newHeaavisideθ = 1

u(t) = $\text{heaviside}(t)$

pulse(t) =

$$\text{heaviside}\left(t+\frac{1}{2}\right)-\text{heaviside}\left(t-\frac{1}{2}\right)$$

triangle(t) =

$$-\left(\text{heaviside}\left(t-\frac{1}{2}\right)-\text{heaviside}\left(t+\frac{1}{2}\right)\right)\ (2\,t-4\,t\,\text{heaviside}(t)+1)$$

==== READ THESE INSTRUCTIONS FOR YOUR REPORT ===

First, this should be opened in "Maatlab Live Editor" to export a pdf.

NOTE: print the pdf in "Hide Code" format (see button on right of maatlab)

Then, make any needed maatlab changes per any questions below.

You must re-run the script for changes to take effect.

Dont forget to add the names of the group members as shown below.

Answer all numbered questions below, Q1, Q2, etc.

Select the "Hide Code" format (see button on right of maatlab) before pdf export.

In live editor, use Save::export-as-pdf to print the report

DO A FINAL CHECK of your pdf before turning it in.

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ECGR 4124 Computer Project: Linear Convolution

Names: Nolan Bushnell, Federico Faggin, Gordon E. Moore

PART 1: Continuous-Time Convolution ============================

parameters and definitions:

x(t) =

$$4\,\text{heaviside}(t-1)-4\,\text{heaviside}\left(t-\frac{3}{2}\right)$$

h(t) =

$$2\,\text{heaviside}\left(t-\frac{3}{2}\right)-2\,\text{heaviside}(t-3)$$

y(t) =

$$\begin{cases} 0 \\ \text{heaviside}\left(t-\frac{5}{2}\right)\ (8\,t-20)-\text{heaviside}(t-3)\ (8\,t-24)-\text{heaviside}(t-4)\ (8\,t-32)+\text{heaviside}\Big(t- \end{cases}$$

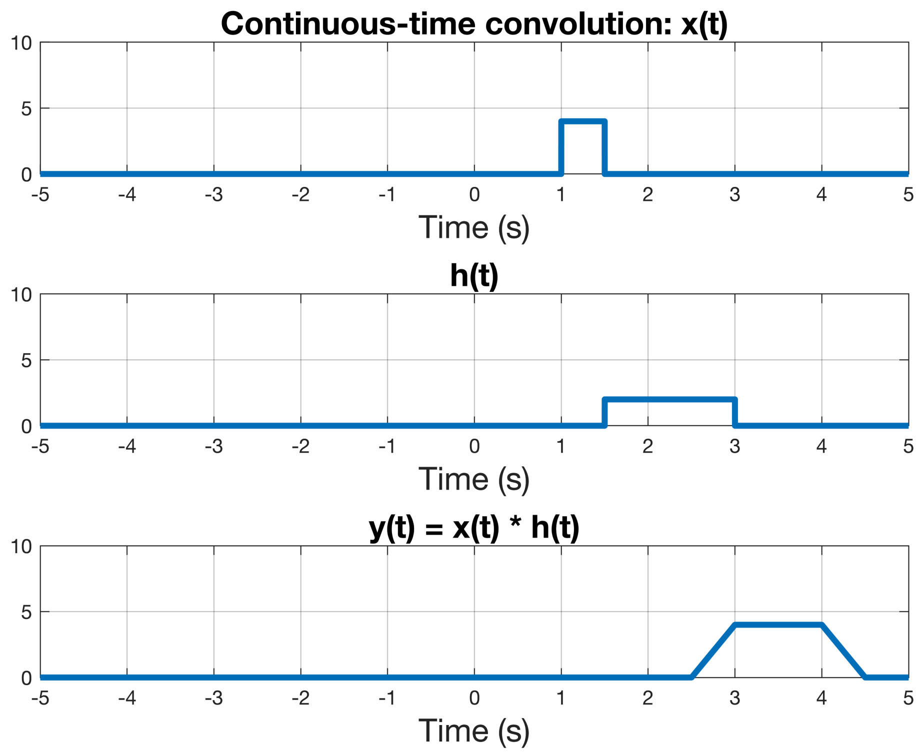

Fig. 1. Continuous-time convolution.

