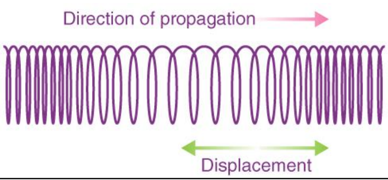
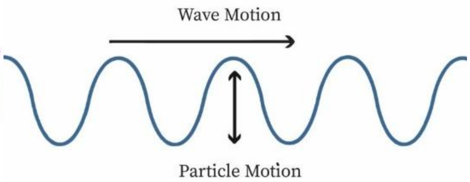
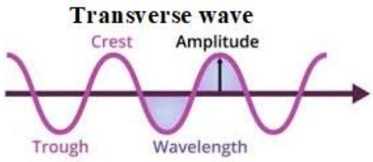
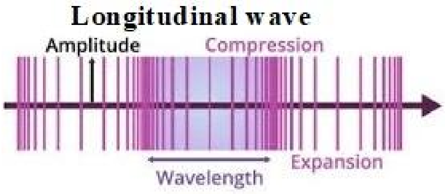
APPLIED PHYSICS-II (2ND SEMESTER DIPLOMA ENGG STUDENTS FROM SUMMER 2025 ONWARDS

UNIT-I (Wave Motion and its Applications)

2 Marks Questions & Solutions		TAXONOMY LEVEL	Marking Scheme
Q1.	**Define Wave motion. Give one example.**		
Ans.	Transfer of energy from one particle to other due to the disturbance caused in the medium without the motion of particle present in the medium is known as wave motion. Ex. **Sound waves**: The vibrations that travel through the air when you speak.   	**Level-1**	**1** **1**
Q2.	**Explosion on other planets are not heard on earth. Why?**	**Level-3**	
Ans.	Explosion on other planets are not heard on earth, because sound wave is a mechanical wave which requires medium for propagation. As there is no material medium between the earth and the planets over a long distance, sound waves cannot propagate.		**1** **1**
Q3.	**A broadcasting station radiates at a frequency 710 KHz. What is the wavelength in meter? Given the velocity of waves = 3×10^8 ms^{-1}.**	**Level-3**	
Ans.	$n = 710$ KHz = 710×10^3 ms^{-1}, $v = 3\times10^8 ms^{-1}$ According to relation $v = n\lambda$ $3\times10^8 = 710\times10^3\times\lambda$ $\lambda = (3\times10^8/710\times10^3)$ m = 422.5 m		**1** **1**
Q4.	**What is Principle of superposition of waves.**	**Level-1**	
Ans.	The principle of superposition of waves tells us that, when two or more waves overlap in space, the net resulting displacement at any point is equal to the algebraic addition of the individual displacement of the respective waves. Let $y_1 = A_1 \sin(\omega t)$ $y_2 = A_2 \sin(\omega t + \phi)$ Where A_1 and A_2 are amplitude of two waves and ϕ is the phase difference between two waves. Resultant wave after superposition has displacement, $Y = y_1 + y_2 = A_1 \sin(\omega t) + A_2 \sin(\omega t + \phi)$ $Y = A \sin(\omega t + \alpha)$ Where A is the resultant amplitude		**1** **½** **½**
Q5.	**A travelling wave is described by the equation $y(x,t) = 0.05 \sin(8x - 4t)$. Find out the wave velocity.**	**Level-3**	

Ans.	On comparing given equation with standard equation $$y = A\sin(kx - \omega t)$$ $v = \frac{\omega}{k} = \frac{4}{8} = 0.5\ ms^{-1}$		**1** **1**
Q6.	**Give any two examples of SHM in daily life.**	**Level-2**	
Ans.	1. A Swing – When you push a swing & let it move back & forth, it follows SHM as long as the motion remains small & air resistance is negligible. The restoring force (gravity) pulls it back towards the equilibrium position. 2. A Vibrating Tuning Fork – When a tuning fork is struck, its prongs oscillate back & forth in SHM, producing sound waves. The restoring force comes from the elasticity of the metal.		**1** **1**
Q7.	**For SHM oscillator, find the force constant(k), the mass attached is 0.2kg & it oscillates with a period of 3s.**	**Level-3**	
Ans.	Time Period (T) = 3s Mass (m) = 0.2kg $$T = 2\pi\sqrt{m/k}$$ $$T^2 = 4\pi^2(m/k)$$ $$k = 4\pi^2(m/T^2)$$ $$= \frac{4 \times \pi^2 \times 0.2}{9}$$ $$= 0.876 N/m$$		**1** **1/2 +1/2**
Q8.	**What is the phase difference between displacement & velocity in SHM?**	**Level-3**	
Ans.	The displacement of a particle in SHM at any instant 't' is $$y = a\sin\omega t$$ $$y = a\sin\frac{2\pi}{T}t$$ The velocity of a particle in SHM at any instant 't' is $$v = \frac{d}{dt}(y)$$ $$= \frac{d}{dt}(a\sin\omega t)$$ $$= a\omega\cos\omega t$$ $$= a\omega\sin\left(\omega t + \frac{\pi}{2}\right)$$ So, in SHM, the velocity is ahead of displacement by a phase angle of $\frac{\pi}{2}$.		**1/2** **1** **1/2**
Q9.	**A particle moves so that its acceleration 'a' is given by $a = -bx$, where x is the displacement from equilibrium position & b is a constant. What will be its period of vibration?**	**Level-2**	
Ans.	Acceleration (a) = - bx Displacement = x $$Time\ period\ (T) = 2\pi\sqrt{\frac{displacement}{acceleration}}$$		**1**

