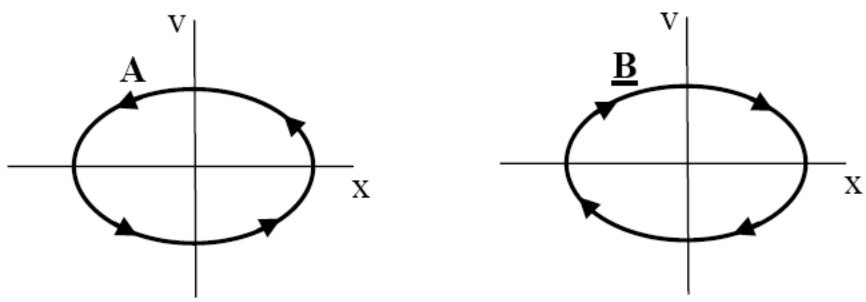
Phase paths A & B below attempt to describe the mass-on-a-spring simple harmonic oscillator.
Which path is physically possible?



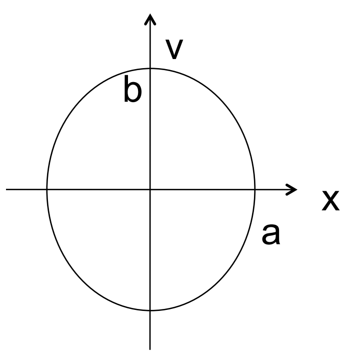
C) both are possible
D) neither is possible

2- 1

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$$a = \sqrt{2E_0 / k} = \text{max displacement}$$

$$b = \sqrt{2E_0 / m} = \text{max speed}$$



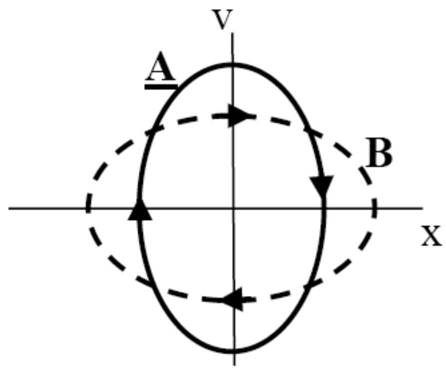
$$b / a = \sqrt{k / m} = \omega$$

1) How does the phase space diagram change, if you start it with a bigger initial stretch?

2) How does the phase space diagram change, if the phase "δ" in x(t)=Acos(ωt-δ) changes?

2- 2

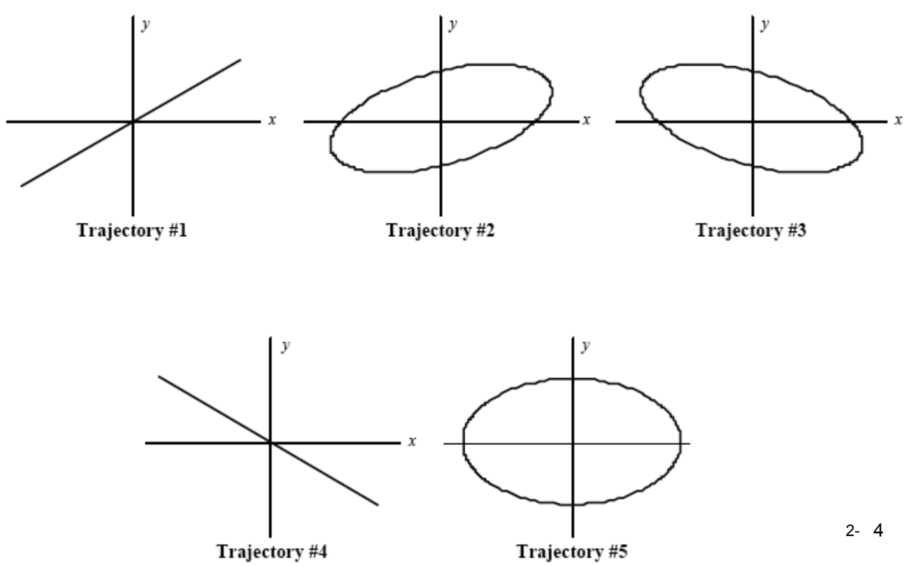
Phase paths A and B both describe a harmonic oscillator with the same mass m. Which path describes the system with a bigger spring constant k?



