1. Consider a solid circular cylinder of diameter **D** moving at a uniform velocity **U** in the fluid of dynamic viscosity μ and density ρ, as shown in Fig 1.
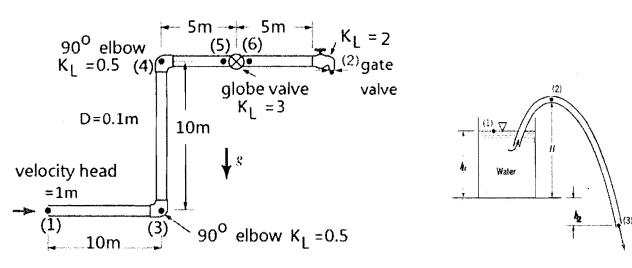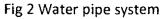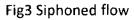
   (A) Define the Reynolds number in this flow. (3%)

   (B) What is the critical Reynolds number? (5%)

   (C) Discuss the drag coefficient C_D if Re are about 0.1, 10^4, 10^6, respectively. (9%)

   Fig 1

2. Fig 2 shows a pipe system including 4 pipes of various lengths, and 4 components with associated loss coefficient **K_L** as indicated. Using velocity head=1 m at section (1), pipe diameter D=0.1m for all pipes, and Darcy's friction factor f=0.02 in this pipe system, please calculate **(A)** the total major head loss and the total minor head loss in the whole pipe (8%); **(B)** the required pressure head at location (1) (5%); and **(C)** draw hydraulic gradient line (HGL) along the pipeline with section numbers indicated in Fig 2 (9%).

Fig 2 Water pipe system　　　　　　　　　　　Fig3 Siphoned flow

3. Consider a siphoned flow of water in the pipe as shown in Fig 3.

   (A) What is the condition at point (2) to maintain this flow in the pipe? (3%)

   (B) What is the pressure and velocity at point (3) if we consider only the friction factor **f** without considering any other loss? (6%)

4. (A) What are the similarity requirements between model and prototype? (6%) (B) Please define the following dimensionless parameters: (1) Froude number, (2)Mach number, (3) Strouhal number and (4) Euler number, by using velocity U, length l, gravitational constant g, surface tension σ, frequency ω, pressure p, speed of sound c, density ρ, bulk modulus of elasticity E, etc. (12%)

5. (18%) Determine the stream functions in a 2D flow with the following velocity fields respectively

   (A) $\vec{V} = 2y\hat{i} + 4x\hat{j}$,　(B) $\vec{V} = (5/r)\hat{\theta}$V,　(C) $\vec{V} = (6r)\hat{\theta}$,　(D) $\vec{V} = 2/(2\pi r)\hat{r}$

   where $\hat{i}, \hat{j}$ are unit vectors in Cartesian (x,y) system and $\hat{r}, \hat{\theta}$ are unit vectors in polar (r,θ) system.

6. (16%) Please translate the following terms into English and describe their physical features.

   (A)孔蝕 **(B)**水錘 **(C)**流線 **(D)**停滯壓力 **(E)**自由渦流 **(F)**離心加速度 **(G)**邊界層 **(H)**物質導數