National Exams May 2012

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.
   A Casio or Sharp approved 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

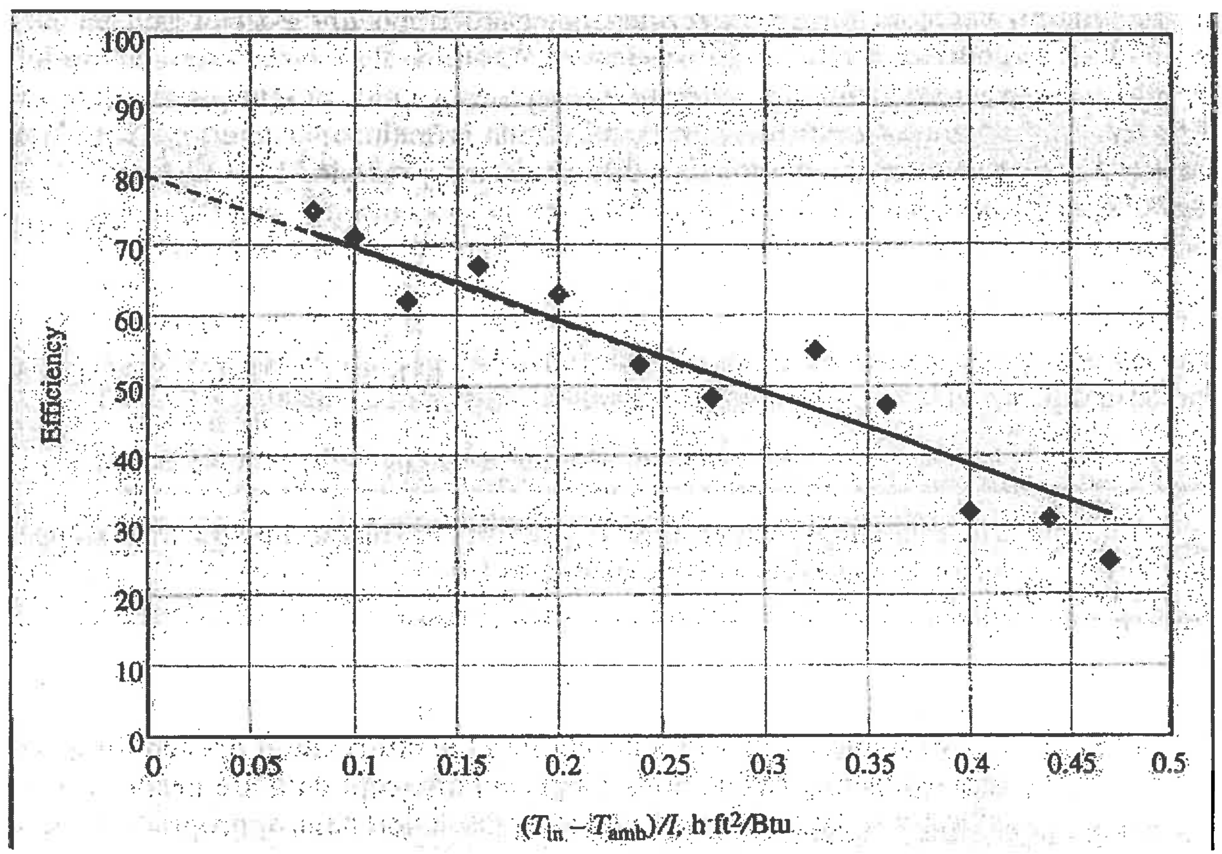
a) Figure below provides the results of a performance test for a single-glazed flat-plate collector. The transmissivity, τ , of the glass is 0.90, and the absorptivity, α , of the surface is 0.92. For the collector, find;

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

Water at 20°C flows through a small-bore tube 1 mm in diameter at a uniform speed of 0.2 m/s. The flow is fully developed at a point beyond which a constant heat flux of 6000 W/m^2 is imposed. How much farther down the tube will the water reach 74°C at its hottest point?
(Water at T=47°C, k=0.6367 W/m.K, $\alpha=1.541\times10^{-7}$ m^2/s, $\nu=0.556\times10^{-6}$ m^2/s).

Problem 3

A jet of liquid metals at 2000°C pours from a crucible. It is 3mm in diameter. A long cylindrical radiation shield, 5 cm in diameter, surrounds the jet through an angle of 330°C, but there is a 30° slit in it. The jet and the shield radiate as black bodies. They sit in a room at 30°C, and the shield has a temperature of 700°C. Calculate the net heat transfer; from the jet to the room through the slit(view factor $F_{jet\text{-}room} = 0.08333$); from the jet to the shield (view factor $F_{jet\text{-}shield} = 0.9167$); and from the inside of the shield to the room (view factor $F_{slit\text{-}jet} = 0.0600$, view factor $F_{shield\text{-}room} = 0.08545$)

Problem 4

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, $\alpha=2.203 \times 10^{-5}$ m^2/s, $\nu=1.556 \times 10^{-5}$ m^2/s, Pr=0.711)