C) both are the same
D) Not enough info/???

2- 3

Shown below are several trajectories for a 2D oscillator. For which one is δ=0?

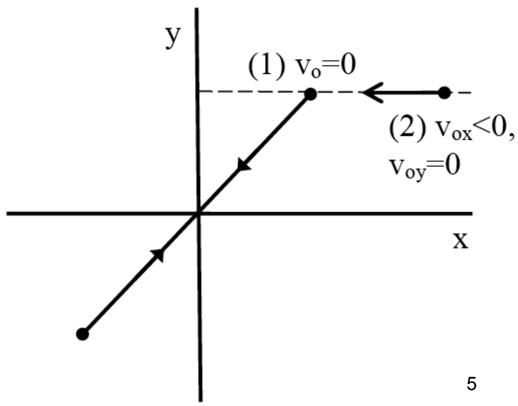


2- 4

Compare the motion of a 2D harmonic oscillator with two different sets of initial conditions. In case (1) the particle is released from rest and oscillates along the path shown. In case (2) the particle starts with a larger x position and with a negative x component of the velocity.

What can you say about the amplitude of the x and y motion?

A) $A_{x1}>A_{x2}$, $A_{y1}>A_{y2}$
B) $A_{x1}<A_{x2}$, $A_{y1}=A_{y2}$
C) $A_{x1}=A_{x2}$, $A_{y1}>A_{y2}$
D) $A_{x1}<A_{x2}$, $A_{y1}<A_{y2}$
E) $A_{x1}=A_{x2}$, $A_{y1}=A_{y2}$

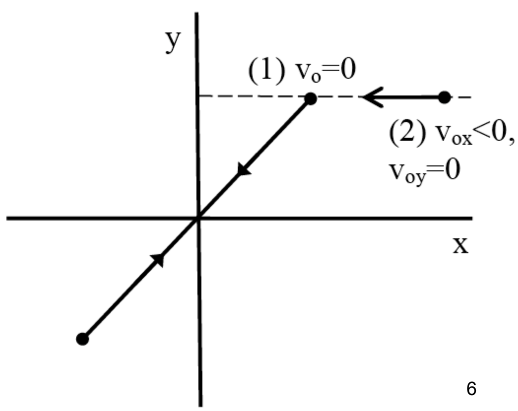


5

Compare the motion of a 2D harmonic oscillator with two different sets of initial conditions. In case (1) the particle is released from rest and oscillates along the path shown. In case (2) the particle starts with a larger x position and with a negative x component of the velocity.

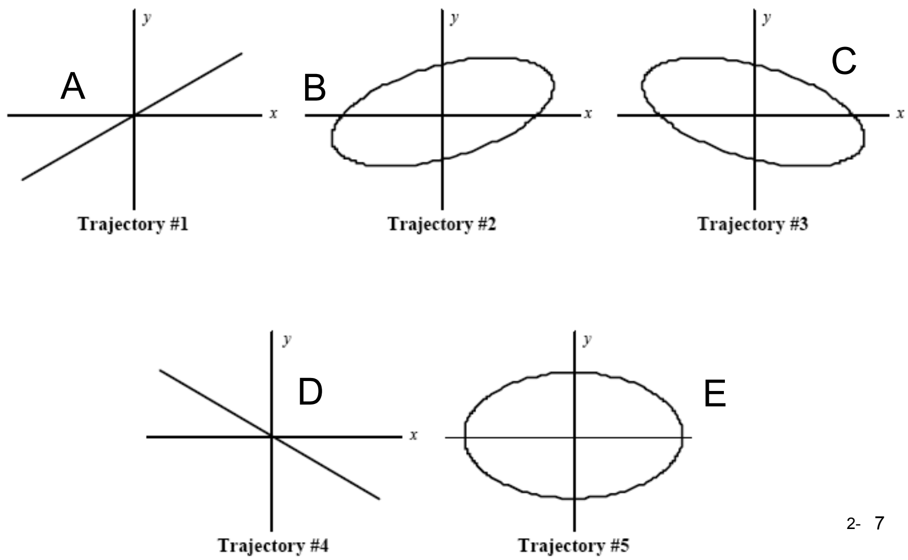
What can you say about the frequency of the x and y motion?

