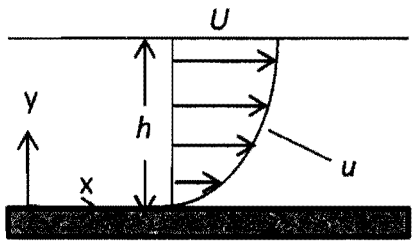
1. (a) Explain the definition of Newtonian fluid and the difference between Newtonian and non-Newtonian fluids. (7%) (b) What are shear thinning and shear thickening? Give an example for each case. (7%)

2. List the mathematical expressions of the following dimensionless numbers and explain their physical meanings:
   (a) Reynolds number (*Re*) (5%)
   (b) Stokes number (*St*) (5%)
   (c) Prandtle number (*Pt*) (5%)
   (d) Wormersley number (α) (5%)

3. A blood stream is flowing on the surface of the endothelial cells cultured in a flow chamber. Determine the magnitude and direction of the shear stress that the blood flow applies: (a) to the base; (b) to the free surface. (15%)

$$\frac{u}{U} = 2\left(\frac{y}{h}\right) - \left(\frac{y}{h}\right)^2$$

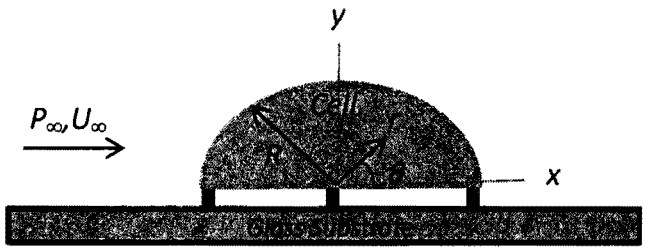


4. A glass substrate is functionalized with some long-chain polymers attached to the surface. A cell is captured by the polymers and stays stationary. A constant and uniform background velocity (U_∞=3 cm/s) is observed in the chip. The density and the free stream pressure are ρ_∞=1 kg/m^3 and P_∞=1.01 mPa, respectively. The cell may be considered to be a closed (no leaks) two dimensional (2D) semi-cylinder with a radius of R=5 μm. Without considering the boundary layer, the velocity distribution over the top of the cell is represented by the potential function (*Notice: the depth in z direction is assumed to be t=1 μm*):

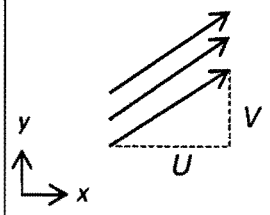
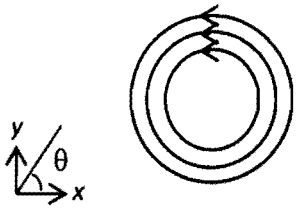
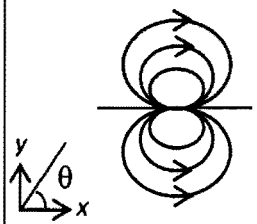
$$\emptyset = U_\infty r\cos\theta(1 + R^2/r^2)$$

   a. What is the velocity distribution over the top surface of the cell? (8%)
   b. What is the pressure distribution over the top surface of the cell? (Hint: Bernoulli's equation) (7%)
   c. What is the net lift force acting on the cell due to the flow? Don't forget to include the effect of the flow under the cell. (Hint: Assuming that the flow under the cell is at rest and the pressure is equal to the stagnation pressure.) (11%)

(背面仍有題目,請繼續作答)



5. Consider the 2D potential flow around a non-rotating cell as shown in the figure. Assuming there is no flow across the cell's membrane ($U_r(R)=0$) and the boundary layer near the cell's surface is ignorable ($U_\theta(R)\neq 0$). Use the necessary building blocks provided in the table to express the bulk velocity field (U_r and U_θ) in polar coordinates. (*Hint*: $\frac{df(z)}{dz} = u_x - iu_y = (u_r - iu_\theta)e^{i\theta}$; $z=x+iy=re^{i\theta}$) (25%)

Uniform Stream	Source (m>0) or Sink (m<0)	Doublet (c>0)
		
$f(z) = (U - iV)z$	$f(z) = \frac{m}{2\pi} log(z)$	$f(z) = \frac{c}{z}$