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# Runge-Kutta

# Hopf bifurcation

## Question: Discuss about Hopf Bifurcation

Most dynamic systems contain both parameters and variables, such that the equation has a set of parameters on which the equations and their solutions depend. A bifurcation is said to occur when the behavior of the model changes qualitatively from one set of parameters to another. For instance, a stable equilibrium point might have become unstable.

In A Hopf Bifurcation, a variation of the parameters destabilizes a stable focus, and the attractor becomes an asymptotically stable, periodic solution(limit cycle) seen as a closed curve in a phase portrait .

There are 2 types of a Hopf bifurcation:

* Supercritical Andronov-Hopf Bifurcation: here, the limit cycle has zero amplitude at the parameters resulting in the bifurcation, however the amplitude groes as the parameters move further into the limit-cycle regime
* Subcritical Andronov-Hopf bifurcation: here a stable limit cycle surrounds an unstable limit cycle that in turn surrounds the equilibrium point. The unstable limit cycle shrinks down to the equilibrium point, which becomes unstable in the process. For systems started near the equilibrium point, the result is a sudden change in behavior from approach to a stable focus, to large -amplitude oscillations.