For each problem, draw a suitable circuit, determine the transfer function, and design the circuit components.

1. One-Pole, Lowpass Filters
   a) Design an RC low-pass filter to approximate the Bode magnitude frequency response shown. Use reasonable component values.

   ![Diagram of an RC low-pass filter with transfer function H(jω).

   b) Modify the design to approximate the Bode magnitude response shown.

   ![Diagram of an RLC low-pass filter with transfer function H(jω).

   c) Modify the design again, so the cutoff frequency is tunable between 100 and 500 rad/s, but so that the high-frequency response is roughly flat above 1000 rad/s.
2. One-Pole Highpass Filters

a. Design an RC high-pass filter to approximate the Bode magnitude frequency response shown. Use reasonable component values.

b. Modify the design to approximate the Bode magnitude response shown.

c. Modify the design again, so the cutoff frequency is tunable between 100 and 1000 rad/s, but so that the low-frequency response is roughly flat below 100 rad/s.
3. Second-Order Filters

a. Design a series RLC lowpass filter to be a Butterworth filter and to have a cutoff frequency of 1 rad/sec. Use a 1 F capacitor. Specify the values of R and L.

b. Design a series RLC highpass filter to be a Butterworth filter and to have a cutoff frequency of 1 rad/sec. Use a 1 F capacitor. Specify the values of R and L.

c. Design a series RLC bandpass filter to have a center frequency of 1 rad/sec and a bandwidth of 1 rad/sec. Use a 1 F capacitor. Specify the values of R and L.

d. Use magnitude and frequency scaling to modify the design in part a) to a Butterworth lowpass filter with cutoff frequency 20,000 rad/s. Use a 10 nF capacitor.

e. Use magnitude and frequency scaling to modify the design in part b) to a Butterworth highpass filter with cutoff frequency 200 rad/s. Use a 100 ohm resistor.

f. Use magnitude and frequency scaling to modify the design in part c) to a bandpass filter with center frequency 5,000 rad/s and bandwidth 5,000 rad/s. Use a 10 mH inductor.

\[ R' = \frac{k_m R}{k_s}, \quad L' = \frac{k_m L}{k_s}, \quad C' = \frac{C}{k_m k_s} \]