Chapter 3
Harmonically Excited Vibration

(3.1) (a) $\delta = \frac{W}{k} = \frac{50}{4000} = 0.0125$ m

(b) $\delta_{st} = \frac{F_0}{k} = \frac{60}{4000} = 0.015$ m

(c) $\omega_n = \sqrt{\frac{k}{m}} = \left(\frac{4000 \times 9.81}{50}\right)^{1/2} = 28.0285$ rad/sec

$\omega = \omega_n = 27.4295$ rad/sec

$x = \delta_{st}\left|\frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}\right| = 0.015\left|\frac{1}{1-\left(\frac{27.4295}{28.0285}\right)^2}\right| = 0.0185$ m

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(3.2) $\tau_b = \frac{2\pi}{\omega_n - \omega} = \frac{2\pi}{2\pi(400 - 39.8)} = 5$ sec

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(3.3) $k = 4000$ N/m, $m = 10$ kg, $F(t) = 400\cos 10t$ N

$F_0 = 400$ N, $\omega = 10$ rad/s

$\omega_n = \sqrt{\frac{k}{m}} = 20$ rad/s, $\frac{\omega^2}{\omega_n} = \frac{10}{20} = 0.5 < 1$

Response is given by Eq. (3.9):

$x(t) = \left(x_0 - \frac{F_0}{k - m\omega^2}\right)\cos\omega_n t + \left(\frac{\dot{x}_0}{\omega_n}\right)\sin\omega_n t + \frac{F_0}{k - m\omega^2}\cos\omega t$

(a) $x_0 = 0.1$, $\dot{x}_0 = 0$:

Eq. (E.1) becomes

$x(t) = \left\{0.1 - \frac{400}{4000 - 10(100)}\right\}\cos 20t + \frac{400}{4000 - 10(100)}\cos 10t$ (E.1)

$= -0.033333\cos 20t + 0.133333\cos 10t$ (E.2)

(b) $x_0 = 0$, $\dot{x}_0 = 10$:

Eq. (E.1) becomes

$x(t) = \left\{0 - \frac{400}{4000 - 10(100)}\right\}\cos 20t + \frac{10}{20}\sin 20t$

$\quad + \left\{\frac{400}{4000 - 10(100)}\right\}\cos 10t$

$= -0.133333\cos 20t + 0.5\sin 20t + 0.133333\cos 10t$ (E.3)

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Jin-Ying Zhang

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TEXTBOOK OF MECHANICAL VIBRATIONS DUKKIPATI, V. RAO,SRINIVAS, J.,2012-03-05 This comprehensive and accessible book now in its second edition covers both mathematical and physical aspects of the theory of mechanical vibrations This edition includes a new chapter on the analysis of nonlinear vibrations The text examines the models and tools used in studying mechanical vibrations and the techniques employed for the development of solutions from a practical perspective to explain linear and nonlinear vibrations To enable practical understanding of the subject numerous solved and unsolved problems involving a wide range of practical situations are incorporated in each chapter This text is designed for use by the undergraduate and postgraduate students of mechanical engineering   Mechanical Vibrations Shrikant Bhave,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   **The Finite Element Method in Engineering** Singiresu S. Rao,2010-12-20 The Finite Element Method in Engineering Fifth Edition provides a complete introduction to finite element methods with applications to solid mechanics fluid mechanics and heat transfer Written by bestselling author S S Rao this book provides students with a thorough grounding of the mathematical principles for setting up finite element solutions in civil mechanical and aerospace engineering applications The new edition of this textbook includes examples using modern computer tools such as MatLab Ansys Nastran and Abaqus This book discusses a wide range of topics including discretization of the domain interpolation models higher order and isoparametric elements derivation of element matrices and vectors assembly of element matrices and vectors and derivation of system equations numerical solution of finite element equations basic equations of fluid mechanics inviscid and irrotational flows solution of quasi harmonic equations and solutions of Helmhotz and Reynolds equations New to this edition are examples and applications in Matlab Ansys and Abaqus structured problem solving approach in all worked examples and new discussions throughout including the direct method of deriving finite element equations use of strong and weak form formulations complete treatment of dynamic analysis and detailed analysis of heat transfer problems All figures are revised and redrawn for clarity This book will benefit professional engineers practicing engineers learning finite element methods and students in mechanical structural civil and aerospace engineering Examples and applications in Matlab Ansys and Abaqus Structured problem solving approach in all worked examples New discussions throughout including the direct method of deriving finite element equations use of strong and weak form formulations complete treatment of dynamic analysis and detailed analysis of heat transfer problems More examples and exercises All figures revised and redrawn for clarity   **Vibration of Continuous Systems** Singiresu S. Rao,2007-02-09 Broad up to date coverage of advanced vibration analysis by the market leading author Successful vibration analysis of continuous structural elements and systems requires a knowledge of material mechanics structural mechanics ordinary and partial differential equations matrix methods variational calculus and integral

