Physics 20

Unit D: Oscillations and mechanical waves

Oscillator energy and resonance

Washboard ruts at 10 Hz

- A pickup west of Drumheller rolls at 8.0 m/s over gravel ruts spaced 0.80 m apart.
- The wheels meet a rut ten times each second, and the cab amplitude grows when the suspension springs share that rhythm.

Energy and stiffness

- In an ideal oscillator that keeps its energy to itself, the joules stay the same total while kinetic energy and potential energy trade places.
- The spring constant k is stiffness in newtons per metre. A pendulum period depends on length and on g, which is 9.81 m/s squared downward.
- Resonance is the big swing you get when each push matches the rhythm the object already has.

Key terms

mechanical resonance

Mechanical resonance is a large amplitude that builds when a driving frequency matches the natural frequency of an oscillator.

spring constant

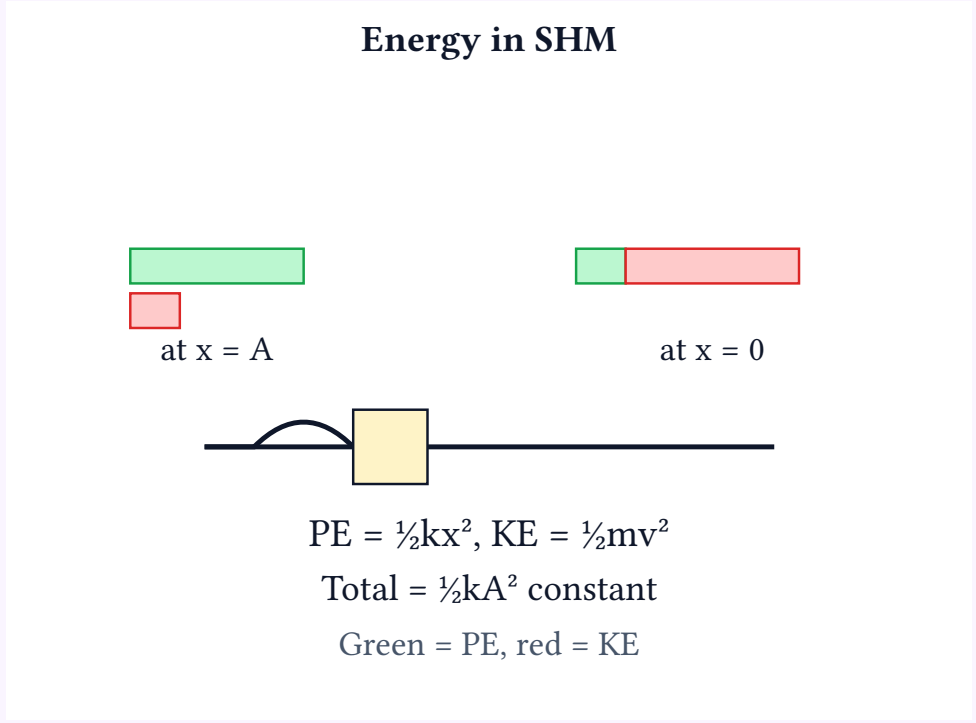
The spring constant is the stiffness of a spring, equal to the magnitude of the force divided by the stretch. (k)

pendulum

A pendulum is a bob on a string or rod that swings through a small angle about a fixed pivot. (T = 2 pi square root of L/g)

Joules trade places and the total holds

- Spring potential energy is one half k x squared, and kinetic energy is one half m v squared.
- At the amplitude the speed is zero and the total energy is one half k A squared.
- At equilibrium the potential energy is zero and the speed is greatest, with the total still equal to one half k A squared.

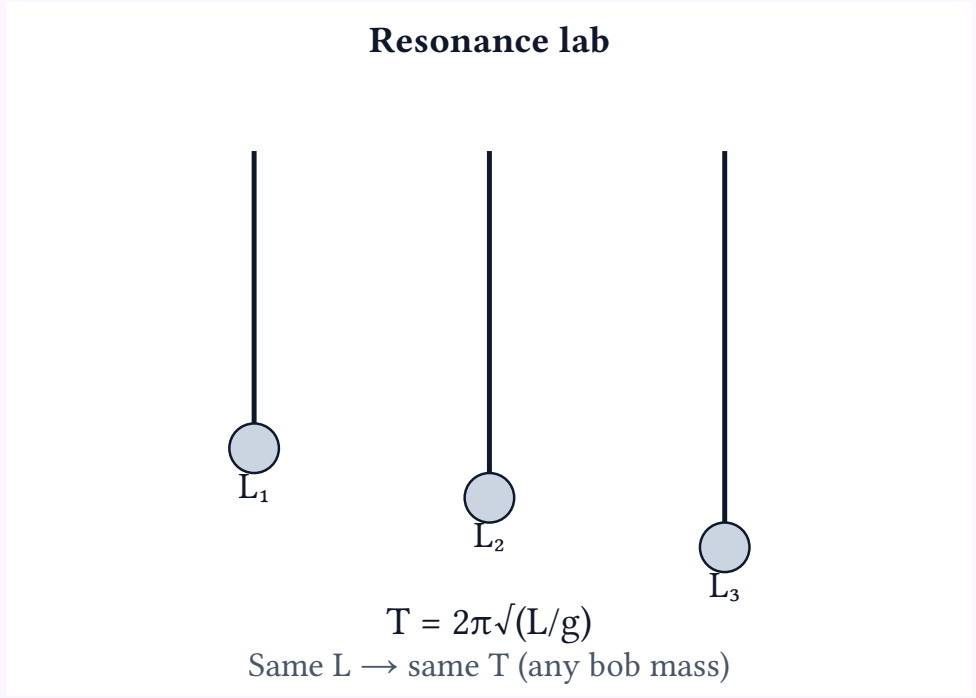


0.144 J in a 45.0 N/m spring

- A 0.180 kg block on a 45.0 N/m spring has amplitude 0.080 m.
- Total energy = one half × 45.0 × $(0.080)^2$ = 0.144 J.
- Greatest speed from one half × 0.180 × v^2 = 0.144 is 1.26 m/s.

Resonance demonstration

- Pendulum data for several lengths should follow T = 2 pi times the square root of L/g.
- Same string length and same g: a heavier bob still has the same period.
- The spring constant comes from F = k x or from the measured period, and a resonance demo stays at a modest amplitude.



Stiffness from a hanging mass

- A 0.400 kg mass stretches a vertical spring by 0.0981 m.
- Find the spring constant from the weight and the stretch.
- A tower sways naturally at 2.40 Hz. A push at 2.40 Hz builds a large sway. A push at 0.70 Hz stays small.

Stored joules and a matched driver

- A 0.180 kg block on a 45.0 N/m spring has amplitude 0.080 m.
- Find the total mechanical energy and the greatest speed.
- The natural frequency is 2.52 Hz. State what a 2.52 Hz driver does to the amplitude.