CARLETON UNIVERSITY

Deferred
EXAMINATION
February, 2005

DURATION: 3 HOURS

Department Name & Course Number: **Mechanical & Aerospace Engineering MAAE 2400A and B**
Instructor(s) **Professor J.E.D. Gauthier, Professor J. Gu**

AUTHORIZED MEMORANDA
Open Book, any calculator permitted

Students **MUST** count the number of pages in this examination question paper **before** beginning to write, and report any discrepancy immediately to a proctor. This question paper has **2** pages.
This examination question paper **MAY** be taken from the examination room.

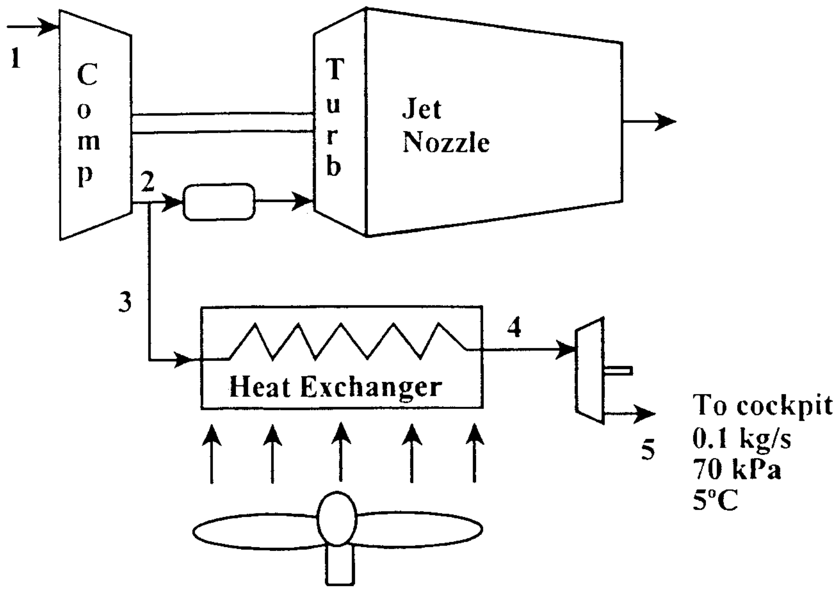
Attempt all questions.
All questions are of equal value.

1. Refrigerant 22 is the working fluid in a power plant operating as a Rankine cycle. Saturated vapour at 40°C enters the turbine having an efficiency of 90 percent. The fluid leaves the condenser at a pressure of 5 bars, as a saturated liquid. Find the overall thermal efficiency of the cycle.

2. Consider a steam power plant. The steam enters the 85%-efficient turbine (Station 1) at a rate of 10 kg/s, at 600°C and 10 MPa and leaves at 50 kPa (Station 2). At Station 2, 10 percent of the total working fluid mass is removed from the cycle to be used for heating purposes. After going through the condenser, the remaining water enters the 90%-efficient pump as saturated liquid (Station 3). At Station 3, liquid water at 20°C is added to the loop to make up for the water removed at Station 2. Find the power output of this cycle.

3. Refrigerant 134a is used as the working fluid in a ideal heat pump cycle. Dry saturated vapour at 1 bar enters the compressor (Station 1). Saturated liquid leaves the condenser and enters the expansion valve (Station 3). What would the pressure have to be at the exit of the compressor (Station 2) to have a COP equal to 2?

4. As shown in the figure, an aircraft cockpit is to be supplied with 0.1 kg/s of cooling air at 70 kPa, 5°C by bleeding air at 350 kPa, 200°C from the jet-engine compressor (at Station 2), cooling it in a heat exchanger (from Station 3 to Station 4), and expanding it through an ideal turbine (from Station 4 to Station 5) that exhaust into the cockpit (Station 5). Disregarding friction and kinetic energy changes, find the heat transfer rate to the air within the heat exchanger in kW.



5. On a cold -20°C winter night, heat is lost through a 1m x 1m , 20 mm thick, single-pane window from a room at 20°C. Measurements made of inside and outside glass surface temperatures give 7°C and -14°C respectively. If the inside convective film coefficient is 3.4 W/m^{2}K, the room can be represented as a black body space, and the glass has a surface emissivity of 0.84:

a) How much heat is transferred from the room to the window by:
i) radiant heat transfer rate
ii) convective heat transfer

b) Find the thermal conductivity, k, for this window.