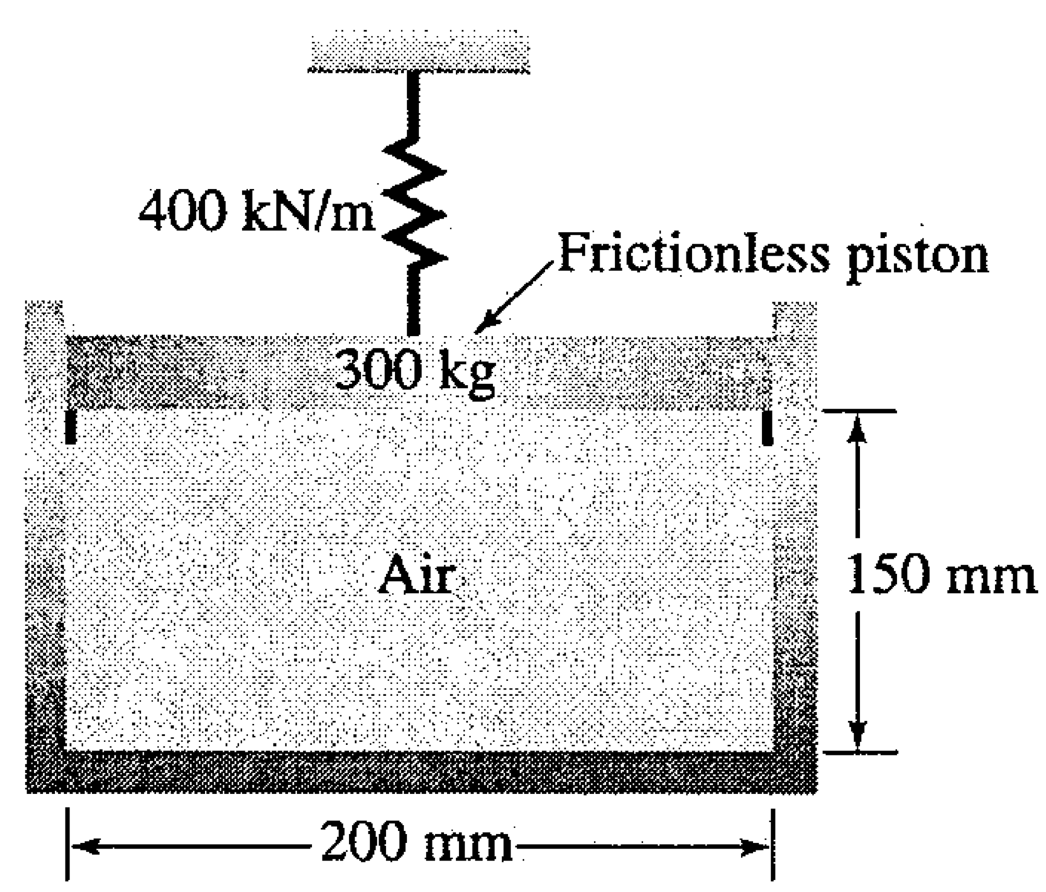
國立清華大學 103 學年度碩士班考試入學試題

系所班組別：動力機械工程學系碩士班 甲組(熱流組)

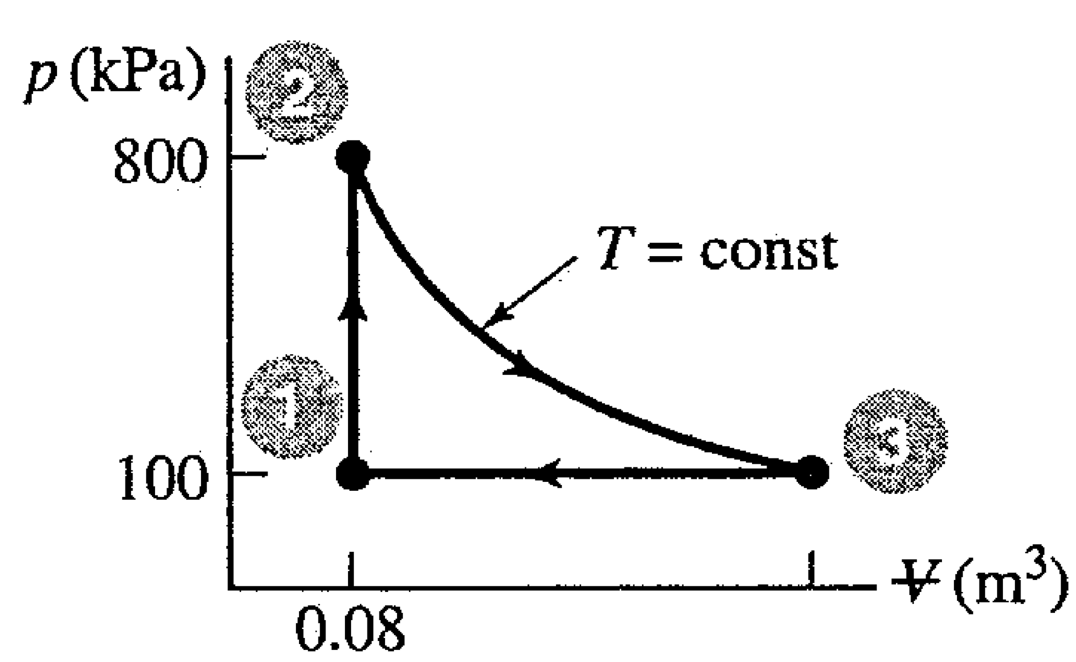
考試科目（代碼）：熱流學一(1102)

