


Physics II

Set no. 1

Ⓔ - exam type question / task

simple harmonic oscillations

$$\vec{F} = -k\vec{r}$$

$$F_x = -kx$$

$$ma_x = -kx$$

$$m\frac{d^2x}{dt^2} = -kx$$

$$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0$$

$$x(t) = A\sin(\omega t + \varphi)\ ;\ \omega = \sqrt{\frac{k}{m}}$$

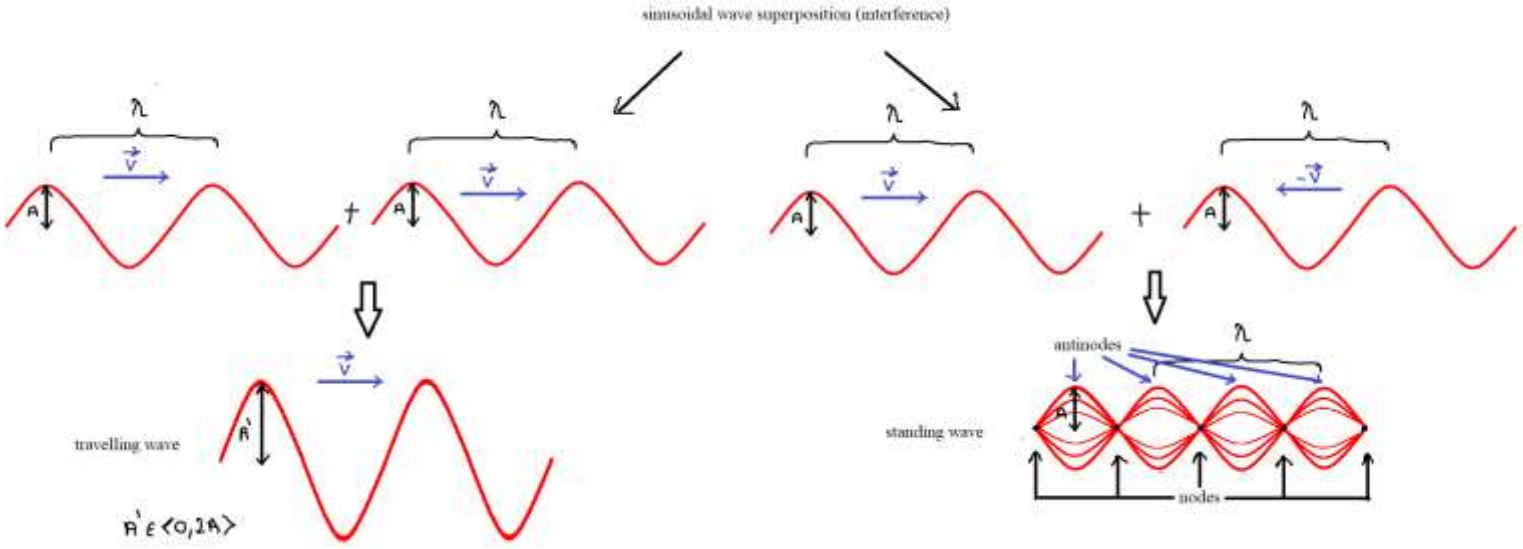
linear (1D) wave equation

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}$$

$$y = y(x \pm vt)$$

e.g.

$$y(x,t) = A\sin(kx - \omega t)$$



1. A particle moves along the x axis from $x = -A$ to $x = A$, in simple harmonic motion with period T. At time $t = 0$ it is at $x = A$. Please:

   a) write the particle position x as a function of time, x(t)
   b) determine the position and velocity v_x when $t = 0.75T$.

2. A particle with mass $m = 0.02$ kg moves in simple harmonic motion according to $x(t) = 2\cos(50t)$, where x is in meters and t is in seconds. Please calculate:
   a) maximum velocity, v_{max}
   b) spring constant, k
   c) maximum potential energy.

3. A $m = 0.25$-kg block oscillates on the end of the spring with a spring constant of $k = 200$ N/m. Please find the amplitude of the oscillation if the oscillation is started by elongating the spring $x = 0.15$ m and giving the block a speed of $v = 3$ m/s.

4. The period of a simple pendulum is $T_1 = 1$ s on Earth. Please determine the period T_2 of this pendulum when brought to a planet where gravitational acceleration is one-tenth that on Earth.

5. Please check that a function $y(x,t) = A\sin(kx - \omega t)$ satisfy the linear wave equation. Determine wave speed as a function of a wave number k and an angular frequency ω.

6. A wave moving along the x axis is described by:

$$y(x,t) = 5 \cdot e^{-(x+4t)^2}$$

   where x is in meters and t is in seconds. Please:
   a) prove that the given wave function satisfy the wave equation,
   b) determine the direction of the wave motion and the speed of the wave.

7. When a particular wire is vibrating with a frequency of $f = 4$ Hz, a transverse wave of wavelength $\lambda = 60$ cm is produced. Please determine the speed of wave pulses along the wire.

8. A sinusoidal wave traveling in the positive x direction has an amplitude of $A = 15$ cm, a wavelength of $\lambda = 40$ cm, and a frequency of $f = 8$ Hz. The vertical displacement of the medium at t = 0 and x = 0 is also y = 15 cm. Please find the angular wave number k, period T, angular frequency ω, and speed v of the wave and then write the wave function.

9. Two waves in one string are described by the wave functions:

$$y_1 = 3.0\cos(4.0x - 1.6t)$$

$$y_2 = 4.0\sin(5.0x - 2.0t)$$

where y and x are in centimeters and t is in seconds. Please find the superposition of the waves:

a) at x = 1 cm, t = 1 s,

b) at x = 1 cm, t = 0.5 s,

c) for all points and for any time (the superposition wave function of these two waves).

E 10. Two sinusoidal waves of the same frequency and the same amplitude *A* propagate in the same direction in the same medium. As a result of their interference, the amplitude of the wave at a certain point is *A*' = 1.93*A*. Please find the phase difference between these two waves.

E 11. Standing waves are produced by the interference of two travelling sinusoidal waves, each of frequency f = 200 Hz. The distance from the 2^{nd} node to the 5^{th} node is d = 60 cm. Please calculate:

a) the wavelength,
b) the speed of each of the two original waves.

12. A transverse wave on a string is described by the expression:

$$y = (0.120\text{ m})\sin(\pi x/8 + 4\pi t)$$

a) Please determine the transverse speed and acceleration of the string at t = 0.2 s for the point on the string located at x = 1.6 m.

E b) What are the wavelength, period, and speed of propagation of this wave?

E 13. Transverse waves with a speed of v = 50 m/s are to be produced in a taut string. A L = 5.00-m length of string with a total mass of m = 0.6 kg is used. What is the required tension?

E 14. A piano string having a mass per unit length $\mu = 5 \cdot 10^{-3}$ kg/m is under a tension of F_T = 1350 N. Please find the speed with which a wave travels on this string