GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO W24 – QUESTION BANK

Subject Name & Code:

Advanced Heat Transfer- 3171911

Unit 1: Conduction

Repeated Questions:

1. **Define/Explain Thermal Contact Resistance and the parameters it depends on.**
   - **Appeared in:** Summer 2023 (03 Marks), Winter 2023 (03 Marks), Winter 2024 (03 Marks).
   - **Total Marks Weightage:** 9 Marks over 3 exams.
2. **Write the general heat conduction equation in Cartesian coordinates and derive it for specific cases (Steady state with heat generation, Unsteady state without generation, etc.).**
   - **Appeared in:** Winter 2022 (03 Marks), Winter 2023 (07 Marks), Winter 2024 (07 Marks).
   - **Total Marks Weightage:** 17 Marks over 3 exams.
3. **Explain the Finite Difference Method for solving multi-dimensional steady-state heat conduction problems.**
   - **Appeared in:** Winter 2022 (07 Marks), Summer 2023 (07 Marks), Winter 2023 (07 Marks), Winter 2024 (07 Marks).
   - **Total Marks Weightage:** 28 Marks over 4 exams. **(Very Important)**
4. **What is Lumped Parameter Analysis? How does it differ from Heisler's chart analysis?**
   - **Appeared in:** Summer 2023 (04 Marks), Summer 2022 (04 Marks), Summer 2024 (04 Marks), Winter 2024 (04 Marks).
   - **Total Marks Weightage:** 16 Marks over 4 exams. **(Very Important)**
5. **Explain the function of extended surfaces (fins) with classification.**
   - **Appeared in:** Winter 2023 (03 Marks), Summer 2024 (03 Marks).
   - **Total Marks Weightage:** 6 Marks over 2 exams.
6. **Derive the equation for heat dissipation for an infinitely long fin.**
   - **Appeared in:** Winter 2022 (04 Marks), Winter 2023 (07 Marks), Summer 2024 (04 Marks).
   - **Total Marks Weightage:** 15 Marks over 3 exams.
7. **Define Biot Number and state its significance.**
   - **Appeared in:** Winter 2023 (03 Marks), Summer 2022 (03 Marks).
   - **Total Marks Weightage:** 6 Marks over 2 exams.
8. **What are the initial and boundary conditions in conduction heat transfer?**
   - **Appeared in:** Summer 2023 (03 Marks), Summer 2022 (03 Marks).
   - **Total Marks Weightage:** 6 Marks over 2 exams.

Other Important Questions:

- **From Summer 2023:**
  - (Q1a) Define transient, non-periodic, and periodic heat conduction with examples. (03 Marks)
  - (Q1b) What are Biot and Fourier numbers? Explain their physical significance. (04 Marks)
  - (Q1c) **Numerical:** Derive a general heat conduction equation in spherical coordinates. (07 Marks)
  - (Q2c) **Numerical:** The inside dimensions of a small cubical furnace constructed of fire clay bricks (k = 1.05 W/m°C) are 0.6 m x 0.6 m x 0.6 m; the walls being of 0.12 m thick. The temperatures at the inside and outside surfaces are 600°C and 70°C respectively. Determine the heat lost through the walls. (07 Marks)
  - (Q2c-OR) Explain radial fins of rectangular and hyperbolic profiles- longitudinal fin of rectangular profile radiating to free space. (07 Marks)
  - (Q3a) Explain effectiveness of fin. (03 Marks)
  - (Q3c) **Numerical:** An egg with mean diameter of 40 mm and initially at 20°C is placed in a boiling water pan for 4 minutes and found to be boiled to the consumer's taste. For how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5°C? Use lumped theory. (Properties given). (07 Marks)
  - (Q3-OR a) Define a semi-infinite body. What is error function? (03 Marks)
- **From Winter 2022:**
  - (Q1c) Explain finite difference method for two-dimensional steady heat conduction. (07 Marks)
  - (Q2c) **Numerical:** A stainless steel wire of length 2 m and diameter 2.5 mm is submerged in a fluid at 50°C and an electric current of intensity 300 amps passes through it. If conductance at wire surface is 4 kW/m²-deg, workout the steady state temperature i) at the centre and ii) at surface of wire. (Properties given). (07 Marks)
  - (Q2c-OR) Explain the analytical method for two-dimensional steady state heat conduction in a rectangular plate. (07 Marks)
- **From Winter 2023:**
  - (Q2c-OR) Derive Temperature distribution relation for cylinder with Steady state and uniform heat generation. (07 Marks)
  - (Q3a) Interpret Grashof number and Rayleigh number with mathematical formula. Also explain their significance in natural convection heat transfer. (03 Marks)
  - (Q3c) Define these terms used in the finite difference formulation: node, nodal network, volume element, nodal spacing, and difference equation. (07 Marks)
- **From Summer 2022:**