　　*請在【答案卷、卡】作答

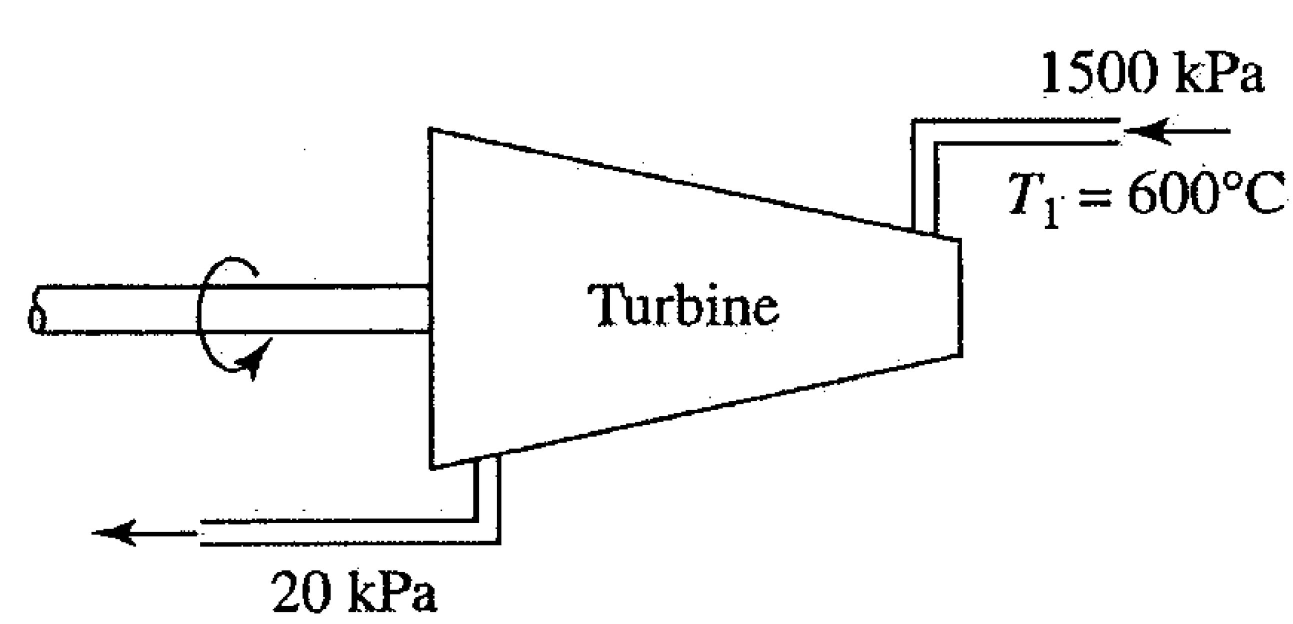
1. Six grams of air is contained in the cylinder shown in the figure below. The air is heated until the piston raises 50 mm. The spring just touches the piston initially. Calculate (a) the temperature when the piston leaves the stops, and (b) the work done by the air on the piston. (R=0.287 kJ/kg K) (8%)



2. For the cycle in the figure below, find the work output and the net heat transfer if the 0.1 kg of air is contained in a piston-cylinder arrangement. (R=0.287 kJ/kg K) (8%)



