BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE - PILANI
Department of Chemical Engineering, Pilani Campus, Rajasthan
II Semester 2017-2018
CHE F241 Heat Transfer

Mid Sem Test (Closed Book + Open Book) **Date: 7.03.2018**
Duration: (60 + 30) Mins **Marks: 90**

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Duration: 60 minutes **Part – A (Closed Book)** **Maximum Marks: 60**

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Q.1 **[15]**

Water at 70 ˚F with a uniform free stream velocity of 0.15 m/s enters between two large parallel plates. Both plates are maintained at 110 ˚F over its entire length. The plates are separated by a distance of 15 mm.
Find
(a) Distance from the leading edge where the flow becomes fully developed,
(b) Thickness of thermal boundary layer at that location,
(c) Local heat transfer coefficient at that location

Q. 2 **[15]**

An alloy sphere 20 cm in diameter is initially at a uniform temperature of 300 °C. It is suddenly subjected to a convection environment at 100 °C and h = 200 W/m^2 °C. Calculate the temperature at a radial position of 4.0 cm and 1 min after the exposure to the environment.
k = 20 W/m °C; α = 8.4 x 10^{-5} m^2/s

Q. 3 **[15]**

A spherical tank, 1 m in diameter, is maintained at a temperature of 120 °C and exposed to a convection environment. With h=25 W/m^2 °C and T_∞= 15 °C, what thickness of urethane foam (k=0.18 W/m °C) should be added to ensure that the outer temperature of the insulation does not exceed 40^{0}C? What percentage reduction in heat loss results from installing this insulation?

Q 4 **[5 X 3 = 15]**

(a) What is the difference between fin efficiency and fin effectiveness?
(b) What are the physical assumptions necessary for a lumped capacity unsteady state analysis to apply?
(c) Explain the physical significance of Biot number and Prandtl Number.

Table A-9 | Properties of water (saturated liquid).†

Note: $\mathrm{Gr}_x \mathrm{Pr} = \left(\frac{g\beta\rho^2 c_p}{\mu k}\right) x^3 \Delta T$

°F	°C	c_p kJ/kg · °C	ρ kg/m^3	μ kg/m · s	k W/m · °C	Pr	$\frac{g\beta\rho^2 c_p}{\mu k}$ 1/m^3 · °C
32	0	4.225	999.8	1.79×10^{-3}	0.566	13.25	
40	4.44	4.208	999.8	1.55	0.575	11.35	1.91×10^9
50	10	4.195	999.2	1.31	0.585	9.40	6.34×10^9
60	15.56	4.186	998.6	1.12	0.595	7.88	1.08×10^{10}
70	21.11	4.179	997.4	9.8×10^{-4}	0.604	6.78	1.46×10^{10}
80	26.67	4.179	995.8	8.6	0.614	5.85	1.91×10^{10}
90	32.22	4.174	994.9	7.65	0.623	5.12	2.48×10^{10}
100	37.78	4.174	993.0	6.82	0.630	4.53	3.3×10^{10}
110	43.33	4.174	990.6	6.16	0.637	4.04	4.19×10^{10}
120	48.89	4.174	988.8	5.62	0.644	3.64	4.89×10^{10}
130	54.44	4.179	985.7	5.13	0.649	3.30	5.66×10^{10}

Figure 4-9 | (*Continued*). (*b*) expanded scale for $0 < \text{Fo} < 3$, from Reference 2.

