

Nonlinear Dynamics: Mathematical and Computational Approaches

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[✓ 3.2 State variables and state space » Quiz](#)
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Question 1

Figure 1 shows a state-space portrait of an undamped pendulum generated by solving the following system of differential equations for a number of different initial conditions:

$$\dot{\theta} = \omega \quad (1)$$

$$\dot{\omega} = -\frac{\beta}{m}\omega - \frac{g}{l}\sin\theta \quad (2)$$

with $m = l = g = 1$ and $\beta = 0$ -- i.e., no friction (damping).

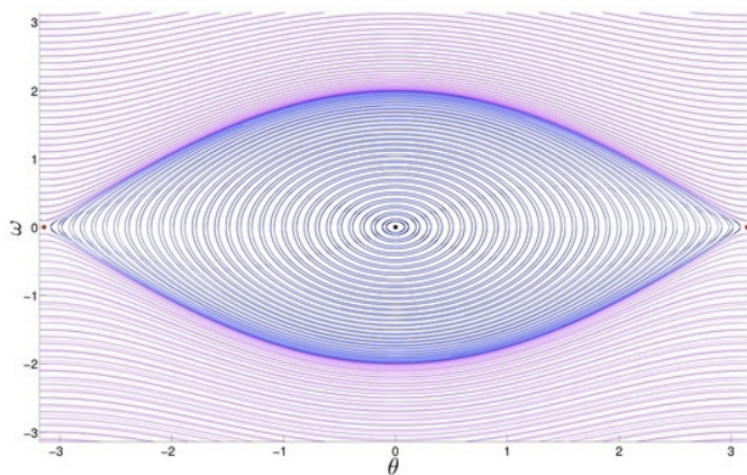


Figure 1: A state-space portrait of an undamped pendulum, whose dynamics are described by equations (1) and (2).

(a)

Which is true about the physical pendulum described by the magenta trajectories?

- ☒ A. The pendulum never becomes inverted.
- ☐ B. The pendulum's arm regularly passes by both the stable and unstable fixed point.
- ☐ C. The pendulum never moves.
- ☐ D. None of the above.

(b)

Which is true about the physical pendulum described by the blue trajectories?

- ☒ A. The pendulum's arm regularly passes by both the stable and unstable fixed point.
- ☐ B. The pendulum never becomes inverted.
- ☐ C. The pendulum never moves.
- ☐ D. None of the above.

(c)

The black dot is a fixed point.

- ☒ A. stable

☐ B. unstable

(d)

The red dots are fixed points.

- ☐ A. stable
- ✓ ☒ B. unstable

(e)

If damping was introduced, e.g., $\beta = 0.5$, how would the trajectories in Figure 1 change?

- ✓ ☒ A. The trajectories would spiral toward the stable fixed points.
- ☐ B. The trajectories would spiral toward the unstable fixed points.
- ☐ C. This parameter change would not be seen in this representation.
- ☐ D. All trajectories would diverge.
- ☐ E. None of the above.

Question 2

In Figure 2, the solutions of equations (1) and (2) were generated starting from the exact same initial conditions as in Figure 1 but *exactly* one parameter in the equations was modified. What parameter was changed?

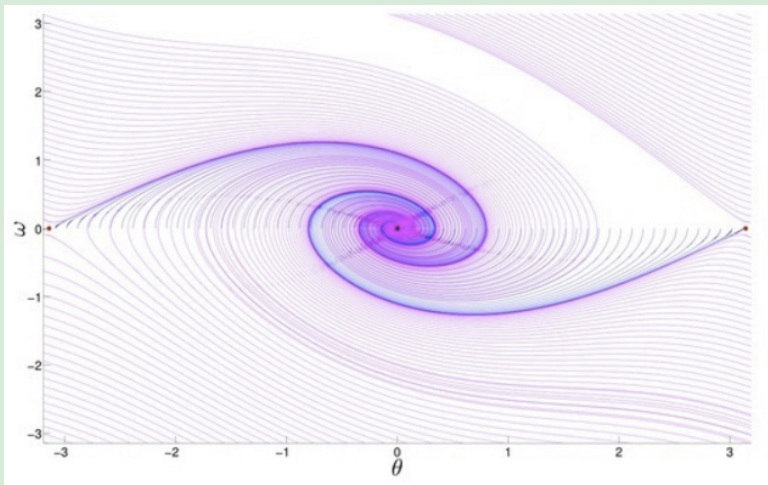


Figure 2: A state-space portrait of a pendulum, whose dynamics are described by equations (1) and (2), but with a slightly different value of one parameter.

- ☐ A. The length, L
- ✓ ☒ B. The coefficient of friction, β
- ☐ C. The pendulum mass, m
- ☐ D. None of the above

You got 4 out of 6 questions correct

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