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Targeted to engineers and researchers in design and investigation of mechanical systems as well as to lecturers and advanced students   Cryogenic Engineering and Technologies Dr. Zuyu Zhao,Dr. Chao Wang,2019-10-16 Cryogen free cryogenics is leading a revolution in research and industry by its significant advantages over traditional liquid helium systems This is the first overview for the field covering the key technologies conceptual design fabrication operation performance and applications of these systems The contents cover important topics such as the operating principles of 4K cryocoolers enabling technologies including vibration reduction for cryogen free systems the cryogen free superconducting magnet and cryogen free systems that reach mK It highlights the wide range of applications in materials science quantum physics astronomy and space science medical sciences and etc Key features Introduce technologies and practical know how employed for cryogen free systems of using 4 K cryocoolers to replace liquid helium Address state of the arts of cryogen free superconducting magnets sub kelvin refrigeration systems of He 3 sorption cooler adiabatic demagnetization refrigerator ADR and dilution refrigerators DR Discuss applications of cryogen free systems in modern instruments and equipment

Mechanical Vibration, 5th Edition, Solutions Manual Haym Benaroya,Mark Nagurka,Seon Mi Han,2022-07-15 No detailed description available for Mechanical Vibration 5th Edition Solutions Manual   Mechanical Vibrations Singiresu S. Rao,1995 This text serves as an introduction to the subject of vibration engineering at the undergraduate level The style of the prior editions has been retained with the theory computational aspects and applications of vibrations presented in as simple a manner as possible As in the previous editions computer techniques of analysis are emphasized Expanded explanations of the fundamentals are given emphasizing physical significance and interpretation that build upon previous experiences in undergraduate mechanics Numerous examples and problems are used to illustrate principles and concepts A number of pedagogical devices serve to motivate students interest in the subject matter Design is incorporated with more than 30 projects at the ends of various chapters Biographical information about scientists and engineers who contributed to the development of the theory of vibrations given on the opening pages of chapters and appendices A convenient format is used for all examples Following the statement of each example the known information the qualities to be determined and the approach to be used are first identified and then the detailed solution is given   **Boundary Elements and Other Mesh Reduction Methods XXXIII** C. A. Brebbia,Viktor Popov,V. Popov,2011 The Wessex Institute of Technology has been convening conferences on the Boundary Element Method since 1978 The now annual conference series is recognised internationally as the premiere forum for sharing the latest advances on the boundary element method and other meshless techniques and their applications which continue to evolve and grow in importance The papers presented at the latest conference will cover topics such as Advanced meshless and mesh reduction methods Heat and mass transfer Electrical engineering and electromagnetics Fluid flow Advanced formulations Computational techniques Advanced structural applications Dynamics and vibrations Damage mechanics and fracture Material characterisation Financial engineering

applications Stochastic modelling and Emerging applications **Mechanics And Mechatronics (Icmm2015) - Proceedings Of The 2015 International Conference** A Mehran Shahhosseini,2015-11-02 This proceedings brings together one hundred and fifty two selected papers presented at the 2015 International Conference on Mechanics and Mechatronics ICMM 2015 which was held in Changsha Hunan China during March 13 15 2015 ICMM 2015 focuses on 7 main areas Applied Mechanics Mechanical Engineering Instrumentation Automation and Robotics Computer Information Processing and Civil Engineering Experts in this field from eight countries including China South Korea Taiwan Japan Malaysia Hong Kong Indonesia and Saudi Arabia contributed to the collection of research results and developments ICMM 2015 provides an excellent international platform for researchers to share their knowledge and results in theory methodology and applications of Applied Mechanics and Mechatronics All papers selected to this proceedings were subject to a rigorous peer review process by at least two independent peers The papers are selected based on innovation organization and quality of presentation **Structural Dynamics** Henry R. Busby,George H. Staab,2017-08-15 Structural Dynamics Concepts and Applications focuses on dynamic problems in mechanical civil and aerospace engineering through the equations of motion The text explains structural response from dynamic loads and the modeling and calculation of dynamic responses in structural systems A range of applications is included from various engineering disciplines Coverage progresses consistently from basic to advanced with emphasis placed on analytical methods and numerical solution techniques Stress analysis is discussed and MATLAB applications are integrated throughout A solutions manual and figure slides for classroom projection are available for instructors Stress, Strain, and Structural Dynamics Bingen Yang,2005-04-07 Stress Strain and Structural Dynamics is a comprehensive and definitive reference to statics and dynamics of solids and structures including mechanics of materials structural mechanics elasticity rigid body dynamics vibrations structural dynamics and structural controls This text integrates the development of fundamental theories formulas and mathematical models with user friendly interactive computer programs written in the powerful and popular MATLAB This unique merger of technical referencing and interactive computing allows instant solution of a variety of engineering problems and in depth exploration of the physics of deformation stress and motion by analysis simulation graphics and animation This book is ideal for both professionals and students dealing with aerospace mechanical and civil engineering as well as naval architecture biomechanics robotics and mechtronics For engineers and specialists the book is a valuable resource and handy design tool in research and development For engineering students at both undergraduate and graduate levels the book serves as a useful study guide and powerful learning aid in many courses And for instructors the book offers an easy and efficient approach to curriculum development and teaching innovation Combines knowledge of solid mechanics including both statics and dynamics with relevant mathematical physics and offers a viable solution scheme Will help the reader better integrate and understand the physical principles of classical mechanics the applied mathematics of solid mechanics and computer methods The Matlab

