Item 2

Butterworth

```
close all; clear all; clc;

% Analog Butterworth bandpass filter design using buttord
Wp = [1000 4000];   % Passband frequencies in Hz
Ws = [200 5000];    % Stopband frequencies in Hz
Rp = abs(db(0.99));           % Passband ripple in dB
Rs = abs(db(0.01));     % Stopband attenuation in dB

% Determine the filter order and cutoff frequencies
[Nbutt, Wcbutt] = buttord(Wp*2*pi, Ws*2*pi, Rp, Rs, 's');

% Design the Butterworth bandpass filter
[Bbutt, Abutt] = butter(Nbutt, Wcbutt, 's');
disp('Lowest-order Butterworth filter that satisfies the specifications:');
```

```
Lowest-order Butterworth filter that satisfies the specifications:
```

```
disp(Nbutt);
```

```
    20
```

```

% Display the transfer function coefficients
disp('Numerator coefficients (b):');
```

```
Numerator coefficients (b):
```

```
disp(Bbutt);
```

```
   1.0e+86 *

         0         0         0         0         0         0         0         0         0         0
```

```
disp('Denominator coefficients (a):');
```

```
Denominator coefficients (a):
```

```
disp(Abutt);
```

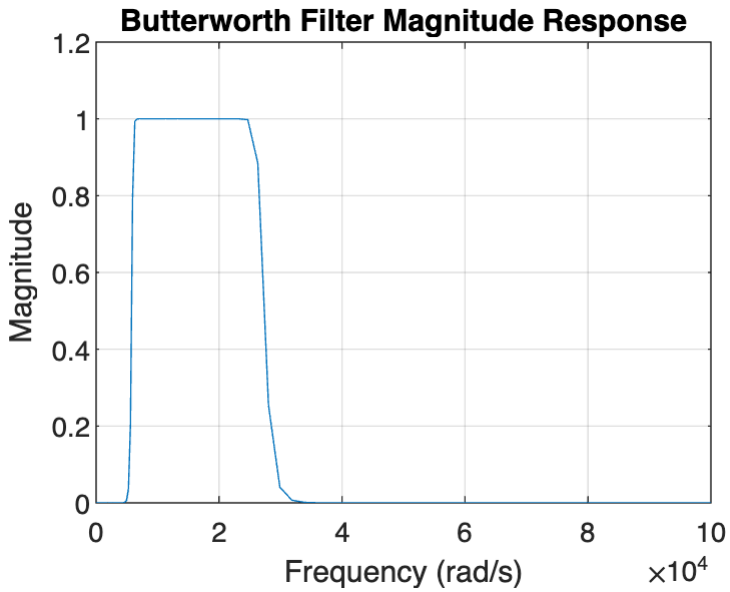
```
  1.0e+163 *

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.
```

```

[Hbutt, Wbutt] = freqs(Bbutt, Abutt);
figure();
plot(Wbutt, abs(Hbutt));
title('Butterworth Filter Magnitude Response')
xlabel('Frequency (rad/s)')
```

```
ylabel('Magnitude')
grid on
```



Chebeyshev-I

```
% Determine the filter order and cutoff frequencies
[Ncheb1, Wccheb1] = cheb1ord(Wp*2*pi, Ws*2*pi, Rp, Rs, 's');

% Design the Chebyshev_i bandpass filter
% The syntax for cheby1 is similar to butter but with Rp after the order
% and Wp instead of the cutoff frequency
[Bcheb1, Acheb1] = cheby1(Ncheb1, Rp, Wp*2*pi, 's');
disp('Lowest-order Chebyshev-I filter that satisfies the specifications:');
```

```
Lowest-order Chebyshev-I filter that satisfies the specifications:
```

```
disp(Ncheb1);
```

```
     9
```

```

% Display the transfer function coefficients
disp('Numerator coefficients (b):');
```

```
Numerator coefficients (b):
```

```
disp(Bcheb1);
```

```
   1.0e+36 *

         0         0         0         0         0         0         0         0         0    8.2353
```

```
disp('Denominator coefficients (a):');
```

