CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME	:	MECHATRONICS MECHANISM
COURSE CODE	:	BEH 41103
PROGRAMME	:	4 BEH
EXAMINATION DATE	:	JUNE 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Figure Q1 (a) shows a gear system that have Gear A as the input and Gear F as the output. The gear ratio for the system is 36 and Gear F revolves at 200 rev/min. Gear A has 25 teeth, Gear B has 120 teeth, Gear C has 40 teeth, Gear D has 200 teeth and Gear F has 50 teeth. The input torque for the system is 30 Nm with 70% efficiency.

(i) Determine the suitable speed and direction of the input gear if the output gear rotates clockwise.
(ii) Evaluate the output power for the gear system.
(iii) Find the proper holding torque to hold case or body of the system from rotating.

(10 marks)

(b) Figure Q1 (b) shows an epicyclic gear box that has a fixed outer gear C and 75% efficiency. The input is the gear D that rotates at 200 rev/min clockwise viewed from the left with a torque of 40 Nm. Gear B and gear D has 140 teeth and 20 teeth respectively. Analyze the output speed and direction of the epicyclic gear box.

(10 marks)

Q2 (a) An induction motor shaft running at 1200 rev/min drives a workshop main shaft by a flat belt drive. The diameter of the pulley on the motor shaft is 40 cm and that on the main shaft is 70 cm. Another pulley of diameter 45 cm drives a countershaft having a pulley 65 cm keyed to it. Evaluate the speeds of the counter shaft if there is 3% slip on each drive.

(5 marks)

(b) An 11.5 cm wide and 1.2 cm thick belt transmits 11 kW between two parallel shafts. Figure Q2 (b) shows two types of connection between the belt and the shafts. The distance between the shafts is 250 cm and the diameter of the smaller pulley is 60 cm. The driving and the driven shaft rotate at 100 rpm and 240 rpm respectively. The coefficient of friction between the belt and the pulley is 0.25. Determine the stress in the belt if the two pulleys are connected by open belt and cross belt.

(15 marks)

Q3 (a) A shaft carries four masses A, B, C and D. The masses are 12 kg, 10 kg, 18 kg and 15 kg, respectively and their radius of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of the masses B, C and D are 60°, 130° and 270° from the mass A. Determine the suitable magnitude and position of the balancing mass at a radius of 100 mm.

(10 marks)

(b) The displacement of a body performing simple harmonic motion is described by the following equation

$$x = A\sin(\omega t + \phi)$$

where A is the amplitude, ω is the natural frequency and ϕ is the phase angle. Given A = 20 mm, ω = 50 rad/s and $\phi = \pi/8$ radian.

(i) Analyze the frequency and the period time.
(iii) Evaluate the displacement, velocity and acceleration when t = T/4.

(10 marks)

Q4 (a) A screw jack having square threads of 5cm mean diameter and 1.25 cm pitch is operated by a 50 cm long hand lever. Coefficient of friction at the threads is 0.2. Determine the effort needed to be applied at the end of the lever to lift a load of 20kN.

(7 marks)

(b) A pitch of 50 mm mean diameter threaded screw of a screw jack is 12.5 mm. The coefficient of friction between the screw and the nut is 0.13.

(i) Determine the torque required on the screw to raise a load of 25kN, assuming the load to rotate with the screw.
(iii) Analyze the ratio of the torque required to raise the load (in Q4 (a) (i)) to the torque required to lower the same load.

(13 marks)

Q5 (a) Briefly explain the actuator.

(2 marks)

(b) List three (3) types of actuator and give examples for each actuator.

(3 marks)

(c) Figure Q5 (c) shows a "rocking lever" mechanism in which steady rotation of the wheel produces an oscillating motion of the lever OA. Both the wheel and the lever are mounted in fixed centres. The wheel rotates clockwise at a uniform angular velocity, ω of 100 rad/s.

(i) Analyze the absolute velocity of point A and the angular velocity of the link AB.
(ii) Determine the centrifugal accelerations of BC, AB and OA.

