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) $\omega_n = \sqrt{\frac{k}{m}} = \left(\frac{4000 \times 9.81}{50}\right)^{1/2} = 28.0143$ rad/sec

$\omega = c \, m = 27.4293$ rad/sec

$x = \delta_{st}\left|\frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}\right| = 0.015\left|\frac{1}{1-\left(\frac{27.4293}{28.0143}\right)^2}\right| = 0.0185$ m

3.2 $\tau_b = \frac{2\pi}{\omega_n-\omega} = \frac{2\pi}{2\pi(400-25.2)} = 5$ sec

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

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

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

Response is given by Eq. (3.3):

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

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

Eq. (E.1) becomes

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

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

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

Eq. (E.1) becomes

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

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

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

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Padhraic Smyth

Mechanical Vibrations Rao 4th Solutions Manual:
   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 *Mechanical vibrations* Singiresu S. Rao,1986-06-01 **Structural Vibration** C. Beards,1996-05-31 Many structures suffer from unwanted vibrations and although careful analysis at the design stage can minimise these the vibration levels of many structures are excessive In this book the entire range of methods of control both by damping and by excitation is described in a single volume Clear and concise descriptions are given of the techniques for mathematically modelling real structures so that the equations which describe the motion of such structures can be derived This approach leads to a comprehensive discussion of the analysis of typical models of vibrating structures excited by a range of periodic and random inputs Careful consideration is also given to the sources of excitation both internal and external and the effects of isolation and transmissability A major part of the book is devoted to damping of structures and many sources of damping are considered as are the ways of changing damping using both active and passive methods The numerous worked examples liberally distributed throughout the text amplify and clarify the theoretical analysis presented Particular attention is paid to the meaning and interpretation of results further enhancing the scope and applications of analysis Over 80 problems are included with answers and worked solutions to most This book provides engineering students designers and professional engineers with a detailed insight into the principles involved in the analysis and damping of structural vibration while presenting a sound theoretical basis for further study Suitable for students of engineering to first degree level and for designers and practising engineersNumerous worked examplesClear and easy to follow *Numerical Methods for Engineers and Scientists Using MATLAB®* Ramin S. Esfandiari,2013-06-04 Designed to benefit scientific and engineering applications Numerical Methods for Engineers and Scientists Using MATLAB focuses on the fundamentals of numerical methods while making use of MATLAB software The book introduces MATLAB early on and incorporates it throughout the chapters to perform symbolic graphical and numerical tasks The text covers a variety of methods from curve fitting to solving ordinary and partial differential equations Provides fully worked out examples showing all details Confirms results through the execution of the user defined function or the script file Executes built in functions for re confirmation when available

Generates plots regularly to shed light on the soundness and significance of the numerical results Created to be user friendly and easily understandable Numerical Methods for Engineers and Scientists Using MATLAB provides background material and a broad introduction to the essentials of MATLAB specifically its use with numerical methods Building on this foundation it introduces techniques for solving equations and focuses on curve fitting and interpolation techniques It addresses numerical differentiation and integration methods presents numerical methods for solving initial value and boundary value problems and discusses the matrix eigenvalue problem which entails numerical methods to approximate a few or all eigenvalues of a matrix The book then deals with the numerical solution of partial differential equations specifically those that frequently arise in engineering and science The book presents a user defined function or a MATLAB script file for each method followed by at least one fully worked out example When available MATLAB built in functions are executed for confirmation of the results A large set of exercises of varying levels of difficulty appears at the end of each chapter The concise approach with strong up to date MATLAB integration provided by this book affords readers a thorough knowledge of the fundamentals of numerical methods utilized in various disciplines **Introduction to Nonlinear Aeroelasticity** Grigorios Dimitriadis,2017-05-01 Introduction to Nonlinear Aeroelasticity Introduces the latest developments and technologies in the area of nonlinear aeroelasticity Nonlinear aeroelasticity has become an increasingly popular research area in recent years There have been many driving forces behind this development increasingly flexible structures nonlinear control laws materials with nonlinear characteristics and so on Introduction to Nonlinear Aeroelasticity covers the theoretical basics in nonlinear aeroelasticity and applies the theory to practical problems As nonlinear aeroelasticity is a combined topic necessitating expertise from different areas the book introduces methodologies from a variety of disciplines such as nonlinear dynamics bifurcation analysis unsteady aerodynamics non smooth systems and others The emphasis throughout is on the practical application of the theories and methods so as to enable the reader to apply their newly acquired knowledge Key features Covers the major topics in nonlinear aeroelasticity from the galloping of cables to supersonic panel flutter Discusses nonlinear dynamics bifurcation analysis numerical continuation unsteady aerodynamics and non smooth systems Considers the practical application of the theories and methods Covers nonlinear dynamics bifurcation analysis and numerical methods Accompanied by a website hosting Matlab code Introduction to Nonlinear Aeroelasticity is a comprehensive reference for researchers and workers in industry and is also a useful introduction to the subject for graduate and undergraduate students across engineering disciplines **Applied Numerical Methods for Engineers and Scientists** Singiresu S. Rao,2002 This book includes over 800 problems including open ended project type and design problems Chapter topics include Introduction to Numerical Methods Solution of Nonlinear Equations Simultaneous Linear Algebraic Equations Solution of Matrix Eigenvalue Problem and more Midwest <u>On the Stability of Sailboats</u> Anthony Craggs,2005-03 The book discusses the dynamics of yacht motion at sea and presents information on stability not obtainable

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