	$$T = 2\pi\sqrt{\frac{x}{bx}}$$ $$T = \frac{2\pi}{\sqrt{b}}$$		**1**
Q10.	**At what distance from the mean position, the kinetic energy & potential energy in SHM becomes equal.**	**Level-2**	
Ans.	Let 'y' be the distance of the particle from mean position when the SHM oscillator has same kinetic energy & potential energy. $\frac{1}{2}m\omega^2(a^2 - y^2) = \frac{1}{2}m\omega^2 y^2$ $(a = amplitude)$ $\Rightarrow a^2 - y^2 = y^2$ $\Rightarrow a^2 = 2y^2$ $\Rightarrow y^2 = a^2/2$ $\Rightarrow y = a/\sqrt{2}$		**1** **1**
Q11.	**The equation for simple harmonic motion is $y = 6\cos(3\pi t + \pi/3)$m. What is its frequency & amplitude?**	**Level-1**	
Ans.	$\boldsymbol{y = a\sin(\omega t + \varphi)}$ $y = 6\cos(3\pi t + \pi/3)$ Comparing the above equations, we get $\omega = 3\pi$ $\Rightarrow 2\pi f = 3\pi$ $\Rightarrow f = \frac{3}{2} = 1.5Hz$ $a = amplitude = 6m$		**1/2** **1/2 + 1/2** **1/2**
Q12.	**Define reverberation and reverberation time.**	**Level-1**	
Ans.	The persistence of sound after the sound source has been stopped due to multiple reflections from surfaces such as room walls, furniture, air etc. within a closed surface is called reverberation. Reverberation time (RT) is the amount of time it takes for sound to decay by 60dB in a room or space after the sound source stops. This is also known as RT_{60}.		**1** **1**
Q13.	**Mention any two methods to control reverberation of time.**	**Level-1**	
Ans.	The two methods to control reverberation of time are as follows- (i)By installation of acoustic panels. (ii)Use of sound absorbing material in ceiling and wall.		**1** **1**
Q14.	**Why are ultrasonic waves not audible to humans?**	**Level-1**	
Ans.	The audible range of frequencies for human beings is between 20HZ to 20,000HZ. Since the frequency of ultrasonic wave is having above 20,000HZ, it is not audible to humans.		**2**
Q15.	**Write two applications of ultrasonic waves.**	**Level-4**	
Ans.	The two applications of ultrasonic waves are as follows- (i) To investigate internal organs of the human body. (ii) Ultrasonic waves are used in the detection of cracks in metal blocks.		**1** **1**

	5 Marks Questions & Solutions	TAXONOMY LEVEL	Marking Scheme
Q1.	**List five differences between transverse wave and Longitudinal wave with examples.**	**Level-1**	
Ans.	**Transverse Wave:** 1. Vibrations of the particles of medium are normal to the direction of wave propagation. 2. Crests and troughs are formed during its propagation.  3. Causes temporary change in shape of the shape of the medium. 4. It can travel either in presence of medium or in absence of medium. 5. It can travel through solid and shallow pool of liquid but not through gases. 6. Examples: Light wave, Vibration in a stretched string. **Longitudinal wave:** 1. Vibrations of the particles of medium are parallel to the direction of wave propagation. 2. Compression and rarefactions are formed during its propagation.  3. Causes temporary change in size of the medium. 4. Needs a medium for its propagation. 5. It can travel through solid, liquid and gases. 6. Examples: Sound wave.		**½** **½** **½** **½** **½** **½** **½** **½** **½** **½**
Q2.	**Define wavelength, frequency and wave velocity and derive the relation between them.**	**Level-1**	
	Every wave is characterized by its wavelength, frequency and wave velocity **Wavelength (λ):** The distance travelled by the wave during the particle of the medium completes one vibration is called as wavelength. In case of transverse wave it is the distance between two consecutive crests or troughs and in case of longitudinal wave it is the distance between two consecutive compressions or rarefactions. S.I unit: meter **Frequency (υ):** The number of complete vibrations that passes		**1** **1**

