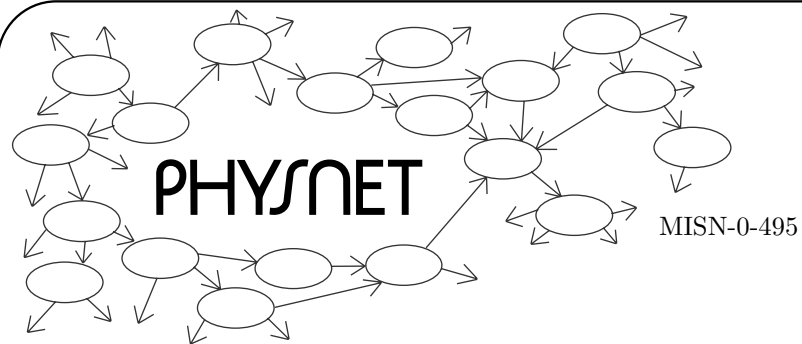




LINEAR OSCILLATIONS

Classical Mechanics

Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

LINEAR OSCILLATIONS

by
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Title: **Linear Oscillations**

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Input Skills:

1. Apply Kirchhoff's circuit equation to find the potential drop around a circuit containing inductors and/or capacitors (MISN-0-119).
2. Define acceleration as a time derivative of the position coordinate for a single particle (MISN-0-493).
3. Write down a second order differential equation for the position coordinate of a single particle acted upon by several external forces (MISN-0-493).

Output Skills (Knowledge):

- K1. Vocabulary: simple harmonic motion, damped oscillation.

Output Skills (Problem Solving):

- S1. Set up and solve the differential equation of a simple harmonic oscillator with given initial conditions. Interpret the various symbols and quantities and represent the solutions on a phase diagram.
- S2. Set up and solve the differential equation of a damped oscillator. Specify the results for the three cases of underdamped, critically damped and overdamped motion.
- S3. Obtain the current as a function of time for an electrical oscillator without the use of the analogy between mechanical and electrical oscillations and/or with the use of such an analogy.

External Resources (Required):

1. J. Marion, *Classical Dynamics*, Academic Press (1988).

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1. Introduction

Among the simple systems encountered in mechanics, the harmonic oscillator and its modifications (for example, with damping and driving forces) are by far the most important. This follows from the fact that any system describable by a potential function and undergoing small amplitude oscillation near equilibrium behaves like a simple harmonic oscillator. Hence, a thorough investigation of harmonic oscillators and the effects of damping and driving forces on such oscillators constitutes an essential part of any study of mechanical systems. This unit reviews some (perhaps already familiar) material on simple harmonic oscillators and the effects of damping forces which are linear in the velocity.

2. Procedures

1. Read Appendix C of Marion, *Ordinary Differential Equations of Second Order*.

Note that:

1. The general solution of the homogeneous equation is always one of the forms given in equations C.10 and C.11 where the r 's are given by the auxiliary equation.
2. The general solution of the inhomogeneous equation is always the sum of the general solution of the homogeneous equation (the complementary function) and any solution of the inhomogeneous equation (a particular integral or solution).

▷ Work problems C-1 and C-2 at the end of Appendix C in Marion.

2. Read Sect. 3.1, 3.2, and 3.4 of Marion.

▷ Work problems 3-1, 3-3 and 3-6 in Marion.

Optional: Read Sect. 3.3 of Marion.

3. Read section 3-5 of Marion.

▷ Work problems 3-2 and 3-11 in Marion.

4. Read section 3-8 of Marion.

▷ Work problems 3-27 and 3-29 in Marion.

5. ▷ Work problems 3-12 and 3-26 in Marion. (Hint for 3-26: See Wylie, pp. 79-80.)

▷ Exercise - A weight of 128 lb hangs from a spring of modulus 75 lb/in. The damping in the system is 28 percent of critical. Determine the motion of the weight if it is pulled downward 2 in. from its equilibrium position and suddenly released.

▷ Exercise - A $1\text{-}\mu\text{f}$ condenser with an initial charge $Q_0 = 10^{-5}$ coulomb is discharged through a resistance of 120 ohms and an inductance of 0.01 henry connected in series with it. Find the current as a function of time.

Acknowledgments

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