國　立　清　華　大　學　命　題　紙

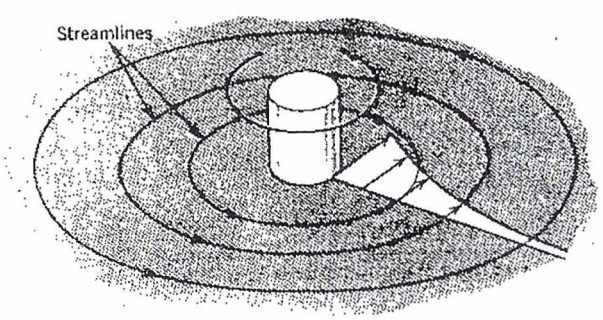
95 學年度＿＿＿＿＿生命科學院＿＿＿＿＿系（所）＿＿＿丙＿＿＿組碩士班入學考試

科目＿輸送現象及單元操作＿科目代碼＿1004＿共_3＿頁第＿1＿頁 *請在【答案卷卡】內作答

1. Determine the dimensionless groups formed from the variables involved in the flow of fluid external to a solid body. The force exerted on the body is a function of ν, ρ, μ, and L (a significant dimension of the body). Please apply Buckingham method with the following table for the variables and dimensions (M, L, t are fundamental dimensions) (15%)

Variable	Symbol	Dimensions
Force	F	ML/t^2
Velocity	ν	L/t
Density	ρ	M/L^3
Viscosity	μ	M/Lt
Length	L	L

2. A rotating shaft, as illustrated in the figure below, causes the fluid to move in circular streamlines with a velocity which is inversely proportional to the distance from the shaft. Find the shape of the free surface if the fluid can be considered inviscid. (15%)



3. Saturated steam at 1915 Pa (saturated temperature 404K) flows inside a steel pipe having an inside diameter of 2.09 cm and an outside diameter of 2.67 cm. **The convective coefficients on the inner** and outer pipe surfaces may be taken as 5680 $W/m^2.K$ and 22.7 $W/m^2.K$, respectively. The surrounding air is at 294 K. Find the heat loss per meter of bare pipe and for a pipe having a 3.8 cm thickness of 85% magnesia insulation on its outer surface. （**20%**）

4. The resistance R to mass transfer in an parallel-membrane artificial kidney is
$R = R_{Blood} + R_{Membrane} + R_{Dialysate}$, where R = 1/K and K is the overall mass transfer coefficient. Given the following data, for the removal of urea from the plasma, (15%)

Thickness of membrane $\delta = 0.5$ mm

Interface equilibrium coefficient $\phi = 0.2$

Diffusion coefficient Dm = 5×10^{-7} cm^2 s^{-1}

K_{Blood} = 1 x 10-6 m s^{-1}

$K_{Dialysate}$ = 1.5 x 10-6 m s^{-1}

Please calculate the percentage of R which can be attributed to following components individually,

(a) R_{Blood}

(b) $R_{Membrane}$

(c) $R_{Dialysate}$

5. In a microwave heated incubator, *E. coli* cells are cultured in a long test tube with diameter of 20 mm to express a recombinant human protein X. The test tube's outer surface is maintained at 37°C. Microware heating warms the test tube's contents uniformly with an intensity Q. What microware intensity will ensure that the temperature at the center o the tube will not rise above 42°C? Please express your answer in the unit of 'W m^{-1}'. **(15%)**

Note: Assuming the thermal conductivity *k* of the culture media remains constant as 0.7 W m-1 K^{-1}.

And in one-dimension steady-state cylindrical coordinates, $\frac{1}{r}\frac{d}{dr}\left(kr\frac{dT}{dr}\right)+Q=0$

6. According to a Poiseuille flow estimate, what is the flow rate in a male's femoral artery that has a radius of 0.5 cm, a dynamic viscosity of 0.05 cm^2 s^{-1} and a wall shear stress of 15 dynes cm^{-2} ? (20%)

Note: Dynamic viscosity is μ, and kinematic viscosity is ν,

The units of dynamic viscosity should be $\frac{g}{cm\cdot s}$.

The Poiseuille equation for velocity is:

$$u=2\bar{u}\left(1-\frac{r^2}{R^2}\right),$$

And the equations for shear stress at the wall and flow rate are:

$$\tau=\mu\frac{du}{dr}=\mu\left[2\bar{u}\left(-\frac{2r}{R^2}\right)\right]_{r=R}=-\frac{4\mu u}{R}, \text{ and } Q=\pi R^2\bar{u}\Rightarrow\bar{u}=\frac{Q}{\pi R^2}$$