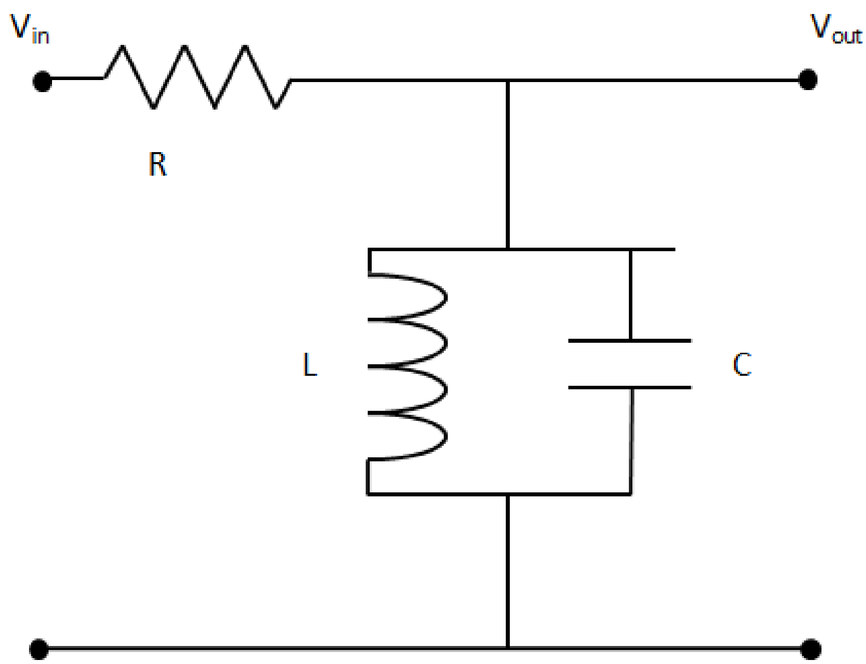
Bandpass Filter Design



> $restart$:

This transfer function defines the response of a Bandpass filter.

> $$G := \frac{\frac{s}{R\,C}}{s^2 + \frac{s}{R\,C} + \frac{1}{L\,C}} :$$

The product L C controls the bandpass frequency while R C controls how narrow the passing band is. To build a bandpass filter tuned to the frequency 1 rad/s, set L=C=1 and use R to tune the filter band.

First define a transfer function object.

> $with(DynamicSystems)$:

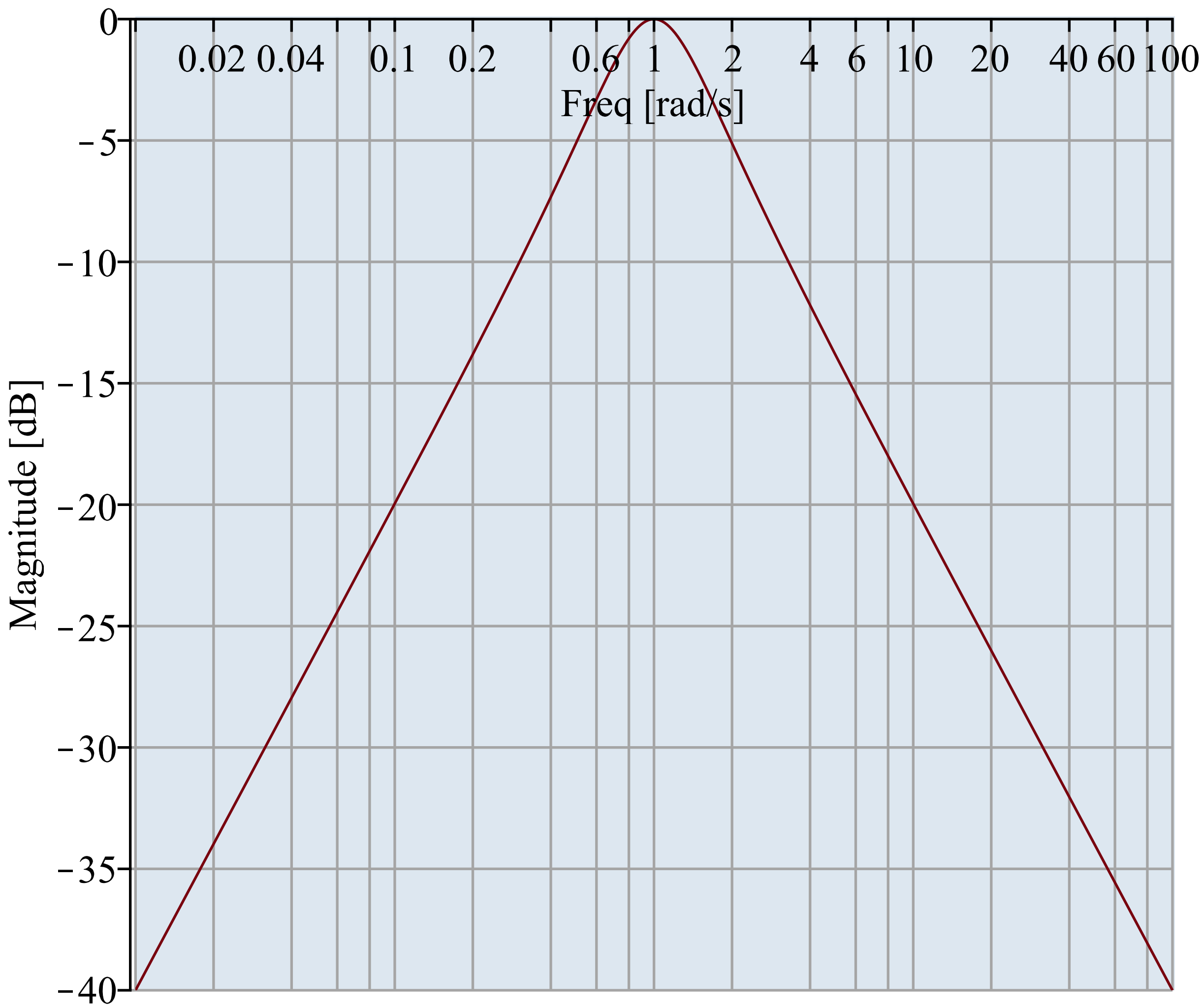
> $sysTF := TransferFunction(G)$

(1)

$$sysTF := \left[\begin{array}{c} \textbf{Transfer Function} \\ \text{continuous} \\ \text{1 output(s); 1 input(s)} \\ \text{inputvariable} = [u1(s)] \\ \text{outputvariable} = [y1(s)] \end{array}\right] \tag{1}$$

