What is order of an Instrument ?

ZERO ORDER

FIRST ORDER

SECOND ORDER

INSTRUMENTATION & CONTROL

B. TECH 4^{TH} SEM

MECHANICAL ENGINEERING

Order of an Instrument

The order of an instrument can be defined as **the highest order of the derivative describing the behavior of the instrument.**

Transfer function of a general instrumentation system is given as

$$G(s) = \frac{C(s)}{R(s)} = \frac{b_m s^m + b_{m-1} s^{m-1} + \ldots + b_1 s + b_0}{a_n s^n + a_{n-1} s^{n-1} + \ldots + a_1 s + a_0}; \; m \leq n$$

The highest power of the complex variable s in the denominator of the transfer function determines the order of a system. For a zero order system the maximum power of s will be zero, and so on.

Zero Order System

Zero Order System : A zero order system is one in which the highest order of the derivative describing the system behavior is zero.

The mathematical model of a zero order system is given by

$$a_0\, c(t) = b_o\, r(t)$$

Any system which closely obeys above equation over its entire operating range is defined as a zero order system.

First Order System

First Order System: In the mathematical model of a first order system, the highest order of derivative describing the system behavior is one.

System with a storage or dissipative capability but negligible inertial forces may be modeled by using a first order differential equation.

The general mathematical model for a measurement system is given by

$$a_n \frac{d^n c(t)}{dt^n} + a_{n-1} \frac{d^{n-1} c(t)}{dt^{n-1}} + \ldots + a_1 \frac{dc(t)}{dt} + a_0 c(t)$$

$$= b_m \frac{d^m r(t)}{dt^m} + b_{m-1} \frac{d^{m-1} r(t)}{dt^{m-1}} + \ldots + b_1 \frac{dr(t)}{dt} + b_0 r(t)$$

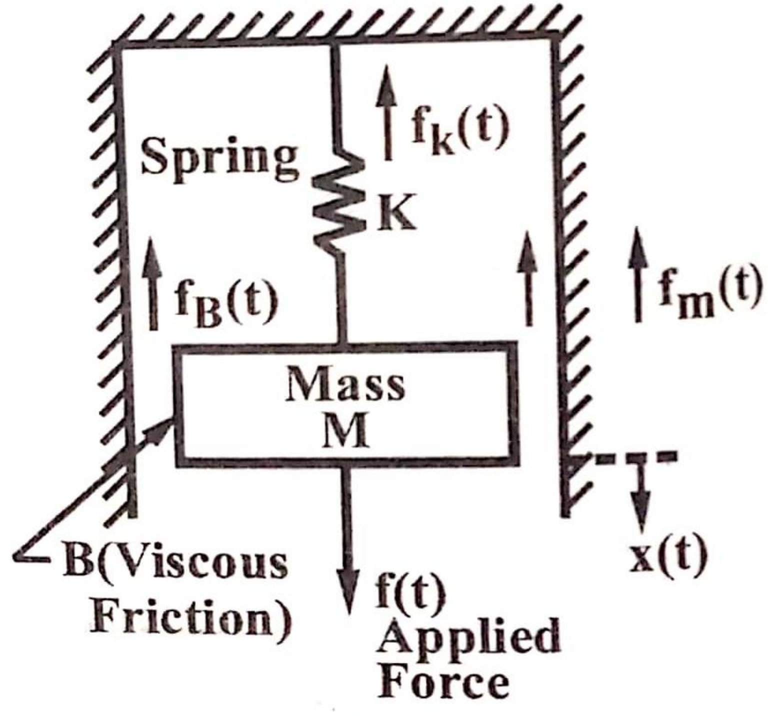
For a first order system in above equation all a's and b's other than a_1, a_0 and b_0 will be zero. Thus the equation will become

$$a_1 \frac{dc(t)}{dt} + a_0 c(t) = b_0 r(t)$$

Second Order System - Systems that possess inertia contain a second order derivative term in their modeled equation and can be considered as a second order system. Accelerometers, diaphragm pressure transducers (including microphones) and mass-damper system are examples of second order systems.

For the mass-damper system, i.e. mechanical translation system, the applied force (input quantity) is resisted by forces $f_m(t)$, $f_k(t)$ and $f_B(t)$. "Thus,

$f(t)= f_m(t) + f_k(t) + f_B(t)$



$$f(t) = M\frac{d^2x(t)}{dt^2} + B\frac{dx(t)}{dt} + K\,x(t)$$

where displacement x(t) is the output.

Thank You