(15 marks)

- END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/20122013 PROGRAMME : 4 BEH
COURSE : MECHATRONICS MECHANISM COURSE CODE : BEH41103

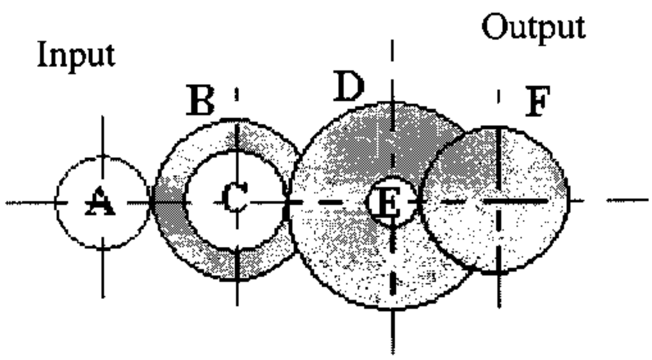


FIGURE Q1(a)

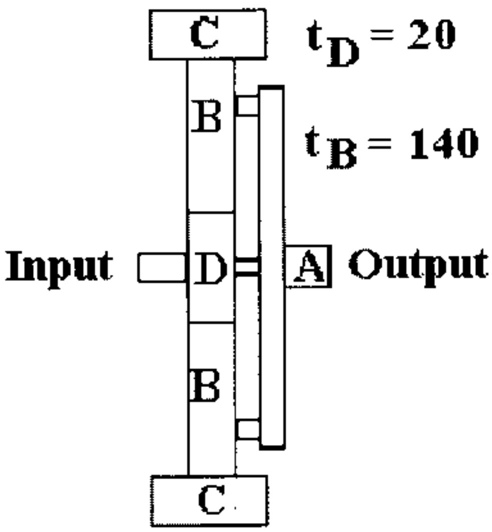
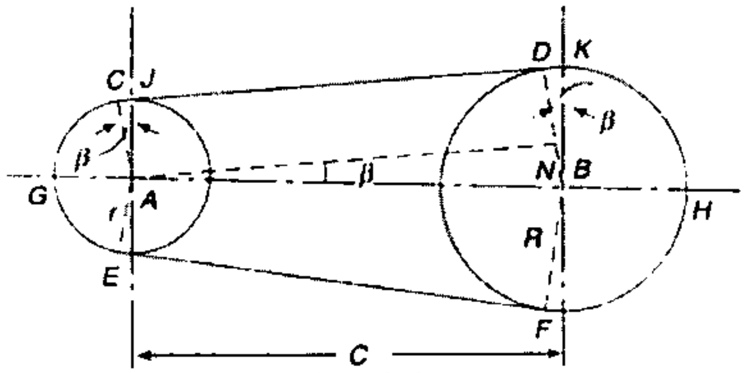


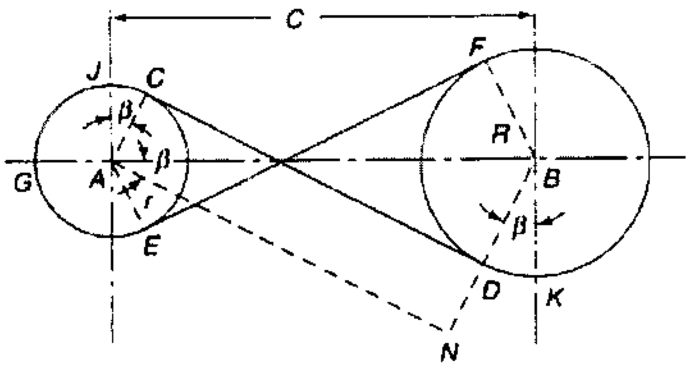
FIGURE Q1(b)

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/20122013 PROGRAMME : 4 BEH
COURSE : MECHATRONICS MECHANISM COURSE CODE : BEH41103



Open belt



Cross belt

FIGURE Q2(b)

