1. Please explain the physical meaning of Moody chart for piping flows, $f = f(Re, e/D)$. (15%)

2. Consider the flow field given by $\vec{V} = ax^2y\hat{i} - by\hat{j} + cz^2\hat{k}$, where $a = 2 \ m^{-2} \cdot s^{-1}$, $b = 3 \ s^{-1}$, and $c = 2 \ m^{-1} \cdot s^{-1}$. Determine (a) the number of dimensions of the flow, (b) if it is a possible incompressible flow, and (c) the acceleration of a fluid particle at point $(x, y, z) = (3, 4, 2)$. (15%)

3. The three components of velocity in a flow field are given by
$$u = x^3 + y^2 + z^2 + xy^2$$
$$v = xy + yz + z^3$$
$$w = -3xz - z^2/2 + 4yz^3$$
(10%)

(a) Determine the volumetric dilatation rate and interpret the results. (b) Determine an expression for the rotation vector. Is this an irrotational flow field?

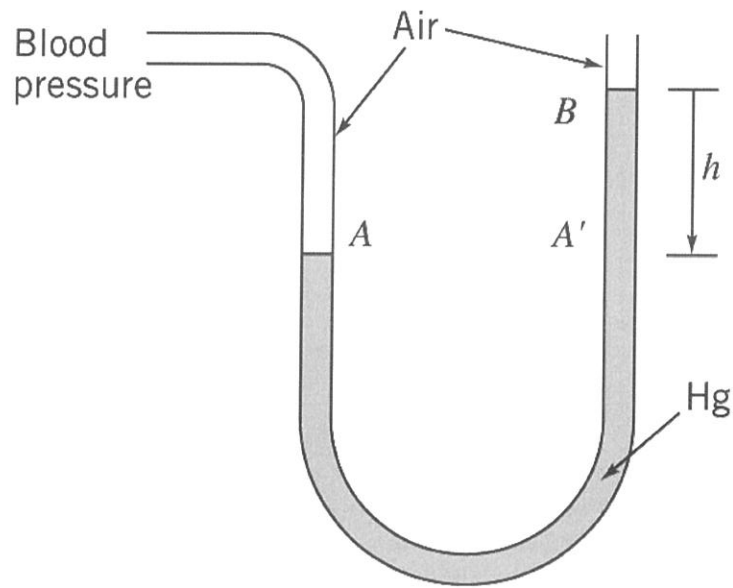4. Why boundary layer flow is important? (10%)

Fluids: Problem I (25 points)

Normal blood pressure for a human is 120/80 mmHg. By modeling a sphygmomanometer pressure gage as a U-tube manometer, convert these pressures to kPa. Note $SG_{Hg} = 13.6$.

Schematic:

Fluids: Problem II (25 points)

Air flows steadily through the duct shown from 350 kPa (abs), 60°C, and 183 m/s at the inlet state to M=1.3 at the outlet, where local isentropic stagnation conditions are known to be 385 kPa (abs) and 350 K. Compute the local isentropic stagnation pressure and temperature at the inlet and the static pressure and temperature at the duct outlet.

Schematic:

$p_1 = 350$ kPa (abs)
$T_1 = 60$°C
$V_1 = 183$ m/s

Flow $\longrightarrow$

$p_{0_2} = 385$ kPa (abs)
$T_{0_2} = 350$ K
$M_2 = 1.3$

①   ②