Unified Engineering Quiz 1 NAME________________________
Fall 2004

Unified Quiz: Thermodynamics

November 12, 2004

Calculators allowed.
No books allowed.
A list of equations is provided.

- **Put your name on each page of the exam.**
- **Read all questions carefully.**
- **Do all work for each problem on the pages provided.**
- **Show intermediate results.**
- **Explain your work --- don't just write equations.**
- **Partial credit will be given (unless otherwise noted), but only when the intermediate results and explanations are clear.**
- **Please be neat. It will be easier to identify correct or partially correct responses when the response is neat.**
- **Show appropriate units with your final answers.**
- **Box your final answers.**

Exam Scoring

#1 (35%)	
#2 (25%)	
#3 (18%)	
#4 (22%)	
Total	

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1) (30%, 5 parts * 7% each -- partial credit given)

a) Explain in physical terms why $c_v < c_p$ for a gas. In your explanation, please include definitions of c_v and c_p and please make reference to different forms of energy and heat and work.

b) Describe what internal energy is in physical terms

c) Describe what enthalpy is in physical terms

1) Continued (30%, 5 parts * 7% each -- partial credit given)

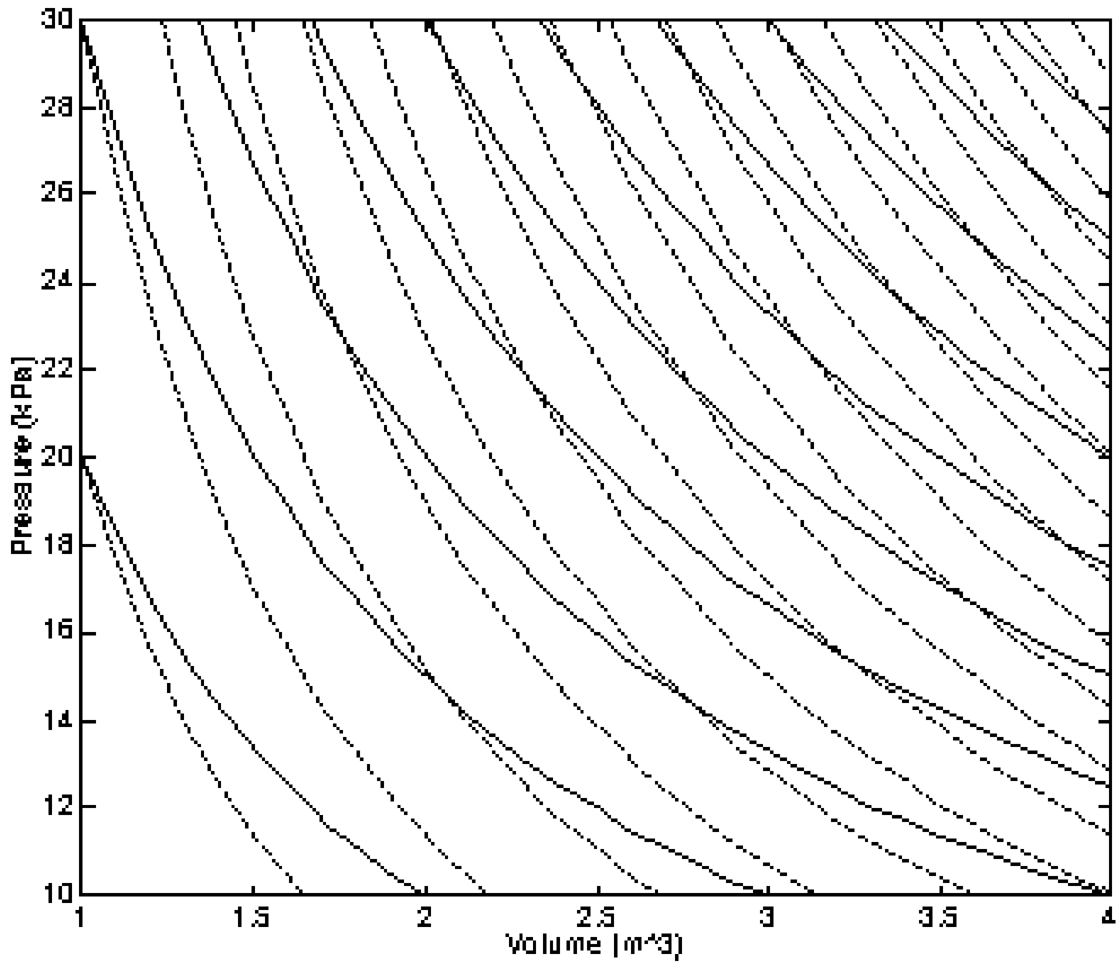
d) Explain the difference between work and energy.

e) When the compression process for an automobile engine is described as adiabatic and quasi-static what are the physical implications relative to the speed and size of the engine, the cylinder design and the properties of the working fluid? (LO# 4, 5)

2) (25%, partial credit given)

a) **(5%, partial credit given)** Draw (and label) a thermodynamic cycle consisting of four quasi-static processes involving an ideal gas: (LO# 4, 6)

1-2: constant volume heating
2-3: isothermal compression
3-4: constant pressure cooling
4-1: adiabatic expansion



(dashed lines = adiabats, solid lines = isotherms)

b) **(15%, partial credit given)** Determine the sign of the heat and work transfers and change in internal energy for each leg and the cycle as a whole.

	q (+, - or zero)	**w (+, - or zero)**	**Δu (+, - or zero)**
Leg 1-2			
Leg 2-3			
Leg 3-4			
Leg 4-1			
Sum for cycle			

c) **(5%, partial credit given)** You are given 2 independent thermodynamic properties at state 1, along with c_p, c_v and R and the following additional information about the cycle:

1-2: constant volume heating
2-3: isothermal compression, compression ratio (v2/v3) = 1.5
3-4: constant pressure cooling
4-1: adiabatic expansion, expansion ratio (v1/v4) = 2

Is enough information given to determine the numerical value of the work of the cycle? If your answer is no, what additional information must be given? If your answer is yes, how would you determine the work (i.e. what steps would you go through)? DO NOT SOLVE THE CYCLE TO ANSWER THIS QUESTION!

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3) (18%, partial credit given) An aircraft is traveling against a headwind. Assume R = 287 J/kg-K, c_p = 1003.5 J/kg-K, c_v = 716.5 J/kg-K, γ = 1.4. (LO# 4)

a) (6%, partial credit given) If the temperature of the atmosphere is 260K and the wind is moving at 10 m/s relative to the ground, what temperature would a thermometer read if it is fixed to the ground?

b) (6% partial credit given) What temperature would a weather balloon read if it was carried along with the wind?

c) (6%, partial credit given) For a thermometer mounted on an airplane that is flying into the wind at 250m/s relative to the moving air mass, what temperature is read?

4) (22%, partial credit given) For this problem assume the working fluid is an ideal gas with R=260 J/kg-K, c_p= 2800 J/kg-K, and c_v = 2540 J/kg-K. (LO #4)

A cold rocket propellant enters a pump at p = 1MPa, T = 200K and c = 50 m/s. The flow rate is 100 kg/s. The flow leaves the pump at p = 5MPa and c = 60 m/s. Assuming the pump behaves adiabatically and quasi-statically, what are the thermodynamic conditions at the pump exit? What are the rates of work, shaft work and flow work done by the propellant during the pumping process?

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