

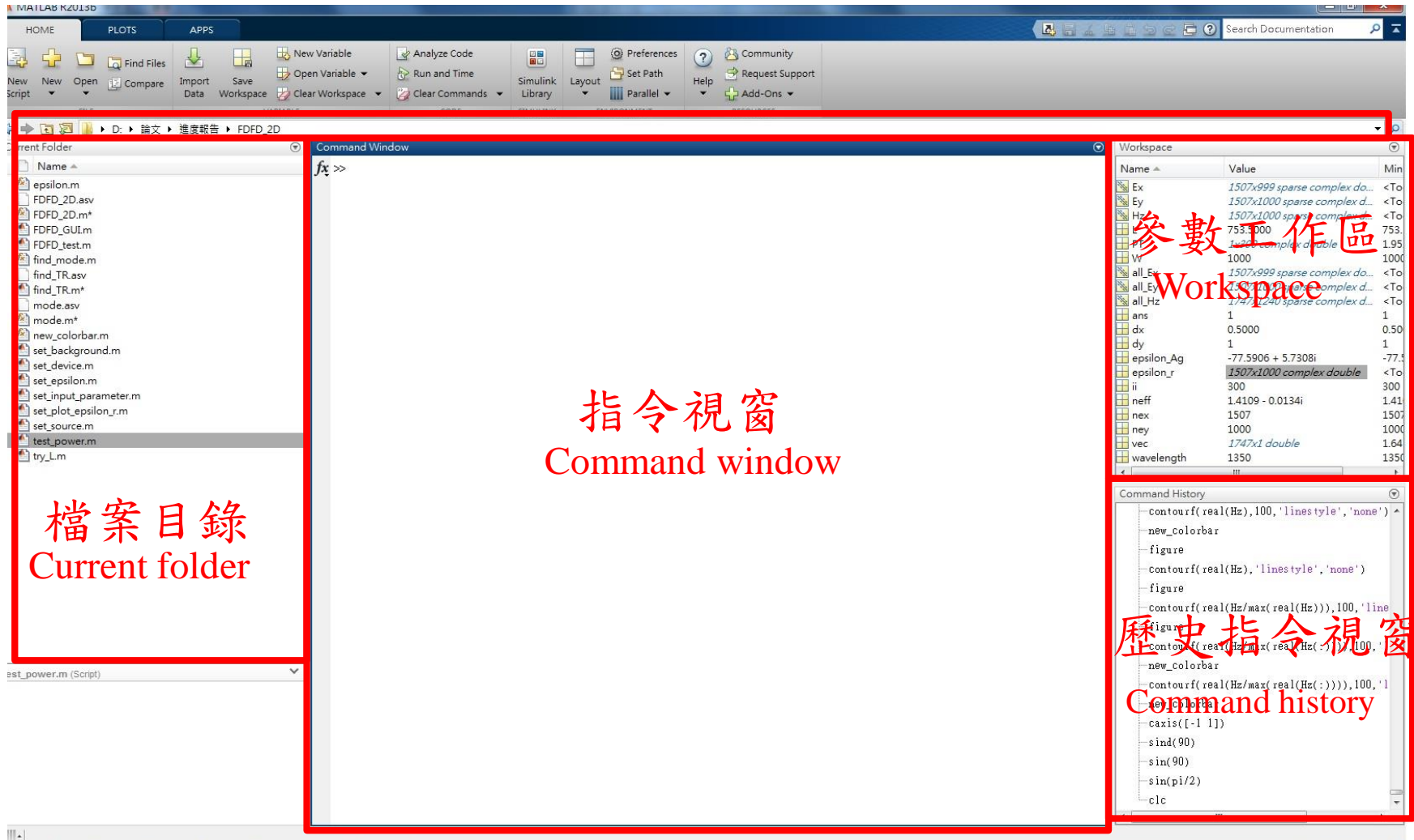
The Language of Technical Computing by Matlab

Class 1 : Scalar calculation

Outline

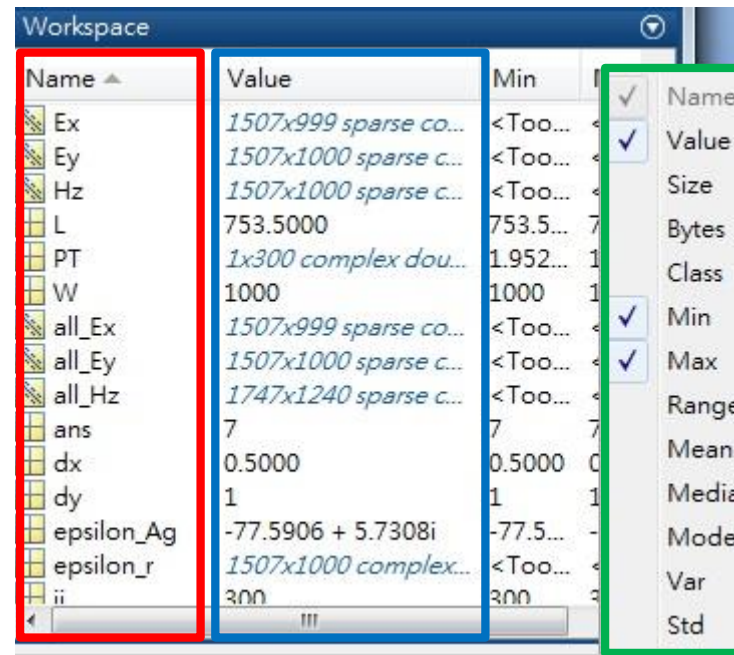
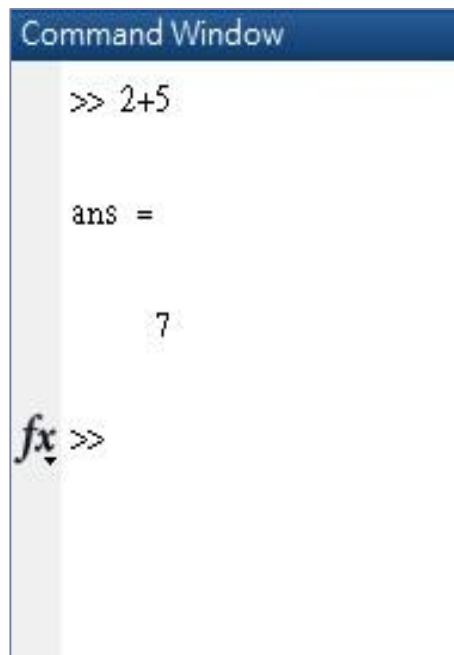
1. Basics of MATLAB
2. Script (底稿)
3. Some functions
4. for loop
5. 習題

