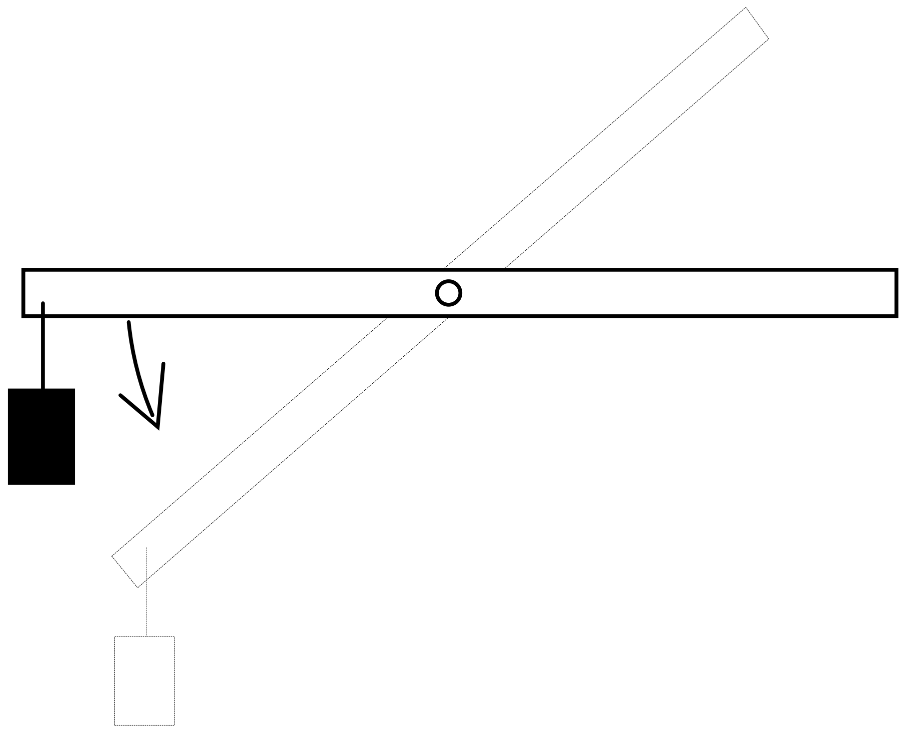
Discuss and Answer:

A mass is hanging from the end of a horizontal bar which pivots about an axis through it center, but it being held stationary. The bar is released and begins to rotate. As the bar rotates from horizontal to vertical, the magnitude of the torque on the bar…

A: increases   B: decreases   C: remains constant

As the bar rotates from horizontal to vertical, the magnitude of the angular acceleration α of the bar…

A: increases   B: decreases   C: remains constant



Recap: Rotational Dynamics

A merry-go-round is a playground ride that consists of a large disk mounted to that it can freely rotate in a horizontal plane. The merry-go-round shown is initially at rest, has a radius R = ***1.1*** meters, and a mass M = ***201*** kg. A small boy of mass m = ***41*** kg runs tangentially to the merry-go-round at a speed of v = ***1.1*** m/s, and jumps on.

Part (a) **Calculate the moment of inertia of the merry-go-round, in kg · m^2.**

Part (b) **Immediately before the boy jumps on the merry go round, calculate his angular speed (in radians/second) about the central axis of the merry-go-round.**

Part (c) **Immediately after the boy jumps on the merry go round, calculate the angular speed in radians/second of the merry-go-round and boy.**

Notes

- Homework on Gravity due today!

- Exam II will be Nov 20 (Momentum, Rotational Motion - Dynamics, and Gravity)

  →We briefly reviewed rotation today

- Next Monday, Nov 18 will be a review day as usual.

