Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	MECHANICS OF MACHINE
COURSE CODE	:	DAM 23803
PROGRAMME CODE	:	DAM
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS ONLY 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION

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

Q1 (a) A compound gear train as in **Figure Q1.1** comprises of six gears A, B, C, D, E and F. The diameter of each of the gear is given in **Table Q1.1**.

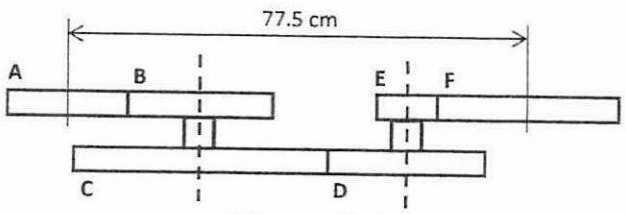

Figure Q1.1

Table Q1.1

Gear	A	B	C	D	E	F
Diameter (cm)	20	25	42	28	10	30

(i) Gear A is rotating at 4000 revolutions per minute, the input power is 2kW the calculated efficiency of the compound gear is 82%. Determine the output torque of the compound gear.

(10 marks)

(ii) The compound gear is changed to simple gear train comprise of four gear A, G, H, and I as in **Figure Q1.2**. If the gear ratio and the efficiency is the same determine the radius of gear G, H and I.

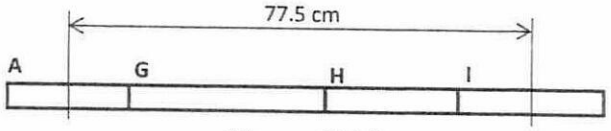

Figure Q1.2

(5 marks)

(b) Gear A is rotating gear B as in **Figure Q1.3**. The moment of inertia of gear A and B is 0.8 kgm^2 and 2 kgm^2 respectively. Gear A rotates at 400 revolutions per minute with an angular acceleration of 3 rad/s^2 while gear B rotates at 250 revolutions per minute. If the gear efficiency is 82%, determine the torque required by gear A to rotate gear B.

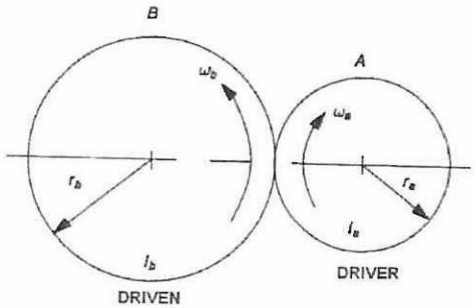

Figure Q1.3

(5 marks)

Q2 (a) Johan represent UTHM in a hammer throw sport. Three forces 'a', 'b' and 'c' appear while he is rotating the hammer as illustrated in **Figure Q2.1**.

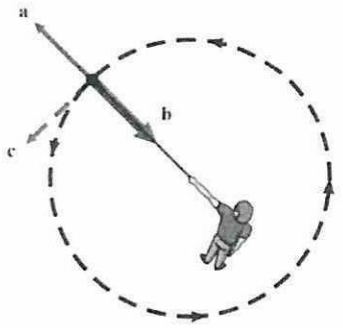

Figure Q2.1

(i) Define the three forces 'a', 'b' and 'c'.

(3 marks)

(ii) Referring to Newton's third law, explain the reason for force 'a" is the reaction of force 'b' while force 'c' does not have reaction.

(2 marks)

(b) An open belt drive system consists of a flat belt connecting driver and driven pulley with 130 cm and 50 cm diameter on a parallel shaft 1.6 m apart with the value of tight tension equal to 800N. The driver pulley is connected to a power source with a speed of 800 revolutions per minute. Given the mass of the belt is 0.2 kg and the coefficient of friction between the belt and the pulley is 0.35,

(i) calculate angle of contact of the belt at the driven pulley.

(4 marks)

(ii) calculate the total length of the belt.

(3 marks)

(iii) determine the centrifugal tension in the system.

