

- 1) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
- 2) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
- 3) Classical Mechanics by Peter Dourmashkin, 2013, John Wiley and Sons.
- 4) Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
- 5) Introduction to Classical Mechanics With Problems and Solutions, David Morin, 2008, Cambridge University Press.
- 6) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 7) Introduction to Special Relativity, Robert Resnick, 2007, Wiley.

Suggestive Link:

[https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_\(Dourmashkin\)/](https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dourmashkin)/)

Suggestive readings:

- 1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 2) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
- 3) Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, 2002, Pearson Education.
- 4) Newtonian Mechanics, A.P. French, 2017, Viva Books.

DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC – 3) WAVES AND OSCILLATIONS

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Waves and Oscillations DSC – 3	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of waves and oscillations learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of free oscillations and superposition of harmonic motion leading to physics of damped and forced oscillations. The course will also introduce students to coupled oscillators, normal

modes of oscillations and free vibrations of stretched strings. Concurrently, in the laboratory component of the course students will perform experiments that expose them to different aspects of real oscillatory systems.

Learning Outcomes

On successful completion of this course, the students will have the skill and knowledge to,

- Understand simple harmonic motion
- Understand superposition of N collinear harmonic oscillations
- Understand superposition of two perpendicular harmonic oscillations
- Understand free, damped and forced oscillations
- Understand coupled oscillators and normal modes of oscillations
- Understand travelling and standing waves, stretched strings

SYLLABUS OF DSC – 3

THEORY COMPONENT

Unit 1: Simple Harmonic Motion (12 Hours)

Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring.

Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats

Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies, effect of variation of phase

Unit 2: Damped and Forced Oscillations (8 Hours)

Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor

Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor

Unit 3: Coupled Oscillations (6 Hours)

Coupled oscillators, normal coordinates and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.

Unit 4: Wave Motion (4 Hours)

One dimensional plane wave, classical wave equation, standing wave on a stretched string (both ends fixed), normal modes. Travelling wave solution

PRACTICAL COMPONENT (60 Hours)

Every student must perform at least 5 experiments

- 1) Experiments using bar pendulum:
 - a) Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.
 - b) Determine the value of g using bar pendulum.
 - c) To study damped oscillations using bar pendulum
 - d) Study the effect of area of the damper on damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers.
- 2) To determine the value of acceleration due to gravity using Kater's pendulum for both the cases (a) $T_1 \approx T_2$ and (b) $T_1 \neq T_2$ and discuss the relative merits of both cases by estimation of error in the two cases.
- 3) Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
- 4) Experiments with spring and mass system
 - a) To calculate g , spring constant and mass of a spring using static and dynamic methods.
 - b) To calculate spring constant of series and parallel combination of two springs.
- 5) To study normal modes and beats in coupled pendulums or coupled springs.
- 6) To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify $\lambda^2 - T$ Law.
- 7) To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.

References (For Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
 - 2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
 - 3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
 - 4) A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
 - 5) An Introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books
- List of experiments

Essential Readings:

FOR THEORY COMPONENT

- 1) Vibrations and Waves by A. P. French. (CBS Pub. and Dist., 1987)

- 2) The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988)
- 3) Fundamentals of Waves and Oscillations By K. Uno Ingard (Cambridge University Press, 1988)
- 4) An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973)
- 5) Waves: BERKELEY PHYSICS COURSE by Franks Crawford (Tata McGrawHill, 2007).
- 6) Classical Mechanics by Peter Dourmashkin, John Wiley and Sons
- 7) [https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_\(Dourmashkin\)](https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dourmashkin))

Suggestive Readings:

- 1) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 2) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.