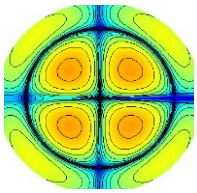

DOING PHYSICS WITH MATLAB

OSCILLATIONS

Graphical User Interface (GUI):
Simple Harmonic Motion and the Sine Function

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DOWNLOAD DIRECTORY FOR MATLAB SCRIPTS

wav_shm_sine.m **wav_shm_sine_cal.m**

mscripts are used to investigate simple harmonic motion through the sine function using a GUI. They also provide a template for creating your own simple GUI using input boxes.

SIMPLE HARMONIC MOTION (SHM)

Linear simple harmonic motion is motion in a straight line with an acceleration proportional to the distance from an equilibrium position and directed towards that equilibrium point.

Consider SHM along the Y-axis and the equilibrium position corresponding to the origin at $y = 0$. In SHM, an object will oscillate around the equilibrium position with an amplitude A and period T. The frequency f and angular frequency ω for the motion are

$$f = \frac{1}{T} \qquad \omega = 2\pi \; f = \frac{2\pi}{T}$$

The displacement $y(t)$ at any time t is given by the sine function which can be expressed as

$$y(t) = A\sin\left(\frac{2\pi t}{T} + \phi\right)$$
$$y(t) = A\sin\left(2\pi f\, t + \phi\right)$$
$$y(t) = A\sin\left(\omega t + \phi\right)$$

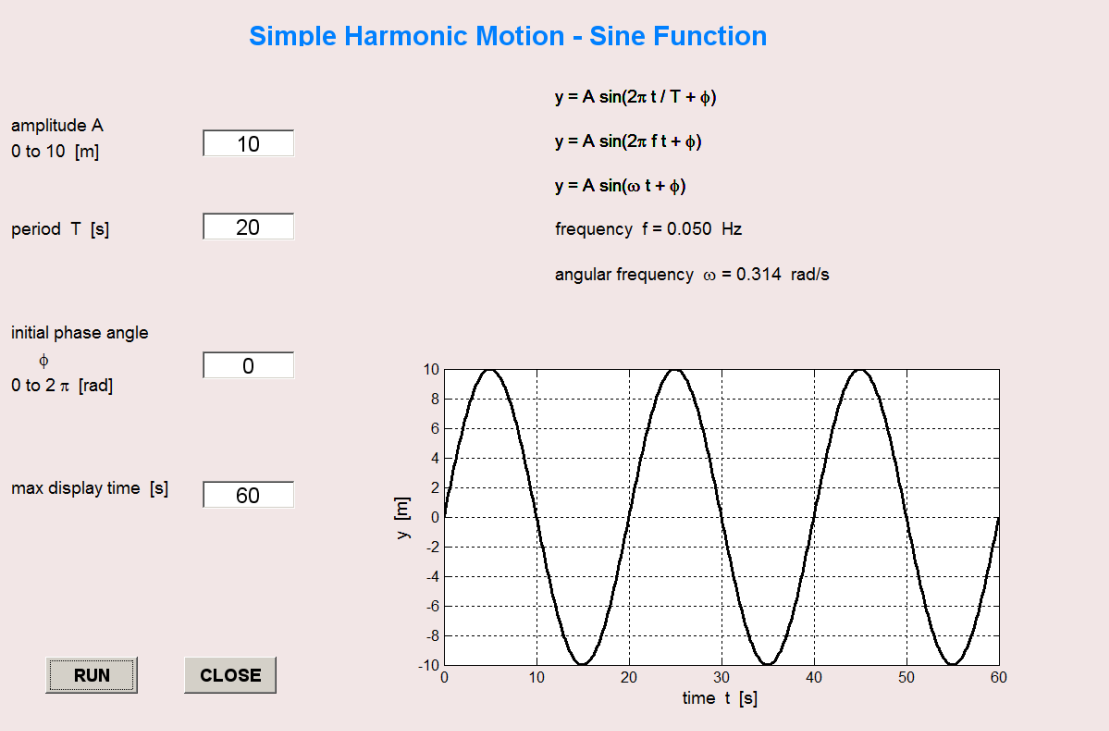
where ϕ is the initial phase angle [radians]. It gives the value of y at time $t = 0$

$$\text{initial position} \quad y(0) = A\sin\left(\phi\right)$$

If $\phi = \frac{\pi}{2}$ then the displacement y can be expressed as

$$y(t) = A\cos\left(\frac{2\pi t}{T}\right)$$

To illustrate the dependence of the displacement y on time t, period T and initial phase angle ϕ you can run the mscript **wav_shm_sine.m** . This mscript uses a GUI to input the parameters and to view the graphical response. The figures below show the Figure Window for the GUI.