3. Every second 3.5 kg of superheated steam flows through the turbine shown in the figure below. Assuming an isentropic process, calculate the maximum power rating of this turbine. (8%)



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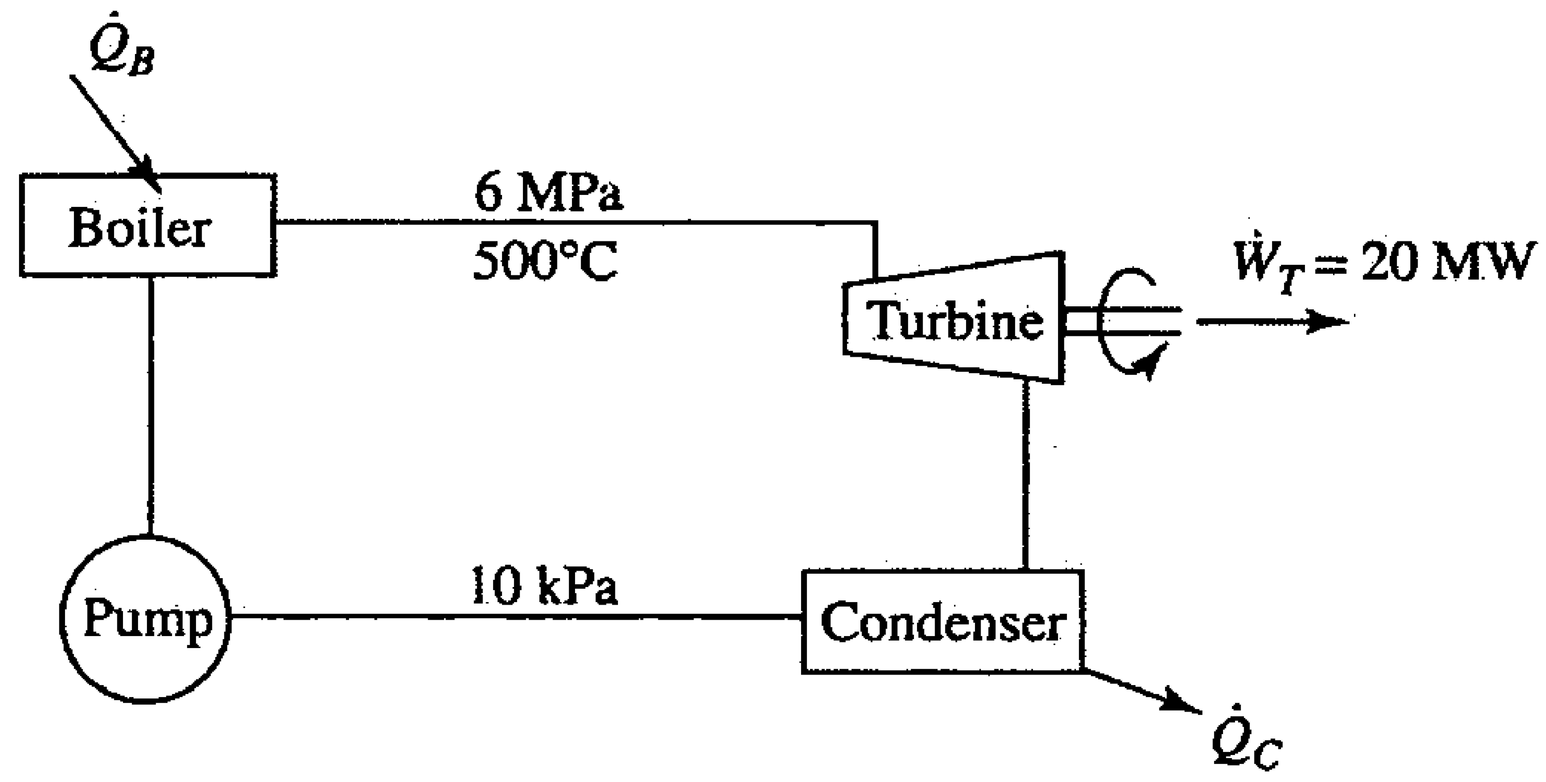
4. For the ideal Rankine cycle, shown in the figure below, determine the mass flow rate of steam and the cycle efficiency. Neglect the pump work. (10%)



