ELIZADE UNIVERSITY, Ilara-Mokin, Ondo State
Department Of Mechanical, Automotive and Production Engineering

ATE 302: POWERTRAIN, NOISE, VIBRATION & HARSHNESS

EXAMINATION 2nd Semester 2016-2017 **Time Allowed: 2 hours**

INSTRUCTIONS:

a) Answer **Question 1** and **any other three questions** (from Qu. 2 – Qu. 6).
b) **Qu. 1 is compulsory and only short correct answers are required**
c) Make clear and properly labeled sketches where required
d) For calculations, you are advised to first state the steps you would use to solve the problem

Question 1

i. Explain the terminologies: powertrain, noise, vibration and harshness (PNVH) in automotive engineering
ii. What units are used to measure or quantify PNVH?
iii. What are the components of a powertrain system?
iv. What are the sources of noise, vibration and harshness (NVH)?
v. What is the link between Powertrain and NVH?
vi. What are the basic types of vibration in an automotive system?
vii. Define transmissibility of forced vibration for a moving vehicle
viii. Derive the equation of motion for torsional vibration of a free, undamped, single degree of freedom system
ix. Explain the differences between sound and noise in automotive system and state their relation to vibration of the system
x. What are the basic principles normally applied by automobile manufacturers for reducing NVH?
xi. List three types of interior noise in an automotive system
xii. Figure 1 below shows a simple gear train with application in automobile manual transmission

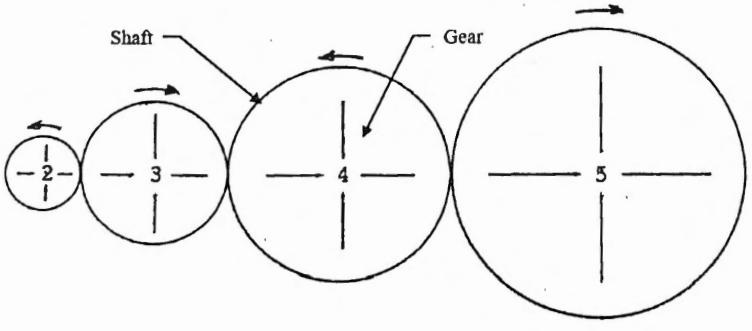

Figure 1

Gear 4 is attached to the drive shaft. Let n_i be the rpm of the i-th gear and N_i the corresponding number of teeth. Derive expression of $\frac{n_2}{n_5}$ in terms of the numbers of teeth.

Question 2

Figure 2 below shows the essential parts of the powertrain of an automobile, together with labels shown in topside projection view below it. For this system, do the following:

- Briefly state the function(s) of each component
- Explain what each component contributes to the NVH issue
- Propose measures to control the NVH problems you have identified

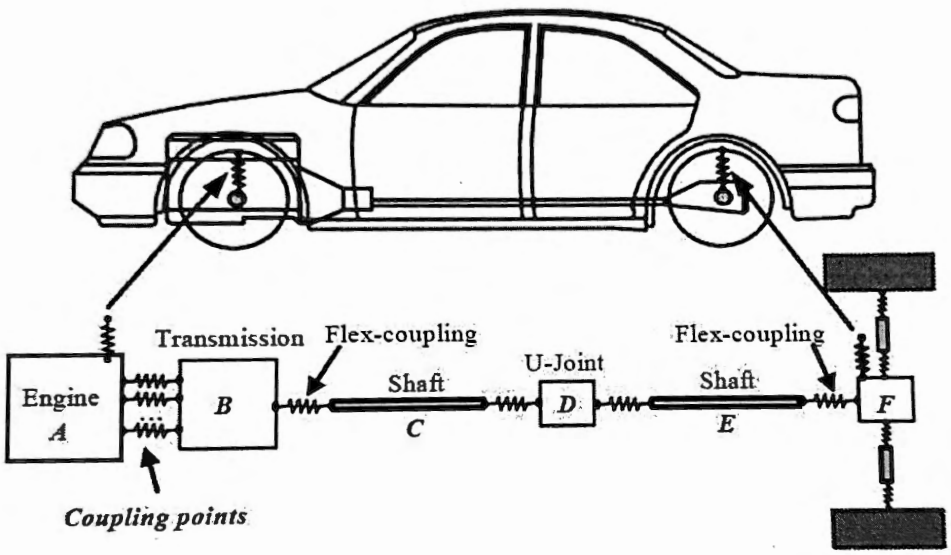

Figure 2

Question 3

Figure 3 below shows the drivetrain of an automobile.