Simple Harmonic Motion - Sine Function

amplitude A
0 to 10 [m] 5

period T [s] 10

initial phase angle
ϕ
0 to 2 π [rad] pi/2

max display time [s] 30

RUN CLOSE

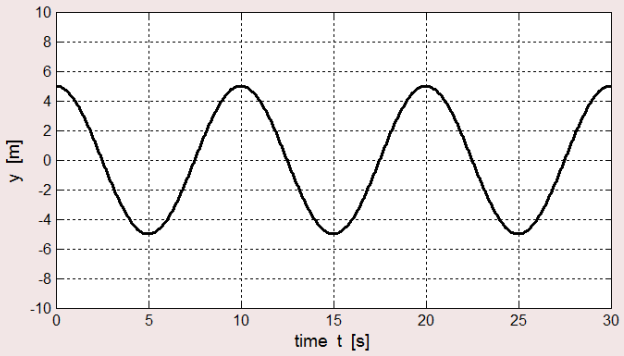
$y = A \sin(2\pi t / T + \phi)$

$y = A \sin(2\pi f t + \phi)$

$y = A \sin(\omega t + \phi)$

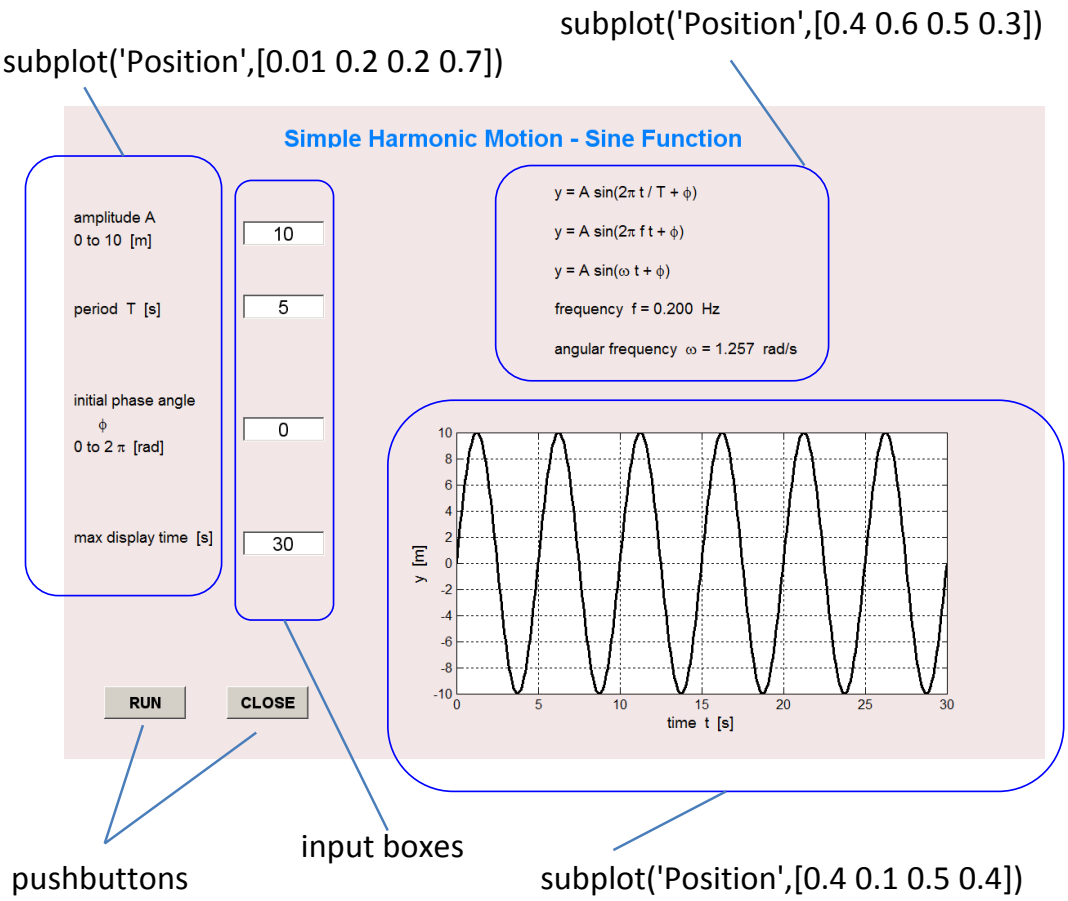
frequency f = 0.100 Hz

angular frequency ω = 0.628 rad/s



THE Graphical User Interface

You can use the two mscripts **wav_shm_sine.m** and **wav_shm_sine.m** as templates to create a simple GUI for your own simulations.



Step 1 Create the Figure Window

Size of Window: origin at (xF, yF) width xL height yL

```
xF = 20; yF = 50; xL = 1200; yL = 800;

% Main figure window ----------------------------------------
 f1 = figure('Color',[0.95 0.9 0.9],'Name','SHM', ...
'NumberTitle','off','Position',[xF yF xL yL]);
```

Step 2 Create the main heading

```
% heading ---------------------------------------------------
pos = [250 750 600 30];
colorBG = [0.95 0.9 0.9];
colorFG = [0 0.5 1];
fs = 18;
textD = 'Simple Harmonic Motion - Sine Function';
t1 = uicontrol(gcf,'Style','text','Position',pos, ...
 'String',textD,'FontSize',fs, ...
 'HorizontalAlignment','center','FontWeight','bold', ...
 'BackgroundColor',colorBG,'ForegroundColor',colorFG);
```

Step 3 Initial values for input boxes and create input boxes A, B, C and D

```
      % Input Initial Data
      ym = 10; T = 5; phi = 0; tMax = 30; Nt = 500;
      boxA = ym; boxB = T; boxC = phi; boxD = tMax;

% box 1 A ------------------------------------------------------------
 pos = [220 630 100 30];
 colorBG = [1 1 1];
 colorFG = [0 0 0];
 fs = 14;
 Edit_A = uicontrol(gcf,'Style','edit','Position',pos, ...
