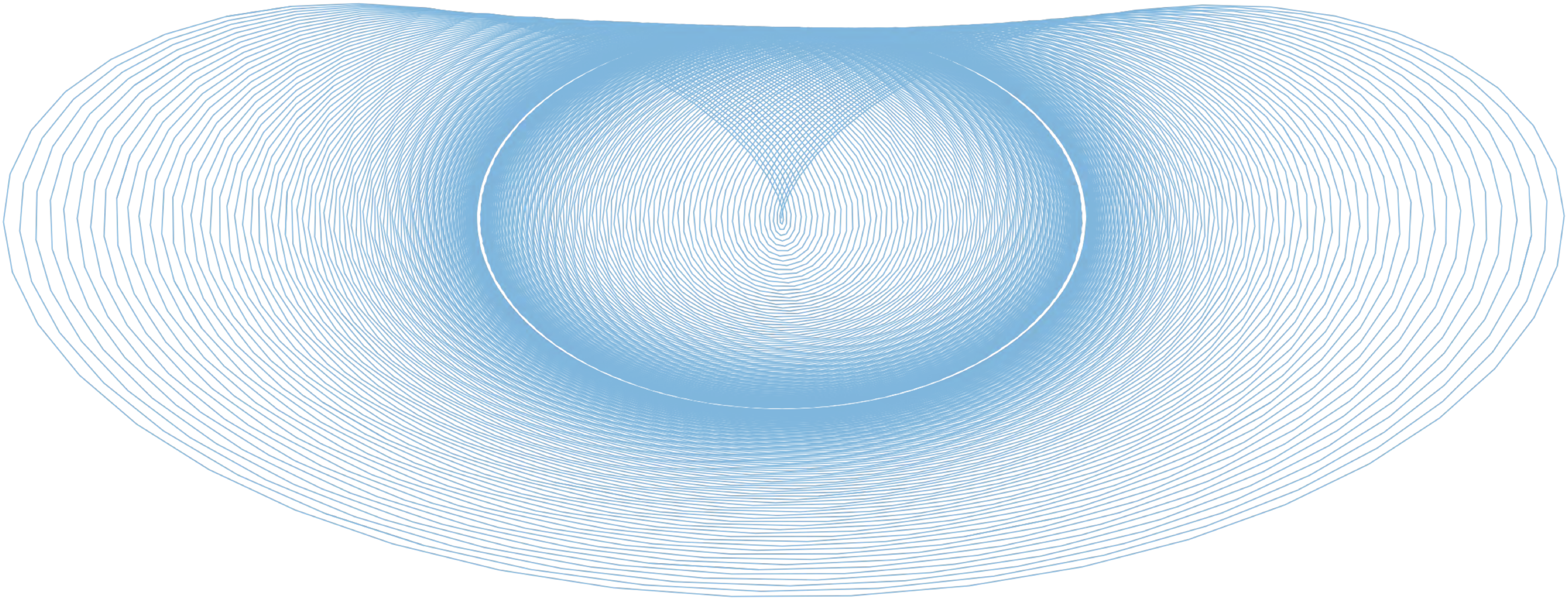
PHYS 1420 (F19)
Physics with Applications to Life Sciences



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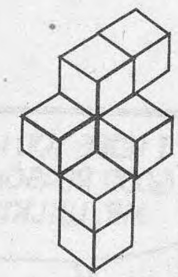
2019.11.19 (Tutorial)

STICKELERS BY TERRY STICKELS

Below is a 7-cube configuration (one cube is hidden from this view).



If you were to pick it up and look at it from every angle, how many faces would you find?

2017.11.29 Toronto Star

1. •Not all oscillatory motion is simple harmonic, but simple harmonic motion is always oscillatory. Explain this statement and give an example to support your explanation. SSM

2. •The fundamental premise of simple harmonic motion is that a force must be proportional to an object's displacement. Is anything else required?

3. •List several examples of simple harmonic motion that you have observed in everyday life.

4. •Explain the difference between a simple pendulum and a physical pendulum.

5. •If the rise and fall of your lungs is considered to be simple harmonic motion, how would you relate the period of the motion to your breathing rate (breaths per minute)? SSM

6. •Explain how *either* a cosine or a sine function will satisfy the force equation for simple harmonic motion.

7. •(a) What are the units of ω? (b) What are the units of ωt?

8. •Galileo was one of the first scientists to observe that the period of a simple harmonic oscillator is independent of its amplitude. Explain what it means that the period is independent of the amplitude. Be sure to mention how the requirement that simple harmonic motion undergo small oscillations is affected by this supposition.

9. •Compare $x(t) = A \cos \omega t$ to $x(t) = A \cos(\omega t + \phi)$. What is the phase angle ϕ and how does it change the solution to simple harmonic motion?

10. •What are three factors that can help you distinguish between a simple pendulum and a physical pendulum?

11. •Explain how you could do an experiment to measure the elevation of your location through the use of a simple pendulum. SSM

12. •In the case of the damped harmonic oscillator, what are the units of the damping constant, *b*?

13. •The application of an external force on a simple pendulum can create many different outcomes, depending on how frequently the force is applied. Explain what will happen to the amplitude of the motion if an external force is applied to a simple pendulum at the same frequency as the natural frequency of the pendulum.

14. •Starting from the full description of an oscillating system,

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = F(t)$$

under what physical and mathematical circumstances will you arrive at the expression describing the basic case of simple harmonic motion?

15. •Explain the difference between the frequency of the driving force and the natural frequency of an oscillator.

81. ••**Calc** Starting with the force equation for a damped harmonic oscillator, show that a solution of the form $x(t) = A\,e^{-(b/2m)t}\sin\omega_1 t$ works. The differential equation and the lightly damped oscillation frequency are

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0 \quad \text{and} \quad \omega_1 = \sqrt{\omega_0^2 - \frac{b^2}{4m^2}}.$$

89. **••Calc** (a) By taking derivatives, show that the following function for $x(t)$ satisfies the complete differential equation for oscillating systems:

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = F(t)$$

$$F(t) = F_0 \cos(\omega t); \quad x(t) = A \sin(\omega t + \phi)$$

(b) Find the values of A and ϕ.

90. ••The *quality factor* Q is a parameter that specifies the width and height of the resonant peak when an oscillator is driven by a sinusoidal external force. It is defined as follows:

$$Q = \frac{m\omega_0}{b}$$

The "width" of the resonant peak is $\Delta\omega = \omega_0/Q$. Although different definitions exist, we'll use the FWHM ("full-width half-max") concept for this width. FWHM is basically the width of the peak at the point that is one-half of the maximum value. For a driven oscillator that has a mass of 100 g, a damping constant of 0.2 kg/s, a peak force of 7.5 N, and a spring constant 25 N/m, calculate the quality factor Q and the FWHM of the resonant peak.