00135

The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX5233 Dynamics of Mechanical System**
Academic Year	:	2016/17
Date	:	14th November 2017
Time	:	0930hrs – 1230hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions.
3. **Question No. 01 is Compulsory.**
4. Answer any 5 questions.

Question No.01: Compulsory (40 Marks)

a. Explain Vibrations Isolation in mechanical engineering using necessary sketches & graphs.
b. Distinguish Relative Vibration measuring instruments & Absolute vibration measuring instruments.
c. Distinguish Active Isolation & Passive Isolation in Vibration.
d. Distinguish between "Open Loop Control Systems" and "Close Loop Control Systems"
e. Define five transient response specifications and sketch it on a typical transient response curve.
f. What are PID controllers and explain the main control objectives of PID controllers.
g. The open loop transfer function of a unity feedback control system is given by,

$$G(S) = \frac{25}{S(5+S)}$$

Calculate the damping ratio and the maximum overshoot.

If the damping ratio is to be made 0.75 using a "tachometer feedback", determine the tachometer constant and the maximum overshoot.

Question No.02: (15 Marks)

A machine of mass 100 kg is mounted on springs and damper as shown in Fig.Q2. The total spring stifness is 50,000 N/m and the damping factor e = 0.2. A harmonic force, F= 500 Sin(13.2t) acts on the mass. For the steady state vibration of the system,
Determine,

a. the amplitude of the motion of the machine
b. its phase with respect to the exciting force
c. the transmissibility
d. the maximum dynamic force transmitted to the foundation
e. the maximum velocity of the motion

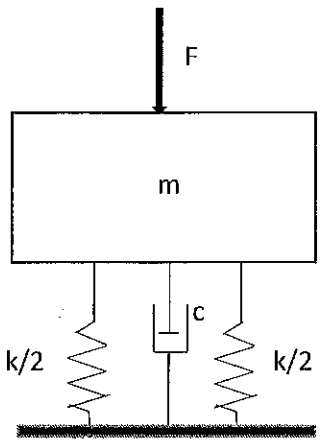


Fig.Q2

Question No.03: (15 Marks)

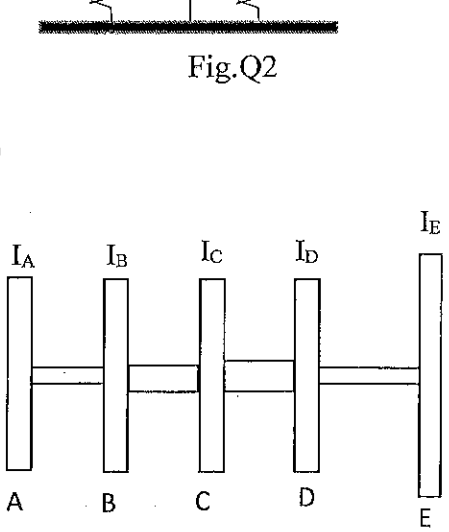


Fig.Q3

Five rotors A, B, C, D and E are mounted on a shaft as shown in Fig.Q3. The polar moment of inertia of the rotors, diameters and length of the sections of the shafts between the rotors are given below,

Polar moment of Inertia of rotors $I_A = 5$ kg.m^2, $I_B = 10$ kg.m^2, $I_C = 20$ kg.m^2, $I_D = 40$ kg.m^2, $I_E = 60$ kg.m^2

Diameter of the shaft: between A & B = 25 mm, B & C = 40 mm, C & D = 50 mm

Length of the shaft: betweenA & B = 0.2 m, B & C = 0.2 m, C & D = 0.3 m, D & E = 0.4 m

Using Holzer analysis determine the diameter of the shaft between rotors D and E, if the system has a natural frequency of torsional vibration of $(50/\pi)$ Hz.

The modules of rigidity of the material of the shaft is 80 GN/m^2.