- (Q1a) Hot air is to be cooled as it is forced to flow through the tubes exposed to atmospheric air. Fins are to be added... Would you recommend attaching the fins inside or outside the tubes? Why? (03 Marks)
- (Q1b) Derive the expression of temperature distribution in a plane wall with uniform heat generation. (04 Marks)
- (Q1c) **Numerical:** A 60 mm thick large steel plate ($k = 42.6$ W/m°C, $\alpha = 0.043$ m²/h), initially at 440°C is suddenly exposed on both side to an environment... Calculate temperature at mid-plane using chart... (07 Marks)
- (Q2c-OR) **Numerical:** A cylindrical shell of inner and outer radii, ri and ro respectively, is filled with a heat generating material... 1) Obtain an expression for the steady state temperature distribution, T(r), in the shell... 2) Determine an expression for the heat rate... (07 Marks)
- (Q3a) For which solid is the lumped system analysis more likely to be applicable? Why? (03 Marks)

- **From Summer 2024:**
  - (Q1c) Explain graphical method used for two-dimensional steady state conduction analysis. (07 Marks)
  - (Q2c) **Numerical:** One end of a long rod of 1 cm diameter is maintained at 500°C... The temperature measured at a distance of 78.6 mm was 147.5°C. Determine the thermal conductivity of the material. (07 Marks)
  - (Q2c-OR) **Numerical:** A cylinder of diameter 0.6 m with surface temperature of 200°C is enclosed in a square of 1.2 m side... Determine the heat loss per 15 m length. (07 Marks)
  - (Q3c) Explain temperature distribution and heat loss for fins of uniform cross-section with different tip conditions. (07 Marks)
  - (Q3-OR a) Define effectiveness of fin and state its equation. (03 Marks)
  - (Q3-OR c) **Conceptual/Numerical:** Compare the heat transfer coefficients for the condition of two-fold increase in the diameter of the tube... (07 Marks)
- **From Winter 2024:**
  - (Q1a) Define Non-periodic and periodic heat conduction with examples? (03 Marks)
  - (Q3a) What is thermal symmetry boundary condition? How is it expressed mathematically? (03 Marks)
  - (Q3-OR b) Explain lumped capacity? Also write the assumptions for the same in detail? (04 Marks)

Unit 2: Convection

Repeated Questions:

1. **Explain with a neat sketch why flow separation over cylinders is delayed in turbulent flow.**
    - **Appeared in:** Summer 2023 (03 Marks), Summer 2024 (04 Marks), Winter 2023 (03 Marks), Winter 2024 (03 Marks).
    - **Total Marks Weightage:** 13 Marks over 4 exams. **(Very Important)**
2. **Explain the concept of Free and Forced convection with suitable examples.**
    - **Appeared in:** Summer 2022 (04 Marks), Winter 2024 (04 Marks).
    - **Total Marks Weightage:** 8 Marks over 2 exams.
3. **Define/Explain the following dimensionless numbers: Nusselt Number, Reynolds Number, Prandtl Number.**
    - **Appeared in:** Winter 2022 (03 Marks), Winter 2023 (07 Marks), Winter 2024 (04 Marks).
    - **Total Marks Weightage:** 14 Marks over 3 exams.
4. **Discuss/Explain heat transfer in high velocity flow.**
    - **Appeared in:** Summer 2024 (03 Marks), Winter 2022 (03 Marks).
    - **Total Marks Weightage:** 6 Marks over 2 exams.
5. **Discuss various theoretical/empirical equations to predict natural convection heat transfer coefficient.**
    - **Appeared in:** Summer 2022 (07 Marks), Summer 2024 (07 Marks).
    - **Total Marks Weightage:** 14 Marks over 2 exams.

Other Important Questions:

- **From Summer 2023:**
    - (Q3-OR b) What is the criterion for transition from laminar to turbulent boundary layer in free convection on a vertical plate? (04 Marks)
    - (Q4b) Derive the Nusselt theory of laminar flow film condensation on a vertical plate? (04 Marks)
    - (Q4c) **Derivation:** Derive expressions for boundary layer thickness and local skin friction coefficient following the Blasius method for a flat plate. (07 Marks)
    - (Q4-OR b) Discuss the significance of bulk temperature in case of fully developed laminar flow in a tube. (04 Marks)
    - (Q4-OR c) **Numerical:** A vertical plate 500 mm high and maintained at 30°C is exposed to saturated steam at atmospheric pressure. Calculate (i) The rate of heat transfer, and (ii) The condensate rate per hour per metre of the plate width for film condensation. (Properties given). (07 Marks)
- **From Winter 2022:**
    - (Q3b) Write the correlations for free convection for vertical plates. (04 Marks)
    - (Q3c) Discuss the hydrodynamic boundary layer on a flat plate. (07 Marks)

