National Exams December 2014

04-Agric-A3, Heat Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Four (4) questions constitute a complete exam paper.
   The first four questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. All questions require calculation.

Problem 1(25 points)

The front of a slab of lead (k=35 W/m.K) is kept at 110°C and the back is kept at 50°C. If the area of the slab is 0.4 m^2 and it is 0.03 m thick, compute the heat flux ,q, and the heat transfer rate, Q.

Problem 2(25 points)

A house wall consists of an outer layer of common brick 10.16 cm thick having a conductivity of k=0.0069W/cm.K , followed by a 1.27 cm layer of Celotex sheathing having a conductivity k=0.00048W/cm.K. A 1.27 cm layer of sheetrock having a conductivity k=0.0074 W/cm.K forms the inner surface and is separated from the sheathing by 9.53 cm of air space-as provided by the wall studs. The air space has a conductance of 6.25×10^{-4} $W/cm^2.K$. The outside brick surface temperature is 4.44°C; the inner wall surface is maintained at 21.1°C. What is the rate of heat loss from the house per centimetre square of wall area?

Problem 3(25 points)

A physics experiment uses liquid nitrogen as a coolant. Saturated liquid nitrogen at 80K flows through 6.35 mm O.D stainless steel line(emissivity ε_l=0.2) inside a vacuum chamber. The chamber walls are at T_c=230K and are at some distance from the line.

Determine the heat gain of the line per unit length.

If a second stainless steel tube, 12.7 mm in diameter, is placed around the line to act as radiation shield

Determine the revised heat gain per unit length.

Hint: Assume that the chamber area is large compared to the shielded line.

Problem 4 (25 points)

A thin-walled metal tank containing fluid at 40°C cools in air at 14°C(β=0.00348 K^{-1}); the average natural convection heat transfer coefficient h is very large inside the tank. If the sides are 0.4 m high, compute h, the average heat flux q, and the thermal boundary layer thickness δ at the top.
(Air properties at 27°C, $\alpha=2.203\times10^{-5}$ m^2/s, $\nu=1.556\times10^{-5}$ m^2/s, Pr=0.711)