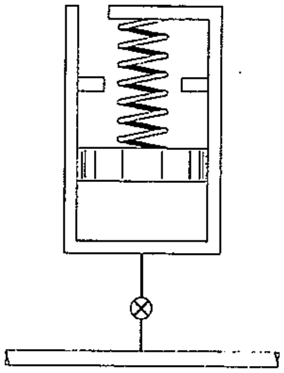
編號： 74

國立成功大學107學年度碩士班招生考試試題

系　所：機械工程學系
考試科目：熱力學　　　　考試日期：0205，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. A frictionless piston/cylinder is loaded with a linear spring, and if the piston sits at the bottom, the spring force balances the other loads on the piston. The cylinder initial volume of 20 L contains air at 200 kPa, 10°C. The cylinder has a set of stops that prevents its volume from exceeding 50 L. A valve connects to a line flowing air at 800 kPa, 50°C. The valve is now opened, allowing air to flow in until the cylinder pressure reaches 800 kPa, at which point the temperature inside the cylinder is 80°C. The valve is then closed and the process ends. Assume air is an ideal gas, with constant specific heat, C_p = 1.004 kJ/kg-K, C_v = 0.717 kJ/kg-K, and R = 0.287 kJ/kg-K. (25%)
    (a) What is the pressure while the piston first hit the stops (P_{stop})?
    (b) Find the air mass that enters.
    (c) Determine the work and heat transfer during the process.
    (d) Plot the process in a P-V diagram and clearly mark each state.



2. An engineer wishes to design an industrial process which requires a steady 0.5 kg/s of air at 200 m/s, at the condition of 150 kPa, 300 K. This air is to be the exhaust from a specially designed turbine with inlet pressure 400 kPa and inlet velocity is negligible. The heat transfer comes from a source at a temperature 400 K higher than the turbine inlet temperature. The change in potential energy is negligible. The turbine process may be assumed to be reversible and polytropic, with polytropic exponent $n = 1.2$. Assume air is an ideal gas, with constant specific heat, C_p = 1.004 kJ/kg-K, C_v = 0.717 kJ/kg-K, and R = 0.287 kJ/kg-K. (25%)
    (a) What is the turbine inlet temperature?
    (b) What are the power output and heat transfer rate for the turbine?
    (c) Is this process possible to occur? Why?

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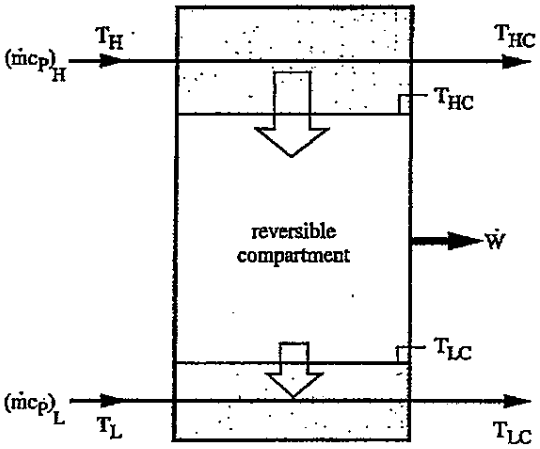
3. The power plant shown in the following figure uses a hot single-phase stream of initial temperature T_H and capacity flow rate $(\dot{m}c_p)_H$ as heat source. The heat sink of the power plant shown is a cold single-phase stream of initial temperature T_L and capacity flow rate $(\dot{m}c_p)_L$. The power plant can be modeled as a device of three parts: a hot-end heat exchanger, a reversible compartment contained between two isothermal surfaces (T_{HC}, T_{LC}), and a cold-end heat exchanger. The heat transfer surfaces of temperatures T_{HC} and T_{LC} are sufficiently large so that each stream reaches thermal equilibrium with the respective surface before it is discharged into the ambient. (a) Express the power output $\dot{W}$ as a function of the variable T_{HC} and the fixed parameters of the device $[T_H, T_L, (\dot{m}c_p)_H, (\dot{m}c_p)_L]$. (b) Maximize $\dot{W}$ with respect to T_{HC} and show that the maximum power output can be expressed as

$$\dot{W}_{max} = \frac{(T_H^{1/2} - T_L^{1/2})^2}{\dfrac{1}{(\dot{m}c_p)_H} + \dfrac{1}{(\dot{m}c_p)_L}} .\quad (20\%)$$



4. Consider a gas which has the equation of state expressed as $P(v-a)=RT$ with *a* denoting a constant. Explain whether this gas can be cooled by throttling or not. (15%)

5. In a vapor-compression refrigeration cycle. Refrigerant 134a is used as the working fluid. The cycle operates at steady state. Refrigerant enters the condenser at 60 °C and exits as saturated liquid. The condenser vapor pressure is 1.2 MPa. and evaporator temperature is 8 °C. The specific enthalpy of the refrigerant is 251.80 kJ/kg at the enterance of the compressor. The refrigeration capacitance of the cycle is 6 tons. Determine the mass flow rate of the refrigerant in kg/s and the efficient of performance using Table 1 and Table 2. (15%)

Table 1. Properties of Saturated R 134a

Temp. (°C)	Pressure (bar)	Sat. Liquid, h_f (kJ/kg)	Sat. Vapor, h_g (kJ/kg)
42	10.720	109.19	269.14
44	11.299	112.22	270.01
48	12.526	118.35	271.68
52	13.851	124.58	273.24