- **From Winter 2023:**
    - (Q3a) Interpret Grashof number and Rayleigh number... (Also covered in Unit 1, but highly relevant here). (03 Marks)
    - (Q3c) Define: Nusselt Number, Reynolds Number, Prandtl Number and give conventional generalized basic equation for forced convection using these numbers. (07 Marks)
- **From Summer 2022:**
    - (Q4c) **Numerical:** Air at 2 atm and 200°C is heated as it flows through a tube with a diameter of 1 inch at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube... How much would the bulk temperature increase over a 3 m length of the tube? (Properties and correlation given). (07 Marks)
    - (Q4-OR c) **Numerical:** Water at 5 atm flows inside a tube of 2.54 cm diameter under local boiling conditions... Estimate the heat transfer in a 1.0 m length of tube. (Correlation given). (07 Marks)
- **From Summer 2024:**
    - (Q3-OR c) **Conceptual/Numerical:** Compare the heat transfer coefficients for a two-fold increase in tube diameter with constant velocity (turbulent flow). (07 Marks)
- **From Winter 2024:**
    - (Q4b) Define following finite difference terms: 1) Node 2) Network (04 Marks) *(Note: This is more relevant to Unit 1 but asked in a Convection context)*

Unit 3: Convection with Phase Change

Repeated Questions:

1. **Draw the boiling curve and identify the burnout point. Explain its cause and why it is avoided in boiler design.**
    - **Appeared in:** Summer 2022 (07 Marks), Winter 2024 (07 Marks).
    - **Total Marks Weightage:** 14 Marks over 2 exams. **(Very Important)**
2. **What are the factors affecting Nucleate boiling?**
    - **Appeared in:** Summer 2023 (03 Marks), Summer 2024 (03 Marks).
    - **Total Marks Weightage:** 6 Marks over 2 exams.
3. **Define condensation. Differentiate between Filmwise and Dropwise condensation. Which is more effective?**
    - **Appeared in:** Winter 2022 (03 Marks), Winter 2023 (07 Marks), Winter 2024 (07 Marks).
    - **Total Marks Weightage:** 17 Marks over 3 exams. **(Very Important)**
4. **What are the effects of non-condensable gases in condensing equipment?**
    - **Appeared in:** Winter 2023 (04 Marks), Winter 2024 (03 Marks).
    - **Total Marks Weightage:** 7 Marks over 2 exams.
5. **Discuss different boiling regimes in the boiling process.**
    - **Appeared in:** Winter 2022 (07 Marks), Winter 2024 (07 Marks).
    - **Total Marks Weightage:** 14 Marks over 2 exams.

Other Important Questions:

- **From Summer 2023:**
    - (Q5a) Explain briefly the physical mechanism of boiling and condensation. (03 Marks)
    - (Q4b) Derive the Nusselt theory of laminar flow film condensation on a vertical plate. (04 Marks) *(Also listed in Unit 2 as it's a fundamental derivation)*
    - (Q4-OR c) **Numerical:** A vertical plate 500 mm high and maintained at 30°C is exposed to saturated steam at atmospheric pressure. Calculate the rate of heat transfer and condensate rate. (Properties given). (07 Marks)
- **From Winter 2022:**
    - (Q4c) **Numerical:** One hundred tubes of 12 mm in diameter are arranged in a square array and are exposed to steam at atmospheric pressure, calculate the mass of steam condensed per unit length of tube if the tube wall temperature remains at 98 °C. (Properties given). (07 Marks)
    - (Q4-OR a) List the applications where heat transfer with phase change is to be considered. (03 Marks)
    - (Q4-OR b) Derive the equation of critical diameter of a bubble. (04 Marks) *(Advanced topic)*
    - (Q3b) Explain the principle of a heat pipe. (04 Marks)
- **From Winter 2023:**
    - (Q4a) Write a short note on liquid-metal heat transfer. (03 Marks)
    - (Q4c) What is an irregular boundary? How is it handled in the finite difference method? (07 Marks) *(More relevant to Unit 1)*
    - (Q4-OR a) Write a short note on high velocity flow. (03 Marks) *(Relevant to Unit 2)*
- **From Summer 2022:**
    - (Q2b) Discuss different modes of the condensation process with their application. Why is dropwise condensation preferred? (04 Marks)

  - (Q2c) **Numerical:** An electric wire of 1.25 mm diameter and 250 mm long is laid horizontally and submerged in water at 7 bar... Calculate the heat flux and boiling heat transfer coefficient. (Properties given). (07 Marks)
  - (Q3c) Draw the boiling curve and identify the burnout point... (07 Marks)
- **From Summer 2024:**
  - (Q4a) State the applications of boiling heat transfer. (03 Marks)
  - (Q4b) Draw the boiling curve and identify the burnout point on the curve. (04 Marks)
  - (Q4-OR b) Differentiate between pool boiling and forced convection boiling. (04 Marks)
  - (Q4-OR c) Discuss different types of processes for condensation of vapour on a solid surface. (07 Marks)
- **From Winter 2024:**
  - (Q3-OR c) Draw the boiling curve and identify the burnout point on the curve. Explain how burnout is caused. Why is the burnout point avoided in the design of boilers? (07 Marks) *(Listed above as repeated)*
  - (Q4c) Discuss different boiling regimes in the boiling process. (07 Marks) *(Listed above as repeated)*

