Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	MECHANICS OF MACHINES
COURSE CODE	:	BNJ 20303
PROGRAMME CODE	:	BNG / BNM
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	1.	ANSWER **ALL** QUESTIONS
	2.	THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
	3.	STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 **Figure Q1** shows mass of AOB bar, M_o is 6 kg. It has 130 mm of centrifugal radius measured from O to B. Two springs K_1 and K_2 are attached at point A and B with the stiffness coefficient is $3K$ N/m and $0.5K$ N/m. Point B also has a 1.5 kg mass connected between spring and bar.

(i) Sketch the geometry displacement diagram for AOB bar. Determine the displacement based on the diagram.

(2 marks)

(ii) Determine the height (extension/compression of spring) at K_1 and K_2 in terms of θ.

(2 marks)

(iii) Determine natural frequency, ω_n in terms of K, in unit Hz by using 2nd Newton Law.

(6 marks)

(iv) Find value of K in Nm, if this system is maintain 10 seconds per one cycle of vibration.

(2 marks)

(v) Based on **Q1 (iv)**, calculate the value of spring constant for K_1 and K_2, in Nm.

(2 marks)

(vi) If the value of stiffness spring is double on K_1 and K_2, determine the new value of mass B so that the time of 10 seconds per one cycle of vibration can be reached.

(6 marks)

Hint: $\omega_n, Hz = 1/2\pi\ (\sqrt{\sum M / \sum I_o})$, $\omega_n, \frac{rad}{s} = 2\pi f$, $f, Hz = 1/time$, $f, Hz = \omega_n / 2\pi$

Q2 (a) **Figure Q2 (a)** shows a plane of rotating shaft carries four unbalanced masses 1st mass: 360 kg, 2nd mass: 280 kg, 3rd mass: 320 kg and 4th mass: 240 kg at radii 50 mm, 60 mm, 70 mm and 60 mm respectively. The 2nd, 3rd and 4th masses revolve in planes 80 mm, 160 mm, and 280 mm, respectively, measured from the plane of the 1st and are angularly located at 60°, 135° and 270°, respectively, measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by Mass A and Mass B, both located at 50 mm radii and revolving in planes mid-way between those of 1st and 2nd masses and midway between those of 3rd and 4th masses.

(i) Tabulate the data balancing for this system.

(2 marks)

(ii) Determine the magnitudes of Mass B and its respective angular position for balance system of moment polygon by using the Vector Diagram method on the graph paper given. Use scale, 1 cm = 0.3 kgm^2.

(5 marks)

(iii) Determine the magnitudes of Mass A and its respective angular position for balance system of force polygon by using the Vector Diagram method on the graph paper given. Use scale, 1 cm = 2 kgm.

(5 marks)

Hint: Taking reference point at point Mass A.

(b) **Figure Q2(b)** shows the position of plane of a 4-cylinder in-line engine with firing order 1-4-2-3 with a mass of 1 kg and reciprocal motion. This engine has 100 mm crank radius, 400 mm connecting rod, and the distance between cylinders is 200 mm.

(i) Determine the angle (θ) between cylinders and draw the position angle between the crank, according to firing order. Take your right, turning counter clockwise as the reference angle (0°).

(1 marks)

(ii) Tabulate the data balancing for this system.

(2 marks)

(iii) Determine the unbalance secondary moment and its respective angular position using vector diagram method on a graph paper. Use scale, 2 cm = 0.01 kgm^2.

(5 marks)

Hint: Taking reference distance at the middle between cylinder 2 and 3.

Q3 (a) A square threaded turnbuckle with a mean radius of 5 mm and a lead of 2 mm is shown in **Figure Q3 (a)**. 2 kN of load is applied at the end of the turnbuckle. If the static friction coefficient between the screw and the turnbuckle is $\mu_s = 0.25$, determine;

(i) Angle of inclination of plane, α.

(3 marks)

(ii) Limiting angle of friction, ϕ.

(3 marks)

(iii) Moment of M that must be applied to draw the end screws closer together.

(4 marks)

(iv) Is the turnbuckle self-locking?

