Data & Analysis for Heat Transfer Lab

Refrigeration (Parts II & VI in lab manual):

Table 1: Refrigeration Lab Data

Test #	1	2	3	4	5	6
Evaporator gauge pressure (kPa)						
Evaporator temperature (°C) T5						
Evaporator water flow rate (gm/s)	20.0	20.0	20.0	20.0	20.0	20.0
Evaporator water inlet temperature (°C) T1						
Evaporator water outlet temperature (°C) T2						
Condenser gauge pressure (kPa)						
Condenser temperature (°C) T6						
Condenser water flow rate (gm/s)	50.0	35.0	20.0	15.0	10.0	7.0
Condenser water inlet temperature (°C) T4						
Condenser water outlet temperature (°C) T3						

- Calculate absolute pressure
- Calculate rate of heat transfer to water in the evaporator and condenser
- Graph saturation pressure vs saturation temperature for both the condenser and evaporator.
- Graph saturation pressure vs condenser mass flow rate.
- Graph heat transfer vs condensing temperature
- Graph heat transfer to water in the condenser vs mass flow rate of the water in the condenser

Boiling Heat Transfer (Part II & IV):

Table 2: Boiling Heat Transfer Lab Data

Voltage (V)	40	70	85	100	110	125
Current (A)						
Pressure (kPa)						
Mass Flow Rate (kg/min)	50	35	20	15	10	7
Liquid Temperature (C)						
Metal Temperature (C)						
Vapor Temperature (C)						
Water Inlet Temperature (C)						
Water Outlet Temperature (C)						

- Calculate heat flux (ϕ) and temperature difference at varying pressures
  - Log-log graph of heat flux vs temperature difference
- Calculate surface heat transfer coefficient (h) at varying pressures
  - Log-log graph of surface heat transfer coefficient vs temperature difference
- Calculate the log-mean temperature difference (ϕ_m)
- Calculate the overall heat transfer coefficient (U)
  - Graph the overall heat transfer coefficient vs saturation pressure

Thermal Radiation:

Table 3: Thermal Radiation Lab Data - Inverse Square Law (Black Plate Only)

Radiometer Distance (X)	Radiometer Intensity (R)	Ambient Temperature
mm	W/m^2	°C
110		
200		
300		
400		
500		
600		
700		
800		
900		
950		

- Inverse Square Law for Heat (Black plate only)
  - Calculate $Log_{10}(R)$ and $Log_{10}(X)$
  - Graph of $Log_{10}(R)$ vs $Log_{10}(X)$
    - Compare slope to -2

Table 4: Thermal Radiation Lab Data - Stefan Boltzmann Law (Black plate only, radiometer at 110 mm)

Power Dial Setting	Temperature (T_S)	Radiometer (R)
	°C	W/m^2
1		
2		
3		
4		
5		
6		

- Stefan-Boltzmann Law (Black plate only)
  - Calculate q_b using both methods (see lab manual)
    - Theoretical: Stefan-Boltzmann law
      - $q_b = \sigma(T_s^4 - T_A^4)$
    - Experimental: Equation using radiometer
      - $q_b = 5.59R$
  - Determine if $q_{b,Radiometer}$ follows the Stefan-Boltzmann law ($q_{b,Theoretical}$) by comparing values.

Table 5: Thermal Radiation Lab Data - Thermal Emissivity (All plates, radiometer at 110 mm)

	Power Dial Setting	Temperature (T_S) °C	Radiometer (R) W/m^2	T_A K
Black Plate	1			
	2			
	3			
	4			
	5			
	6			
Polished Plate	1			
	2			
	3			
	4			
	5			
	6			
Silver Anodized Plate	1			
	2			
	3			
	4			
	5			
	6			

- Emissivity (Black, Polished, Silver Anodized)
  - Chart of calculations (q_b, ε, $\varepsilon_{Average}$, comparison with $\varepsilon_{theoretical}$)
  - Bar graph of average emissivity for each plate compared to theoretical emissivity
    - $\varepsilon_{Theoretical}$
      - Black plate = 0.98
      - Silver anodized plate = 0.87
      - Polished plate = 0.16