5. A simple steam power plant operates between pressure of 10 kPa and 4 MPa with a maximum temperature of 400°C. The power output from the steam turbine is 100 MW. A gas turbine provides the energy to the boiler; it accepts air at 100 kPa and 25°C, has a pressure ratio of 5, and has a maximum temperature of 850°C. The exhaust gases exit the boiler at 350 K. Determine the thermal efficiency of the combined Brayton-Rankine cycle. Refer to the figure below in the solution. Assume properties of air are k = 1.4 and Cp = 1.005 kJ/(kg · K). (16%)

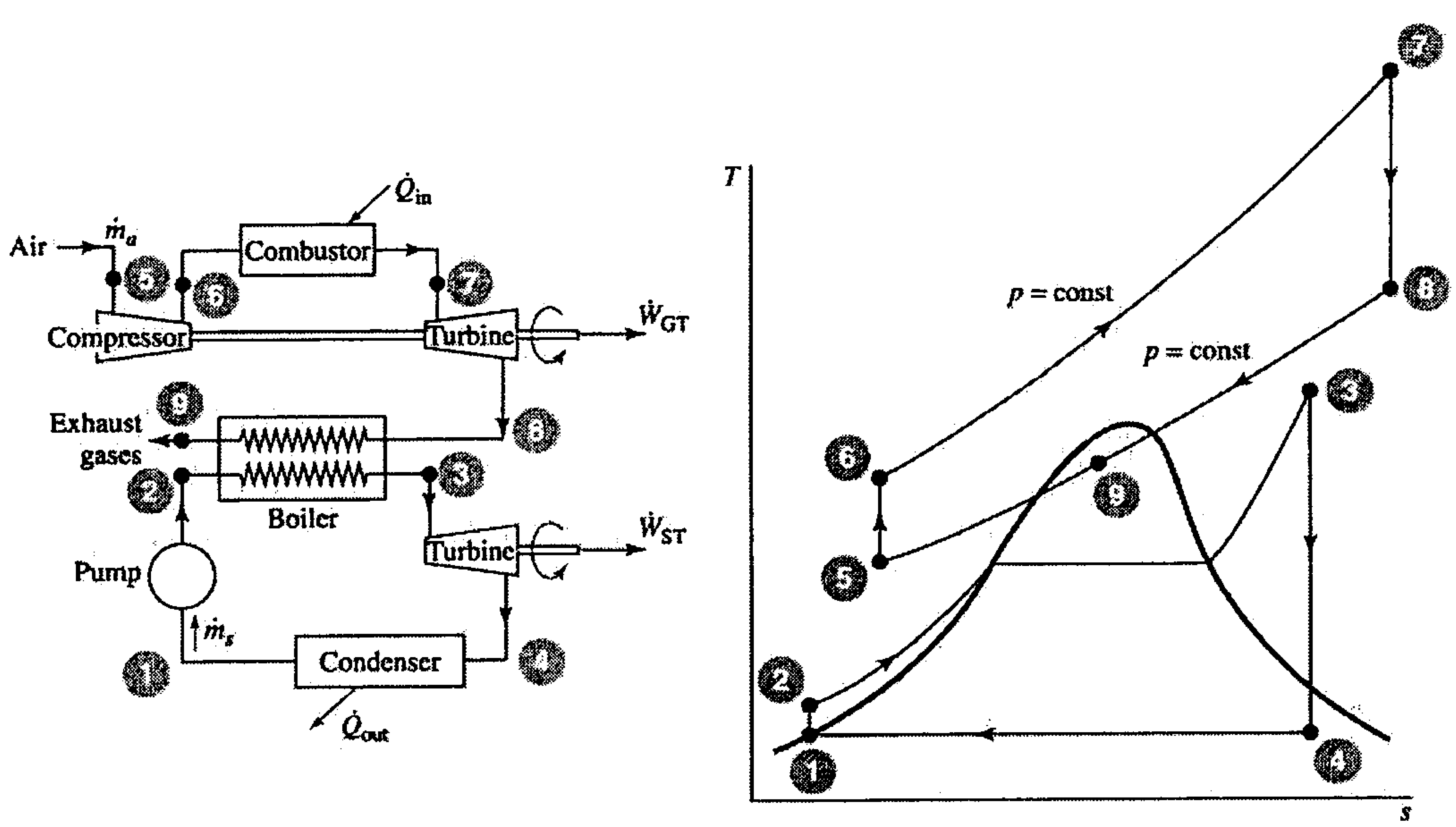


Table 3. Compressed Water and Superheated Steam (continued)

