

CARLETON UNIVERSITY

**Final
EXAMINATION
April, 2000**

DURATION: 3 HOURS

No. of Students: 92

Department Name & Course Number: **Mechanical & Aerospace Engineering 86.240B**

Instructor(s): **Professor J.E.D. Gauthier**

**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 MAY be taken from the examination room.

Attempt all questions

All questions are of equal value

1. Consider a refrigeration unit using R 22 refrigerant. At the inlet of the compressor the refrigerant is a saturated vapour at -20°C and the exit conditions are 80°C and 16 bars. The refrigerant leaves the condenser as a saturated liquid. Find:
 - a) the efficiency of the compressor,
 - b) the coefficient of performance of this unit, and
 - c) the quality of the refrigerant mixture at the inlet of the evaporator

2. Consider a jet aircraft with an engine running under the following characteristics:

Inlet temperature: 15°C	Inlet pressure: 101 kPa
Pressure ratio: 10	Compressor efficiency: 80%
Turbine inlet temperature: 1100°C	Turbine efficiency: 90%
Mass flow of air: 30 kg/s	Nozzle Efficiency: 100%

Assuming that the mass flow rate of fuel is negligible compared to the air flow rate, find the efficiency of this engine at static (i.e., at zero flight velocity) conditions.

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3. A Carnot cycle uses steam as the working fluid and operates between pressures of 7.0 MPa and 7 kPa. Find:
 - a) the thermal efficiency,
 - b) the turbine work in kJ/kg, and
 - c) the compressor work in kJ/kg.

4. A closed system undergoes a polytropic process according to $pV^{1.3} = \text{cte}$. The initial temperature and pressure are 320 °C and 200 kPa, respectively. The final temperature is 640 °C. The mass of fluid is 3 kg. Find the change of entropy in J/K for the process if:
 - a) air is the working fluid, and
 - b) water vapour is the working fluid.

5. The flat wall of a furnace, is composed of 6 cm of brick in the inside and 1 cm of metal on the outside. The thermal conductivity of the brick is 2.5 W/m-K and that of the metal 50 W/m-K. The outside face of the furnace is exposed to a convective heat loss to ambient air at 35°C through a surface heat coefficient of $h = 20 \text{ W/m}^2\text{-K}$. The outside face of the metal, which is gray with an emissivity, $\epsilon = 0.8$, also exchanges radiant heat with the walls of a very large room in which the furnace is located. These black walls are at a temperature of 30°C.
 - a) Find the maximum temperature allowable at the inside surface of the brick if the metal temperature must not exceed 800 K.
 - b) Find the temperature on the outside face of the furnace for the conditions at a).

6. An air-standard Otto cycle has an initial temperature of 100°F and a pressure of 14.7 psia, and a compression pressure, $p_2 = 356 \text{ psia}$. The pressure after heat addition is 1100 psia. Find:
 - a) the thermal efficiency, and
 - b) the maximum temperature.

Bonus problem for up to 10% extra marks

7. Hand in Assignment 9.4. No photocopy accepted.