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Table 2. Properties of Superheated R 134a

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 8.0 bar = 0.80 MPa (T_{sat} = 31.33°C)				p = 9.0 bar = 0.90 MPa (T_{sat} = 35.53°C)			
Sat.	0.02547	243.78	264.15	0.9066	0.02255	245.88	266.18	0.9054
40	0.02691	252.13	273.66	0.9374	0.02325	250.32	271.25	0.9217
50	0.02846	261.62	284.39	0.9711	0.02472	260.09	282.34	0.9566
60	0.02992	271.04	294.98	1.0034	0.02609	269.72	293.21	0.9897
70	0.03131	280.45	305.50	1.0345	0.02738	279.30	303.94	1.0214
80	0.03264	289.89	316.00	1.0647	0.02861	288.87	314.62	1.0521
90	0.03393	299.37	326.52	1.0940	0.02980	298.46	325.28	1.0819
100	0.03519	308.93	337.08	1.1227	0.03095	308.11	335.96	1.1109
110	0.03642	318.57	347.71	1.1508	0.03207	317.82	346.68	1.1392
120	0.03762	328.31	358.40	1.1784	0.03316	327.62	357.47	1.1670
130	0.03881	338.14	369.19	1.2055	0.03423	337.52	368.33	1.1943
140	0.03997	348.09	380.07	1.2321	0.03529	347.51	379.27	1.2211
150	0.04113	358.15	391.05	1.2584	0.03633	357.61	390.31	1.2475
160	0.04227	368.32	402.14	1.2843	0.03736	367.82	401.44	1.2735
170	0.04340	378.61	413.33	1.3098	0.03838	378.14	412.68	1.2992
180	0.04452	389.02	424.63	1.3351	0.03939	388.57	424.02	1.3245
	p = 10.0 bar = 1.00 MPa (T_{sat} = 39.39°C)				p = 12.0 bar = 1.20 MPa (T_{sat} = 46.32°C)			
Sat.	0.02020	247.77	267.97	0.9043	0.01663	251.03	270.99	0.9023
40	0.02029	248.39	268.68	0.9066				
50	0.02171	258.48	280.19	0.9428	0.01712	254.98	275.52	0.9164
60	0.02301	268.35	291.36	0.9768	0.01835	265.42	287.44	0.9527
70	0.02423	278.11	302.34	1.0093	0.01947	275.59	298.96	0.9868
80	0.02538	287.82	313.20	1.0405	0.02051	285.62	310.24	1.0192
90	0.02649	297.53	324.01	1.0707	0.02150	295.59	321.39	1.0503
100	0.02755	307.27	334.82	1.1000	0.02244	305.54	332.47	1.0804
110	0.02858	317.06	345.65	1.1286	0.02335	315.50	343.52	1.1096
120	0.02959	326.93	356.52	1.1567	0.02423	325.51	354.58	1.1381
130	0.03058	336.88	367.46	1.1841	0.02508	335.58	365.68	1.1660
140	0.03154	346.92	378.46	1.2111	0.02592	345.73	376.83	1.1933
150	0.03250	357.06	389.56	1.2376	0.02674	355.95	388.04	1.2201
160	0.03344	367.31	400.74	1.2638	0.02754	366.27	399.33	1.2465
170	0.03436	377.66	412.02	1.2895	0.02834	376.69	410.70	1.2724
180	0.03528	388.12	423.40	1.3149	0.02912	387.21	422.16	1.2980
	p = 14.0 bar = 1.40 MPa (T_{sat} = 52.43°C)				p = 16.0 bar = 1.60 MPa (T_{sat} = 57.92°C)			
Sat.	0.01405	253.74	273.40	0.9003	0.01208	256.00	275.33	0.8982
60	0.01495	262.17	283.10	0.9297	0.01233	258.48	278.20	0.9069
70	0.01603	272.87	295.31	0.9658	0.01340	269.89	291.33	0.9457
80	0.01701	283.29	307.10	0.9997	0.01435	280.78	303.74	0.9813
90	0.01792	293.55	318.63	1.0319	0.01521	291.39	315.72	1.0148
100	0.01878	303.73	330.02	1.0628	0.01601	301.84	327.46	1.0467
110	0.01960	313.88	341.32	1.0927	0.01677	312.20	339.04	1.0773
120	0.02039	324.05	352.59	1.1218	0.01750	322.53	350.53	1.1069
130	0.02115	334.25	363.86	1.1501	0.01820	332.87	361.99	1.1357
140	0.02189	344.50	375.15	1.1777	0.01887	343.24	373.44	1.1638
150	0.02262	354.82	386.49	1.2048	0.01953	353.66	384.91	1.1912
160	0.02333	365.22	397.89	1.2315	0.02017	364.15	396.43	1.2181
170	0.02403	375.71	409.36	1.2576	0.02080	374.71	407.99	1.2445
180	0.02472	386.29	420.90	1.2834	0.02142	385.35	419.62	1.2704
190	0.02541	396.96	432.53	1.3088	0.02203	396.08	431.33	1.2960
200	0.02608	407.73	444.24	1.3338	0.02263	406.90	443.11	1.3212