Name: **John E. Moore III**

Problem	Points	Score
1a	10	
1b	10	
1c	10	
2a	10	
2b	10	
2c	10	
2d	10	
3a	10	
3b	10	
3c	10	
Total	100	

Notes:

1. The exam is closed books/closed notes - except for one page of notes.

2. Please show ALL work. Incorrect answers with no supporting explanations or work will be given no partial credit.

3. Please indicate clearly your answer to the problem. If I can’t read it (and I am the judge of legibility), it is wrong. If I can’t follow your solution (and I get lost easily), it is wrong. All things being equal, neat and legible work will get the higher grade:)

Problem No. 1: ***Fourier Series***

(a) For the system below, compute the Fourier series of the output.

$$y(t)=A^2Cos^2\omega_0t$$

Since y(t) is an even function, B_n is equal to zero.

The Fourier series of y(t) is equal to the following,

$$A_0 + \sum A_nCos\omega t$$

where

$$A_0 = 1/T_0\int A^2Cos^2\omega_0tdt$$

and

$$A_n = 2/T_0\int(A^2Cos^2\omega_0t)Cos\omega tdt$$

Evaluating A_0 and A_n, we get

$$A_0 = A^2/2$$

and

$$A_n = 0$$

Therefore, the Fourier series is

$$y(t) = A^2/2$$

(b) Compute the energy and power of the output. (Comment: Think about orthogonality before you write the answer that is most obvious.)

The energy of the system is

$$E = \int |A^2 Cos^2 \omega_0 t|^2 dt$$

Therefore,

$$E = \infty$$

and the power of the system is

$$P = \lim_{T \to \infty} (1/2T) \int | A^2 Cos^2 \omega_0 t|^2 dt$$

hence,

$$P = 3/16 \text{ Watts}$$

(c) Now assume x(t) is as shown to the right. Compute the energy and power of y(t).

$$x(t) = x + 2$$

$$y(t) = x^2 + 4x + 4$$

The energy of the signal is equal to

$$E = \int | x^2 + 4x + 4|^2 dt$$

therefore,

$$E = 198.4 \text{ Joules}$$

The power of the signal is equal to

$$P = \lim_{T \to \infty} (1/2T) \int | x^2 + 4x + 4|^2 dt$$

so,

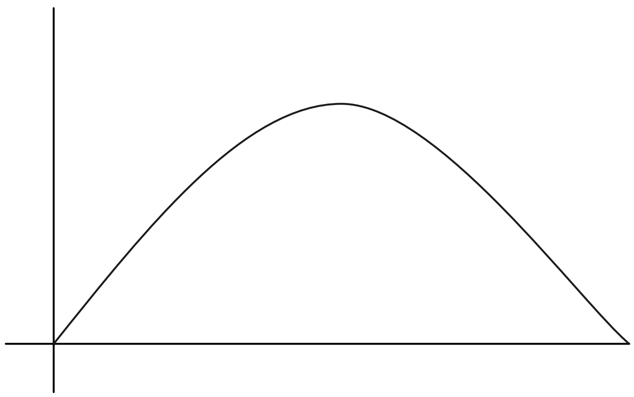
$$P = 0 \text{ Watts}$$

Problem No. 2: Time-Domain Solutions

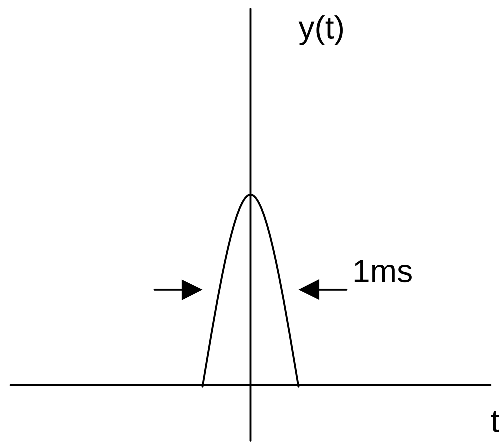
(a) For the circuit shown, using concepts developed in this class, sketch the output signal, , if x(t) is the unit step function. Explain.

The circuit acts as a low-pass filter. So, the higher frequencies can not be passed through this circuit.

This is shown graphically by the following graph of y(t) Vs. time.

