

1. Detail of Unit Revision

Subject Name	Physics
Course Name	Physics 02 (Physics Part-2, Class XI)
Module Name/Title	Unit 10: Oscillations and Waves_Revision
Objectives	After going through this lesson, the learners will be able to understand <ul style="list-style-type: none">• How to plan for study• How to consolidate the unit
Keywords	Oscillation, vibration, amplitude, time period, wavelength, simple harmonic motion, wave motion, standing waves, Doppler's effect

2. Development Team

Role	Name	Affiliation
National MOOC Coordinator (NMC)	Prof. Amarendra P. Behera	Central Institute of Educational Technology, NCERT, New Delhi
Course Coordinator / PI	Anuradha Mathur	Central Institute of Educational Technology, NCERT, New Delhi
Teaching Assistants	Chinty Chhawari	Central Institute of Educational Technology, NCERT, New Delhi
	Shivam Dixit	Central Institute of Educational Technology, NCERT, New Delhi

STUDY GUIDE

UNIT 10:

Oscillations and waves

Syllabus

Chapter 14: oscillations

Periodic motion, time period, frequency, displacement as a function of time, periodic functions Simple harmonic motion (S.H.M) and its equation; phase; oscillations of a loaded spring-restoring force and force constant; energy in S.H.M. Kinetic and potential energies; simple pendulum derivation of expression for its time period.

Free forced and damped oscillations (qualitative ideas only) resonance

Chapter 15: Waves

Wave motion transverse and longitudinal waves, speed of wave motion, displacement, relation for a progressive wave, principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, fundamental mode and harmonics, beats, Doppler effect.

Oscillation

For this unit read from the e content, watch the videos. In some derivations NCERT book uses advanced mathematics; you could do it in a simpler way. Read the NCERT book any way for complete picture of SHM.

Keep in mind that SHM, oscillatory or vibratory motions are special types of motion. Like we studied motion in 1, 2 dimensions, motion in a circle, each had a special set of equations of motion relating the initial velocity, final velocity, and displacement in a time interval and moving with constant acceleration. The equations could be used to determine any unknown parameters if others were known. We need to focus on the oscillatory motion and describe its displacement, velocity and acceleration at any instant of time. SHM is a case of periodically varying displacement, velocity and acceleration. Watch the animation before you try to understand the derivation for equation of motion.

Make your check list for study of oscillations

1. Periodic motion,
2. Time period,
3. Frequency,
4. Displacement as a function of time,
5. Periodic functions
6. Simple harmonic motion (S.H.M) and its equation;
7. Phase;
8. Oscillations of a loaded spring-

9. Restoring force and force constant;
10. Energy in S.H.M.
11. Kinetic and potential energies;
12. Simple pendulum
13. Derivation of expression for its time period.
14. Free forced and damped oscillations (qualitative ideas only)
15. Resonance

Put a Tick mark on each concept, only when you understand it or else study more.

Make a list of graphs and formulae, do assignments and questions from e content and the NCERT book.

Waves

Before you go further to the idea of waves and wave motion, try and understand the relation between SHM and wave motion.

1. Wave motion – method of transfer of energy
(Classification as mechanical, such as sound waves, water waves which involves a medium and requires the medium to possess inertia and elasticity or electromagnetic waves which can travel in vacuum)
2. Transverse and longitudinal waves, (distinguished by mode of vibration of particles or electric and magnetic vectors with respect to the direction of propagation)
3. Speed of wave motion, (as speed of travel of energy and speed of oscillation of medium particles in sound waves)
4. Displacement relation for a progressive wave,
5. Principle of superposition of waves,
6. Reflection of waves, (properties of waves reflection, attenuation, refraction, polarisation, diffraction, special cases of superposition -interference, standing waves and beats)
7. Standing waves in strings and organ pipes, (factors which determine the speed of wave in air column and strings)
8. Fundamental mode and harmonics, (application of standing waves)
9. Beats, (see the activity power point presentation on beats and then do problems)
10. Doppler effect (take time to understand the phenomenon of Doppler effect, use your experiences from daily life to understand it, then do numerical problems)

Collect the formulae

Learn to draw waves with proper measurements so that wavelength and amplitude is not seen as varying

Understand the formation of standing waves in strings and air column and then draw accurately labelling the diagrams appropriately.

Connect the formation of stationary waves and its application by the laboratory experiments in your course, do these with care and enjoy the experience.

