

MATLAB 프로그래밍

Computational Design Laboratory
Department of Automotive Engineering
Hanyang University, Seoul, Korea

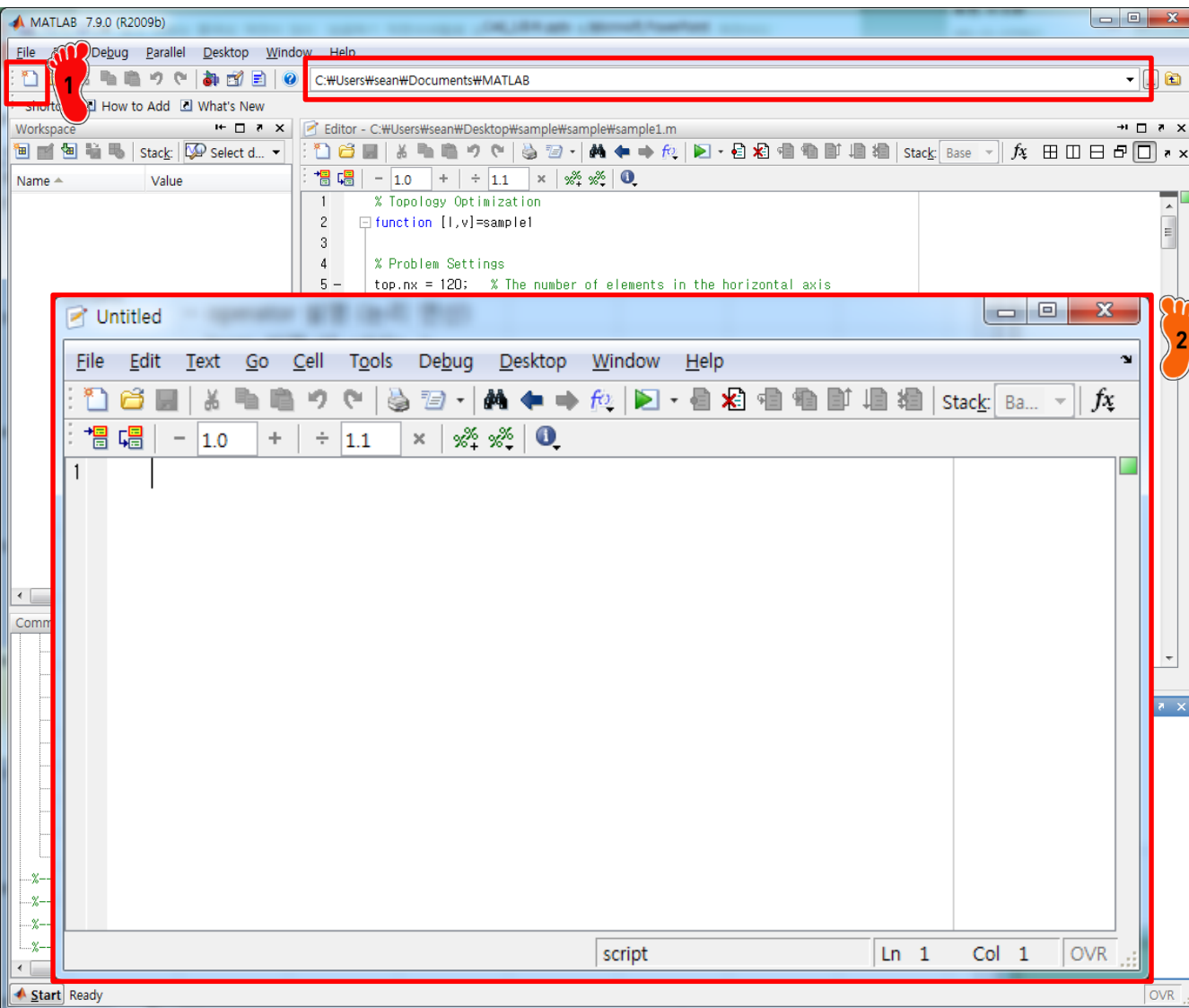


CONTENTS

- **M-files**
- **Input-output**
- **Structured programming**
- **Passing functions to m-files**
- **Case study**
- **Assignment**

- **M-files**
 - ✓ **Script file**
 - ✓ **Function file**
 - ✓ **Subfunction**

SCRIPT FILE



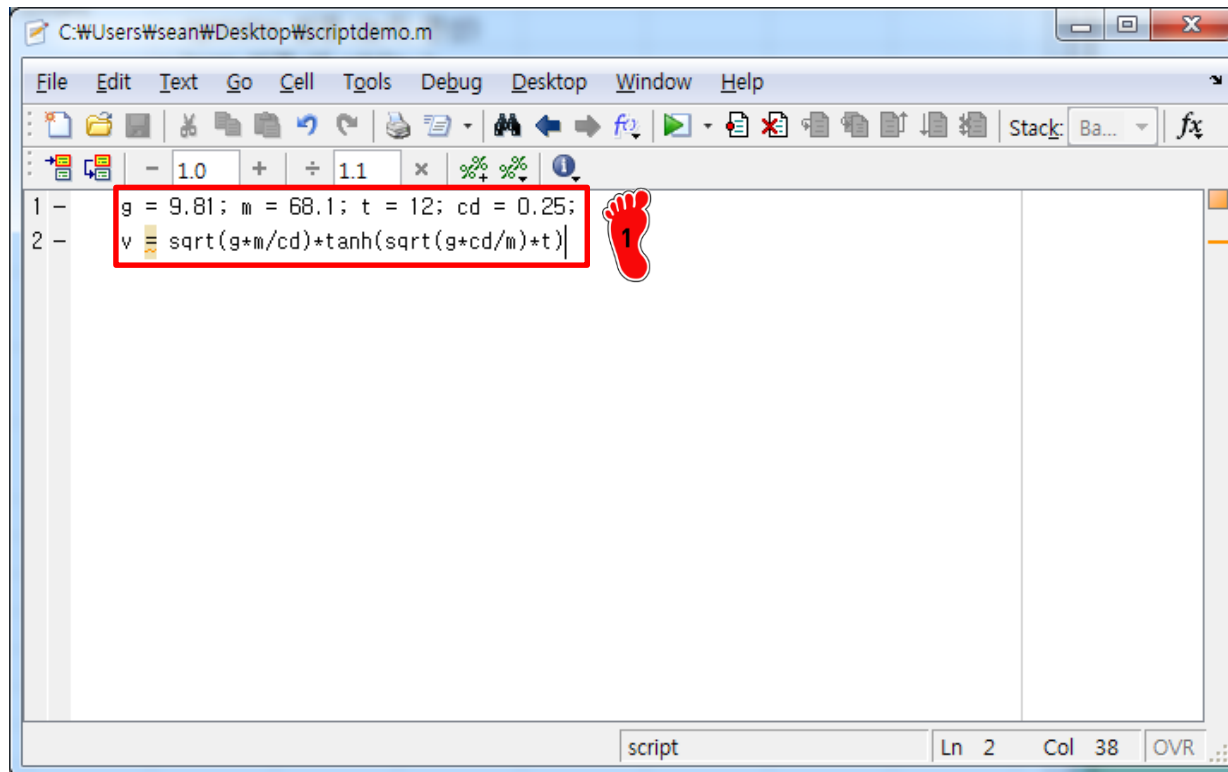
1 New m-file 을 클릭하면 script 를 작성할 수 있는 빈 창이 생성됨

2 이 m-file 을 저장하면 *.m 파일로 저장되고 현재 매틀랩에서 설정되어있는 경로는 상단에 표시되어 있음

따라서 저장된 경로와 매틀랩에서 설정된 경로가 일치해야 script file 을 실행시킬 수 있음

혹은 script file 을 저장 후 F5 키를 이용하여 실행시키면 자동으로 매틀랩 설정 경로가 script file 이 저장된 경로로 변경

EXAMPLE



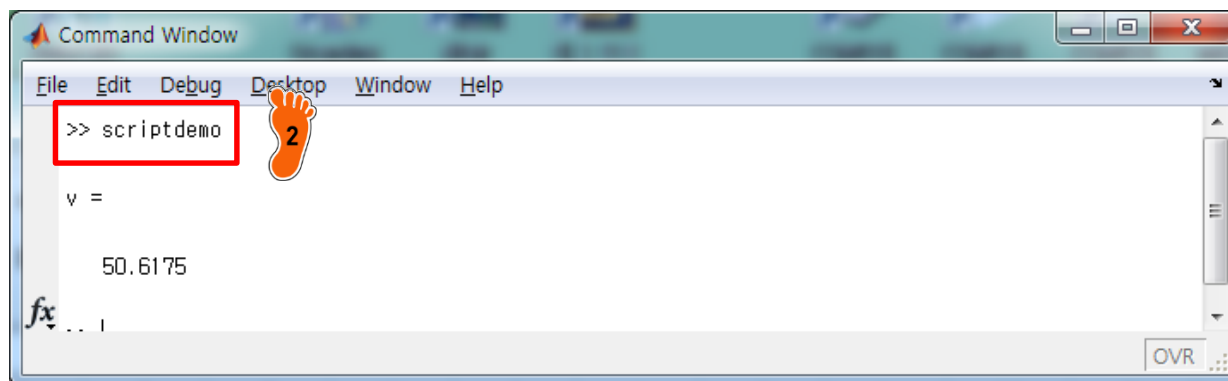
The screenshot shows a script editor window titled 'C:\Users\sean\Desktop\scriptdemo.m'. The menu bar includes File, Edit, Text, Go, Cell, Tools, Debug, Desktop, Window, and Help. The toolbar contains various icons for file operations and execution. The script content is as follows:

```

1 - g = 9.81; m = 68.1; t = 12; cd = 0.25;
2 - v = sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t)
  
```

A red box highlights the second line of the script, and a red footprint icon with the number '1' is placed next to it.

1 전 시간에 배운 커맨드 창에 입력하는 방식으로 script를 작성 후 scriptdemo 라는 파일 이름으로 저장



The screenshot shows a Command Window titled 'Command Window'. The menu bar includes File, Edit, Debug, Desktop, Window, and Help. The command prompt shows the following:

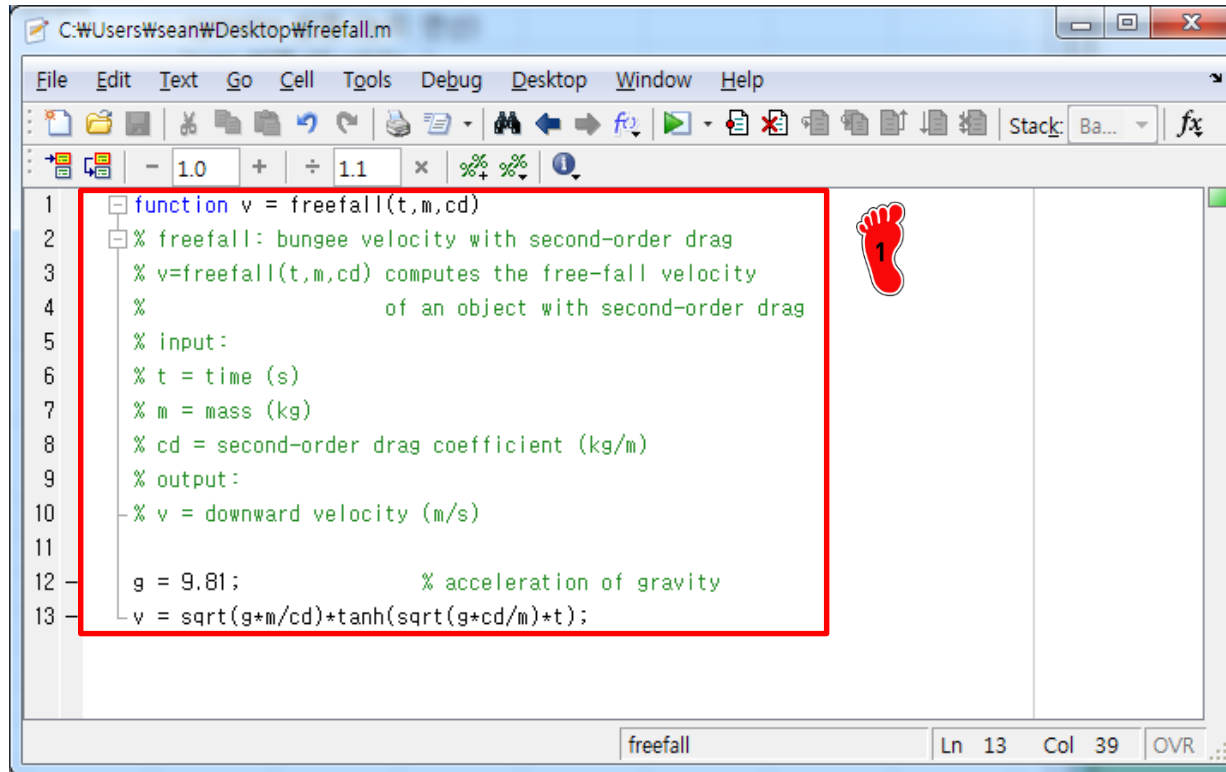
```

>> scriptdemo
v =
    50.6175
  
```

A red box highlights the command '>> scriptdemo', and an orange footprint icon with the number '2' is placed next to it.

