國立臺灣科技大學 110 學年度碩士班招生試題

系所組別：化學工程系碩士班

科　　目：工程數學與輸送現象

(總分為 100 分)

1. (10%) Solve the initial value problem: $y' + \frac{2}{x+1} y = 3; y(0) = 3.$

2. (10%) Solve the initial value problem: $y'' - 2y' - 8y = f(t); y(0) = 1, y'(0) = 0.$

3. (10%) Evaluate the line integral $\int_C \vec{F} \cdot d\vec{R}$ with $\mathbf{F} = 2x\mathbf{i} + y\mathbf{j} - z\mathbf{k}$ and C is parts of circle ($x^2+y^2 = 4$, $z = 0$) from (2,0,0) to (0,2,0).

4. (14%) Solve the heat equation $u_t = 4\,u_{xx}$ for $0 < x < L$, $t > 0$, in which both ends are insulated: $u_x(0,t) = 0$, $u_x(L,t) = 0$ for $t > 0$; IC: $u(x,0) = f(x)$.

5. (6%) Find the eigenvalues of matrix **A**: $\mathbf{A} = \begin{pmatrix} 1 & -2 \\ 2 & 0 \end{pmatrix}$.

6. (a) (10%) In transport phenomena, we can divide into two parts and one part is related to the molecular transport processes for momentum, heat and mass. Please write down the corresponding equations for *momentum*, *heat* and *mass* individually in *one-dimensional* case and give *SI unit* of correlated material's coefficient.

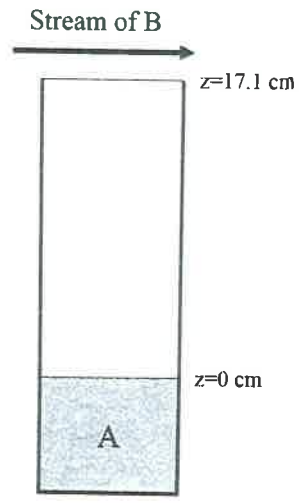
   (b) (5%) The stream function ψ is a convenient parameter by which we can represent two-dimensional steady incompressible flow. Herein, we want to use stream function to describe the velocity in *cylindrical flow*, v_r and v_θ. Please describe v_r and v_θ by stream function, ψ. [*Hint*: $\nabla = \frac{\partial}{\partial r}\bar{\delta}_r + \frac{1}{r}\frac{\partial}{\partial r}\bar{\delta}_\theta + \frac{\partial}{\partial z}\bar{\delta}_z$ in cylindrical coordinates]

7. (a) (7%) Please give the definition of humidity (**H**), percentage humidity ($\mathbf{H_P}$) and percentage relative humidity ($\mathbf{H_R}$).

   (b) (8%) A granular insoluble solid material wet with water is being dried in the constant-rate period in a pan 0.61 x 0.61 m^2 and the depth of material is 25.4 mm. The sides and bottoms are insulated. Air flows parallel to the top drying surface at a velocity of 3.05 m/s and has a dry bulb temperature of 60°C and wet bulb temperature of 29.4°C. The pan contains 11.34 kg of dry solid having a free moisture content of 0.35 kg H_2O/kg dry solid, and the material is to be dried in the constant-rate period to 0.22 kg H_2O/kg dry solid. Please predict *the drying time (unit:hours)* needed.

8. (20%)

Consider solvent A stored in a container and solvent A is evaporating into gas B as the right diagram. The liquid level maintains at z=0 cm and the vapor pressure of solvent A in this level is 33 mmHg. A stream of gas B flows slowly past the top of the container to maintain 755 mmHg at z=17.1 cm. The entire system is kept at 0°C and 755 mmHg. Solvent A vapor and gas B are assumed to be *ideal* and the cross-section area of the container is 0.82 cm^2. If we can find that 0.0208 cm^3 of solvent A evaporated in 10 h after steady-state. *Please determine the value of diffusion coefficient* D_{AB}? Where the density of solvent A is 1.59 g/cm^3, the molecular weight is 154 g/gmol and gas constant is 82.05 (cm^3·atm/gmol·K). *Please state clearly the assumption when you solve the problem.*



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Supporting materials:

- **Humid heat of an air-water vapor mixture:**

$$c_s\left(\frac{kJ}{kJ\ dry\ air\cdot K}\right)=1.005+1.88\times H,\ H\ is\ humidity$$

- **Humid volume of an air-water vapor mixture:**

$$v_H\left(\frac{m^3}{kg\ dry\ air}\right)=\left(2.83\times10^{-3}+4.56\times10^{-3}\times H\right)\times T$$

where H is humidity and T is temperature in K

- **Total enthalpy of an air-water vapor mixture:**

$$H_y\left(\frac{kJ}{kg\ dry\ air}\right)=c_s\left(T-T_o\right)+H\lambda_0$$

where T_0 is datum temperature and λ_0 is latent heat

- **Drying rate at constant rate period:**

$$R_C\left(\frac{kg\ H_2O}{h\cdot m^2}\right)=\frac{h}{\lambda_w}\left(T-T_w\right)\times3600$$

$$h=0.0204\times G^{0.8}\quad\left(G:\ 2450\sim293000\ \frac{kg}{m^2\cdot h}\right)$$

where h is heat transfer coefficient, unit: $\frac{W}{m^2\cdot K}$

G is mass velocity, unit: $\frac{kg}{m^2\cdot h}$

λ_w is latent heat at T_w, unit: $\frac{J}{kg}$

T_w is wet-bulb temperature

- **Drying time at constant rate period:**

$$t=\frac{L_s}{AR_c}\Delta X$$

where L_s is dry solid used

A is exposed surface area for drying

ΔX is free moisture content difference

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Steam table

T (°C)	P (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	5.5794
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

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Humidity chart