

PROBLEM 19.11

A 2 kg block is supported as shown by a spring of constant $k = 400 \text{ N/m}$, which can act in tension or compression. The block is in its equilibrium position when it is struck from below by a hammer, which imparts to the block an upward velocity of 2.5 m/s . Determine (a) the time required for the block to move 100 mm upward, (b) the corresponding velocity and acceleration of the block.

SOLUTION

Simple harmonic motion.

$$x = x_m \sin(\omega_n t + \phi)$$

Natural frequency:

$$\omega_n = \sqrt{\frac{k}{m}}, \quad k = 400 \text{ N/m}$$

$$\omega_n = \sqrt{\frac{400 \text{ N/m}}{2}}$$

$$\omega_n = 10\sqrt{2} = 14.1421 \text{ rad/s}$$

$$x(0) = 0 = x_m \sin(0 + \phi)$$

$$\phi = 0$$

$$\dot{x}(0) = x_m \omega_n \cos(0 + 0)$$

$$\dot{x}(0) = 2.5 \text{ m/s}$$

$$2.5 = x_m (14.1421) \quad x_m = 0.17678 \text{ m}$$

$$x = (0.17678) \sin(14.1421 t) \text{ (m/s)} \quad (1)$$

(a) Time at $x = 100 \text{ mm}$ ($x = 0.1 \text{ m}$)

$$0.1 = 0.17678 \sin(14.1421 t)$$

$$t = \frac{\sin^{-1}\left(\frac{0.1}{0.17678}\right)}{14.1421} = 0.04252 \text{ s}$$

$$t = 0.046 \text{ s} \quad \blacktriangleleft$$

Note: Since ω is in rad/s, convert the argument of \sin^{-1} to radians.

(b) Velocity and acceleration.

$$\dot{x} = x_m \omega_n \cos(\omega_n t)$$

$$\ddot{x} = -x_m \omega_n^2 \sin \omega_n t$$

$$t = 0.04252$$

$$\dot{x} = (0.17678)(14.1421) \cos[(14.1421)(0.04252)]$$

$$\dot{x} = 2.0615 \text{ m/s} \quad \mathbf{v} = 2.06 \text{ m/s} \uparrow \quad \blacktriangleleft$$

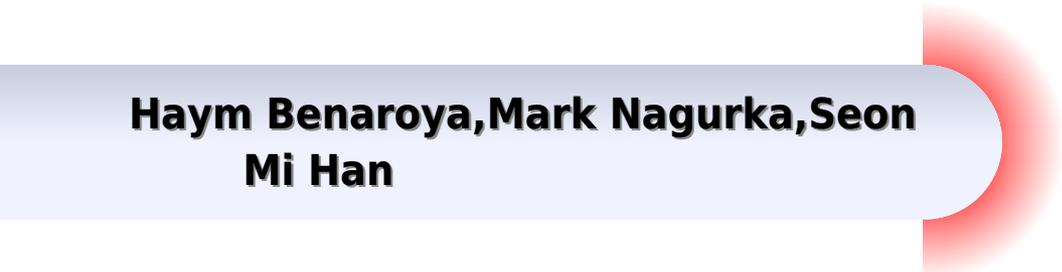
$$\ddot{x} = -(0.17678)(14.1421)^2 \sin[(14.1421)(0.04252)]$$

$$= -20 \text{ m/s}^2 \quad \mathbf{a} = 20.0 \text{ m/s}^2 \downarrow \quad \blacktriangleleft$$



Dynamics Vibrations Solution Manual

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



Dynamics Vibrations Solution Manual:

Solutions Manual to Accompany Vibration of Mechanical and Structural Systems James, 1994-01-01 *System Dynamics for Engineering Students* Nicolae Lobontiu, 2017-08-29 Engineering system dynamics focuses on deriving mathematical models based on simplified physical representations of actual systems such as mechanical electrical fluid or thermal and on solving these models for analysis or design purposes *System Dynamics for Engineering Students Concepts and Applications* features a classical approach to system dynamics and is designed to be utilized as a one semester system dynamics text for upper level undergraduate students with emphasis on mechanical aerospace or electrical engineering It is the first system dynamics textbook to include examples from compliant flexible mechanisms and micro nano electromechanical systems MEMS NEMS This new second edition has been updated to provide more balance between analytical and computational approaches introduces additional in text coverage of Controls and includes numerous fully solved examples and exercises Features a more balanced treatment of mechanical electrical fluid and thermal systems than other texts Introduces examples from compliant flexible mechanisms and MEMS NEMS Includes a chapter on coupled field systems Incorporates MATLAB and Simulink computational software tools throughout the book Supplements the text with extensive instructor support available online instructor s solution manual image bank and PowerPoint lecture slides **NEW FOR THE SECOND EDITION** Provides more balance between analytical and computational approaches including integration of Lagrangian equations as another modelling technique of dynamic systems Includes additional in text coverage of Controls to meet the needs of schools that cover both controls and system dynamics in the course Features a broader range of applications including additional applications in pneumatic and hydraulic systems and new applications in aerospace automotive and bioengineering systems making the book even more appealing to mechanical engineers Updates include new and revised examples and end of chapter exercises with a wider variety of engineering applications **The Shock and Vibration Bulletin** ,1968-08 **Vibration Control of Active Structures** A. Preumont, 2002-09-30 This book consists of 14 chapters Chapters 2 and 3 are devoted to the dynamics of active structures the open loop transfer functions are derived from the constitutive equations the discussion includes active trusses with piezoelectric struts and beams and shells with embedded laminar piezoelectric actuators and sensors Chapters 4 and 5 discuss the virtues of collocated actuator sensor configurations and how they can be exploited to develop active damping with guaranteed stability Chapter 6 addresses vibration isolation for one and 6 d o f Chapter 7 discusses optimal control for SISO systems with symmetric root locus Chapter 8 discusses the design tradeoffs for SISO systems in the frequency domain including the Bode amplitude phase relationship Chapter 9 provides a more general discussion of optimal control using of optimal control using the Riccati equation spillover is examined Chapters 10 and 11 review briefly the concepts of controllability observability and stability Chapter 12 discusses the semi active control including some materials on magneto rheological fluids Chapter 13 describes

various practical applications to active damping precision positioning and vibroacoustics and chapter 14 discusses the active damping of cable structures *Engineering Vibration Analysis with Application to Control Systems* C. Beards,1995-06-17 Most machines and structures are required to operate with low levels of vibration as smooth running leads to reduced stresses and fatigue and little noise This book provides a thorough explanation of the principles and methods used to analyse the vibrations of engineering systems combined with a description of how these techniques and results can be applied to the study of control system dynamics Numerous worked examples are included as well as problems with worked solutions and particular attention is paid to the mathematical modelling of dynamic systems and the derivation of the equations of motion All engineers practising and student should have a good understanding of the methods of analysis available for predicting the vibration response of a system and how it can be modified to produce acceptable results This text provides an invaluable insight into both

ICE Manual of Geotechnical Engineering Volume 2 Hilary Skinner,D G Toll,Kelvin Higgins, Mike Brown,John Burland,2023-11-17 ICE Manual of Geotechnical Engineering Second edition brings together an exceptional breadth of material to provide a definitive reference on geotechnical engineering solutions Written and edited by leading specialists each chapter provides contemporary guidance and best practice knowledge for civil and structural engineers in the field *Practical Solution of Torsional Vibration Problems* William Ker Wilson,1956

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Vibration Analysis Rao V. Dukkipati,2004 Discusses in a concise but through manner fundamental statement of the theory principles and methods of mechanical vibrations

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SV. Sound and Vibration ,1996

Solutions Manual to Accompany Vibration Analysis Robert K. Vierck,1979

The Shock and Vibration Digest ,1993

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

Applied Mechanics Reviews ,1949

Analysis and Design of Dynamic Systems Ira Cochin,Harold J. Plass,1990 Using practical examples to enhance student understanding this text introduces fundamental systems techniques for the analysis and design of dynamic systems integrating discussions of control systems physical principles and vibration with coverage of system

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