Basics of MATLAB



Basics of MATLAB

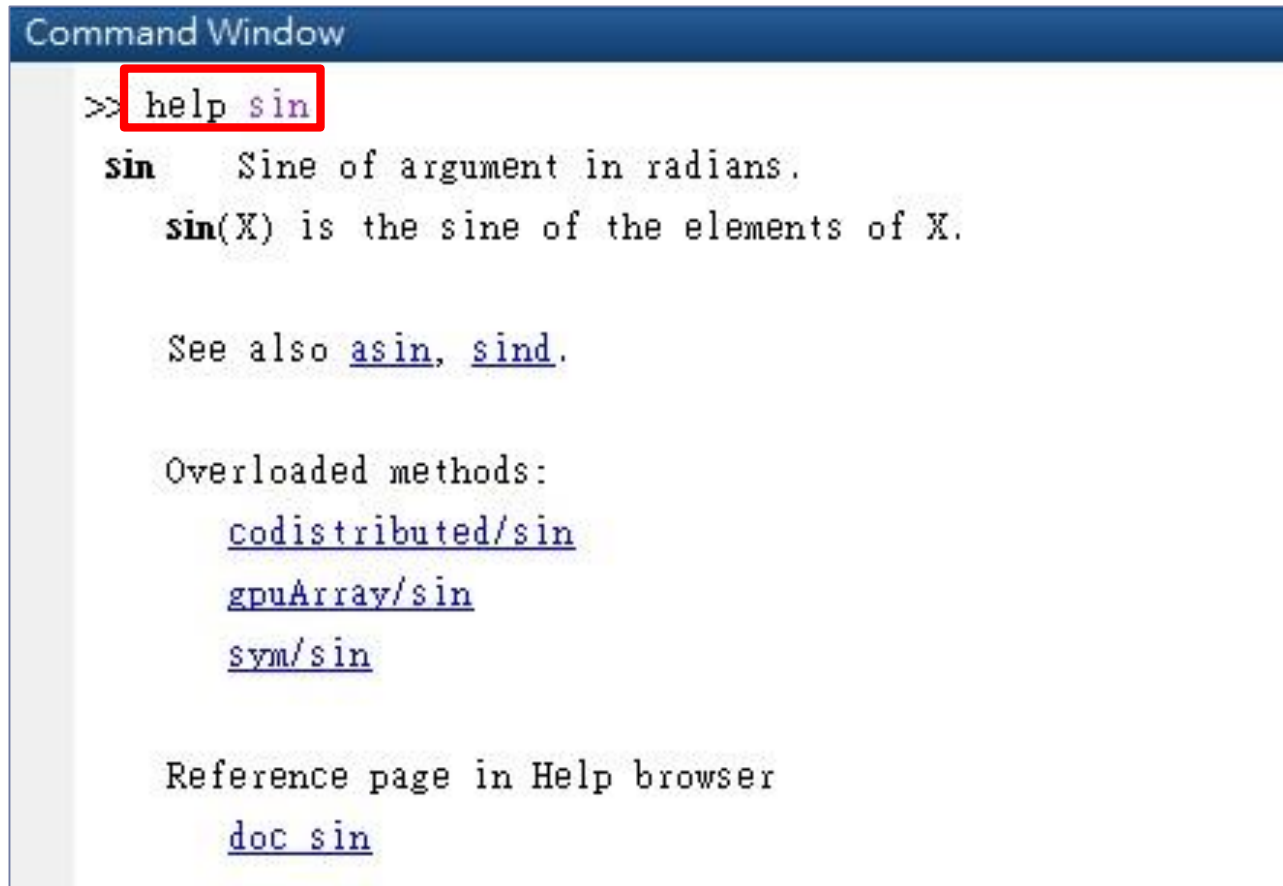
- Input and output
- Workspace (variable explorer)



變數名稱 變數值 按下滑鼠右鍵，可以選擇視窗裡要呈現的內容。

Basics of MATLAB

- help + 查詢指令名稱



```
Command Window
>> help sin
sin    Sine of argument in radians.
      sin(X) is the sine of the elements of X.

See also asin, sind.

Overloaded methods:
  codistributed/sin
  gpuArray/sin
  sym/sin

Reference page in Help browser
doc sin
```

Basics of MATLAB

- `clc` : Clear command window

```
Command Window

ans =

     7

>> ccw
Undefined function or variable 'ccw'.

>> contourf(real(Hz/max(real(Hz(:))))),100,'linestyle','none')
>> new_colorbar
>> 2+5

ans =

     7

>> sind(90)

ans =

     1

>> sin(pi/2)

ans =

     1

fx >> clc
```

輸入clc



```
Command Window

fx >>
```

Basics of MATLAB

- `clear` : Clear variables and functions from memory.

