Ap 2001 No Solutions

THE UNIVERSITY OF MANITOBA

April 25, 1:30 p.m. 2001 Final Examination

Paper No.: 712

Dept. and Course No.: 130.112 Time: 3 Hours

Examination: Thermal Sciences

Examiners: Professors L. Magalhaes, G. Naterer, R. Schilling

Notes: (i) This is an Open Textbook examination. Students are permitted to use calculators and textbook "Thermodynamics, An Engineering Approach", 3rd Edition, by Y.A. Cengel and M.A. Boles. No other materials (i.e., notes, solved problems in textbooks etc.) are allowed.

(ii) Attempt all five questions. The values are indicated in the margin.

(iii) Do all of your calculations in the examination booklet provided. Include your section number and the name of your instructor on the front cover page of the examination booklet.

(iv) Students may use both sides of each page in the examination booklet if necessary.

Value

Problem #1

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A 1.6 m^3 rigid tank is divided into two sections which are separated by a partition. The left side contains $0.6 m^3$ of Ar at 240 kPa and 60°C. The other compartment contains moist air at 100 kPa, a Tdry bulb of 30°C, and 40% relative humidity.

Ar (Argon)	Air – H_2O
60°C, 240 kPa	30°C, 100 kPa, 40% RH
0.6 m^3	1.0 m^3

(a) Find the initial partial pressure of air in the right compartment.

(b) Now the partition is removed. The gases on both sides are fully mixed together while 30 kJ of heat are lost to the surroundings. Find the final temperature (°C) and pressure (kPa) of the mixture.

Problem #2

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A piston-cylinder device contains 1 kg of refrigerant – 134 A at 0.8 MPa and 85°C. The refrigerant is then cooled at constant pressure until the volume is reduced by 60%.

(a) sketch the process on a T-υ diagram with respect to saturation lines

(b) determine the final temperature

(c) find the total enthalpy change during the entire process

(d) determine the amount of heat lost from the system

(e) how would the result change in part (c) if the pressure decreased during the cooling process? Assume that the same volume change is observed.

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Problem #3

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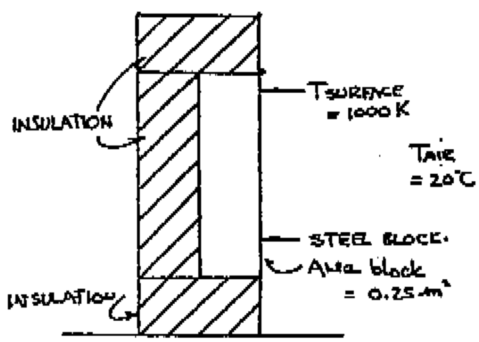
A hot steel block rests on an insulated bench as shown. Three sides of the block are insulated as shown in the sketch, and it can be assumed that no heat is lost from the insulated surfaces. The other side of the block which is at 1000 K transfers heat to the surrounding air by both free convection and radiation. For the information given, calculate the total heat transferred from the block to the surroundings.



Emissivity of steel block = 0.6
Surface area of block at 1000 K = 0.25 m^2
Convective heat transfer coefficient =
$40 \frac{W}{m^2 {}^\circ C}$

Problem #4

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Air passes through a gas turbine system at a rate of 4.5 kg/s. It enters the turbine with a velocity of 90 m/s and a specific volume of 0.85 m^3/kg. It leaves the turbine with a specific volume of 1.45 m^3/kg. The exit area of the turbine is 0.038 m^2. In its passage through the turbine the specific enthalpy is reduced by 200 kJ/kg and there is a heat loss from the turbine of 40 kJ/kg. The gas enters the turbine at a temperature of 350°C.

a) Sketch the turbine system and add the relevant information for the solution of the problem.
b) Calculate the inlet area of the turbine in m^2.
c) Calculate the exit velocity of the air in m/s.
d) Calculate the outlet temperature of the air leaving the turbine in K.
e) Calculate the power developed by the turbine in Kilowatts.

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Problem #5

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The power produced by a gas turbine engine is used to drive a heat pump as shown. The heat pump is pumping heat from a low temperature thermal reservoir that consists of cool R134A, to a high temperature thermal reservoir that consists of water. For the properties shown calculate COP_R (ie. $COP_{REFRIGERATION}$) and the mass flow rate $(\dot{m}_3)$ for the water flowing through the high temperature thermal reservoir in $\frac{kg}{s}$.