2 command window에 scriptdemo라고 저장된 파일 이름을 입력할 경우 결과값을 출력

FUNCTION FILE



```

C:\Users\sean\Desktop\freefall.m
File Edit Text Go Cell Tools Debug Desktop Window Help
1 function v = freefall(t,m,cd)
2 % freefall: bungee velocity with second-order drag
3 % v=freefall(t,m,cd) computes the free-fall velocity
4 % of an object with second-order drag
5 % input:
6 % t = time (s)
7 % m = mass (kg)
8 % cd = second-order drag coefficient (kg/m)
9 % output:
10 % v = downward velocity (m/s)
11
12 g = 9.81; % acceleration of gravity
13 v = sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t);
  
```

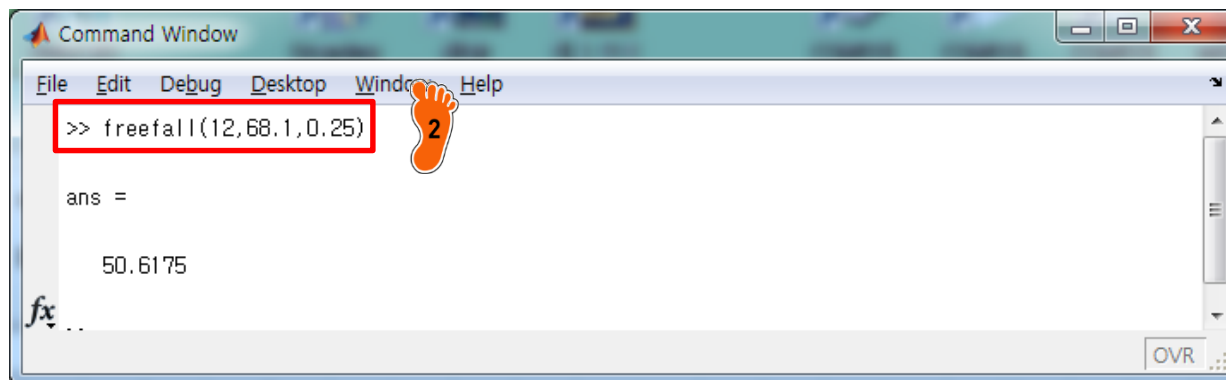
1 function outvar =
funcname(arglist)

outvar = value;

함수의 기본 형태

주의할 점
함수로 정의한 outvar가 함수 내부에 동일한 이름으로 존재해야하고 m-file 을 funcname 으로 저장

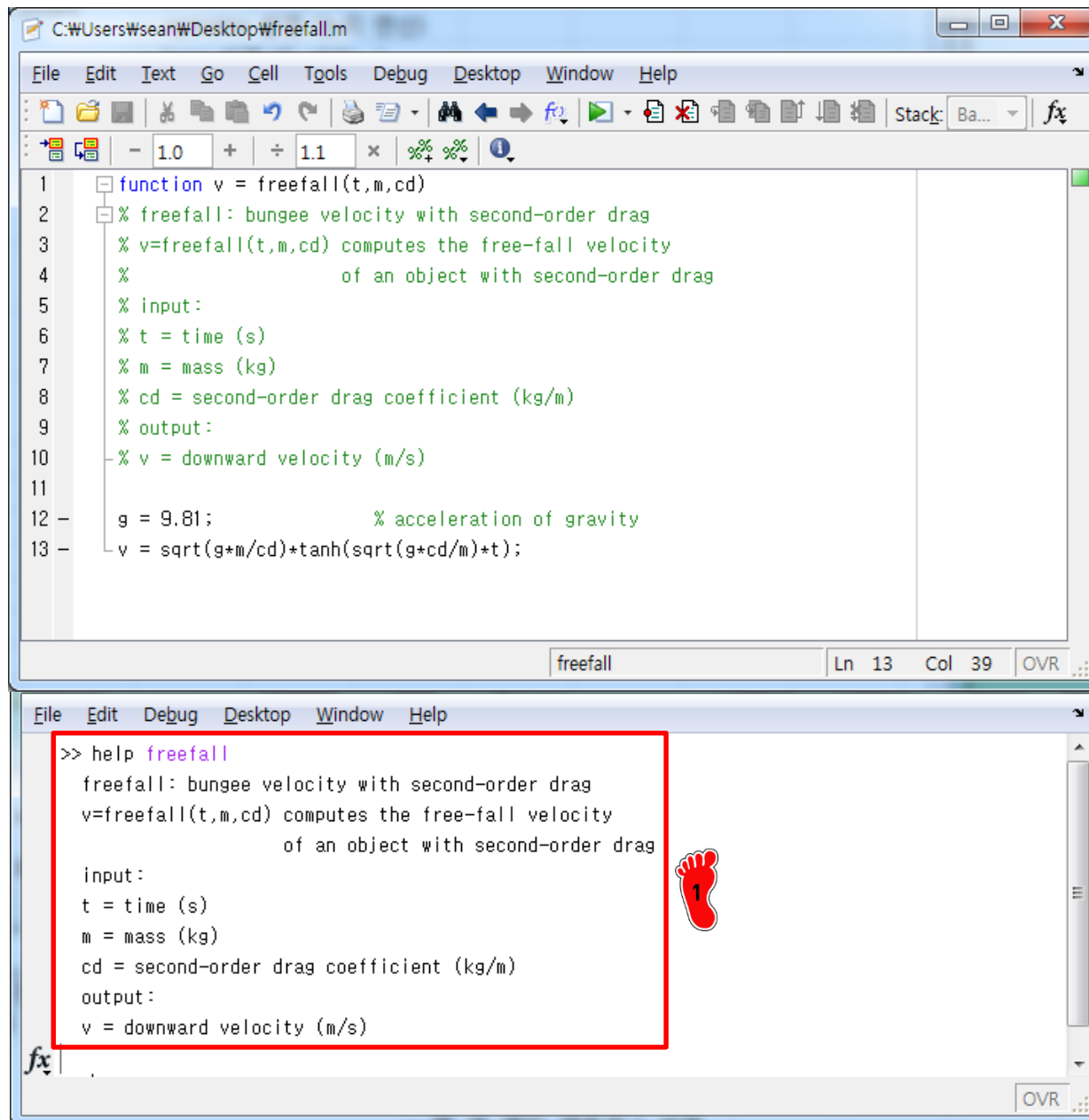
2 Command window에서
funcname(arglist)를 입력하여 결과값 출력



```

Command Window
File Edit Debug Desktop Window Help
>> freefall(12,68.1,0.25)
ans =
50.6175
  
```

FUNCTION FILE



The image shows two windows from the MATLAB environment. The top window is the MATLAB Editor, displaying a function file named 'freefall.m'. The code defines a function 'v = freefall(t,m,cd)' and includes comments describing its purpose, inputs, and outputs. The bottom window is the MATLAB Command Window, showing the command 'help freefall' and the resulting help text for the function. A red box highlights the help text in the Command Window, and a red footprint icon with the number '1' is placed next to it.

```

1 function v = freefall(t,m,cd)
2 % freefall: bungee velocity with second-order drag
3 % v=freefall(t,m,cd) computes the free-fall velocity
4 % of an object with second-order drag
5 % input:
6 % t = time (s)
7 % m = mass (kg)
8 % cd = second-order drag coefficient (kg/m)
9 % output:
10 % v = downward velocity (m/s)
11
12 g = 9.81; % acceleration of gravity
13 v = sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t);
  
```

```

>> help freefall
freefall: bungee velocity with second-order drag
v=freefall(t,m,cd) computes the free-fall velocity
of an object with second-order drag

input:
t = time (s)
m = mass (kg)
cd = second-order drag coefficient (kg/m)

output:
v = downward velocity (m/s)
  
```

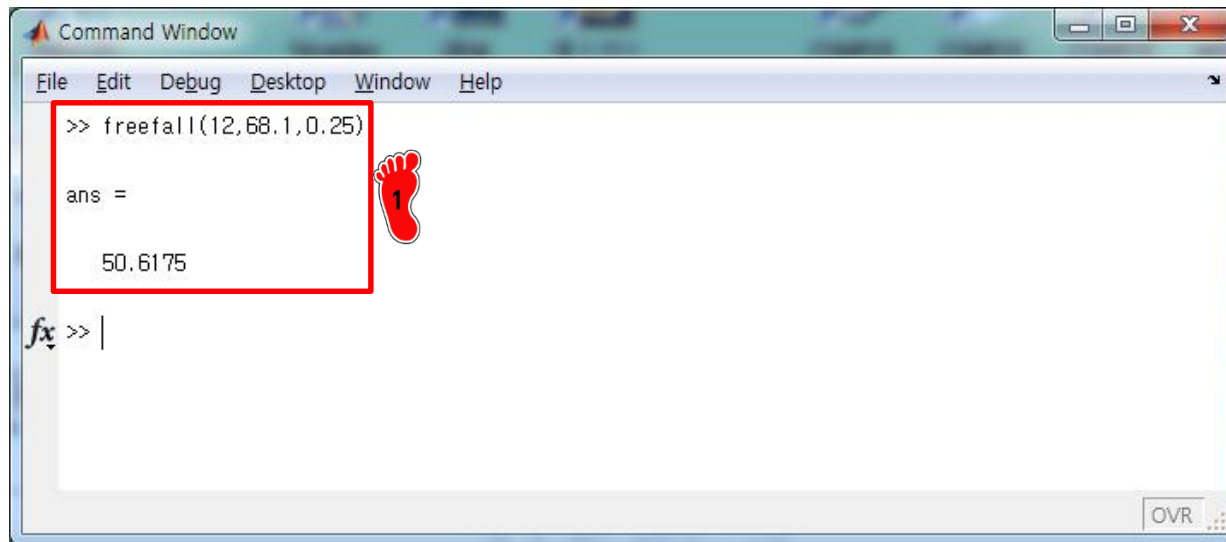


Command window에 help
freefall 을 입력할 경우
script 창에서 주석으로 입
력했던 내용이 출력

주석 처리는 % 기호로 하며
script 창에서는 초록색으로
표시됨



FUNCTION FILE



Command Window

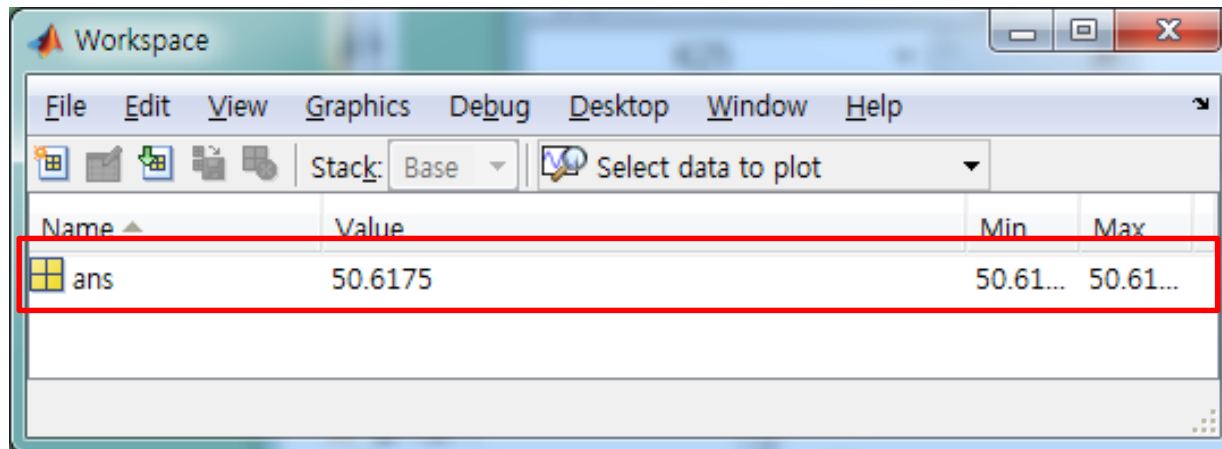
```
>> freefall(12,68.1,0.25)

ans =

    50.6175
```

fx >> |

OVR



Workspace

File Edit View Graphics Debug Desktop Window Help

Stack: Base Select data to plot

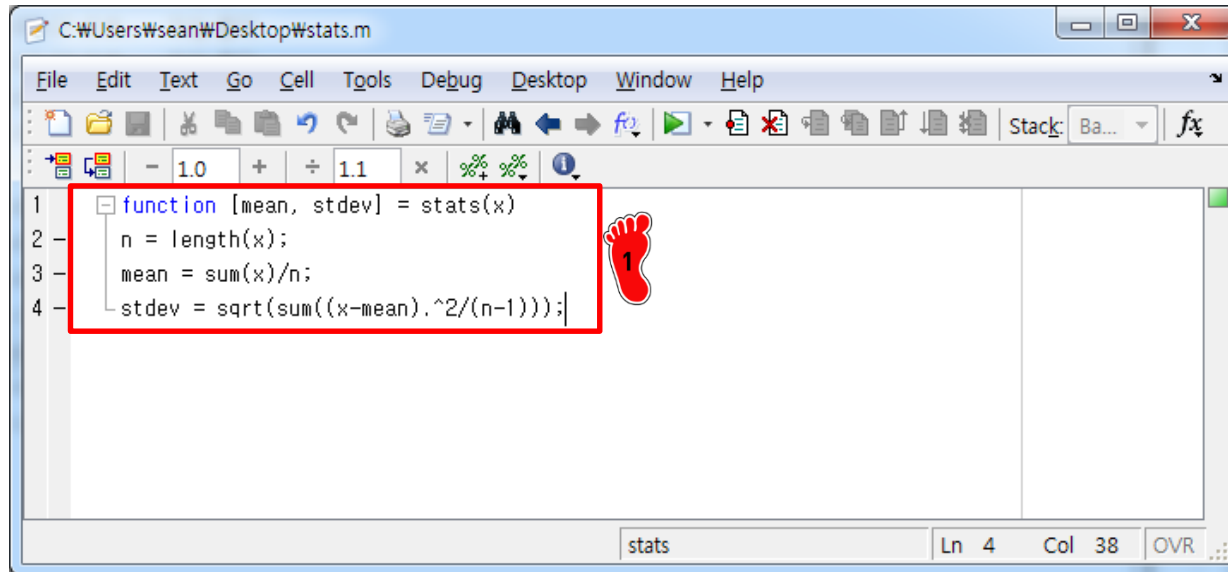
Name	Value	Min	Max
ans	50.6175	50.61...	50.61...