(4 marks)

(iv) determine the power transmitted by the belt.

(4 marks)

Q3 A disc is out of balance as illustrated in **Figure Q3.1** because there are three balls A, B and C attached to it. The three balls are said to be coplanar and they rotate about a common center. A fourth ball D is added to balance the disc.

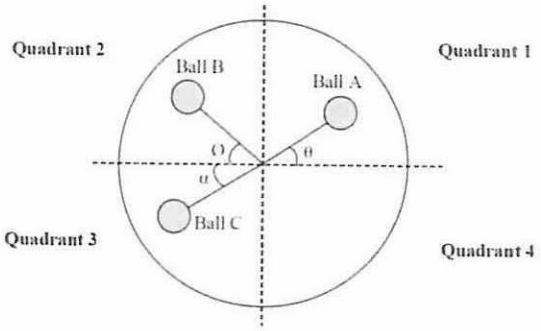

Figure Q3.1

(a) If the mass and the radius of each of the three balls A, B, C are known, explain how to determine the location of the fourth ball either should be at quadrant 1, 2, 3 or 4 using the below method:

(i) vector diagram

(2 marks)

(ii) mathematical calculation.

(2 marks)

(b) The properties value of ball A, B and C as shown in **Table Q3.1**. For ball D, only the mass is known.

Table Q3.1

	Ball A	Ball B	Ball C	Ball D
Mass (kg)	7	3	6	3
Radius (m)	0.3	0.25	0.4	
Angle	$\theta = 25^{o}$	$\emptyset = 40^{o}$	$\alpha = 30^{o}$	

Determine the value of radius and angle of ball D using:

(i) vector diagram

(6 marks)

(ii) mathematical calculation.

(10 marks)

Q4 (a) A diagram of square threaded screw moving up a plane is shown in **Figure Q4.1**. The equation of the diagram given by $P = W \tan(\alpha + \emptyset)$, where P is horizontal force, W is the load and α is the pitch angle.

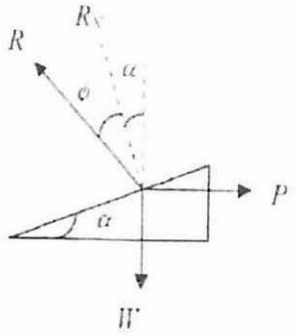

Figure Q4.1

(i) Explain the angle $\emptyset$ and how to determine the value of $\emptyset$.

(3 marks)

(ii) Using calculation method, show that only if the resultant force when the screw is moving up a plane is zero, the equation $P = W \tan(\alpha + \emptyset)$ can be derived.

(4 marks)

(b) The mean diameter of a Vee' threaded screw jack as shown in **Figure Q4.2** is 60 mm. The pitch of the thread is 15 mm and the angle of thread β is 20°. The coefficient of friction is 0.2. Calculate the efficiency and force that must be applied at the end of a 0.5 m long lever, which is perpendicular to the longitudinal axis of screw to raise a load of 30 kN.

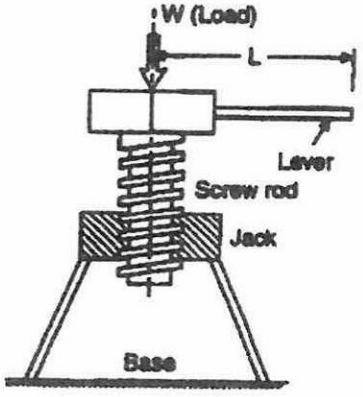

Figure Q4.2

(13 marks)

Q5 (a) Describe four (4) types of inversion in slider crank mechanism and provide example of each of the inversion.

(4 marks)

(b) The four bars chain in **Figure Q5.1** comprises of link AB = 0.8 m, link BC = 1.0 m and link CD = 0.3 m. The distance between point A and D is 1.5 m. Crank AB is rotating anticlockwise with an angular velocity of 3 rad/s which is decreasing at 3.5 rad/s^2.

