No. of pages..... 3
No. of questions..... 6
Total marks..... 100

THE UNIVERSITY OF ADELAIDE

MECHENG 3020 Heat Transfer

Department of Mechanical Engineering

Semester 1, 2002

Duration: 3.0 hours + 10 minutes.

Allocate the first 10 minutes to reading the paper.

Candidates are required to answer **Five** of the six questions in this paper.

All questions are of equal value.

Calculators, notes and prescribed textbook are permitted.

The standard problem solving protocol is required.

Question 1 is worth 20 marks
(allow 30 minutes)

[5 Marks]

(a) Explain the concept of Product Solution used to calculate multi-dimensional heat conduction in solids. Give an example.

[15 Marks]

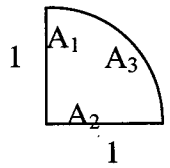
(b) A brass sphere, 50-cm in diameter, initially at 80°C is placed in a cooling fluid with T_F=15°C. Assume the heat transfer coefficient to be h=500 W/m^{2}C.

Determine:
(1) the time required for the center of the sphere to reach 30°C
(2) the fraction of energy loss during this process.

Question 2 is worth 20 marks
(allow 30 minutes)

A very long three-surface enclosure (see figure below) has the following internal characteristics:

Surface 1: approximated as black body, T_1 = 200°C, width = 1 m
Surface 2: T_1 = 27°C, ε_2 = 0.7, width = 1 m (perpendicular to surface 1)
Surface 3: q_1 = 1 kW/m^2, ε_3 = 0.5, radius = 1 m



All surfaces are insolated on the outside.
Determine the radiation heat transfer fluxes from surfaces A_1 and A_2 and the temperature of surface A_3.

Question 3 is worth 20 marks
(allow 30 minutes)

Water at 14°C enters a 2.54-cm diameter pipe of 5-m length. The flow enters the pipe at fully developed thermal and hydrodynamic conditions. The mass flow rate of water is 0.65 kg/s and the wall temperature is 80°C.

Determine:
(a) the heat transfer rate
(b) the temperature of the water at the outlet.

Question 4 is worth 20 marks
(allow 30 minutes)

A shell-and-tube heat exchanger is to have one pass on the shell side and eight passes on the tube side. It is required to cool 100 kg/s of a petroleum oil inside the tubes from 135°C to 50°C. Water is supplied to the shell at 160 kg/s and enters at 15°C. The exchanger has 200 steel tubes of 3-cm OD and 2-mm wall thickness. The inside and outside heat transfer coefficients are estimated to be 260 and 970 W/m^2K, respectively, and a fouling resistance of 3.5E-4 $[W/m^2K]^{-1}$ should be included on the water side.

Determine the required surface area using:
(a) the LMTD method
(b) the ε-Ntu method.

Question 5 is worth 20 marks
(allow 30 minutes)

Air at 280 K and 1 atm pressure flows at 3.0 kg/s along a duct of cross section 1×0.6 m. The duct contains a 44 rows tube bank of 1 m long, 10 mm OD tubes in a staggered arrangement, with a longitudinal pitch of 24 mm and a transverse pitch of 20 mm. Steam at 1.29E5 Pa condenses inside the tubes. Assume steam-side and tube-wall resistance are negligible.
Take T_{sat}(@P=1.29E5Pa)=380 K.

Determine:
(a) the mean heat convection coefficient
(b) the pressure drop.

Question 6 is worth 20 marks
(allow 30 minutes)

A wall has its surface maintained at 180°C and is in contact with a fluid at 80°C. Find the percent increase in the heat dissipation if triangular fins are added to the surface. The fins are 6 mm thick at the base, are 300 mm long, and are spaced at a pitch of 15 mm. Assume that the heat transfer coefficient is 20 W/m^2K for both the plain and finned surfaces, an that the material thermal conductivity is 50 W/mK.

End of Examination