          'String',boxA,'FontSize',fs,'BackgroundColor',colorBG, ...
          'Callback','boxA = str2num(get(Edit_A,''String''));');

  % box 2 B ------------------------------------------------------------
  pos = [220 540 100 30];
  colorBG = [1 1 1];
  colorFG = [0 0 0];
  fs = 14;
  Edit_B = uicontrol(gcf,'Style','edit','Position',pos, ...
          'String',boxB,'FontSize',fs,'BackgroundColor',colorBG, ...
          'Callback','boxB = str2num(get(Edit_B,''String''));');

% box 3 C ------------------------------------------------------------
  pos = [220 390 100 30];
  colorBG = [1 1 1];
  colorFG = [0 0 0];
  fs = 14;
  Edit_C = uicontrol(gcf,'Style','edit','Position',pos, ...
          'String',boxC,'FontSize',fs,'BackgroundColor',colorBG, ...
          'Callback','boxC = str2num(get(Edit_C,''String''));');

% box 4 D ------------------------------------------------------------
  pos = [220 250 100 30];
  colorBG = [1 1 1];
  colorFG = [0 0 0];
  fs = 14;
  Edit_D = uicontrol(gcf,'Style','edit','Position',pos, ...
          'String',boxD,'FontSize',fs,'BackgroundColor',colorBG, ...
          'Callback','boxD = str2num(get(Edit_D,''String''));');
```

Step 4 Create and position pushbuttons RUN and CLOSE

```
% PUSHBUTTONS  ++++++++++++++++++++++++++++++++++++++++++++++++++

pushbutton_run = uicontrol(gcf,'Style','pushbutton','Position',...
     [50 50 100 40], 'FontSize',12,'FontWeight','bold',
'String','RUN', ...
     'CallBack', 'wav_shm_sine_cal');


 pushbutton_close = uicontrol(gcf,'Style','pushbutton','Position',...
     [200 50 100 40], 'FontSize',12,'FontWeight','bold',
'String','CLOSE', ...
     'CallBack', 'close');
```