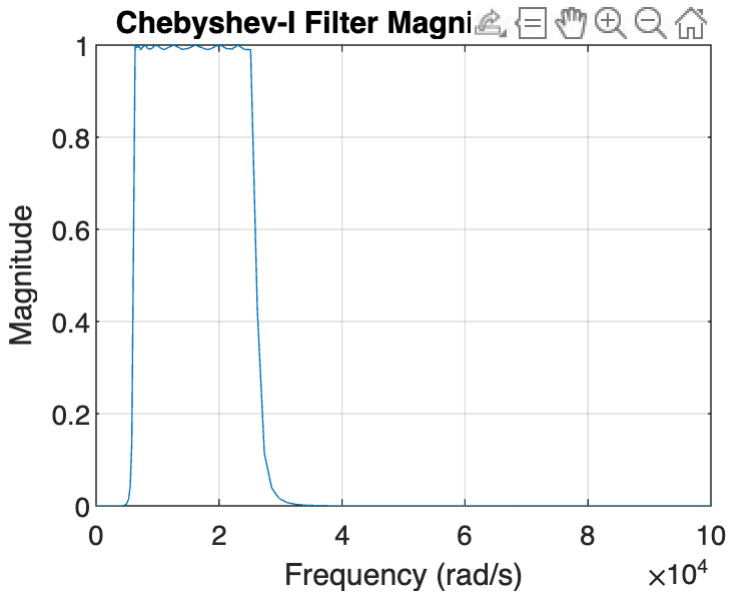
```
Denominator coefficients (a):
```

```
disp(Acheb1);
```

```
   1.0e+73 *

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.
```

```
[Hcheb1, Wcheb1] = freqs(Bcheb1, Acheb1);
figure();
plot(Wcheb1, abs(Hcheb1));
title('Chebyshev-I Filter Magnitude Response')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
grid on
```



Chebyshev-II

```
% The script for Chebyshev-II is the same as in Chebyshev-I
% variables and functions were properly renamed

% Determine the filter order and cutoff frequencies
[Ncheb2, Wccheb2] = cheb2ord(Wp*2*pi, Ws*2*pi, Rp, Rs, 's');

% Design the Chebyshev-II bandpass filter
% Intead of the Rp and Wp, cheby2 syntax involves Ra and Ws
[Bcheb2, Acheb2] = cheby2(Ncheb2, Rs, Ws*2*pi, 's');
disp('Lowest-order Chebyshev-II filter that satisfies the specifications:');
```

```
Lowest-order Chebyshev-II filter that satisfies the specifications:
```

```
disp(Ncheb2);
```

```
     9
```

```
% Display the transfer function coefficients
disp('Numerator coefficients (b):');
```

```
Numerator coefficients (b):
```

```
disp(Bcheb2);
```

```
   1.0e+64 *

         0    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000   -0.
```

```
disp('Denominator coefficients (a):');
```

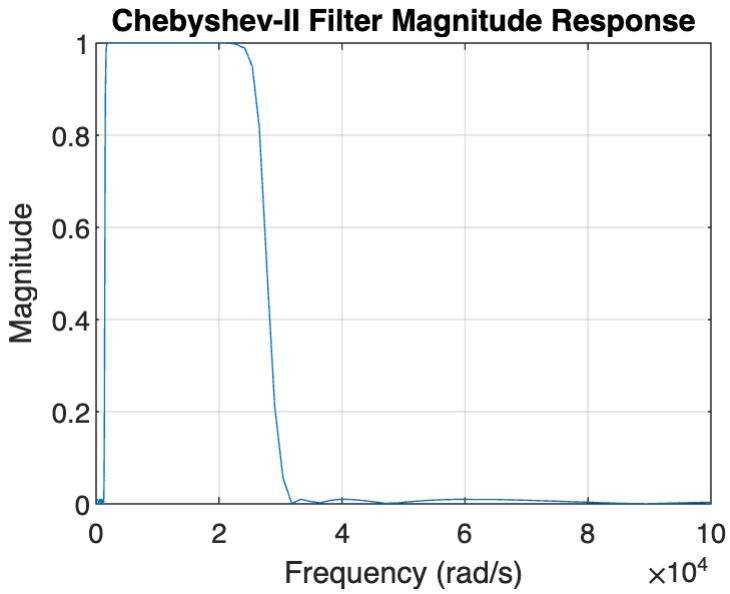
```
Denominator coefficients (a):
```

```
disp(Acheb2);
```

```
   1.0e+68 *

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.
```

```
[Hcheb2, Wcheb2] = freqs(Bcheb2, Acheb2);
figure();
plot(Wcheb2, abs(Hcheb2));
title('Chebyshev-II Filter Magnitude Response')
xlabel('Frequency (rad/s)')
xlim([0, 10*10^4]); % I included this to make the x axis uniform
ylabel('Magnitude')
grid on
```



A summary of the plots

```
figure();
```

```
subplot(311);
plot(Wbutt, abs(Hbutt));
title('Butterworth Filter Magnitude Response')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
grid on

subplot(312);
plot(Wcheb1, abs(Hcheb1));
title('Chebyshev-I Filter Magnitude Response')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
grid on

subplot(313);
[Hcheb2, Wcheb2] = freqs(Bcheb2, Acheb2);
plot(Wcheb2, abs(Hcheb2));
xlim([0, 10*10^4]);
title('Chebyshev-II Filter Magnitude Response')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
grid on
```