(3 marks)

(b) A collar bearing in **Figure Q3 (b)** uniformly supports an axial force of P.

(i) If the coefficient of static friction is $\mu_s = 0.3$ and P is 4 kN, determine torque, M required to overcome friction.

(4 marks)

(ii) If the calculated torque in **Q3(b)(i)** is applied and the axial force of P is reduced to 2 kN, the shaft can be rotated at constant velocity. Determine the coefficient of kinetic friction at the surface of contact.

(3 marks)

Q4 (a) A set of gear trains in **Figure Q4 (a)** is composed of gear *A*, *B*, and *C* which have 20 teeth, 60 teeth, and 10 teeth respectively. Gear *A* revolves at 60 rpm in clockwise direction.

(i) Determine rotation speed at gear *C* in rad/s.

(3 marks)

(ii) Determine rotation direction for gear *C*.

(1 mark)

(b) A gear system in **Figure Q4 (b)** is used to drive a 1.2 m diameter hoist through two sets of gear which has 90 % efficiency for each set. The number of teeth for gear 1, gear 2, gear 3, and gear 4 are 20, 70, 10, and 45 respectively. Moment of inertia for the motor shaft is 5 kgm^2, middle shaft is 40 kgm^2 and hoist shaft is 500 kgm^2. By assuming the system is frictionless, determine;

(i) Gear ratio for the gear system.

(3 marks)

(ii) Equivalent moment of inertia.

(3 marks)

(iii) Total torque required by the motor to raise the 6000 kg of load at 0.4 m/s^2.

(10 marks)

Q5 (a) Define velocity ratio, define slip, and discuss the effect of belt thickness and slip on velocity ratio.

(5 marks)

(b) The slack side of the belt drive is preferable to place on the top side as shown in **Figure Q5 (b)**. Discuss the possible reason behind this.

(3 marks)

(c) An open belt drives connects two pulleys 120 cm and 50 cm diameter, on parallel shafts 4 metres apart. The mass of belt per metre length is 0.9 kg and maximum tension is not to exceed 2000 N. The coefficient of friction is 0.3. The 120 cm pulley, which is the driver, runs at 200 rpm. Because of belt slip on one of the pulleys, the velocity of the driven shaft is only 450 rpm. Calculate;

(i) The torque on each of the two shafts.

(6 marks)

(ii) The power transmitted.

(2 marks)

(iii) The power lost in friction.

(2 marks)

(iv) Calculate the efficiency of the drive?

(2 marks)

-END OF QUESTIONS-

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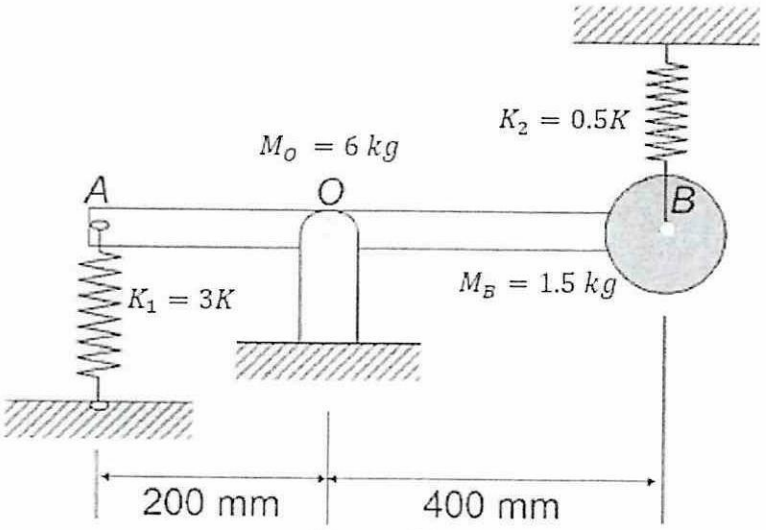