Problems on Oscillations

1. Obtain the equation of simple harmonic motion of a particle whose amplitude is 0.04m and whose frequency is 50 Hz. The initial phase is $\pi/3$.
2. The shortest oscillation is represented by $y = 0.34 \cos (3000 t + 0.74)$ where y and t are in mm and s respectively. Deduce a) amplitude b) frequency c) angular frequency d) period and e) initial phase
3. The shortest distance travelled by a particle executing SHM from mean position in 2 seconds is equal to $3/2$ times its amplitude. Determine its time period.
4. A body of mass 16 Kg is oscillating on a spring of force constant 100N/m. Deduce its angular frequency.
5. A spring has a load of 0.50 Kg attached at its end, a weight of 4.0 Kg extends the spring by 16 cm. This 4 kg weight is removed and replaced by a 0.5 Kg load. Calculate its time period.
6. A particle executes SHM of $T = 4$ s and amplitude 0.02m. Find max speed, speed at displacement 0.01m, value of acceleration at the extreme position, acceleration at 0.01m.
7. In what time after its motion begins, will a particle oscillating in a straight line according to $x = 7 \sin 0.5 \pi t$ move from the mean position to the maximum displacement?
8. A particle in SHM of amplitude = 25 cm and $T = 3$ s. What is the minimum time required for the particle to move between two points 12.5cm on either side of the mean position?
9. A particle executing SHM with amplitude of 4 cm and time period 12 s. The time taken by the particle in going from its mean position of displacement equal to 2 cm is t_1 . The time taken from this displaced position of 2 cm to reach the extreme position is t_2 . Find the ratio of t_1 and t_2 .
10. A particle of mass 0.1 Kg is executing SHM of amplitude 0.1m. When the particle passes through the mean position, its kinetic energy is 8×10^{-3} J. Find the equation of motion of the particle if the initial phase of oscillation is 45° .

WAVEMOTION, INTERFERENCE, STATIONARY WAVES

1. A transverse harmonic wave on a string is described by

$$y = 3.0 \sin (36t + 0.018 x + \pi/4)$$
 x, y are in cm and t is in sec.
 - a. Give reasons why the expression indicates a travelling or a progressive wave and not a stationary wave.
 - b. What are its amplitude and frequency?
 - c. What is its initial phase?
 - d. What is the distance between two alternate crests in the wave?

2. The transverse displacement of a string clamped at its two ends is given by

$$y = 0.06 \sin 2\pi/3 x \cos 120 \pi t$$
 - a. Why is this equation representing stationary wave?
 - b. What are the wavelength, frequency and speed of propagation of each wave?
 - c. Find the tension in the string if its length is 1.5 m and mass 3×10^{-2} kg.

3. $y = 2.0 \cos 2 \pi (10 t - 0.008 x + 35)$
 What is the phase difference between two points separated by a distance of 4m, 0.5m?

4. Fill in the blanks
 - a. In case of progressive waves, no particle of the media is permanently at _____
 (at rest, in motion)
 - b. In stationary waves the particles of the medium at _____ are permanently at rest.
 - c. The frequency of the fundamental note emitted by an organ pipe open at both ends is _____ the frequency of the fundamental note emitted by a closed organ pipe of the same length. (twice, four times, half)
 - d. In case of an open organ pipe _____ harmonics are present , but in case of a closed pipe only _____ harmonics are present (all, odd, even)
 - e. The quality of sound produced by _____ is better than that produced by _____ (closed pipe , an open pipe)

5. A hospital uses an ultrasonic scanner to locate tumours in a tissue. What is the wavelength of the wave if the speed is 1.7 km/s operating frequency is 4.2 MHz?

6. When we start filling an empty bucket with water, the pitch of the sound produced goes on changing, why?

7. Calculate the frequency of overtones in an open pipe of length 1m , velocity of sound in air = 330 m/s

8. An air column with a tuning fork of $f = 256$ Hz gives resonance at column lengths 33.4 cm and 101.8 cm. Find the speed of sound in air.
9. A resonance occurs with a fork of 512 Hz at a length of 17.4 cm, if the speed of sound is 340 m/s. Find if it is open at both ends or closed at one but open at one end.
10. A string A has thrice the length, thrice the diameter, thrice the tension and thrice the density of another string B. Which overtone of A will have the same frequency as the fundamental of A?