Unit 4: Radiation

Repeated Questions:

1. **Define Intensity of Radiation. How is the solid angle measured?**
   - **Appeared in:** Summer 2023 (03 Marks), Summer 2022 (03 Marks), Winter 2022 (03 Marks), Summer 2024 (03 Marks), Winter 2024 (04 Marks).
   - **Total Marks Weightage:** 16 Marks over 5 exams. **(Extremely Important)**
2. **Explain Kirchhoff's Law and define Emissivity.**
   - **Appeared in:** Winter 2023 (03 Marks), Winter 2022 (03 Marks), Winter 2024 (03 Marks).
   - **Total Marks Weightage:** 9 Marks over 3 exams.
3. **Write a short note on the Greenhouse Effect.**
   - **Appeared in:** Winter 2023 (04 Marks), Winter 2022 (04 Marks), Winter 2024 (07 Marks).
   - **Total Marks Weightage:** 15 Marks over 3 exams.
4. **Explain Radiation Shape Factor / View Factor.**
   - **Appeared in:** Winter 2023 (03 Marks), Summer 2024 (04 Marks).
   - **Total Marks Weightage:** 7 Marks over 2 exams.
5. **Derive the equation for heat flow between infinite long parallel plates.**
   - **Appeared in:** Winter 2023 (07 Marks), Winter 2022 (07 Marks).
   - **Total Marks Weightage:** 14 Marks over 2 exams.

Other Important Questions:

- **From Summer 2023:**
  - (Q5b) What do you mean by thermal capacity and thermal diffusivity of material? Explain with example. (04 Marks) *(More relevant to Unit 1)*
  - (Q5c) Derive expressions for the radiation heat exchange for two gray surfaces connected by a single refractory surface. (07 Marks)
  - (Q5-OR b) Write a short note on radiation from gases, vapours, and flames. (04 Marks)
  - (Q5-OR c) **Numerical:** For a hemispherical furnace, the flat floor is at 700 K (ε=0.5). The hemispherical roof is at 1000 K (ε=0.25). Find the net radiative heat transfer from roof to floor. (07 Marks)
- **From Winter 2022:**
  - (Q5b) **Numerical:** Black body of 0.2 m² area has effective temperature of 800 K. Calculate the total rate of energy emission and the intensity of normal radiation. (04 Marks)
  - (Q5-OR c) Discuss the salient features of radiation from gases and vapors. (07 Marks)
- **From Winter 2023:**
  - (Q5b) Explain all the different mechanisms of heat transfer from the human body (a) through the skin and (b) through the lungs. (04 Marks)
  - (Q5c) Write a note on Emissivity and absorptivity of gases and gas mixtures. (07 Marks)
  - (Q5-OR a) Write the statement of Kirchoff's law and define emissivity. (03 Marks) *(Listed as repeated)*
- **From Summer 2022:**

  - (Q5b) Explain heat transfer mechanism from human body. (04 Marks)
  - (Q5c) **Numerical:** The overall heat transfer coefficient due to convection and radiation for a steam pipe... is 18 W/m²K. Calculate heat transfer coefficient due to convection and radiation taking the emissivity of the pipe surface as 0.81. (07 Marks)
- **From Summer 2024:**
  - (Q5a) State reciprocity theorem for shape factors. (03 Marks)
  - (Q5b) Using Planck's equation derive the Stefan-Boltzmann equation for emissive power of a black surface. (04 Marks) *(Important derivation)*
  - (Q5c) Explain combined heat transfer coefficient with convection and radiation. (07 Marks)
  - (Q5-OR c) **Numerical:** The heat transfer coefficient including convection radiation is 30 W/m²°C for the outer surface of a pipe... Calculate the radiation heat transfer coefficient... Also find heat transfer coefficient by convection. (07 Marks)
- **From Winter 2024:**
  - (Q5a) Explain Kirchhoff's law. (03 Marks) *(Listed as repeated)*
  - (Q5b) What is radiation? Define intensity of radiation. (04 Marks)
  - (Q5-OR a) Define following terms. 1) Emissivity 2) Solid Angle (03 Marks)
  - (Q5-OR b) Explain radiation effect on temperature measurement. (04 Marks)
  - (Q5-OR c) Derive expressions for the radiation heat exchange for two gray surfaces connected by a single refractory surface. (07 Marks)

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