GUJARAT TECHNOLOGICAL UNIVERSITY

BE-4 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:
Heat Transfer (3140503)

Unit 1 – Introduction & Conduction

Repeated Questions:

1. **Explain thermal conductivity of gases, liquids, and solids.**
   - Appeared in: S25 (Q1a, 03 marks), W25 (Q1b, 04 marks), S23 (Q3a, 03 marks), W23 (Q1a, 03 marks)
2. **Derive the equation for heat transfer through a composite wall.**
   - Appeared in: S25 (Q2c OR, 07 marks), W25 (Q1c, 07 marks), S22 (Q1c, 07 marks), W24 (Q1c, 07 marks)
3. **Define and derive the critical radius of insulation.**
   - Appeared in: S24 (Q1c, 07 marks), W25 (Q2b, 04 marks), S23 (Q1b, 04 marks), W22 (Q2b, 04 marks)
4. **Explain Fourier's law of heat conduction.**
   - Appeared in: W25 (Q1a, 03 marks), S22 (Q3a, 03 marks)

Other Important Questions:

1. **List the properties of insulating materials.**
   - Appeared in: S25 (Q1b, 04 marks)
2. **Determine heat loss through a composite wall (numerical).**
   - Appeared in: S25 (Q2c, 07 marks), S24 (Q1b, 04 marks), S23 (Q1c, 07 marks), W23 (Q2c, 07 marks), W22 (Q2c, 07 marks)
3. **Discuss the effect of temperature on thermal conductivity of solids, liquids, and gases.**
   - Appeared in: W25 (Q1b, 04 marks), S23 (Q3a, 03 marks)
4. **Explain unsteady-state heat transfer and Biot number correlation.**
   - Appeared in: W23 (Q1b, 04 marks)
5. **Write examples illustrating the importance of heat transfer in engineering.**
   - Appeared in: W22 (Q1b, 04 marks)
6. **Distinguish between conduction, convection, and radiation.**
   - Appeared in: W22 (Q1a, 03 marks)
7. **Explain heat transfer with and without phase change.**
   - Appeared in: S22 (Q1a, 03 marks)

Unit 2 – Convection

Repeated Questions:

1. **Explain velocity and thermal boundary layers and relate them to dimensionless numbers.**
    - Appeared in: S24 (Q2b, 04 marks), S22 (Q2b, 04 marks), W22 (Q3b, 04 marks)
2. **Give physical significance of Prandtl, Nusselt, Grashof, Biot, Peclet numbers.**
    - Appeared in: S25 (Q3a, 03 marks), S24 (Q2a, 03 marks), S22 (Q2a, 03 marks), W25 (Q3a, 03 marks), W23 (Q3b, 04 marks)
3. **Derive expression for forced convection in turbulent flow using dimensional analysis.**
    - Appeared in: S25 (Q3c, 07 marks), W25 (Q2c, 07 marks), W23 (Q3c, 07 marks)

Other Important Questions:

1. **Explain natural convection phenomenon.**
    - Appeared in: S25 (Q3b, 04 marks)
2. **Calculate heat transfer coefficient using Dittus-Boelter or Sieder-Tate equation (numerical).**
    - Appeared in: S24 (Q2c, 07 marks), S23 (Q2a, 03 marks), W24 (Q3a, 03 marks), W25 (Q3c, 07 marks)
3. **Differentiate between free and forced convection.**
    - Appeared in: W25 (Q3b, 04 marks), W23 (Q3a, 03 marks)
4. **Discuss Reynold's analogy for heat transfer.**
    - Appeared in: S23 (Q2b, 04 marks)
5. **Derive overall heat transfer coefficient from individual coefficients.**
    - Appeared in: S24 (Q2c OR, 07 marks), S22 (Q2c OR, 07 marks)
6. **Calculate heat loss by natural convection from a pipe/cylinder (numerical).**
    - Appeared in: S22 (Q2c, 07 marks), W22 (Q3c, 07 marks)
7. **Explain Rayleigh number and its significance.**
    - Appeared in: W22 (Q3a, 03 marks)

Unit 3 – Radiation

Repeated Questions:

1. **Explain laws of black body radiation (Planck's, Stefan-Boltzmann, Kirchhoff's, Wien's).**
   - Appeared in: S25 (Q1c, 07 marks), S24 (Q3b, 04 marks), S22 (Q3b, 04 marks), W25 (Q4b, 04 marks), W23 (Q3a, 03 marks)
2. **Define absorptivity, emissivity, transmissivity, reflectivity.**
   - Appeared in: S25 (Q3a, 03 marks), S23 (Q3b, 04 marks), W25 (Q4a, 03 marks)
3. **Calculate radiative heat transfer between parallel plates/shields (numerical).**
   - Appeared in: S23 (Q3b, 04 marks), W25 (Q4c, 07 marks), W24 (Q2c, 07 marks)

