

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:

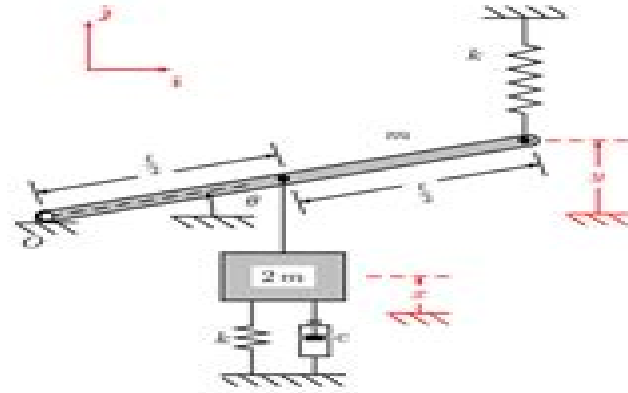
- find the equations of motion;
- Identify the damping ratio and natural frequency in terms of the parameters m , c , k , and ℓ .
- For:

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

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 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.

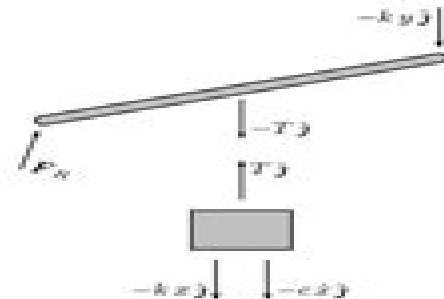
A free body diagram for this system is shown to the right. Note that the tension in the cable between the bar and the block is unknown and represented with T while the reaction force \mathbf{F}_R is included, although both its magnitude and direction are unspecified. In terms of the identified coordinates,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

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

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

**Haym Benaroya, Mark Nagurka, Seon
Mi Han**



Mechanical Vibration Solved Problems:

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

Schaum's Outline of Theory and Problems of Mechanical Vibrations William W. Seto,1964 **Mechanical Vibrations** Michel Geradin,Daniel J. Rixen,2014-12-24 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

Mechanical Vibrations Shrikant Bhawe,2010 Mechanical Vibrations is an unequaled combination of conventional vibration techniques along with analysis design computation and testing Emphasis is given on solving vibration related issues and failures in industry *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 **Theory and problems of mechanical vibrations** William W. Seto,1970 **An Introduction to Mechanical Vibrations** Robert F. Steidel,1971 **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> **Mechanical Vibration** Haym Benaroya,Mark Nagurka,2009-06-10 Mechanical Vibration Analysis Uncertainties and Control simply and comprehensively addresses the fundamental principles of vibration theory emphasizing its application in solving practical engineering problems The authors focus on strengthening engineers command of mathematics as a cornerstone for understanding vibration control and the ways in which uncertainties affect analysis It provides a detailed exploration and explanation of the essential equations involved in modeling vibrating systems and shows readers how to employ MATLAB as an advanced tool for analyzing specific problems Forgoing the extensive and in depth analysis of randomness and control found in more specialized texts this straightforward easy to follow volume presents the format content and depth of description that the authors themselves would have found useful when they first learned the subject The authors assume that the readers have a basic knowledge of dynamics mechanics of materials differential equations and some knowledge of matrix algebra Clarifying necessary mathematics they present formulations and explanations to convey significant details The material is organized to afford great flexibility regarding course level content and usefulness in self study for practicing engineers or as a text for graduate engineering students This work includes example problems and explanatory figures biographies of renowned contributors and access to a website providing supplementary resources These include an online MATLAB primer featuring original programs that can be used to solve complex problems and test solutions *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* *Basic Mechanical Vibrations* A J Pretlove,2013-09-24 BASIC Mechanical Vibrations deals

with vibrations and combines basic theory with the development of useful computer programs to make design calculations. The programs in the book are written in BASIC. This book is comprised of six chapters and begins with a brief introduction to computing with special emphasis on the fundamentals of the BASIC computer language. The chapters that follow give concise elements of vibration theory followed by problem solving examples making use of BASIC programs. The vibration analysis of engineering systems which may be modeled by a single degree of freedom is presented. Simple systems with damping and no damping are considered along with systems having two and several degrees of freedom. The final chapter is concerned with bending vibrations. The text includes some subroutines for performing simple matrix operations on two dimensional arrays that can be used in vibration calculations. This monograph will be useful to engineers who need to make vibration design calculations and to students of mechanical engineering.

