

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:

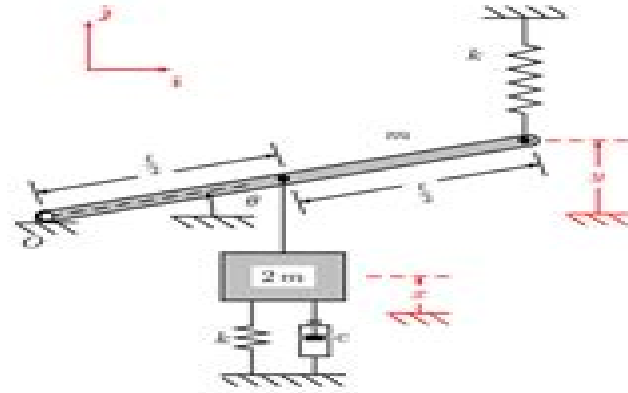
- find the equations of motion;
- Identify the damping ratio and natural frequency in terms of the parameters m , c , k , and ℓ .
- For:

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

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

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

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



Solution:

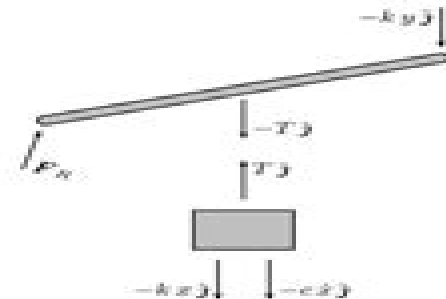
- In addition to the coordinate θ identified in the original figure, we also define x and y as the displacement of the block and end of the bar respectively. The directions \hat{i} and \hat{j} are defined as shown in the figure.

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 α_θ 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

M Woodhall



Mechanical Vibration Solved Problems:

Schaum's Outline of Theory and Problems of Mechanical Vibrations William W. Seto, 1964 *Mechanical Vibration* Ivana Kovacic, Dragi Radomirovic, 2017-07-17 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

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Solved Problems in Mechanical Vibrations. Ediz. Integrale S. Zuin, G. Bucca, F. Ripamonti, A. Collina, S. Bruni, 2021

Introductory Course on Theory and Practice of Mechanical Vibrations J. S. Rao, 1999 The Book Presents The Theory Of Free Forced And Transient Vibrations Of Single Degree Two Degree And Multi Degree Of Freedom Undamped And Damped Lumped Parameter Systems And Its Applications Free And Forced Vibrations Of Undamped Continuous Systems Are Also Covered Numerical Methods Like Holzers And Myklestads Are Also Presented In Matrix Form Finite Element Method For Vibration Problem Is Also Included Nonlinear Vibration And Random Vibration Analysis Of Mechanical Systems Are Also Presented The Emphasis Is On Modelling Of Engineering Systems Examples Chosen Even Though Quite Simple Always Refer To Practical Systems Experimental Techniques In Vibration Analysis Are Discussed At Length In A Separate Chapter And Several Classical Case Studies Are Presented Though The Book Is Primarily Intended For An Undergraduate Course In Mechanical Vibrations It Covers Some Advanced Topics Which Are Generally Taught At Postgraduate Level The Needs Of The Practising Engineers Have Been Kept In Mind Too A Manual Giving Solutions Of All The Unsolved Problems Is Also Prepared Which Would Be Extremely Useful To Teachers

Theory and problems of mechanical vibrations William W. Seto, 1970 *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

Mechanical Vibrations Michel Geradin, Daniel J. Rixen, 2015-02-16 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

Solving Vibration Analysis Problems Using MATLAB Rao V. Dukkipati, 2007 Solving Engineering Vibration Analysis Problems using MATLAB book is designed as an introductory undergraduate or graduate course for engineering students of all disciplines Vibration analysis is a multidisciplinary subject and presents a system dynamics methodology based on mathematical fundamentals and stresses physical system modeling The classical methods of vibration analysis engineering are covered matrix analysis Laplace transforms and transfer functions The numerous worked examples and unsolved exercise problems are intended to provide the reader with an awareness of the general applicability

of vibration analysis problems using MATLAB An extensive bibliography to guide the student to further sources of information on vibration analysis using MATLAB is provided at the end of the book All end of chapter problems are fully solved in the Solution Manual available only to Instructors

Mechanical Vibration Practice with Basic Theory
Viswanatha Ramamurti, 2000 Use of 3D beam element to solve the industrial problems along with the source code and more than 100 practical worked out examples make the book versatile Written in a lucid language emphasising concepts the book will be a priceless possession for students teachers and professional engineers BOOK JACKET

