IB Physics SL Y2 – Paper 1 and Paper 2 Review – Topic 4 (Oscillations and Waves)

Name: ____ Date: _____________________ Period: _______

Objectives:
4.1 Kinematics of simple harmonic motion (SHM)
4.2 Energy changes during simple harmonic motion (SHM)
4.3 Forced oscillations and resonance
4.4 Wave characteristics
4.5 Wave properties

4.1.1 Describe examples of oscillations.

4.1.2 Define the terms displacement, amplitude, frequency, period and phase difference.
The connection between frequency and period should be known.

4.1.3 Define simple harmonic motion (SHM) and state the defining equation as $\boldsymbol{a = -\omega^2 x}$
Students are expected to understand the significance of the negative sign in the equation and to recall the connection between ω and T.

4.1.4 Solve problems using the defining equation for SHM.

4.1.5 Apply the equations
$v = v_0 sin\omega t$
$v = v_0 cos\omega t$
$v = \pm\omega\sqrt{(x_0^2 - x^2)}$
$x = x_0 cos\omega t$
as solutions to the defining equation for SHM.

4.1.6 Solve problems, both graphically and by calculation, for acceleration, velocity and displacement during SHM.

4.2.1 Describe the interchange between kinetic energy and potential energy during SHM.

4.2.2 Apply the expressions
$E_K = \frac{1}{2}m\omega^2(x_0^2 - x^2)$, for the kinetic energy of a particle undergoing SHM,
$E_T = \frac{1}{2}m\omega^2 x_0^2$, for the total energy and
$E_P = \frac{1}{2}m\omega^2 x^2$, for the potential energy.

4.2.3 Solve problems, both graphically and by calculation, involving energy changes during SHM.

4.3.1 State what is meant by damping.
It is sufficient for students to know that damping involves a force that is always in the opposite direction to the direction of motion of the oscillating particle and that the force is a dissipative force.

4.3.2 Describe examples of damped oscillations.
Reference should be made to the degree of damping and the importance of critical damping. A detailed account of degrees of damping is not required.

4.3.3 State what is meant by natural frequency of vibration and forced oscillations.

4.3.4 Describe graphically the variation with forced frequency of the amplitude of vibration of an object close to its natural frequency of vibration.
Students should be able to describe qualitatively factors that affect the frequency response and sharpness of the curve.

4.3.5 State what is meant by resonance.

4.3.6 Describe examples of resonance where the effect is useful and where it should be avoided.
Examples may include quartz oscillators, microwave generators and vibrations in machinery.

4.4.1 Describe a wave pulse and a continuous progressive (travelling) wave.
Students should be able to distinguish between oscillations and wave motion, and appreciate that, in many examples, the oscillations of the particles are simple harmonic.

4.4.2 State that progressive (travelling) waves transfer energy.
Students should understand that there is no net motion of the medium through which the wave travels.

4.4.3 Describe and give examples of transverse and of longitudinal waves.
Students should describe the waves in terms of the direction of oscillation of particles in the wave relative to the direction of transfer of energy by the wave. Students should know that sound waves are longitudinal, that light waves are transverse and that transverse waves cannot be propagated in gases.

4.4.4 Describe waves in two dimensions, including the concepts of wave fronts and of rays.

4.4.5 Describe the terms crest, trough, compression and rarefaction.

4.4.6 Define the terms displacement, amplitude, frequency, period, wavelength, wave speed and intensity.
Students should know that intensity $\propto$ amplitude^2.

4.4.7 Draw and explain displacement–time graphs and displacement–position graphs for transverse and for longitudinal waves.

4.4.8 Derive and apply the relationship between wave speed, wavelength and frequency.

4.4.9 State that all electromagnetic waves travel with the same speed in free space, and recall the orders of magnitude of the wavelengths of the principal radiations in the electromagnetic spectrum.

4.5.1 Describe the reflection and transmission of waves at a boundary between two media.
This should include the sketching of incident, reflected and transmitted waves.

4.5.2 State and apply Snell's law.
Students should be able to define refractive index in terms of the ratio of the speeds of the wave in the two media and also in terms of the angles of incidence and refraction.

4.5.3 Explain and discuss qualitatively the diffraction of waves at apertures and obstacles.
The effect of wavelength compared to aperture or obstacle dimensions should be discussed.

4.5.4 Describe examples of diffraction.

4.5.5 State the principle of superposition and explain what is meant by constructive interference and by destructive interference.

4.5.6 State and apply the conditions for constructive and for destructive interference in terms of path difference and phase difference.

4.5.7 Apply the principle of superposition to determine the resultant of two waves.

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Formula Sheet:

$$\omega = \frac{2\pi}{T}$$

$$x = x_0 \sin \omega t; \quad x = x_0 \cos \omega t$$

$$v = v_0 \cos \omega t; \quad v = -v_0 \sin \omega t$$

$$v = \pm\omega\sqrt{(x_0{}^2 - x^2)}$$

$$E_K = \tfrac{1}{2} m\omega^2 (x_0{}^2 - x^2)$$

$$E_{K(max)} = \tfrac{1}{2} m\omega^2 x_0{}^2$$

$$E_T = \tfrac{1}{2} m\omega^2 x_0{}^2$$

$$v = f\lambda$$

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$

$$\text{path difference} = n\lambda$$

$$\text{path difference} = \left(n + \tfrac{1}{2}\right)\lambda$$

ω: angular frequency (rad s^{-1})
T: period (s)
x: displacement (m)
x_0: amplitude (m)
t: time (s)
$E_{K(max)}$: maximum kinetic energy (J)
E_T: total energy (J)
f:frequency (Hz)
λ: wavelength (m)
n_1, n_2: index of refraction
θ_1: angle of refraction
θ_2: angle of incidence

Unit Conversions:
1 atm = 1.01 x 10^5 N m^{-2} = 101 kPa = 760 mm Hg