Figure Q1

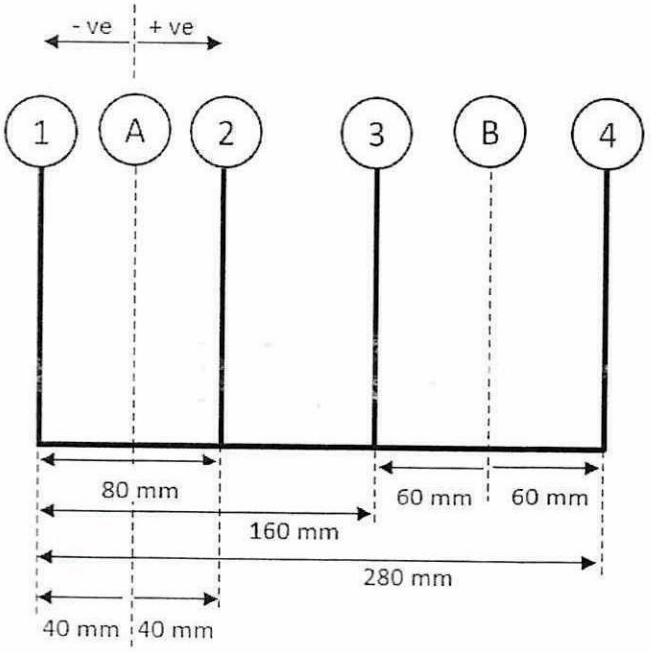

Figure Q2 (a)

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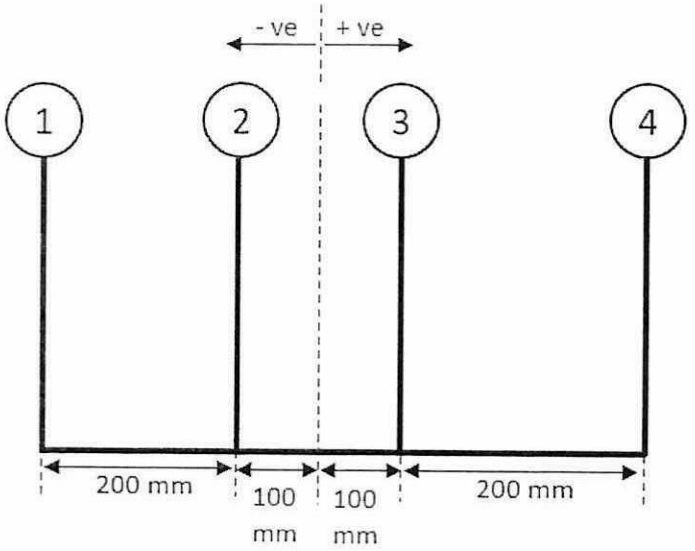

Figure Q2 (b)

Figure Q3 (a)

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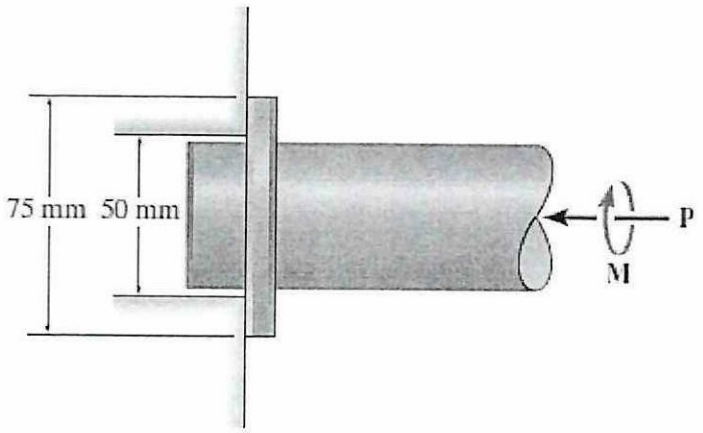

Figure Q3 (b)

