Review of Terminologies

Oscillation, vibration

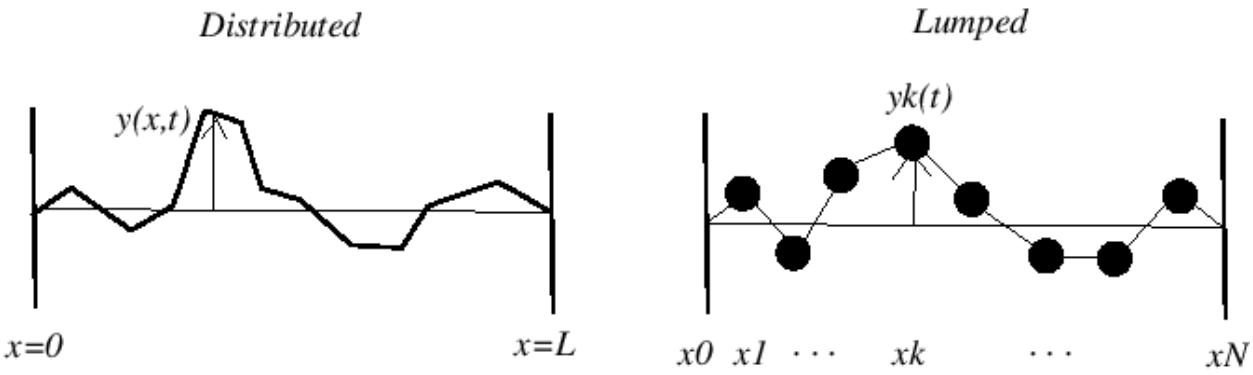
An oscillation is a periodic fluctuation between two 'things' – it's a general term that can refer to anything from a person's decision-making process, tides, or the pendulum of a clock.

Vibrations are oscillations of a mechanical or structural system about an equilibrium position.

Distributed model, lumped-parameter model; or Continuous model, discrete model

A lumped-parameter model is a system where all dependent variables are a function of time. This generally means solving a set of ordinary differential equations – you could also consider this to be a discrete model.

On the other hand, a distributed model is a system where the dependent variables are a function of time and one (or more) additional spatial variables – you could also consider this to be an analog model.



Degrees-of-freedom (DOFs)

The number of degrees of freedom for a system is the number of kinematically independent variables necessary to completely describe the motion of every particle in the system.

(Simple) Harmonic Motion, periodic motion

This is a 'all squares are rectangles, but not all rectangles are squares' scenario. Periodic motion is motion repeated in equal intervals of time – consider a rocking chair, a bounding ball, or a tuning fork.

The undamped motion of a SDOF system is known as simple harmonic motion – that is, simple harmonic motion is a special case of periodic motion where the restoring force on the moving object is directly proportional to the object's displacement magnitude and acts towards to object's equilibrium position, resulting in an oscillation that continues indefinitely (so long as it is uninhibited by friction or other means of dissipating energy)

Amplitude, period, circular frequency (or frequency)

The amplitude of a vibration is the maximum displacement from equilibrium. The period is the time required to execute one cycle – it's usually measured in seconds.

The reciprocal of the period is the frequency and is the number of cycles executed in one second. The units for frequency are cycles/second, or more accurately the inverse of a second, which is known as

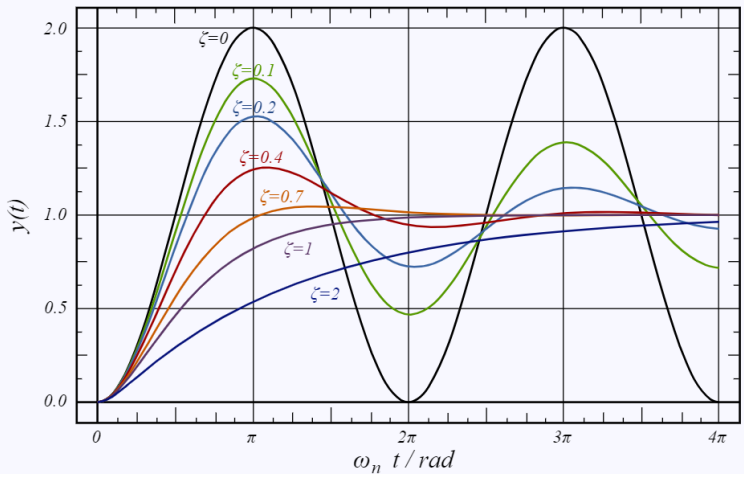
Hertz (Hz). Don't confuse this with the circular frequency, which is also referred to as frequency. The circular frequency (or angular frequency) is the rate at which an angle is changing and is measured in rad/s or revolutions per minute (rpm).

Damping coefficient, damping ratio, critical damping, logarithmic decrement

The damping coefficient of a system is a measure of how quickly it returns to rest as the frictional force dissipates its oscillation energy.