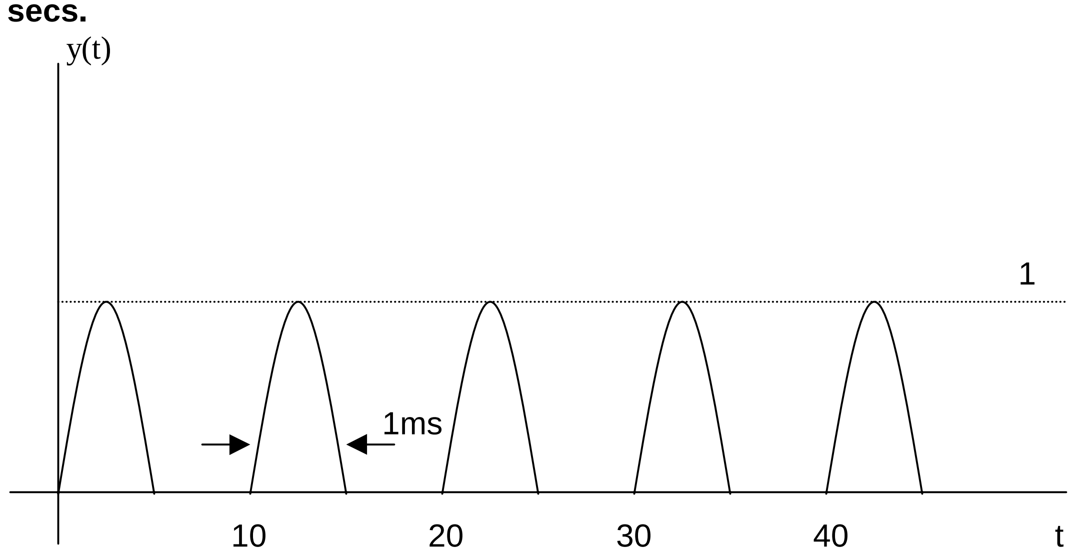


(b) Sketch the output if x(t) is a unit pulse. Explain.

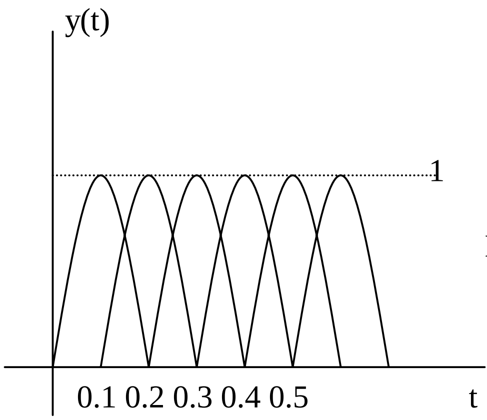


Again, the circuit acts as a lowpass filter, filtering out the higher frequencies of the input signal.

(c) Sketch the output if x(t) is a periodic sequence of unit pulses with a period of 10 secs.



(d) Suppose the period in (c) is decreased to 0.1 secs. How does this affect the shape of the output?



Note: the pulses shown are all 1ms in width.

Lowpass filters impact modem design for the following reasons:

- If there is too much filtering, there will be a loss of data
- If the pulses overlap too much the data will be useless
- and, the closer the pulses are, the faster data can be transmitted.

Problem No. 3: The dreaded thought problem...

(a) Using concepts developed in the first three chapters of the book, characterize the cruise control circuit in an automobile as a system.

The cruise control circuit in an automobile is a dynamic, causal, time invariant system. It is dynamic because the output only depends on present values of the input. The system is causal because it does not depend upon future values of the input. And it is time-invariant because the input-ouput relationship of the circuit does change over time.

(b) If this system were a linear time-invariant system, design the impulse response of a "good" system. Explain how you might implement this in a circuit.

If this were a 'good' system, the output would be constant. No matter what values of input, the output would always remain the same. This could be achieved by using the same technology used in CD players to prevent skipping. A buffer could be implemented so that there is enough information stored, so that the system would ignore minor fluctuations in the input.

(c) It is well-known that cruise controls are not optimal for terrain that is mountainous (such as ski country in Colorado). Why (explain this in terms of concepts discussed in this class)? What modifications would you need to make (again, explain this in terms of concepts such as causality)?

Cruise control systems do not work well in mountainous terrain because of the causality of the system. When the vehicle travels 'down hill', the system does nothing to prevent the vehicle from accelerating above a certain speed.

A cruise control system would operate better if it was an instantaneous system. The system would cycle more often, and therefore the velocity of the vehicle would be more constant.