Engineering Tripos Part IA, 1P1: Mechanical Vibrations, 2017-18

Lecturer

Prof R Langley [1]

Timing and Structure

Weeks 7-8 Lent term and weeks 1-4 Easter term, 12 Lectures

Aims

The aims of the course are to:

- Describe mathematically the behaviour of simple mechanical vibrating systems.
- Determine the response of these systems to transient and harmonic excitation.
- Analyse systems with more than one degree of freedom.

Objectives

As specific objectives, by the end of the course students should be able to:

- Obtain differential equations for mechanical systems comprising masses, rigid bodies, rotors, springs and viscous dashpots, noting the analogy with tuned electric circuits.
- Reduce all differential equations to a standard form.
- Solve these standard-form equations for the response to step, ramp, impulsive and harmonic excitation.
- Understand the concept of damping and the meaning of damped natural frequency, damping factor and logarithmic decrement.
- Obtain and solve differential equations in matrix form for mechanical systems with more than one degree of freedom.
- Apply the rudimentary principles of modal analysis to the free vibration of a two-degree-of-freedom oscillator subject to initial conditions.
- Apply these results to the design of a vibration absorber and to methods of vibration isolation.

Content

For each topic, the letter in parentheses is the link to the table at the bottom of the page, giving page numbers in the references.

Introductory material

- The system elements: masses, rigid bodies, rotors, springs and dashpots and their analogies in tuned electric circuits: inductors, resistors and capacitors (a)
- Obtaining differential equations for the motion of linear mechanical systems (b)

First order systems

Go to (c) for book reference pages (c)

- Response to step, ramp and impulsive inputs (d)

- Response to harmonic excitation (e)
- Using the exp(iwt) notation for harmonic response calculations (f)

Second order systems

Go to (g) for book reference pages (g)

- Response to step and impulsive inputs; free vibration and damped SHM (h)
- Response to harmonic excitation (i)
- Damping factor, logarithmic decrement, loss factor (j)

Systems with Two or more Degrees of Freedom

Go to (k) for book reference pages (k)

- Degrees of freedom (l)
- Equations of motion in matrix form, obtaining mass and stiffness matrices (m)
- Natural frequencies and mode shapes (n)
- Eigenvalues and Eigenvectors (o)
- Free vibration and the superposition of modes (p)
- Harmonic excitation (q)
- Vibration isolation and absorption (r)

References

(1) DEN HARTOG, J.P. MECHANICAL VIBRATIONS
(2) HIBBELER, R.C. ENGINEERING MECHANICS: DYNAMICS (SI UNITS)
(3) MEIROVITCH, L. ELEMENTS OF VIBRATION ANALYSIS
(4) MERIAM, J.L. & KRAIGE, L.G. ENGINEERING MECHANICS. VOL.2: DYNAMICS
(5) PRENTIS, J.M. DYNAMICS OF MECHANICAL SYSTEMS

Relevant page numbers are given for each topic in the table. Parentheses indicate an incomplete treatment.

Topic	Den Hartog	Hibbeler	Meirovitch	Meriam & Kraige	Prentis
a	2	(212)	(57, 556)	-	25, 27
b	10	212	537	543	25, 27
c	17	174	-	-	-
d	17	186	-	-	-
e	46	197	-	-	-
f	19, 47, 66	-	-	-	11
g	18	210	533	521	23
h	24	216	534	522	31, 37
i	50	219, 306	551	538	42, 47
j	24, 30, 53	(215)	540	(545)	38, 40
k	107	331	-	-	79
l	107	331	-	-	79
m	109, 145	-	-	-	-
n	110	335	-	-	79
o	161	-	-	-	-
p	123	-	-	-	84
q	129	-	-	-	130
r	67, 131	313, 338	-	-	69, 87

Booklists

Please see the Booklist for Part IA Courses [2] for references to this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links
[1] mailto:rsl21@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364071&chapterid=41881
[3] http://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] http://www.engc.org.uk/ukspec.aspx
[5] http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/
[6] http://teaching.eng.cam.ac.uk/content/output-standards-matrices