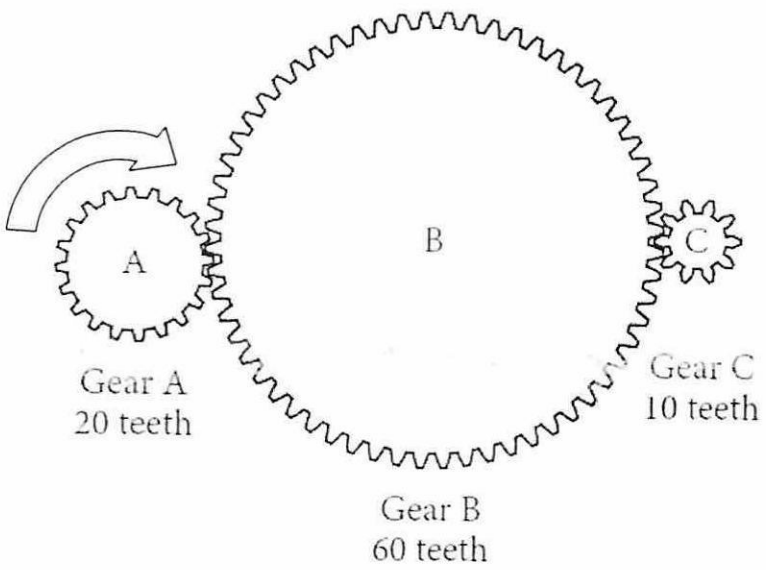

Figure Q4 (a)

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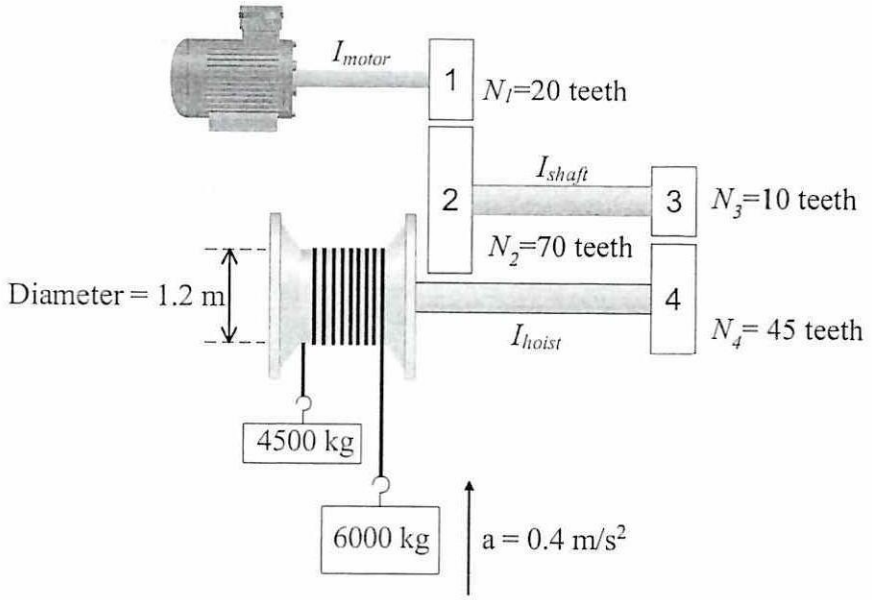

Figure Q4 (b)

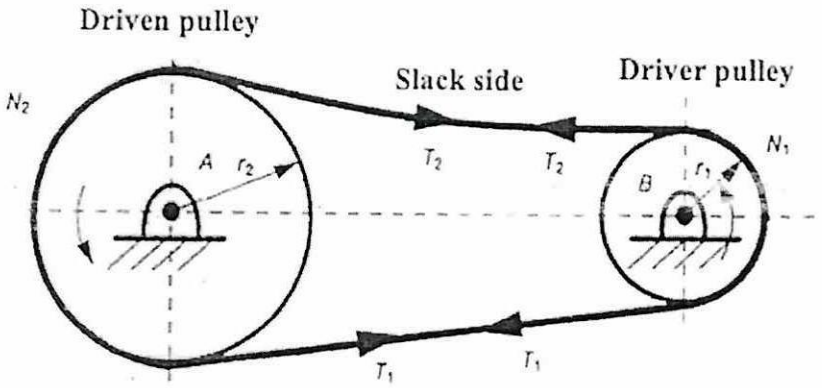

Figure Q5 (b)