Mechanical Vibration William John Palm, 2007. Model, analyze and solve vibration problems using modern computer tools. Featuring clear explanations, worked examples, applications and modern computer tools. William Palm's *Mechanical Vibration* provides a firm foundation in vibratory systems. You'll learn how to apply knowledge of mathematics and science to model and analyze systems ranging from a single degree of freedom to complex systems with two and more degrees of freedom. Separate MATLAB sections at the end of most chapters show how to use the most recent features of this standard engineering tool in the context of solving vibration problems. The text introduces Simulink where solutions may be difficult to program in MATLAB such as modeling Coulomb friction effects and simulating systems that contain non-linearities. Ample problems throughout the text provide opportunities to practice identifying, formulating and solving vibration problems.

KEY FEATURES: Strong pedagogical approach including chapter objectives and summaries. Extensive worked examples illustrating applications. Numerous realistic homework problems. Up to date MATLAB coverage. The first vibration textbook to cover Simulink. Self-contained introduction to MATLAB in Appendix A. Special section dealing with active vibration control in sports equipment. Special sections devoted to obtaining parameter values from experimental data.

Schaum's Outline of Theory and Problems of Mechanical Vibrations S. Graham Kelly, 1996-01-01. *Theory and Problems of Mechanical Vibrations* William W. Sete, 1984. *Mechanical Vibrations* Francis S. Tse, Ivan E. Morse, Rolland Theodore Hinkle, 1978.

Mechanical Vibration Haym Benaroya, Mark Nagurka, Seon Mi Han, 2022-07-15. *Mechanical Vibration Analysis: Uncertainty and Control* 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. In dealing with the subject of vibration the engineer must also consider the effects of uncertainties in the analysis and methods for the control of vibration. As such this book includes treatment of both subjects: modeling of uncertainties and vibration control. Many example problems with solutions are included and are carefully chosen and are presented at strategic points enabling the reader to have a thorough understanding of the subject and to help cement core ideas. The book includes compelling case studies and stories of real

world applications of mechanical vibration
Vibrations ,1964

Applied Mechanical Vibrations David V. Hutton,1981

Mechanical

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web easy handling bolt numbering shall be done clockwise around the flange with the following sequence the table below shows the torque sequence for flanges with 4 to 32 bolts number of bolt studbolt tightening sequence to follow4 bolt flange1 3 2 4 8 bolt flange1 5 3 7 2 6 4 8 12 bolt flange1 7 4 10 2 8 5 11 3 9 6 12 16 bolt

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web for flanges with 12 or more bolts 1 st round 20 percent of final torque 2 nd round 40 percent of final torque 3 rd round 80 percent of final torque 4 th round 100 percent of final torque final round clockwise or counter clockwise around the flange please take note the above bolt tightening sequences are the most

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web number of bolt stud bolt tightening sequence to follow 4 bolt flange 1 3 2 4 8 bolt flange 1 5 3 7 2 6 4 8 12 bolt flange 1 7 4 10 2 8 5 11 3 9 6 12 16 bolt flange 1 9 5 13 3 11 7 15 2 10 6 14 4 12 8 16 20 bolt flange 1 11 6 16 3 13 8 18 5 15 10 20 2 12 7 17 4 14 9 19 24 bolt flange

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web ensure the bolt lengths allow for a minimum of 2 3 threads protruding beyond the top of the nut when tightened bolts must be tightened according to the below sequence options assemble bolts hand tight maximum 30 of final tightening torque as per below cross pattern sequences

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web step 1 liberally lubricate all load bearing surfaces including threads and flat washers then install and finger tighten all fasteners number the bolts flange according to the bolt torque sequence step 2 set the torque wrench to 1 3 of the target torque value and tighten in an order bolts 1 2 3 4 until all have been tightened

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web tightening sequence the first pass lightly tighten the first bolt then move directly across or 180 degrees for the second bolt then move 1 4 turn around the circle or 90 degrees for the third bolt and directly across for the fourth continue this sequence until all bolts are tightened when tightening a four bolt flange use a criss cross

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web dec 17 2020 bolt tightening sequence why it matters to complete a flange joint securely it is essential to control the

stress variation in the flange joint components in the case of the gasket this needs to be compressed evenly across the flange face if you were to tighten adjacent bolts when those opposite remain loose the result will be

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web jan 10 2016 twelve bolt tightening sequence sequential order 1 2 3 4 5 6 7 8 9 10 11 12 rotation order 1 5 9 3 7 11 2 6 10 4 8 12 sixteen bolt tightening sequence sequential order 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 rotation order 1 9 5 13 3 11 7 15 2 10 6 14 4 12 8 16 twenty bolt tightening sequence

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