Step 5 Create subplot regions for text and graphs

Description of input parameters

```
plot1 = subplot('Position',[0.01 0.2 0.2 0.7]);
set(gca,'Xlim',[0 10]);
set(gca,'Ylim',[0 10]);
text(0,9,'amplitude A','FontSize',12');
text(0,8.5,'0 to 10  [m]','FontSize',12');
text(0,7,'period  T  [s]','FontSize',12');
text(0,5,'initial phase angle','FontSize',12');
text(0,4.5,'      \phi ','FontSize',12');
text(0,4,'0 to 2 \pi  [rad]','FontSize',12');
text(0,2,'max display time  [s]','FontSize',12');
axis off
```

Output parameters

```
plot1 = subplot('Position',[0.4 0.6 0.5 0.3]);
set(gca,'Xlim',[0 10]);
set(gca,'Ylim',[0 10]);
text(2,9,'y = A sin(2\pi t / T + \phi)','FontSize',12');
text(2,7,'y = A sin(2\pi f t + \phi)','FontSize',12');
text(2,5,'y = A sin(\omega t + \phi)','FontSize',12');
tm1 = 'frequency  f = ';
tm2 = num2str(f,'%3.3f\n');
tm3 = '  Hz';
tm = [tm1 tm2 tm3];
text(2,3,tm,'FontSize',12');
tm1 = 'angular frequency  \omega = '; tm2 =
num2str(w,'%3.3f');
tm3 = '  rad/s';
tm = [tm1 tm2 tm3];
text(2,1,tm,'FontSize',12');
axis off
```

Plot

```
plot1 = subplot('Position',[0.4 0.1 0.5 0.4]);
xP = t; yP = y;
plot(xP,yP,'k','lineWidth',2);
axis on; grid on;
xlabel('time  t  [s]','FontSize',12');
ylabel('y  [m]','FontSize',12');
set(gca,'Ylim',[-10 10]);
```

Step 6 Create the mscript for the CallBack for the RUN pushbutton

Reads values entered into input boxes, calculates output parameters and updates graph and output parameters

```
% wav_shm_sine_cal.m
% CallBack mscript for wav_shm_sine.m

% Reads values from input boxes ------------------------------------
----
ym = boxA;
T  = boxB;
phi = boxC;
tMax = boxD;
t = linspace(0,tMax,Nt);
y = ym .* sin(2*pi*t/T + phi);
f = 1 / T; w = 2*pi*f;
```

```
% PLOT ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    plot1 = subplot('Position',[0.4 0.1 0.5 0.4]);
    xP = t; yP = y;
    plot(xP,yP,'k','lineWidth',2);
    axis on; grid on;
    xlabel('time  t  [s]','FontSize',12');
    ylabel('y  [m]','FontSize',12');
    set(gca,'Ylim',[-10 10]);

% Output parameters ------------------------------------------------

     plot1 = subplot('Position',[0.4 0.6 0.5 0.3]);
     set(gca,'Xlim',[0 10]);
     set(gca,'Ylim',[0 10]);
     text(2,9,'y = A sin(2\pi t / T + \phi)','FontSize',12');
     text(2,7,'y = A sin(2\pi f t + \phi)','FontSize',12');
     text(2,5,'y = A sin(\omega t + \phi)','FontSize',12');
      colorBG = [0.95 0.9 0.9];
     tmA = 'yyyyyyyyyyyyyyyyyyyyyyyyyyyyyy';
      text_h =
     text(2,3,tmA,'FontSize',16','color',colorBG,'EdgeColor',colorBG,
      ...
     'BackgroundColor',colorBG);
      tm1 = 'frequency  f = ';
     tm2 = num2str(f,'%3.3f\n');
     tm3 = '  Hz';
     tm = [tm1 tm2 tm3];
     text(2,3,tm,'FontSize',12');
     text_h =
     text(2,1,tmA,'FontSize',16','color',colorBG,'EdgeColor',colorBG,
      ...
     'BackgroundColor',colorBG);
     tm1 = 'angular frequency  \omega = '; tm2 = num2str(w,'%3.3f');
     tm3 = '  rad/s';
     tm = [tm1 tm2 tm3];
     text(2,1,tm,'FontSize',12');
     axis off
```