Windowed-Sinc Filter

- y = sin(2*pi*f*t) / t

Create the filter

```
sample_rate = 1000; % hz
t = -4:1/sample_rate:4;
num_points = length(t);

f = 8; % cutoff freq in hz
sinc_filter = sin(2*pi*f*t) ./ t;

% adjust for when t = 0 and normalize
sinc_filter(~isfinite(sinc_filter)) = max(sinc_filter);
sinc_filter = sinc_filter./sum(sinc_filter);

hz_vals = linspace(0, sample_rate/2, floor(num_points/2)+1);
power_sinc = abs(fft(sinc_filter));
```

Window the filter

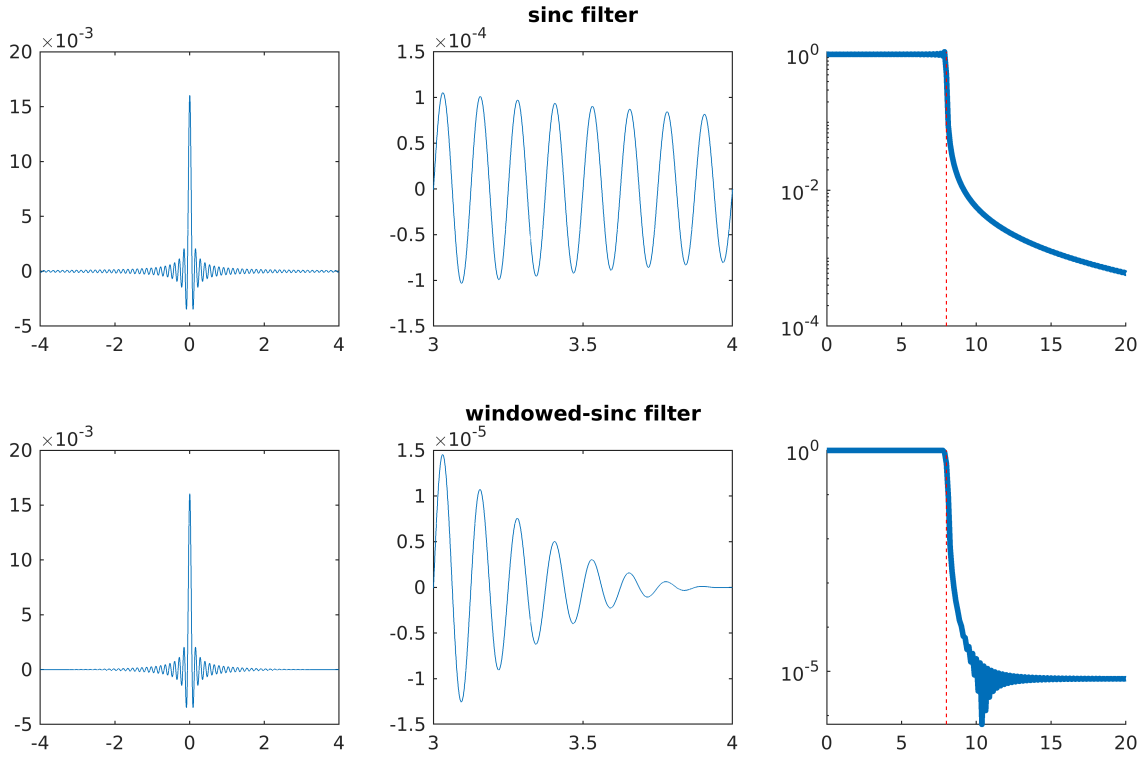
- use hann window https://www.mathworks.com/help/signal/ref/hann.html
- https://en.wikipedia.org/wiki/Window_function

```
windowed_sinc = sinc_filter .* hann(num_points)';
power_windowed = abs(fft(windowed_sinc));
```

Plot the filters

```
f1 = figure(1); clf;
f1.Position = [0 0 1000 600];

subplot(231);
plot(t, sinc_filter);

subplot(232);
plot(t, sinc_filter);
xlim([3 4]);
title({"sinc filter", ""}); % creates a space below title

subplot(233);
hold on;
plot(hz_vals, power_sinc(1:length(hz_vals)), 'linew', 3);
xlim([0 20]);
set(gca, 'YScale', 'log');
plot([1 1]*f, get(gca,'ylim'), 'r--'); % cutoff line
hold off;
```

```
subplot(234);
plot(t, windowed_sinc);

subplot(235);
plot(t, windowed_sinc);
xlim([3 4]);
title({"windowed-sinc filter", ""});

subplot(236);
hold on;
plot(hz_vals, power_windowed(1:length(hz_vals)), 'linew', 3);
xlim([0 20]);
set(gca, 'YScale', 'log');
plot([1 1]*f, get(gca,'ylim'), 'r--'); % cutoff line
hold off;
```