함수에 적용된 argument
들은 workspace 에 저장되
지 않음

따라서 예제와 같이 t, m,
cd 는 v 를 계산하기 위해
잠시 사용될 뿐, 최종적으로
저장되지 않음

FUNCTION FILE



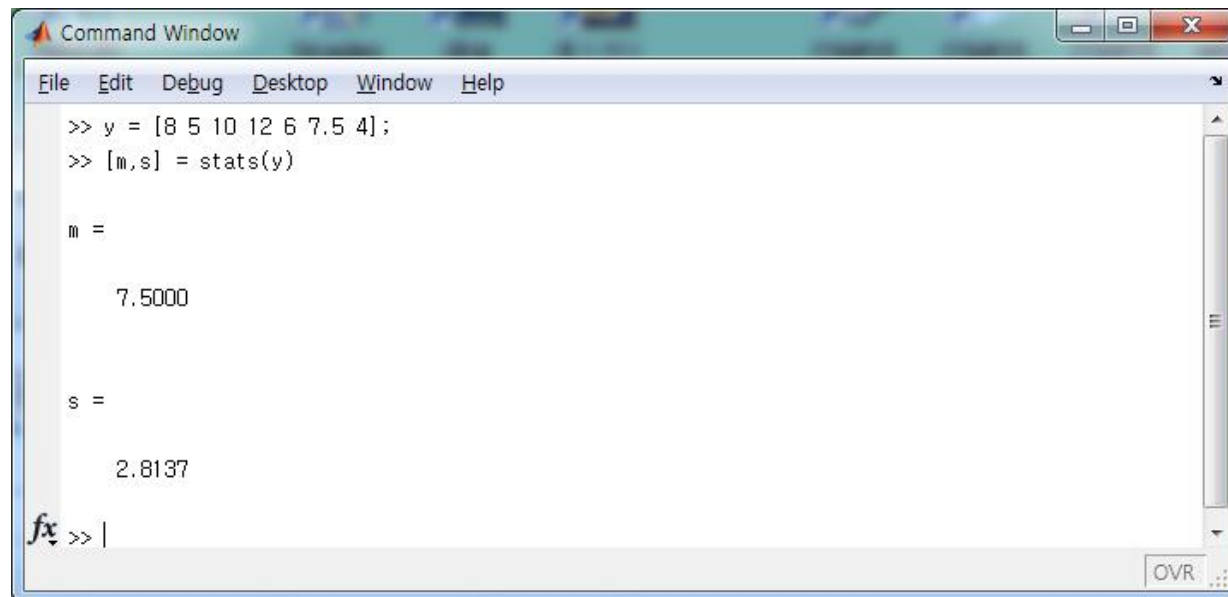
```

1 function [mean, stdev] = stats(x)
2     n = length(x);
3     mean = sum(x)/n;
4     stdev = sqrt(sum((x-mean).^2/(n-1)));
  
```



평균과 분산을 계산하는 함수 예제

여기서 outvar 이 한 개가 아닌 여러 개의 원소를 갖는 벡터로 지정할 수 있음



```

>> y = [8 5 10 12 6 7.5 4];
>> [m,s] = stats(y)

m =

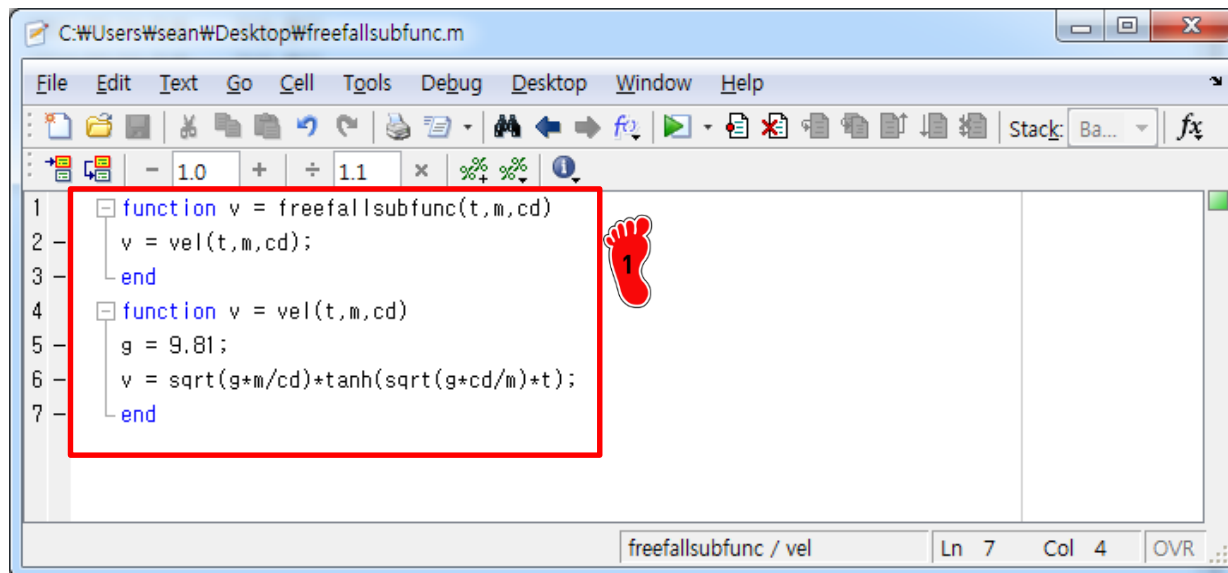
    7.5000

s =

    2.8137

fx >> |
  
```

SUBFUNCTION



```

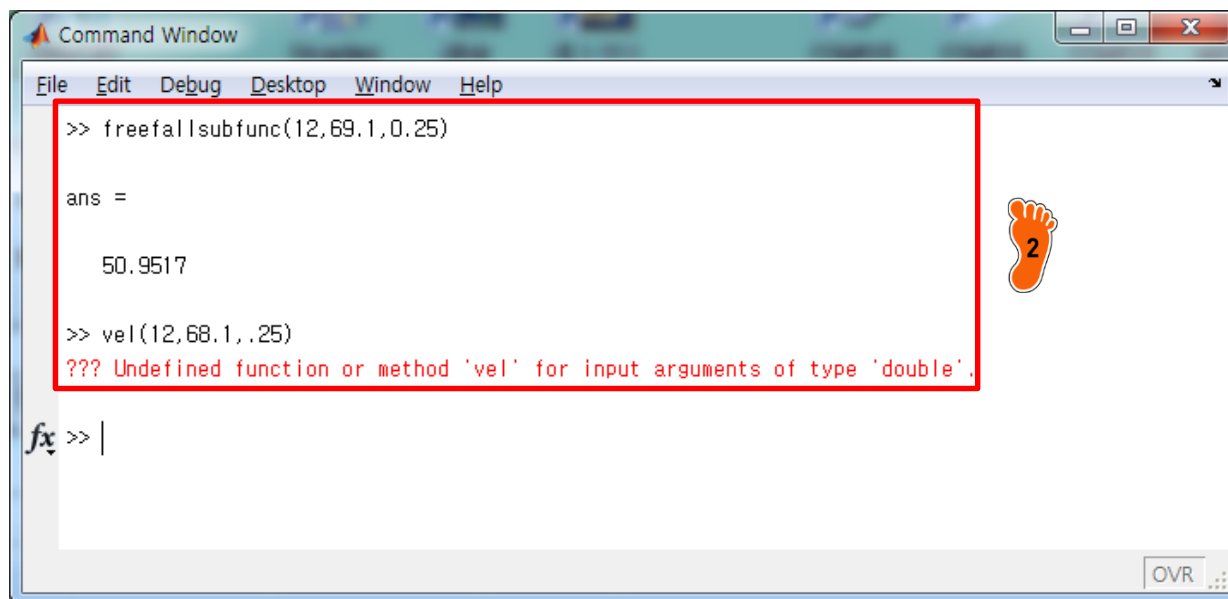
1 function v = freefallsubfunc(t,m,cd)
2     v = vel(t,m,cd);
3     end
4 function v = vel(t,m,cd)
5     g = 9.81;
6     v = sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t);
7     end
  
```

 함수 안에 또 다른 함수를 입력하여 적용 가능

이 때는 end를 이용하여 함수가 끝난 것을 표시

m-file명은 처음 정의한 함수 이름으로 저장

 vel 함수는 freefallsubfunc 안에 있는 함수로 인식할 수 없음



```

>> freefallsubfunc(12,69.1,0.25)

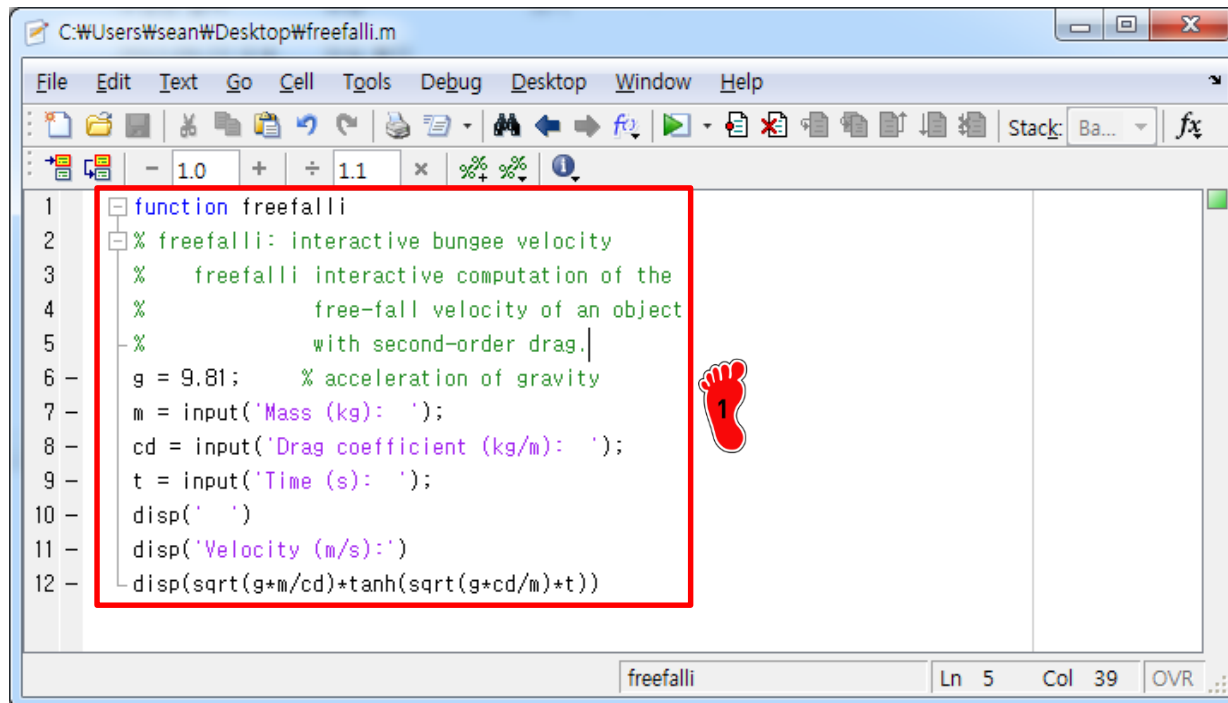
ans =

    50.9517

>> vel(12,69.1,.25)
??? Undefined function or method 'vel' for input arguments of type 'double'.
  
```

- **Input-output**
 - ✓ **Input function**
 - ✓ **Fprint function**

INPUT FUNCTION



The image shows a MATLAB script editor window titled 'C:\Users\sean\Desktop\freefalli.m'. The script defines a function 'freefalli' that calculates the velocity of an object in free fall with second-order drag. The function uses the 'input' function to prompt the user for mass, drag coefficient, and time. The output is displayed using 'disp'. A red box highlights the function definition, and a red footprint icon with the number '1' is placed next to it.

```

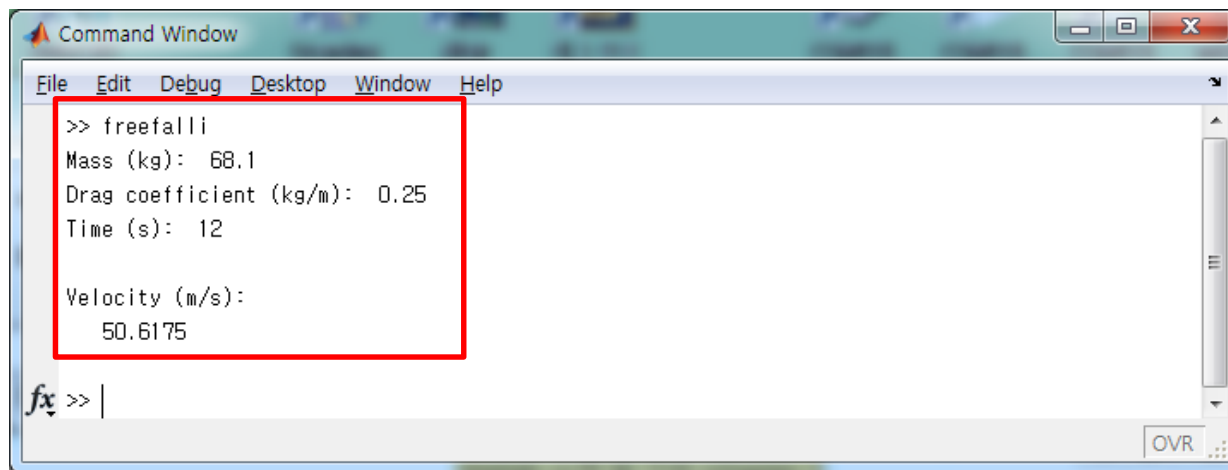
1 function freefalli
2 % freefalli: interactive bungee velocity
3 % freefalli interactive computation of the
4 % free-fall velocity of an object
5 % with second-order drag.
6 g = 9.81; % acceleration of gravity
7 m = input('Mass (kg): ');
8 cd = input('Drag coefficient (kg/m): ');
9 t = input('Time (s): ');
10 disp(' ')
11 disp('Velocity (m/s):')
12 disp(sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t))
  
