Homework II

I. REMARK

- Reading materials: Ch 1-5 in the textbook.
- “Can not see the wood for the trees!!”

II. PROBLEM SET

1) A car rolling on a hill can be modeled as shown in Figure E.22. The excitation is the force f(t) for which a positive value represents accelerating the car forward with the motor and a negative value represents slowing the car by braking action. As it rolls, the car experiences drag due to various frictional phenomena that can be approximately modeled by a coefficient k_f that multiplies the car's velocity to produce a force, which tends to slow the car when it moves in either direction. The mass of the car is m and gravity acts on it at all times, tending to make it roll down the hill in the absence of other forces. Let the mass m of the car be 1000 kg, let the friction coefficient k_f be 5 N·s/m and let the angle θ be π/12.

   (a) Write a differential equation for this system with the force f(t) as the excitation and the position of the car y(t) as the response.

   (b) If the nose of the car is initially at position y(0) = 0 with an initial velocity $[y'(t)]_{t=0} = 10$ m/s and no applied acceleration or braking force, graph the velocity of the car $y'(t)$ for positive time.

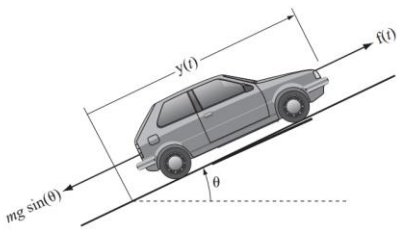


Figure E.22
Car on an inclined plane

2) Figure E.24 shows a MATLAB program simulating a system.

   (a) Without actually running the program, find the value of x when n = 10 by solving the difference equation for the system in closed form.

   (b) Run the program and check the answer in part (a).

```
x = 1 ; y = 3 ; z = 0 ; n = 0 ;
   while n <= 10,
      z = y ;
      y = x ;
      x = 2*n + 0.9*y - 0.6*z ;
      n = n + 1 ;
   end
```

Figure E.24

3) A system is described by the block diagram in Figure E.25.

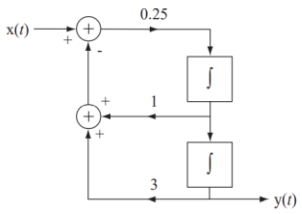
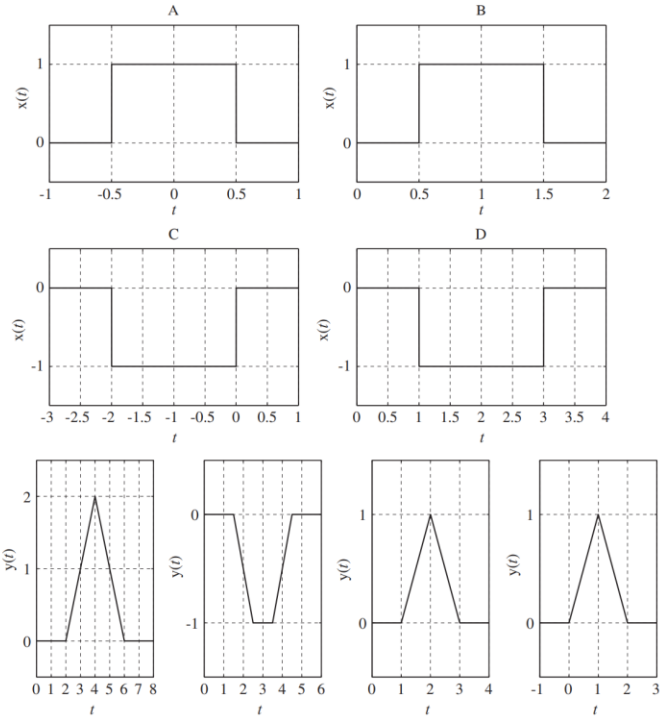


Figure E.25
A system

Classify the system as to homogeneity, additivity, linearity, time-invariance

4) These four rectangle functions are convolved in pairs (including a rectangle function being convolved with itself). The convolutions are illustrated below. For each convolution, determine which rectangle functions were convolved to produce each graph.



5) Graph g[n]. Verify with the MATLAB `conv` function.

   (a) $g[n] = (u[n+1] - u[n-2]) * \sin(2\pi n/9)$

   (b) $g[n] = (u[n+2] - u[n-3]) * \sin(2\pi n/9)$

6) What function convolved with $-2\cos(t)$ would produce $6\sin(t)$? (There is more than one correct answer.)

7) Find the impulse response h[n] of the system in Figure E.36.

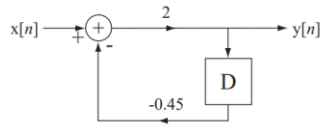


Figure E.36 System block diagram

---

8) Non-textbook problem: You recorded your voice for the last assignment. Let the voice signal be x[n] where n is the sample index starting 0. Plot the signals using MATLAB:

   (a) y[n] = x[2n]

   (b) y[n] x[n/2] * h[n] where h[n] = δ[n]+δ[n-1]

   Make sound files using (a) and (b) in MATLAB and listen them. Interpret your results.