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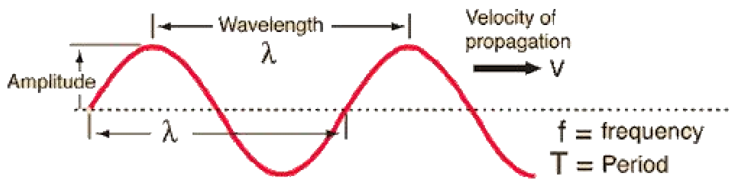
through a specific point within a second.

$\upsilon = \frac{1}{T} = \frac{1}{Timeperiod}$

S.I unit: Hertz (Hz) or s^{-1}



<u>Wave Velocity (v):</u>It is the distance (λ) travelled by the wave during the time (T), a particle completes one vibration.

<u>Relation between wave parameters:</u>

Velocity 'v' of the wave is given by

$v = \frac{distance}{time} = \frac{\lambda}{T} (\frac{1}{T} = \upsilon)$

$\mathbf{v = \upsilon\lambda}$

Velocity of wave= frequency × wavelength
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<td>Q3.</td>
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(i) Define beat and beat frequency with diagram.
(ii) Two sitar strings A and B playing the note 'Dha' are slightly out of tune and produce beats of frequency 5 Hz. The tension in the string slightly increased and the beat frequency found to decreased to 3 Hz. What is the original frequency of B, if the frequency of A is 427Hz.
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<td>Ans.</td>
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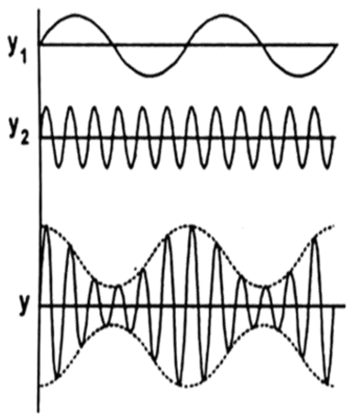
(i) Definition: Periodic variation of intensity of the resultant wave due to superposition of two sound waves of slightly difference in frequencies, travel in a same medium is called as 'Beat'

The beat frequency is the number of beats produced per second

$$\boldsymbol{v_{beat} = v_1 - v_2}$$
$$\boldsymbol{v_1 \& v_2 = Frequencies\ of\ the\ two\ waves}$$



(ii)Increase in tension of a string increases its frequency. If the original frequency of B (υ_B) were greater than that of A (υ_A), further increase in υ_B should have resulted in an increase in the beat frequency. But the beat frequency is found to decrease to 3 Hz. This shows that υ_B<υ_A . Since $\upsilon_A - \upsilon_B$ = 5 Hz,

427 Hz - υ_B = 5 Hz (Given υ_A = 427 Hz)
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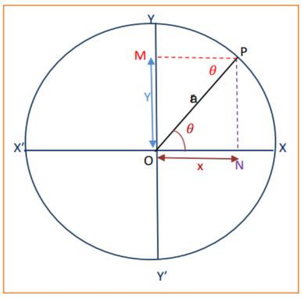
	υ_B = 422 Hz		
Q4.	**Define Simple Harmonic Motion. Derive the expressions for displacement, velocity & acceleration of a body executing SHM.**	**Level-2**	
Ans.	<u>Simple Harmonic Motion</u> -: It is the motion in which the restoring force is proportional to displacement from the mean position & opposes its increase. <u>Displacement</u>-: Let us consider a particle moving with a constant angular velocity (ω) in a circular path. When the particle moves in a circular path its projection makes SHM about the diameter of circle of reference.  $\omega = \frac{\theta}{t}$ $\Rightarrow \theta = \omega t$ $\sin\theta = {}^{y}/_{a}$ (a=amplitude of SHM) $\Rightarrow y = a\sin\omega t$ <u>Velocity(v)</u>-: Velocity of a particle in SHM at any instant is defined as the time rate of change of displacement of the particle at that instant. $v = \frac{d}{dt}(y)$ $= \frac{d}{dt}(a\sin\omega t)$ $v = a\omega\cos\omega t$ <u>Acceleration</u>-: Acceleration of a particle in SHM at any instant is defined as the time rate of change of velocity of the particle at that instant. $v = \frac{d}{dt}(v)$ $= \frac{d}{dt}(a\omega\cos\omega t)$ $=- a\omega^2\sin\omega t$ $=- \omega^2(a\sin\omega t)$ $a =- \omega^2 y$ Negative sign indicates that acceleration is always directed towards the mean position (opposite to displacement).		1 1 1 1 1
Q5.	**Show that the total energy transferred from one particle to another particle as the simple harmonic wave travels through the medium will remain same at each instant of time.**	**Level-4**	
Ans.	A particle executing SHM possesses 2 types of energy i.e. potential energy & kinetic energy. <u>Potential Energy</u> -: It is due to the displacement of the particle from mean position. The restoring force $(F) =- ky$ $=- m\omega^2 y$ (k – force constant) Displacement $(y) = a\sin\omega t$, where a – amplitude of the particle		