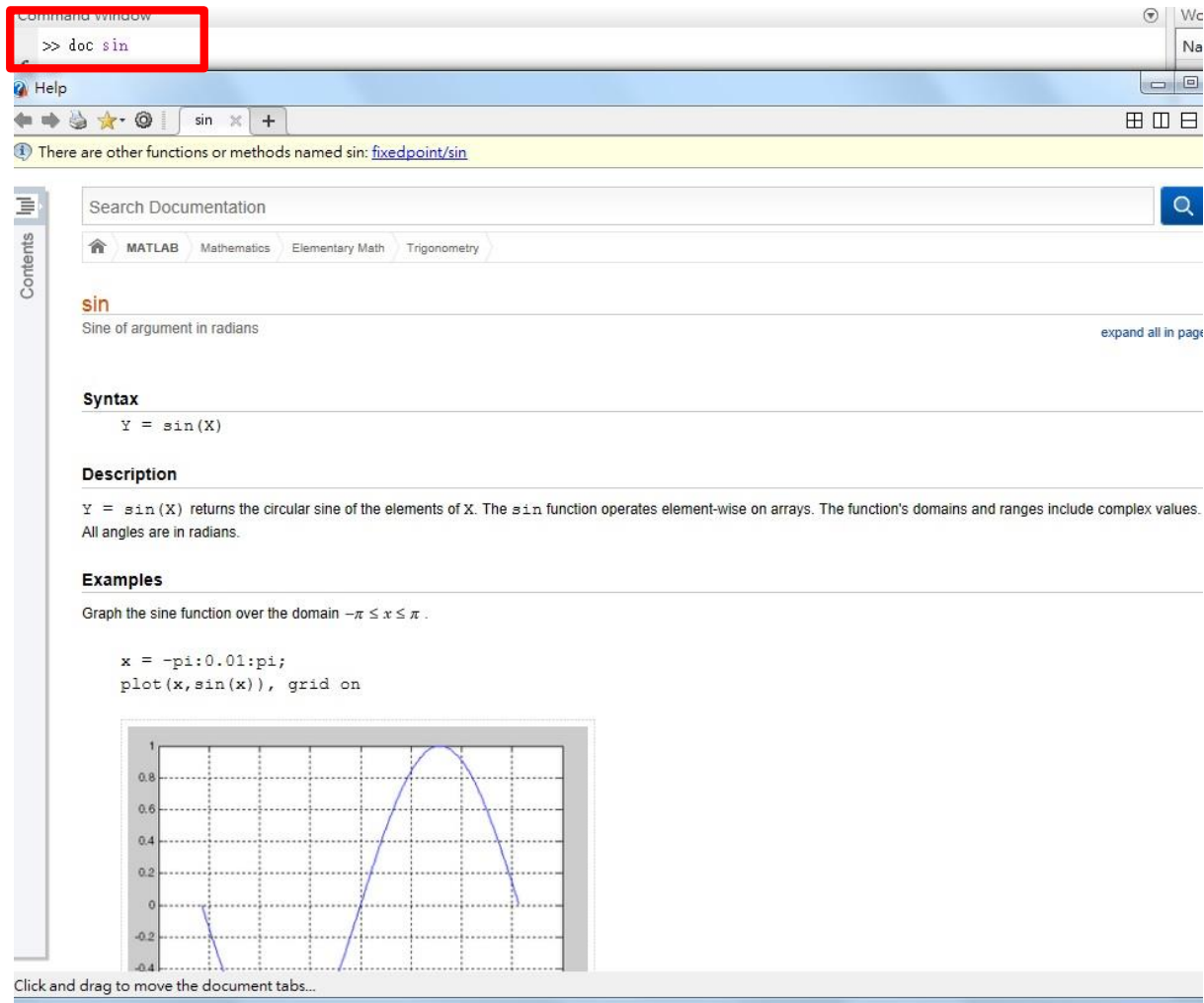
Workspace			
Name ▲	Value	Min	Max
Ex	1507x999 sparse co...	<Too...	<Too...
Ey	1507x1000 sparse c...	<Too...	<Too...
Hz	1507x1000 sparse c...	<Too...	<Too...
L	753.5000	753.5...	753.5...
PT	1x300 complex dou...	1.952...	1.991...
W	1000	1000	1000
all_Ex	1507x999 sparse co...	<Too...	<Too...
all_Ey	1507x1000 sparse c...	<Too...	<Too...
all_Hz	1747x1240 sparse c...	<Too...	<Too...
ans	1	1	1
dx	0.5000	0.5000	0.5000
dy	1	1	1
epsilon_Ag	-77.5906 + 5.7308i	-77.5...	-77.5...
epsilon_r	1507x1000 complex...	<Too...	<Too...
ii	300	300	300
neff	1.4109 - 0.0134i	1.410...	1.410...
nex	1507	1507	1507
ney	1000	1000	1000
vec	1747x1 double	1.641...	1
wavelength	1350	1350	1350

輸入clear

Workspace			
Name ▲	Value	Min	Max

Basics of MATLAB

- doc+查詢指令名稱



The screenshot shows the MATLAB Command Window and the Help browser. In the Command Window, the command `>> doc sin` is entered. The Help browser displays the documentation for the `sin` function. The documentation includes a search bar, navigation tabs (MATLAB, Mathematics, Elementary Math, Trigonometry), and sections for Syntax, Description, and Examples. The Syntax section shows `Y = sin(X)`. The Description section explains that `Y = sin(X)` returns the circular sine of the elements of `X`. The Examples section shows a code snippet for plotting the sine function over the domain $-\pi \leq x \leq \pi$.

Syntax

```
Y = sin(X)
```


Description

`Y = sin(X)` returns the circular sine of the elements of `X`. The `sin` function operates element-wise on arrays. The function's domains and ranges include complex values. All angles are in radians.

Examples

Graph the sine function over the domain $-\pi \leq x \leq \pi$.

