DOING PHYSICS WITH MATLAB

APP DESIGNER

GUI SIMULATIONS

SINUSOIDAL FUNCTIONS

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DOWNLOAD DIRECTORY FOR MATLAB SCRIPTS

https://github.com/D-Arora/Doing-Physics-With-Matlab/tree/master/mpScripts

https://drive.google.com/drive/u/3/folders/1j09aAhfrVYpiMavajrgSvUMc89ksF9Jb

ad_002B.mlapp

You can explore the relationship between the two equations

$$y_1 = A_1 \sin\left(2\pi\, t / T_1\right)$$

and

$$y_2 = A_2 \sin\left(2\pi\, t / T_2 + \phi_2\right)$$

ad_002C.mlapp

You can explore the relationship between the two equations

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

and

$$y_{SC} = a\sin(\omega t) + b\cos(\omega t)$$

Part 1 ad_002B.mlapp

Graphs of sinusoidal functions can be either expressed in terms of sine functions or cosine functions. The parameters of sinusoidal functions are:

A amplitude

T period [s]

f frequency [Hz]

ω angular frequency [rad.s-1]

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

$(\omega t - \phi)$ phase [rad]

ϕ initial phase angle (phase at t = 0) or

Phase shift [rad]

δt time shift [s]

Consider two sinusoidal functions which have the same amplitude A and angular frequency ω but with a phase difference ϕ.

$$y_1 = A\sin(\omega t)$$

$$y_2 = A\sin(\omega t + \phi) = A\sin(\omega(t + \delta t))$$

The **phase shift** ϕ can be used to describe the relationship between these two sine functions using the terms "**leading**" and "**lagging**". Because of the phase difference, the functions reach their maximum at different times. We will take the sine function y_1 as a reference and ask whether the sine function y_2 is lagging or leading the reference sine function y_1.

$\delta t,\ \phi > 0$

$\max(y_2)$ occurs **before** $\max(y_1)$ then y_2 **leads** y_1

$\delta t,\ \phi < 0$

$\max(y_2)$ occurs **after** $\max(y_1)$ then y_2 **lags** y_1

$\delta t,\ \phi = 0$

the two maxima occur at the same time,

then y_1 and y_2 are said to be **in-phase**

The time interval between the first two maxima is called the **time shift** δt. If the function y_2 reaches its maximum first then the time shift is known as a **time lead**, if the y_2 maximum occurs after the maximum of y_1, then time shift is known as the time **lead**.

Increasing the value of ϕ or δt shifts the sine function y_2 to the left (lower values of t) and decreasing the values of ϕ or δt, shifts the curve to the right (higher values of t)

From the two expressions for y_2, the relationship between the initial phase angle ϕ and the time shift δt is

$$\frac{\phi}{2\pi} = \frac{\delta t}{T}$$

since $\omega t + \phi = \omega(t + \delta t) \Rightarrow \phi = (2\pi / T)\delta t$

A sinusoidal signal can be represented by a vector in the complex plane called a **phasor**. A phasor is simply a shorthand way of representing a signal that is sinusoidal in time. The complex representation of a sinusoidal function is

$$Y = A\exp(j\omega t + \phi) = A\left(\cos(\omega t + \phi) + j\sin(\omega t + \phi)\right)$$

$$\sin(\omega t + \phi) = \mathrm{Im}(Y) \qquad \cos(\omega t + \phi) = \mathrm{Re}(Y)$$

The **phasor diagram** is constructed like drawing a vector and its components: the length of the phasor is the amplitude of the signal; the real part (X component) and imaginary part (Y component. Figure 1 shows a phasor diagram at the instant when *t* = 0.

$$Y(t = 0) = A\exp(\phi) = A(\cos\phi + j\sin\phi)$$

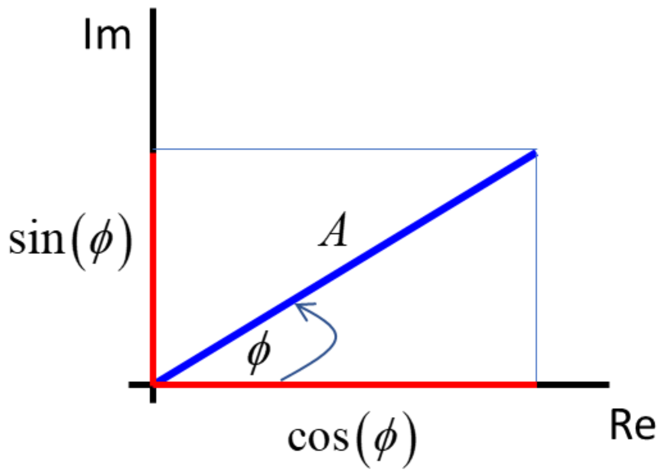


Fig. 1 Phasor diagram of a sinusoidal function at time *t* = 0.