Now generate a Magnitude plot

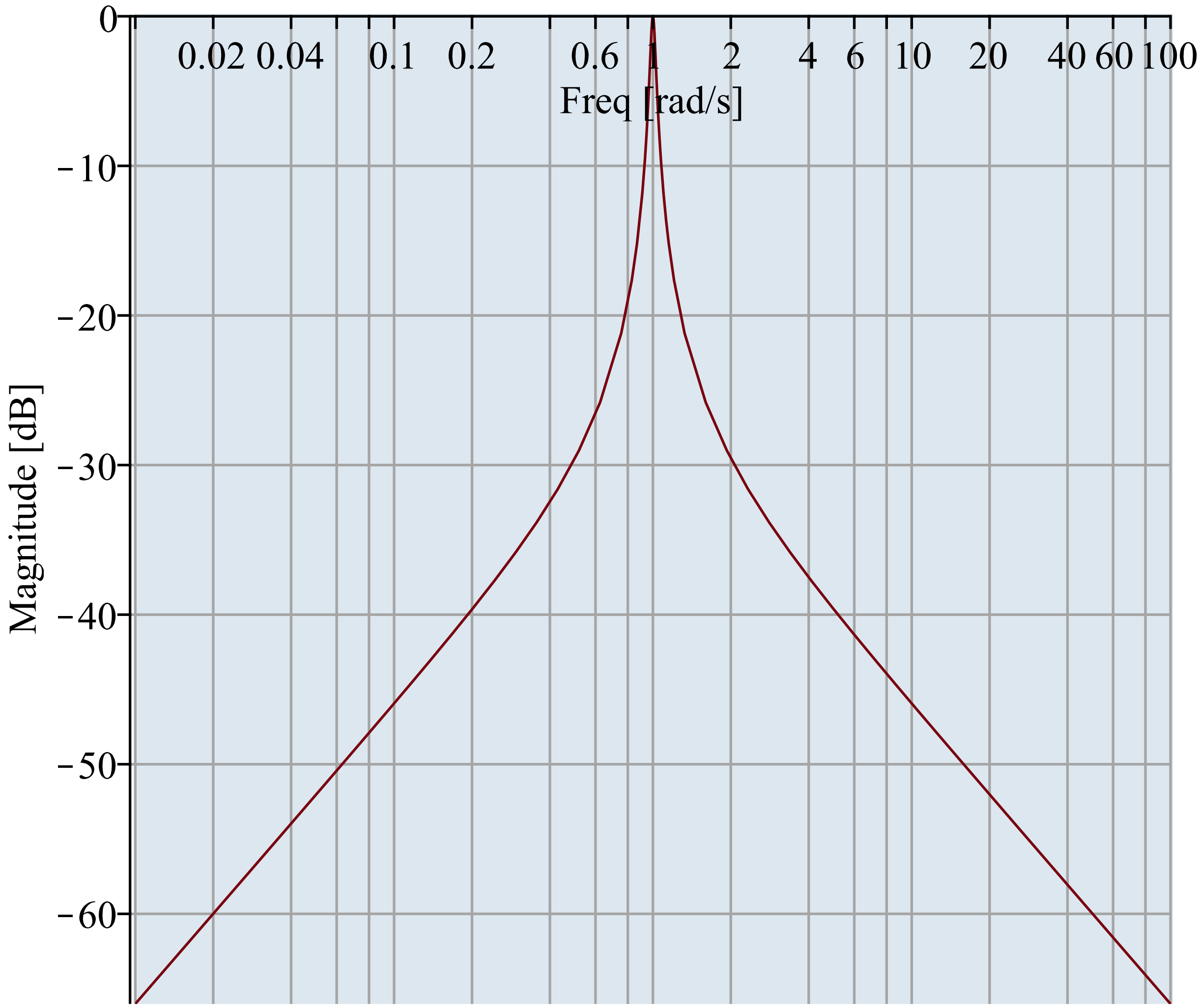
> *MagnitudePlot*(*sysTF*, *size* = [800, 400], *parameters* = [*R* = 1, *L* = 1, *C* = 1], *background* = *ColorTools*:-*Color*("RGB", [221 / 255, 231 / 255, 240 / 255]), *thickness* = 0)



As expected, the RLC filter has maximum gain at the frequency 1 rad/s. However, the attenuation is only -10dB half a decade away from this frequency.

To get a narrower passing band, try increasing values of R.

> *MagnitudePlot*(*sysTF*, *size* = [800, 400], *parameters* = [R = 20, L = 1, *C* = 1], *background* = *ColorTools*:-*Color*("RGB", [221 / 255, 231 / 255, 240 / 255]), *thickness* = 0)