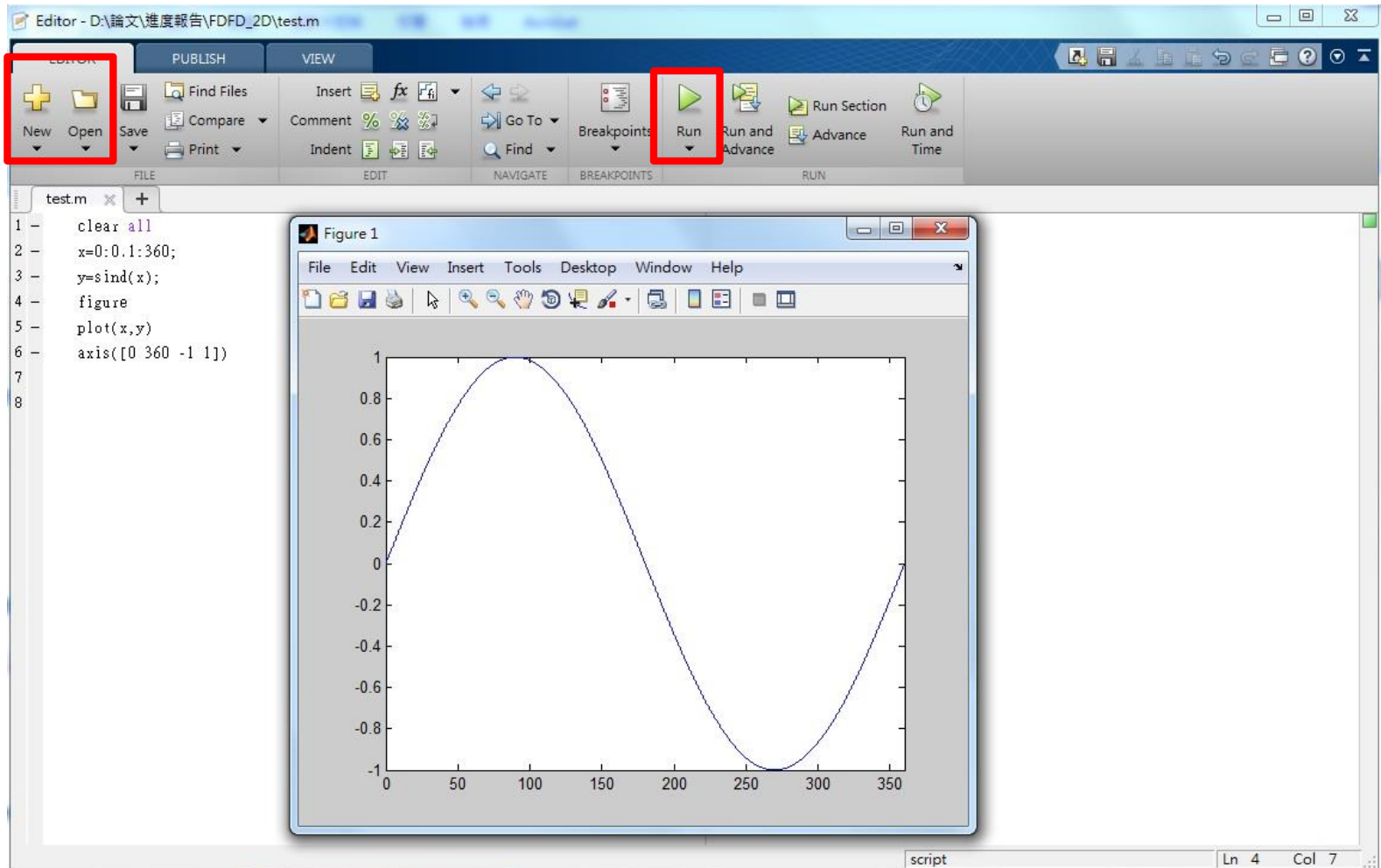
```
x = -pi:0.01:pi;  
plot(x,sin(x)), grid on
```



Click and drag to move the document tabs...

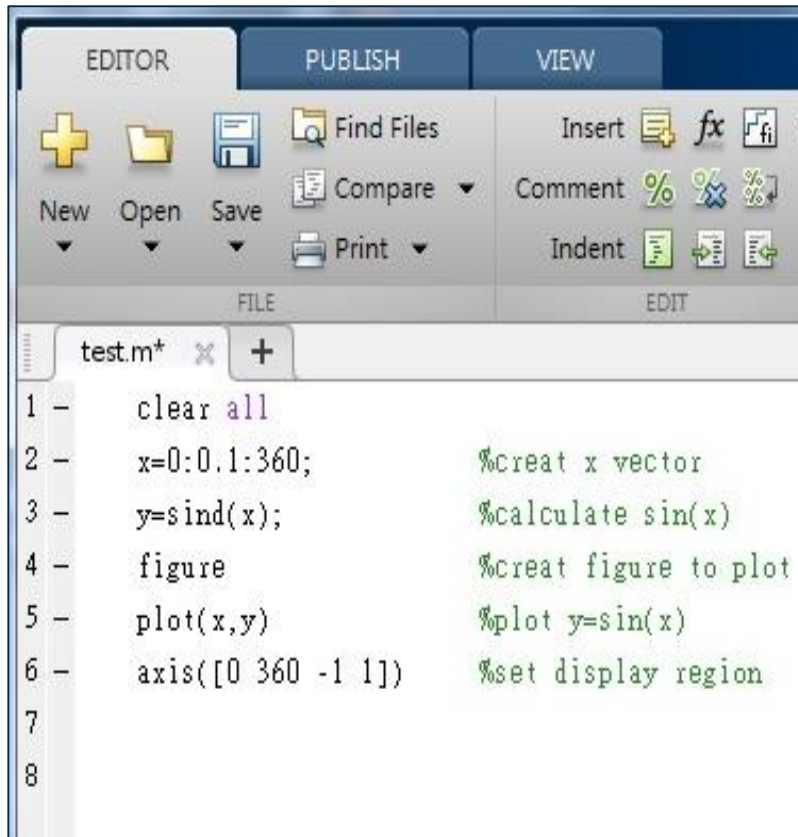
Script (可存檔底稿)

