THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

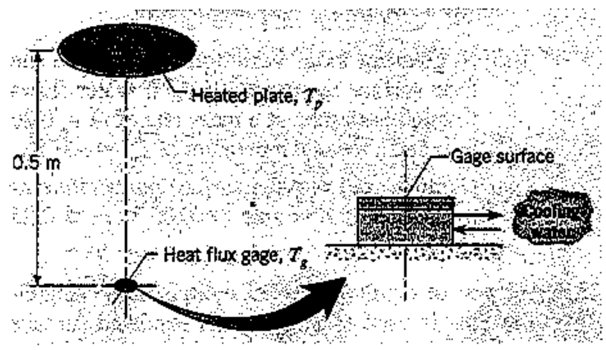
#9900: HEAT TRANSFER
JUNE 2001

TIME: THREE HOURS AND TEN MINUTES

- Students are advised to devote 10 minutes to reading the paper and planning their approach
- Candidates are required to answer **FIVE** of the six questions in this paper.
- Each question is worth 20 marks.
- The use of notes, prescribed textbook and calculators is permitted. The textbook will be necessary to solve some of the problems.
- Marks are assigned within each question for problem layout and especially for comments both through the solution and concerning the significance of the answer.

Question 1:

(a) The arrangement shown is to be used to calibrate a heat flux gage. The gage has a black surface that is 10 mm in diameter and is maintained at 17°C by means of a water-cooled section at the back. The heater plate, 200 mm in diameter, has a black surface that is maintained at 800K and is located 0.5 m from the gage. The surroundings and the air are at 27°C and the convection heat transfer coefficient between the gage and the air is 15 W/m^2.K.



(i) Determine the net radiation exchange between the heater and the gage.

(ii) Determine the net transfer of radiation to the gage per unit area of the gage.

(iii) What is the net heat transfer rate to the gage per unit area of the gage?

(b) If we paint the gage surface **Yellow,** determine qualitatively the effect on the net heat transfer to the gage per unit area. Briefly explain you answer.

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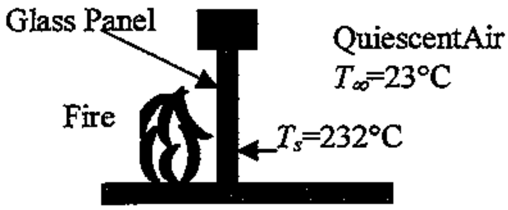
Question 2:

A glass door fire-screen, used to reduce exfiltration of room air through a chimney, has a height of 0.71 m and a width of 1.02 m and reaches a temperature of 232°C. If the room temperature is 23°C, estimate the heat rate from the fire place to the room.



(i) Due to Natural Convection only

(ii) Due to Radiation only. (assume ε=1.0)

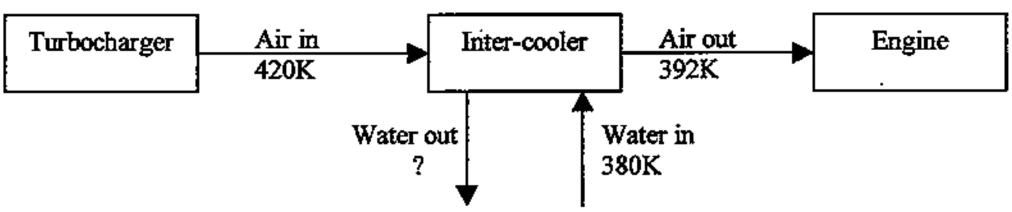
Question 3:

Hot exhaust gasses, which enter a finned-tube, cross-flow heat exchanger at 300°C and leave at 100°C, are used to heat pressurized water at a flow rate of 1 kg/s from 35 to 125°C. The exhaust gas specific heat is approximately 1000 J/kg.K, and the overall heat transfer coefficient based on the gas side surface area is U_h=100 W/m^2.K. Determine the required gas side surface area A_h.

(i) Using the LMTD model
(ii) Using the NTU model

Question 4:

A diesel truck engine is turbocharged with 500 kg/hr of air. The air is heated to 420K by the compressor in the turbocharger. It is desired to cool the air to 392K before it enters the engine. Water at 380K is taken from the truck radiator at a rate of 1000 kg/hr to provide cooling. An intercooler configured as a counterflow heat exchanger is used. The air-side heat transfer coefficient is 30 W/m^2.K, the water-side is 9000 W/m^2.K, and the air-side is finned (η=1) with a ratio of air to water area of 5 to 1. Determine the required effectiveness, the overall heat transfer coefficient based on the water-side area, and the required water-side heat transfer area.



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Question 5:

A 4 cm diameter rod of composite material is initially at 30°C. It is immersed into a chamber in which saturated steam at 120°C condenses on the rod and heats it. When the centerline temperature reaches 100°C, the rod is removed and allowed to cool in 20°C air until the center falls to 30°C. How long does each stage take? Assume a very large heat transfer coefficient for the heating process, and a value of 15 W/m^2.K for the cooling process. Properties of the composite include c = 1800 J/kg.K, k = 1.2 W/m.K and ρ = 1500 kg/m^3.
Note: you need to calculate an average rod temperature at the start of the cooling stage.

Question 6:

A blank for a telescope mirror is a 25 cm diameter, 5 cm thick glass disk (can be treated as finite cylinder). The blank is at room temperature, 20°C, and is placed in an oven at 420°C for stress relieving. If the heat transfer coefficient is 8.75 W/m^2.K, how long will it be before the minimum temperature of the glass disk is 400°C?, Take k=1.09 W/m.K, α = 0.51E-06 m^2/s for the glass.
Note: you need to decide where the minimum temperature will be and if an iterative solution is required please perform up to two iterations.

End of Examination Paper