

Name \_\_\_\_\_

**ES201**  
Examination III  
February 13, 1998

Problem	Score
1	/20
2	/10
3	/35
4	/35
Total	/100

Show all work for credit  
AND  
Box your answer with appropriate units  
AND  
Turn in your signed help sheet

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 ES201 Examination III

**Problem 1**

20 pts  
 February 13, 1998

A piston cylinder assembly contains a gas which undergoes a series of quasistatic processes which make up a cycle. Information about state and processes that make up this cycle are shown in the table below.

State/Process	P, kPa	V, m <sup>3</sup>	T, K	U, kJ
1	110	$5 \times 10^{-4}$	300	0.137
1 → 2	Adiabatic Compression			
2	950	$1.25 \times 10^{-4}$	600	0.305
2 → 3	Constant Pressure Expansion			
3	950	$2.5 \times 10^{-4}$	1300	0.659
3 → 4	Adiabatic Expansion			
4	390	$5.0 \times 10^{-4}$	1060	0.522
4 → 1	Constant Volume Compression			

For each process determine the work and heat transfer and fill out the rest of the table below. Show all work for credit.

Process	Q (kJ)	W (kJ)	$\Delta U$ (kJ)
1 → 2			0.168
2 → 3			0.354
3 → 4			-0.137
4 → 1			-0.385
Total			

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**Problem 2**

10 pts

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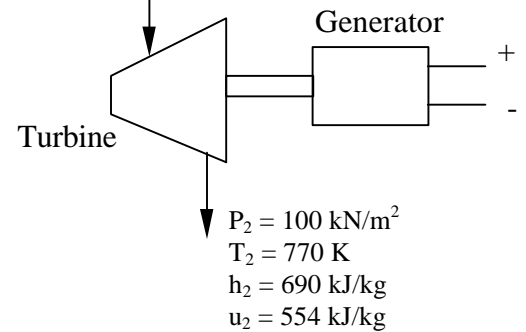
Is the cycle give in Problem 1 a power cycle or a refrigeration/heat pump cycle?

Determine the thermal efficiency or COP (assuming it is a heat pump cycle).

A gas flows into a turbine at a rate of 1.4 kg/s and with a negligible velocity. The gas leaves the turbine at a velocity of 200 m/s. The turbine operates under steady state conditions and generates 240 kW of shaft power. Assume changes in gravitational energy are negligible.

- Determine the rate of heat transfer from the turbine in kW.
- If the turbine is used to drive a generator producing 60 cycle ac power, determine the torque produced at the turbine shaft, in kN-m, if the turbine-generator spins at 3600 rpm.
- The generator delivers electrical power equal to 95% of the shaft power supplied by the turbine. Determine the heat transfer from the generator in kW.

$$\begin{aligned}P_1 &= 500 \text{ kN/m}^2 \\T_1 &= 940 \text{ K} \\h_1 &= 900 \text{ kJ/kg} \\u_1 &= 724 \text{ kJ/kg}\end{aligned}$$



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**Problem 3**

35 pts

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The light rod and its fixed 5 lbm ball are released from rest in the  $45^\circ$  position and rotate in the vertical plane about O under the action of the constant 3 lbf horizontal force. In the position shown the spring,  $k = 6 \text{ lbf/in}$ , is held by two cables each with a tension 3 lbf. Compute velocity of the ball when the rod is in the vertical position.