- Coding in the script instead of command window



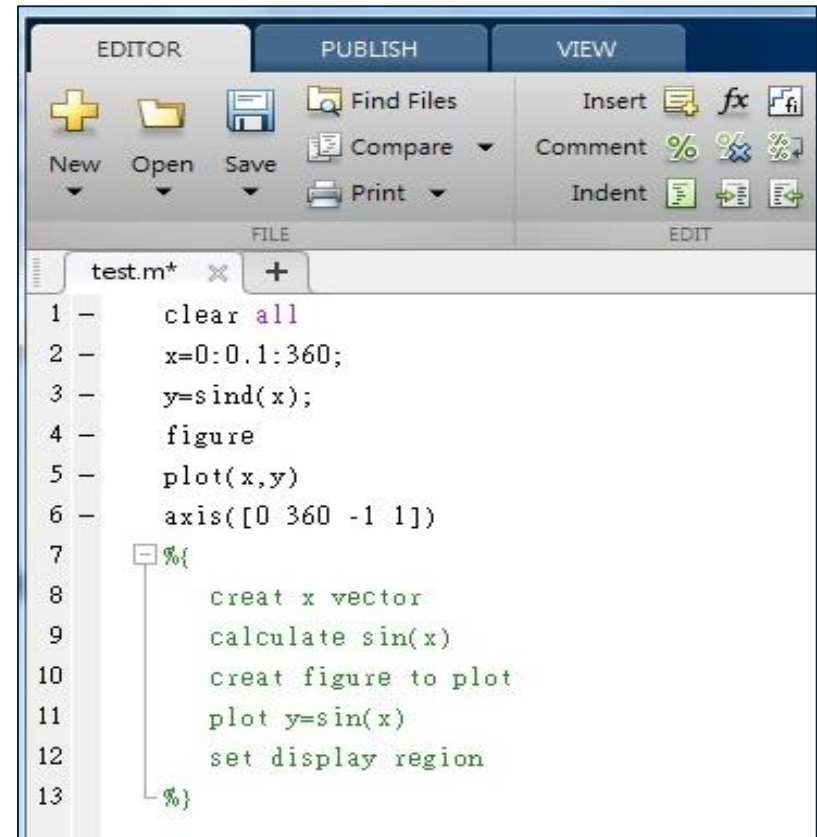
Script

- Comment % 標註



The image shows the MATLAB Editor window with a script named 'test.m'. The script contains the following code with comments:

```
1 - clear all
2 - x=0:0.1:360;      %creat x vector
3 - y=sind(x);        %calculate sin(x)
4 - figure           %creat figure to plot
5 - plot(x,y)         %plot y=sin(x)
6 - axis([0 360 -1 1]) %set display region
7
8
```

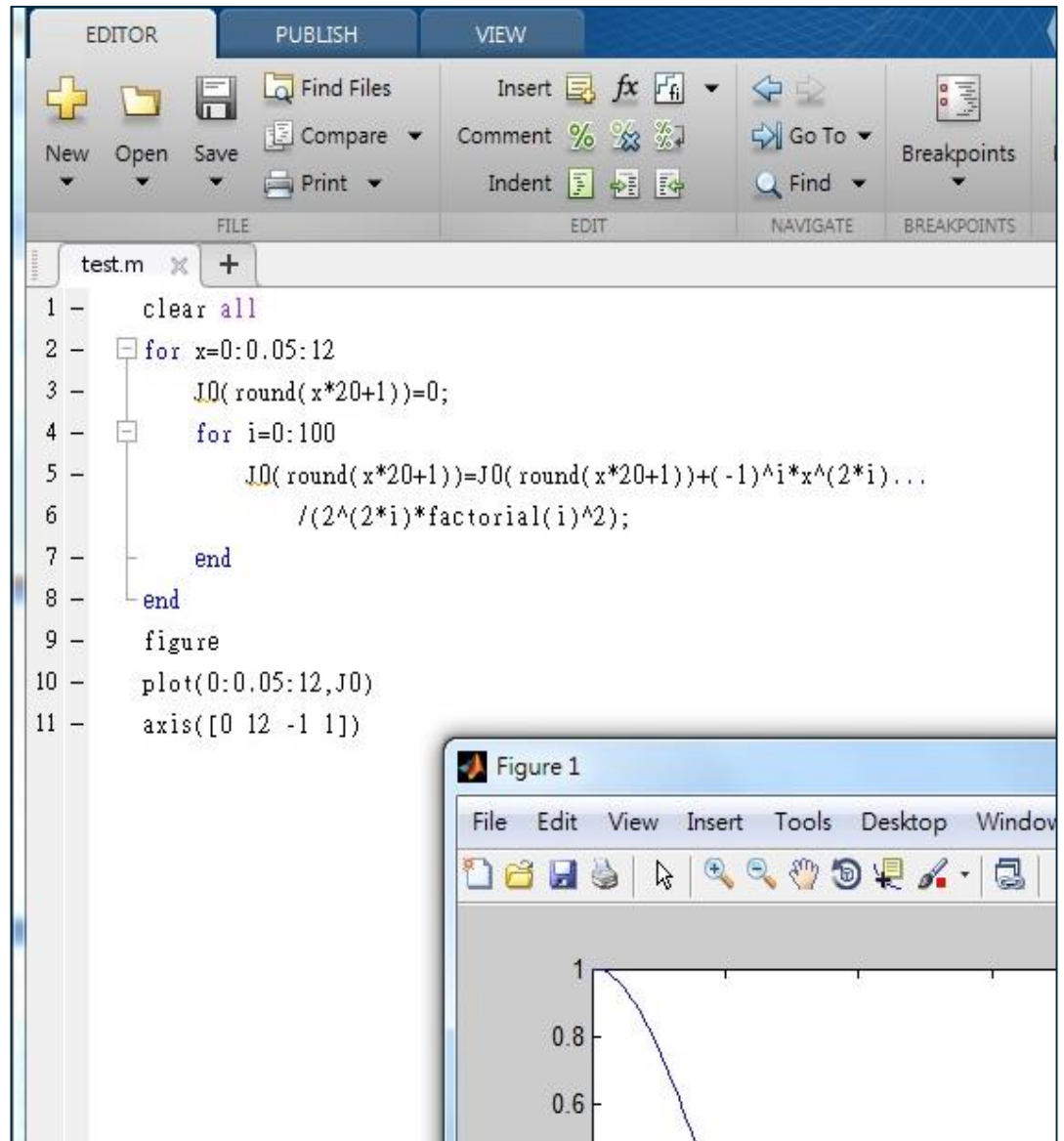


The image shows the MATLAB Editor window with a script named 'test.m'. The script contains the following code with comments:

```
1 - clear all
2 - x=0:0.1:360;
3 - y=sind(x);
4 - figure
5 - plot(x,y)
6 - axis([0 360 -1 1])
7 - %{\
8 -     creat x vector
9 -     calculate sin(x)
10 -    creat figure to plot
11 -    plot y=sin(x)
12 -    set display region
13 - %}
```