Question No.04: (15 Marks)

A uniform beam of mass '**m**' per unit length, flexural rigidity **EI** and length '**L**' is simply supported at one end and free at the other. If a transverse harmonic force **P sin ωt** acts at the free end, show that the amplitude (A) of forced vibrations under the load is given by,

$$A = \frac{2P \sin \lambda L . \sin h\, \lambda L}{EI\, \lambda^3 [\cos \lambda L \sin h\, \lambda L - \sin \lambda L \cos h\, \lambda L]}$$

Question No.05: (15 Marks)

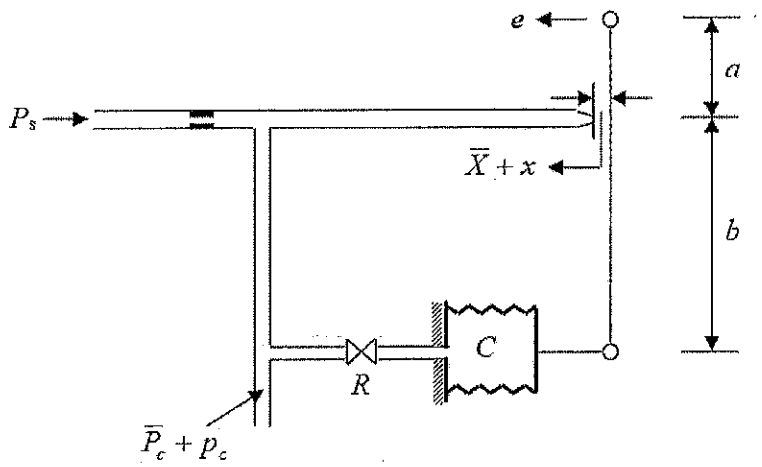


Fig.Q4

Fig.Q4 shows a pneumatic control system in which R is the pneumatic resistance of the restriction and C is the capacitance of the bellows. The spring constant of the bellows is K_s and the effective area of the bellows is A. A small step change in e will cause an instantaneous change in the control pressure p_c. Restriction R will momentarily prevent the feedback bellows from sensing the pressure change p_c. As time goes on the feedback bellows will expand. Draw a complete block diagram for the overall system and obtain the transfer function relating $P_c(s)$ and $E(s)$. A unit change in x causes a change in control pressure equal to Kx where K is a constant.

Question No.06: (15 Marks)

(a) Fig.Q5 shows an Industrial type arc welding robot. In manufacturing industry, sensors are used to improve the quality of the welding. Given system uses a vision based system to measure the puddle of melted metal as shown in the given block diagram. The system uses a constant rate of feeding the wire to be melted.

i Calculate the maximum value for K for the system that will result in a stable system,

ii For half of the maximum value of K found in part (a), determine the roots of the characteristic equation.

iii Estimate the overshoot of the system of part (b) when it is subjected to a step input.

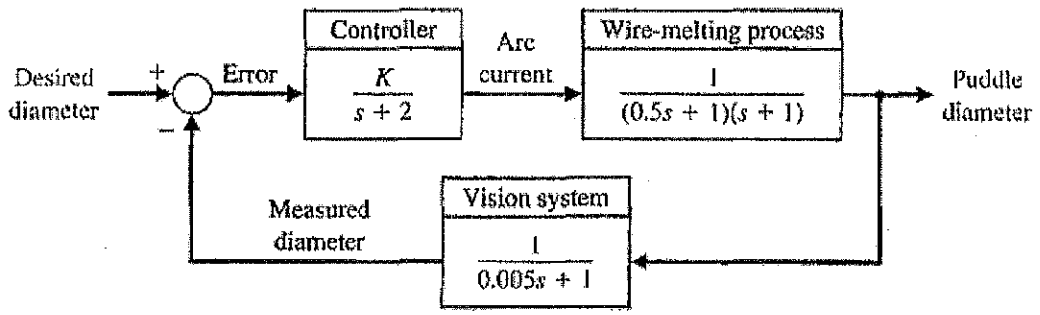


Fig.Q5

(b) Given unity feedback system represents an orientation controller of a satellite.

$$G(s) = \frac{15K}{S(S^2 + 15S + 75)}$$

i Sketch the root locus of the given system as K increases.

Ii Find the value of K that results in an unstable system.

Question No.07: (15 Marks)

The following unity feedback system with the loop transfer function is a controller developed for a robot gripping mechanism.

$$G(s) = \frac{K}{S(S+1)(S+4)}$$

a. Sketch the bode diagram for K =4.
b. Determine the gain margin.
c. The value of **K** if gain margin is 12dB.

d. Find the value of **K** to yield a steady state error of 25% of the magnitude A for the ramp input $r(t) = At,\ t > 0$. Explain whether this gain be utilized and achieve acceptable performance?

Question No.08: (15 Marks)

The open loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{20K}{s(s+1)(s+20)}.$$

Draw Nyquist plot and determine the value of K for

a. a gain margin of 15 db
b. a phase margin of 40°.

ALL RIGHTS RESERVED

END