Computational Skills
Class 1

EC 2000 Modules

Robert Leland
Electrical and Computer Engineering

Objectives

After this module you should be able to:

- Use Matlab to solve computational problems.
- Give a step by step description of how to compute the solution to an engineering problem.
- Determine the accuracy of computed results.

Justification

- Modern engineering problems require extensive computation.
- Increasing computer capabilities are opening up problems we couldn’t solve before.
- Many problems cannot be solved with pencil and paper analysis.
- Engineers need to be proficient with modern computational tools.

Class 1: Matlab

- Challenge problem.
- Solution by numerical integration.
- Solution in Matlab.
- Matlab graphics.
- Online help.

Challenge Problem

Water flows into a basin with flow rate

$$f(t) = u(t-1)e^{-(t-1)^2} \ \ liters / \sec ond$$

Find the amount of water added to the basin from t = 0 to t = 3 seconds. Also, plot f(t) versus t.

Note: u(t) = 0 for t < 0, and 1 otherwise.

Exercise 1

Find a mathematical expression for the amount of water added to the basin during $0 < t < 3$ seconds if the flow rate is

$$f(t) = u(t-1)e^{-(t-1)^2} \ \ liters / \sec ond$$

Solution to Exercise 1

$$\text{Water added} = \int_0^3 f(t)\,dt$$

$$= \int_0^3 u(t-1)e^{-(t-1)^2}\,dt$$

Numerical Integration

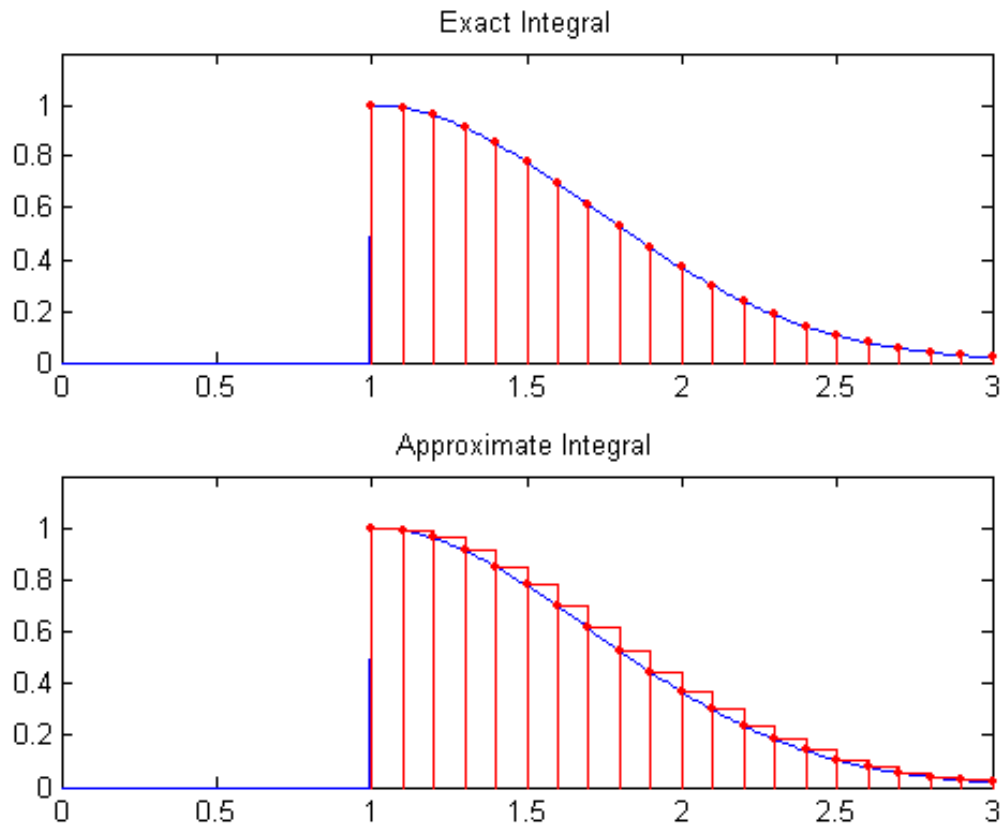
- This problem cannot be solved analytically.
- A numerical solution is required.
- This solution will be approximate.
- The approximation can be made sufficiently accurate for all practical purposes.