Theory and Problems of Mechanical Vibrations, 1964* *Hilbert Transform Applications in Mechanical Vibration* Michael Feldman, 2011-03-08

Hilbert Transform Applications in Mechanical Vibration addresses recent advances in theory and applications of the Hilbert transform to vibration engineering enabling laboratory dynamic tests to be performed more rapidly and accurately The author integrates important pioneering developments in signal processing and mathematical models with typical properties of mechanical dynamic constructions such as resonance nonlinear stiffness and damping A comprehensive account of the main applications is provided covering dynamic testing and the extraction of the modal parameters of nonlinear vibration systems including the initial elastic and damping force characteristics This unique merger of technical properties and digital signal processing allows the instant solution of a variety of engineering problems and the in depth exploration of the physics of vibration by analysis identification and simulation This book will appeal to both professionals and students working in mechanical aerospace and civil engineering as well as naval architecture biomechanics robotics and mechatronics Hilbert Transform Applications in Mechanical Vibration employs modern applications of the Hilbert transform time domain methods including The Hilbert Vibration Decomposition method for adaptive separation of a multi component non stationary vibration signal into simple quasi harmonic components this method is characterized by high frequency resolution which provides a comprehensive account of the case of amplitude and frequency modulated vibration analysis The FREEVIB and FORCEVIB main applications covering dynamic testing and extraction of the modal parameters of nonlinear vibration systems including the initial elastic and damping force characteristics under free and forced vibration regimes Identification methods contribute to efficient and accurate testing of vibration systems avoiding effort consuming measurement and analysis Precise identification of nonlinear and asymmetric systems considering high frequency harmonics on the base of the congruent envelope and congruent frequency Accompanied by a website at www.wiley.com/go/feldman housing MATLAB SIMULINK codes

Applied Structural and Mechanical Vibrations Paolo L. Gatti, 2014-02-24 The second edition of Applied Structural and Mechanical Vibrations Theory and Methods continues the first edition's dual focus on the mathematical theory and the practical aspects of engineering vibrations measurement and analysis This book emphasises the physical concepts brings together theory and practice and includes a number of worked out examples of varying difficulty and an extensive list of references What's New in the Second Edition Adds new material on response spectra Includes revised chapters on modal

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Mechanical Vibrations György Szeidl, László Péter Kiss, 2020-06-16 This book presents a unified introduction to the theory of mechanical vibrations The general theory of the vibrating particle is the point of departure for the field of multidegree of freedom systems Emphasis is placed in the text on the issue of continuum vibrations The presented examples are aimed at helping the readers with understanding the theory This book is of interest among others to mechanical civil and aeronautical engineers concerned with the vibratory behavior of the structures It is useful also for students from undergraduate to postgraduate level The book is based on the teaching experience of the authors

Fundamentals of Mechanical Vibrations Liang-Wu Cai, 2016-04-25 This introductory book covers the most fundamental aspects of linear vibration analysis for mechanical engineering students and engineers Consisting of five major topics each has its own chapter and is aligned with five major objectives of the book It starts from a concise rigorous and yet accessible introduction to Lagrangian dynamics as a tool for obtaining the governing equations for a system the starting point of vibration analysis The second topic introduces mathematical tools for vibration analyses for single degree of freedom systems In the process every example includes a section Exploring the Solution with MATLAB This is intended to develop student's affinity to symbolic calculations and to encourage curiosity driven explorations The third topic introduces the lumped parameter modeling to convert simple engineering structures into models of equivalent masses and springs The fourth topic introduces mathematical tools for general multiple degrees of freedom systems with many examples suitable for hand calculation and a few computer aided examples that bridges the lumped parameter models and continuous systems The last topic introduces the finite element method as a jumping point for students to understand the theory and the use of commercial software for vibration analysis of real world structures

Theory and Problems of Mechanical Vibrations William W. Sete, 1984
Mechanical Vibration Haym Benaroya, Mark Nagurka, Seon Mi Han, 2022-07-15 The Fifth edition of this classic textbook

includes a solutions manual Extensive supplemental instructor resources are forthcoming in the Fall of 2022 Mechanical Vibration Theory and Application presents comprehensive coverage of the fundamental principles of mechanical vibration including the theory of vibration as well as discussions and examples of the applications of these principles to practical engineering problems The book also addresses the effects of uncertainties in vibration analysis and design and develops passive and active methods for the control of vibration Many example problems with solutions are provided These examples as well as compelling case studies and stories of real world applications of mechanical vibration have been carefully chosen and presented to help the reader gain a thorough understanding of the subject There is a solutions manual for instructors who adopt this book Request a solutions manual here <https://www.rutgersuniversitypress.org/mechanical-vibration>

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