

Vibrations and Waves

Problem C**SIMPLE HARMONIC MOTION OF A MASS SPRING SYSTEM
PROBLEM**

The antennae of male mosquitoes have many hairs that receive sound signals from female mosquitoes. Female mosquitoes emit a frequency of about 230 Hz.

Suppose a mass is attached to a spring with a spring constant of 1.14×10^4 N/m. How large is the mass if its oscillation frequency is the same as a mosquito's?

SOLUTION

Given: $f = 230$ Hz $k = 1.14 \times 10^4$ N/m

Unknown: $m = ?$

Choose the equation(s) or situation:

Use the equation for the period of a mass-spring system to solve for m :

$$T = 2\pi \sqrt{\frac{m}{k}} = \frac{1}{f}$$

$$\frac{1}{f^2} = \frac{4\pi^2 m}{k}$$

$$m = \frac{k}{4\pi^2 f^2} = \frac{1.14 \times 10^4 \text{ N/m}}{(4\pi^2)(230 \text{ s}^{-1})^2} = 5.46 \times 10^{-3} \text{ kg} = \boxed{5.46 \text{ g}}$$

ADDITIONAL PRACTICE

- Honeybee scouts inform other honeybees where to find food by flapping their wings and “waggle-dancing.” During part of the dance, a scout bee’s wings flap with a maximum frequency of 3.00×10^2 Hz. Suppose a mass is attached to a spring with a spring constant of 8.65×10^4 N/m. How large is the mass if its oscillation frequency is the same as the wings of a waggle-dancing bee?
- On Halloween, you see an “alien” that has one antenna made of a glittery foam ball connected to a spring. The springs oscillate with a period of 0.079 s, and have a spring constant of 63 N/m. Find the mass of the ball.
- A farmer rides over a bumpy field on his tractor. The tractor seat is supported by a spring with a spring constant of 2.03×10^3 N/m. As the farmer drives over a bump, the seat oscillates at a frequency of 0.79 Hz. For the first few seconds, the vibration approximates simple harmonic motion. Find the farmer’s mass if the tractor seat acts like a spring scale.
- A 32 N sack of potatoes vibrates with a period of 0.42 s placed on a spring scale. What is the spring constant?
- A 66 N pumpkin vibrates with a period of 2.9 s when attached to the end of a spring scale. What is the spring constant?

6. As the wind moves the bough of a tree, it oscillates up and down. During the first few seconds, it approximates simple harmonic motion. If the bough has a weight of 87 N and oscillates with a period of 0.64 s, what is the spring constant of the bough?
7. A certain trampoline acts like a single spring with a spring constant of 364 N/m. If a 24 kg child jumps on the trampoline, what would be the period of oscillation?
8. Two children jump on their parent's bed (when the parents are not looking). The combined mass of both kids is 55 kg. The mattress is supported by 36 springs, each with a spring constant of 458 N/m. If the children jump at the same time, what would be the period of oscillation?
9. An 8.2 kg infant is placed in a jumper that is made of a seat that is suspended from a door frame by a spring. If the spring has a spring constant of 221 N/m. Calculate the period of oscillation.
10. Your friend's key chain is coiled like a spring. Three keys, each with a mass of 24 g, are on the chain. When your friend removes the keys from a pocket, the keys bob up and down. If the key chain has a spring constant of 99 N/m, what is the frequency of oscillation?