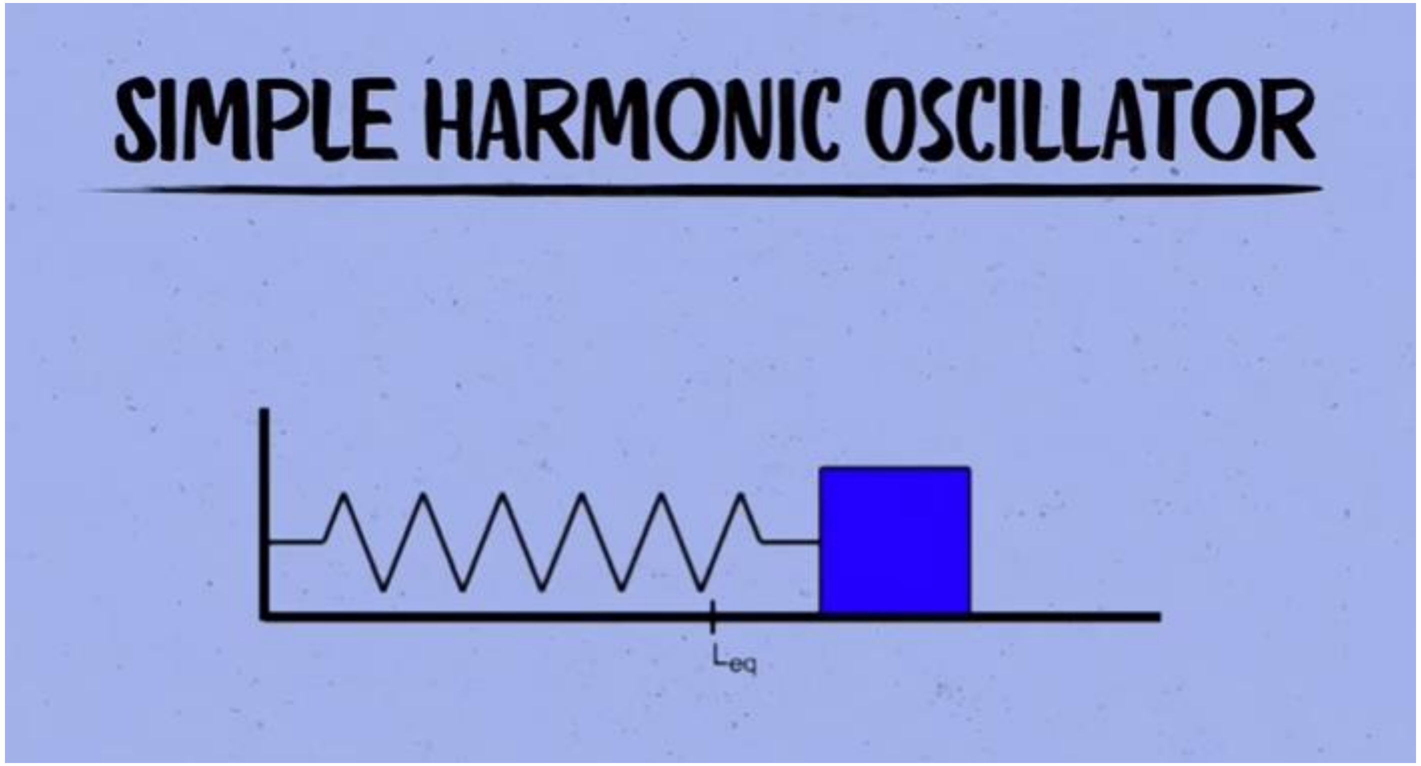
Hint for Homework Problem

- The gravitational effect of a spherically symmetric mass distribution is such that only the mass within M contributes a net force, and it's as if it's at the center of mass.
- For Parts b+c use oscillations, but won't be on exam!

Problem 13: Consider a spherical planet of radius R and mass M. The planet has uniform density.

Part (a) Someone has drilled a hole straight through the center of this planet to the other side and is about to drop a small object of mass *m* into the hole. We can show that the object will experience simple harmonic motion in the hole by showing that the gravitational force on the object will obey Hooke's law, $F_{grav} = -kx$, where *k* is the force constant and *x* denotes the displacement

Prelecture Review: Small Oscillations



$$x(t) = A\cos\omega t + B\sin\omega t$$

Energy near an equilibrium:

$$U \approx U_0 + \frac{1}{2}kx^2 + \cdots$$

Oscillations:

$$\ddot{x} = -\omega^2 x$$

Natural Frequency

$$\omega = \sqrt{\frac{k}{m}}$$

What are our comments and questions?

