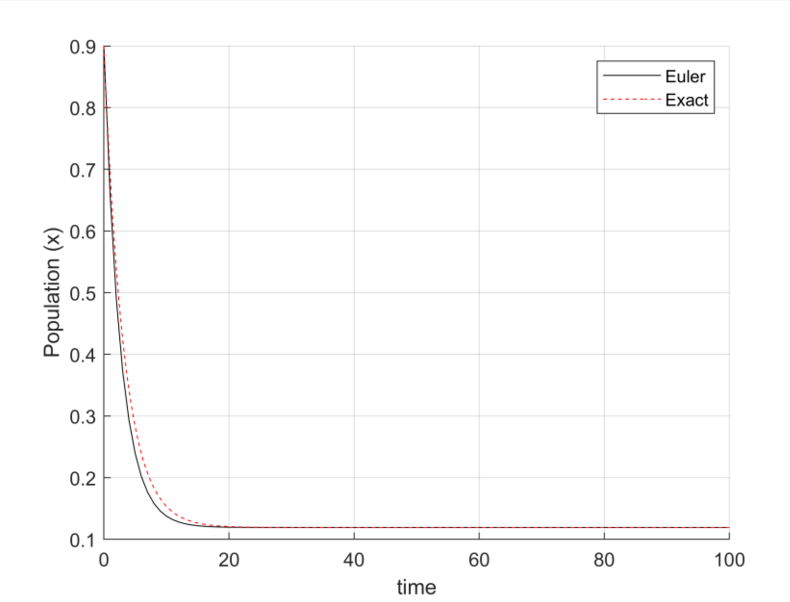
Solutions to practical session 1

Part 1: The Euler Method

1. An example code for `EulerODE.m` can be found in the folder:
   ./intro_to_modelling/practical1/solutions

2. When you run `SimulateFiringRateModel.m`, you should get the following output:

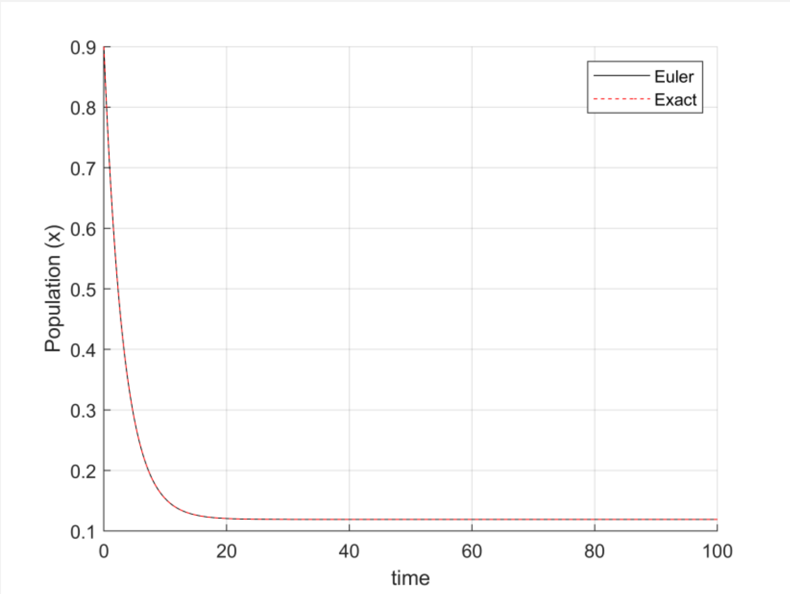
```
Simulating...
Elapsed time is 0.003804 seconds.
RMSError =
     0.0120
```



3. The following page contains two example simulations with `h=0.5` and `h=0.0001`. You should run more simulations. As the step size gets smaller, the solution becomes more accurate (lowered root mean square error, and you can visually see the Euler solution fits the exact solution better), but it is slower to generate the solution. There is a speed/accuracy trade off whenever you solve an ODE.

