國立臺灣大學 105 學年度碩士班招生考試試題

Useful Equations

$$N_{Nu} = 2.0 + 0.6 N_{\mathrm{Re}}^{0.5} N_{\mathrm{Pr}}^{1/3}$$

Prandtl number at room temperature ≒ 0.71

Air density ≒ 1.20 kg/m^3

viscosity ≒ 1.80*10^{-5} kg/m s

conductivity ≒ 0.025 W/m K

Stefan-Boltzmann constant = 5.67*10^{-8} W/m^2

Henderson equation

$1 - rh = \exp(-c\,T\,M_e^{\,n})$

rh = relative humidity (decimal)

T = temperature ˚C

c = 5.78*10^{-5}

n = 1.52

Me = equilibrium moisture content dry basis (%)

Conduction Heat Transfer in a Sphere

Bi->∞

$$\frac{T - T_\infty}{T_i - T_\infty} = 1 - \frac{6}{\pi} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp\left(-\alpha n^2 \pi^2 t / r^2\right)$$

Ti = initial temperature

T∞= surface temperature

α = thermal conductivity

r = radius

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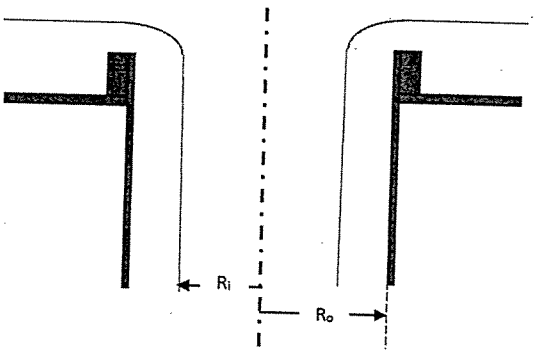
1. As shown schematically figure below, a viscos fluid flow over a weir at the end of a circular tube to form an annular flow in the tube and into a storage tank. Develop a mathematical model to explain why there are bubbles continuously arising from the liquid in the tanks.



a. Write the models in differential equations with boundary conditions, clearly define all variables used in the models with appropriate dimensions in SI units. You don't have to solve those equations for credits. (15 points)
b. If the flow rate of viscos fluid is known, explain how to estimate the amount of air flowing into the tanks. (5 points)

2. A sphere with radius 0.25 m at 37 ˚C is enclosed in the center of a spherical shell with radius 5 m at 5 ˚C, air in the shell is stationary at 10 ˚C. Calculate heat loss from the sphere in the shell. Write your major assumptions in your procedure. (20 points)

3. A soybean kernel diameter 8mm, density 1100 kg/m^3 (moisture contain 20% wet basis) is continuously drying in hot air. If it is a falling rate drying and moisture migrating in the kernel follows Fick's law with moisture diffusivity D = 2.0 * 10^{-10} m^2/s. Moisture at the soybean surface equilibrium with hot air instantaneously. Equilibrium moisture content of soybean can be predicted from Henderson equation.

a. An air stream having a dry-bulb temperature of 20.5 ˚C and wet-bulb temperature 18 ˚C being heated through a heat exchanger to 45 ˚C is used in soybean drying. What is the equilibrium moisture content of soybean in the hot airstream? (10 points)
b. Try to estimate the final moisture contain in wet basis after 30 min of drying. (10 points)

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4. A continuous single-effect evaporator concentrates 10800kg/h of a 1.0 wt% salt solution entering at 30 °C to a final concentration of 1.5 wt%. The vapor space of the evaporator is at 70.14kPa and the steam supplied is saturated at 143.3kPa. The overall coefficient U = 2000 W/m^{2}K. Calculate the amounts of vapor and liquid product and heat-transfer area required, Assume that, since it is dilute, the solution has the same boiling point and enthalpy as water. (20 points)

5. A continuous deodorizing system, involving a single stage steam stripping operation, is under consideration for the removal of a taint from cream. If the taint component is present in the cream to the extent of 8 parts per million (ppm) and if steam is to be passed through the contact stage in the proportions of 0.75 kg steam to every 1 kg cream, calculate the concentration of the taint in the leaving cream. The equilibrium concentration distribution of the taint has been found experimentally to be in the ratio of 1 in the cream to 10 in the steam and it is assumed that equilibrium is reached in each stage. (20 points)

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A.2-9 Properties of Saturated Steam and Water (Steam Table), SI Units