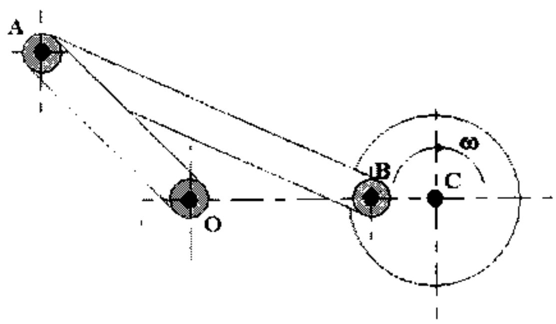


FIGURE Q5(c)

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/20122013 PROGRAMME : 4 BEH
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FORMULA

1. Gear ratio, $GR = \dfrac{N_A}{N_B} = \dfrac{t_B}{t_A}$
   where N_A is the input speed, N_B is the output speed, t_A is the number of teeth on gear A and t_B is the number of teeth on gear B.

2. The effect of slip on the velocity ratio
   $VR = \dfrac{N_B}{N_A} = \left(\dfrac{D_A}{D_B}\right)\left(\dfrac{100 - S}{100}\right)$
   where N_A is rotational speed of motor shaft, N_B is rotational speed of the main shaft, D_A is the diameter of motor pulley (driver), D_B is the diameter of 1st pulley on the main shaft (driven) and S is the percentage slip.

3. Efficiency, $\eta = \dfrac{Power\ out}{Power\ in} \times 100\%$

4. Shaft power, $P = \dfrac{2\pi NT}{60}$
   where N is the speed and T is the torque

5. linear velocity on a circle $v = \omega D/2$
   where ω is the angular velocity and D is the diameter of a circle.

6. Power transmission of belt drives, $P = (T_1 - T_2)v$
   where T_1 is the tension on the tight side, T_2 is the tension on the slack side and v is the linear velocity of the belt.

7. Maximum power transmission, $P = T_1 kv$
   $k = 1 - \dfrac{1}{e^{\mu\theta}}$
   where T_1 is the tension on tight side, v is the linear velocity of the belt, k is the constant, μ is the coefficient of friction between belt and pulley and θ is the angle of lap of the belt over pulley.

8. Friction tensions ratio for flat belt, $\dfrac{T_1}{T_2} = e^{\mu\theta}$

FINAL EXAMINATION

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Friction tension ration for v-belt and rope, $\frac{T_1}{T_2} = \frac{e^{\mu\theta}}{\sin\alpha}$

where T_1 is the tension on tight side, T_2 is the tension on the slack side, θ is the angle of lap of the belt over pulley, μ is the coefficient of friction between belt and α is the angle of the groove.

9. Tension, $T = b \times t \times f$
   where b is the width of the belt, t is the thickness of belt and f is the stress.

10. Centrifugal force, $F_{c1} = m_1\omega^2 r_1 \text{N}$
    where m_1 is the mass attached to the shaft in kg, r_1 is the distance of centre of gravity of the revolving mass m_1 from the axis rotation and ω is the angular velocity of the shaft in rad/s.

11. Effort for upward motion
    $P_0 = mg\tan\alpha$ without friction ($\phi = 0$)
    $P = mg\tan(\alpha + \phi)$ with friction
    $= \frac{mg(\tan\alpha + \tan\phi)}{1 - \tan\alpha\tan\phi}$
    Where mg is the weight of the body, ϕ is the angle of friction and α is the angle of inclination of the plane to the horizontal.
    But $\tan\alpha = \frac{p}{\pi d_m}$ and $\tan\phi = \mu$
    Where p is the pitch, d_m is the mean diameter of the screw and μ is the coefficient of friction

12. Effort for downward motion
    $P = mg\tan(\phi - \alpha)$
    $= \frac{mg(\tan\alpha - \tan\phi)}{1 - \tan\alpha\tan\phi}$
    Where mg is the weight of the body, ϕ is the angle of friction and α is the angle of inclination of the plane to the horizontal.

13. Horizontal force applied tangentially at the end of a tommy bar in a horizontal plane, $P_e = \frac{P \times r}{L}$
    where P_e is the force applied by the tommy bar, P is the force applied at screw tangentially in a horizontal plane, r is the radius of the screw and L is the horizontal distance between central axis of the screw and the end of the tommy bar.