



**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
SEMESTER II  
SESSION 2018/2019**

COURSE NAME : MECHANICS OF MACHINES  
COURSE CODE : BNJ 20303  
PROGRAMME CODE : BNG / BNH / BNK / BNL / BNM  
EXAMINATION DATE : JUNE / JULY 2019  
DURATION : 3 HOURS  
INSTRUCTION : ANSWER **ALL** QUESTIONS

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

**Q1** (a) **Figure Q1(a)** shows the ABC lever that has a uniform section and masses of 1.5 kg. Given the moment inertia for ABC lever is  $\frac{1}{3}ml^2$ . It is pivoted at C (reference) and carries a mass of 1 kg at A. Arm BD of 1 kg and carries a mass of 2 kg at D. The spring constant at A is 400 N / m and at BD is 1 kN / m. If the ABC lever is pulled up and then released,

- (i) Draw the geometry diagram for the lever at maximum position and determine the height (extension/compression of spring) at B and A.
- (ii) Identify by drawing the FBD (springs force) for the lever at maximum position and determine the distance perpendicular to the spring force 1 and 2.
- (iii) Determine the natural frequency of the system in the Hz unit, using the **Second Newton Laws** method. Ignore all pendulum effects.

(12 marks)

(b) **Figure Q1(b)** shows a vibration system having a length of EFGH steel shaft 1.5 m and a flywheel at its tip, A. The mass of the flywheel is 50 kg and its radius is 0.55 m. Shaft has 40 mm diameter ( $= d_1$ ) for section GH = 0.4 m, for FG = 0.5 m its diameter is 60 mm ( $= d_2$ ) and for EF part = 0.6 m, its diameter is  $d_3$  mm. If the shaft rigid modular is 80 GN / m and the natural frequency of this vibration system is 8 Hz, determine the diameter  $d_3$ .

Hints :

- This is vibration system having a series shaft system
- Natural frequency of this system is,  $\omega_n = \sqrt{\frac{6\pi(d')^4}{32.I.(l')}} \text{ rad/s}$

(8 marks)

**Q2** (a) A shaft is rotating with constant speed,  $\omega$  rad/s carries masses A, B, C and D with radius of each masses from shaft axes is  $r_A = 80$  mm,  $r_B = 120$  mm,  $r_C = 150$  mm and  $r_D = 120$  mm. As shown in **Figure Q2(a)(i)**, each mass is arrange 0.5 m to each other on the shaft and taking position B as the reference distance. Given mass A and mass D are 12 kg and 5 kg respectively. **Figure Q2(a)(ii)** shows angle between mass A and mass D is  $90^\circ$ .

- (i) Tabulate the data balancing for this system.
- (ii) If the shaft and masses are to in complete balance, determine the angle and mass C, by constructing the Moment vector, using the diagram/vector method on the graph paper given. Use scale, 1 cm = 0.1 kg m<sup>2</sup>. Taking mass, A as the reference angle ( $0^\circ$ ), on your right turning counter clockwise.

(7 marks)

- (b) The cranks and connecting rods of a 4 cylinders inline engine running at 1800 rpm. The cranks are 6 cm and connecting rod are 24 cm each respectively. The cylinders are numbered 1 to 4 in sequence from one end. The cranks appear at intervals of  $90^{\circ}$  in an end view. The cylinders are spaced 15 cm apart. The reference plane distance is taken at the center distance of the cylinders that is between cylinder 2 and 3. The reciprocating mass corresponding to each cylinder is 1.5 kg. Firing order 1- 4-2-3.
- (i) Identify by drawing position angle between the crank, according to firing order and taking on your right turning counter clockwise as the reference angle ( $0^{\circ}$ ), and also draw the position of each cylinder showing the reference plane distance.
  - (ii) Tabulate the data balancing for this system.
  - (iii) Determine the unbalanced primary moment using the diagram/vector method on the graph paper given and also calculate the magnitude and angle for this primary moment. Use scale, 2 cm = 60 kg cm<sup>2</sup>.
  - (iv) Determine the unbalanced secondary moment using the diagram/vector method on the graph paper given and also calculate the magnitude and angle for this secondary moment. Use scale, 2 cm = 60 kg cm<sup>2</sup>.

(13 marks)

- Q3** (a) A body of mass 30 kg lied on a surface at the same plane. The friction coefficient between body and surface is 0.15. A force P directed at an angle  $15^{\circ}$  to the plane, was to move the body. The position of this force is also  $40^{\circ}$  to the horizontal.

- (i) Calculate the value of P which will cause **motion up the plane**.
- (ii) Calculate the value of P which will cause **motion down the plane**.

Hints:

- Any formula use should be established or explained by vector diagrams of forces.

