onto metal and with the other bare foot onto wood. Explain why the metal feels cool and the wood feels warm, even though they have the same temperature.

8. Define insulator.

9. How do birds vary their insulation?

10. Classify each of the following materials by writing *C* beside each conductor and *I* beside each insulator.

____ a. wood
____ b. aluminum
____ c. straw
____ d. silver
____ e. air
____ f. cork
____ g. iron
____ h. wool
____ i. paper
____ j. copper
____ k. polystyrene

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Chapter 22 heat transfer exercises answers are crucial for students and professionals alike who are delving into the fascinating world of thermodynamics and heat transfer. Understanding the principles of heat transfer is essential in various fields, including engineering, meteorology, and environmental science. This chapter often presents a range of problems that test one’s comprehension of heat transfer mechanisms such as conduction, convection, and radiation. In this article, we will explore the key concepts related to heat transfer, discuss common exercises found in Chapter 22, and provide answers and explanations for these exercises.

Understanding Heat Transfer

Heat transfer is the movement of thermal energy from one object or substance to another due to temperature differences. The primary modes of heat transfer include:

1. Conduction: The transfer of heat through a solid material without any motion of the material itself. This occurs at the molecular level, where faster-moving molecules collide with slower ones, transferring energy.
2. Convection: The transfer of heat by the physical movement of a fluid (liquid or gas). This process involves the mixing of the fluid, which distributes heat throughout.
3. Radiation: The transfer of energy through electromagnetic waves. This method does not require a medium and can occur in a vacuum.

Each of these modes has unique characteristics and equations associated with them, which are often explored through various exercises in educational settings.

Common Exercises in Chapter 22

Exercises in Chapter 22 typically encompass a range of difficulty levels and applications. Here are some common types of exercises found in this chapter:

1. Conduction Problems

These problems often involve calculating the rate of heat transfer through materials using Fourier's law of heat conduction:

$$
Q = -k \cdot A \cdot \frac{dT}{dx}
$$

Where:
- Q is the heat transfer rate (W)
- k is the thermal conductivity (W/m·K)
- A is the area through which heat is being transferred (m^2)
- $\frac{dT}{dx}$ is the temperature gradient (K/m)

2. Convection Problems

Convection problems may require the use of Newton's law of cooling:

$$
Q = h \cdot A \cdot (T_s - T_\infty)
$$

Where:
- h is the convective heat transfer coefficient ($W/m^2 \cdot K$)
- T_s is the surface temperature (K)
- T_∞ is the fluid temperature far from the surface (K)

3. Radiation Problems

Radiation exercises often involve Stefan-Boltzmann law, which states:

$$
Q = \epsilon \cdot \sigma \cdot A \cdot (T^4 - T_{env}^4)
$$

Where:
- ϵ is the emissivity of the surface
- σ is the Stefan-Boltzmann constant ($5.67 \times 10^{-8} \, \text{W/m}^2\cdot$

\text{K}^4\))
- T is the absolute temperature of the surface (K)
- T_{env} is the absolute temperature of the environment (K)

Detailed Solutions to Selected Exercises

Let us delve into some example exercises and provide detailed solutions to illustrate the application of the aforementioned principles.

Exercise 1: Heat Transfer by Conduction

Problem: A metal rod of length 2 m and cross-sectional area 0.01 m^2 has one end maintained at 100°C and the other at 20°C. The thermal conductivity of the metal is 200 W/m·K. Calculate the rate of heat transfer through the rod.

Solution:

1. Given:
- Length, $L = 2 \, \text{m}$
- Area, $A = 0.01 \, \text{m}^2$
- Thermal conductivity, $k = 200 \, \text{W/m·K}$
- $T_1 = 100 \, \text{°C}$
- $T_2 = 20 \, \text{°C}$

2. Calculate the temperature gradient:

$$
\frac{dT}{dx} = \frac{T_1 - T_2}{L} = \frac{100 - 20}{2} = 40 \, \text{°C/m}
$$

3. Apply Fourier’s law:

$$
Q = -k \cdot A \cdot \frac{dT}{dx} = -200 \cdot 0.01 \cdot 40 = -80 \, \text{W}
$$

Thus, the rate of heat transfer through the rod is 80 W.

