UNIVERSITY OF JOHANNESBURG

PROGRAM : BACHELOR OF ENGINEERING TECHNOLOGY
ENGINEERING: MECHANICAL

SUBJECT **MECHANICS OF MACHINES 3A**

CODE : **MEMMIA 3**

DATE : WINTER SSA EXAMINATION 2019
18 JULY 2019

DURATION : 11:30 – 14:30

WEIGHT : 40 : 60

TOTAL MARKS : (100 marks = 100%)

EXAMINER : Dr K. TEKWEME

MODERATOR : Mrs D. IONESCU

NUMBER OF PAGES : 3 PAGES + 1 ANNEXURE

INSTRUCTIONS:

1) ALL SKETCHES MUST BE DONE WITH DRAWING INSTRUMENTS. MARKS WILL BE DEDUCTED FOR UNTIDY WORK.
2) STUDENTS MUST SUPPLY OWN DRAWING EQUIPMENT.
3) ANSWER ALL THE QUESTIONS.

QUESTION 1

Model the system shown in Figure 1 by a block attached to a single spring of an equivalent stiffness K_{eq}. If k = 2200 N/m, determine the mass of the block m such that the natural frequency is 25 Hz.

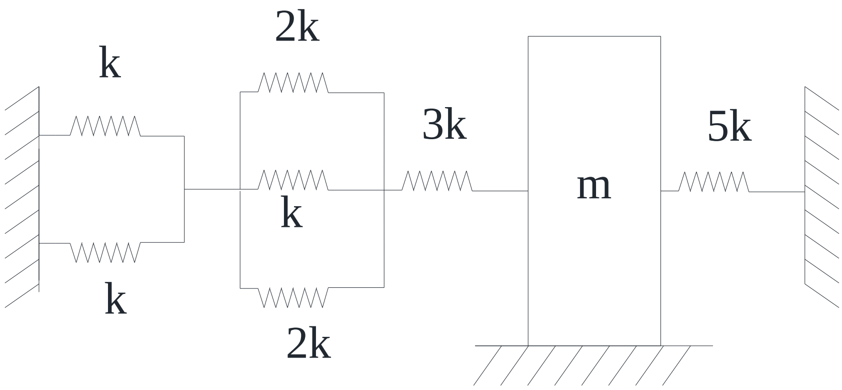

Figure 1

[10]

QUESTION 2

Investigate the out-of-balance of primary forces and couples of a 2-stroke six-cylinder in line engine for the firing order 1 - 2 - 4 - 6 -5 – 3, taking a plane mid-way between the cylinders 3 and 4 as the reference plane. The radius of crank is 60 mm and the ratio of connecting rod to crank is 5.0. The reciprocating mass per line is 2.5 kg, the distance between the center lines of the cylinders is 120 mm, and the engine speed is 3000 r.p.m.

[30]

QUESTION 3

3.1) Design a cam that will give a lift of 34 mm to a roller follower. The diameter of the roller is 20 mm. The outstroke of the follower takes place with a simple harmonic motion during 90^0 of cam rotation followed by a dwell during 30^0 of cam rotation. The follower then returns to its initial position by simple harmonic motion in the next 120^0 of cam rotation. The minimum radius of the cam is 25 mm; and

(27)]

3.2) Determine the maximum velocity and acceleration of the follower during outstroke and return, if the cam rotates at 300 r.p.m. (5)

[32]

QUESTION 4

The propeller of a steamer weighing 5.8 kN rotates at 3120 r.p.m. clockwise when viewed from the rear. The rotor has a radius of gyration of 0.6 m. Determine the magnitude and the effects of the gyroscopic effects in the following conditions:

4.1) The steamer pitches 10 degree above and 10 degree below the horizontal position. The pitching motion is simple harmonic and a complete oscillation takes 15 seconds. The bow is descending with its maximum velocity. (7)

4.2) The steamer sails at a speed of 45 km/h and steers to the right at a curve having 70 m radius. (4)

4.3) The steamer rolls and at a certain instant it has an angular velocity of 0.06 rad/s anticlockwise when viewed from the rear. (3)

[14]

QUESTION 5

The connecting rod of a reciprocating machine is 2 m long and rotates at 150 r.p.m. The stroke of the piston is 800 mm and its diameter is 180 mm. The radius of gyration of the rod about its centroidal axis is 580 mm. The reciprocating mass is 240 kg and the mass of the connecting rod is 200 kg. The distance of the center of gravity of the connecting rod from crank pin is 430 mm. Determine the magnitude and direction of the inertia torque on the crank shaft when the crank turns through 45^0 from inner dead center.

[14]

TOTAL MARKS AVAILABLE = 100 (100 MARKS = 100%)

FORMULA SHEET

$$I = \frac{\pi}{64} D^4$$

$$I = mk^2$$

$$V_{max} = \frac{2h\omega}{\theta_0}$$

$$A_{max} = \frac{2\pi h\omega^2}{\theta_0^2}$$

$$V_{max} = \frac{2\pi h\omega^2}{\theta_R}$$

$$A_{max} = \frac{2\pi h\omega^2}{\theta_R^2}$$

$$C_{max} = mrl\omega^2$$

$$\omega = \frac{2\pi N}{60}$$

$$\omega_0 = \frac{2\pi}{\tau}$$

$$\left(\omega_p\right)_{max} = \phi\omega_0$$

$$C_{max} = I\omega\left(\omega_p\right)_{max}$$

$$\omega_p = \frac{V}{R}$$

$$C = I\omega\omega_p$$

$$L_E = a + \frac{k^2}{a}$$

$$W_P = R + \frac{(l-a)}{l} W_c$$

$$F_P = m_p r\omega^2 \left(cos\theta + \frac{cos2\theta}{5}\right)$$

$$T_P = F_P r \left(sin\theta + \frac{sin2\theta}{2\sqrt{(n^2 - sin^2\theta)}}\right)$$

$$T_C = \left(\frac{W_C}{g}\right) a(l - L_E) \frac{\omega^2}{2n^2} sin2\theta$$

$$T_w = W_C \left(\frac{a}{n}\right) cos\theta$$

$$T_i = T_P + T_C + T_w$$

5/…