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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX3273 – MODELLING OF MECHATRONICS SYSTEMS**
Academic Year	:	2012/13
Date	:	23rd August 2013
Time	:	0930 – 1230 Hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.
4. Laplace transformation table is attached at the end of this question paper.

Q1. (a) Models simplify reality by eliminating other characteristics that are not important for their intended purpose. Elaborate on this statement by using an appropriate example.

(b) Both numerical and analytical models are considered to be mathematical models. Briefly explain the difference between numerical models and analytical models. You may quote an example to illustrate your answer.

(c) Verification ensures that the system model is right, whereas, validation is about modeling the right system. Do you agree? Justify your answer.

(d) Real systems are often considered non-liner. However, in most cases these systems are modeled as linear systems. How is this achievable? Explain by taking a suitable example.

Q2. (a) Distinguish between a signal and a noise in the context of mathematical representation of signals and systems.

(b) Write the mathematical definition for a unit impulse signal and a unit step signal and establish a mathematical relationship between them.

(c) The input-output relationship for a capacitor is given by the expression $y(t)=\frac{1}{C}\int_{-\infty}^{t} x(t)\,dt$. Where, C is the capacitance. Use the relationship to substantiate the statement 'that all memoryless systems are causal, but not vice versa'.

(d) Give an example of a system that satisfies the condition of homogeneity but not the condition of additivity.

Q3. (a) Obtain the governing equations for the basic mechanical elements.

(b) Figure 01 shows two masses m_1 and m_2 of which m_1 is attached by a spring of stiffness k and rolls on a frictionless base. Mass m_2 slides on a thin lubricant film having a viscous friction of b and subjected to a force F which varies harmonically with time at a frequency of f Hz = ω rad/sec. Using first principles, derive the governing equation of motion for the mass m_2. (Express as a input-output equation using D operators)

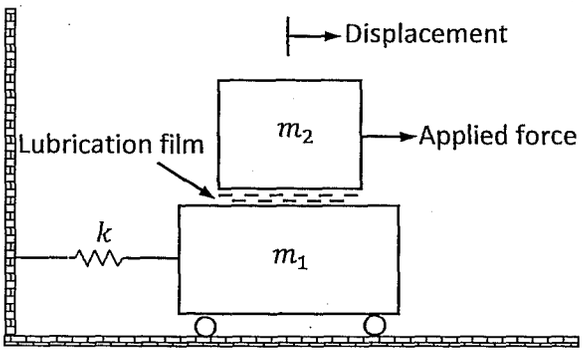


Figure 01

(Hint: You may model the lubrication film as a viscous damper)

Q4. (a) Using Force-Voltage analogy, find the corresponding electrical elements for the basic mechanical elements.

(b) Represent the analogous electrical system for the mechanical system depicted in Figure 02 below. Also write the system equations for both of the systems.

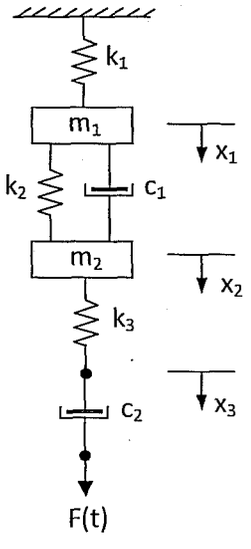


Figure 02

Q5. The electro-mechanical system shown in Figure 03 represents an equivalent circuit of a loudspeaker system. The resistance, inductance and capacitance of the loudspeaker coil are *R*, *L* and *C* respectively, while the mass, stiffness and the damping friction in the loudspeaker cone and its accessories are *m*, *k* and *b* respectively. Determine the transfer function of the loudspeaker system, when the input voltage is *v(t)* and the corresponding cone displacement is *x(t)*. State all assumptions you make.

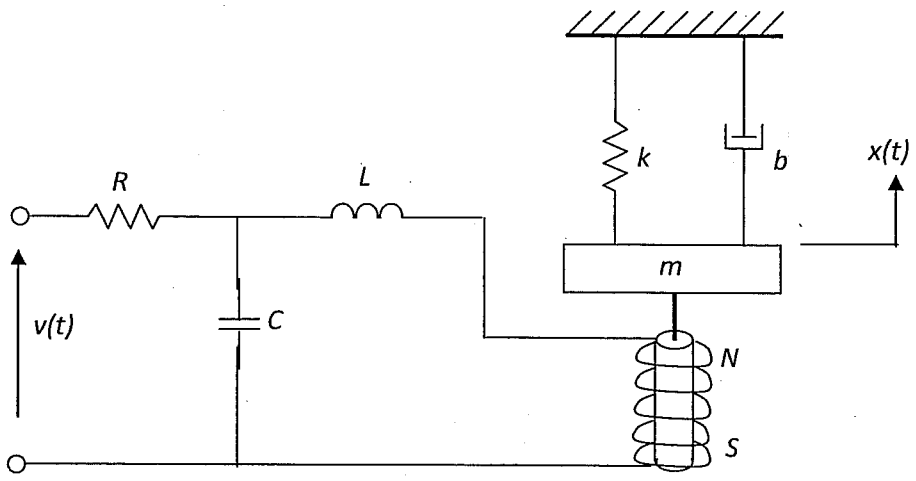


Figure 03

Q6. (a) Obtain the impedances for the basic mechanical and electrical elements.

(b) Obtain an expression for the transfer function V_0 / Vi by using the impedance method for the electrical circuit given in Figure 04. State any assumptions you make.