Exercise 2: Heat Transfer by Convection

Problem: A hot plate at a temperature of 150°C is placed in a room where the air temperature is 25°C. If the convective heat transfer coefficient between the plate and the air is 25 W/m^2·K and the area of the plate is 0.5 m^2, calculate the rate of heat loss from the plate.

Solution:

1. Given:

- $T_s = 150 \, \text{°C}$
- $T_\infty = 25 \, \text{°C}$
- $h = 25 \, \text{W/m²·K}$
- $A = 0.5 \, \text{m}^2$

2. Apply Newton's law of cooling:

$$
Q = h \cdot A \cdot (T_s - T_\infty) = 25 \cdot 0.5 \cdot (150 - 25) = 25 \cdot 0.5 \cdot 125 = 1562.5 \, \text{W}
$$

Thus, the rate of heat loss from the plate is 1562.5 W.

Exercise 3: Heat Transfer by Radiation

Problem: A black body at a temperature of 600 K radiates heat to the surroundings at 300 K. Calculate the rate of heat loss from the body if its surface area is 1 m^2.

Solution:

1. Given:
- $T = 600 \, \text{K}$
- $T_{env} = 300 \, \text{K}$
- $A = 1 \, \text{m}^2$
- $\epsilon = 1$ (for a black body)
- $\sigma = 5.67 \times 10^{-8} \, \text{W/m}^2\cdot \text{K}^4$

2. Apply Stefan-Boltzmann law:

$$
Q = \epsilon \cdot \sigma \cdot A \cdot (T^4 - T_{env}^4)
$$

$$
Q = 1 \cdot 5.67 \times 10^{-8} \cdot 1 \cdot (600^4 - 300^4)
$$

Calculating 600^4 and 300^4:
- $600^4 = 1.296 \times 10^{11}$
- $300^4 = 8.1 \times 10^9$

So:

$$
Q = 5.67 \times 10^{-8} \cdot (1.296 \times 10^{11} - 8.1 \times 10^9) = 5.67 \times 10^{-8} \cdot 1.215 \times 10^{11} \approx 6.9 \, \text{W}
$$

Thus, the rate of heat loss from the body is approximately 6.9 W.

Conclusion

In summary, Chapter 22 heat transfer exercises answers provide invaluable insights into the principles of heat transfer and their practical applications. By solving problems related to conduction, convection, and radiation, students can better understand how thermal energy moves through different materials and environments. Mastering these concepts not only prepares individuals for academic success but also equips them with essential skills applicable in various engineering and scientific fields. Whether through theoretical exercises or real-world applications, the knowledge gained from this chapter serves as a foundation for further exploration into the dynamics of heat transfer.

Frequently Asked Questions

What is the primary focus of chapter 22 in heat transfer studies?

Chapter 22 primarily focuses on the methods and principles of heat transfer, including conduction, convection, and radiation, along with relevant exercises to apply these concepts.

What types of exercises are included in chapter 22 of heat transfer?

Chapter 22 includes various exercises such as numerical problems, conceptual questions, and practical applications related to heat transfer calculations and scenarios.

How can I access the answers to the exercises in chapter 22?

The answers to the exercises in chapter 22 are typically provided in the textbook's solution manual, or they may be available online through educational resources or the publisher's website.

Are the exercise answers in chapter 22 intended for self-study or classroom use?

The exercise answers in chapter 22 are designed for both self-study and classroom use, helping students verify their solutions and understand the underlying concepts.

What skills can be developed by completing the exercises in chapter 22?

Completing the exercises in chapter 22 helps develop critical problem-solving skills, enhances understanding of heat transfer principles, and improves mathematical application in engineering contexts.

Can I find video explanations for the exercises in chapter 22?

Yes, many educational platforms and YouTube channels offer video explanations and step-by-step solutions for exercises in chapter 22 of heat transfer textbooks.

What is the significance of understanding heat transfer concepts in engineering?

Understanding heat transfer concepts is crucial in engineering as it impacts the design of thermal systems, energy efficiency, and safety in various applications, such as HVAC, chemical processes, and material processing.

How do the exercises in chapter 22 relate to real-world applications?

The exercises in chapter 22 are designed to reflect real-world applications of heat transfer, such as heating and cooling systems, thermal insulation, and energy management, making the concepts more relevant to practical engineering challenges.

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