FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
Thermodynamics I		ENGR 251	M
EXAMINATION Final	DATE December 22, 2009	TIME & PLACE Room: 14:00 – 17:00 H-509; H-520; H-521	# OF PAGES 4

PROFESSORS
L. Kadem

LAB INSTRUCTOR

MATERIALS ALLOWED ❑ NO ❑ YES (PLEASE SPECIFY)

CALCULATORS ALLOWED ❑ NO ❑ YES (non programmable)

SPECIAL INSTRUCTIONS:

Answer ALL the questions.
State clearly any assumptions you make.
Draw a clear sketch of the problem.
Return the Exam paper with the answers' book.

X

x

Name: ______________________________ **I.D.:** ______________________
Surname, given names

Question no. 1 (20 Marks)

Consider a 210 MW steam power plant that operates on a simple Rankine cycle. Steam enters the turbine at 10 MPa and 500°C and is cooled in the condenser at a pressure of 10 kPa. The isentropic efficiency for both the turbine and the pump is 85%.
- a) Show the cycle on a T-s diagram with respect to saturation lines.
- b) Compute the thermal efficiency of the cycle.
- c) Compute the mass flow rate of the steam.

Thermal efficiency	
Mass flow rate of the steam	

Question no. 2 (20Marks)

Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300 K, and a turbine inlet temperature of 1000 K. Determine the required mass flow rate of air for a net power output of 90 MW, assuming both the compressor and the turbine have an isentropic efficiency of: (a) 100% and (b) 80%.

Assume constant specific heats at room temperature.

Mass flow rate (100 %)	
Mass flow rate (80 %)	

Question no. 3 (20 Marks)

The compression ratio of an ideal Otto cycle is 8. At the onset of the compression stroke, the pressure is 0.1 MPa and the temperature is 15°C.
The heat supplied to air, per cycle, is 1800 kJ/kg. Determine:

-a) The pressure, the specific volume and the temperature at each state.
-b) The thermal efficiency.

Assume constant specific heats at room temperature.

	T	P	v
Point 1			
Point 2			
Point 3			
Point 4			
Thermal efficiency			

<u>Question no. 4 (20 Marks)</u>

An insulated vertical piston-cylinder device initially contains 10 kg of water, 2 kg of which is in the liquid phase. The mass of the piston is such that it maintains a constant pressure of 300 kPa inside the cylinder. Now steam at 0.5 MPa and 350°C is allowed to enter the cylinder from a supply line until all liquid in the cylinder has vaporized.

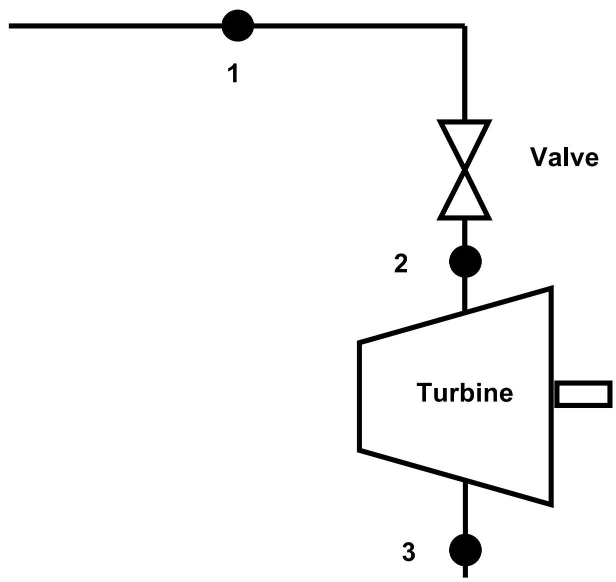
- Determine the final temperature in the cylinder.
- Determine the mass of the steam that has entered.

Final temperature	
Mass of the steam	

<u>Question no. 5 (20 Marks)</u>

A) The conditions at the inlet of a steam turbine can be controlled using a valve (see figure below). The pressure before the valve is 1.4 MPa and the temperature 300°C. The pressure at the turbine exit is fixed at 10 kPa. Assuming the expansion through the turbine is adiabatic and reversible, determine:

- The pressure at point (2) to produce 75% of the maximal work.



Pressure (2)	

B)**-** The efficiency of a certain cycle is given by:

$$\eta = 1 - \frac{T_1}{T_3} r_p^{\frac{k-1}{k}}$$

Where T_1 is the lowest temperature; T_3 is the highest temperature and r_p is the pressure ratio. Under which conditions the efficiency of this cycle is equal to the efficiency of a Carnot cycle? Demonstrate why?

Formulae and Constants
For Air: k= 1.4; C_p = 1.005 kJ/kg K; R=0.287 kJ/kg K
For Helium: k= 1.667

$$\left(\frac{T_2}{T_1}\right)_{s=cte} = \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$\left(\frac{T_2}{T_1}\right)_{s=cte} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$\left(\frac{P_2}{P_1}\right)_{s=cte} = \left(\frac{v_1}{v_2}\right)^{k}$$