A) $\omega_{x1}>\omega_{x2}$, $\omega_{y1}>\omega_{y2}$
B) $\omega_{x1}<\omega_{x2}$, $\omega_{y1}=\omega_{y2}$
C) $\omega_{x1}=\omega_{x2}$, $\omega_{y1}>\omega_{y2}$
D) $\omega_{x1}<\omega_{x2}$, $\omega_{y1}<\omega_{y2}$
E) $\omega_{x1}=\omega_{x2}$, $\omega_{y1}=\omega_{y2}$



6

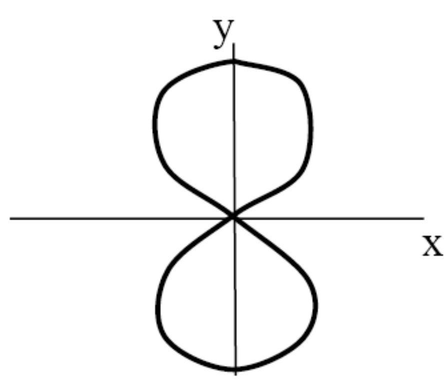
Which of the below trajectories most closely resembles case 2 in the last question, where $v_{y0}=0$ and $v_{x0}<0$ at the release point?



2- 7

A 2D oscillator traces out the following path in the xy-plane.
What can you say about the frequencies of the x and y motion?

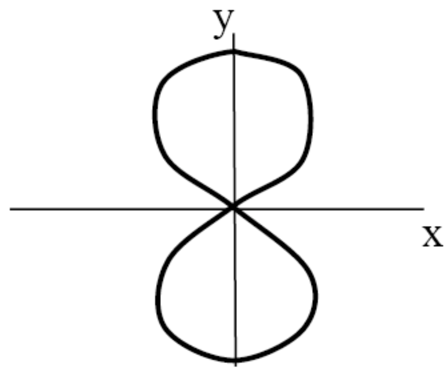
A) $\omega_x = 4\omega_y$
B) $\omega_x = 2\omega_y$
C) $\omega_x = \omega_y$
D) $\omega_x = 0.5\ \omega_y$
E) $\omega_x = 0.25\ \omega_y$



2- 8

A 2D oscillator traces out the following path in the xy-plane.
What can you say about the Amplitudes of the x and y motion?

A) $A_x > A_y$
B) $A_x \approx A_y$
C) $A_x < A_y$



2- 9

The ODE for damped simple harmonic motion is:

$$\frac{d^2y}{dt^2} + 2\beta\frac{dy}{dt} + \alpha y = 0$$

What are the signs of the constants α and β?

A) α,β>0
B) α,β<0
C) α<0, β>0
D) α>0, β<0
E) Depends!

2- 10

For a mass on a spring, with damping: $\mathbf{F} = -k\mathbf{x} - b\dot{x}$
with k, b>0.
The ODE for damped simple harmonic motion is:

$$\frac{d^2y}{dt^2} + 2\beta\frac{dy}{dt} + \alpha y = 0$$

What are the signs of the constants α and β?

A) α,β>0
B) α,β<0
C) α<0, β>0
D) α>0, β<0
E) Depends!

2- 11

What are the roots of the auxiliary equation
$D^2 + D - 2 = 0$?

A) 1 and 2
B) 1 and -2
C) -1 and 2
D) -1 and -2
E) Other/not sure...

2- 12

What are the roots of the auxiliary equation
$y''(t) + y(t) = 0$?

A) 1 and -1
B) 1 and 0
C) just 1
D) just i
E) i and -i

2- 13

A mass on a spring has a small damping term added. When it passes through x=0, which is correct?

A) The mass is instantaneously speeding up
B) The mass is instantaneously slowing down
C) The mass is at a maximum speed (and is thus neither speeding up nor slowing down
D) The answer depends on which WAY it is passing through the origin.