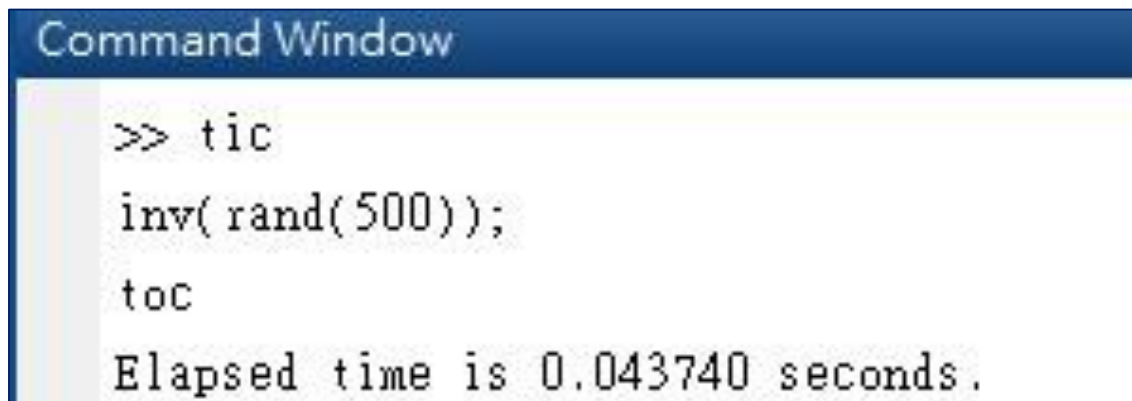
Script

- If there's too ...
much stuff in a line



Script

- Variable names
 - ▶ Always start with a letter.
 - ▶ Spacings are not allowed.
 - O** answer_1, pig123, TAisFat
 - X** 9487cat, cat 9487
- tic toc
 - ▶ timer

A screenshot of the MATLAB Command Window. The window has a dark blue title bar with the text "Command Window" in white. The main area is white with a light gray vertical bar on the left. The text in the window is as follows:

```
>> tic  
inv(rand(500));  
toc  
Elapsed time is 0.043740 seconds.
```

Script

- When semicolon is at the end;
 - ▶ Suppress the output display.

```
Command Window
>>
x = 3*pi*10
y = x*12345

x =

    94.2478

y =

    1.1635e+06
```

```
Command Window
>>
x = 3*pi*10; % 不顯示x
y = x*12345

y =

    1.1635e+06
```

加減乘除

運算符號	代表意義	範例
+	加法	5+3
-	減法	5-3
*	乘法	5*3
/ or \	除法	5/3
^	次方	5^3

```
Command Window
>> 5+3
ans =
    8
>> 5-3
ans =
    2
>> 5*3
ans =
   15
>> 5/3
ans =
   1.6667
>> 5^3
ans =
   125
```

永久常數

永久常數	說明
pi	圓周率
inf	無限大
i,j	虛數(complex)
nan	不存在
realmax	系統的最大數值
realmin	系統的最小數值

```
Command Window
>> pi
ans =
    3.1416
>> 1/0
ans =
    Inf
>> 0/0
ans =
    NaN
>> realmax
ans =
    1.7977e+308
>> realmin
ans =
    2.2251e-308
```

三角函數(徑度)

三角函數(徑度)	範例
$\sin(x)$	$\sin(\pi)$
$\cos(x)$	$\cos(\pi)$
$\tan(x)$	$\tan(\pi)$
$\cot(x)$	$\cot(\pi)$
$\sec(x)$	$\sec(\pi)$
$\csc(x)$	$\csc(\pi)$

Command Window

```
>> sin(pi)

ans =

    1.2246e-16

>> cos(pi)

ans =

    -1

>> tan(pi)

ans =

   -1.2246e-16

>> cot(pi)

ans =

   -8.1656e+15

>> sec(pi)

ans =

    -1

>> csc(pi)

ans =

    8.1656e+15
```


三角函數(度)

三角函數(度)	範例
<code>sind(x)</code>	<code>sind(180)</code>
<code>cosd(x)</code>	<code>cosd(180)</code>
<code>tand(x)</code>	<code>tand(180)</code>
<code>cotd(x)</code>	<code>cotd(180)</code>
<code>secd(x)</code>	<code>secd(180)</code>
<code>cscd(x)</code>	<code>cscd(180)</code>

```
Command Window
>> sind(180)

ans =

    0

>> cosd(180)

ans =

   -1

>> tand(180)

ans =

    0

>> cotd(180)

ans =

   Inf

>> secd(180)

ans =

   -1

>> cscd(180)

ans =

   Inf
```

反三角函數(徑度)

反三角函數(徑度)	範例
$\text{asin}(x)$	$\text{asin}(1)$
$\text{acos}(x)$	$\text{acos}(1)$
$\text{atan}(x)$	$\text{atan}(1)$
$\text{acot}(x)$	$\text{acot}(1)$
$\text{asec}(x)$	$\text{asec}(1)$
$\text{acsc}(x)$	$\text{acsc}(1)$

```
Command Window
>> asin(1)
ans =
    1.5708
>> acos(1)
ans =
    0
>> atan(1)
ans =
    0.7854
>> acot(1)
ans =
    0.7854
>> asec(1)
ans =
    0
>> acsc(1)
ans =
    1.5708
```

反三角函數(度)

反三角函數(度)	範例
<code>asind(x)</code>	<code>asind(1)</code>
<code>acosd(x)</code>	<code>acosd(1)</code>
<code>atand(x)</code>	<code>atand(1)</code>
<code>acotd(x)</code>	<code>acotd(1)</code>
<code>asecd(x)</code>	<code>asecd(1)</code>
<code>acscd(x)</code>	<code>acscd(1)</code>

```

Command Window
>> asind(1)

ans =

    90

>> acosd(1)

ans =

     0

>> atand(1)

ans =

    45

>> acotd(1)

ans =

    45

>> asecd(1)

ans =

     0

>> acscd(1)

ans =

    90
    
```

雙曲函數

雙曲函數	範例
$\sinh(x)$	$\sinh(1)$
$\cosh(x)$	$\cosh(1)$
$\tanh(x)$	$\tanh(1)$
$\coth(x)$	$\coth(1)$
$\operatorname{sech}(x)$	$\operatorname{sech}(1)$
$\operatorname{csch}(x)$	$\operatorname{csch}(1)$

Command Window

```
>> sinh(1)

ans =

    1.1752

>> cosh(1)

ans =

    1.5431

>> tanh(1)

ans =

    0.7616

>> coth(1)

ans =

    1.3130

>> sech(1)

ans =

    0.6481

>> csch(1)

ans =

    0.8509
```

