Project #1

Part I:

Consider the *FitzHugh-Nagumo oscillator model* which is a two-dimensional simplification of the *Hodgkin-Huxley model* of spike generation in neurons.

$$\dot{x} = \alpha \left[y + x - \frac{x^3}{3} + z \right]$$
$$\dot{y} = -\frac{1}{\alpha} \left[\omega^2 x - a + by \right]$$

Where x is the excitability variable, y is the refractoriness variable, and z is the stimulus intensity.

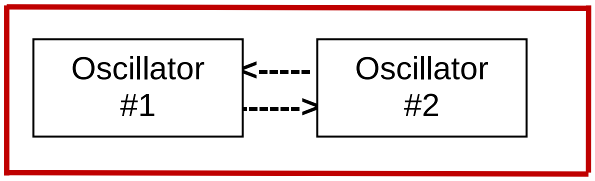
α, ω^2, a, b are model parameters

Choose a=0.7, b=0.8 and ω^2 =1

(a) Investigate the intrinsic frequency of the oscillator output by plotting it as a function of "*stimulus z=constant=k*" for the special case *α=3*.

Part II:

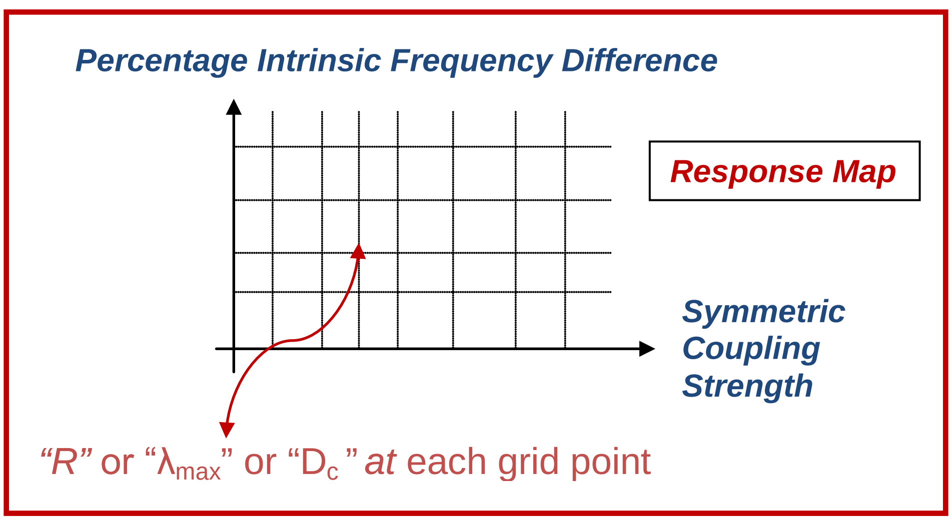
Consider two bidirectionally coupled *FitzHugh-Nagumo* oscillators.



(b) Investigate the phase coherence index “R” of the coupled oscillators as a function of their percentage intrinsic frequency difference and symmetric coupling strength.

Hints:

- For bidirectional coupling use $z_1=k_1+c\,x_2$ and $z_2=k_2+c\,x_1$ where “k_1”and “k_2” are associated with intrinsic frequency of oscillators #1&2 respectively, and “c” is the symmetric coupling strength.
- The intrinsic frequency is estimated from Part I when c=0.
- Use ***response maps*** to indicate different regions of *system behaviour*, in your investigations of coupled oscillators in Parts II and III.



Part III:

(c) Investigate two ***complexity measures*** the maximum Lyapunov exponent “λ_{max}” and the correlation dimension “D_c”, using the oscillator output time series $x_1(t)$ & $x_2(t)$, for each grid point in the depicted response map.

Hints:

- This will produce 6 response maps (3 for each oscillator).
- Use a Rosenstein's algorithm to compute “λ_{max}” from short time series data.
- Use a Grassberger-Procaccia algorithm to compute “D_c”.