```



함수에 arguments가 없어도
다른 방식으로 arguments를
입력 가능

input 함수를 이용하여 직접
arguments를 입력 가능

이 경우도 입력받은 변수는
workspace에 저장되지 않음



The image shows the MATLAB Command Window titled 'Command Window'. It displays the execution of the 'freefalli' function. The user is prompted for input values, and the resulting velocity is displayed. A red box highlights the input and output, and a red footprint icon with the number '1' is placed next to it.

```

>> freefalli
Mass (kg): 68.1
Drag coefficient (kg/m): 0.25
Time (s): 12

Velocity (m/s):
50.6175
fx >>
  
```

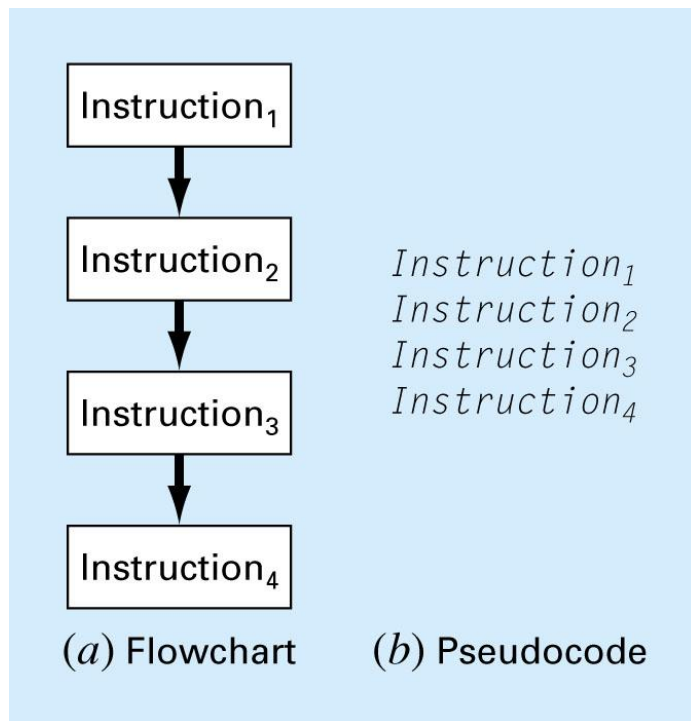
- **Structured programming**
 - ✓ **Algorithm**
 - ✓ **If structure**
 - ✓ **Switch structure**
 - ✓ **For ... end structure**
 - ✓ **While structure**
 - ✓ **Examples**

ALGORITHM

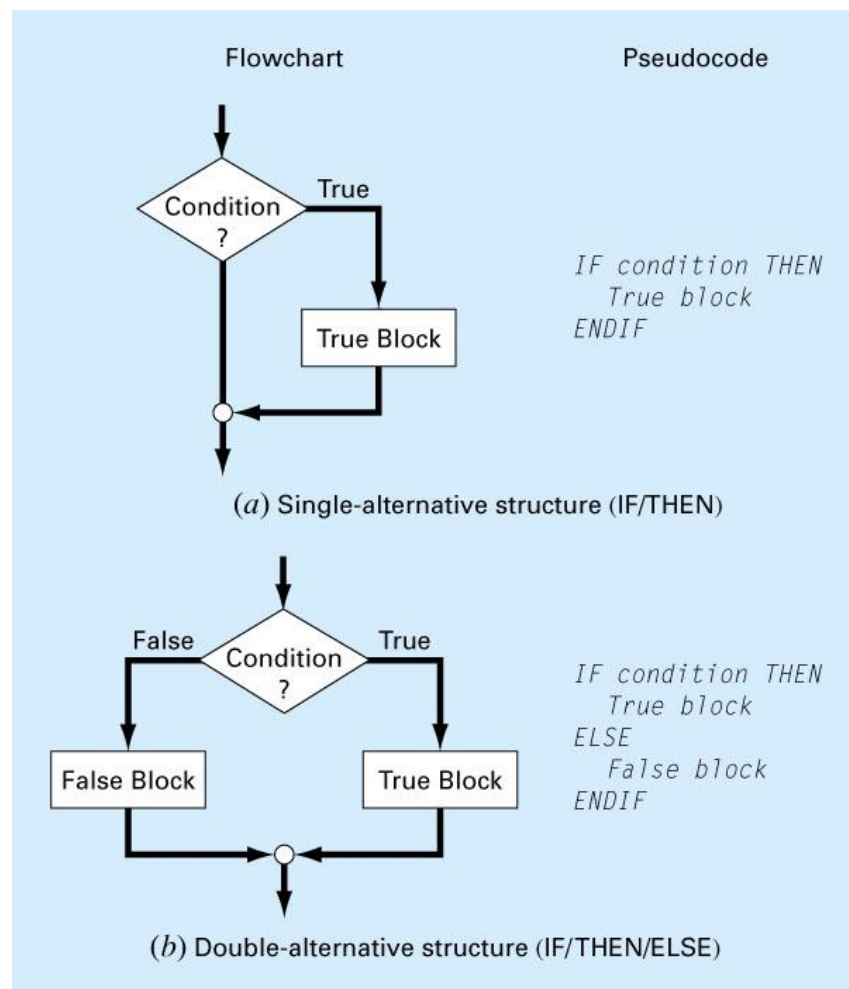
- **Benefits to writing organized, well-structured code**
 - ✓ Shorter time to develop, test, and update
- **Three fundamental control structures**
 - ✓ Sequence, selection and repetition
- **Flowchart**
 - ✓ Visual or graphical representation of an algorithm
- **Pseudocode**
 - ✓ Code-like statements in place of the graphical symbols of the flowchart
 - ✓ Bridges the gap between flowcharts and computer code

LOGICAL REPRESENTATION (1)

- Sequence

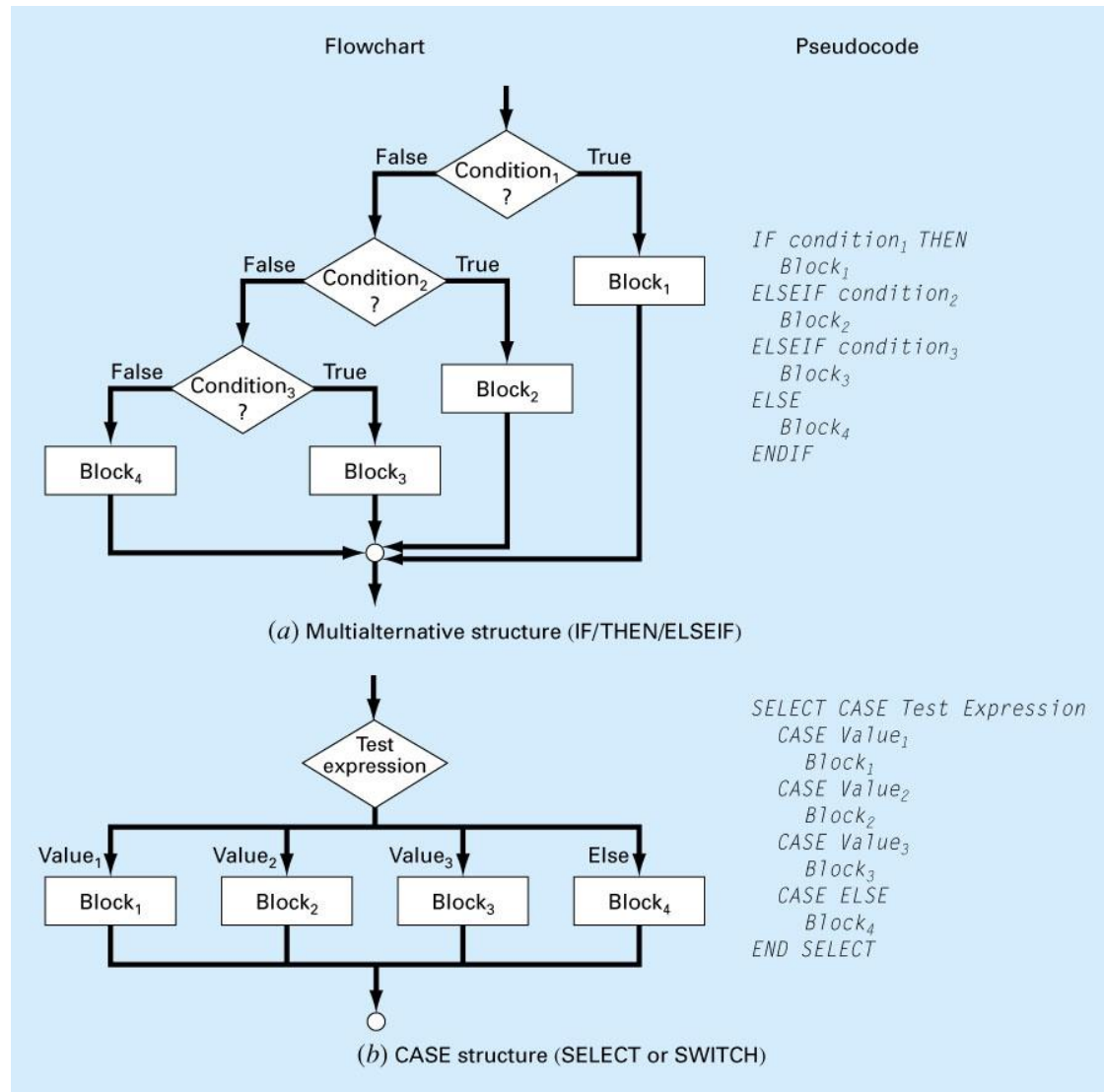


- Selection (1)



LOGICAL REPRESENTATION (2)

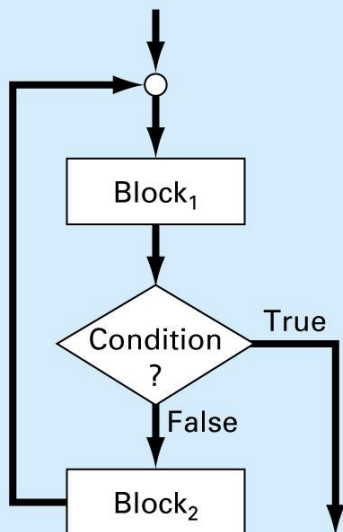
- Selection (2)



LOGICAL REPRESENTATION (3)

- Repetition

Flowchart

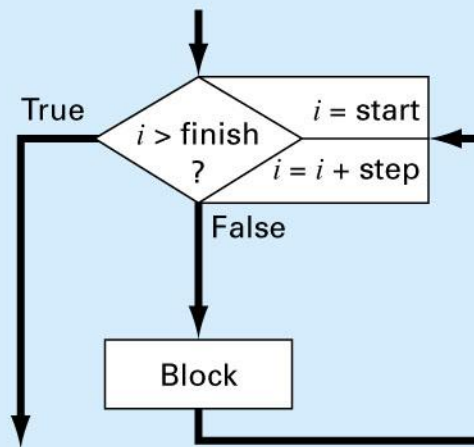


Pseudocode

```

DO
  Block1
  IF condition EXIT
  Block2
ENDDO
  
```

Flowchart



Pseudocode

```

DOFOR i = start, finish, step
  Block
ENDDO
  
```

IF STRUCTURE

if condition
statements
end



if 문의 문법

condition: relational operator 를 이용하여 조건을 입력

statements: condition 이 참일 경우 실행



성적이 60 점 이상일 경우 'passing grade' 문구를 출력하는 예제



```

C:\Users\sean\Desktop\grader.m
File Edit Text Go Cell Tools Debug Desktop Window Help
1 function grader(grade)
2 % grader(grade):
3 % determines whether grade is passing
4 % input:
5 % grade = numerical value of grade (0-100)
6 % output:
7 % displayed message
8 if grade >= 60
9     disp('passing grade')
10 end
  
```

```

Command Window
File Edit Debug Desktop Window Help
>> grader(95.6)
passing grade
fx >>
  
```

RELATIONAL OPERATORS



논리 연산의 operator 는 다음의 표에 정리 되어 있음

Example	Operator	Relationship
$x == 0$	<code>==</code>	Equal
<code>unit ~= 'm'</code>	<code>~=</code>	Not equal
$a < 0$	<code><</code>	Less than
$s > t$	<code>></code>	Greater than
$3.9 \leq a/3$	<code><=</code>	Less than or equal to
$r \geq 0$	<code>>=</code>	Greater than or equal to



LOGICAL CONDITIONS

~ (Not): Used to perform logical negation on an expression
~expression

& (And): Used to perform a logical conjunction on two expressions
expression₁ & expression₂

| (Or): Used to perform a logical disjunction on two expressions
expression₁ | expression₂