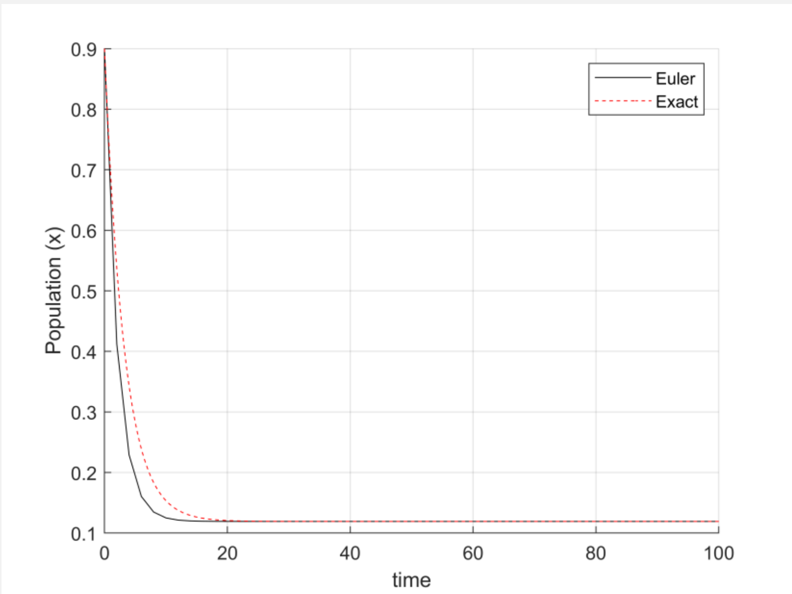
Simulation with `h=0.0001`:

```
Simulating...
Elapsed time is 1.786445 seconds.
RMSError =

     1.0192e-06
```



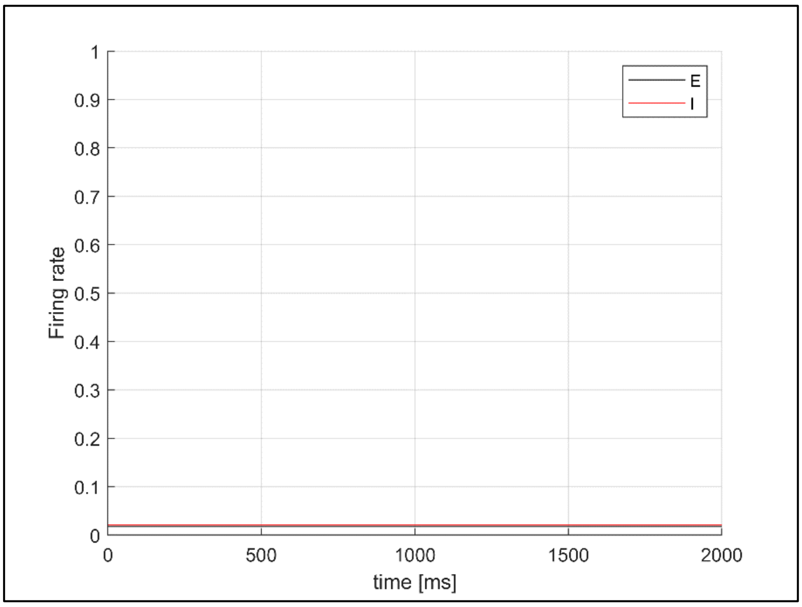
Simulation with `h=2`:

```
Simulating...
Elapsed time is 0.002704 seconds.
RMSError =

     0.0274
```



Part 2: The Wilson-Cowan Equations

4. An example code for `WilsonCowanODE.m` can be found in the folder: *./intro_to_modelling/practical1/solutions*
5. You should find a steady state at `x=[0.0181;0.0207]`. The output of the simulation is the plot below:

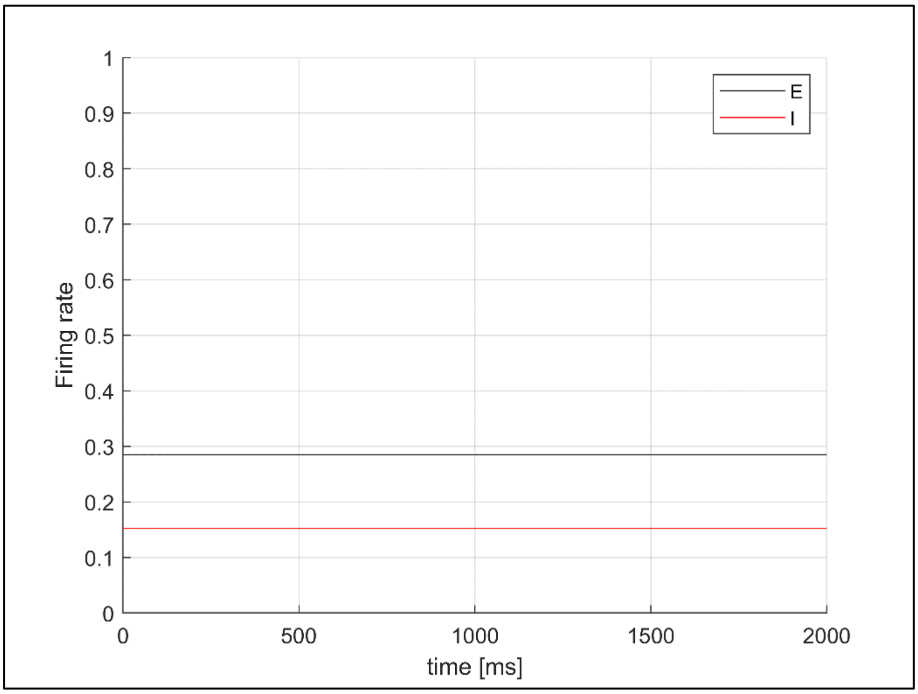


6. Simulations are shown on the next two page for a range of values of P. Below P=0.4, there is a stable steady state. For P between 0.4 and 1.2, there is a gamma oscillation periodic orbit (and, though you don't see it, an unstable steady state. There is always at least one unstable steady state at the centre of a stable periodic orbit). These sudden transitions in behaviour are known as ***bifurcations***, and will be covered more in the 2nd tutorial. The generation of gamma oscillations given an input are common in cortical neuronal networks. At P=1.2, there is another bifurcation, and above this value we have a stable steady state and no oscillations.

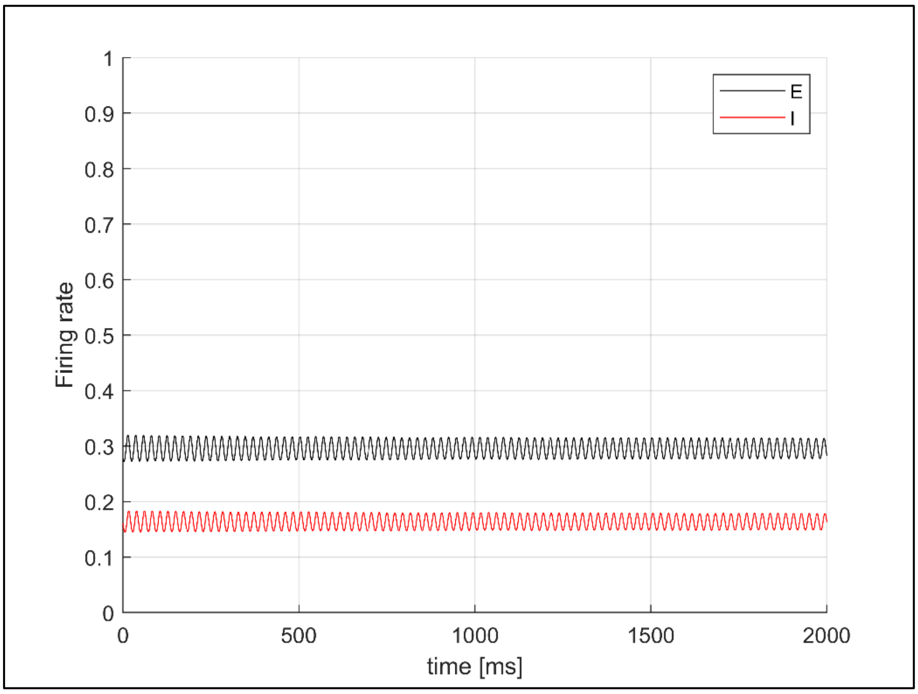
7. There should be no oscillations and a stable steady state for either c_{EI} or $c_{IE} = 0$. This is because removing the input from one population to another essentially isolates that population, making it a 1d equation. For example, when $c_{IE} = 0$, the equation for the E population is identical to the equations for a single isolated population (and similar for $c_{IE} = 0$ and the I population). 1d equations cannot oscillate.

