FDE 205 FLUID MECHANICS

Lecture 5

Overall Mechanical Energy Balance

- A more useful type of energy balance for flowing fluids, is a modification of the total energy balance to deal with mechanical energy.
- Engineers are often concerned with this special type of energy called mechanical energy.
- Mechaniacl energy is a form of energy that is either work or a form that can be directly converted into work.

- It includes the work term, kinetic energy, potential energy and the flow work part of the enthalpy term.
- The other terms in the energy balance equation, heat terms and internal energy do not permit simple conversion into work.
- Mechanical energy terms can be covnerted almost completely into work.
- Energy converted to heat or internal energy is lost work or a loss in mechanical energy caused by frictional resistance to flow.

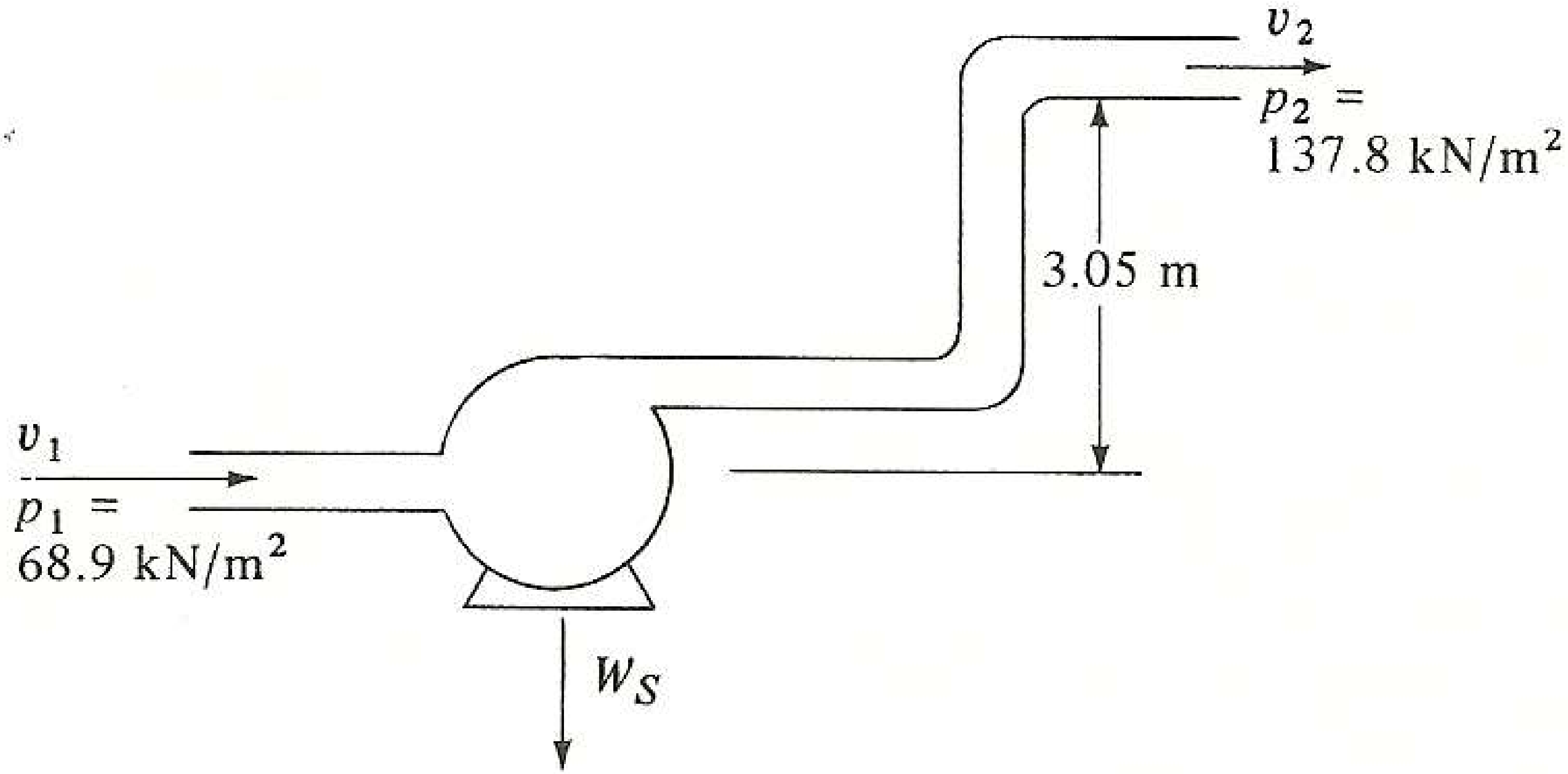
- If the fluid is imcompressible (density of the fluid does not change with pressure), the overall mechanic energy equation can be written as:

$$\frac{1}{2\alpha}\left(v_2^2 - v_1^2\right) + g(z_2 - z_1) + \frac{p_2 - p_1}{\rho} + \sum F + W_s = 0$$

Example 2.7-4

- Water with a density of 998 kg/m^3 is flowing at a steady mass flow rate through a uniform-diameter pipe. The entrance pressure of the fluid is 68.9 kN/m^2 abs in the pipe, which connects to a pump that actually supplies 155.4 J/kg of fluid flowing in the pipe. The exit pipe from the pump is the same diameter as the inlet pipe. The xit section of the pipe is 3.05 m higher than the entrance, and the exit pressure is 137.8 kN/m^2 abs. The reynolds number in the pipe is above 4000 in the system. Calculate the frictional loss in the pipe system.

Example 2.7-4



Bernoulli Equation for Mechanical Energy Balance

- In special cases, the friction term and the shaft work term can be neglected.

$$\sum F = 0$$

$$W_s = 0$$

- For those cases mechanical energy equation is called as Bernoulli Equation.

$$\frac{1}{2\alpha}\left(v_2^2 - v_1^2\right) + g(z_2 - z_1) + \frac{p_2 - p_1}{\rho} = 0$$

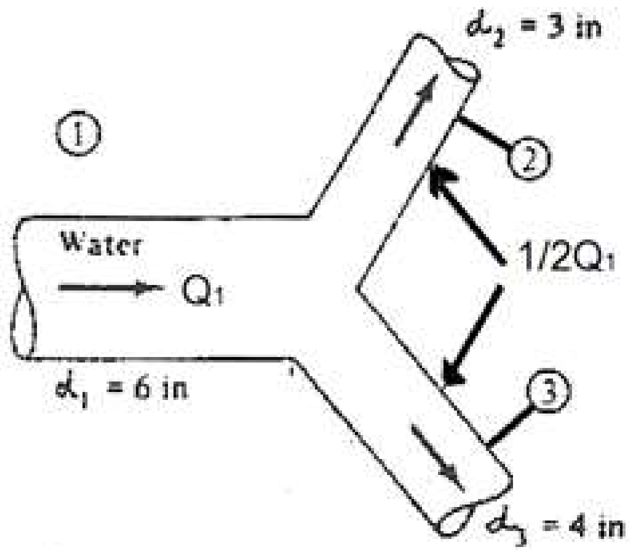
Example 2.7-6

- A liquid with a constant density ρ (kg/m^3) is flowing at an unknown velocity v_1 (m/s) through a horizontal pipe of cross-sectional area A_1 (m^2) at a pressure P_1 (N/m^2) and then it passes to a section of the pipe in which the area is reduced gradually to A_2 (m^2) and the pressure is P_2. Assuming no friction losses, calculate the velocities, if we know the pressure differences (P_1-P_2).

Example 2.7-7

- A nozzle of cross-sectional area A_2 is discharging to the atmoshpere and is located in the side of a large tank, in which the open surface of the liquid in the tank is H (m) above the center line of the nozzle. Calculate the velocity v_2 in the nozzle and the volumetric rate of dischage if no friction losses are assumed.

- Water flows inside the pipe below. $Q_1=4ft^3/s$ $P_1=20psig$. $Q_2=Q_3=1/2Q_1$. Calculate P_2 and P_3. Neglect any losses due to friction. Assume that pipes are at the same level (no potential energy difference).



- Homework 2.7.4 and 2.7.7 from the book (at the end of chapter 2)