T : true, F : false

x	y
T	T
T	F
F	T
F	F



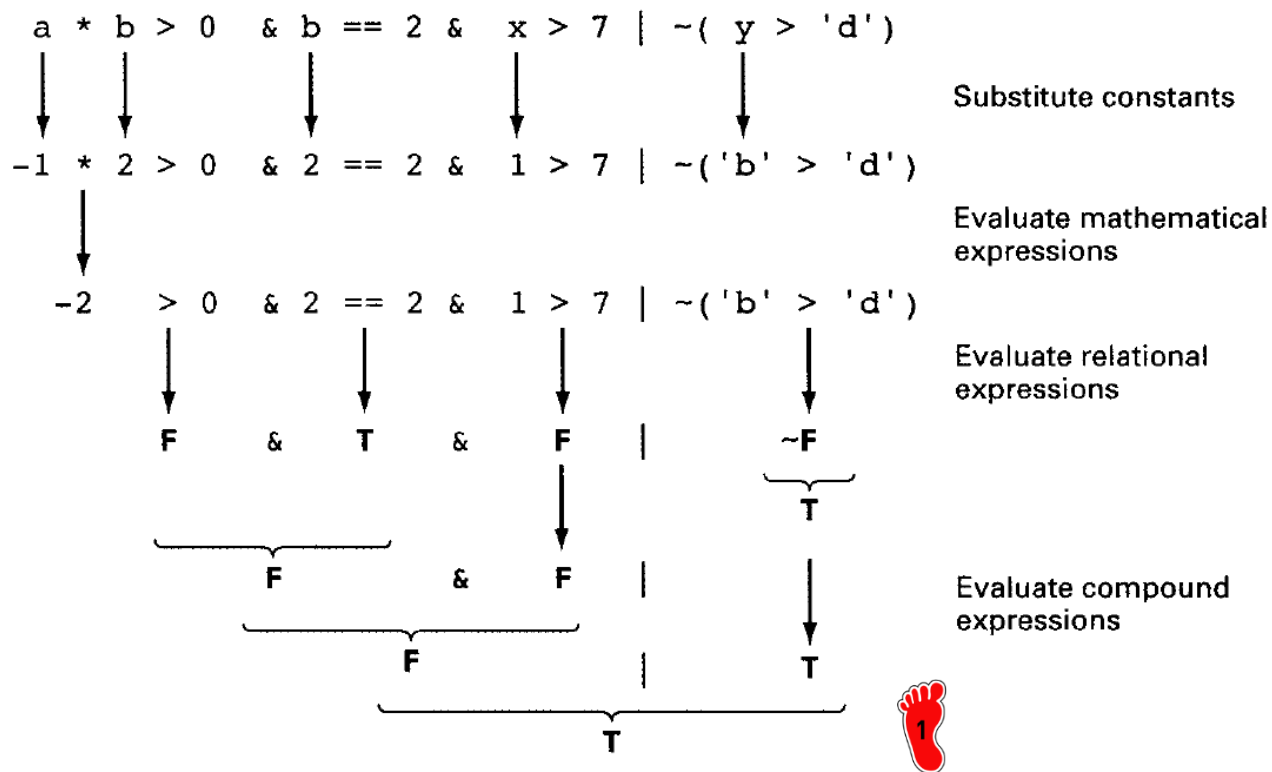
~x	x&y	x y
F	T	T
F	F	T
T	F	T
T	F	F



논리 조건과 연산기호의
구체적인 예는 다음의
표에 정리

LOGICAL CONDITIONS

$a = -1$, $b = 2$, $x = 1$, and $y = 'b'$



논리 연산이 매틀랩 안에서
어떻게 수행이 되는지 알 수
있는 예제



IF... ELSE STRUCTURE

```

if condition
statements1
else
statements2
end

```



1 if... elseif 문의 문법

2 개의 statements 를 이용
가능



2 입력받은 값의 부호를 판단
하는 예제

The screenshot displays the MATLAB IDE. The top window, titled 'C:\Users\sean\Desktop\mysign.m', contains the following code:

```

1 function sgn = mysign(x)
2 % mysign(x) returns 1 if x is greater than zero.
3 % -1 if x is less than or equal to zero
4 if x > 0
5     sgn = 1;
6 else
7     sgn = -1;
8 end

```

The code is highlighted with a red box. The bottom window, titled 'Command Window', shows the execution of the function:

```

>> mysign(-0.776)

ans =

    -1

```

The Command Window prompt is shown as 'fx >> |'.



IF... ELSEIF STRUCTURE

```

if condition1
    statements1
elseif
condition2
    statements2
.
.
.
else
statementselse
end
  
```



```

1 function sgn = mysign(x)
2 % mysign(x) returns 1 if x is greater than zero.
3 %           -1 if x is less than or equal to zero
4 %           0 if x is equal to zero.
5
6 if x > 0
7     sgn = 1;
8 elseif x < 0
9     sgn = -1;
10 else
11     sgn = 0;
12 end
  
```

```

>> mysign(0)

ans =

    0

fx >>
  
```



if... elseif 문의 문법

여러개의 condition 을 입력 가능

else 명령어를 삽입 가능



입력받은 값의 부호를 판단하는 예제
값이 0 일 경우 부호가 아닌 0 을 return



OVR

OVR

SWITCH STRUCTURE



margin의 의미는 number of arguments in 의 약자로 입력되는 변수의 개수를 의미

입력되는 변수의 개수에 따라서 결과값 출력하는 예제

```

C:\Users\sean\Desktop\freefall2.m
File Edit Text Go Cell Tools Debug Desktop Window Help
1 function v = freefall2(t,m,cd)
2 % freefall2: bungee velocity with second-order drag
3 % v=freefall2(t,m,cd) computes the free-fall velocity
4 % of an object with second-order drag.
5 % input:
6 % t = time (s)
7 % m = mass (kg)
8 % cd = drage coefficient (default = 0.27 kg/m)
9 % output:
10 % v = downward velocity (m/s)
11 switch nargin
12 case 0
13     error('Must enter time and mass')
14 case 1
15     error('Must enter mass')
16 case 2
17     cd = 0.27;
18 end
19 g = 9.81; % accerleration of gravity
20 v = sqrt(g*m/cd)*tanh(sqrt(g*cd/m)*t);
  
```



```

Command Window
File Edit Debug Desktop Window Help
>> freefall2(12,68.1,0.25)

ans =

    50.6175

>> freefall2(12,68.1)

ans =

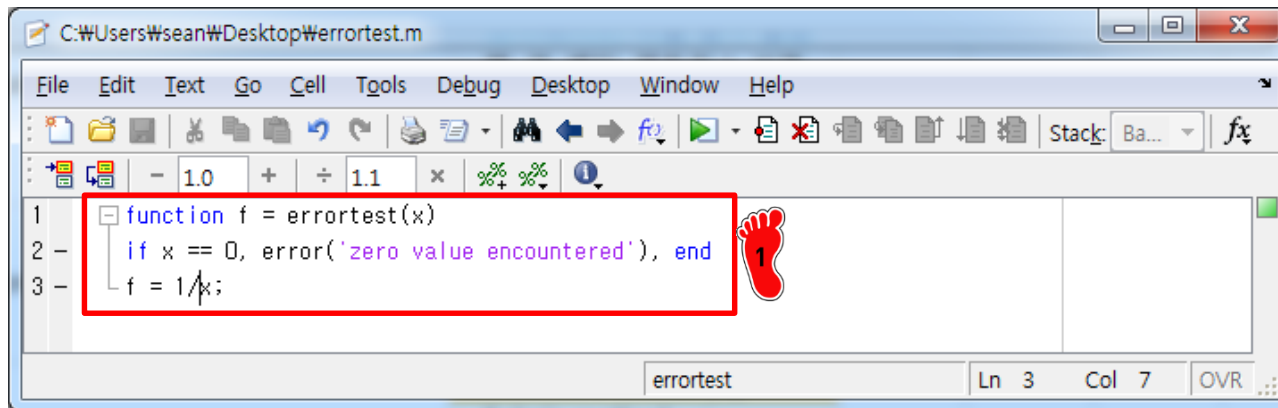
    48.8747

>> freefall2(12)
??? Error using ==> freefall2 at 15
Must enter mass

>> freefall2()
??? Error using ==> freefall2 at 13
Must enter time and mass

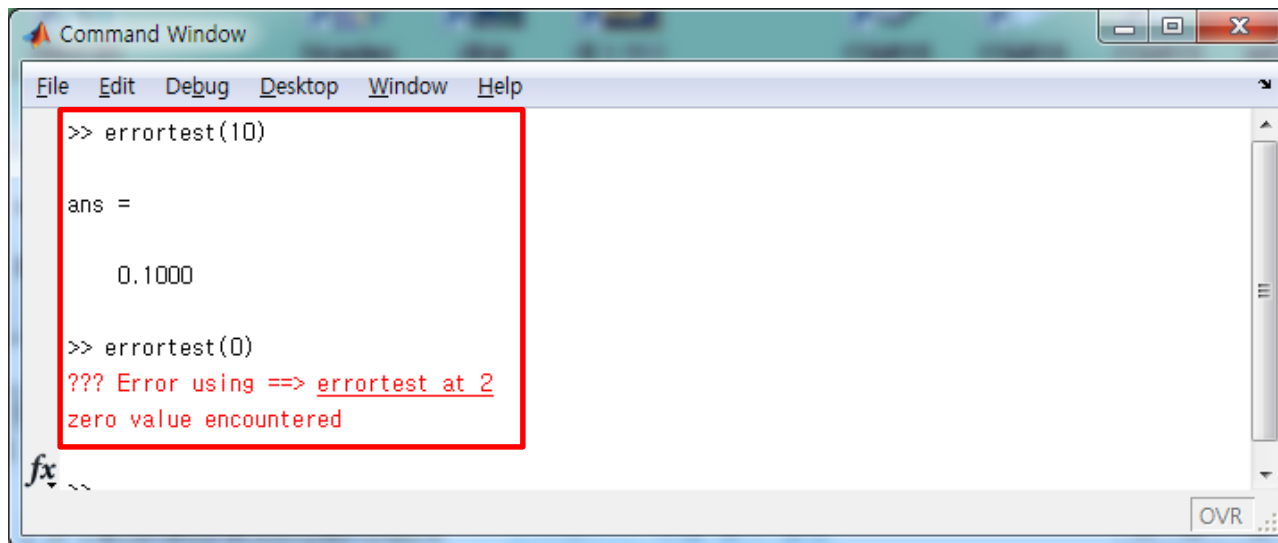
fx >>
  
```

ERROR FUNCTION



```

1 function f = errortest(x)
2     if x == 0, error('zero value encountered'), end
3     f = 1/x;
  
```



```

>> errortest(10)

ans =

    0.1000

>> errortest(0)
??? Error using ==> errortest at 2
zero value encountered
  
```



error 함수는 원하는 값을 입력받지 못할 경우 혹은 프로그래밍 상에서 멈춰야 할 경우 에러 메시지를 출력하면서 프로그램을 중단하는 함수

FOR STRUCTURE

for index = start:step:finish
statements
end



for 문의 문법

콜론 (:) operator 를 이용하여 index 를 결정



factorial 을 계산하는 예제

The screenshot shows the MATLAB environment. The top window displays a function file named 'factor.m' with the following code:

```
1 function fout = factor(n)
2 % factor(n) :
3 %   Computes the product of all the integers from 1 to n.
4 x = 1;
5 for i = 1:n
6     x = x*i;
7 end
8 fout = x;
9 end
```

The 'for' loop is highlighted with a red box. Below the function editor is the Command Window, which shows the execution of the function:

```
>> factor(5)

ans =

    120

>> factor(0)

ans =

     1

fx >>
```



Factorial

$$0! = 1$$

$$1! = 1$$

$$2! = 1 \times 2 = 2$$

$$3! = 1 \times 2 \times 3 = 6$$

$$4! = 1 \times 2 \times 3 \times 4 = 24$$

$$5! = 1 \times 2 \times 3 \times 4 \times 5 = 120$$

·
·
·

WHILE STRUCTURE

while condition
statements
end



while 문의 문법

if 문의 문법과 동일



x 값이 8부터 -3 단위로 감소하는 예제



condition 을 1로 입력할 경우 무한루프가 실행됨

statements 에 if 문과 break 명령어를 입력하여 프로그램을 중단

```

1 - x = 8
2 - while x > 0
3 -     x = x-3;
4 -     disp(x)
5 - end
  
```

Command Window output:

```

x =
    8
    5
    2
   -1
  
```

```

1 - x = 20;
2 - while (1)
3 -     x = x-5;
4 -     disp(x)
5 -     if x < 0
6 -         break
7 -     end
8 - end
  
```

Command Window output:

```

    15
    10
     5
     0
    -5
  
```

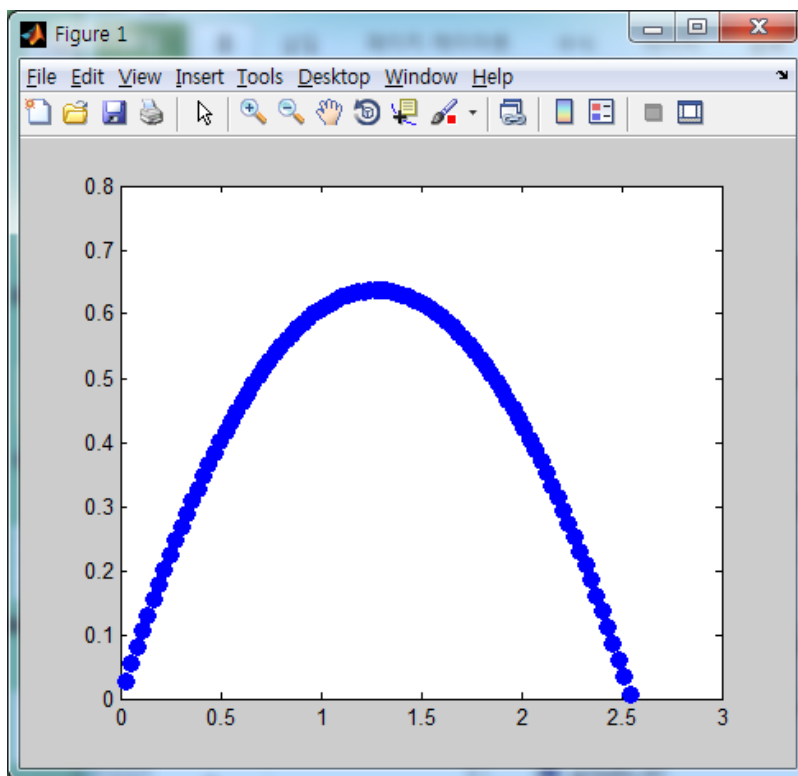
EXAMPLE I

Problem Statement: In the absence of air resistance, the Cartesian coordinates of a projectile launched with an initial velocity (v_0) and angle (θ_0) can be computed with

$$x = v_0 \cos(\theta_0)t$$

$$y = v_0 \sin(\theta_0)t - 0.5gt^2$$

where $g = 9.81 \text{ m/s}^2$. Develop a script to generate an animated plot of the projectile trajectory given that $v_0 = 5 \text{ m/s}$ and $\theta_0 = 45^\circ$.