反雙曲函數

反雙曲函數	範例
$\operatorname{asinh}(x)$	$\operatorname{asinh}(-1)$
$\operatorname{acosh}(x)$	$\operatorname{acosh}(-1)$
$\operatorname{atanh}(x)$	$\operatorname{atanh}(-1)$
$\operatorname{acoth}(x)$	$\operatorname{acoth}(-1)$
$\operatorname{asech}(x)$	$\operatorname{asech}(-1)$
$\operatorname{acsch}(x)$	$\operatorname{acsch}(-1)$

Command Window

```
>> asinh(-1)

ans =

    -0.8814

>> acosh(-1)

ans =

    0.0000 + 3.1416i

>> atanh(-1)

ans =

    -Inf

>> acoth(-1)

ans =

    -Inf

>> asech(-1)

ans =

    0.0000 + 3.1416i

>> acsch(-1)

ans =

    -0.8814
```

指數對數

指數	說明	範例
$\exp(x)$	自然指數函數	$\exp(3)$

對數	說明	範例
$\log(x)$	以自然數為底	$\log(\exp(1))$
$\log_2(x)$	以2為底	$\log_2(8)$
$\log_{10}(x)$	以10為底	$\log_{10}(1e+3)$

```
Command Window
>> exp(3)

ans =

    20.0855

>> log(exp(1))

ans =

     1

>> log2(8)

ans =

     3

>> log10(1e+3)

ans =

     3
```

在Matlab裡，小寫e或大寫E
都用來表示10的次方。

PS : 任意底數 $\log_b x = \log(x) / \log(b)$

平方、根號

次方	說明	範例
x^n	x的n次方	5^{10}

根號	說明	範例
$\text{sqrt}(x)$	x開根號	$\text{sqrt}(-36)$
$\text{nthroot}(x,n)$	x開n次根	$\text{nthroot}(-853,6)$

Command Window

```
>> 5^10
```

```
ans =
```

```
9765625
```

```
>> sqrt(-36)
```

```
ans =
```

```
0.0000 + 6.0000i
```

```
>> nthroot(-853,6)
```

```
Error using nthroot (line 32)
```

```
If X is negative, N must be an odd integer.
```

```
>> -853^(1/6)
```

```
ans =
```

```
-3.0796
```

複數運算

函數	說明	範例
abs(z)	z的絕對值	abs(3+4i)
angle(z)	z的主幅角(徑度) ($-\pi \sim \pi$)	angle(3+4i)
complex(a,b)	建立複數， 實部a虛部b	complex(3,4)
conj(z) or z'	複數z的共軛複數	conj(3+4i)
imag(z)	取出複數z的虛部	imag(3+4i)
real(z)	取出複數z的實部	real(3+4i)

```

Command Window

>> abs(3+4i)

ans =

    5

>> angle(3+4i)

ans =

    0.9273

>> complex(3,4)

ans =

    3.0000 + 4.0000i

>> conj(3+4i)

ans =

    3.0000 - 4.0000i

>> imag(3+4i)

ans =

    4

>> real(3+4i)

ans =

    3
  
```


捨取、餘數函數

函數	說明	範例
fix(x)	捨棄x的小數	fix(-4.2)
floor(x)	小於等於x的最大整數	floor(-4.2)
ceil(x)	大於等於x的最小整數	ceil(-4.2)
round(x)	最靠近x的整數	round(-4.2)
rem(x,y)	x/y的餘數	rem(50.4,3)

Command Window

```
>> fix(-4.2)

ans =

    -4

>> floor(-4.2)

ans =

    -5

>> ceil(-4.2)

ans =

    -4

>> round(-4.2)

ans =

    -4

>> rem(50.4,3)

ans =

    2.4000
```

其它函數

函數	說明	範例
factor(x)	求出整數x的質因數	factor(17892)
factorial(x)	$x!$ (階)	factorial(10)
gcd(a,b)	a,b的最大公因數	gcd(48,120)
lcm(a,b)	a,b的最小公倍數	lcm(48,120)
primes(x)	小於等於x的所有質數	primes(10)
isprime(x)	判斷x是否為質數， 1(是)0(否)	isprime(17891)

```

Command Window
>> factor(17892)

ans =

     2     2     3     3     7    71

>> factorial(10)

ans =

    3628800

>> gcd(48,120)

ans =

     24

>> lcm(48,120)

ans =

    240

>> primes(10)

ans =

     2     3     5     7

>> isprime(17891)

ans =

     1
    
```

for

- for loop to repeat specified number of times

迴圈變數 某個值

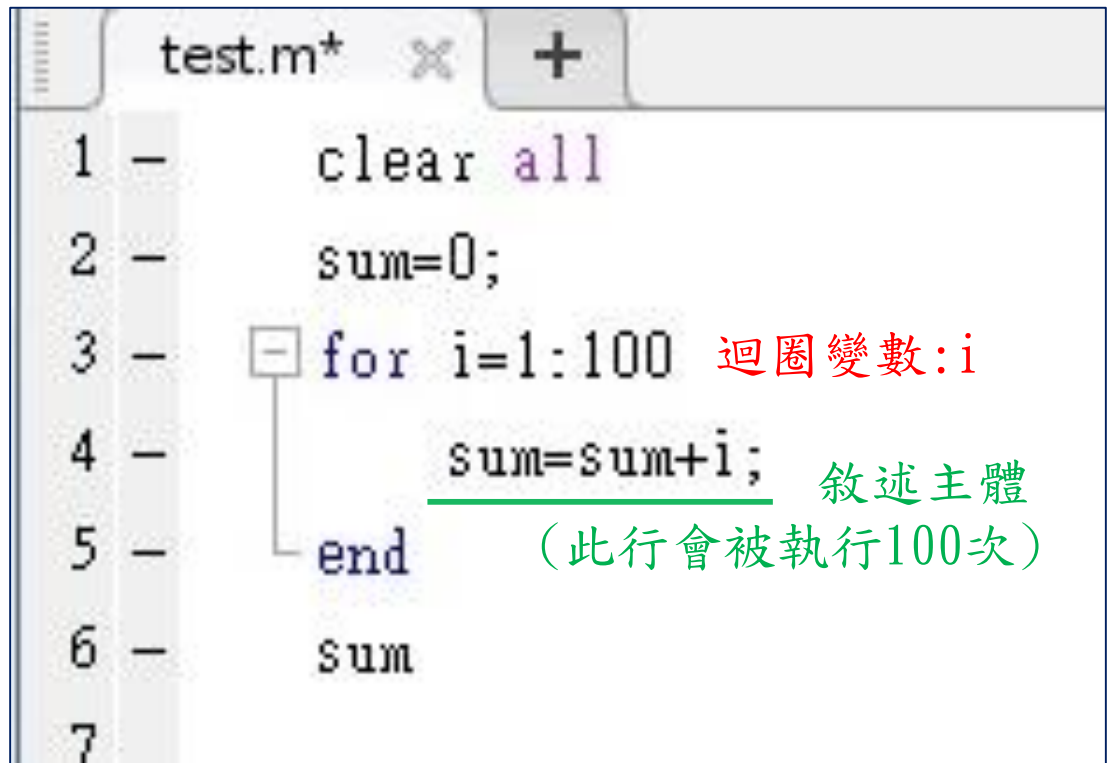
```
for index = values  
    statement1;  
    statement2
```

```
end
```

