WATERHAMMER QUESTIONS

A pipe connecting two large tanks has a constant flow positive displacement pump at its upstream end and a valve at its downstream end. Initially, the valve is fully open, the pump is stopped and the conditions in the pipe are P_o=20BAR U_o=0m/s. The ρa of the pipe is 10 BAR/[m/s]. Then, the pump suddenly starts and generates a velocity of 1 m/s. At the instant the pump starts, the valve suddenly closes. Using algebraic water hammer analysis, determine the pressure and velocity at the ends of the pipe for 3 steps in time. [30] Using graphical waterhammer analysis, determine the pressure and velocity at the ends of the pipe for 3 steps in time. [30] Explain what happens in the pipe.

The starting conditions are:

$P_m = 20 \quad U_m = 0 \qquad P_n = 20 \quad U_n = 0$

The stepping equations are:

$$\leftarrow F : \Delta P = + \rho a \, \Delta U$$

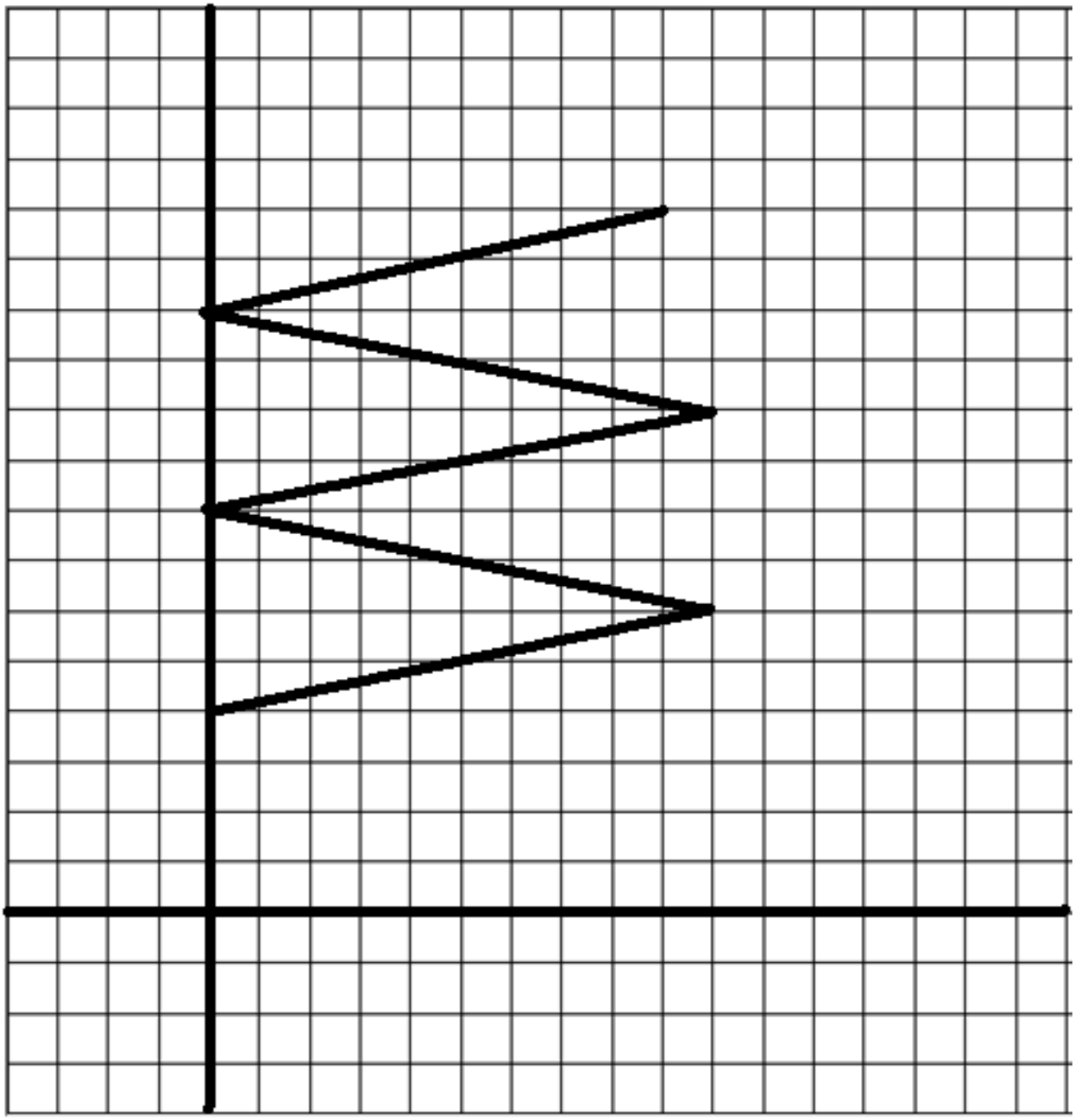
$$P_M - P_n = + [\rho a] \, [U_M - U_n]$$