주어진 조건대로 독립변수 x 와 종속변수 y 를 animation 으로 plot 을 하는 예제





clc: command window 창
에 표기 되어있는 것을 초
기화 (clear command)

clf: 현재 pop up 되어있는 모든 plot 창을 초기화 (clear figure)

clear: workspace 에 저장되어 있는 변수들을 초기화

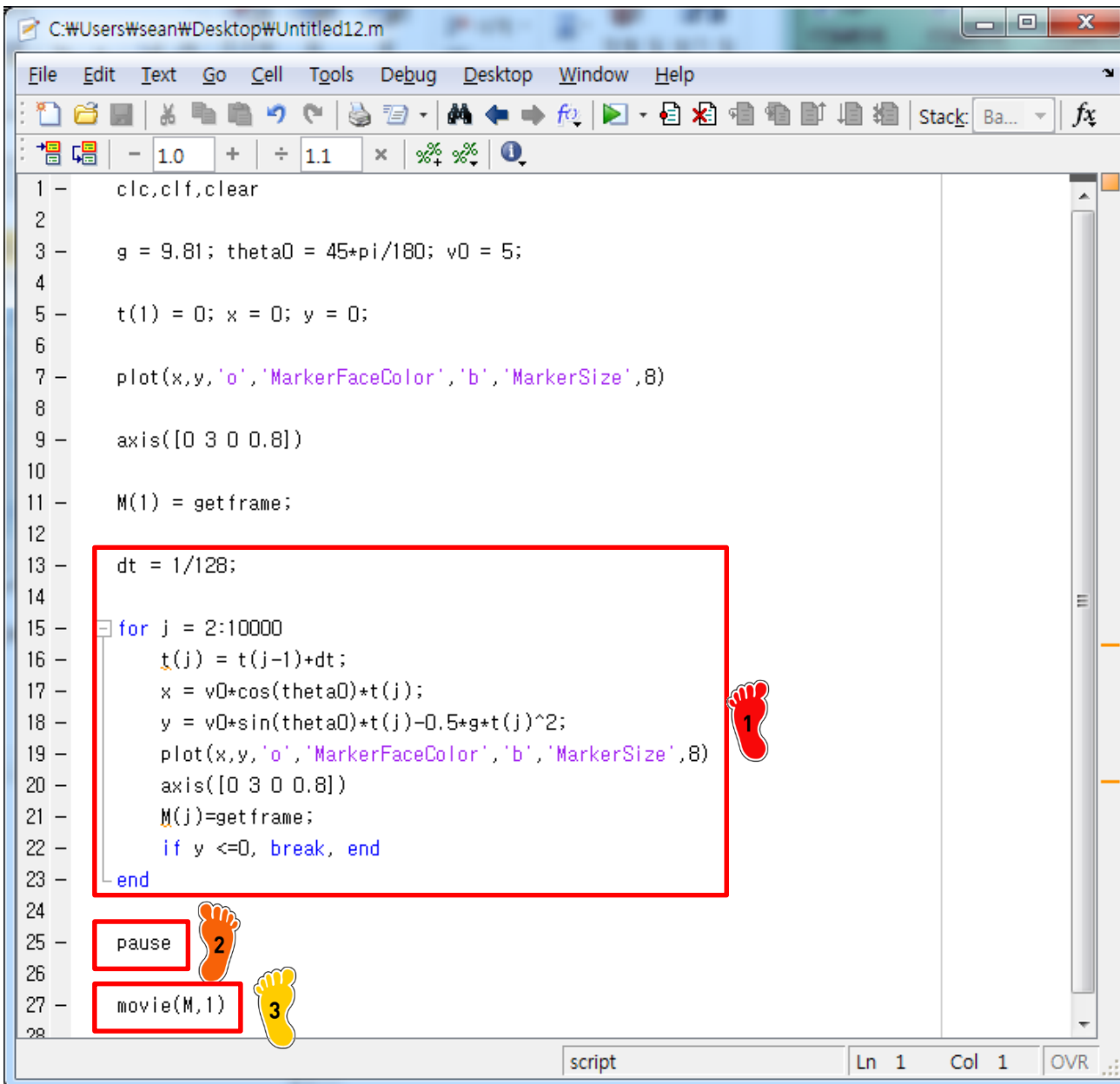


연산에 사용하는 변수들 선언, 주의할 점은 매틀랩에서 모든 각도는 radian 단위로 입력 해야함



Animation 을 실행하기 위해 frame 을 저장하는 명령어

EXAMPLE I



```

1  clc,clf,clear
2
3  g = 9.81; theta0 = 45*pi/180; v0 = 5;
4
5  t(1) = 0; x = 0; y = 0;
6
7  plot(x,y,'o','MarkerFaceColor','b','MarkerSize',8)
8
9  axis([0 3 0 0.8])
10
11 M(1) = getframe;
12
13 dt = 1/128;
14
15 for j = 2:10000
16     t(j) = t(j-1)+dt;
17     x = v0*cos(theta0)*t(j);
18     y = v0*sin(theta0)*t(j)-0.5*g*t(j)^2;
19     plot(x,y,'o','MarkerFaceColor','b','MarkerSize',8)
20     axis([0 3 0 0.8])
21     M(j)=getframe;
22     if y <=0, break, end
23 end
24
25 pause
26
27 movie(M,1)
28

```

1 for 문을 이용하여 단계별로 시간을 증가시키면서 독립 변수 x 와 종속변수 y 값을 저장 및 plot

그 후 animation 을 생성하기 위한 frame 을 매 iteration 마다 저장

for 문이지만 break 명령어를 이용하여 중간에 중단할 수 있음

2 pause 명령어는 매틀랩 실행을 잠시 중단시키는 명령어
pause on 혹은 pause off 로 조절 가능

3 movie(m,n,fps) 명령어는 현재 저장된 frame m 을 n 번 단위 초당 몇 개의 frame 을 재생하는 함수

$$f(x) = ax^2 + bx + c$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

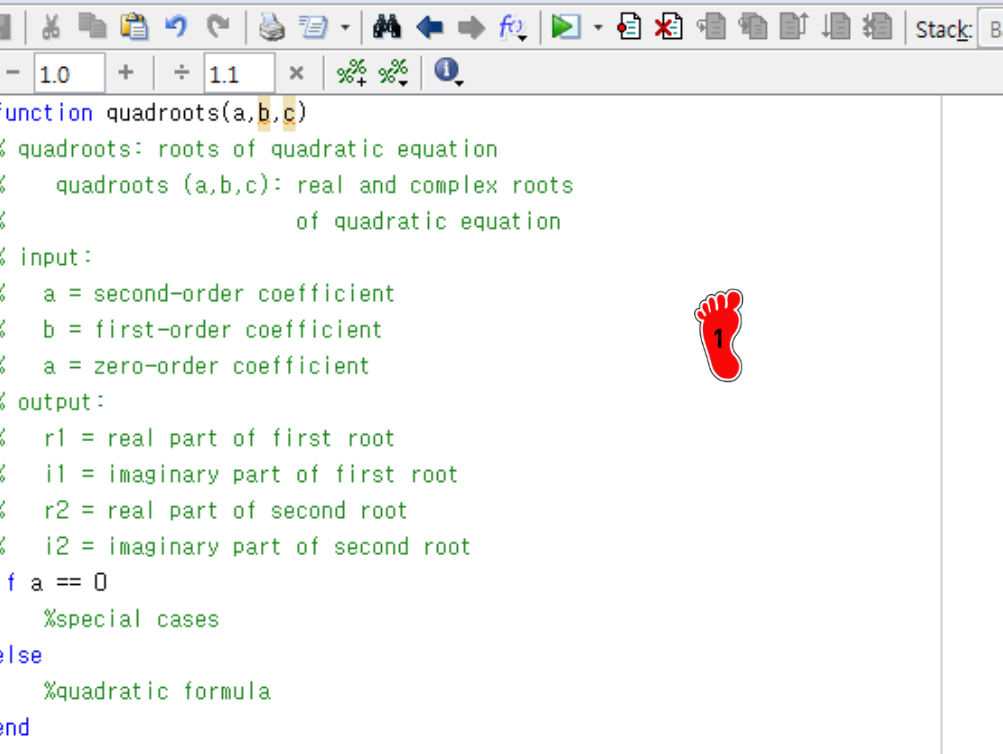


coding 작업은 기본적으로
top-down design 방식으로
진행

1. 프로그램은 위부터 아래로 한줄 씩 실행되며 input 및 output 과 예상되는 오류를 생각하여 알고리즘을 구성
2. 본 예제는 근의 공식을 이용하여 2차 방정식을 푸는 script를 코딩하는 방법을 보여줌

Input: 계수
Output: 근

3. 계수 a 가 0 일 경우에는
무한대이므로 논리 구조를
special case 와 quadratic
formula 로 삼임

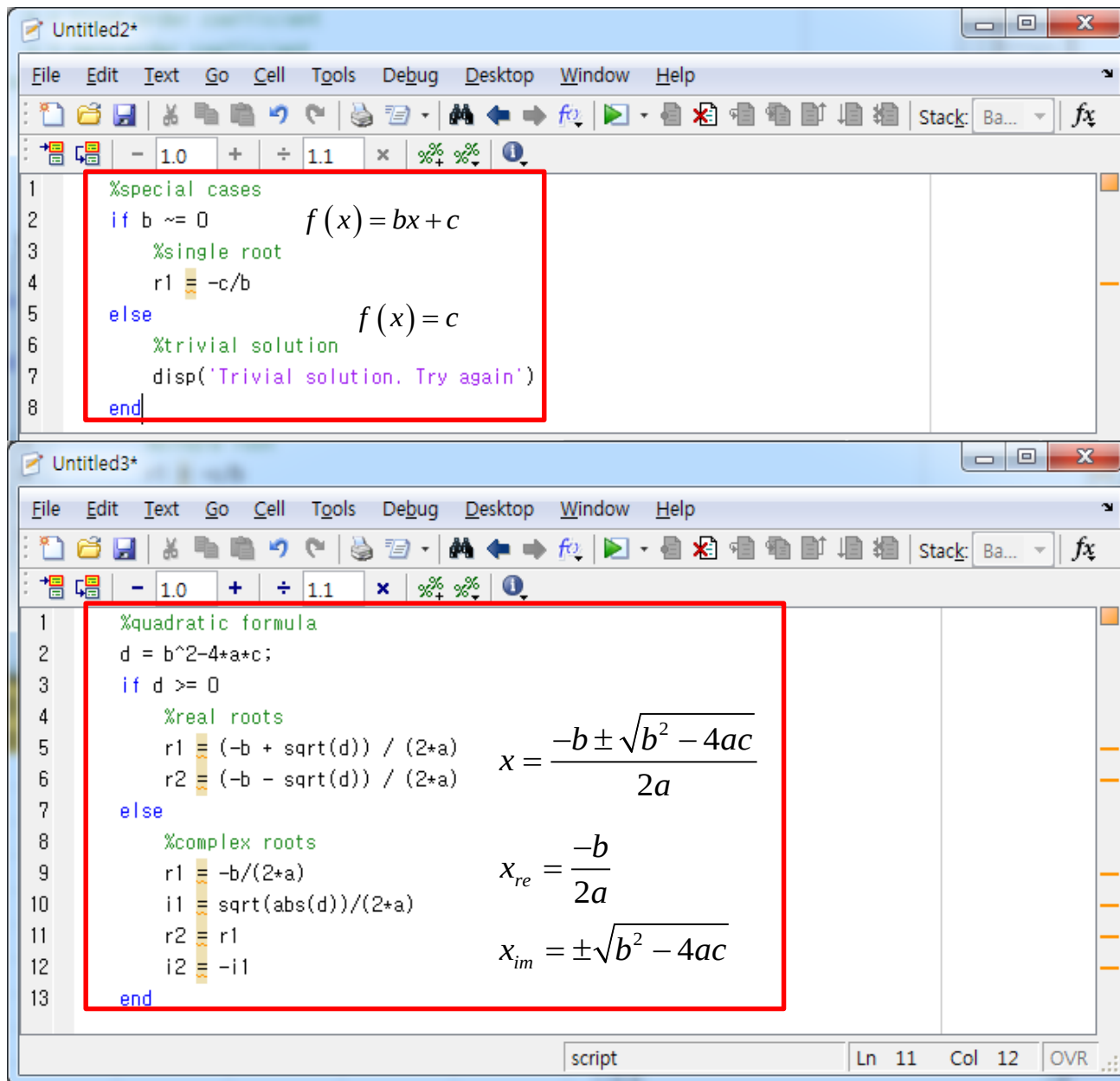


The image shows a MATLAB Editor window with the file path C:\Users\sean\Desktop\quadroots.m. The script content is as follows:

```
1 function quadroots(a,b,c)
2 % quadroots: roots of quadratic equation
3 %   quadroots (a,b,c): real and complex roots
4 %               of quadratic equation
5 % input:
6 %   a = second-order coefficient
7 %   b = first-order coefficient
8 %   a = zero-order coefficient
9 % output:
10 %   r1 = real part of first root
11 %   i1 = imaginary part of first root
12 %   r2 = real part of second root
13 %   i2 = imaginary part of second root
14 if a == 0
15     %special cases
16 else
17     %quadratic formula
18 end
```

A red footprint icon with the number 1 is positioned over the code, specifically near line 8.