Simulations for task 6

P=0.39

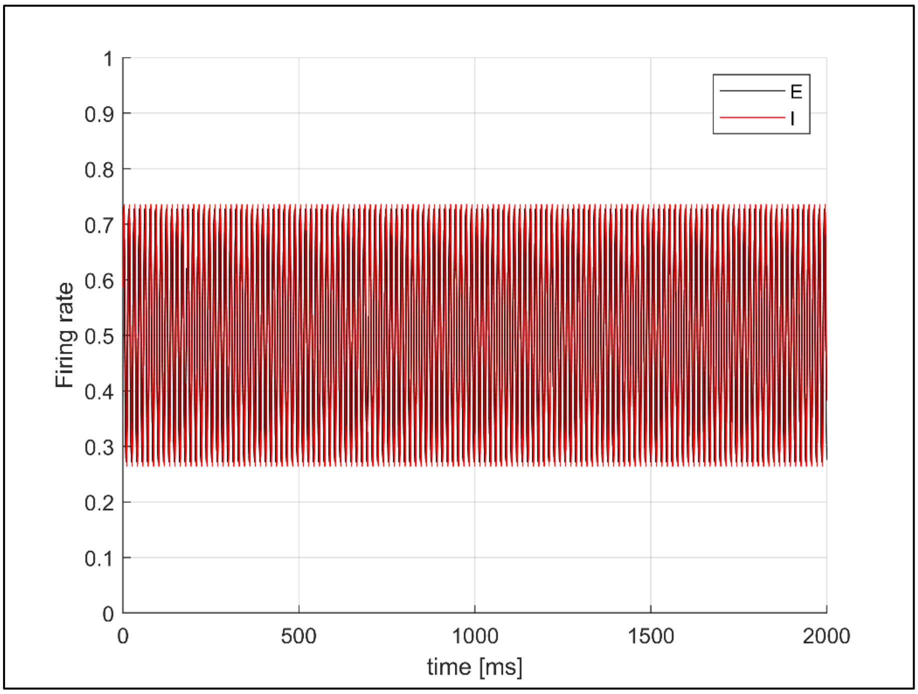


P=0.40

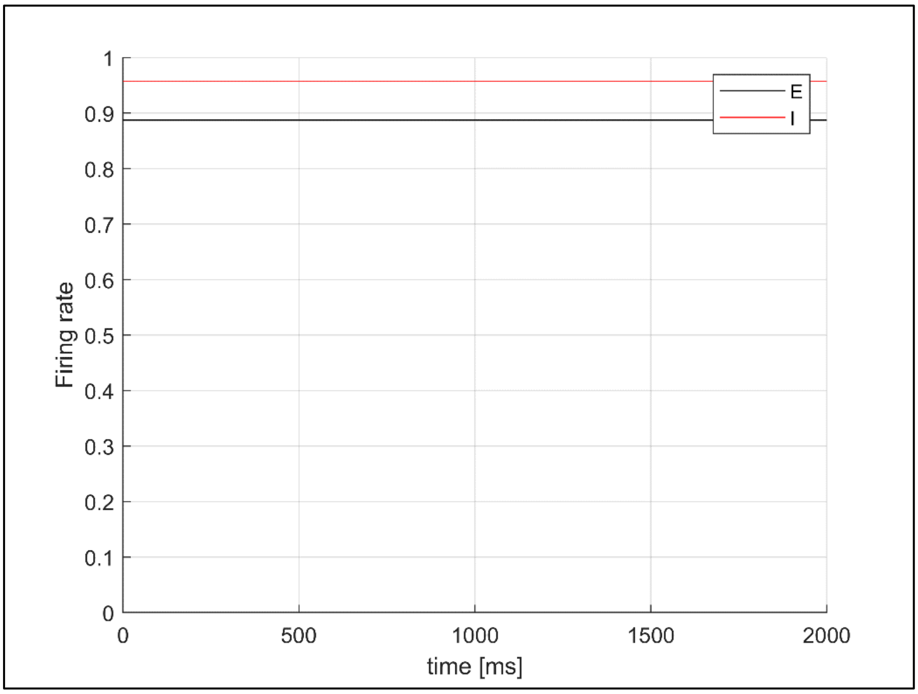


Simulations for task 6

P=0.8

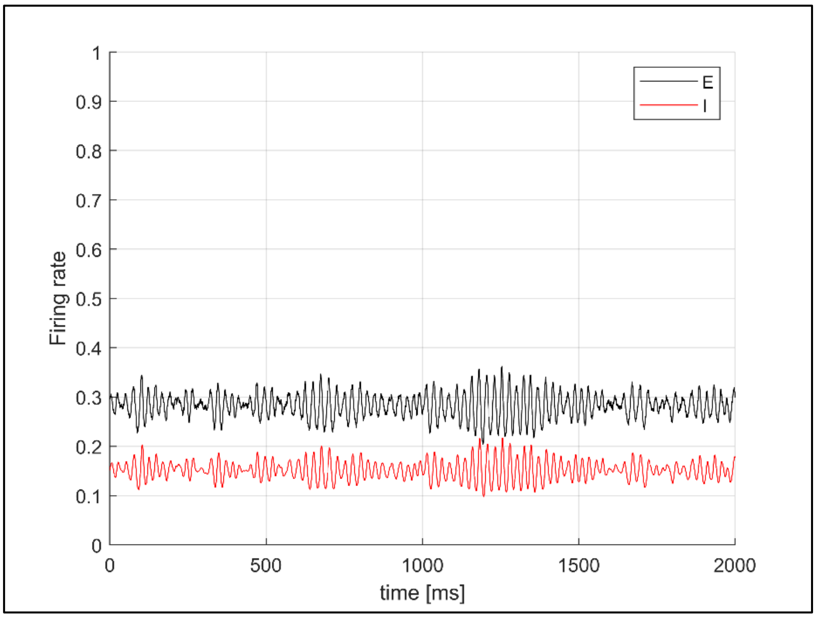


P=1.3



Part 3: Stochastic differential equations (SDEs)

8. An example code for `EulerSDE.m` can be found in the folder: *./intro_to_modelling/practical1/solutions*
9. For all of the values of `P` on the last two pages, you should get the same plots here. The stochastic Euler is equivalent to the deterministic Euler if there is no noise.
10. With noise set to zero, you should get the first plot on page 4. With `stdEnoise=0.01`, you should see noise-induced gamma oscillations as shown in the plot below (with power spectrum below that).



As you decrease `P`, the noise-induced gamma oscillations disappear (shown below). Close to the bifurcation the system is highly resonant, as it is close to oscillating. The further you move from the bifurcation, the further the system is from oscillating so the less dominant the resonance. This type of resonant steady state is called a ‘focus’.