Convection over a Cylinder

Table 6: Convection over a Cylinder Lab Data

Distance (in)	T_2 (°F)
0 (T_1)	
0.001	
0.002	
0.003	
0.004	
0.005	
0.006	
0.007	
0.008	
0.009	
0.010	
0.020	
0.030	
0.040	
0.050	
0.060	
0.070	
0.080	
0.090	
0.100	
0.200	
0.300	
0.400	
0.500	
0.600	
0.700	
0.800	
0.900	
1.000	
1.100	
1.200	

Distance (in)	T_2 (°F)
0 (T_1)	
0.001	
0.002	
0.003	
0.004	
0.005	
0.006	
0.007	
0.008	
0.009	
0.010	
0.020	
0.030	
0.040	
0.050	
0.060	
0.070	
0.080	
0.090	
0.100	
0.200	
0.300	
0.400	
0.500	
0.600	
0.700	
0.800	
0.900	
1.000	
1.100	
1.200	

Distance (in)	T_2 (°F)
0 (T_1)	
0.001	
0.002	
0.003	
0.004	
0.005	
0.006	
0.007	
0.008	
0.009	
0.010	
0.020	
0.030	
0.040	
0.050	
0.060	
0.070	
0.080	
0.090	
0.100	
0.200	
0.300	
0.400	
0.500	
0.600	
0.700	
0.800	
0.900	
1.000	
1.100	
1.200	

Power (W)			
Velocity (m/s)			
T_S (F)			
T_A (F)			
T_S (K)			
T_A (K)			

T1: Surface temperature, T_S

T2: Thermal Boundary Layer temperature

T3: Ambient temperature, T_A

- Graph temperature vs distance for each test
- Determine approximate thermal boundary layer height
  - Graph thermal boundary layer vs. velocity
- Calculate heat transfer due to convection and radiation from the surface of the cylinder by following the equations in the additional handout.
  - D = 1 in; L = 6 in
    - Note: Surface area is used in convection over a surface.
  - $\varepsilon_{Brass} = 0.9$
  - Graph heat transfer coefficient (h) vs velocity
  - Graph Q_C and Q_R vs velocity

Free and Forced Convection

	Power Input (W)	Air Speed (m/s)
Free Convection	5	0
	10	
	15	
	20	
Forced Convection	20	0
		2
		4
		6
		8

- Calculate surface-ambient temperature difference
- Free Convection: All Plates
    - Graph ΔT vs Power input
- Forced Convection: All Plates
    - Graph heater temperature vs air velocity
    - Graph Surface to Air temperature difference vs air velocity
- Forced Convection: Finned & Pinned Plates Only
    - Graph temperature vs distance from heater surface for all air velocities
        - Pinned Plate
            - Heater→T4→T3→T5→Tip
        - Finned Plate
            - Heater→T8→T7→T6→Tip

Table 7: Free & Forced Convection Lab Data

Free Convection on Varying Surfaces

Flat Plate			Finned Plate						Pinned Plate					
P (W)	T_1 (°C)	Surface-Air Temperature Difference (T_S-T_A)	P (W)	T_1 (°C)	T_8 (°C)	T_7 (°C)	T_6 (°C)	Surface-Air Temperature Difference (T_S-T_A)	P (W)	T_1 (°C)	T_4 (°C)	T_3 (°C)	T_5 (°C)	Surface-Air Temperature Difference (T_S-T_A)
$T_{9,Avg}$ (C)			$T_{9,Avg}$ (C)						$T_{9,Avg}$ (C)					

