國立臺灣科技大學
113學年度碩士班招生
試題

系所組別：0600化學工程系碩士班

科　　目：工程數學與輸送現象

<<506001>>

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(總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分)

1. (10 %) Solve for the general solution $y''-4y'+4y=4e^{2x}-9e^{-x}$.

2. (14 %) Solve the initial value problem

$$y''-2y'-3y=\begin{cases}0 & 0\le t<4\\ 12 & t\ge 4\end{cases},\quad y(0)=1,\quad y'(0)=0.$$

3. (6%) Suppose that $\vec{F}=2xy\vec{i}+xe^{y}\vec{j}+2z\vec{k}$. Calculate

(a) $\nabla\cdot F$ (2%)

(b) $\nabla\times\vec{F}$ (2%)

(c) $\nabla\cdot\left(\nabla\times\vec{F}\right)$ (2%).

4. (20%) Solve the partial differential equation $\dfrac{\partial u}{\partial t}=\dfrac{\partial^2 u}{\partial x^2}$ for $0<x<2,\ t>0$ with the boundary conditions $u(0,t)=u(2,t)=0$ and the initial condition

$$u(x,0)=\begin{cases}x & \text{for } 0<x<1\\ 0 & \text{for } 1<x<2\end{cases}$$

5. (34%) Water at an average temperature of 20°C flows with a velocity of 4 m/s in a stainless-steel pipe. The outer and inner diameters are 6 cm and 5 cm. The pipe is coated by an insulation layer with a thickness of 0.6 cm on the outer surface. The conductivities of stainless-steel and insulation materials are 50 and 0.2 $\frac{W}{m\cdot K}$, respectively. Steam at 110°C is condensed on the outside of the insulation layer. The temperature of the outer surface of the insulation layer can be regarded as the temperature of condensed steam. Calculate the heat transfer rate with the pipe length of 10 m.

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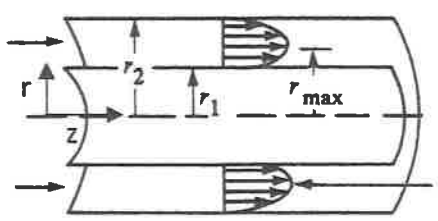
6. (16%) Choose the CORRECT one(s) from the following descriptions.

(a) For a fully-developed, laminar and Newtonian annulus flow as shown in the following figure, the maximum flow velocity occurs at $r_{max} = \frac{r_1+r_2}{2}$



(b) The Bernoulli's principle is applicable to ideal and incompressible fluids.

(c) The dimension of viscosity is $M^1L^{-1}T^{-1}$

(d) The dimensions of thermal diffusivity and mass diffusivity are the same as L^2T^{-1}.

(e) The actual driving force of mass transfer is chemical potential.

(f) Schmidt number is a dimensionless group representing the ratio of the convective mass transfer to the diffusive mass transfer.

(g) The air pressure is p_0 containing water vapor with a partial pressure p_A. The saturated pressure of water vapor is p_{AS} according to the adiabatic process. The percentage humidity is $\frac{p_A}{P_{As}} \times 100$

(h) The temperature in a distillation tower is at its lowest at the column bottom. It is because the heat rises to the top due to the natural convection of the hot gas flow.

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Table 1 Heat Transfer Properties of Liquid Water

T (°C)	T (K)	ρ (kg/m^3)	c_p ($kJ/kg \cdot K$)	$\mu \times 10^3$ ($Pa \cdot s$, or $kg/m \cdot s$)	k ($W/m \cdot K$)	N_{Pr}	$\beta \times 10^4$ ($1/K$)	$(g\beta\rho^2/\mu^2) \times 10^{-8}$ ($1/K \cdot m^3$)
0	273.2	999.6	4.229	1.786	0.5694	13.3	−0.630	
15.6	288.8	998.0	4.187	1.131	0.5884	8.07	1.44	10.93
26.7	299.9	996.4	4.183	0.860	0.6109	5.89	2.34	30.70
37.8	311.0	994.7	4.183	0.682	0.6283	4.51	3.24	68.0
65.6	338.8	981.9	4.187	0.432	0.6629	2.72	5.04	256.2
93.3	366.5	962.7	4.229	0.3066	0.6802	1.91	6.66	642
121.1	394.3	943.5	4.271	0.2381	0.6836	1.49	8.46	1300
148.9	422.1	917.9	4.312	0.1935	0.6836	1.22	10.08	2231
204.4	477.6	858.6	4.522	0.1384	0.6611	0.950	14.04	5308
260.0	533.2	784.9	4.982	0.1042	0.6040	0.859	19.8	11 030
315.6	588.8	679.2	6.322	0.0862	0.5071	1.07	31.5	19 260

Table 2 The Heat Transfer Equations for the Flow Inside a Pipe

Equation	Prerequisites
$N_{Nu} = 1.86\left(N_{Re}N_{Pr}\frac{D}{L}\right)^{1/3}\left(\frac{\mu_b}{\mu_w}\right)^{0.14}$	$N_{Re} < 2100$, $\frac{N_{Re}N_{ReD}}{L} > 100$
$N_{Nu} = 0.027N_{Re}^{0.8}N_{Pr}^{1/3}\left(\frac{\mu_b}{\mu_w}\right)^{0.14}$	$N_{Re} < 6000$, $0.7 < N_{Pr} < 16000$, L/D > 60