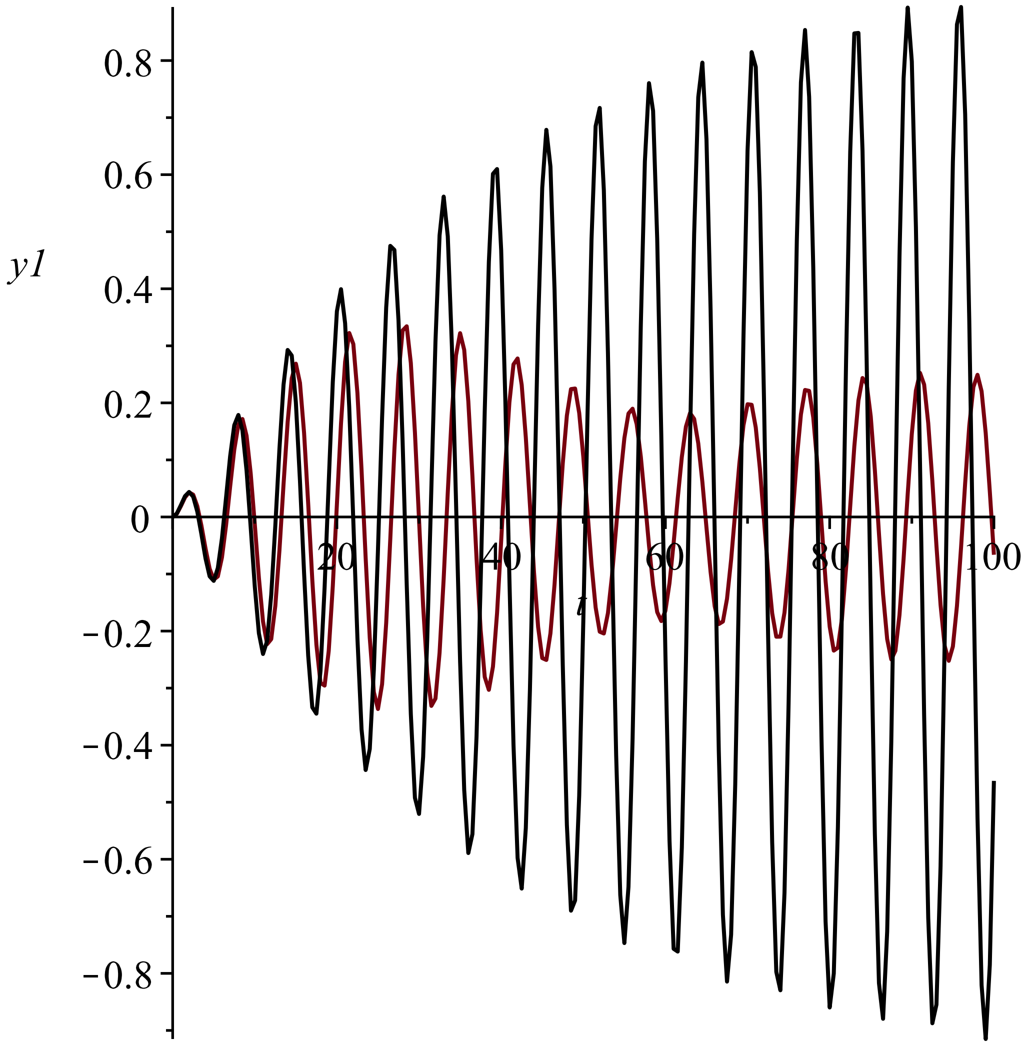


The resistor value R=20 gives a filter narrowly tuned around the target frequency of 1 rad/s.

We can confirm the attenuation properties of the circuit (R=20) by simulating how this filter transforms sine waves with frequency 0.9, 1, and 1.1 rad/s.

Create two response plots for the filter at R=20 with two inputs: sin(0.9 t) and sin(t).

```
> p1 := ResponsePlot(sysTF, sin(0.9·t), duration = 100, parameters = [R = 20, L = 1, C = 1]) :
> p2 := ResponsePlot(sysTF, sin(t), duration = 100, parameters = [R = 20, L = 1, C = 1], color
      = black) :
> plots:-display(p1, p2)
```



y1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
20
40
60
80
100
t

>