EXAMPLE II



```

Untitled2*
File Edit Text Go Cell Tools Debug Desktop Window Help
1 %special cases
2 if b ~= 0      f(x) = bx + c
3   %single root
4   r1 = -c/b
5 else          f(x) = c
6   %trivial solution
7   disp('Trivial solution. Try again')
8 end

Untitled3*
File Edit Text Go Cell Tools Debug Desktop Window Help
1 %quadratic formula
2 d = b^2-4*a*c;
3 if d >= 0
4   %real roots
5   r1 = (-b + sqrt(d)) / (2*a)
6   r2 = (-b - sqrt(d)) / (2*a)
7 else
8   %complex roots
9   r1 = -b/(2*a)
10  i1 = sqrt(abs(d))/(2*a)
11  r2 = r1
12  i2 = -i1
13 end
  
```



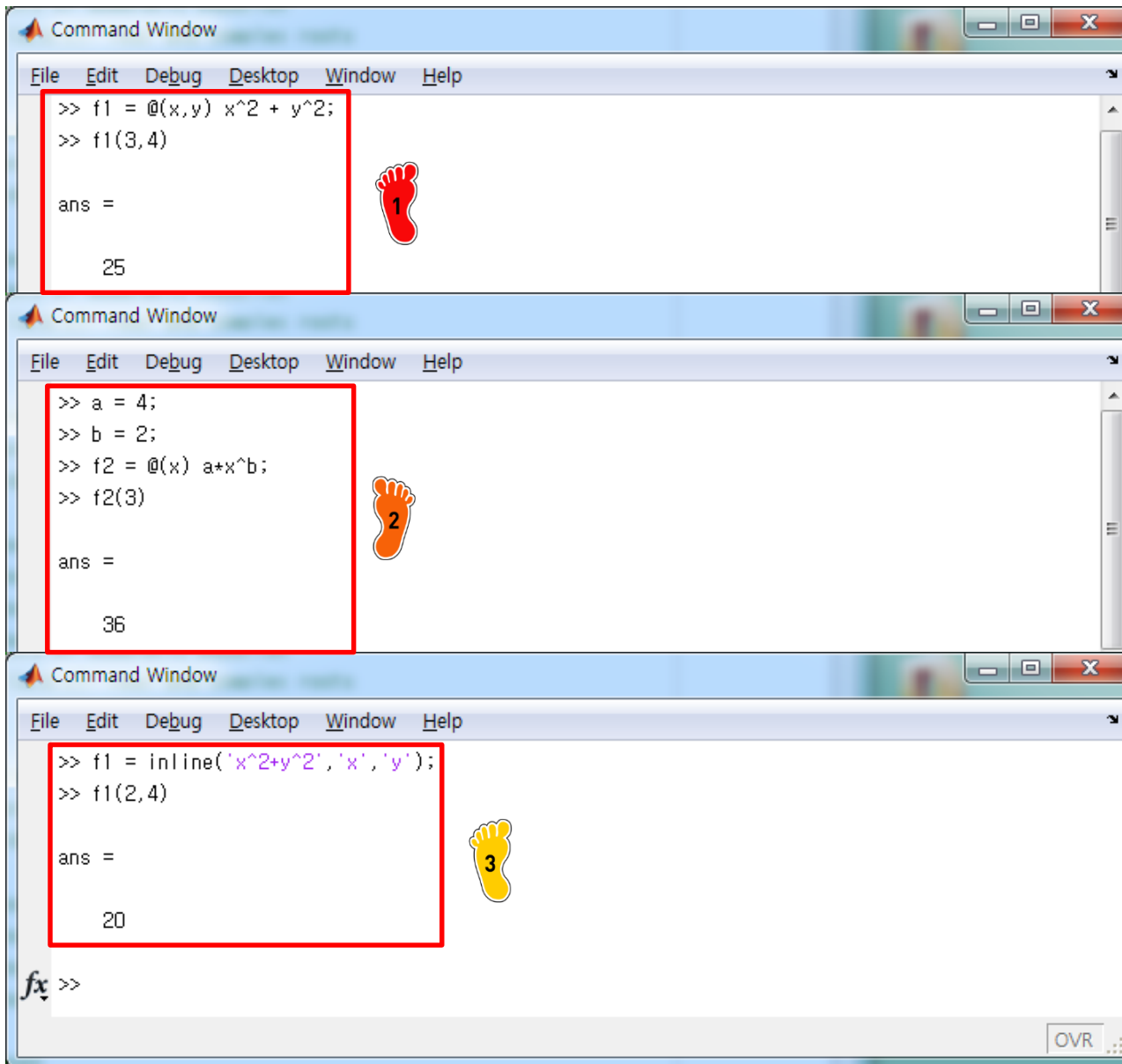
다음 과정은 세부 structure
를 코딩



마지막으로 코딩한 script
를 본 코드에 옮겨서 확인
작업을 마치면 structured
programming 작업이 끝남

- **Passing functions to m-files**
 - ✓ **Anonymous functions**
 - ✓ **Function functions**
 - ✓ **Example**
 - ✓ **Passing parameters**

ANONYMOUS FUNCTIONS



1 Command Window

```
>> f1 = @(x,y) x^2 + y^2;
>> f1(3,4)

ans =

    25
```

2 Command Window

```
>> a = 4;
>> b = 2;
>> f2 = @(x) a*x^b;
>> f2(3)

ans =

    36
```

3 Command Window

```
>> f1 = inline('x^2+y^2','x','y');
>> f1(2,4)

ans =

    20
```

fx >>

1 @ 기호를 이용하여 간단하게 함수를 지정할 수 있다.

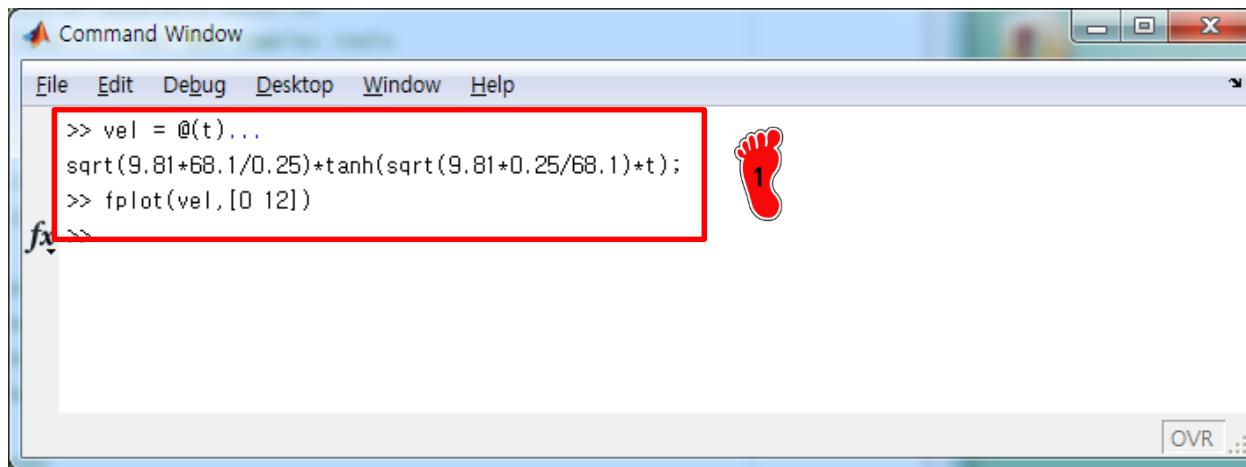
지정하는 방식

fhandle = @(arglist)
expression

2 상수가 미리 저장되어 있으면 상수를 이용하여 함수를 지정할 수 있음
이 때 상수 값을 변경하면 자동으로 함수값도 변경됨

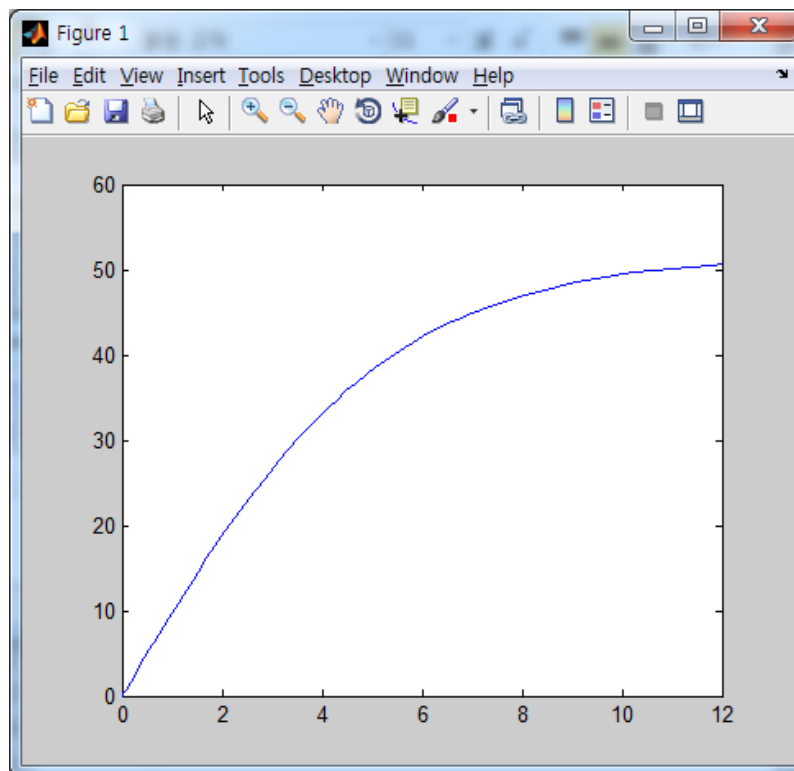
3 inline 명령어의 경우 @ 기호처럼 함수를 저장 가능

FUNCTION FUNCTIONS



```

>> vel = @(t)...
sqrt(9.81*68.1/0.25)*tanh(sqrt(9.81*0.25/68.1)*t);
>> fplot(vel,[0 12])
>>
  
```



fplot: function 을 이용하여 그래프를 그리는 함수

`fplot(func,lims)`

func: fplot 에 입력되는 함수

lims: 입력되는 function 의 argument limit

`lims = [xmin,xmax]`

EXAMPLE

Problem statement: Develop an M-file function to determine the average of a function over a range. Illustrate its use for the bungee jumper velocity over the range from $t = 0$ to 12 s:

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

where $g = 9.81$, $m = 68.1$, and $c = 0.25$



1주차에서 강의했던 수식을 이용하여 평균 속도를 구하는 예제

기본적으로 다음과 같이 script 를 구성하여 답을 구할 수 있지만 function function 원리를 이용하여 일반적으로 코드를 구성할 수 있음

```

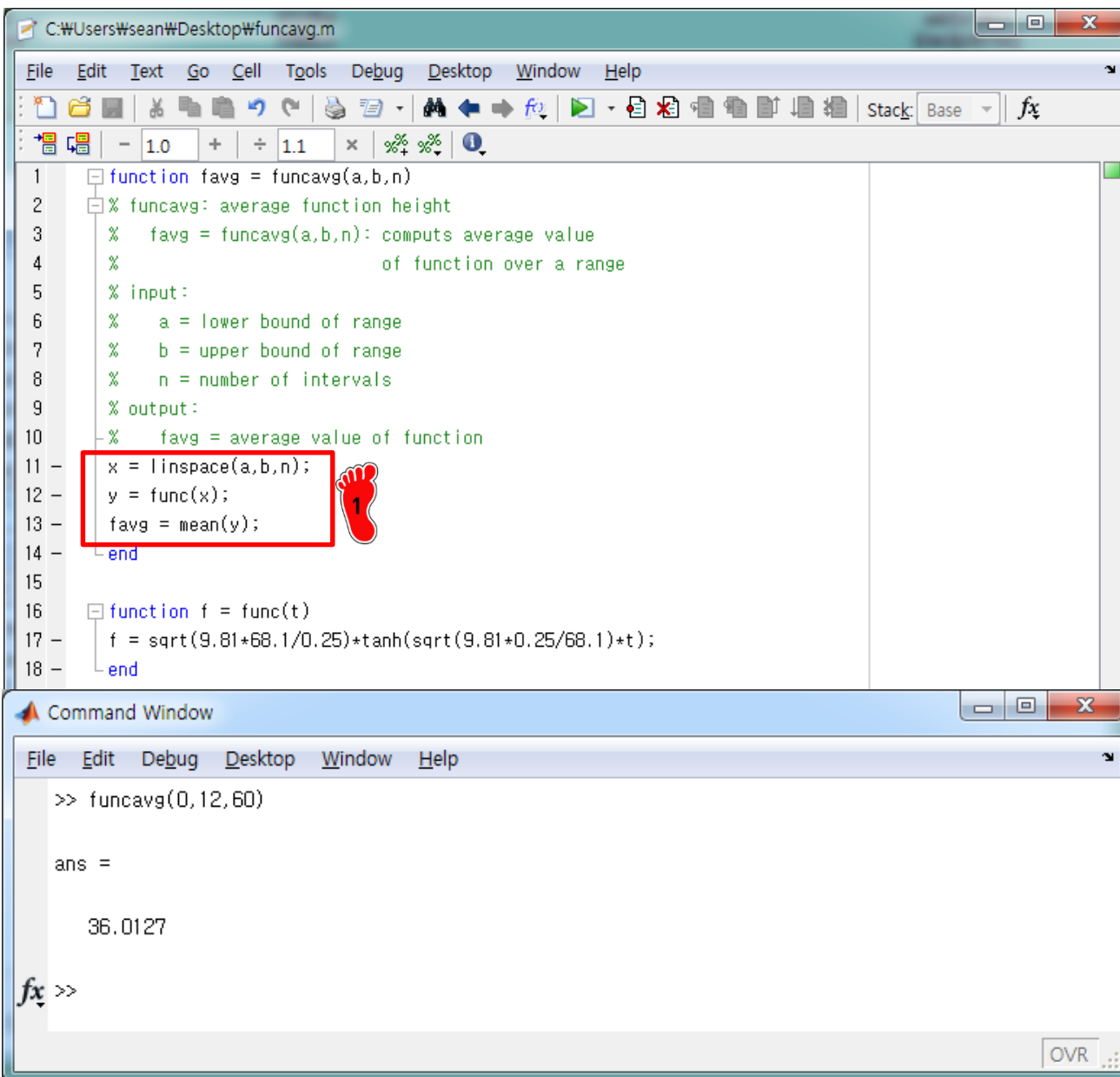
C:\Users\sean\Desktop\Untitled4.m
File Edit Text Go Cell Tools Debug Desktop Window Help
t = linspace(0,12);
v = sqrt(9.81*68.1/0.25)*tanh(sqrt(9.81*0.25/68.1)*t);
mean(v)
  