Other Important Questions:

1. **Define black body, white body, grey body, transparent and opaque bodies.**
   - Appeared in: S22 (Q3b, 04 marks), W25 (Q4a OR, 03 marks)
2. **Explain radiation shield and radiation from gases vs. solids.**
   - Appeared in: W24 (Q3a, 03 marks)
3. **Discuss monochromatic emissive power and Planck's distribution law.**
   - Appeared in: W24 (Q2a, 03 marks), W22 (Q4a, 03 marks)
4. **Explain electromagnetic spectrum and thermal radiation.**
   - Appeared in: W22 (Q4a, 03 marks)
5. **State and prove Stefan-Boltzmann law.**
   - Appeared in: S22 (Q3b, 04 marks)
6. **Explain intensity of radiation and total emissive power.**
   - Appeared in: W24 (Q2a, 03 marks), W22 (Q4a, 03 marks)

Unit 4 – Heat Exchangers

Repeated Questions:

1. **Derive LMTD and explain its importance.**
   - Appeared in: S25 (Q4c, 07 marks), W25 (Q5b, 04 marks), S23 (Q2c OR, 07 marks), S22 (Q4c, 07 marks)
2. **Explain shell & tube heat exchanger with neat sketch.**
   - Appeared in: S25 (Q4c OR, 07 marks), W24 (Q4c, 07 marks), W23 (Q4c, 07 marks)
3. **Define tube pitch, baffle spacing, range.**
   - Appeared in: S24 (Q4a, 03 marks), S22 (Q4a, 03 marks)
4. **Explain fouling and its effect on heat exchanger performance.**
   - Appeared in: S24 (Q4b, 04 marks), S22 (Q4b, 04 marks)

Other Important Questions:

1. **Draw temperature profiles for co-current and counter-current flow.**
   - Appeared in: S25 (Q4a, 03 marks), W23 (Q4a, 03 marks), W24 (Q2c OR, 07 marks)
2. **Explain LMTD correction factor and when it is used.**
   - Appeared in: S25 (Q4a OR, 03 marks), W24 (Q4a, 03 marks)
3. **Derive overall heat transfer coefficient for double pipe heat exchanger.**
   - Appeared in: S25 (Q4b OR, 04 marks), W23 (Q4b, 04 marks)
4. **Compare square pitch and triangular pitch arrangements.**
   - Appeared in: S24 (Q4b OR, 04 marks), W24 (Q4b, 04 marks), W23 (Q4a, 03 marks)
5. **Explain NTU method and effectiveness.**
   - Appeared in: S22 (Q4b, 04 marks), S23 (Q4c, 07 marks), W22 (Q4c, 07 marks)
6. **Calculate heat transfer area for parallel/counter flow (numerical).**
   - Appeared in: W25 (Q5c, 07 marks), W24 (Q5a, 07 marks), S23 (Q4c, 07 marks), W22 (Q4c, 07 marks)
7. **Explain classification of heat exchangers.**
   - Appeared in: W25 (Q5a, 03 marks), W22 (Q4b, 04 marks)
8. **Define passes, segmental baffle, tie rods.**
   - Appeared in: S23 (Q4a, 03 marks)

Unit 5 – Boiling & Condensation

Repeated Questions:

1. **Explain pool boiling regimes with diagram.**
   - Appeared in: S25 (Q3c OR, 07 marks), S23 (Q3c, 07 marks), W25 (Q4c OR, 07 marks), W23 (Q3c, 07 marks)
2. **Differentiate filmwise and dropwise condensation.**
   - Appeared in: S24 (Q3c, 07 marks), S22 (Q3c, 07 marks), W25 (Q3c, 07 marks), W23 (Q3c, 07 marks)
3. **Define boiling and explain nucleate boiling.**
   - Appeared in: S24 (Q3c OR, 07 marks), S22 (Q3c, 07 marks)

Other Important Questions:

1. **Explain effect of non-condensable gases on condensation.**
   - Appeared in: W24 (Q3b, 04 marks)
2. **Discuss factors affecting boiling heat transfer.**
   - Appeared in: W22 (Q1c, 07 marks)
3. **Explain critical heat flux and temperature drop in boiling.**
   - Appeared in: S25 (Q3c OR, 07 marks), W23 (Q3c, 07 marks)
4. **Explain condensation on vertical/horizontal surfaces.**
   - Appeared in: W25 (Q3b OR, 04 marks)
5. **Derive heat transfer coefficient for condensation on vertical plate.**
   - Appeared in: W24 (Q4c, 07 marks)