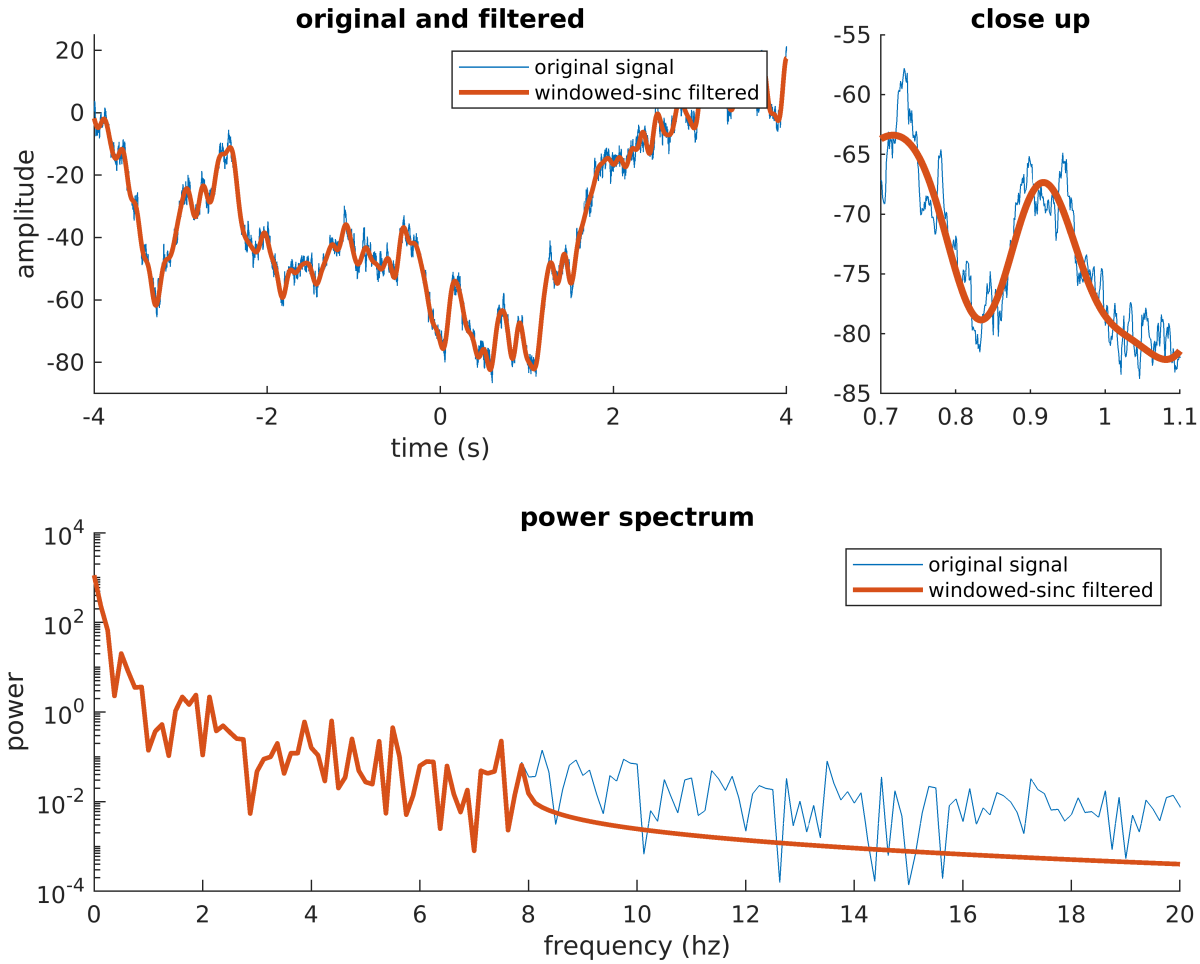
Apply the filter

- generate brownian noise
- apply reflection
- apply filter with zero phase shift
- remove reflected points
- compare power spectrums

```
data = cumsum(randn(num_points, 1)); % brownian noise
data_c = [data; data(end:-1:1)]; % reflection

filtered = filter(windowed_sinc, 1, data_c); % filter w/ zero phase shift
filtered = filter(windowed_sinc, 1, filtered(end:-1:1));

filtered = filtered(end:-1:num_points+1); % remove reflection

hz_data = linspace(0, sample_rate/2, floor(num_points/2)+1);
power_data = abs(fft(data)/num_points).^2;
power_filtered = abs(fft(filtered)/num_points).^2;
```

Plot the results

```
f2 = figure(2); clf;
f2.Position = [0 0 800 600];

subplot(2,3,[1 2]);
hold on;
plot(t, data);
plot(t, filtered, 'linew', 2);
hold off;
ylim([-90 25]);
xlabel("time (s)");
ylabel("amplitude");
legend({"original signal", "windowed-sinc filtered"});
title("original and filtered");

subplot(233);
hold on;
plot(t, data);
plot(t, filtered, 'linew', 3);
hold off;
xlim([.7 1.1]);
title("close up");

subplot(2,3,[4 6]);
hold on;
plot(hz_data, power_data(1:length(hz_data)));
plot(hz_data, power_filtered(1:length(hz_data)), 'linew', 2');
hold off;
xlim([0 20]);
set(gca, 'YScale', 'log');
xlabel("frequency (hz)");
ylabel("power");
legend({"original signal", "windowed-sinc filtered"});
title("power spectrum");
```



TODO:

add hamming and gaussian windows