As time advances, the phasor rotates in an anticlockwise direction with the angle of the phasor being $(\omega t + \phi)$. The speed at which the phasor rotates is equal to the angular frequency (angular speed rad.s^{-1}) ω.

Using the app **ad_002B.mlapp**, you can explore many aspects of sinusoidal functions. The GUI graphically displays the two equations

$$y_1 = A_1 \sin\left(2\pi\, t / T_1\right)$$

where A_1 = 6.00, T_1 = 20.0, f_1 = 0.050, ω_1 = 0.314, ϕ_1 = 0

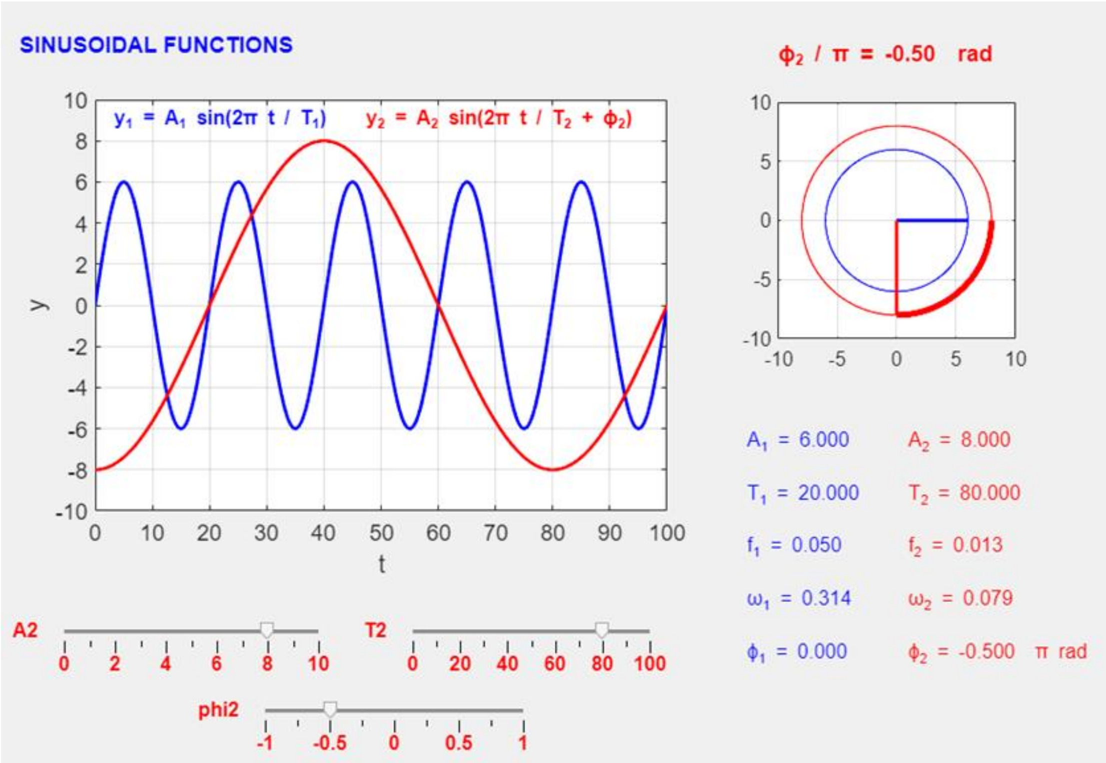
and

$$y_2 = A_2 \sin\left(2\pi\, t / T_2 - \phi_2\right)$$

where the values of $A_2,\, T_2,\, \phi_2$ are set by the three sliders. The units for the phase slider are π rad.