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Q1. Change the simulation for h(t) to be a pulse with amplitude = 3 beginning at t=1 s and ending at t=3 s. Do not change x(t). (Fig. 1 simulation should change accordingly.)

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Q2. After making the changes in Q1,

observe Fig. 1, and use the cursor tool to measure the maximum amplitude of y(t).

Also compute the theoretical maximum of y(t) by calculating the area of x(t) multiplied by h(t), when x(t) is centered in the middle of h(t).

Hint: multiply the functions point by point at each time t, then take the area

Answer: measured peak of y(t) = ???

Answer: calculated area = ???

parameters and definitions:

x2(t) =

$$-10\left(\mathrm{heaviside}\left(t-\frac{1}{4}\right)-\mathrm{heaviside}\left(t-\frac{3}{4}\right)\right)\left(4\,\mathrm{heaviside}\left(t-\frac{1}{2}\right)(2\,t-1)-4\,t+1\right)$$

x2(t) = $4\,\mathrm{heaviside}(t)-4\,\mathrm{heaviside}(t-1)$

h2(t) = $\mathrm{heaviside}(t-2)-\mathrm{heaviside}(t-4)$

y2(t) =

$$\begin{cases} 0 \\ \mathrm{heaviside}(t-2)\,(4\,t-8)-\mathrm{heaviside}(t-3)\,(4\,t-12)-\mathrm{heaviside}(t-4)\,(4\,t-16)+\mathrm{heaviside}(t-5) \end{cases}$$

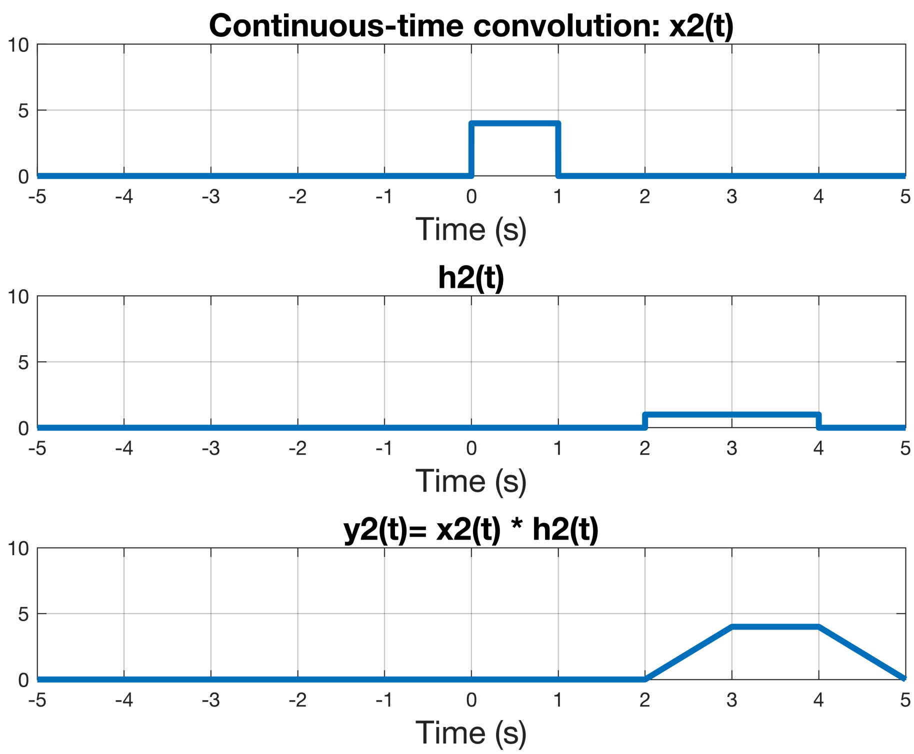

Fig. 2. Continuous-time convolution.

