Order of the System

The first step in any unsteady flow analysis is to subdivide the system into components; the points separating two (or more) components will be referred to as system nodes. Typically, there would be nodes at the inlet and discharge flanges of a pump. Having done this, it is necessary to determine the order of the system, N, and this can be accomplished in one of several equivalent ways. The order of the system is the minimum number of independent fluctuating quantities which must be specified at a system node in order to provide a complete description of the unsteady flow at that location. It is also equal to the minimum number of independent, simultaneous first order differential equations needed to describe the fluid motion in, say, a length of pipe. In this summary we shall confine most of our discussion to systems of order two in which the dependent variables are the mass flow rate and either the pressure or the total head. This includes most of the common analyses of hydraulic systems. It is, however, important to recognize that order two systems are confined to

1. Incompressible flows at the system nodes, definable by pressure (or head), and flow rate.
2. Barotropic compressible flows in which, $\rho(p)$, so only the pressure (or head) and flow rate need be specified at system nodes. This category also includes those flexible structures for water-hammer analysis in which the local area is a function only of the local pressure. If, on the other hand, the local area depends on the area *and* the pressure elsewhere, then the system is of order 3 or higher.
3. Two-phase flows at the system nodes that can be represented by a *homogeneous flow model* that neglects the relative velocity between the phases. Any of the more accurate models that allow relative motion produce higher order systems.

Note that the order of the system can depend on the choice of system nodes. Consequently, an ideal evaporator or a condenser can be incorporated in an order two system provided the flow at the inlet node is single-phase (of type 2) and the flow at the discharge node also single-phase. A cavitating pump or turbine also falls within this category, provided the flow at both the inlet and discharge is pure liquid.