

# 1 Free Vibration of Single Degree-of-freedom Systems

## 1.1 Solved Problems

### Problem 1:

For the mechanical system shown to the right, the uniform rigid bar has mass  $m$  and pinned at point  $O$ . For this system:

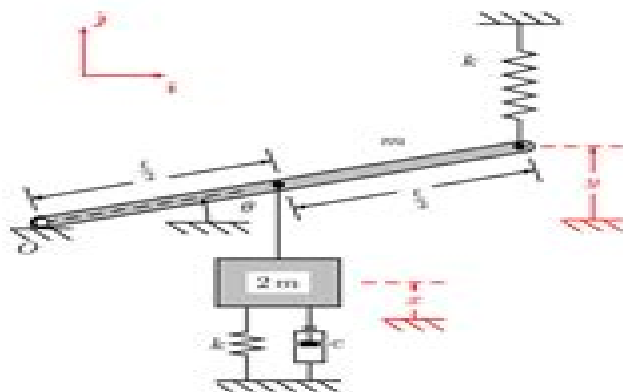
- find the equations of motion;
- Identify the damping ratio and natural frequency in terms of the parameters  $m$ ,  $c$ ,  $k$ , and  $\ell$ .
- For:

$$m = 1.50\text{kg}, \quad \ell = 45\text{cm}, \\ c = 0.125\text{N}/(\text{m}/\text{s}), \quad k = 250\text{N}/\text{m},$$

find the angular displacement of the bar  $\theta(t)$  for the following initial conditions:

$$\theta(0) = 0, \quad \dot{\theta}(0) = 10\text{rad}/\text{s}.$$

Assume that in the horizontal position the system is in static equilibrium and that all angles remain small.



### Solution:

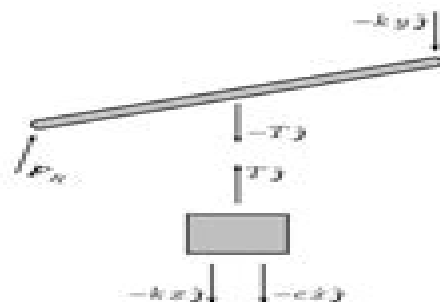
- In addition to the coordinate  $\theta$  identified in the original figure, we also define  $x$  and  $y$  as the displacement of the block and end of the bar respectively. The directions  $\hat{i}$  and  $\hat{j}$  are defined as shown in the figure.

A free body diagram for this system is shown to the right. Note that the tension in the cable between the bar and the block is unknown and represented with  $T$  while the reaction force  $\mathbf{F}_R$  is included, although both its magnitude and direction are unspecified. In terms of the identified coordinates, the angular acceleration of the bar  $\alpha_\theta$  and the linear acceleration of the block  $\mathbf{a}_c$  are

$$\alpha_\theta = \ddot{\theta} \hat{k}, \quad \mathbf{a}_c = \ddot{x} \hat{i}.$$

We can also relate the identified coordinates as

$$x = \frac{\ell}{2} \theta, \quad y = \ell \theta.$$



The equations of motion for this system can be obtained with linear momentum balance applied to the block and angular momentum balance about  $O$  on the bar. These can be

# Mechanical Vibration Solved Problems

**Huangqi Zhang**



## **Mechanical Vibration Solved Problems:**

**Schaum's Outline of Theory and Problems of Mechanical Vibrations** William W. Seto, 1964      **Mechanical Vibration** Ivana Kovacic, Dragi Radomirovic, 2017-10-02 Mechanical oscillators in Lagrange's formalism a thorough problem solved approach This book takes a logically organized clear and thorough problem solved approach at instructing the reader in the application of Lagrange's formalism to derive mathematical models for mechanical oscillatory systems while laying a foundation for vibration engineering analyses and design Each chapter contains brief introductory theory portions followed by a large number of fully solved examples These problems inherent in the design and analysis of mechanical systems and engineering structures are characterised by a complexity and originality that is rarely found in textbooks Numerous pedagogical features explanations and unique techniques that stem from the authors extensive teaching and research experience are included in the text in order to aid the reader with comprehension and retention The book is rich visually including numerous original figures with high standard sketches and illustrations of mechanisms Key features Distinctive content including a large number of different and original oscillatory examples ranging from simple to very complex ones Contains many important and useful hints for treating mechanical oscillatory systems Each chapter is enriched with an Outline and Objectives Chapter Review and Helpful Hints Mechanical Vibration Fundamentals with Solved Examples is essential reading for senior and graduate students studying vibration university professors and researchers in industry

Mechanical Vibrations Michel Geradin, Daniel J. Rixen, 2014-11-24 Mechanical Vibrations Theory and Application to Structural Dynamics Third Edition is a comprehensively updated new edition of the popular textbook It presents the theory of vibrations in the context of structural analysis and covers applications in mechanical and aerospace engineering Key features include A systematic approach to dynamic reduction and substructuring based on duality between mechanical and admittance concepts An introduction to experimental modal analysis and identification methods An improved more physical presentation of wave propagation phenomena A comprehensive presentation of current practice for solving large eigenproblems focusing on the efficient linear solution of large sparse and possibly singular systems A deeply revised description of time integration schemes providing framework for the rigorous accuracy stability analysis of now widely used algorithms such as HHT and Generalized Solved exercises and end of chapter homework problems A companion website hosting supplementary material      **Solved Problems in Mechanical Vibrations. Ediz. Integrale** S. Zuin, G. Bucca, F. Ripamonti, A. Collina, S. Bruni, 2021

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**Schaum's Outline of Mechanical Vibrations** S Graham Kelly,1996-04-22 Logically organized this book guides readers through all aspects of vibration analysis Each chapter explains how to harness the problem solving capabilities of today s popular engineering software including Mathcad Maple Matlab and Mathematica Topics covered include vibration measurement finite element analysis and eigenvalue determination Included are more than 300 solved problems completely explained

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