FOUNDATIONS OF SIGNALS AND SYSTEMS
9.4 Homework assignment
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Exercises 9.4

Solve the following MatLab problems:

1. Plot the signal $s(t) = \tanh(t)$ together with its time-shifted and scaled versions $\tanh(at)$, $\tanh(t/a)$, $\tanh(at - b)$, $\tanh(at + b)$, $\tanh((t - b)/a)$, $\tanh((t+b)/a)$ in the same plot in the time range $[-10, 10]$, by using $a = 2$ and $b = 6$.

2. Plot the signal $x(t) = \tanh(t)$ together with its time-reversed and shifted versions $y_u(t) = x(u - t)$ with u an integer in the range $[-9, 10]$. Make sure that each couple (x, y_u) is plotted on a different area of a 4×5 grid, and that the time span of each plot is $[-10, 10]$. You will need to check how a for cycle works to solve the exercise.

3. Consider the signals

$$x(t) = \cos(2\pi t + \tfrac{\pi}{2}) \ , \quad y(t) = \sin(\omega_0 t + \tfrac{\pi}{3}) \ ,$$

   and their sum $z(t) = x(t) + y(t)$. Plot the three signals on two separate subplots, one for $\omega_0 = \pi$ and one for $\omega_0 = 2$. Are the signals all periodic? Why? Use MAtLab functions cos() and sin() for defining the signals.

4. Consider the complex exponential

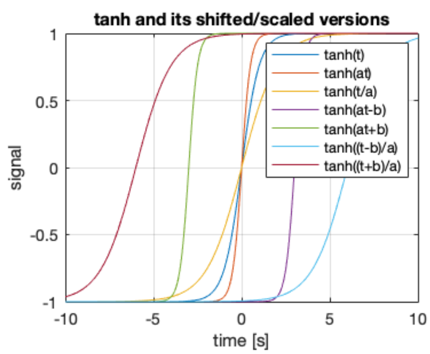
$$s(t) = 100\, e^{(-1+j2\pi)\, t}\, 1(t) \ ,$$

   by representing, in four separate subplots its real and imaginary parts, its absolute value, and its phase. Use MatLab functions real(), imag(), abs(), and angle().

Solutions.

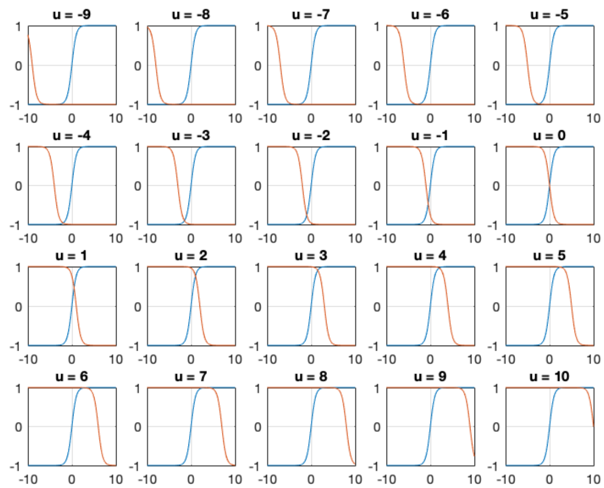
1. The code can mimic that of Exercise 9.3.1, as follows

```
t = -10:.1:10;
a = 2;
b = 6;
figure
plot(t,tanh(t),... % <-- this continues the code in
    the next line
     t,tanh(a*t),t,tanh(t/a),...
     t,tanh(a*t-b),t,tanh(a*t+b),...
     t,tanh((t-b)/a),t,tanh((t+b)/a))
grid on
xlabel('time [s]')
ylabel('signal')
legend('tanh(t)','tanh(at)','tanh(t/a)',...
    'tanh(at-b)','tanh(at+b)',...
    'tanh((t-b)/a)','tanh((t+b)/a)')
title('tanh and its shifted/scaled versions')
```



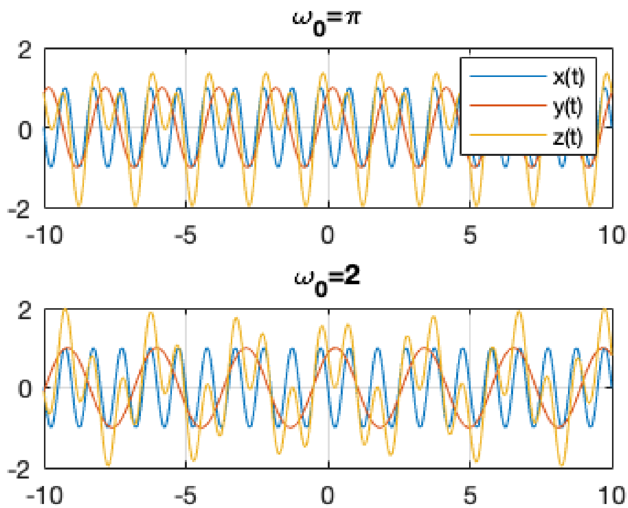
2. In this case, since there are many subplots active, we can skip insering xlabel and ylabel, and we can solve the dependence on integer u through a for cycle. Note how the subplot position is here set to $u + 10$, ranging from 1 to 20. Note also how we insert the value of u in the string title through the map num2str.

```
t = -10:.1:10;
figure
for u = -9:10
    subplot(4,5,u+10)
    plot(t,tanh(t),t,tanh(u-t))
    grid on
    title(['u = ' num2str(u)])
end
```



3. The key point of this exercise is to correctly choose the time span and the time samples, here set to $[-10, 10]$ and .01, respectively. We also note that all signals are periodic except for $z(t)$ when $\omega_0 = 2$. Sinusoids are periodic by construction, but their sum is only in case the pulsations are in rational relation, which is true for 2π and π, but not for 2π and 2. Observe also how we can write ω_0 and π in the title by exploiting the standard LaTeX format.

```
t = -10:.01:10;
x = cos(2*pi*t+pi/2);
y1 = sin(pi*t+pi/3);
y2 = sin(2*t+pi/3);
figure
subplot(2,1,1)
plot(t,x,t,y1,t,x+y1)
grid on
title('\omega_0=\pi')
legend('x(t)','y(t)','z(t)')
subplot(2,1,2)
plot(t,x,t,y2,t,x+y2)
grid on
title('\omega_0=2')
```



4. The key point of this exercise is to correctly choose the time span and the time samples, here set to $[-1, 5]$ and .01, respectively. We also note that in the code we control the active area of each plot through the function axis(), and we also force the grid in the plot of the phase to appear on the values set by yticks() with labels set by yticklabels(). Observe how function angle() reports the phase in the symmetric interval $[-\pi, \pi]$.

```
t = -1:.01:5;
s = (t>=0).*exp((-1+1i*2*pi)*t);
figure
subplot(2,2,1)
plot(t,real(s))
grid on
axis([-1 5 -1.1 1.1])
title('real part')
subplot(2,2,2)
plot(t,imag(s))
grid on
axis([-1 5 -1.1 1.1])
title('imaginary part')
subplot(2,2,3)
plot(t,abs(s))
grid on
axis([-1 5 -.1 1.1])
title('absolute value')
subplot(2,2,4)
plot(t,angle(s))
grid on
```

```
yticks([-pi,-pi/2,0,pi/2,pi])
yticklabels({'-\pi','-\pi/2','0','\pi/2','\pi'})
axis([-1 5 -3.5 3.5])
title('phase')
```