The damping ratio, ζ, describes how oscillations in a system decay after a disturbance – it's defined as the ratio of the damping coefficient of the system's differential equation to the critical damping coefficient. There are four different cases that are represented by the damping ratio:

$\zeta = 0$: undamped
$\zeta < 1$: underdamped
$\zeta = 1$: critically damped
$\zeta > 1$: overdamped



Critical damping exists between the overdamped and underdamped cases, where the system returns to equilibrium in the minimum amount of time – the system fails to overshoot and not a single oscillation is made.

Logarithmic decrement, δ, is defined for underdamped free vibrations as the natural logarithm of the ratio of the amplitudes of vibration on successive cycles. Which doesn't read very well, but if you have a vibration with decreasing amplitudes, it's the natural log of the ratio at which the amplitudes are decreasing.

Free vibration, forced vibration, self-excited vibration

If the vibrations are initiated by an initial energy present in the system and no other source is present, the resulting vibrations are called free vibrations. That is, it's a term that's generally used to indicate that the vibrations present in a system are only due to the initial conditions of the system, and not from external sources.

Conversely, if the vibrations are caused by external forces or motion, then the vibrations are called forced vibrations.

Self-excited vibration is a little more complicated – consider systems where the exciting force is a function of the motion variables (displacement, velocity, or acceleration) and thus varies with the motion it produces (this is called coupling) – this is known as self-excited vibration. This is a wordy definition, but consider examples like friction-induced vibration in vehicle clutches and brakes, or flow-induced vibration in circular saws and CDs.

Transient response, steady state response

The behavior of the system as time gets very large (read: infinite) is called the steady state response. It's independent of the initial position and velocity of the mass. The behavior of the system while it is approaching the steady state is called the transient response.

Time domain, frequency/spectrum domain

A time domain graph shows how a signal changes over time, whereas a frequency-domain graph shows how much of the signal lies within each given frequency band over a range of frequencies. The 'spectrum' of frequency components is the frequency-domain representation of the signal.

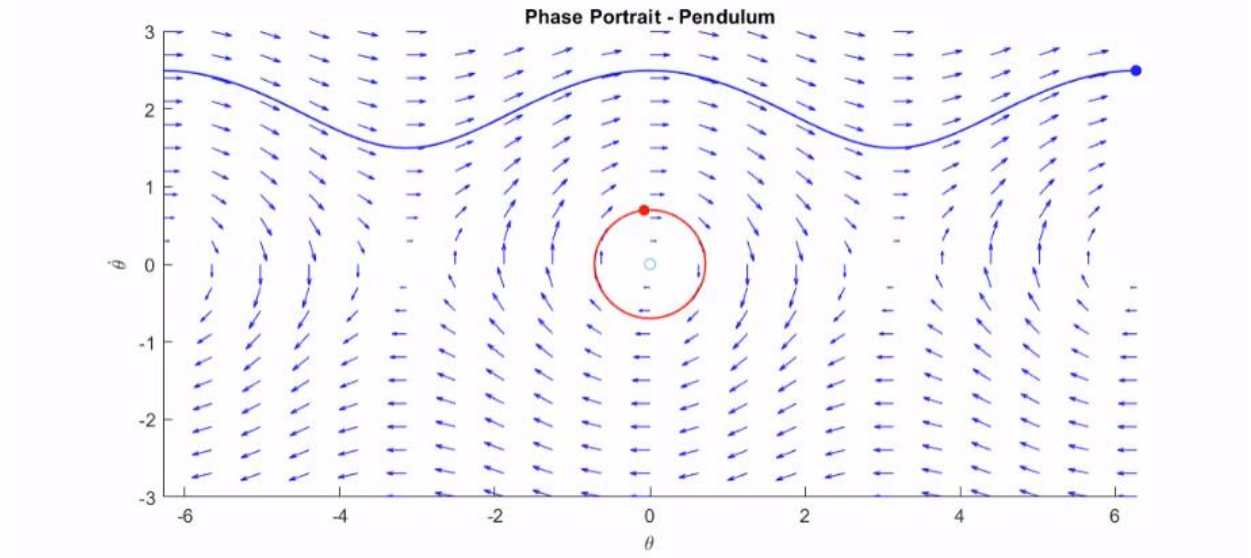
State, state variables, state space model

A state space model is a representation of the dynamics of an N^{th} order system as a first order differential equation in an N −vector. This N −vector is called the state, and the variables contained within the state space model are the state variables.

Phase Portrait

A phase portrait is a geometric representation of the trajectories of a dynamical system in the phase plane.

For example, consider this phase portrait for a pendulum – where the x-axis corresponds to the angle of the pendulum, and the y-axis corresponds to the angular velocity.



(Amplitude) Resonance

Resonance refers to the phenomenon when a quantity (or a state) becomes large.

In addition to amplitude resonance, there are also velocity resonance or phase resonance, and energy resonance, and so on.

FFT, Nyquist Frequency

Nyquist frequency is the minimum sampling frequency without introducing errors. It should be (at least) twice the highest frequency present in the signal.