Integration by Rectangles

First we break up the interval [0,3] into subintervals of length h. For each subinterval, we approximate its integral as:

$$\int_{t}^{t+h} f(\tau)\,d\tau \approx hf(t)$$

Graphical Interpretation



The integral is approximated by adding up the areas of each rectangle. Rectangle k has width h, height f(kh), and area hf(kh).

$$\int_0^3 f(t)dt = \sum_{k=0}^{\frac{3}{h}-1} \int_{kh}^{(k+1)h} f(t)dt$$

$$\approx \sum_{k=0}^{\frac{3}{h}-1} hf(kh) = h\sum_{k=0}^{\frac{3}{h}-1} f(kh)$$

```
int = 0;    n = 100;  h = 3/n;                % Matlab Solution
for k = 1:n
        t = h*(k-1);
        if  t >= 1                            % compute f(t)
                f(k) = exp(-(t-1)^2);
        else
                f(k) = 0;          % semicolon prevents printing
        end
        int = int+f(k);                       % compute sum
end
int = h*int;                                  % compute integral
```

Solution Using Vector Operations

```
n=100; h = 3/n;
t = 0:h:(3-h);                  % time vector
u = [zeros(1,34)  ones(1,66)];
f = u.*exp(-(t-1).^2);          % function vector
int = h*sum(f);                 % integral
plot(t,f)
```

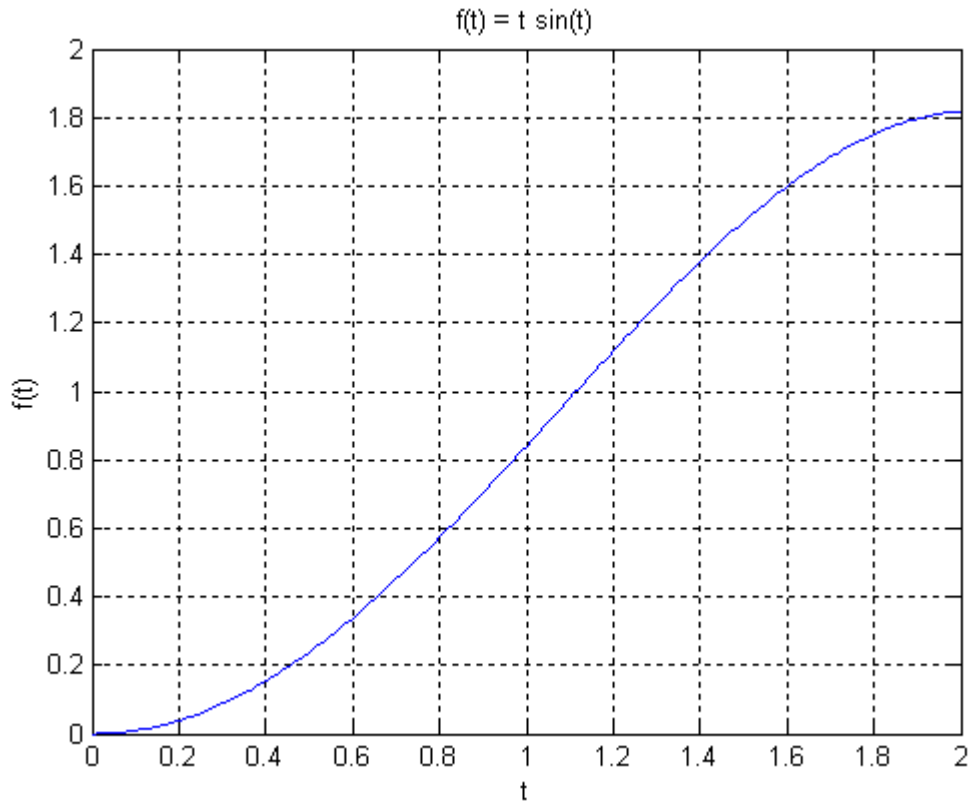
Exercise 2

Write a sequence of Matlab commands to plot $f(t) = t \sin(t)$ versus t for $0 < t < 2$. You will need to create vectors for t and f(t).

Solution to Exercise 2

```
t = 0:.01:2;
f = t.*sin(t);
plot(t,f)
title('f(t) = t sin(t)')          % add title
xlabel('t')                       % add x axis label
ylabel('f(t)')                    % add y axis label
grid                              % add grid
```

Plot for Exercise 2



Online Help

To find out what help is available:

type: help help

To find out about a specific function:

type: help <function>

Where <function> is the name of the function.

Exercise 3

Use the online help to find out how to calculate the log base 10 of 35.