Lecture 5

- Function files (how these are different from script files)
- Conditional statements, for loop, while loop
- Numerical solution of Free-Fall gravity problem
- Error in numerical solution

Function file Create new function that takes in the input (scalar/vector/matrix, one or many inputs) and performs computation and produces output (scalar/vector/matrix, one or many outputs)

Recall Velocity of object falling due to gravity satisfies

$$\frac{dv(t)}{dt} = g - \frac{C_d}{m} v^2 \quad \text{for any } t,\ t>0$$

$$v(0) = 0$$

$\Downarrow$ Exact solution

$$v(t) = \sqrt{\frac{gm}{C_d}} \tanh\left(t\sqrt{\frac{gC_d}{m}}\right)$$

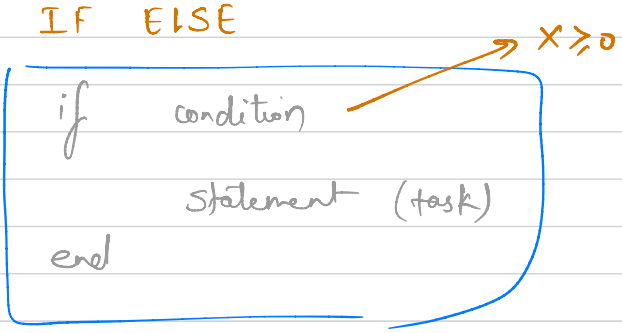
We create a MATLAB function that computes velocity of an object at specified time and for specified drag coefficient

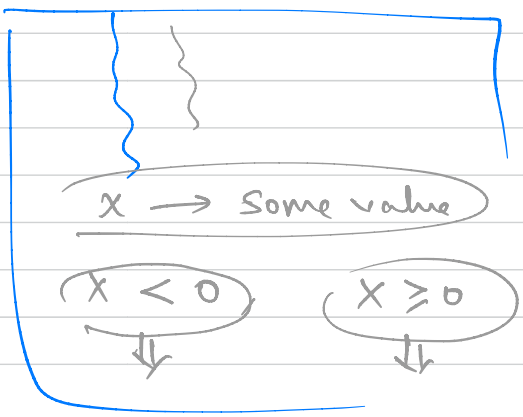
gravityExample.m

```
function v = freefall(t, cd)
% freefall: compute velocity of free falling object assuming mass
          m = 1 kg
% v = freefall(t, cd)
% input:
%     t = time (s)   ~~vector of time~~   (scalar or vector)
%     cd = drag coefficient (kg/m)   (scalar)
% Output:
%     v = downward velocity (m/s)   (scalar or vector)
g = 9.81;        % gravity acceleration
m = 1;
a = sqrt(m*g/cd);
b = sqrt(g*cd/m);
v = a*tanh(b*t);
```

- Conditional statements in MATLAB

(1) IF ELSE





```
if   condition
        statement 1
else
        statement 2
end
```

```
if   condition 1
        statement 1
elseif  condition 2
        statement 2
  :
else
        statement N
end
```

n = ? 1, 2, 3, . . , 5

n = 1

n = 2

.
.
.

n = 5

n ≠ 1, 2, 3, 4, 5

2. SWITCH

```
switch    test expression
    Case    value 1
            statement 1
    Case    value 2
            statement 2
      .
      .
    Otherwise
            statement N
end
```

```
switch    n
    Case    n = 1
            do task 1
    Case    n = 2
              :
              .
    Otherwise
            do task 6
end
```

- Loops

1. FOR LOOP

```
for   index = start : step : finish
      task that may or may not depend
      on index
end
```

```
for  n = 1:1:5
     disp(n)
end
```

2. WHILE LOOP

```
while  condition
       statement
end
```

stops when condition is no longer true.

```
n = 1;
while "n ≤ 5"
      disp(n)
      n = n+1
end
```

• **Numerical solution** Suppose exact solution for the problem

$$\frac{dv}{dt} = g - \frac{c_d}{m} v^2$$ with $v(0) = 0$ is not known.

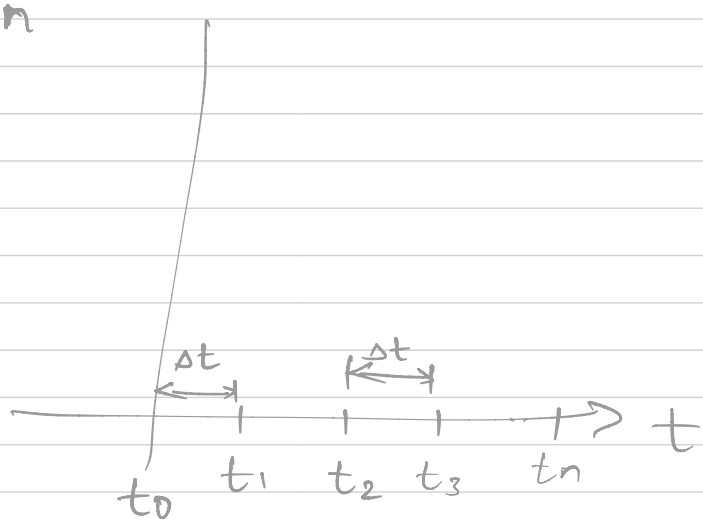
$v(0)$ non zero value

How do I still solve the problem?

↓

"Numerical method"

$t_0 = 0, t_1, t_2, \ldots, t_n$



(*)

$$\frac{dv}{dt}(t_1) = g - \frac{c_d}{m} v(t_1)^2$$

$$\frac{dv}{dt}(t_2) = g - \frac{c_d}{m} v(t_2)^2$$

$$\vdots$$

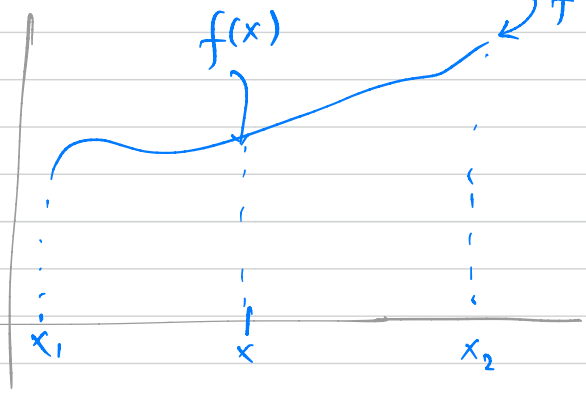
$$\frac{dv}{dt}(t_n) = g - \frac{c_d}{m} v(t_n)^2$$

$f = f(x)$, x is a variable $x_1 \le x \le x_2$

Derivative of function

$$\frac{df}{dx}(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{(x+h) - x}$$

$$\boxed{\frac{df}{dx}(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}}$$



$$\frac{df}{dx}(x) \approx \frac{f(x+h) - f(x)}{h}$$

provided h is small!

$$\frac{dv}{dt}(t_1) \approx \frac{v(t_1 + \Delta t) - v(t_1)}{\Delta t} = \frac{v(t_2) - v(t_1)}{\Delta t}$$

in general

$$\frac{dv}{dt}(t_i) \approx \frac{v(t_{i+1}) - v(t_i)}{\Delta t}$$

define

$$v_i := v(t_i)$$

$$\frac{dv}{dt}(t_i) \approx \frac{v_{i+1} - v_i}{\Delta t}$$

Substitute to discrete set of equations (*)