Temperature (°C)	Vapor Pressure (kPa)	Specific Volume (m^3/kg)		Enthalpy (kJ/kg)		Entropy (kJ/kg·K)	
		Liquid	Sat'd Vapor	Liquid	Sat'd Vapor	Liquid	Sat'd Vapor
0.01	0.6113	0.0010002	206.136	0.00	2501.4	0.0000	9.1562
3	0.7577	0.0010001	168.132	12.57	2506.9	0.0457	9.0773
6	0.9349	0.0010001	137.734	25.20	2512.4	0.0912	9.0003
9	1.1477	0.0010003	113.386	37.80	2517.9	0.1362	8.9253
12	1.4022	0.0010005	93.784	50.41	2523.4	0.1806	8.8524
15	1.7051	0.0010009	77.926	62.99	2528.9	0.2245	8.7814
18	2.0640	0.0010014	65.038	75.58	2534.4	0.2679	8.7123
21	2.487	0.0010020	54.514	88.14	2539.9	0.3109	8.6450
24	2.985	0.0010027	45.883	100.70	2545.4	0.3534	8.5794
25	3.169	0.0010029	43.360	104.89	2547.2	0.3674	8.5580
27	3.567	0.0010035	38.774	113.25	2550.8	0.3954	8.5156
30	4.246	0.0010043	32.894	125.79	2556.3	0.4369	8.4533
33	5.034	0.0010053	28.011	138.33	2561.7	0.4781	8.3927
36	5.947	0.0010063	23.940	150.86	2567.1	0.5188	8.3336
40	7.384	0.0010078	19.523	167.57	2574.3	0.5725	8.2570
45	9.593	0.0010099	15.258	188.45	2583.2	0.6387	8.1648
50	12.349	0.0010121	12.032	209.33	2592.1	0.7038	8.0763
55	15.758	0.0010146	9.568	230.23	2600.9	0.7679	7.9913
60	19.940	0.0010172	7.671	251.13	2609.6	0.8312	7.9096
65	25.03	0.0010199	6.197	272.06	2618.3	0.8935	7.8310
70	31.19	0.0010228	5.042	292.98	2626.8	0.9549	7.7553
75	38.58	0.0010259	4.131	313.93	2635.3	1.0155	7.6824
80	47.39	0.0010291	3.407	334.91	2643.7	1.0753	7.6122
85	57.83	0.0010325	2.828	355.90	2651.9	1.1343	7.5445
90	70.14	0.0010360	2.361	376.92	2660.1	1.1925	7.4791
95	84.55	0.0010397	1.9819	397.96	2668.1	1.2500	7.4159
100	101.35	0.0010435	1.6729	419.04	2676.1	1.3069	7.3549
105	120.82	0.0010475	1.4194	440.15	2683.8	1.3630	7.2958
110	143.27	0.0010516	1.2102	461.30	2691.5	1.4185	7.2387
115	169.06	0.0010559	1.0366	482.48	2699.0	1.4734	7.1833
120	198.53	0.0010603	0.8919	503.71	2706.3	1.5276	7.1296
125	232.1	0.0010649	0.7706	524.99	2713.5	1.5813	7.0775
130	270.1	0.0010697	0.6685	546.31	2720.5	1.6344	7.0269
135	313.0	0.0010746	0.5822	567.69	2727.3	1.6870	6.9777
140	316.3	0.0010797	0.5089	589.13	2733.9	1.7391	6.9299
145	415.4	0.0010850	0.4463	610.63	2740.3	1.7907	6.8833
150	475.8	0.0010905	0.3928	632.20	2746.5	1.8418	6.8379
155	543.1	0.0010961	0.3468	653.84	2752.4	1.8925	6.7935
160	617.8	0.0011020	0.3071	675.55	2758.1	1.9427	6.7502
165	700.5	0.0011080	0.2727	697.34	2763.5	1.9925	6.7078
170	791.7	0.0011143	0.2428	719.21	2768.7	2.0419	6.6663
175	892.0	0.0011207	0.2168	741.17	2773.6	2.0909	6.6256
180	1002.1	0.0011274	0.19405	763.22	2778.2	2.1396	6.5857
190	1254.4	0.0011414	0.15654	807.62	2786.4	2.2359	6.5079
200	1553.8	0.0011565	0.12736	852.45	2793.2	2.3309	6.4323
225	2548	0.0011992	0.07849	966.78	2803.3	2.5639	6.2503
250	3973	0.0012512	0.05013	1085.36	2801.5	2.7927	6.0730
275	5942	0.0013168	0.03279	1210.07	2785.0	3.0208	5.8938
300	8581	0.0010436	0.02167	1344.0	2749.0	3.2534	5.7045

Source: Abridged from J. H. Keenan, F. G. Keyes, P. G. Hill, and J. G. Moore, *Steam Tables—Metric Units*. New York: John Wiley & Sons, Inc., 1969. With permission of the authors and publishers.

