Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2019					

ENG432 – Dynamics of Engineering Systems	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

1. Read all questions carefully.
2. Answer all questions.
3. Exam is worth 50% of total marks for this unit.
4. Total marks available on this test are 100.
5. Questions are not of equal value.
6. Lecture Textbook permitted: "Mechanical Vibration" by William J. Palm III.

EXAM CONDITIONS

<u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only.

This is a RESTRICTED OPEN BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
Lecture Textbook/s (Unannotated)	1 x 20 Page Book

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1

(a) Consider the spring-mass arrangement on Figure 1. Determine the equivalent spring constant and calculate the natural frequency of the system.

(Marks: 10)

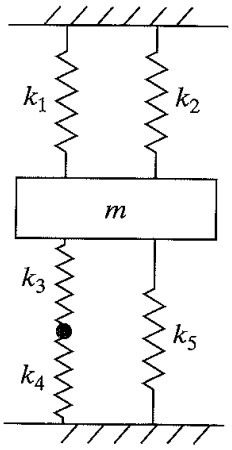

Figure 1: Reference figure for Q1 (a)*

**D.J.Inman: Engineering vibration, Pearson Education, 2008*

(b) A machine of mass m=800 kg is mounted on a simply supported steel beam of length l=2 m having rectangular cross section (h = 0.1 m, w = 1.2 m) and Young's modulus E=2.06×10^{11} N/m^2. To reduce vertical deflection of the beam, a spring of stiffness k is attached at mid-span (Figure 2). Determine the value of the k to reduce deflection of the beam to 20 % and 50 % of its original value.

(Marks: 10)

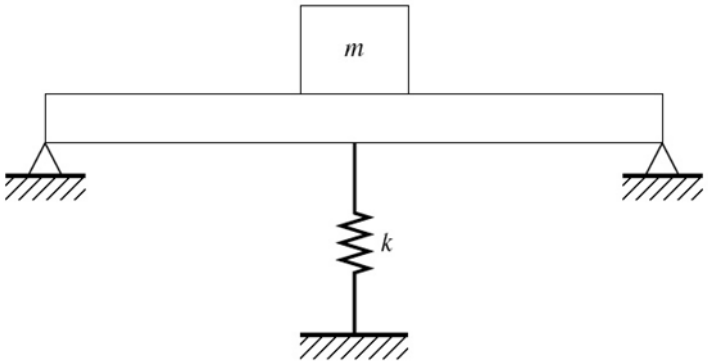

Figure 2: Reference figure for Q1 (b) **

***W.J.Palm: Mechanical vibration, Wiley, 2007, S.S. Rao: Mechanical vibrations, Pearson Education, 2011*

Question 2

A system has been modelled by the following equation:

$$3\ddot{x} + 2\dot{x} + 30x = f(t)$$

(a) When $f(t)=0$, find both the undamped natural frequency and damped natural frequency of the system

(Marks: 5)

(b) When $f(t)= 10\, u_s(t)$, find the total response of the system with $x(0) =2$ and $v(0) = -1$

(Marks: 15)

Question 3

A harmonic force of maximum value 25 N and frequency of 180 cycles/min acts on a machine of 25 kg mass. Design a support system for the machine (calculate c and k if $\zeta = 0.1$) so that only 10% of the force applied to the machine is transmitted to the base supporting the machine.

(Marks: 20)

Question 4

An accelerometer measurement of a mass in harmonic motion shows that the frequency is 7 Hz and the maximum acceleration is 80 mm/s^2.

(a) Using the nomograph, what are the corresponding rms displacement and rms velocity?

(Marks: 5)

(b) Is the system within the acceptable levels of vibration for human health? If not, what measures would you take to bring vibration to acceptable levels?

(Marks: 5)

