Solution (1)

This system is $\boxed{\textit{linear}}$*. Proof.*

$$y_1(t) = x_1(\sin(t)), \quad y_2(t) = x_2(\sin(t)),$$

$$x(\sin(t)) = a_1 x_1(\sin(t)) + a_2 x_2(\sin(t))$$

$$y(t) = x(\sin(t)) = a_1 x_1(\sin(t)) + a_2 x_2(\sin(t))$$

So

$$a_1 y_1(t) + a_2 y_2(t) = y(t)$$

Solution (2)

This system is $\boxed{\textit{time-varying}}$.

$$y(t-t_0) = x(\sin(t-t_0))$$

$$x_d = x(t-t_0)$$

$$y_d(t) = x_d(\sin(t)) = x(\sin(t) - t_0)$$

So

$$y(t-t_0) \neq y_d(t)$$

A counter example

$$x(t) = \sin^{-1}(t) \Longrightarrow y(t) = \sin^{-1}(\sin(t)) = t$$

$$y(t-1) = t-1$$

$$x_d(t) = x(t-1) \Longrightarrow y_d(t) = \sin^{-1}(\sin(t) - 1) \neq y(t-1)$$

Solution (3)

This system is $\boxed{\textit{non-causal}}$.

$$y(t) = x(\sin(t)) \Longrightarrow y(-\pi/2) = x(\sin(-\pi/2)) = x(-1)$$

So $y(-\pi/2)$ *depends on future input because* $-\pi/2 < -1$.

If there is any time instance such that $t < \sin(t)$*, this system is non-causal.*
Since $-1 \le \sin(t) \le 1$*, for any* $t < -1$, $\sin(t) > t$*. So this system is non-causal.*

Solution (4)

This system has $\boxed{\textit{memory}}$.
$\sin(t)$ *is not always equal to* t.