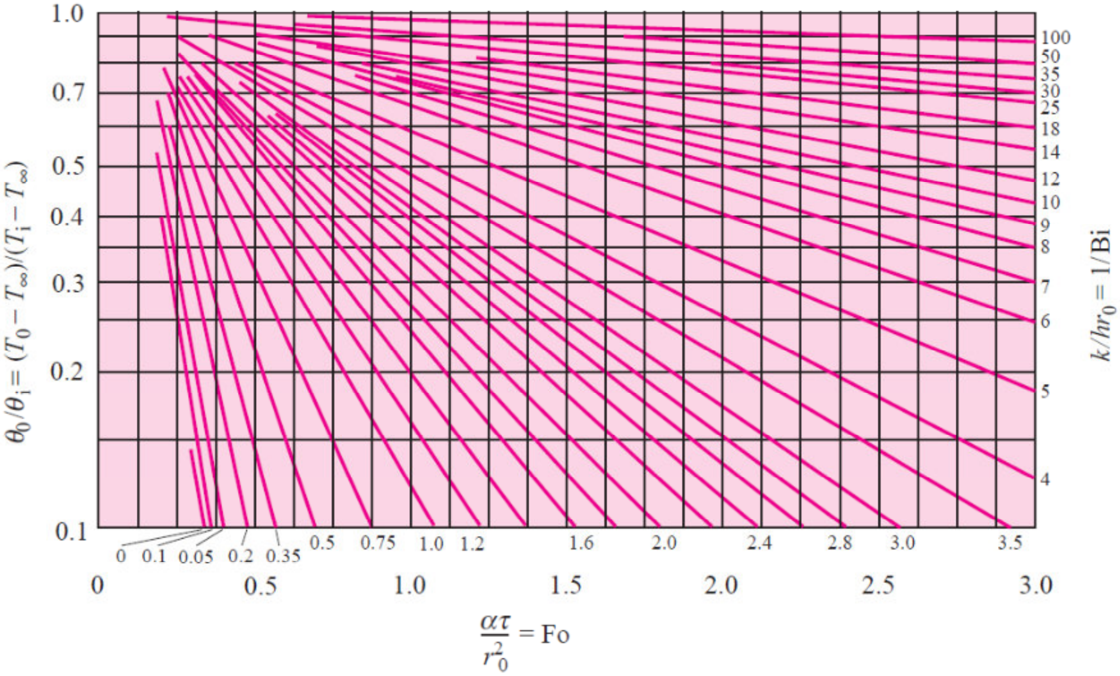
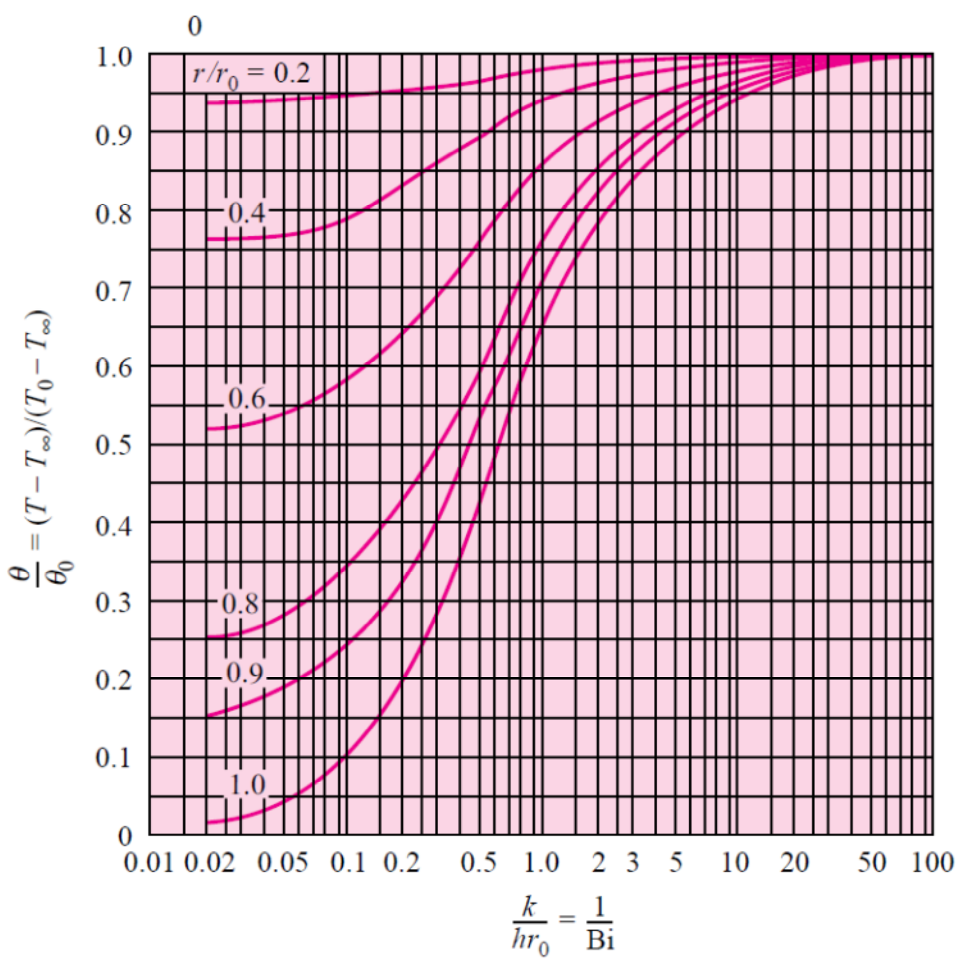


Figure 4-12 | Temperature as a function of center temperature for a sphere of radius r_0, from Reference 2.



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Duration: 30 minutes **Part – B (Open Book)** **Maximum Marks: 30**

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Q. 1 **[10]**

A thick wall of low density particle board material is at a uniform temperature of 30 °C. It is suddenly subjected to a constant temperature of 10 °C. Calculate the temperature in the board at a depth of 7 cm after 2 hrs. Also calculate the total heat removed (in W/m^2) from the surface.

Q. 2 **[20]**

Air flows at 100 °C and at 2 atm in a 1.2-cm-(inside)-diameter tube at a velocity such that a Reynolds number of 15,000 is obtained. The outside of the tube is subjected to a cross flow of air at 2 atm, 30 °C, and a free-stream velocity of 20 m/s. The tube wall thickness is 10 mm and made of pure aluminum. Calculate the overall heat transfer coefficient for this system considering unit length.