programs will allow professional engineers to develop a wider range of complex engineering analytical problems using closed solution methods to test against numerical and other open ended methods Allows for solution of higher order problems at earlier engineering level than traditional textbook approaches   Essentials of Applied Dynamic Analysis Junbo Jia,2014-01-09 This book presents up to date knowledge of dynamic analysis in engineering world To facilitate the understanding of the topics by readers with various backgrounds general principles are linked to their applications from different angles Special interesting topics such as statistics of motions and loading damping modeling and measurement nonlinear dynamics fatigue assessment vibration and buckling under axial loading structural health monitoring human body vibrations and vehicle structure interactions etc are also presented The target readers include industry professionals in civil marine and mechanical engineering as well as researchers and students in this area   **MEKANİK TİTREŞİMLER - I: Ayrık Lineer Sistemler** Özgür Turhan,   **Structural Dynamics of Earthquake Engineering** S Rajasekaran,2009-05-30 Given the risk of earthquakes in many countries knowing how structural dynamics can be applied to earthquake engineering of structures both in theory and practice is a vital aspect of improving the safety of buildings and structures It can also reduce the number of deaths and injuries and the amount of property damage The book begins by discussing free vibration of single degree of freedom SDOF systems both damped and undamped and forced vibration harmonic force of SDOF systems Response to periodic dynamic loadings and impulse loads are also discussed as are two degrees of freedom linear system response methods and free vibration of multiple degrees of freedom Further chapters cover time history response by natural mode superposition numerical solution methods for natural frequencies and mode shapes and differential quadrature transformation and Finite Element methods for vibration problems Other topics such as earthquake ground motion response spectra and earthquake analysis of linear systems are discussed Structural dynamics of earthquake engineering theory and application using Mathematica and Matlab provides civil and structural engineers and students with an understanding of the dynamic response of structures to earthquakes and the common analysis techniques employed to evaluate these responses Worked examples in Mathematica and Matlab are given Explains the dynamic response of structures to earthquakes including periodic dynamic loadings and impulse loads Examines common analysis techniques such as natural mode superposition the finite element method and numerical solutions Investigates this important topic in terms of both theory and practise with the inclusion of practical exercise and diagrams   **Inverse Problems, Design and Optimization - vol. 2** ,   Vibration Fatigue by Spectral Methods Janko Slavič,Miha Boltezar,Matjaz Mrsnik,Martin Cesnik,Jaka Javh,2020-08-20 Vibration Fatigue by Spectral Methods relates the structural dynamics theory to the high cycle vibration fatigue The book begins with structural dynamics theory and relates the uniaxial and multiaxial vibration fatigue to the underlying structural dynamics and signal processing theory Organized in two parts part I gives the theoretical background and part II the selected experimental research The time and frequency domain aspects of signal processing in general related to structural

dynamics and counting methods are covered in detail It also covers all the underlying theory in structural dynamics signal processing uniaxial including non Gaussianity and non stationarity Finally it provides the latest research on multiaxial vibration fatigue and the non stationarity and non Gaussianity effects This book is for engineers graduate students researchers and industry professionals working in the field of structural durability under random loading and vibrations and also those dealing with fatigue of materials and constructions Introduces generalized structural dynamics theory of multiaxial vibration fatigue Maximizes understanding of structural dynamics theory in relation to frequency domain fatigue Illustrates connections between experimental work and theory with case studies cross referencing and parallels to accelerated vibration testing   Advanced Mechanical Vibration: Modeling, Analysis, and Simulation Bingen Yang,2025-02-28 Modeling analysis and simulation everything vibration engineering students need to succeed including late breaking advances in this ever changing field Advanced Mechanical Vibration covers modeling and analysis of vibrating systems with damping and gyroscopic effects dynamics of combined distributed lumped systems and approximate methods for solutions of complex vibration problems which are often overlooked in other such textbooks Case studies and pre coded MATLAB toolboxes for vibration analysis and simulation help readers understand and retain the most important concepts This is an ideal text for an upper undergraduate or graduate course in vibration engineering Includes both analytical and numerical methods for vibration analysis Addresses the latest developments in this fast changing field Prepares the student and professional for advanced R D Includes chapter ending questions with faculty only answer key multiple case studies and MATLAB toolkit for simulations SI units are used with a table converting to US

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