ROSE-HULMAN Institute of Technology
Department of Mechanical Engineering

ME301 – Thermodynamics II Fall 2014-2015

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Name

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CM

Exam 2

Oct 27, 2014

Problem 1	______/ 15
Problem 2	______/ 20
Problem 3	______/ 30
Problem 4	______/ 35
Total	______/ 100

Show all work for full credit.

Open book, computer use for computational purposes, one 8 ½ x 11" handwritten equation sheet.

If you use tabular data from your text, do **not** interpolate values. Use the nearest value in the table(s).

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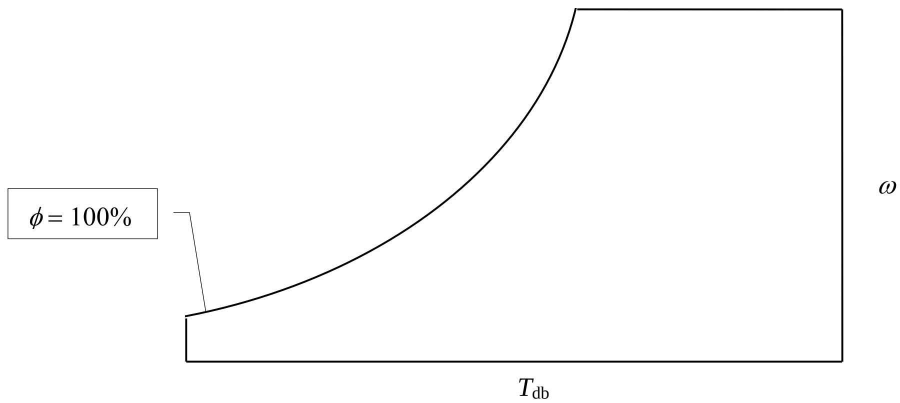
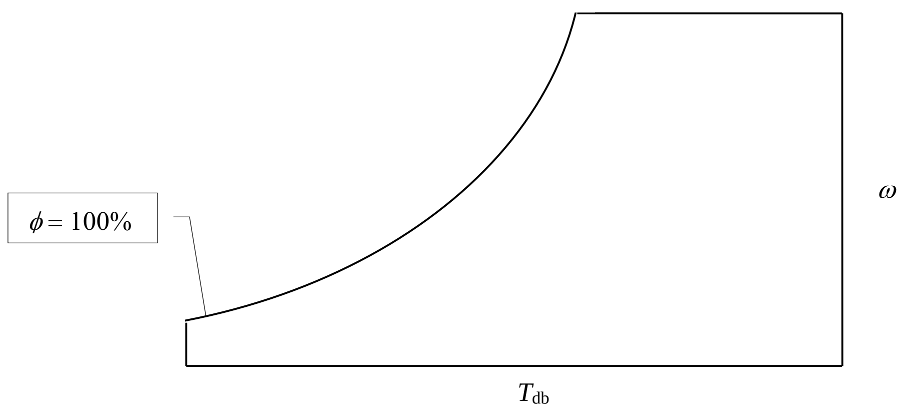
Problem 1 (15 pts)

Sketch the process path on a psychrometric chart for the following physical processes:

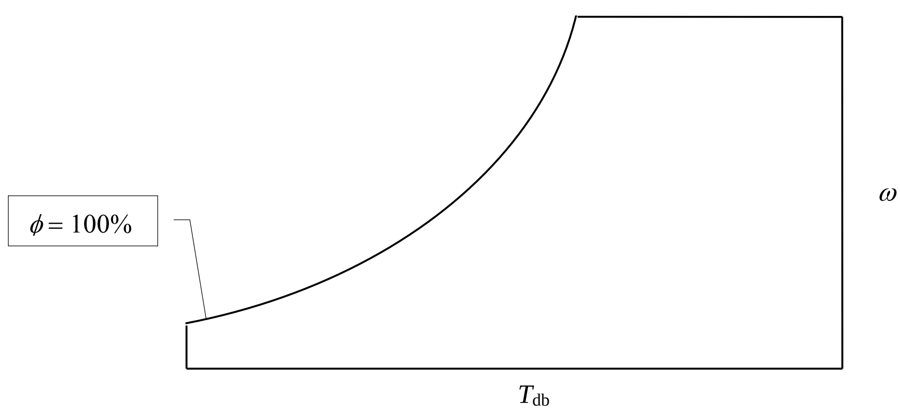
(a) heating of a moist air sample from an initial temperature T_1 to a final temperature T_2



(b) cooling of a moist air sample from an initial temperature T_1 to a final temperature T_2 (where T_2 is below the dew point temperature)

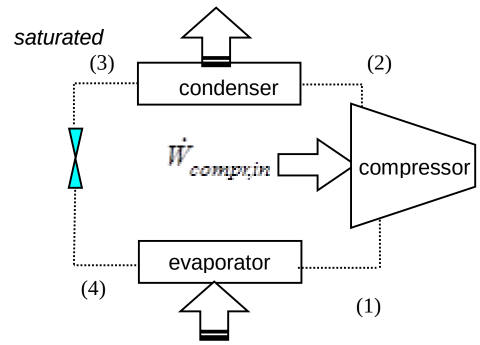


(c) humidification of a relatively dry air sample (φ_1 = 30%) at an initial temperature T_1 by a liquid spray at a lower temperature



Problem 2 (20 pts)

A vapor-compression **heat pump cycle** uses **R-134a** to provide heating. The power into the compressor is $\dot{W}_{compr,in}$ =10 kW. Other data are shown in the figure and the table.