Unit 6 – Evaporation

Repeated Questions:

1. **Define capacity and economy of evaporator.**
    - Appeared in: S25 (Q5a, 03 marks), W25 (Q5a OR, 03 marks), W23 (Q5a OR, 03 marks), S22 (Q5a, 03 marks)
2. **Explain Boiling Point Elevation (BPE).**
    - Appeared in: S24 (Q5b, 04 marks), W25 (Q5b OR, 04 marks), W23 (Q5b, 04 marks), S22 (Q5a OR, 03 marks)
3. **Explain forward/backward feed in multiple effect evaporators.**
    - Appeared in: S25 (Q5a OR, 03 marks), W25 (Q5c OR, 07 marks), W23 (Q5b, 04 marks)
4. **Derive material and energy balances for multi-effect evaporator.**
    - Appeared in: S25 (Q5c, 07 marks), W23 (Q5c, 07 marks)

Other Important Questions:

1. **Explain working of vertical tube evaporator.**
    - Appeared in: S25 (Q5b, 04 marks)
2. **Write short note on multiple effect evaporator.**
    - Appeared in: S25 (Q5c OR, 07 marks), W23 (Q5c OR, 07 marks), S24 (Q5c, 07 marks)
3. **Explain vapor recompression in evaporators.**
    - Appeared in: S25 (Q5b OR, 04 marks), W24 (Q5b, 04 marks)
4. **Calculate heat load and steam economy for evaporator (numerical).**
    - Appeared in: S23 (Q5c, 07 marks), W24 (Q5c, 07 marks)
5. **Draw and explain falling film evaporator.**
    - Appeared in: S24 (Q4c OR, 07 marks), S22 (Q5c OR, 07 marks)
6. **Discuss methods of feeding in multiple effect evaporators.**
    - Appeared in: S22 (Q5c, 07 marks), W23 (Q5a, 03 marks)
7. **Explain Duhring's rule and BPE.**
    - Appeared in: S22 (Q5a OR, 03 marks)
8. **Compare natural and forced circulation evaporators.**
    - Appeared in: S22 (Q5b, 04 marks)

Heat Transfer (3140503) – Important Numerical Problems

Based on GTU Previous Year Papers (Summer 2022 – Summer 2025)

1. Conduction – Composite Wall/ Cylinder

Problem Statement	Appeared in	Marks
A furnace is constructed with 24 cm fire brick, 12 cm insulating brick, 24 cm building brick. Inside temp = 950°C, outside temp = 55°C. $k_{fb} = 6.05$, $k_{ib} = 0.59$, $k_{bb} = 2.4$ W/m°C. Find heat loss per unit area and interface temperatures.	S25 (Q2c)	07
A furnace with 225 mm fire brick, 120 mm insulating brick, 225 mm building brick. Inside temp = 1200 K, outside temp = 330 K. $k_{fb} = 1.4$, $k_{ib} = 0.2$, $k_{bb} = 0.7$ W/mK. Find heat loss per unit area and junction temperature.	S24 (Q1b)	04
Determine heat transfer through composite wall (A, B, C, D, E) with given conductivities and areas. $T_{in} = 800^{\circ}C$, $T_{out} = 100^{\circ}C$.	S23 (Q1c)	07
A furnace wall: three layers 250 mm, 100 mm, 150 mm with $k = 1.65, k, 9.2$. Inside exposed to gases at 1250°C ($h = 25$), inside surface at 1100°C, outside at 25°C ($h = 12$). Find unknown k and overall U.	W22 (Q2c)	07
Saturated steam at 110°C inside copper pipe (ID=10 cm, OD=12 cm, $k = 450$). $h_{steam} = 12000$, $h_{air} = 18$, ambient 25°C. Find heat loss with and without 5 cm insulation ($k = 0.22$).	W22 (Q2c OR)	07