(10 marks)

- (b) A threaded screw has a mean diameter of 60 mm and pitch of 13 mm. Given that the coefficient of friction between the nut and screw is 0.2. Assuming the load to rotate with the screw,
- (i) Determine the torque required on the screw to raise a load of 25 kN.
  - (ii) Determine the percentage efficiency.

(5 marks)

(c) **Figure Q3(c)** shows blocks A and B weigh 50 N and 30 N, respectively. If both blocks are freely slide (both block not together),

- (i) Identify by drawing FBD of block B.
- (ii) Determine the cable force needed at static equilibrium.

(5 marks)

**Q4** (a) **Figure Q4(a)**, a motor is accelerating a mass, 250 kg load with acceleration of  $1.2 \text{ m/s}^2$  through a gear system as shown below. The rope that carries the load are encircled on a hoist with diameter 1.2 m. Gear for the hoist's shaft has 200 teeth, gear for motor shaft has 20 teeth. Gear efficiency is 90%. Mass and radius of gyration of each shaft is as below;

	Mass (kg)	Radius of gyration (mm)
Motor shaft	250	100
Hoist shaft	1100	500

Calculate the torque of the motor needed to bring up the load with acceleration  $1.2 \text{ m/s}^2$ .

Hints:

- Neglect friction effect.
- Draw the FBD for the raising up load

(9 marks)

(b) A vehicle with a capacity to move up a gradient of 15 of the dead ( $15^\circ$  inclination). Gear ratio used to produce wheel spin 400 rpm when the engine speeds of 2000 rpm. The engine produces total torque of 532 Nm and used gear transmission efficiency is 90% to reach the summit at a distance of 100 m. If the moving up vehicle is hampered by a force of 300 N,

- (i) Determine the minimum time for the vehicle to reach this summit of distance 100 m.
- (ii) Identify by drawing the FBD for this vehicle moving up.

Regular vehicle data are given as follows:

- the mass of the vehicle and load = 2000 kg,
- spokes = 0.4 m (wheel radius)
- the total moment of inertia of the wheel =  $20 \text{ kg m}^2$
- The total moment of inertia of the engine =  $2 \text{ kg m}^2$

(11 marks)

- Q5** (a) An open belt drive connects two pulleys 120 cm and 50 cm diameter, on parallel shafts 4 meters apart. The mass of the belt per meter length is 0.9 kg. The coefficient of friction between belt and pulley surface is 0.3. The maximum tension is not to exceed 2000 N. The 120 cm pulley, which is the driver, runs at 200 rpm and because of belt slip on one of the pulleys that is the driven, the velocity of the driven shaft is only 450 rpm.
- (i) Determine the torque on each of the two shafts
  - (ii) Determine the power transmitted
  - (iii) Calculate the power lost
  - (iv) Calculate efficiency of the drive
- (14 marks)
- (b) A pulley with a groove angle of  $\alpha = 30^\circ$  is used as a driver in the belt drive system to transmit power of 40 kW at 180 rpm. Diameter of the pulley is 1.5 m and angle of contact (lap) with the belt,  $\theta = 170^\circ$ . If  $\mu=0.23$  and the maximum tension of the belt is 860 N, determine the numbers of belt needed to transmit the power
- (6 marks)

- END OF QUESTIONS -

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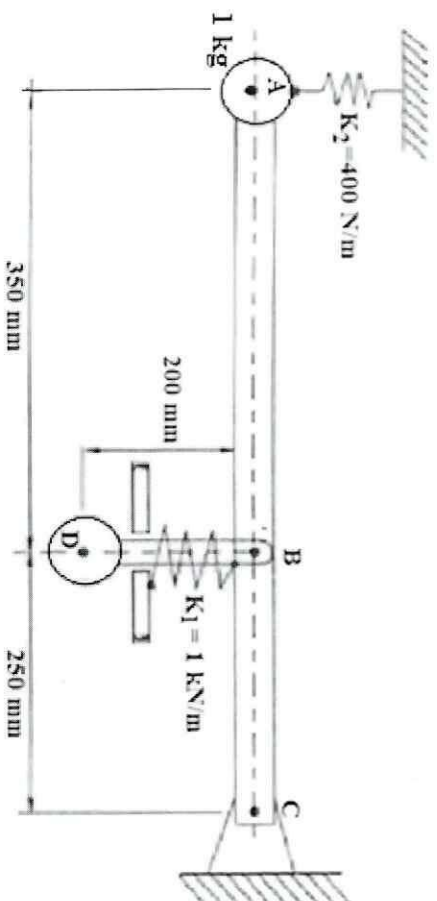


Figure Q1(a)

