

2.24

$$F_1 = F_3 = k_1 \times \cos 45^\circ$$

$$F_2 = F_4 = k_2 \times \cos 135^\circ$$

$$F = \text{force along } x = F_1 \cos 45^\circ + F_2 \cos 135^\circ + F_3 \cos 45^\circ + F_4 \cos 135^\circ$$

$$= 2k \left( k_1 \cos^2 45^\circ + k_2 \cos^2 135^\circ \right)$$

$$k_{eq} = \frac{F}{x} = 2 \left( \frac{k_1}{2} + \frac{k_2}{2} \right) = k_1 + k_2$$

$$\text{Equation of motion: } m \ddot{x} + (k_1 + k_2)x = 0$$



2.25

Let  $\alpha_i$  denote the angle made by  $i^{\text{th}}$  spring with respect to  $X$  is.

Let  $x =$  displacement of mass along the direction defined by  $\theta$ .

If  $k_{eq} =$  equivalent spring constant, the equivalence of potential gives

$$\frac{1}{2} k_{eq} x^2 = \frac{1}{2} \sum_{i=1}^6 k_i \{x \cos(\theta - \alpha_i)\}^2$$

$$k_{eq} = \sum_{i=1}^6 k_i \cos^2(\theta - \alpha_i) = \sum_{i=1}^6 k_i \left( \cos^2 \theta \cos^2 \alpha_i + \sin^2 \theta \sin^2 \alpha_i + 2 \cos \theta \sin \theta \cos \alpha_i \sin \alpha_i \right)$$

$$= \sum_{i=1}^6 k_i \left( \cos^2 \alpha_i \cos^2 \theta + \sin^2 \alpha_i \sin^2 \theta + 2 \cos \alpha_i \sin \alpha_i \cos \theta \sin \theta \right)$$

$$+ 2 \sum_{i=1}^6 k_i \cos \alpha_i \sin \alpha_i \cos \theta \sin \theta$$

$$\text{Natural frequency} = \omega_n = \sqrt{\frac{k_{eq}}{m}}$$

For  $\omega_n$  to be independent of  $\theta$ ,

$$\sum_{i=1}^6 k_i \cos^2 \alpha_i = \sum_{i=1}^6 k_i \sin^2 \alpha_i \quad \text{--- (E}_1\text{)}$$

and

$$\sum_{i=1}^6 k_i \cos \alpha_i \sin \alpha_i = 0 \quad \text{--- (E}_2\text{)}$$

(E<sub>1</sub>) and (E<sub>2</sub>) can be rewritten as

$$\sum_{i=1}^6 k_i \left( \frac{1}{2} + \frac{1}{2} \cos 2\alpha_i \right) = \sum_{i=1}^6 k_i \left( \frac{1}{2} - \frac{1}{2} \cos 2\alpha_i \right)$$

$$\text{and } \frac{1}{2} \sum_{i=1}^6 k_i \sin 2\alpha_i = 0$$

$$\text{i.e. } \sum_{i=1}^6 k_i \cos 2\alpha_i = 0 \quad \text{--- (E}_3\text{)}$$

$$\text{and } \sum_{i=1}^6 k_i \sin 2\alpha_i = 0 \quad \text{--- (E}_4\text{)}$$

# Mechanical Vibrations Rao Solutions Manual

**Singiresu S. Rao**



## **Mechanical Vibrations Rao Solutions Manual:**

**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, 1986-06-01      *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 Myklestad's 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      **Solutions Manual to Accompany Mechanical Vibrations** Francis S. Tse, Ivan E. Morse, Roland Theodore Hinkle, 1978      *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 transmissibility 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 engineers Numerous worked examples Clear and easy to follow      **Solutions Manual** Robert Francis Steidel, Steidel, 197?      **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 *An Introduction to Mechanical Vibrations* Steidel,1989-03-01 *Proceedings of the 10th International Conference on Industrial Engineering* Andrey A. Radionov,Vadim R. Gasiyarov,2024-07-20 This book highlights recent findings in industrial manufacturing and mechanical engineering and provides an overview of the state of the art in these fields mainly in Russia and Eastern Europe A broad range of topics and issues in modern engineering is discussed including the machinery and mechanism design dynamics of machines and working processes friction wear and lubrication in machines design and manufacturing engineering of industrial facilities transport and technological machines mechanical treatment of materials industrial hydraulic systems This book gathers selected papers presented at the 10th International Conference on Industrial Engineering ICIE held in Sochi Russia in May 2024 The authors are experts in various fields of engineering and all papers have been carefully reviewed Given its scope this book will be of interest to a wide readership including mechanical and production engineers lecturers in engineering disciplines and engineering graduates

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**Recent Advances in Computational Mechanics and Simulations** Sandip Kumar Saha, Mousumi Mukherjee, 2020-11-23 This book presents selected papers from the 7th International Congress on Computational Mechanics and Simulation held at IIT Mandi India The papers discuss the development of mathematical models representing physical phenomena and apply modern computing methods to analyze a broad range of applications including civil offshore aerospace automotive naval and nuclear structures Special emphasis is given on simulation of structural response under extreme loading such as earthquake blast etc The book is of interest to researchers and academics from civil engineering mechanical engineering aerospace engineering materials engineering science physics mathematics and other disciplines

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