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科目：單操與輸送

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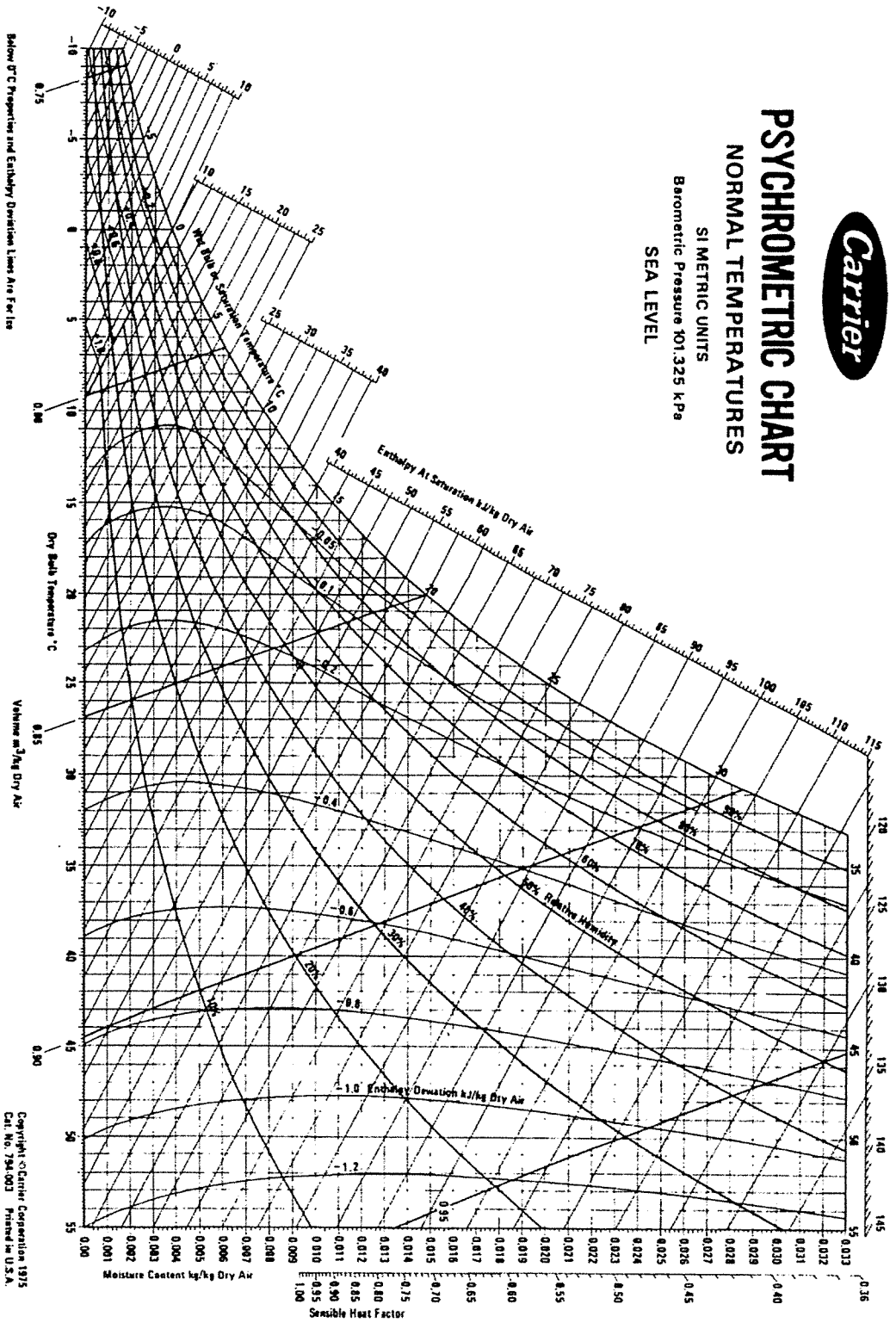

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