1.5 MPa (t_s = 198.287 °C)					1.6 MPa (t_s = 201.370 °C)					1.8 MPa (t_s = 207.112 °C)			
v	ρ	h	s	t, °C	v	ρ	h	s	t, °C	v	ρ	h	s
266.78	3.7484	3694.7	7.8405	**600**	249.99	4.0002	3693.9	7.8100	**600**	222.00	4.5044	3692.3	7.7543
273.07	3.6621	3739.5	7.8912	**620**	255.89	3.9079	3738.7	7.8608	**620**	227.26	4.4002	3737.3	7.8052
279.34	3.5799	3784.5	7.9411	**640**	261.78	3.8200	3783.8	7.9108	**640**	232.51	4.3008	3782.4	7.8552
285.61	3.5013	3829.8	7.9902	**660**	267.66	3.7360	3829.2	7.9599	**660**	237.75	4.2060	3827.8	7.9044
291.87	3.4262	3875.4	8.0385	**680**	273.54	3.6558	3874.7	8.0082	**680**	242.99	4.1154	3873.5	7.9528

3.0 MPa (t_s = 233.853 °C)					3.5 MPa (t_s = 242.557 °C)					4.0 MPa (t_s = 250.354 °C)			
v	ρ	h	s	t, °C	v	ρ	h	s	t, °C	v	ρ	h	s
99.379	10.062	3231.7	6.9234	**400**	84.556	11.826	3223.2	6.8427	**400**	73.431	13.618	3214.5	6.7714
101.10	9.8911	3254.4	6.9570	**410**	86.062	11.620	3246.3	6.8769	**410**	74.776	13.373	3238.1	6.8061
102.81	9.7265	3277.1	6.9900	**420**	87.556	11.421	3269.4	6.9104	**420**	76.108	13.139	3261.5	6.8402
104.51	9.5682	3299.7	7.0224	**430**	89.039	11.231	3292.3	6.9433	**430**	77.429	12.915	3284.8	6.8736
106.20	9.4159	3322.3	7.0542	**440**	90.513	11.048	3315.2	6.9756	**440**	78.741	12.700	3308.0	6.9064

6.0 MPa (t_s = 275.585 °C)					6.5 MPa (t_s = 280.858 °C)					7.0 MPa (t_s = 285.829 °C)			
v	ρ	h	s	t, °C	v	ρ	h	s	t, °C	v	ρ	h	s
56.671	17.646	3423.1	6.8826	**500**	52.087	19.199	3417.3	6.8399	**500**	48.157	20.765	3411.4	6.8000
58.426	17.116	3470.5	6.9432	**520**	53.726	18.613	3465.1	6.9011	**520**	49.696	20.122	3459.7	6.8617
60.161	16.622	3517.7	7.0020	**540**	55.344	18.069	3512.7	6.9603	**540**	51.214	19.526	3507.7	6.9214
61.877	16.161	3564.8	7.0591	**560**	56.943	17.561	3560.2	7.0179	**560**	52.713	18.971	3555.5	6.9794
63.578	15.729	3611.8	7.1149	**580**	58.526	17.086	3607.4	7.0740	**580**	54.196	18.452	3603.1	7.0359