2. Convection – Forced/Natural

Problem Statement	Appeared in	Marks
Water flowing in 16 mm dia tube at 3 m/s. Tube temp = 297 K, water inlet = 353 K, outlet = 309 K. Use Dittus-Boelter and Sieder-Tate to find h. Properties given at 331 K.	S24 (Q2c)	07
Vertical pipe 80 mm dia, 2 m height, surface temp = 120°C, air temp = 30°C. Find natural convection heat loss.	S22 (Q2c)	07
Water at 60°C flowing through 0.625 cm dia tube, velocity 0.9 m/s. Wall temp = 40°C. Find h. Given viscosity, k, C_p.	W25 (Q3c OR)	07
Estimate heat transfer from 40 W bulb at 125°C to 25°C air (sphere dia = 50 mm). Use Nu = 0.6(Gr·Pr)^0.25. Find % power lost by free convection.	W22 (Q3c)	07
Heat loss from human body (vertical cylinder 30 cm dia, 1.75 m high) in 30 km/hr wind at 15°C. Skin temp = 35°C. Use Nu = 0.664 Re^0.5 Pr^0.33.	W22 (Q3c OR)	07
Pipe (OD=30 cm) at 405°C in room at 35°C. Emissivity = 0.8. Find radiative	W24 (Q2c)	07

Problem Statement	Appeared in	Marks
heat loss per meter. Also find loss if inside brick conduit (OD=50 cm, ε=0.91).		

3. Radiation – Parallel Plates/Shields

Problem Statement	Appeared in	Marks
Two large parallel planes at 527°C (ε=0.3) and 127°C (ε=0.5). Find heat transfer without shield and with shield (ε=0.05 both sides).	S23 (Q3b)	04
Two large parallel plates at 400°C (ε=0.4) and 900°C (ε=0.75). Find radiative heat transfer rate. $\sigma = 56.7 \times 10^{-9}$.	W25 (Q4c)	07
Rate of heat loss from thermoflask: polished silvered surfaces ε=0.05, liquid at 368 K, casing at 293 K. Also find loss if both black.	S24 (Q5b)	04

4. Heat Exchangers – LMTD/NTU Method

Problem Statement	Appeared in	Marks
Counter flow double pipe HX: steam 180°C to 130°C, water 10500 kg/hr from 30°C to 80°C. $U = 814$ W/m^{2}K. Find area. Also for parallel flow.	S23 (Q4c)	07
Hot oil (5000 kg/hr, $C_p = 0.5$ kcal/kg°C) from 360°C to 300°C, cold fluid from 30°C to 200°C. $U = 800$ kcal/hrm^2°C. Find area for parallel flow.	W25 (Q5c)	07
Counter flow HX: oil (0.55 kg/s, $C_p = 2.45$) from 115°C to 40°C, water from 15°C to 75°C. $U = 1450$. Use NTU to find: (i) water flow rate, (ii) effectiveness, (iii) area.	S23 (Q4c)	07
Parallel flow HX: hot water 0.2 kg/s (75°C to 45°C), cold water 0.5 kg/s (20°C). $h_i = h_o = 650$. Find area.	W22 (Q4c)	07
Parallel flow HX: chemical (20000 kg/hr, $C_p = 3.3$) at 120°C, water (50000 kg/hr, $C_p = 4.186$) at 20°C. Area = 10 m², $U = 1050$. Find outlet temperatures.	W22 (Q4c OR)	07
Double pipe HX: hot oil (1.3 kg/s, $C_p = 2083$) 643 K to 583 K, cold fluid 313 K to 410 K. $U = 500$. Find area for parallel flow.	W24 (Q5a)	07

5. Evaporation – Material & Energy Balance

Problem Statement	Appeared in	Marks

Problem Statement	Appeared in	Marks
Single effect evaporator: feed 15000 kg/h from 7% to 14% salt. Steam at 399 K, BPR = 7 K, feed temp = 298 K, $C_{p,f} = 4.0$, $\lambda_{steam} = 2185$, $\lambda_{water} = 2257$ kJ/kg. Find heat load and steam economy.	S23 (Q5c)	07
Evaporator at atm pressure: feed 5000 kg/h from 5% to 20% solute. Steam at 399 K, feed at 298 K, BPR = 5 K, $U = 2350$, $C_{p,f} = 4.187$, $\lambda_{steam} = 2185$, $\lambda_{water} = 2257$. Find economy and area.	W24 (Q5c)	07

6. Fins & Extended Surfaces

Problem Statement	Appeared in	Marks
Pin fin (dia=2.5 mm, copper $k = 396$), wall at 95°C, air at 25°C, $h = 10$. Find heat loss for (1) L=25 mm, (2) L=infinite.	W25 (Q2c OR)	07

7. Critical Radius of Insulation

Problem Statement	Appeared in	Marks
Derive critical radius for sphere.	S23 (Q1b)	04
Derive critical thickness for composite cylinder.		

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