```

```

Command Window
File Edit Debug Desktop Window Help
ans =

    36.0870
fx >>
  
```

EXAMPLE



The image shows a MATLAB Editor window with a script named `funcavg.m`. The script defines a subfunction `funcavg` and a main function `func`. The subfunction `funcavg` calculates the average value of a function `f` over a range `[a, b]` using `n` intervals. The main function `func` defines a function `f` and calls `funcavg` to calculate the average value.

```

1 function funcavg = funcavg(a,b,n)
2 % funcavg: average function height
3 %   funcavg(a,b,n): computes average value
4 %                   of function over a range
5 % input:
6 %   a = lower bound of range
7 %   b = upper bound of range
8 %   n = number of intervals
9 % output:
10 %   funcavg = average value of function
11 x = linspace(a,b,n);
12 y = func(x);
13 funcavg = mean(y);
14 end
15
16 function f = func(t)
17 f = sqrt(9.81*68.1/0.25)*tanh(sqrt(9.81*0.25/68.1)*t);
18 end
  
```

The Command Window shows the execution of `funcavg(0,12,60)`, resulting in `ans = 36.0127`.

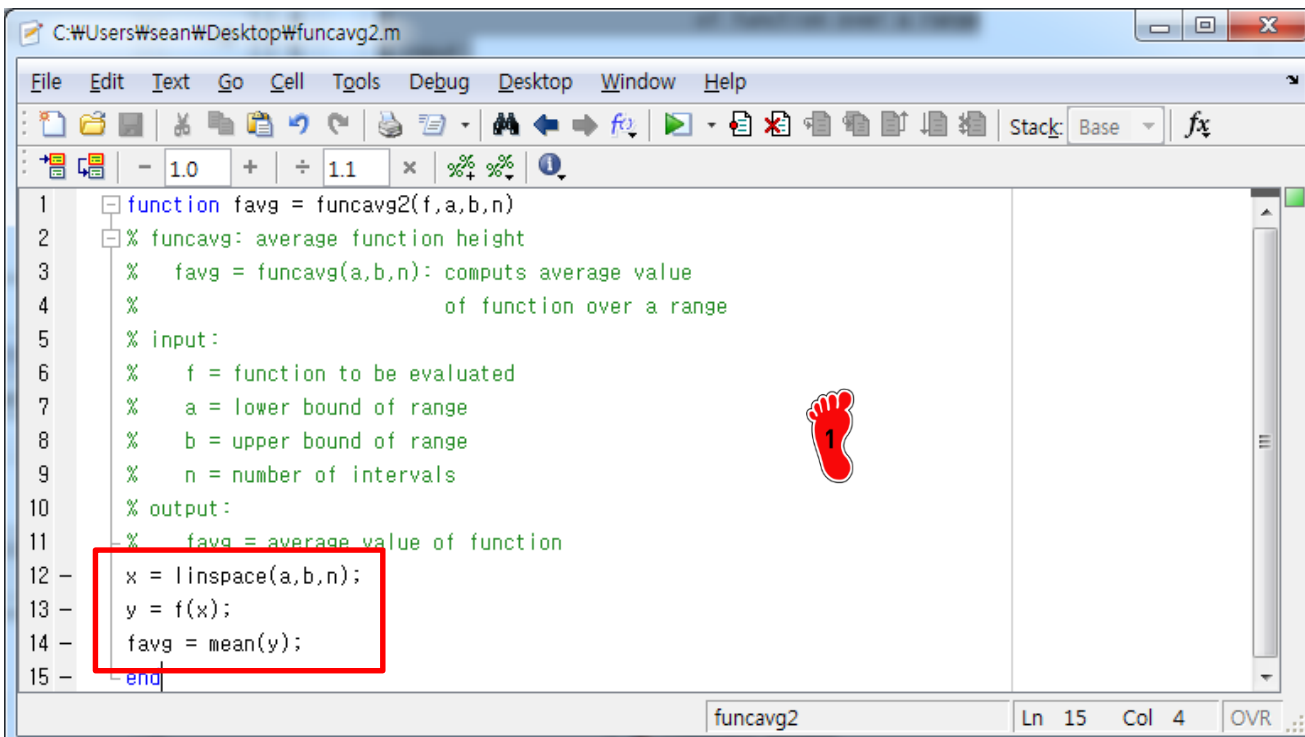


Subfunction 으로 구성하여 일반적인 형태로 script 를 구성한 예제

평균값을 구하는 y 함수를 subfunction 으로 지정
평균값을 구하는 mean 함수는 y 함수를 이용하여 계산

따라서 subfunction 을 다른 함수로 입력할 경우 그 함수에 대한 평균값을 구할 수 있음

EXAMPLE



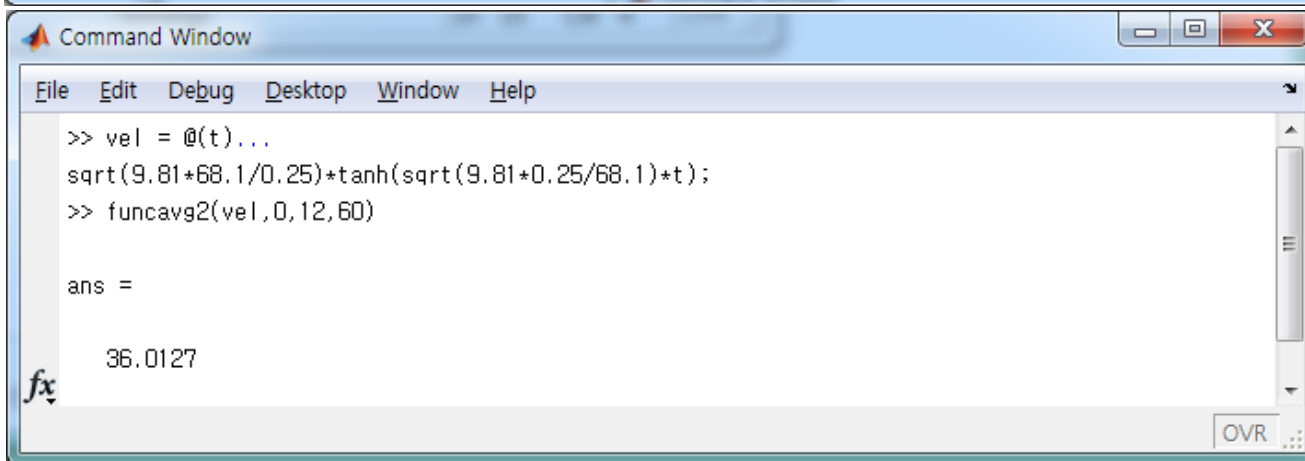
```

C:\Users\sean\Desktop\funcavg2.m
File Edit Text Go Cell Tools Debug Desktop Window Help
1 function favg = funcavg2(f,a,b,n)
2 % funcavg: average function height
3 %   favg = funcavg(a,b,n): computes average value
4 %   of function over a range
5 % input:
6 %   f = function to be evaluated
7 %   a = lower bound of range
8 %   b = upper bound of range
9 %   n = number of intervals
10 % output:
11 %   favg = average value of function
12 x = linspace(a,b,n);
13 y = f(x);
14 favg = mean(y);
15 end
  
```



평균값을 계산할 함수를
argument 로 입력받아 계
산하는 예제

@ 기호를 이용하여 다양한
함수의 평균값을 계산 가능



```

Command Window
File Edit Debug Desktop Window Help
>> vel = @(t)...
sqrt(9.81+68.1/0.25)*tanh(sqrt(9.81+0.25/68.1)*t);
>> funcavg2(vel,0,12,60)

ans =

36.0127
  
```

PASSING PARAMETERS



앞의 예제들은 함수에 들어가는 파라미터 수를 미리 정하여 입력

하지만 파라미터 수가 변할 경우, 매번 함수를 다시 정의해야 하는 불편함이 있으므로 파라미터 수를 `varargin` 명령어로 입력 받을 수 있게 script 를 구성한 예제

```

C:\Users\sean\Desktop\funcavg3.m
File Edit Text Go Cell Tools Debug Desktop Window Help
1 function favg = funcavg3(f,a,b,n,varargin)
2     x = linspace(a,b,n);
3     y = f(x,varargin{:});
4     favg = mean(y);
funcavg3 Ln 4 Col 16 OVR
  
```

```

Command Window
File Edit Debug Desktop Window Help
>> vel = @(t,m,cd) sqrt(9.81*m/cd)*tanh(sqrt(9.81*cd/m)*t);
>> funcavg3(vel,0,12,60,68.1,0.25)

ans =

    36.0127
fx >> |
OVR
  
```

- **Case study**
- **Assignment**

CASE STUDY

Background. In this section, we will use MATLAB to solve the free-falling bungee jumper problem we posed at the beginning of this chapter. This involves obtaining a solution of

$$\frac{dv}{dt} = g - \frac{c_d}{m} v|v|$$

Recall that, given an initial condition for time and velocity, the problem involved iteratively solving the formula,

$$v_{i+1} = v_i + \frac{dv_i}{dt} \Delta t$$

Now also remember that to attain good accuracy, we would employ small steps. Therefore, we would probably want to apply the formula repeatedly to step out from our initial time to attain the value at the final time. Consequently, an algorithm to solve the problem would be based on a loop.

<Parameter Values>

time step = 0.5 s or 0.001 s

initial time = 0 s

final time = 12 s

initial velocity = 0 m/s

ASSIGNMENT

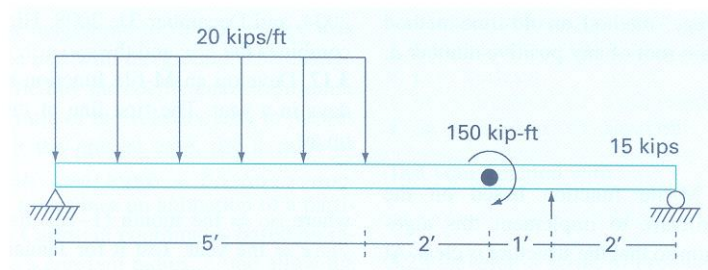


FIGURE P3.10

3.9 Manning's equation can be used to compute the velocity of water in a rectangular open channel:

$$U = \frac{\sqrt{S}}{n} \left(\frac{BH}{B + 2H} \right)^{2/3}$$

where U = velocity (m/s), S = channel slope, n = roughness coefficient, B = width (m), and H = depth (m). The following data are available for five channels:

n	S	B	H
0.036	0.0001	10	2
0.020	0.0002	8	1
0.015	0.0012	20	1.5
0.030	0.0007	25	3
0.022	0.0003	15	2.6

Write an M-file that computes the velocity for each of these channels. Enter these values into a matrix where each column represents a parameter and each row represents a channel. Have the M-file display the input data along with the computed velocity in tabular form where velocity is the fifth column. Include headings on the table to label the columns.

3.10 A simply supported beam is loaded as shown in Fig. P3.10. Using singularity functions, the displacement along the beam can be expressed by the equation:

$$u_y(x) = \frac{-5}{6} [(x-0)^4 - (x-5)^4] + \frac{15}{6} (x-8)^3 + 75(x-7)^2 + \frac{57}{6} x^3 - 238.25x$$

By definition, the singularity function can be expressed as follows:

$$\langle x-a \rangle^n = \begin{cases} (x-a)^n & \text{when } x > a \\ 0 & \text{when } x \leq a \end{cases}$$

Develop an M-file that creates a plot of displacement (dashed line) versus distance along the beam, x . Note that $x = 0$ at the left end of the beam.

3.11 The volume V of liquid in a hollow horizontal cylinder of radius r and length L is related to the depth of the liquid h by

$$V = \left[r^2 \cos^{-1} \left(\frac{r-h}{r} \right) - (r-h) \sqrt{2rh - h^2} \right] L$$

Develop an M-file to create a plot of volume versus depth. Here are the first few lines:

```
function cylinder(r, L, plot_title)
% volume of horizontal cylinder
% inputs:
% r = radius
% L = length
% plot_title = string holding plot title
```

Test your program with

```
>> cylinder(3,5,...
'Volume versus depth for horizontal...
cylindrical tank')
```