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Q3. Change the simulation for h2(t) to be a pulse with amplitude = 2

beginning at t=1 s and ending at t=2 s.

```
    (Fig. 2 simulation should change accordingly.)



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Q4. After making the changes in Q3,
    observe Fig. 2, and use the cursor tool to measure the
    maximum amplitude of y2(t).  Be sure to measure the peak.
    Also compute the theoretical maximum of y2(t) by calculating the
    area of x2(t) multiplied by h2(t), when x2(t) is centered in the middle
    of h2(t).
    Hint: multiply the functions point by point at each time t,
    then take the area

Answer: measured peak of y2(t) = ???
Answer: calculated area = ???



PART 2: Discrete-Time Linear Convolution =============================
```

```
xn = 1×20
     0     0     0     0     4     4     0     0     0     0     0     0     0 ···

hn = 1×20
     1     2     3     2     1     0     0     0     0     0     0     0     0 ···

yn = 1×20
     0     0     0     0     4    12    20    20    12     4     0     0     0 ···

nn = 1×20
     0     1     2     3     4     5     6     7     8     9    10    11    12 ···
```

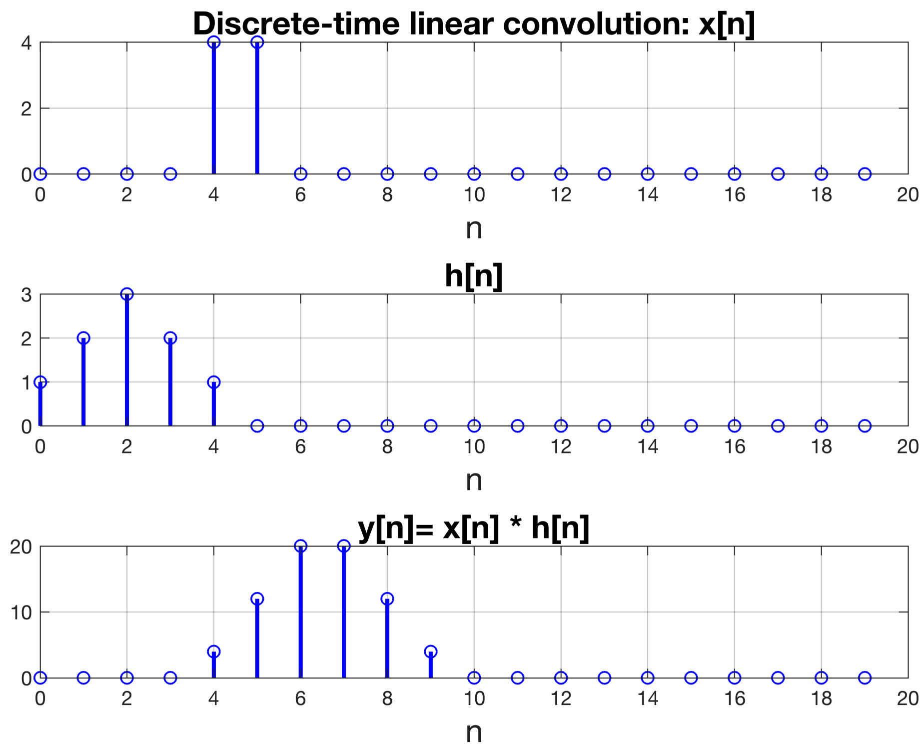

Fig. 3. Discrete-time convolution.

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Q5. Change the simulation, setting

hn= [3 3 3 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]

(Fig. 3 simulation should change accordingly.)

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Q6. After making the changes in Q5,

observe Fig. 3, and use the cursor tool to measure the

maximum amplitude of yn (denoted y[n] in the plot).

Also compute the theoretical maximum of y[n] by calculating the

sum of x[n] multiplied by h[n], when x[n] is centered in the middle

of h[n].

