1) (20%)

The mean atmospheric temperature variation on earth is found to drop off linearly from 15℃ on sea level to –56.5℃ at an altitude of 11 km and then remain isothermal till an altitude of 20.1 km. Please derive an equation (or equations) of atmospheric pressure variation in terms of the altitude. Also calculate the pressure at an altitude of 15 km. Assume the atmospheric pressure at sea level is 101.33kpa.

2. (20%) A cylinder of diameter, D (m), is observed to oscillate with frequency f (cycles/sec) when held in a uniform flow of U (m/s).
   (a) Write down the equations of motion. (4%)
   (b) Perform a dimensional analysis on the equations of motion. (6%) What are the dimensionless parameters involved in this problem? (4%) Explain their physical meaning.(6%)

3) (20%)

(a) (7%)The Bernoulli equation can usually be expressed between two specific points, points 1 and 2, as

$$\frac{p_1}{\rho g}+\frac{1}{2g}V_1^2+z_1=\frac{p_2}{\rho g}+\frac{1}{2g}V_2^2+z_2=const. \quad \text{----------(1)}$$

Please state the assumptions and conditions for the above equation.

(b) (6%)Now let's consider a less restrictive situation. Let's start with the one-dimensional steady flow energy equation with one inlet (point 1) and one outlet (point 2). Please write down this equation. Please be noted that heat transfer, shaft work, viscous work should be included in the equation.

(c) (7%)Please rearrange the equation in (b) into a form similar to the above Bernoulli eq. (1), and call it eq. (2). Compare eq. (2) with eq. (1) and explain the meaning of the *const.* in eq. (1). Now can you write down a general Bernoulli equation for a flow process including shaft work, viscous work and heat transfer.

4. (20%)

(a) In consideration of boundary layer, what is the Newton law of viscosity of a fluid? Explain it in terms of fluid deformation. What is the international unit of viscosity ? (6%)

(b) Perform an order analysis to derive a simplified y-momentum equation using necessary assumptions for a boundary layer problem. (7%)

(c) What are the governing equations for a boundary layer over a flat plate.(7%)

5. An air compressor is used to pressurize an initially evacuated tank. The tank is 1 m in diameter and 2 m long. The supply line is 20 cm in diameter and conveys a flow with velocity 2 m/s . The air compressors' output pressure and temperature are constants at 350 Kpa and 30 °C. The tank temperature is keeping in constant of 20 °C.

(a) Write down the governing equation and the related initial conditions of this problem. (10%)

(b) Calculate the time required for the tank pressure to reach 110 Kpa. (10%)

Note: The gas constant for air is **R=287.05 N • m/Kg • K**