

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA
SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING
FIRST SEMESTER 2018/2019 BENG. DEGREE EXAMINATION
COURSE: MCE 415(VIBRATION ANALYSIS AND CONTROL)

INSTRUCTION: Attempt Any Four (4) Questions of your choice

TIME ALLOWED: 3 Hours.

Question 1 (25marks) [Introduction to Vibration Analysis]

A secondary school student in your locality is keen on knowing more about vibration study and its relevant, convincingly:

- (a.) Give at least two reasons why vibration study is important in Vehicles. **(10marks)**
- (b.) Explain the term Vibration and enumerate its Elementary Parts to the student. **(5marks)**
- (c.) List any five (5) areas which the application and the study of vibratory equipment has considerably increased its operational efficiency to the young secondary school student. **(10marks)**

Question 2 (25marks) [System Degree of Freedom]

A tricycle is of what Degree Of Freedom Systems (DOFS)? **(1mark).**

Hence base on your understanding;

- (a.) Explain the termed number of degrees of freedom in a vibrating system and its relevance in system stability. Justify with examples. **(4marks)**
- (b.) Some system vibrates Freely and some vibrates Forcefully, explain why it is so with typical Electrical Transmission line scenario using Shiroro – Gidan Kwano line example and how its affects your electricity supply. **(6marks)**
- (c.) What happens to a vibrating system under the following conditions?
 - i. Undamped
 - ii. Damped conditions. **(5marks)**
- (d.) It is generally believed that the amount of damping in a system is always very small such that it can be disregarded, then why is it still extremely important in analyzing vibratory systems. **(5marks)**
- (e.) Draw a sketch to show a free and force vibrating system **(5marks)**

Question 3 (25marks) [Introduction to System Harmonics]

- (a.) Describe the term Harmonic motion and give two (2) examples of the harmonic motions. With suitable diagram, derive the harmonic motion expression to reflect the following: Displacement, velocity and acceleration. **(10marks)**
- (b.) Using your example described in Q3(a.) explain the following terms with associated equations (i.) cycle (ii.) Amplitude (iii.) Period of oscillation (iv.) Frequency of Oscillation (v) Natural frequency (vi) Beats (vii.) Octave (viii.) Decibel. **(8marks)**
- (c.) Differentiate between three degree of freedom system and four degree of freedom system using automobile with relevant diagrams and equations to substantiate your claims. **(7marks)**

Question 4 (25marks) [Vibration Analysis and Modelling]

Department of Mechatronics Engineering of Federal University of Technology Minna, recently developed a Garri processing plant. The model was found to be a second order system with a unity feedback and open loop transfer function given as:

$$G(S) = \frac{500}{s(s+15)} \dots\dots\dots \text{Equation 1}$$

- (a.) Draw a block diagram for the closed loop system after remodeling the open loop transfer given in Figure 1. (5marks)
- (b.) What will be the characteristic equation of the closed loop system you have remodeled? (5marks)
- (c.) What is the numerical values of the natural frequency and damping ratio of the remodeled plant? (5marks)
- (d.) What is the settling time of the remodeled system? (5marks)
- (e.) If the system is subjected to ramp input signal of 0.5 rad/sec, what is the steady state error? (5marks)

Question 5 (25marks) [Vibration Analysis & Analogous Systems]

Using the Mechanical Translational System shown in Figure 1,

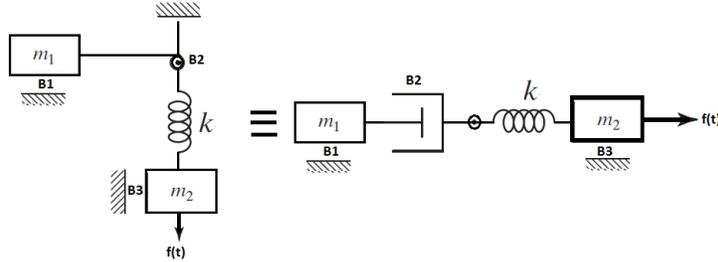


Figure 1

- (a.) State the enabling principle governing the translational mechanical system. Redraw and derive the mathematical expression for the system shown in figure 1. (10marks)
- (b.) Draw the Force -Voltage and Force - Current Circuit for the system. (6marks)
- (c.) Express the Force - Voltage and Force - Current Analogous equation for the system (9marks)

Question 6 (25marks) [Vibration Measurement and Applications]

Basically, before the motion (or dynamic force) of the vibrating body is converted into an electrical readable signal at the output by the vibration transducer, it must follow a general sequence or scheme. A non-destructive (vibration) test is to be carried on a newly molded Concert slap meant for domestic toilet manifold, hence:

- (a.) With your knowledge of basic vibration measurement scheme, discuss each of the constituent sections of its measuring scheme using appropriate block diagram. (7marks)
- (b.) Explain the concept of the vibration pickup and state the most commonly used pickup instrument. (3marks)
- (c.) Explain the operation of a Piezoelectric as one of the commonly used transducers in vibration measurement with illustration. (10marks)
- (d.) Match the vibration items in column I to the corresponding meaning in column II from Table 1 and give explanation to justify the corresponding answer of your choice. (5marks)

Table 1

	Column I	Column II
i.	Piezoelectric accelerometer	a. produces light pulses intermittently
ii.	Electrodynamic transducer	b. has high output and is insensitive to temperature
iii.	LVDT transducer	c. frequently used in velocity pickups
iv.	Fullarton tachometer	d. has high sensitivity and frequency range
v.	Stroboscope	e. variable-length cantilever with a mass at its free end