CHARLES DARWIN UNIVERSITY

Family Name	
Given Names	
Student Number	
Teaching Period	Semester 1, 2017

FINAL EXAMINATION	**DURATION**
ENG432 – Dynamics of Engineering Systems	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 95.
5. Questions are not of equal value.
6. Lecture Textbook permitted: "Mechanical Vibration" by William J. Palm III.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. 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.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

Question 1

A foot pedal mechanism for a machine is modelled as a pendulum connected to a spring (Figure 1). Calculate the spring stiffness needed to keep the pendulum at 1° from the horizontal and the corresponding natural frequency. Assume that the angular deflections are small, that the pedal may be treated as a point mass, and that pendulum rod has negligible mass. The values are m=0.5 kg, l_1=0.2 m, l_2=0.3 m.

(Marks:10)

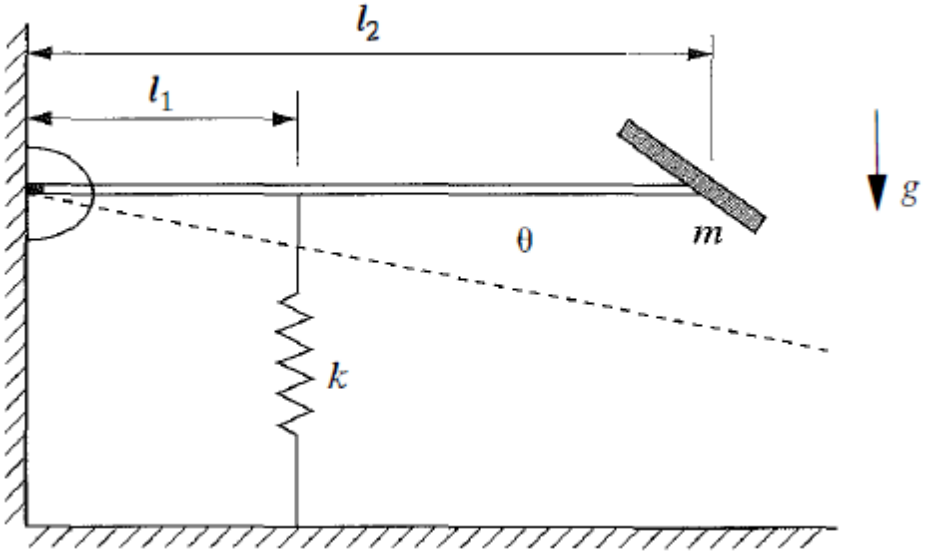

Figure 1*

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

Question 2

A 2-kg printed circuit board for a computer is to be isolated from external vibration of frequency 3 rad/s at maximum amplitude of 1 mm (Figure 2).

a) Design an undamped isolator such that the transmitted displacement is 10 % of the base motion. Also calculate the steady-state amplitude of the transmitted force.

(Marks: 14)

b) Change the design of the isolator by using a damping material with damping value ζ calculated such that the maximum displacement transmissibility at resonance is 200 %.

(Marks: 6)

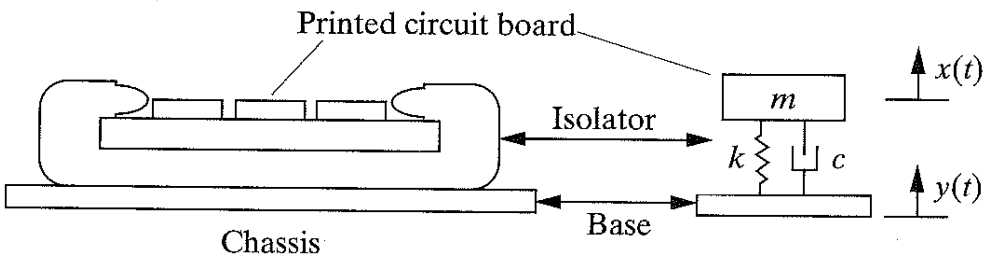

Figure 2

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

Question 3

a) Find the response for the following model. The initial conditions are zero.

$$5\ddot{x} + 20\dot{x} + 20x = 7t$$

(Marks: 16)

b) Do we have to include a calculation for the free response? Why?

(Marks: 4)

Question 4

Figure 3 shows two railway cars, each with a mass of 2000kg that are connected by a coupler. The coupler can be modelled as a spring of stiffness k=280 kN/m.

a) Write the equation of motion and determine the natural frequencies and mode shapes.