To make the most of the app as a learning tool it is a good idea to use the **Predict Observe Explain** (**POE**) method. Before any input values are changed using the sliders, **predict** the output response – all plots and numerical results. **Observe** the output response and compare with your predictions. **Explain** any discrepancies.

Figure 2 shows the GUI: Plots of the two functions, a summary of all numerical values and the phasor diagram (the two circles have radii equal to A_1 and A_2. Zero phase $\phi_1 = 0$ corresponds to the **blue** horizontal line and the **red** radius line is for the phasor for the phase shift ϕ_2 / π.



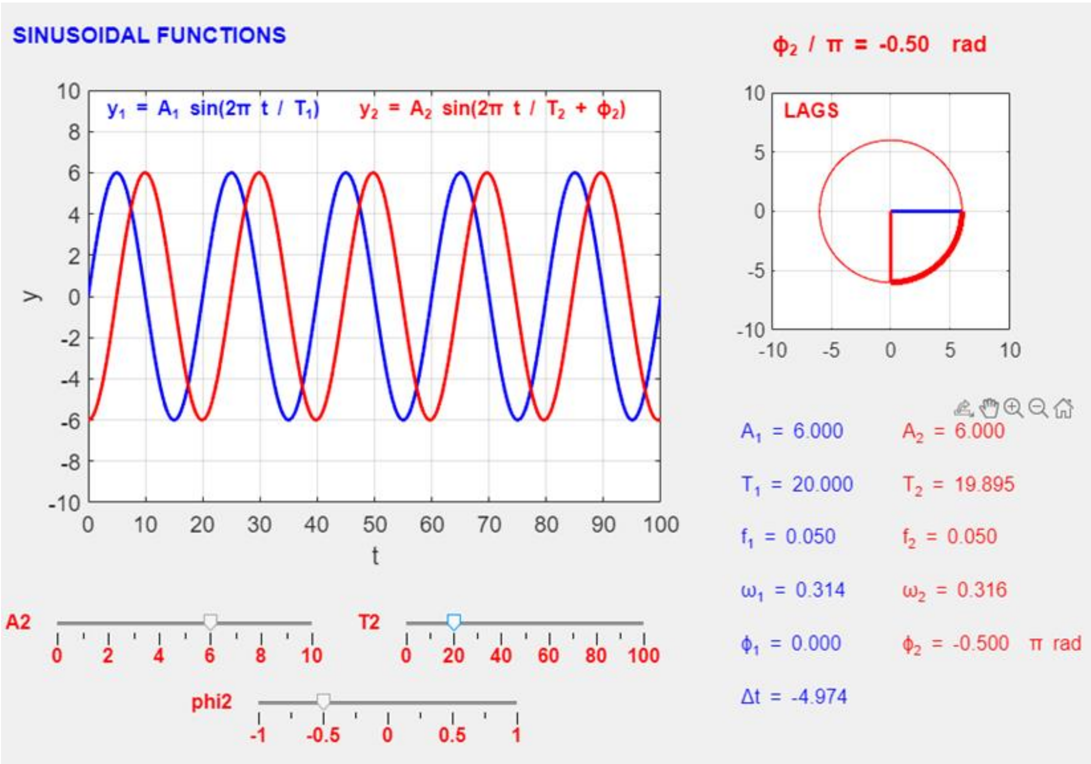


Fig. 2 GUI for **ad_002B.mlapp**.

Part 2 ad_002C.m

Consider the four sinusoidal functions

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

$$y_S = a\sin(\omega t) \quad y_C = b\cos(\omega t)$$

$$y_{SC} = y_S + y_C = a\sin(\omega t) + b\cos(\omega t)$$

You can use the app **ad_002C.m** to investigate these four sinusoidal functions. There are four input sliders:

$$A \quad \phi \quad a \quad b$$

The period of each sinusoidal function is fixed

$$T = 40.00 \quad f = 0.0250 \quad \omega = 0.1571$$

The GUI is shown in figure 3.

Implement the **POE** strategy before changing any input values.

You can now play a game.