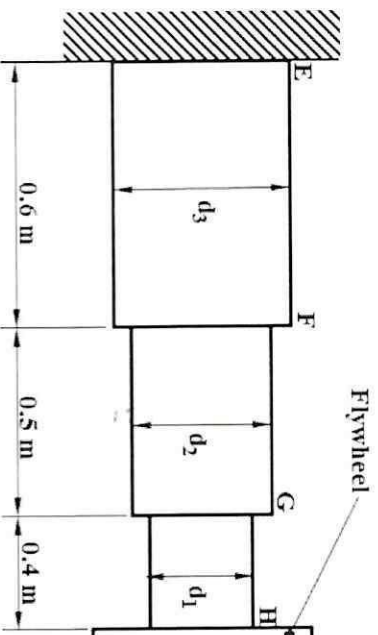


Figure Q1(b)

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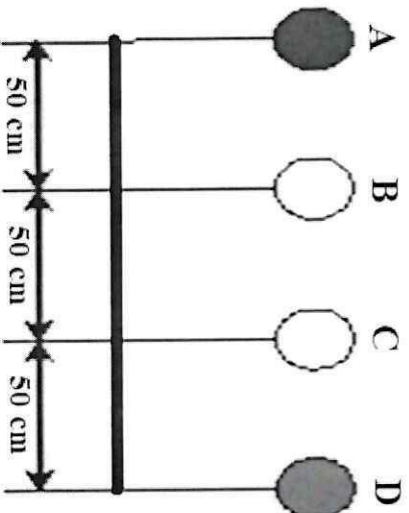


Figure Q2(a)(i)

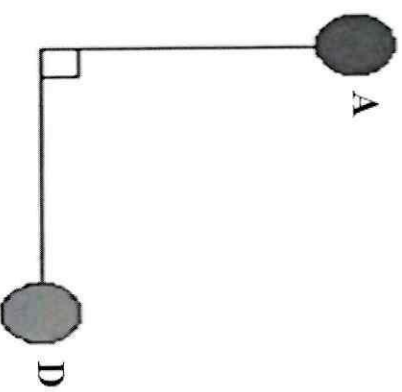


Figure Q2(a)(ii)

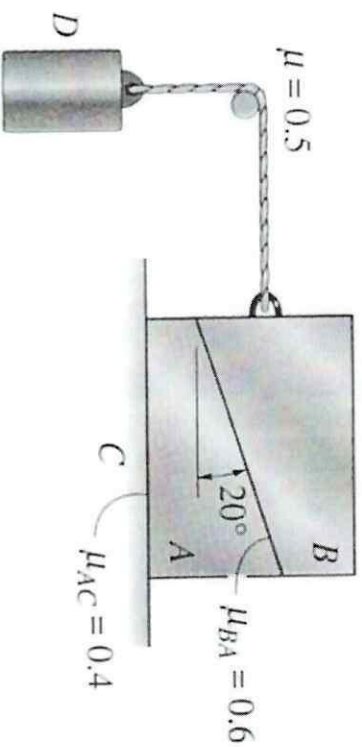


Figure Q3(c)

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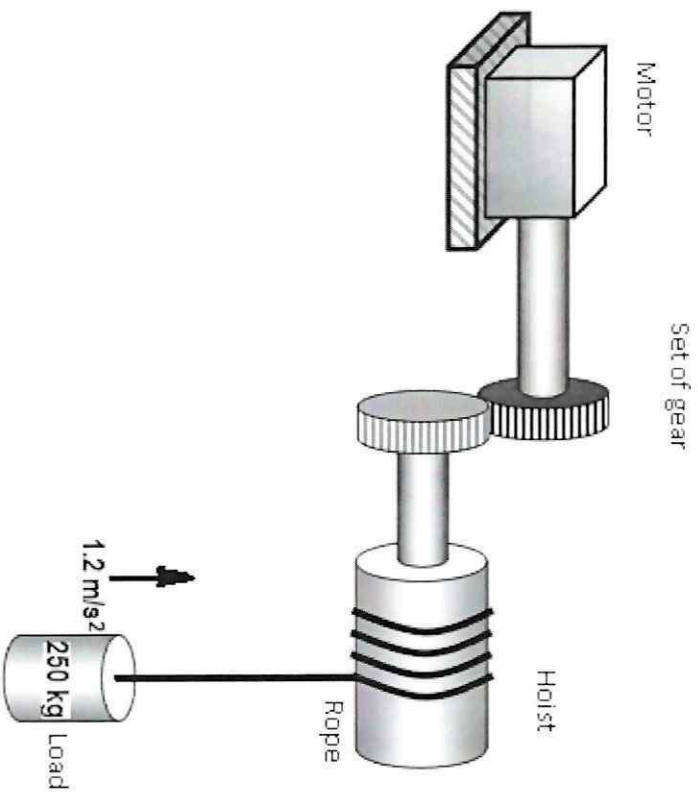


Figure Q4(a)