SATURATED STEAM -PRESSURE TABLE

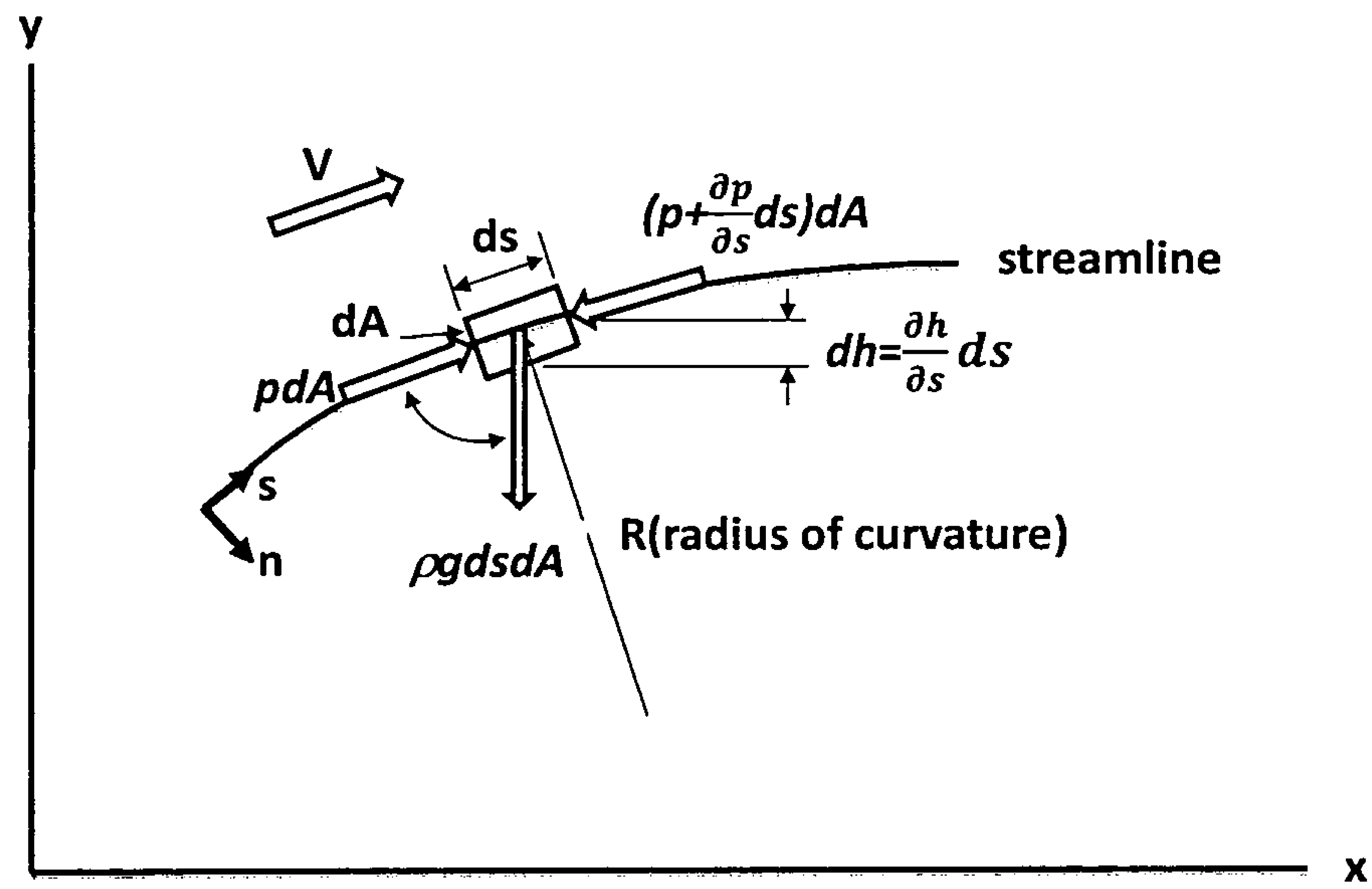
		Spec. vol. m^3=kg		Int. Ener. kJ/kg		Enthalpy kJ/kg		Entropy kJ=(kg°K)	
P bar	T °C	Sat. liq. v_f X1000	Sat. vap. v_g	Sat. liq. u_f	Sat. vap. u_g	Sat. liq. h_f	Sat. vap. h_g	Sat. liq. s_f	Sat. vap. s_g
0.04	28.96	1.004	34.80	121.4	2415	121.4	2554	0.423	8.475
0.06	36.15	1.006	23.75	151.5	2425	151.5	2567	0.521	8.331
0.08	41.5	1.008	18.11	173.8	2432	173.8	2577	0.593	8.229
0.1	45.8	1.010	14.68	191.8	2438	191.8	2585	0.649	8.150
0.2	60.07	1.017	7.649	251.4	2457	251.4	2610	0.832	7.908
0.3	69.11	1.023	5.229	289.2	2468	289.2	2625	0.944	7.769

6. Answer the following questions briefly

(a) Define pathlines, streaklines, streamlines, and streamtube. Under what condition pathlines, streaklines, and streamlines are all coincident? (10%)

(b) Write the definition of Reynolds number and provide physical explanation. (5%)

7. Derive the Bernoulli equation starting with the application of Newton's second law to a fluid particle, as shown in the following figure (next page), with length *ds* and cross-sectional area *dA*. Make necessary assumptions and clearly list the assumptions in the answer. (20%)



8. Experimental measurements are made in a low-speed wind tunnel to find the drag force on a two-dimensional object. The velocity profiles at upstream and downstream of the object have been acquired where the pressure is uniform. Determine the drag force per unit width acting on the object. (15%)