Hint:

Matlab裡1:100代表一個
從1到100的向量。

a = 1:3 等同於 a = [1,2,3]



```
test.m*  ×  +  
1 -      clear all  
2 -      sum=0;  
3 -      for i=1:100  迴圈變數:i  
4 -          sum=sum+i;  敘述主體  
5 -      end          (此行會被執行100次)  
6 -      sum  
7
```

```
>> sum 5050
```

for

• Ex:
$$\sum_{n=0}^{100} \frac{(-1)^n x^{2n}}{2^{2n} (n!)^2}$$

迴圈變數: x

向量: 0:0.05:12

```
test.m* x +
1 - clear all
2 - for x=0:0.05:12
3 -     J0(round(x*20+1))=0;
4 -     for i=0:100
5 -         J0(round(x*20+1))=J0(round(x*20+1))+(-1)^i*x^(2*i)/(2^(2*i)*factorial(i)^2);
6 -     end
7 - end
8 - figure
9 - plot(0:0.05:12,J0)
10 - axis([0 12 -1 1])
11
```

敘述主體1(執行了 $\frac{12-0}{0.05} = 240$ 次)

敘述主體2(執行了 $240 * 101$ 次)

Hint:

round(): 四捨五入至整數

習題

1. 已知 $\sin(x)$ 、 $\cos(x)$ 的Taylor級數展開為：

$$\sin(x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{(2n+1)}}{(2n+1)!}$$

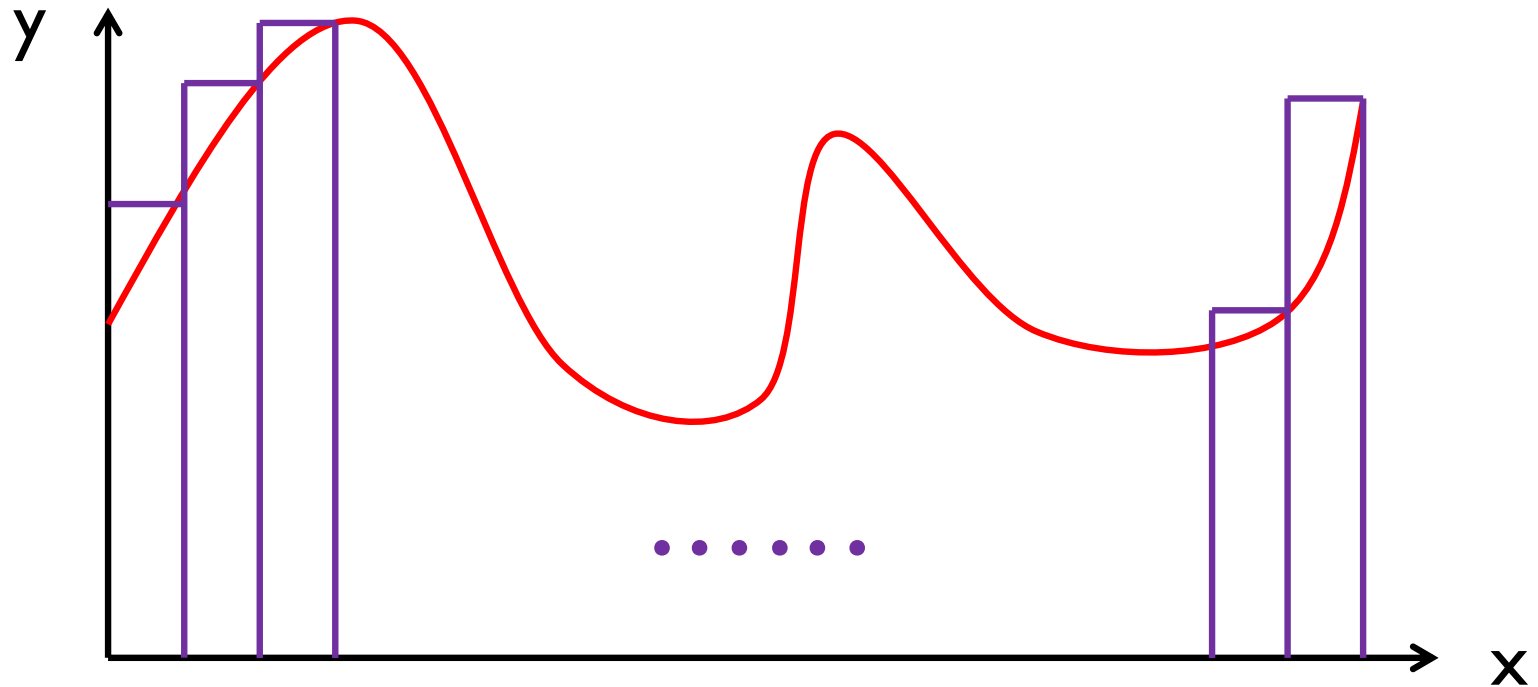
$$\cos(x) = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n}}{(2n)!}$$

請利用此方程式去計算 $\sin(\pi)$ 和 $\cos(\pi)$ 的值，並且計算其誤差。

(加分題) $n = ?$ 誤差 < 0.00001

習題

2. 利用微積分中積分的定義，請計算 $\int_0^{10} e^x dx$ 的數值，並計算其誤差。



Hint: 將此積分圖切成小等分的長方形，分割越精細誤差越小。