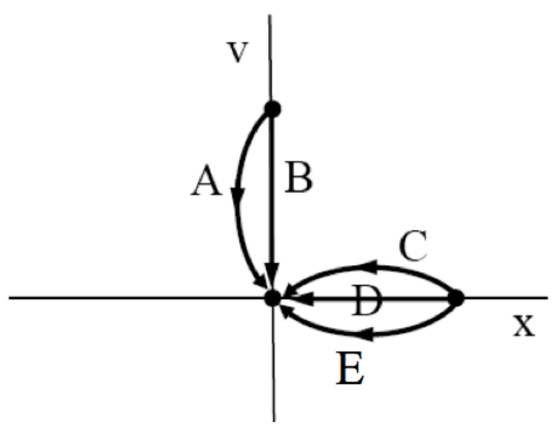
2- 14

A mass on a spring has a small damping term added. What happens to the period of oscillation?

A) Slightly *larger* than the undamped case.
B) Slightly *smaller* than the undamped case
C) The *same* as the undamped case

2- 15

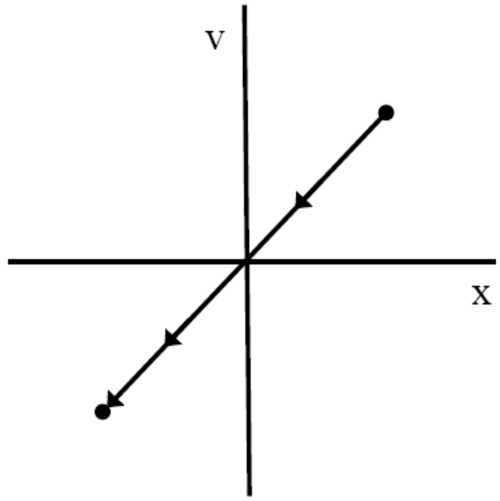
Which phase path below best describes overdamped motion for a harmonic oscillator released from rest?



2- 16

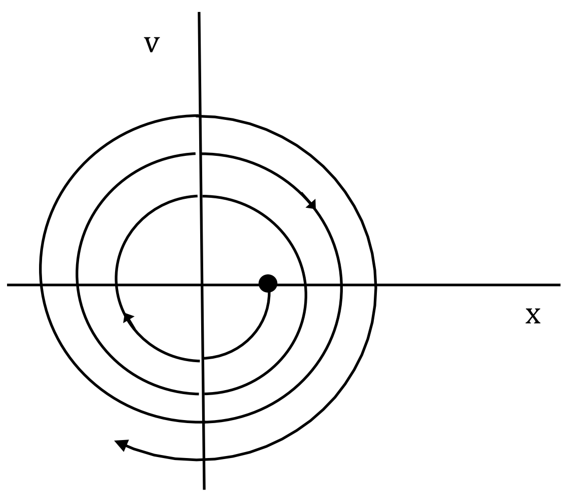
What kind of motion does this phase path describe?

A) overdamped
B) underdamped
C) critically damped
D) undamped
E) ??? (not possible?)



2- 17

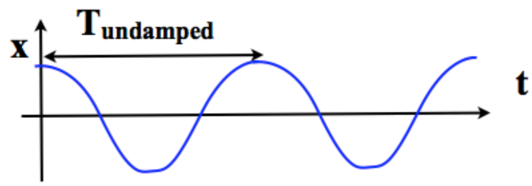
What kind of motion αoes this phase path describe?



A) overdamped
B) underdamped
C) critically damped
D) impossible to tell
E) This motion is impossible

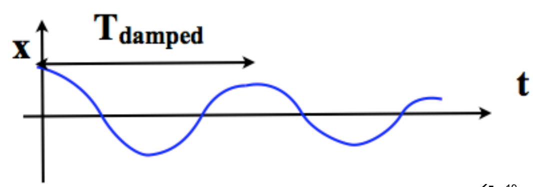
2- 18

For a damped oscillator, how does the the period between successive maxima compare to the undamped case? (Assume k and m are the same)



A) same
B) damped is bigger
C) undamped is bigger

Not necessarily on the same horizontal scale!



2- 19

What kind of damping behavior should the shock absorbers in your car have, for the most comfortable ride?

A) No damping is best
B) under-damping
C) critical damping
D) over-damping

2- 20