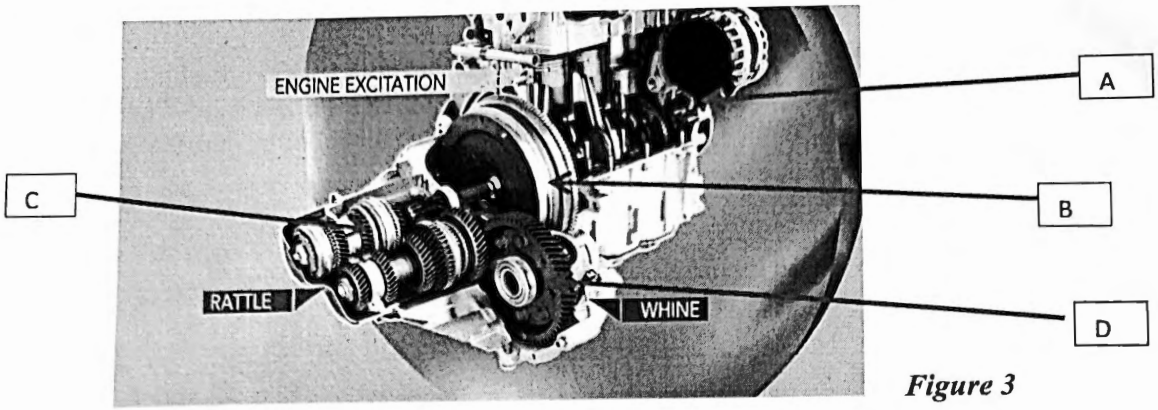

Figure 3

(a). For this system, do the following:

i. State the name and function(s) of each labelled component (i.e. A, B, C, D)
ii. Explain what each component contributes to the NVH problem
iii. Propose measures to control the NVH problems you have identified

(b). Explain the difference between rattle noise and whine noise

Question 4

a) Explain the differences between manual transmission and automatic transmission in an automobile.
b) What is the range of efficiency of a manual transmission system? What are means of improving the efficiency?
c) Figure 4 below shows a torque converter used in automatic transmission. State the key components of the torque converter.
d) Describe how the torque converter works, including its fluid coupling operation.

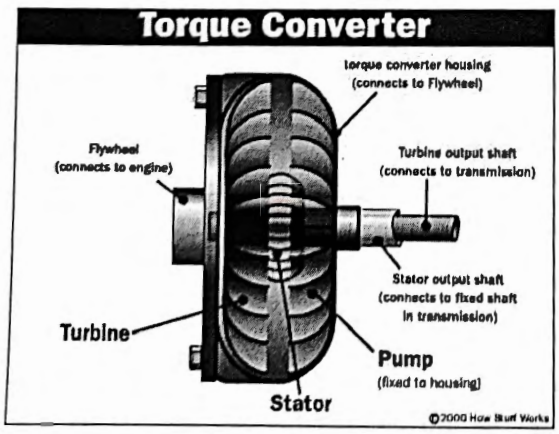

Figure 4

Question 5

Figure 5 below shows the model for analyzing the vibration of a single degree of freedom (sdof) forced damped system.

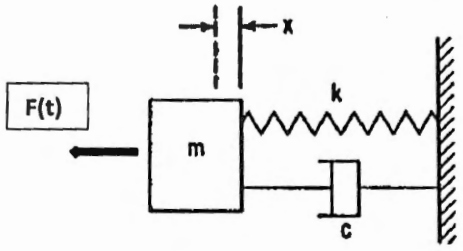

Figure 5

For this case, do the following:

a) State the equation of motion
b) What type of equation is it?
c) Detrive the general solution of the equation for the case of free damped vibration
d) Explain the cases of under damped, critically damped and over damped
e) Sketch the response, i.e. x(t), for the three cases on the same graph

Question 6

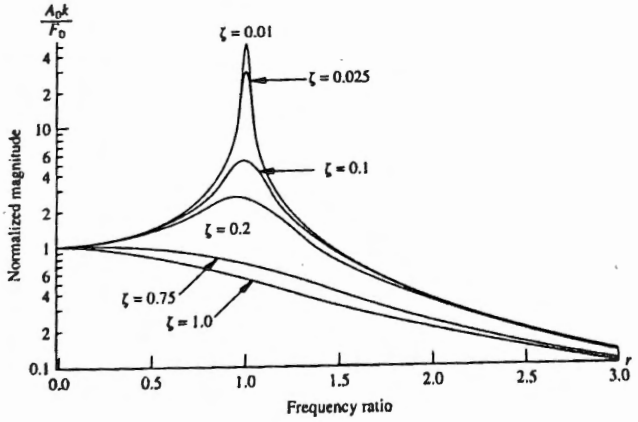

Figure 6a

The graph in Figure 6a above shows the amplitude transmissibility ratio, A, as a function of frequency ratio, r, for various damping ratios, ζ, which can be expressed in the form:

$$A = f(r, \zeta) = \sqrt{\frac{4r^2\zeta^2 + 1}{r^4 + (4\zeta^2 - 2)r^2 + 1}}$$

a) Write the standard expressions for r and ζ
b) Explain the characteristics of the graphs in respect of increasing damping ratio, ζ, Use Fig 6b
c) What is the significance of the case of r = 1?
d) Sketch the limiting case of no damping, i.e. for $\zeta \rightarrow 0$
e) Using the formula above, show that for transmission isolation, r must be greater than $\sqrt{2}$.

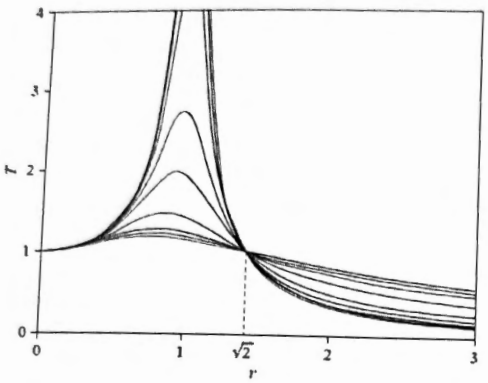

Figure 6b