$$U_M = 1 \qquad P_M = P_n + 10 \, [U_M - U_n]$$

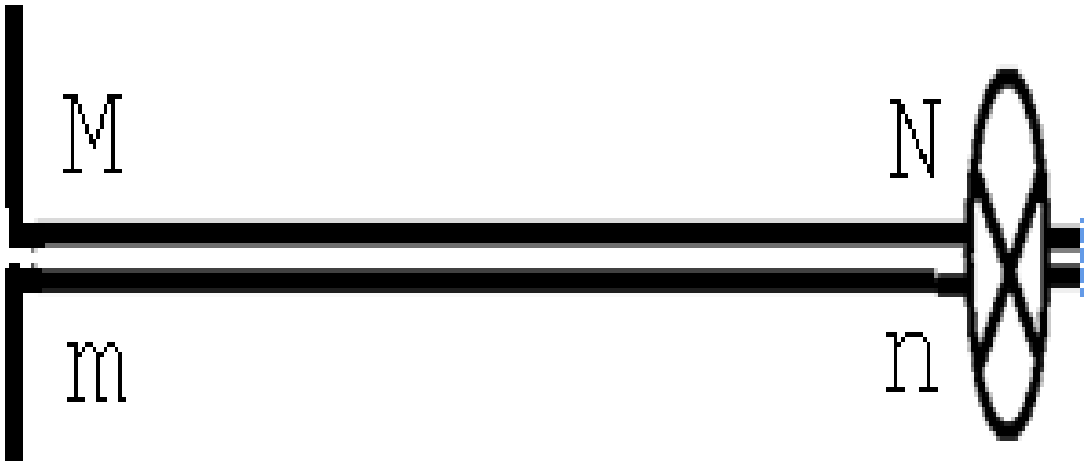
$$\rightarrow f : \Delta P = - \rho a \, \Delta U$$

$$P_N - P_m = - [\rho a] \, [U_N - U_m]$$

$$U_N = 0 \qquad P_N = P_m - 10 \, [U_N - U_m]$$



A pipe has a tank at its upstream end and a valve at its downstream end. Initially, the valve is closed, and conditions in the pipe are P_o=30 U_o=0. The ρa of the pipe is 10. Then, the valve is suddenly opened. Its pressure flow characteristic is P_N=20U_N. Using algebraic water hammer analysis, determine the pressure and velocity at the ends of the pipe for 2 steps in time. [30] Using graphical waterhammer analysis, determine the pressure and velocity at the ends of the pipe for 2 steps in time. [30] Explain what happens in the pipe.



The starting conditions are:

$P_m = 30 \quad U_m = 0 \qquad P_n = 30 \quad U_n = 0$

The stepping equations are:

$$\leftarrow F : \Delta P = + \rho a \, \Delta U$$

$$P_M - P_n = + [\rho a] \, [U_M - U_n]$$

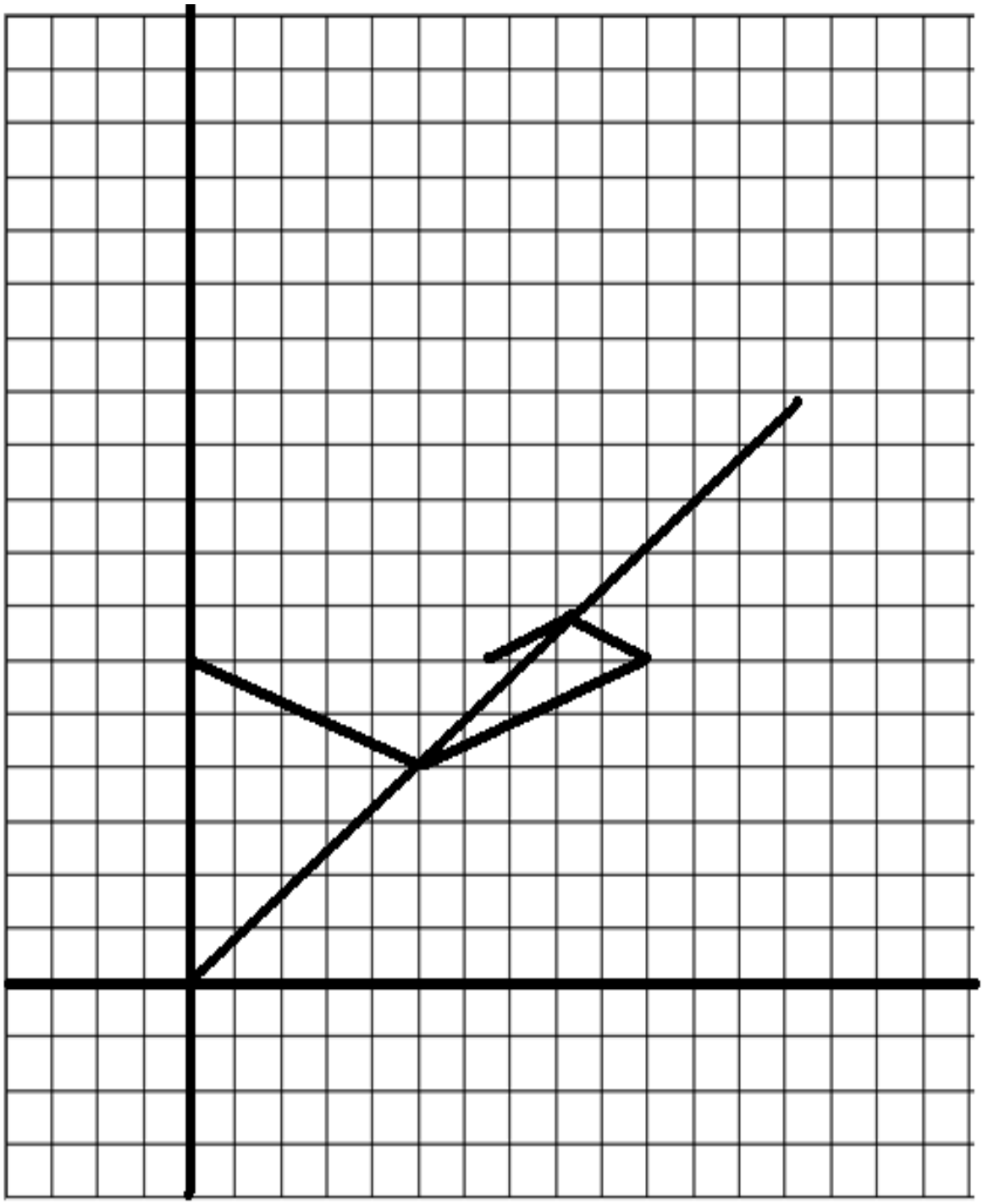
$$P_M = 30 \qquad U_M = U_n + [P_M - P_n]/10$$

$$\rightarrow f : \Delta P = - \rho a \, \Delta U$$

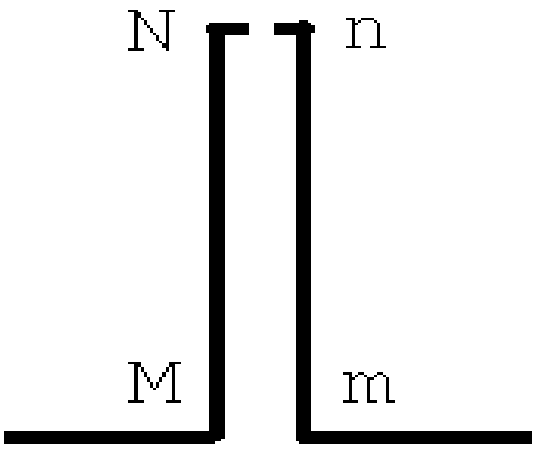
$$P_N - P_m = - [\rho a] \, [U_N - U_m] \qquad P_N = 20 \, U_N$$

$$20 \, U_N - P_m = - 10 \, [U_N - U_m]$$

$$U_N = P_m/30 + U_m/3$$



A small pipe is attached to a large pipe. The large pipe acts like a tank at the upstream end of the small pipe. There is a leak at the downstream end of the small pipe. The leak has the pressure flow characteristic is $P_N=20U_N$. Initially pressure is 20 BAR everywhere. Then suddenly a surge wave in the large pipe passes by the entrance of the small pipe. The pressure of the surge wave is 30 BAR. The ρa of the pipes is 10 BAR/[m/s]. Using algebraic water hammer analysis, determine the pressure and velocity at the ends of the small pipe for 2 steps in time. [30] Using graphical waterhammer analysis, determine the pressure and velocity at the ends of the small pipe for 2 steps in time. [30] Explain what happens in the pipe.



The starting conditions are:

$P_m = 20 \quad U_m = 1 \qquad P_n = 20 \quad U_n = 1$

The stepping equations are:

$$\leftarrow F : \Delta P = + \rho a \, \Delta U$$

$$P_M - P_n = + [\rho a] \, [U_M - U_n]$$

$$P_M = 30 \qquad U_M = U_n + [P_M - P_n]/10$$

$$\rightarrow f : \Delta P = - \rho a \, \Delta U$$

$$P_N - P_m = - [\rho a] \, [U_N - U_m] \qquad P_N = 20 \, U_N$$

$$20 \, U_N - P_m = - 10 \, [U_N - U_m]$$

$$U_N = P_m/30 + U_m/3$$