Hint: multiply the functions point by point at each point n,

then take the sum.

```
Answer: measured peak of y[n] = ???

Answer: calculated sum =???
```

```
xn2 = 1×20
     1     2     3     0     0     0     0     0     0     0     0     0     0⋯

hn2 = 1×20
     0     0     0     1     0     0     0     0     1     0     0     0     0⋯

yn2 = 1×20
     0     0     0     1     2     3     0     0     1     2     3     0     0⋯

nn2 = 1×20
     0     1     2     3     4     5     6     7     8     9    10    11    12⋯
```

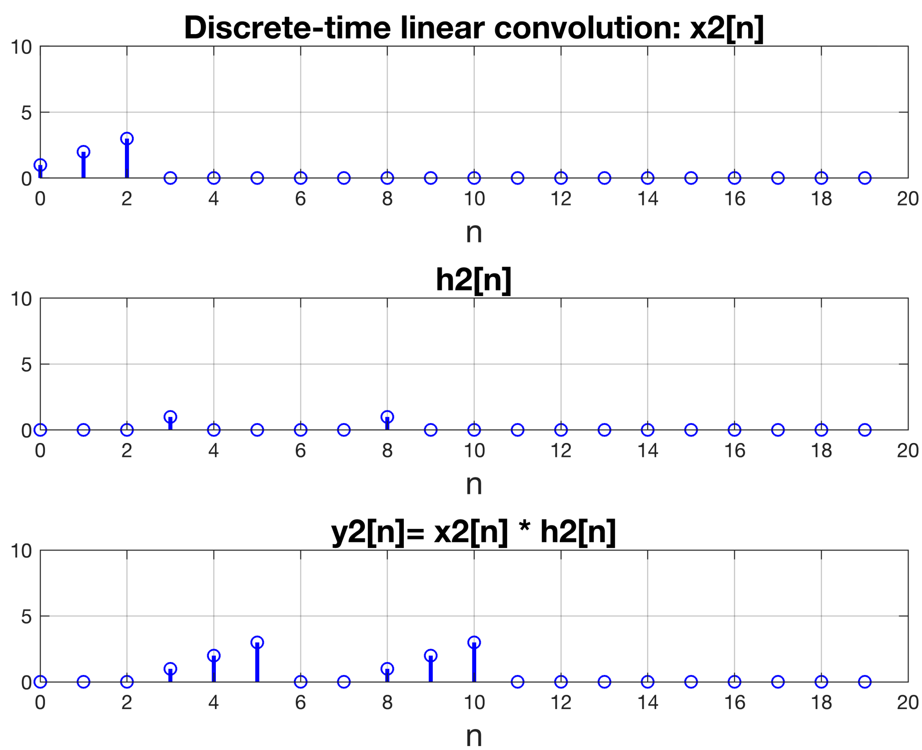

Fig. 4. Discrete-time convolution.

```
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Q7. Change the simulation, setting

    xn= [1 1 1 0  0 0 0 0  0 0 0 0  0 0 0 0  0 0 0 0  ]

    hn= [3 3 3 0  0 0 0 0  0 0 0 0  0 0 0 0  0 0 0 0  ]

    (Fig. 4 simulation should change accordingly.)
```

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Q8. After making the changes in Q7,

observe Fig. 4, and use the cursor tool to measure the

maximum amplitude of yn2 (denoted y2[n] in the plot).

Also compute the theoretical maximum of y2[n] by calculating the

sum of x2[n]multiplied by h2[n], when x2[n] is centered in the middle

of hn2.

Hint: multiply the functions point by point at each point n,

then take the sum.

Answer: measured peak of yn = ???

Answer: calculated sum = ???

Cformula = $\mathrm{Ai}\,\mathrm{Ar} + \mathrm{Ai}\,\mathrm{Bi}\,\mathrm{i} + \mathrm{Ar}\,\mathrm{Br}\,(1 - \mathrm{i})$

A = 2.0000 + 3.0000i

B = 5.0000 + 7.0000i

Cmult = -11.0000 + 29.0000i

Cformula = $16 + 11\,\mathrm{i}$

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Q9.

Observe the values of Cmult and Cformula above, where Cformula

is the explicit formula for complex multiplication WITH ERRORS.

Correct the errors in the formula for Cformula, such that

Cmult = Cformula above. Note: A*B is NOT the answer.

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Q10.

What famous 1971 integrated circuit has Federico Faggin initials,

and what was the function this digital circuit?

Hint: see www.intel4004.com

Answer: ???