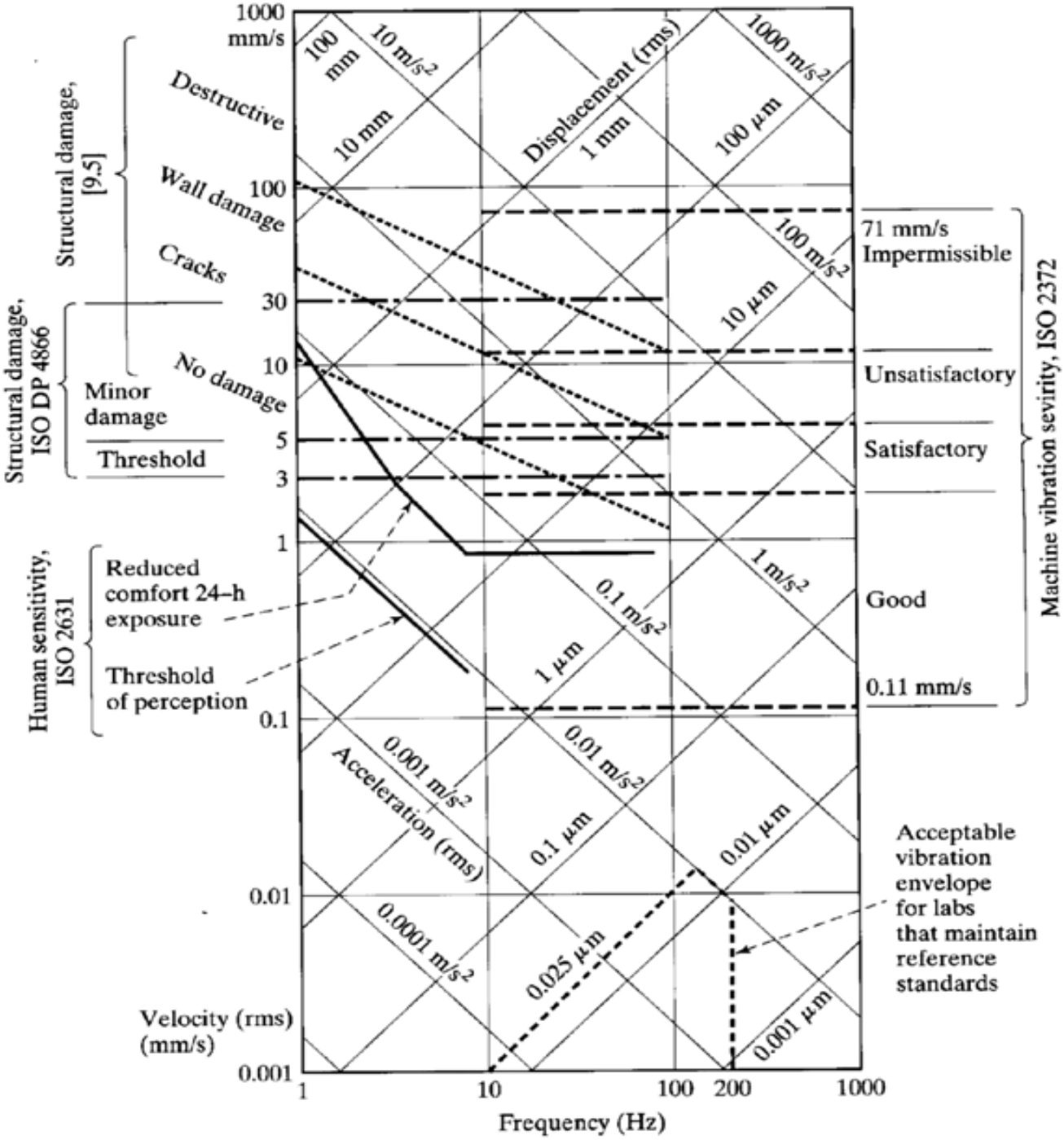

Figure 3: Reference figure for Q4***

*** *S.S. Rao: Mechanical vibrations, Pearson Education, 2011*

Question 5

The modulus and density of a 1-m aluminium rod are E =7.1×10^{10} N/m^2, G = 2.7×10^{10} N/m^2, and ρ=2.7×10^{3} kg/m^3. Compare the first three torsional natural frequencies (in Hz) with longitudinal natural frequencies for a fixed-free rod.

(Marks: 10)

Question 6

Obtain the equations of motion in global coordinates, and the expressions for the natural frequencies of the endpoint of the truss shown in Figure 4. Use one bar element for each truss member. Assume the truss members have the same density ρ, area A and modulus E.

(Marks: 20)

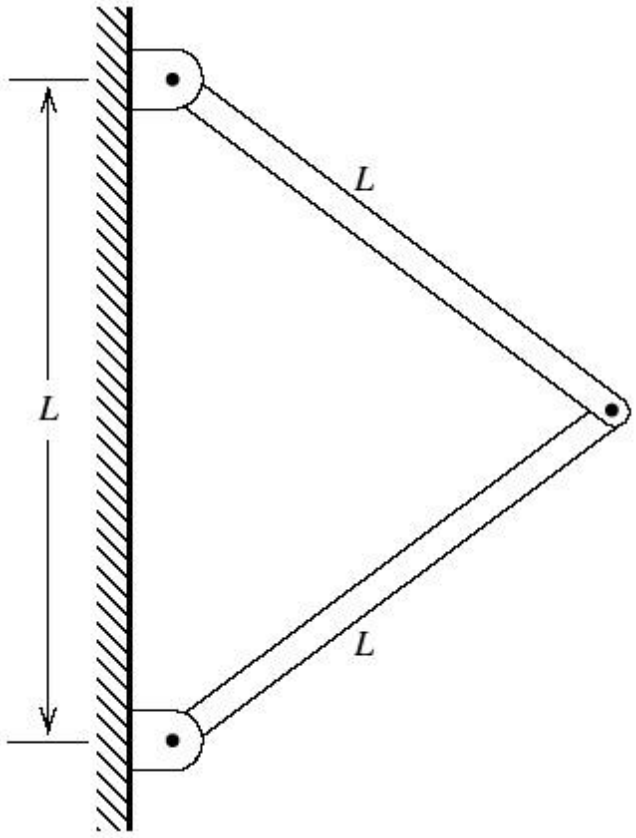

Figure 4: Reference figure for Q6****

**** *W.J.Palm: Mechanical vibration, Wiley, 2007*