※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. **Explain** the following terms
(a) Free body diagram (2%)
(b) Young's Modulus (2%)
(c) Plane Stress and Plane Strain (4%)
(d) Hagen-Poiseuille Flow (2%)
(e) Bernoulli Equation (2%)

2. For **laminar** blood flow within a vessel (inelastic, cylindrical and straight as shown in Fig. 1), the wall shear stress can be estimated by the equation:

$$\tau_{wall} = \frac{4\mu\bar{U}}{R},$$

where R is the radius of the vessel, $\bar{U}$ is the average velocity, and μ is the blood viscosity. Given that $u = U_{max}\left[1-\left(\frac{r}{R}\right)^2\right]$ and $\tau = \mu\frac{\partial u}{\partial r}$, **show how the wall shear stress is derived**? (20%)

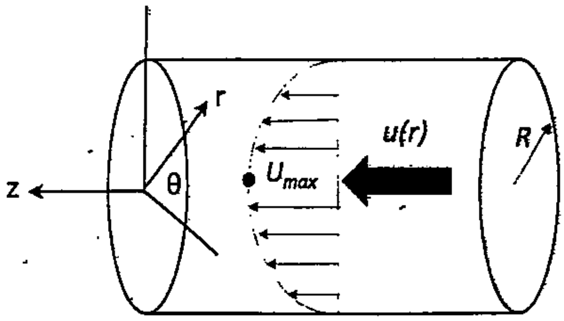

Fig. 1

3. A skeletal diagram of the lower leg is shown in Fig. 2. The leg is lifted by the quadriceps muscle attached to the hip at A and to the patella bone at *B*. This bone slides freely over cartilage at the knee joint. The quadriceps is further extended and attached to the tibia at *C*. A schematic of the equivalent mechanical system is modeled in the upper figure. Determine the **tension at *C*** and the **resultant force at *D*** (pin support). The lower leg has a mass of m_1 and a mass center at G_1; the foot has a mass of m_2 and a mass center at G_2. (24%)

1	cos(A + B) = cos A cos B - sin A sin B
2	cos(A - B) = cos A cos B + sin A sin B
3	sin(A + B) = sin A cos B + cos A sin B
4	sin(A - B) = sin A cos B - cos A sin B
5	sin 2A = 2 sin A cos A

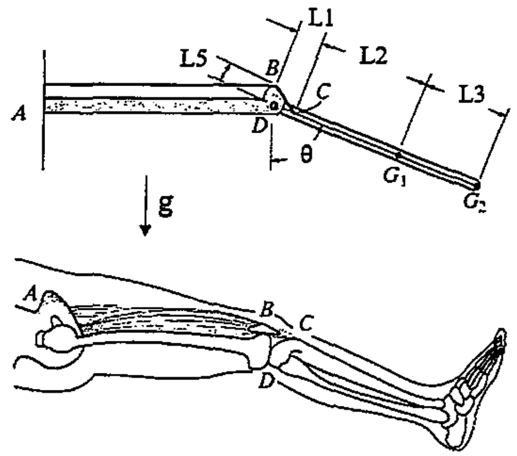

Fig. 2

4. Slender bars with a cross-section of right triangle (Fig. 3) are used to construct a wheel chair. To ensure the bar can withstand the maximum loading, please **determine (a) the orientation θ_p** of its principal axes and **(b) the maximum and minimum moments of inertia** by Mohr's Circle. (Hint: $I_x = \frac{a^4}{36}, \ I_y = \frac{a^4}{36}, \ I_{xy} = -\frac{a^4}{72}$) (24%)

5. Vena Contracta (VC) is commonly used in clinic to evaluate the mitral/aortic regurgitation. Assume you are given a Doppler image showing the mitral valve in the phase of rapid ejection to evaluate the heart function (Fig. 4). The flowrate through the orifice is *Q* with a pressure difference *ΔP=P1-P3*. d1, d2, d3 are known diameters at the entrance, orifice, and VC point, respectively. **Determine the contraction coefficient $C_c=(d3/d2)^2$**? (ρ_B is the density of blood) (20%)

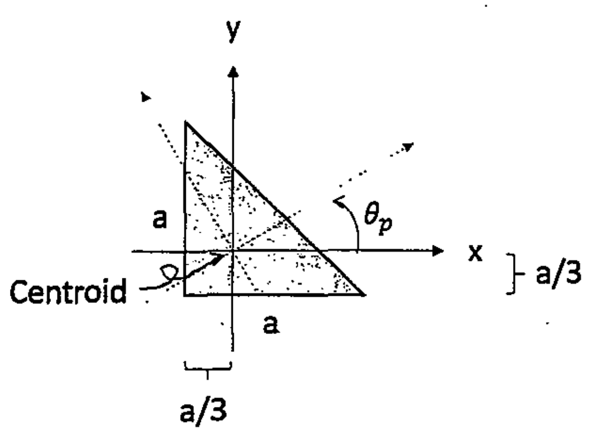

Fig. 3

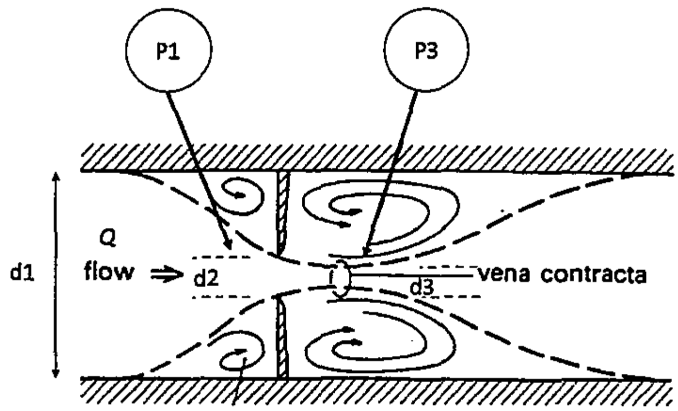

Fig. 4