State	T [°C]	P [kPa]	h [kJ/kg]		other
1	10	320			Compressor inlet
2		1000	295		
3		1000			Saturated liquid
4		320			

(a) Determine the mass flow rate of R134a through the system.

(b) Determine the heating capacity in kW.

(c) Determine the heat pump coefficient of performance.

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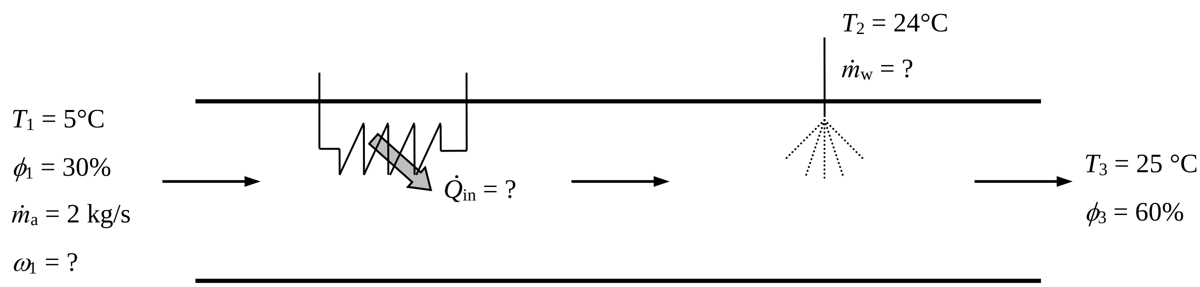
Problem 3 (30 Points)

During the cold winter months, a gas heater is commonly used to keep the indoor temperature at a comfortable level. However, the warmer air is usually dry which may cause troubles for people with sensitive skin.

A combined heating-humidification system is proposed to control both the temperature and the relative humidity of the indoor air stream. Please refer to the following schematic for details.



Assuming a uniform total pressure of 101.325 kPa throughout the process,

(a) Determine the humidity ratio of the air at the entrance,

(b) the spray rate of liquid water, in kg/s, and

(c) the heat transfer rate during the heating process, in kW.

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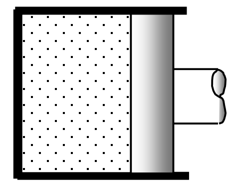
Problem 4 (35 pts)

A **Really Bad Idea Cycle** (RBI cycle) is a closed-system/periodic cycle consisting of only three steps as follows:

(1)→(2) Constant volume heat addition
(2)→(3) Reversible, adiabatic expansion
(3)→(1) Constant temperature heat rejection

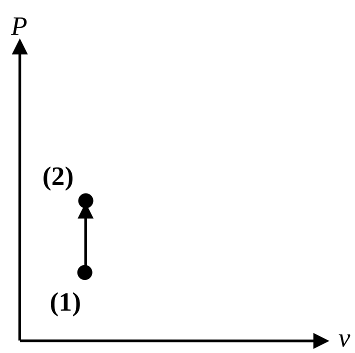


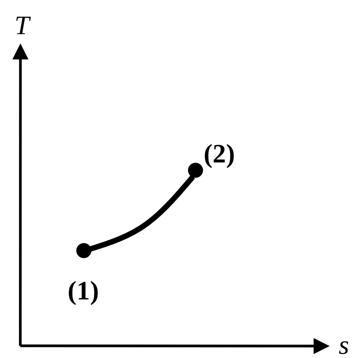
A particular RBI cycle is to be modeled using the **cold air standard** assumptions. (For air, c_p= 1.005 kJ/kg-K, c_v = 0.718 kJ/kg-K, R = 0.287 kJ/kg.) The air at the beginning of the heat addition is P_1 = 90 kPa and T_1 = 20°C. The heat added during the constant volume process (1)→(2) is $q_{in,12}$ = 200 kJ/kg.

This information is sumKmarized in the table below. (You do not need to fill in all values in the table.)

State	T [°C]	P [kPa]	
1	20	90	
	$q_{in,12}$ = 200 kJ/kg		
2			
3			

(a) Complete the sketches of the P-v and T-s diagrams for a RBI cycle.





(b) Find the <u>temperature</u> T_2 at the end of the constant volume heat addition (in °C).
(c) Find the <u>compression ratio</u>, $r = v_3/v_2$
(d) Find the <u>work and heat transfer per unit mass</u> (in kJ/kg) for each step in the given cycle (in kJ/kg). (Hint: For a constant temperature process of an ideal gas, Pv = constant.)
(e) Find the cycle efficiency.

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