National Exams December 2013

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.

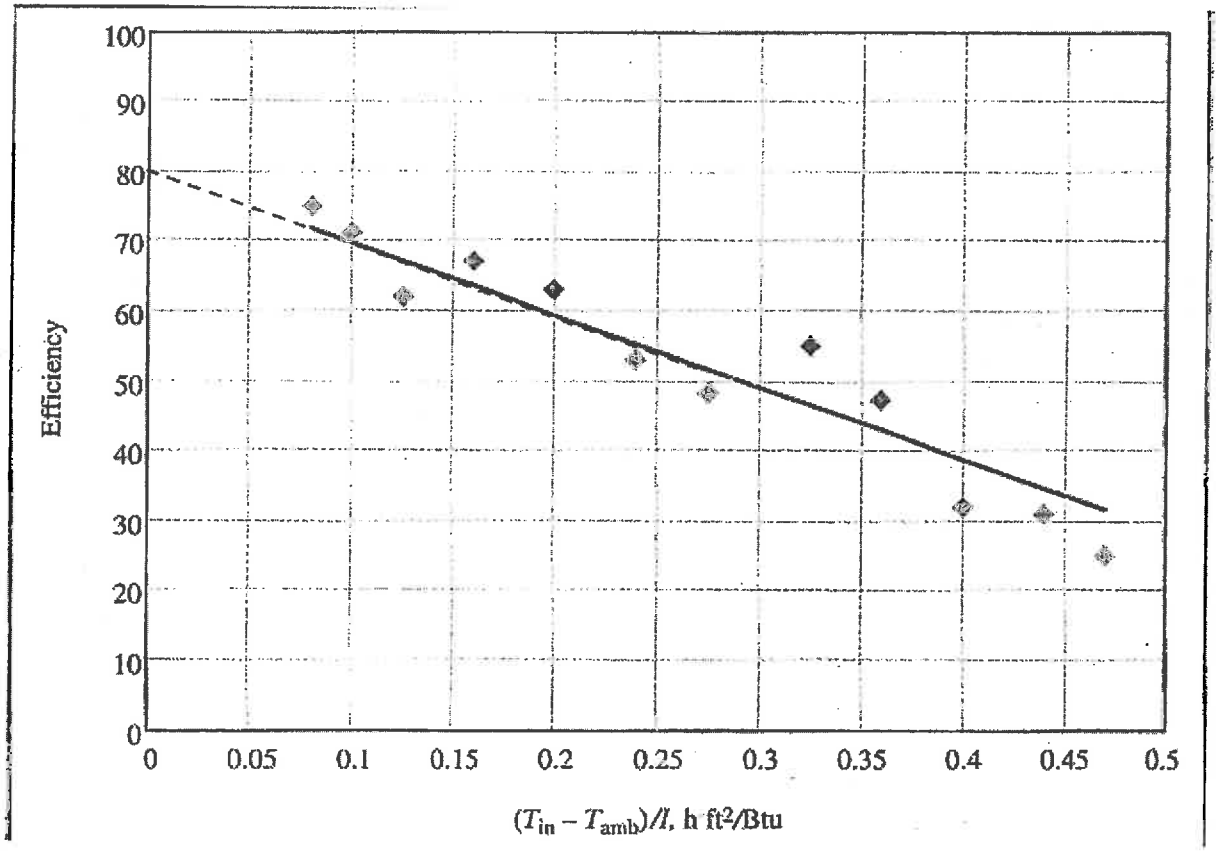
4. Each question is of equal value.

5. All questions require calculation.

Problem 1(25 points)

a) Figure below provides the results of a performance test for a single-glazed flat-plate collector. The transmissivity, τ , of the glass is 0.90, and the absorptivity, α , of the surface is 0.92. For the collector, find;

a) The collector heat removal factor, F_R
b) The overall conductance, U_L in Btu/ft^2.°F
c) The rate at which the collector can deliver useful energy when the irradiation incident on the collector per unit area is 200 BTU/ft^2.h , the ambient temperature is 30°F, and the inlet water temperature is 60 °F.
d) The collector temperature when the flow rate is zero(collector efficient η=0).



Problem 2(25 points)

The front of a slab (k=0.2 W/m.K) is kept at 415°C and the back is losing heat by conduction (q_{cond}=3 KW). If the area of the slab is 10 m^2 and it is 2.5 cm thick, compute the temperature at the back of the slab.

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, α=2.203x10^{-5} m^2/s, ν=1.556x10^{-5} m^2/s, Pr=0.711)