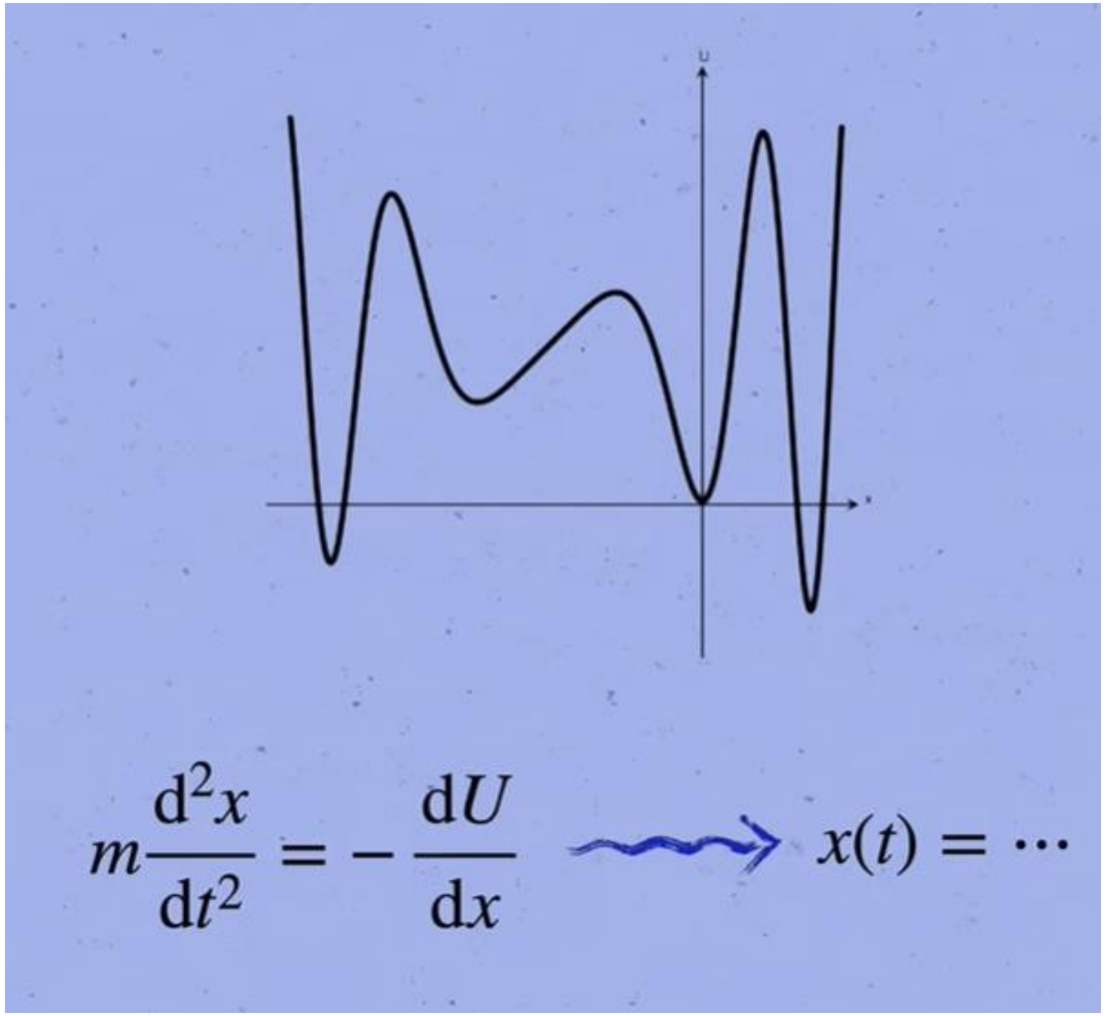
Discuss and Answer:

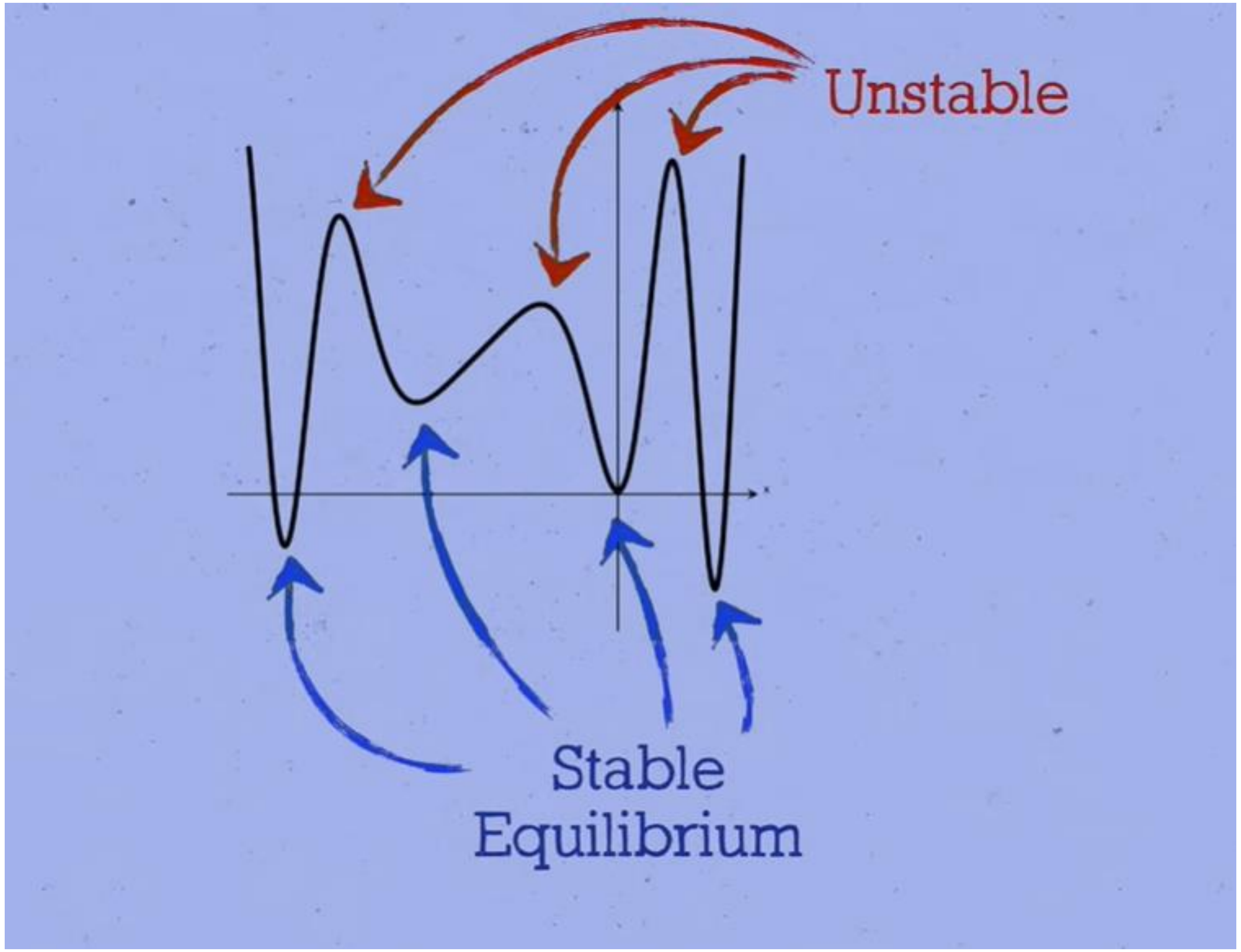
A mass on a spring oscillates with a certain amplitude and a certain period T. If the mass is doubled, the spring constant of the spring is doubled, and the amplitude of motion is doubled, the period …

A: increases

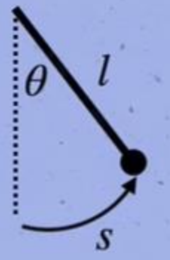
B: decreases

C: stays the same.


U
$m\frac{d^2x}{dt^2} = -\frac{dU}{dx}$
$x(t) = \cdots$

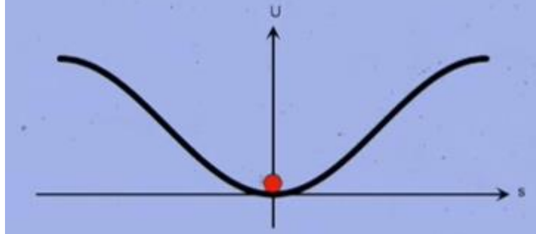

Unstable
Stable
Equilibrium

Example: Pendulum



$$h = l - l\cos\theta$$

$$\theta = \frac{s}{l}$$



$$U(s) = mgl\left(1 - \cos\left(\frac{s}{l}\right)\right)$$

$$U'(s) = mg\sin\left(\frac{s}{l}\right) \rightsquigarrow U'(0) = 0$$

$$U''(s) = \frac{mg}{l}\cos\left(\frac{s}{l}\right) \rightsquigarrow U''(0) = \frac{mg}{l}$$

$$U(s) \approx \frac{1}{2}U''(0)s^2$$

$$k = \frac{mg}{l}$$

$$\rightsquigarrow \Omega = \sqrt{\frac{g}{l}}$$

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

$$g\left(\frac{T}{2\pi}\right)^2 = l?$$

Comments and Questions

- What I wonder is if that harmonic oscillating pattern applies for all angles, or up to a certain angle.
- Does hookes law explain why the earth spins in an elipse instead of a perfect circle?
- How would the behavior of the system change if we were to include damping forces, such as friction, and how would this affect our understanding of small oscillations in both classical and quantum contexts?
- I'm confused by the introduction of sin and cos from omega squared; does this come from the pythagorean theorem or a different trig identity?

My comments and Questions

- Comment: “Empty” space in our universe is near equilibrium. Particles are, in some sense, oscillations of fields about this equilibrium in the same way.

- Question: How can we describe systems that a far from equilibrium? We have to go beyond approximations like Taylor series, which is challenging.

Discuss and Answer:

What will happen if the pendulum is given a tangential velocity (See board). What path will it traverse? What/will there be an associated period?