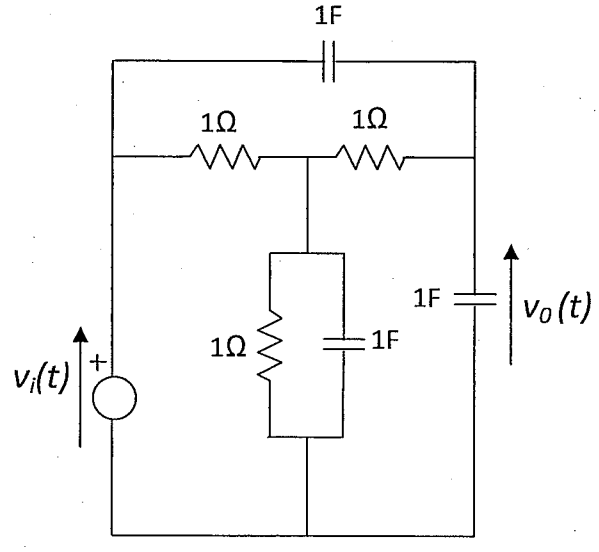


Figure 04

Q7. (a) Define the following terms with regard to state-space representation of dynamic systems

(i) State of a system.
(ii) State variables.
(iii)State vector.
(iv)State-space.

b) Figure 05 represents a simplified version of a suspension system. An external force *u(t)* is applied to mass m_2 and displacements of the respective masses are measured from their equilibrium positions as shown in the figure. Obtain a state space representation for the above system.

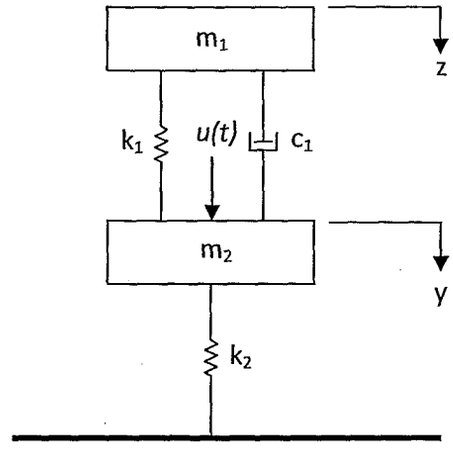


Figure 05

Q8.(a) What is a unity feedback system in relation to block diagram representation? Explain the manner in which a simple feedback system can be reduced to a unity feedback system.

(b) Reduce the block diagram shown in Figure 06 below to canonical form.

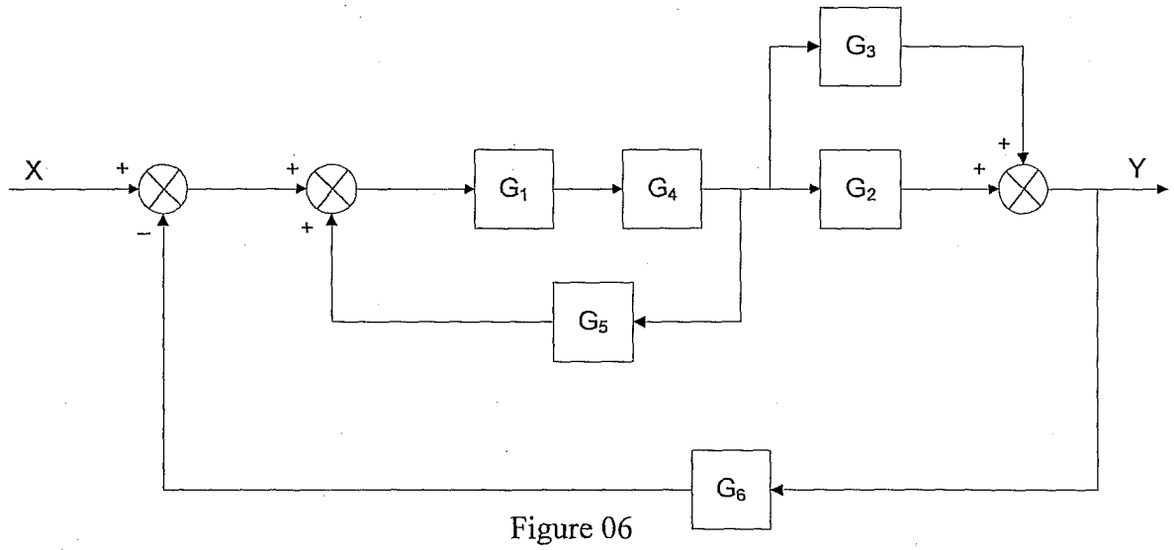


Figure 06

(c) Transform the above block diagram to a signal flow graph.

End

Laplace Transforms

f(t)	F(s)
Unit impulse $\delta(t)$	1
Unit step $u(t)$	$1/s$
t	$1/s^2$
t^n	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$f^{(k)}(t) = \frac{d^k(t)}{dt^k}$	$s^k F(s) - s^{k-1}f(0^-) - s^{k-2}f'(0^-) \ldots\ldots - f^{k-1}(0^-)$
$\int_{-\infty}^{t} f(t)dt$	$\frac{F(s)}{s} + \frac{1}{s}\int_{-\infty}^{0} f(t)dt$
$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a^2)+\omega^2}$
$e^{-at}\cos \omega t$	$\frac{(s+a)}{(s+a^2)+\omega^2}$