(Marks: 15)

b) Determine the time domain response of both cars if $x_1(0) = 0$ and $x_2(0) = 0.1$ m and initial velocities $v_1(0) = v_2(0) = 0$.

(Marks: 10)

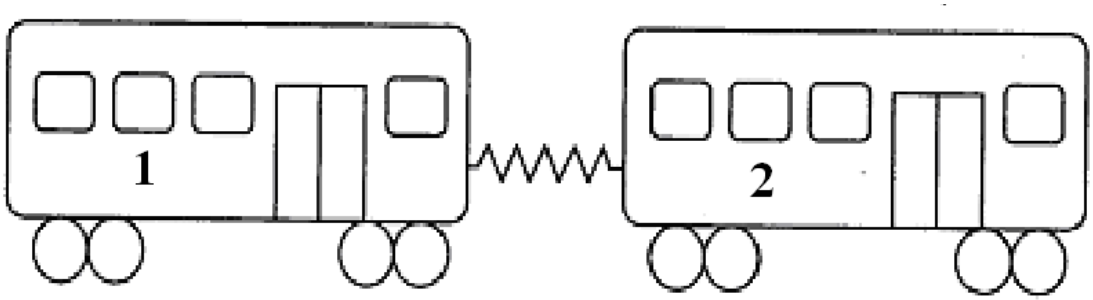

Figure 3*

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

Question 5

a) The sample magnitude plot for a simple structure is shown on Figure 4. How many natural frequencies does this system have, and what are their approximate values?

(Marks: 5)

b) If it is expected that a certain system with two degrees of freedom has the natural frequencies ω_1 = 15 rad/s and ω_2 = 28 rad/s. What is the minimum recommended sampling frequency to measure the motion?

(Marks: 5)

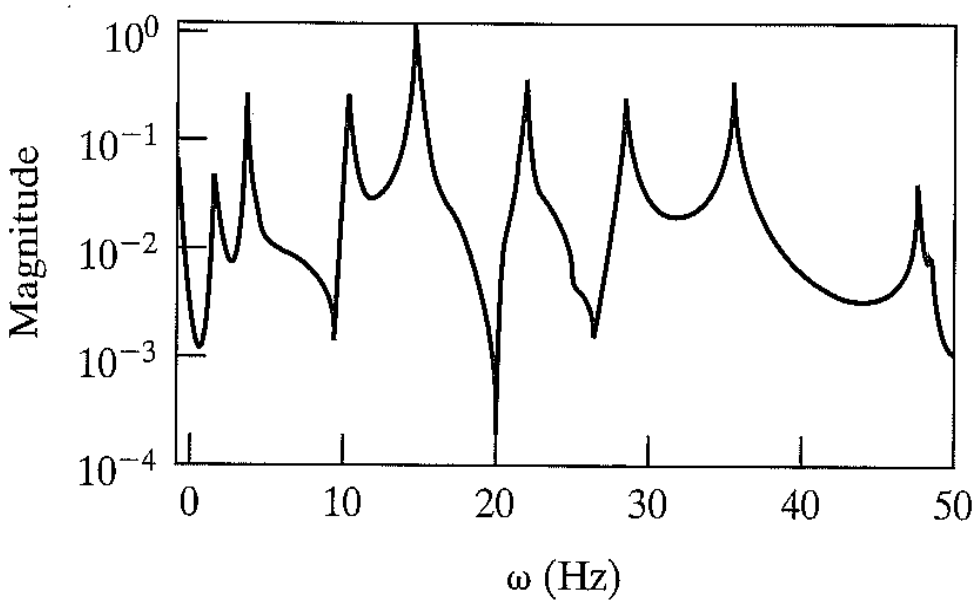

Figure 4*

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

Question 6

It is desired to design a 12.82 m fixed-free bar such that its first natural frequency is 100 Hz. Of what material should it be made (Use table 1)?

(Marks: 10)

Table 1 *Physical constants for some common materials**

Material	Young's modulus, $E(\mathrm{N/m^2})$	Density, $(\mathrm{kg/m^3})$
Steel	2.0×10^{11}	7.8×10^{3}
Aluminum	7.1×10^{10}	2.7×10^{3}
Brass	10.0×10^{10}	8.5×10^{3}
Copper	6.0×10^{10}	2.4×10^{3}
Concrete	3.8×10^{9}	1.3×10^{3}
Rubber	2.3×10^{9}	1.1×10^{3}
Plywood	5.4×10^{9}	6.0×10^{2}

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