Mass-spring oscillator: period

FizziQ activity · High school · 35 min

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Vary mass then stiffness in the FizziQ Web spring oscillator simulation on computer: reading the period on the position-time graph verifies $T = 2\pi\sqrt{m/k}$ and gives k.

Learning objectives

- Measure the period of a spring-mass oscillator from a position-time graph
- Identify the influence of mass on the period (T increases as m increases)
- Identify the influence of stiffness on the period (T decreases as k increases)
- Verify the relationship $T = 2\pi\sqrt{m/k}$ by plotting T^2 versus m
- Verify that the period is independent of amplitude

Instruments and sensors

FizziQ Web simulation (Spring Oscillator)

Materials

- Computer, tablet, or smartphone with FizziQ Web
- Note: the protocol remains adaptable to any simulation environment offering a comparable spring-oscillator model with position-time graphing.

Protocol

1. Open the Spring Oscillator simulation in FizziQ Web (Experiment → Simulations → Spring Oscillator).
2. Part 1 — Effect of mass: set the stiffness to 20 N/m, amplitude to 0.3 m, and damping to 0. Set the mass to 0.5 kg.
3. Start the simulation with REC. Record a few oscillations, then stop. In the experiment notebook, measure the period T (time between two consecutive maxima).
4. Repeat for masses 1.0 kg, 1.5 kg, 2.0 kg, 3.0 kg, and 4.0 kg. Record the period T for each mass in a table.
5. Plot T versus m. Is the curve a straight line? Then plot T^2 versus m. This time, you should get a straight line through the origin.
6. The slope of $T^2(m)$ equals $4\pi^2/k$. Calculate k from the slope and compare with the set value (20 N/m).
7. Part 2 — Effect of stiffness: set the mass to 1.0 kg and amplitude to 0.3 m. Vary the stiffness: 5, 10, 20, 40, and 80 N/m.
8. For each value of k, measure the period T. Record the results in a table. How does T change when k increases?
9. Part 3 — Effect of amplitude: set m = 1.0 kg and k = 20 N/m. Measure the period for amplitudes 0.1 m, 0.3 m, and 0.5 m.
10. Does the period change with amplitude? State your general conclusion: $T = 2\pi\sqrt{m/k}$, independent of amplitude.

Expected results

Part 1: T increases with mass. For k = 20 N/m: T ≈ 0.99 s (m = 0.5 kg), 1.40 s (1.0 kg), 1.72 s (1.5 kg), 1.99 s (2.0 kg), 2.43 s (3.0 kg), 2.81 s (4.0 kg). The graph T(m) is a curve, but $T^2(m)$ is a straight line through the origin with slope $4\pi^2/k \approx 1.97\ s^2/kg$, giving k ≈ 20 N/m. Part 2: T decreases when k increases. Part 3: T does not depend on amplitude (within measurement precision).

Questions

- If you double the mass, does the period double? Why?
- If you double the stiffness, how does the period change?
- Why does the period not depend on the amplitude?
- How could you use a spring-mass system to measure an unknown mass?
- What happens to the period if you use two identical springs in parallel?
- Why is the $T^2(m)$ graph more useful than the $T(m)$ graph for verification?

Going further

- Plot the velocity versus time and identify the moments when velocity is maximum (passing through equilibrium) and zero (extreme positions)
- Enable damping and observe how the period is affected by friction
- Try to determine an unknown mass by measuring the period and using the formula
- Compare simulated results with a real spring-mass experiment using the smartphone accelerometer
- Investigate the relationship $T = 2\pi\sqrt{(m/k)}$ by keeping m fixed and plotting T^2 versus $1/k$