MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIED YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 311 MECHANICS OF MACHINES II

DATE: 16/6/2017 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS

i ***This paper consists of FIVE questions.***

ii ***Answer QUESTION ONE and any other TWO questions.***

iii ***Use CLEAR, NEAT and WELL-LABELLED sketches.***

iv ***Marks will be awarded for reasonably drawn and labeled diagrams.***

Provided

Design values for journal bearings.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Differentiate between *simple harmonic motion* and *natural vibrations* (2 marks)

b) A heavy bob of mass m is suspended at the end of a light and extensible string making a simple pendulum. If the string is given an initial displacement of θ degrees from the vertical plane. Show that $\eta = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$ Hz. Where η is the natural frequency, g is is the gravitational acceleration and L is the length of the string (6 marks)

c) Figure Q1(c) shows a single rotating disturbing mass, m_1 of *50 g* with a radius of rotation, r_1 of *30 mm* being balanced by a single mass, m_2 with a radius of rotation, r_2 of 45 mm rotating in the same plane;

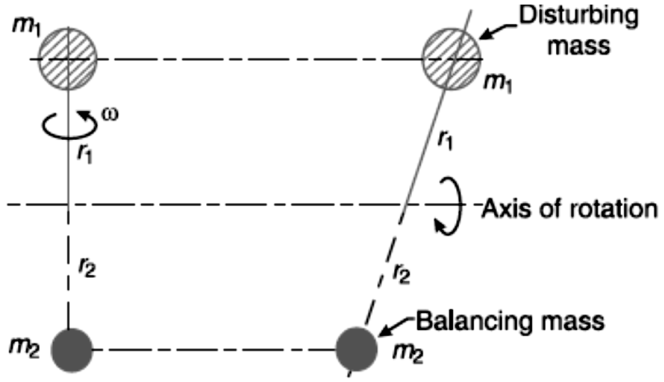

Figure Q1(c)

If the shaft is rotating at an angular speed of ω rads/s, calculate the balancing mass m_2 (5 marks)

d) A spring of stiffness 2 kN/m is suspended vertically and two equal masses of 4 kg each are attached to the lower end. One of these masses is suddenly removed and the system oscillates. Determine :

i The amplitude of vibration (2 marks)

ii The frequency of vibration (2 marks)

iii The velocity and acceleration of the mass when passing through half amplitude position (4 marks)

iv Kinetic energy of the vibration in joules (3 marks)

e) Define the term *damping ratio.* A body of mass 85 kg is suspended from a spring of stiffness 8600 N/m. if the motion is opposed by a viscous resistance of 689 Ns/m when acted upon by a force of 265 N, the frequency of which is variable. Determine the damping ratio, ʒ. (6 marks)

QUESTION TWO (20 MARKS)

a) Derive an expression for the frequency of torsional vibrations of a shaft fixed at one end and carrying a heavy disc on the free end (5 marks)

b) A steel disc 330 mm diameter with a mass of 34 kg is suspended from the end of a wire 3.5 mm diameter and 1.56 m long which is clamped into a central hole of the disc. The upper end of the wire being rigidly supported. When the disc is set in torsional vibrations, it is found to make 15 complete oscillations in 85.2 seconds. Find the modulus of rigidity of the wire and calculate the amplitude of oscillation which may be allowed if the maximum permissible intensity of shearing stress is not to exceed 140 MPa (6 marks)

c) A uniform shaft 85 mm diameter carries three rotors, A, B and C having moments of inertia 17 kgm^2, 40kgm^2 and 24 kgm^2 respectively. The distance between A and B is 1.35 m and between B and C=0.75m. Find the frequencies of the free torsional vibrations. If rotor A has an amplitude of 1^0, find the amplitudes of rotors B and C. Take G=80GN/m^2 (9 marks)

QUESTION THREE (20 MARKS)

a) A single cylinder reciprocating engine has speed 340 r.p.m., stroke 360 mm, mass of reciprocating parts 55 kg, mass of revolving parts at 156 mm radius 47 kg. If two fifth of the reciprocating parts and all the revolving parts are to be balanced, find :

i The balance mass required at a radius of 400 mm (4 marks)

ii The residual unbalanced force when the crank has rotated 60° from top dead center (3 marks)

b) What is the importance of balancing rotating masses in a machine? (3 marks)

c) Four masses m_1, m_2, m_3 and m_4 are 250 kg, 350 kg, 290 kg and 310 kg respectively. The corresponding radii of rotation are 0.25 m, 0.2 m, 0.3 m and 0.35 m respectively and the angles between successive masses are 52°, 82° and 142°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.24 m. (10 marks)

QUESTION FOUR (20 MARKS)

a) Define the term bearing and with the aid of neat sketches and examples briefly describe two categories under which bearings fall (5 marks)

b) State **FIVE** materials from which bearings are made (2.5 marks)

c) Explain the following terms as used with hydrodynamic journal bearing

i Diametral clearance

ii Radial clearance

iii Diametral clearance ratio

iv Eccentricity

v Minimum oil film thickness

vi Attitude or eccentricity ratio

vii Short and long bearing (3.5 marks)

d) Design a journal bearing for a centrifugal pump from the following data:

Load on journal = 20,000 N; Speed of journal =900 rpm; Type of oil is SAE 10, for which absolute viscosity at 55^0 C = 0.017 kg/m-s; Ambient temperature of oil = 15.5^0C; Maximum bearing pressure for the pump = 1.5 N/mm^2. Calculate also mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited to 10^0C. Heat dissipation coefficient = 1232 W/m^2/^{0}C. (9 marks)

QUESTION FIVE (20 MARKS)

a) Define the term transmissibility ratio, ε (1 mark)

b) Show that when damping is not provided,

$$\varepsilon = \frac{1}{1 - \left(\frac{w}{w_n}\right)^2}$$

Where w is the forced frequency and w_n is the natural frequency (6 marks)

c) A machine has a mass of 100 kg and unbalanced reciprocating parts of 2 kg which move through a vertical stroke of 80 mm with simple harmonic motion. The machine is mounted on four springs, symmetrically arranged with respect to center of mass, in such a way that the machine has one degree of freedom and can undergo vertical displacements only. Neglecting damping, calculate the combined stiffness of the spring in order that the force transmitted to the foundation is 4% of the applied force, when the speed of rotation of machine crankshaft is 1000 rpm. When the machine is actually supported on springs, it is found that the damping reduces the amplitude of successive free vibrations by 25%. Calculate;

i The force transmitted to the foundation at 1000 rpm.

ii The force transmitted to the foundation at resonance

iii The amplitude of the forced vibration at resonance. (13 marks)

3. Design values for journal bearings.

Machinery	*Bearing*	*Maximum bearing pressure (p) in N/mm²*	*Operating values*			
			Absolute Viscosity (Z) in kg/m-s	*ZN/p Z in kg/m-s p in N/mm²*	$\frac{c}{d}$	$\frac{l}{d}$
Automobile and air-craft engines	Main	5.6 – 12	0.007	2.1	—	0.8 – 1.8
	Crank pin	10.5 – 24.5	0.008	1.4		0.7 – 1.4
	Wrist pin	16 – 35	0.008	1.12		1.5 – 2.2
Four stroke-Gas and oil engines	Main	5 – 8.5	0.02	2.8	0.001	0.6 – 2
	Crank pin	9.8 – 12.6	0.04	1.4		0.6 – 1.5
	Wrist pin	12.6 – 15.4	0.065	0.7		1.5 – 2
Two stroke-Gas and oil engines	Main	3.5 – 5.6	0.02	3.5	0.001	0.6 – 2
	Crank pin	7 – 10.5	0.04	1.8		0.6 – 1.5
	Wrist pin	8.4 – 12.6	0.065	1.4		1.5 – 2
Marine steam engines	Main	3.5	0.03	2.8	0.001	0.7 – 1.5
	Crank pin	4.2	0.04	2.1		0.7 – 1.2
	Wrist pin	10.5	0.05	1.4		1.2 – 1.7
Stationary, slow speed steam engines	Main	2.8	0.06	2.8	0.001	1 – 2
	Crank pin	10.5	0.08	0.84		0.9 – 1.3
	Wrist pin	12.6	0.06	0.7		1.2 – 1.5
Stationary, high speed steam engine	Main	1.75	0.015	3.5	0.001	1.5 – 3
	Crank pin	4.2	0.030	0.84		0.9 – 1.5
	Wrist pin	12.6	0.025	0.7		13 – 1.7
Reciprocating pumps and compressors	Main	1.75	0.03	4.2	0.001	1 – 2.2
	Crank pin	4.2	0.05	2.8		0.9 – 1.7
	Wrist pin	7.0	0.08	1.4		1.5 – 2.0
Steam locomotives	Driving axle	3.85	0.10	4.2	0.001	1.6 – 1.8
	Crank pin	14	0.04	0.7		0.7 – 1.1
	Wrist pin	28	0.03	0.7		0.8 – 1.3

Machinery	*Bearing*	*Maximum bearing pressure (p) in N/mm²*	*Operating values*			
			Absolute Viscosity (Z) in kg/m-s	*ZN/p Z in kg/m-s p in N/mm²*	$\frac{c}{d}$	$\frac{l}{d}$
Railway cars	Axle	3.5	0.1	7	0.001	1.8 – 2
Steam turbines	Main	0.7 – 2	0.002 – 0.016	14	0.001	1 – 2
Generators, motors, centrifugal pumps	Rotor	0.7 – 1.4	0.025	28	0.0013	1 – 2
Transmission shafts	Light, fixed	0.175	0.025-	7	0.001	2 – 3
	Self -aligning	1.05	0.060	2.1		2.5 – 4
	Heavy	1.05		2.1		2– 3
Machine tools	Main	2.1	0.04	0.14	0.001	1–4
Punching and shearing machines	Main	28	0.10	—	0.001	1–2
	Crank pin	56				
Rolling Mills	Main	21	0.05	1.4	0.0015	1–1.5