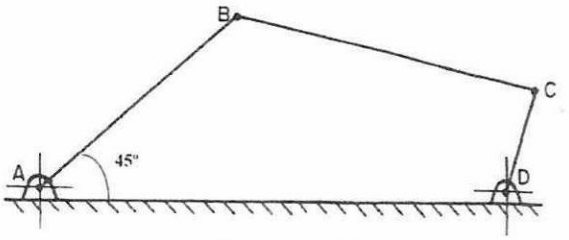

Figure Q5.1

(i) Redraw the **Figure Q5.1** to appropriated scale.

(2 marks)

(ii) Determine the velocity and acceleration of each link.

(9 marks)

(iii) Draw the velocity and acceleration diagram of the bar chain.

(5 marks)

Q6 (a) Define the Simple Harmonic Motion (SHM) and list two (2) criteria of SHM.

(4 marks)

(b) An undamped system vibrates with a frequency of 15 Hz and an amplitude of one milimeter. Determine the maximum value of the system's velocity and acceleration.

(6 marks)

(c) A uniform thin rod, AB with mass of 1.3 kg is hinged at point A and able to rotate at this point as shown in **Figure Q6.1**. A concentrated mass of 3.5kg is then added at point B. The thin rod is then balanced horizontally by attaching a spring with a stiff thickness of 3.0 kN/m.

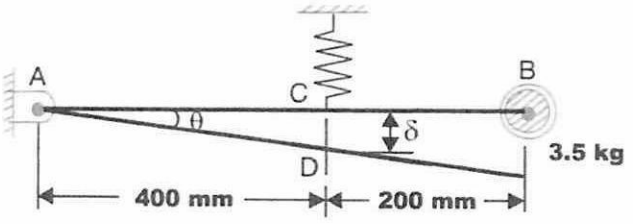

Figure Q6.1

(i) If the moment of inertia of rod AB is given by $\frac{1}{3}mr^2$ where m is the mass of the thin rod and r is the length of the thin rod, determine the moment inertia of the thin rod and the concentrated mass at point A.

(3 marks)

(ii) Determine the spring tension in term of θ.

(2 marks)

(iii) Determine the frequency of oscillation when the thin rod is pulled and released.

(5 marks)

- END OF QUESTIONS -

APPENDIX A

List of Formula

1. Linear velocity at the contact surface of gear, $\pi D_1 N_1 = \pi D_2 N_2$
2. Equivalent Moment of Inertia, $I_{equiv} = \left(I_A + \frac{I_B n^2}{\eta_G} \right)$
3. Velocity Ratio for belt drives, $n = \frac{N_2}{N_1} = \frac{d_1}{d_2}$
4. Belt tension ratio for flat belt, $\frac{T_1}{T_2} = e^{\mu\theta}$
5. Belt tension ratio for V-Belt, $\frac{T_1}{T_2} = e^{\left(\frac{\mu\theta}{\sin\beta}\right)} = e^{(\mu\theta)(\operatorname{cosec}\beta)}$
6. V-Belt type force balance, $R_N = \frac{R}{2\sin\beta}$
7. Maximum Power for Belt Drives, $P = (T_1 - T_2)v$
8. Centrifugal force term, $\rho A v^2 = T_C$
9. Limiting Angle of Friction, $\tan\phi = \frac{F}{R_N} = \mu$
10. Inclination of Square Threaded Screw, $\tan\alpha = \frac{p}{\pi d}$
11. Efficiency for Square Threaded Screw, $\eta = \frac{p}{\pi D \tan(\beta + \alpha)}$
12. Radial component of acceleration, $f_{BA}^r = \omega^2 (BA) = \frac{(V_{BA})^2}{BA}$
13. Tangential component of acceleration, $f_{BA}^t = \alpha (BA)$
14. Newton's Second Law of Motion, $\sum M_O = I_O \ddot{\theta}$
15. Principle of conversion of energy, $\frac{d}{dt}[T.K + T.U]$