November 18, 2009

98學年度第1學期2009 Fall Semester
奈米科技導論一(A)期中考題
Introduction to Nanotechnology (IA)−Midterm Exam

Name: **Student ID No.:**

1. Name three experimental methods to determine the diffusion coefficient of a particle. Explain how it works. (25 points)

2. Name three applications of using micro-to-nanofluidic interfaces for fundamental or applied research. Explain briefly your choice of examples. (25 points)

3. The Navier-Stokes Equation for Newtonian fluid reads

$$\rho\left[\frac{\partial v}{\partial t}+(v\cdot\nabla)v\right]=\eta\nabla^2 v-\nabla p,$$

where ρ is the density of the fluid, v the mean fluid velocity, η the dynamic viscosity of the fluid, and p the pressure.

(1) Use L as a characteristic length of the object that the flow is going through to define "Reynold's number" (inertial forces/viscous forces). (5 points)
(2) At low Reynold's number, derive that the fluid flow in a pipe (your choice of rectangular or circular shape) is a Poiseuille flow with a parabolic velocity profile. Assume it is a steady flow with no-slip boundary condition. (10 points)
(3) What is the volumetric flow rate? (5 points)
(4) What is its hydrodynamic resistance? (5 points)

4. (1) Explain how polymerase chain reaction (PCR) works for DNA amplification. (15 points)
(2) If a PCR cycle has only 80% of efficiency, how many cycles it takes to reach 10^6-fold amplification? (10 points)

For cylindrical coordinates:

$$\nabla^2 f=\frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial f}{\partial\rho}\right)+\frac{1}{\rho^2}\frac{\partial^2 f}{\partial\varphi^2}+\frac{\partial^2 f}{\partial z^2}.$$