Forced Convection on Varying Surfaces

Flat Plate			Finned Plate						Pinned Plate					
V (m/s)	T_1 (°C)	Surface-Air Temperature Difference (T_S-T_A)	V (m/s)	T_1 (°C)	T_8 (°C)	T_7 (°C)	T_6 (°C)	Surface-Air Temperature Difference (T_S-T_A)	V (m/s)	T_1 (°C)	T_4 (°C)	T_3 (°C)	T_5 (°C)	Surface-Air Temperature Difference (T_S-T_A)
$T_{9,Avg}$ (C)			$T_{9,Avg}$ (C)						$T_{9,Avg}$ (C)					
P_{Avg} (W)			P_{Avg} (W)						P_{Avg} (W)					

Thermal Conductivity of Liquids and Gases

Table 8: Thermal Conductivity of Liquids and Gases Lab Data

Air				
Voltage (V)	**Amps (I)**	**Power (W)**	**T_1 (°C)**	**T_2 (°C)**
10				
20				
30				
40				
50				
60				

Water				
Voltage (V)	**Amps (I)**	**Power (W)**	**T_1 (°C)**	**T_2 (°C)**
10				
20				
30				
40				
50				
60				

- Nominal resistance of heating element: 57Ω
- Nominal radial clearance between plug and jacket: 0.30 mm
- Effective area of conducting path through fluid: 0.0133 m^2

- Produce a calibration equation by calculating the incidental heat transfer and linearly fitting a $\dot{Q}_\iota$vs ΔT graph.
- Calculate the thermal conductivity (k) for distilled water for each voltage
- Graph k_{Water} vs T_1

Thermal Conductivity of Solids

Table 9: Thermal Conductivity of Solids Lab Data

I. Conduction Along a Simple Bar (Brass)

Power	Voltage	Current	T1	T2	T3	T4	T5	T6	T7	T8
W	V	A	°C	°C	°C	°C	°C	°C	°C	°C
	50									
	85									
	115									
Distance from T1 (mm)			0	15	30	45	60	75	90	105

II. Conduction Along a Composite Bar (Stainless Steel)

Power	Voltage	Current	T1	T2	T3	T4	T5	T6	T7	T8
W	V	A	°C	°C	°C	°C	°C	°C	°C	°C
	50					-	-			
	85					-	-			
	115					-	-			
Distance from T1 (mm)			0	15	30	45	60	75	90	105

III. Conduction Along a Composite Bar (Aluminum)

Power	Voltage	Current	T1	T2	T3	T4	T5	T6	T7	T8
W	V	A	°C	°C	°C	°C	°C	°C	°C	°C
	50					-	-			
	85					-	-			
	115					-	-			
Distance from T1 (mm)			0	15	30	45	60	75	90	105

IV. Effect of Cross-Sectional Area (Brass)

Power	Voltage	Current	T1	T2	T3	T4	T5	T6	T7	T8
W	V	A	°C	°C	°C	°C	°C	°C	°C	°C
	50					-	-			
	85					-	-			
	115					-	-			
Distance from T1 (mm)			0	15	30	45	60	75	90	105

- Graph temperature vs distance for each of the 4 parts
- Determine the thermal conductivity (k) **of the inserted piece** for all parts
- Graph k vs power comparing each part
- Bar chart for k at 85 volts comparing each part

Heat Exchanger

A report on heat exchangers will be done in place of an actual experiment. The report should consist of, at the very least, five pages of typed content (text). Pictures, diagrams, graphs, and charts are highly encouraged; but will not be counted as part of the five pages of text. You must also use five sources for your report, which must also be properly cited at the end of your report (MLA is fine). Sources must be from actual engineering textbooks or from journal papers or periodicals (google scholar, UTRGV library website). Wikipedia sources will not be counted as a legitimate source, but you can include them as well. Below is the content that must be included in your report.

- Introduction to heat exchangers (thesis of report)
- Types of heat exchangers and mechanisms involved (how they function)
- Industrial applications of heat exchangers (at least three applications)
- Efficiencies of heat exchangers
- Conclusion

It may be important to note that grammar will have a heavy weight on your grade. Therefore, you are encouraged to use the writing center to help, should you have issues. Reports should also be independently written. Any issues involving plagiarism will be reported to the appropriate administrators.