C.6.2 Independent section

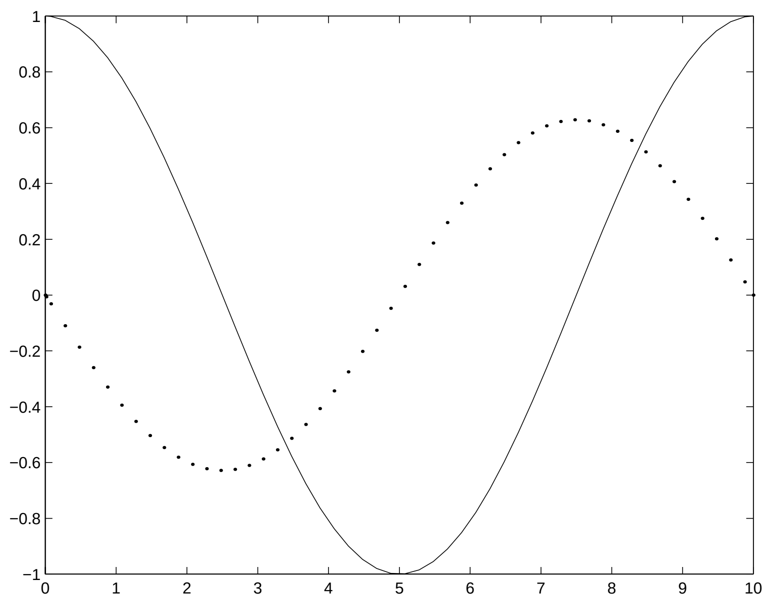
1. The A matrix is given by

$$A = \begin{bmatrix} 0 & 1 \\ -\omega_0^2 & 0 \end{bmatrix}.$$

2. The gain of the MatrixGain block is set to

```
[0, 1; -4*pi*pi/100, 0]
```

to make the period 10 seconds. This corresponds to $\omega_0 = 2\pi/10$, which evidently has units of radians per second. The two state variables oscillate with frequency $1/10$ Hz, as shown in the following plot:



3. Letting $\omega_0 = 2\pi \times 440$, we set the gain of the MatrixGain block to

```
[0, 1; -4*pi*pi*440*440, 0]
```

We expect the simulation to complete five cycles in $5/440$ seconds, so we set the simulation to stop at that time. This time, the two state variables have very different amplitudes.

4. The block diagram that generates the tuning fork output is shown in figure C.11. The Matlab command to listen to the output is

```
soundsc(simout(:,1))
```

Note that there is a Simulink block “To Wave Device” that will produce audio output, but it seems more awkward to use than the above method. Nonetheless, it represents a perfectly acceptable solution.

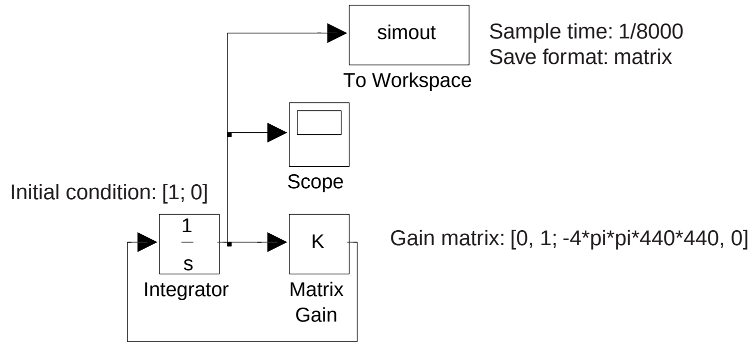


Figure C.11: Block diagram for part 4.

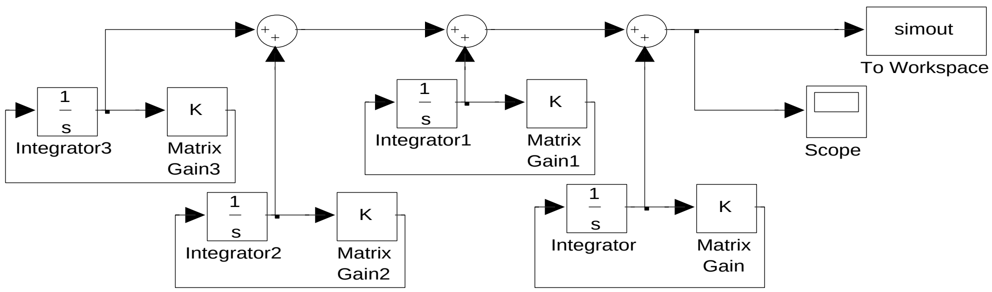


Figure C.12: A block diagram generating a plucked string sound with a fundmental and three harmonics.

5. The sound decays exponentially. Larger negative values of $a_{2,2}$ result in faster decay. Positive values result in exponential growth (the system is unstable). The system is stable if $a_{2,2} < 0$.

6. A block diagram generating a fundamental plus harmonics is show in figure C.12. The four matrix gain blocks have the following parameters, creating a reasonably good plucked-string sound for an A-440:

```
[0, 1; -4*pi*pi*440*440, -5]
[0, 1; -4*pi*pi*440*440*4, -20]
[0, 1; -4*pi*pi*440*440*9, -30]
[0, 1; -4*pi*pi*440*440*16, -40]
```