1) Examining correlations and convolutions numerically

Define a few short vectors to use to calculate convolutions and correlations:

```
a = mod(1:100,3);
b = abs(sin(1:100));
c = randn(100,1);
d = [-2,-1,0,1,2];
e = [ 3,-2,4,1,-5];
f = [-1,3,2,-5,2,3,-1];
```

Use conv(f,g,'same') for convolution $\otimes$ and
conv(f,flip(g),'same') for correlation $*$

Graph 1: $a, a \otimes d, a \otimes e$
Graph 2: $b, b \otimes d, b \otimes e$
Graph 3: $c, c \otimes d, c \otimes e$
Graph 4: $c, (c \otimes d) \otimes e, c \otimes (d \otimes e)$
Graph 5: $a, a * d, a * e$
Graph 6: $a, (a * d) * e, a * (d * e)$
Graph 7: $c, (c * d) * f, c * (d * f)$
Graph 8: $c, (c * d), c \otimes d, c * f, c \otimes f$

Questions to answer:
- When are correlation and convolutions the same?
- Are correlations associative?
- Are convolutions associative?

2) Membrane potential– filtering with exponentials

Construct a time vector that runs from 0 to 999.9 milliseconds in bins of 1 millisecond. Make another vector, called *s* that is the same size as *t* and use what you learnt in the probability lecture to put 1s in *s* at the times that there would be spikes in a Poisson process with mean rate 40 spikes/sec.

Imagine that each of these spikes produces a sudden influx of electric charge into a postsynaptic membrane. The postsynaptic neuron is far enough below threshold that we'll ignore any active channels in it. In those circumstances, the membrane potential will *s* be convolved by an exponential filter, with time constant τ = RC where R is the membrane resistance and C the membrane capacitance.

The exponential filter is $r(t) = \tau\, \mathrm{e}^{\frac{-t}{\tau}}$ for t>0, otherwise it is 0.

1. Assume τ = 20ms, and convolve *s* with an exponential filter with that time constant. What does V(t) look like?
2. Now play with different values of τ . What does V look like as τ gets large? What does it look like if τ is small?

Let's reconsider the problem, but let's now assume that each synaptic connection has two components: a fast excitatory component, and a slower inhibitory component. Let's imagine both components are exponential, so we are going to convolve our spike train *s* with the filter:

$r(t) = \frac{1}{\tau_1} e^{\frac{-t}{\tau_1}} - \frac{1}{\tau_2} e^{\frac{-t}{\tau_2}}$ for t>0, 0 otherwise

3. Let τ_1=5 ms, τ_2=10 ms and convolve *s* with this filter. What does V(t) look like now?