Select the values of (A, ϕ)

Then find the values of the coefficients (a, b)

such that

$$y = y_{SC} = y_S + y_C$$

$$A\sin(\omega t + \phi) = a\sin(\omega t) + b\cos(\omega t)$$

Then set the values of (a, b) and find the values for (A, ϕ)

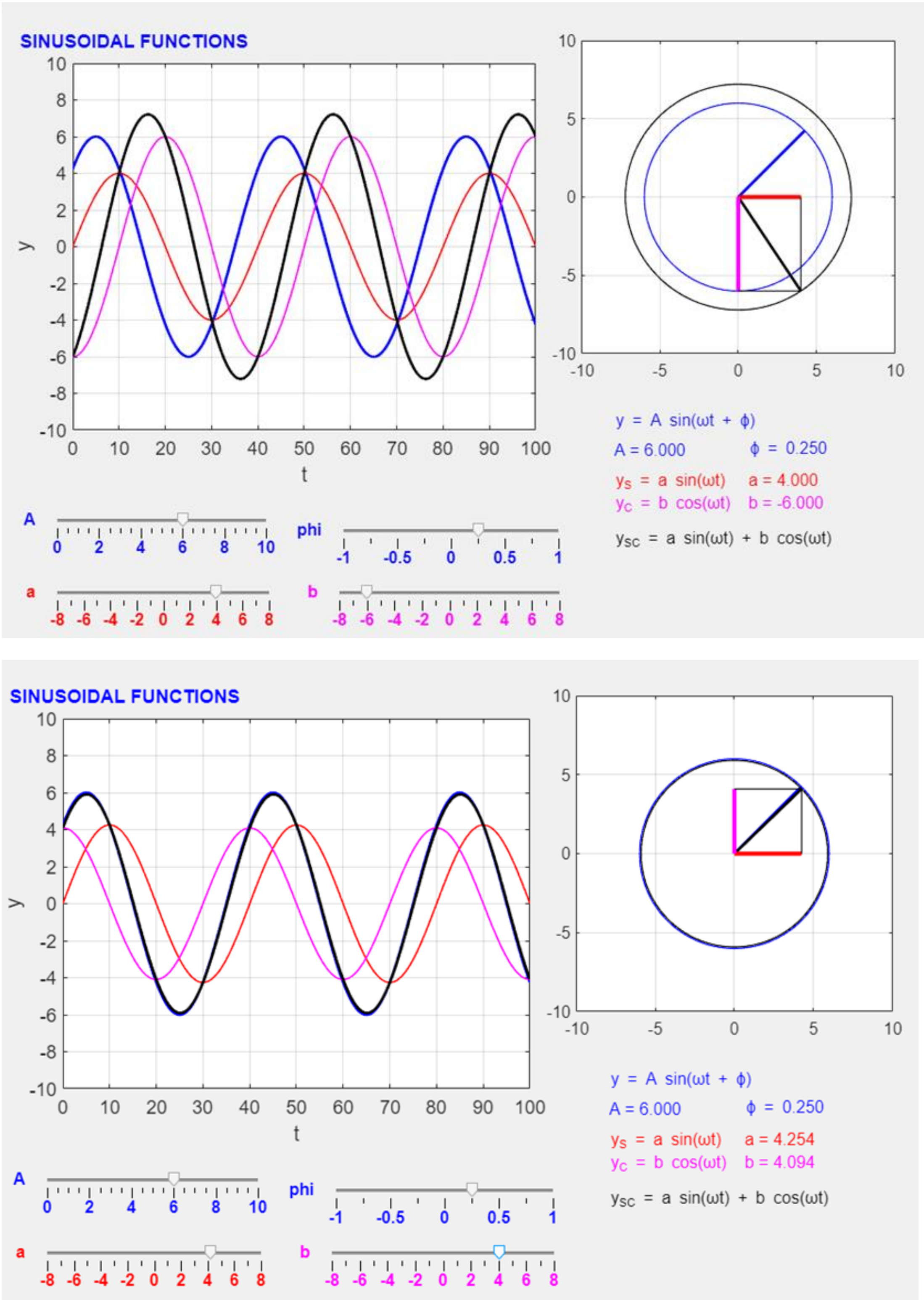


Fig. 3 GUI for **ad_002C.mlapp**

For more details of simple harmonic motion and the sine function click the documentation link

Documentation

An excellent web site on phasor diagrams can be viewed at

Link