	If 'dw' is the workdone against the restoring force for displacing the particle through 'dy', then $dw = \vec{F}.\vec{dy}$ $= Fdy\cos 180°$ $= -(-ky)dy$ $= kydy$ Total workdone in displacing the particle from 0 (mean position) to 'y' is $W = \int_0^w dw$ $= \frac{ky^2}{2}$ *So,* $P.E. = \frac{ky^2}{2}$ $= \frac{1}{2}m\omega^2 a^2 sin^2\omega t$		**1.5**
	<u>Kinetic Energy</u> -: It is due to the velocity of the particle. Velocity of the particle in SHM is $v = \frac{d}{dt}(y)$ $= a\omega\cos\omega t$ So, $KE = \frac{1}{2}mv^2$ $= \frac{1}{2}\mathrm{m}(\mathrm{a}\omega\cos\omega\mathrm{t})^2$ $= \frac{1}{2}\mathrm{m}\omega^2\mathrm{a}^2\cos^2\omega\mathrm{t}$		**1.5**
	Neglecting the frictional forces, the total energy of the particle at any instant is the sum of kinetic energy & potential energy. $\text{Total energy} = \mathrm{KE} + \mathrm{PE}$ $= \frac{1}{2}\mathrm{m}\omega^2\mathrm{a}^2\cos^2\omega\mathrm{t} + \frac{1}{2}m\omega^2 a^2 sin^2\omega t$ $= \frac{1}{2}\mathrm{m}\omega^2\mathrm{a}^2(\cos^2\omega\mathrm{t} + sin^2\omega t)$ $= \frac{1}{2}\mathrm{m}\omega^2\mathrm{a}^2$		**1**
	This energy is transferred from one particle to another particle. For a given particle in SHM the mass(m), angular velocity(ω) & *amplitude*(*a*) are constants. Therefore, the total energy of the particle executing SHM remains constant at all times.		**1**
Q6.	**Distinguish between the free, forced & resonant vibrations with examples.**	**Level-2**	
Ans.	<u>Free vibration -:</u> A system capable of oscillating is said to be executing free vibrations if it vibrates with its own natural frequency without the help of any external periodic force.		**1**
	Ex- The vibrations of the prongs of a tuning fork when one of its prong is struck once on a rubber pad.		**0.5**
	<u>Forced vibration-:</u> When a body vibrates with the help of an external periodic force with a frequency different from the natural frequency of the body, its		**1**

	oscillations are called forced vibration. Ex- The sound boards of all stringed musical instruments like violin, sitar etc Resonant vibration-: When a body oscillates with its own natural frequency with the help of an external periodic force whose frequency is equal to the natural frequency of the body, the oscillations of the body are called resonant vibration. Ex- In resonance apparatus, the loud sound is heard due to resonant vibrations.		**0.5** **1.5** **0.5**
Q7.	**Discuss the coefficient of absorption of sound. What is Sabine's formula?**	**Level-2**	
Ans.	The coefficient ofabsorption of sound is used to evaluate the sound absorption efficiency of materials. It is the ratio of absorbed energy to incident energy and is represented by α. $\alpha = \frac{Ea}{Ei}$ where Ea is the absorbed sound energy on the surface and Ei is the incident sound energy on the surface. If the acoustic energy is entirely absorbed on the surface then, Ea= Ei $\Rightarrow \alpha = 1$ The sound absorption coefficient of materials is correlated with frequency, and it varies with different frequencies. **Sabine's formula** is used to calculate reverberation time of room or space. The formula is $RT_{60}=0.165V/S\alpha$. Where, RT_{60} = the time in seconds required for a sound to decay by 60dB V = the volume of the room in m^3 S = the boundary surface area in m^2 α = the average absorption coefficient of material for a given frequency.		**2.5** **2.5**