



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 301: MECHANICS OF MACHINES 1

DATE: 11/8/2021

TIME: 8:30 – 10:30 AM

INSTRUCTIONS

Answer question ONE and any other two questions.

QUESTION ONE (30 MARKS)

- a) Define the following terms as used in mechanics of machines
 - i. Kinematic link (1 mark)
 - ii. Mechanism (1 mark)
 - iii. Kinematic constraint (1 mark)
 - iv. Kinematic inversion (1 mark)
 - v. Slipping (in belt drives) (1 mark)
- b) Differentiate between sliding and rolling kinematic pairs and provide an example of each motion (2 marks)
- c) Explain **THREE** advantages of using chain drives over belt drives in transmitting power between two shafts (3 marks)
- d) Explain **FOUR** reasons why flat frictional clutches have replaced conical clutches in most engineering applications (4 marks)
- e) The link **AB** shown in Figure Q1(e) is moving in a vertical plane. At a certain instant when the link is inclined at 30° to the horizontal, the point **A** is moving horizontally at 4 m/s and the point **B** is moving vertically upwards. Find the velocity of the point **B**. (4 marks)

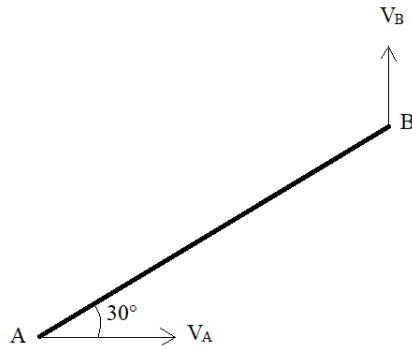


Figure Q1(e)

- f) Consider the slider-crank mechanism shown in Figure Q1(f) below. If the crank rotates clockwise with an angular velocity of 10 rad/s , use the instantaneous centres method to find:
- The angular velocity of link **AB**. (4 marks)
 - The velocity of link **A** (2 marks)

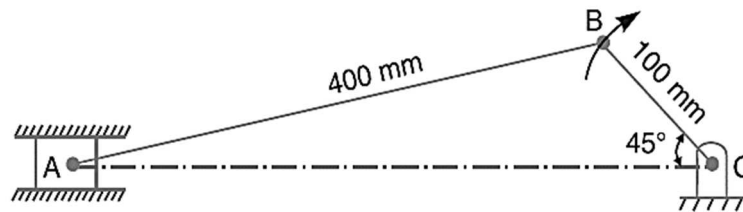


Figure Q1(f)

- g) Two pulleys, one 450 mm diameter and the other 200 mm diameter, are on parallel shafts 1.95 m apart and are connected by a cross belt as shown in Figure Q1(g). Find the length of the belt required. (6 marks)

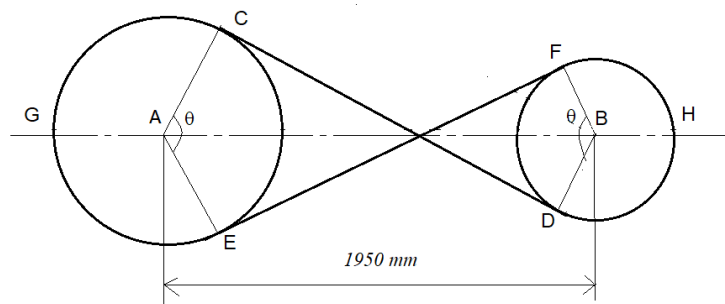


Figure Q1(g)

QUESTION TWO (20 MARKS)

- a) Figure Q2(a) shows a 4-bar mechanism. The lengths of the various links are: $AB = 62.5$ mm; $BC = CD = 75$ mm and $AD = 125$ mm. If link AB rotates at a uniform speed of 10 rpm in the clockwise direction:

- Use the Aronhold-Kennedy theorem to locate all the instantaneous centres (4 marks)
- Find the angular velocity of link BC (4 marks)
- Find the angular velocity of link CD (4 marks)

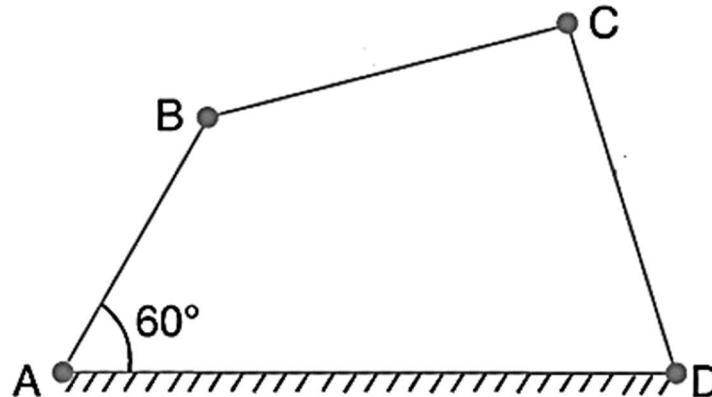


Figure Q2(a)

- b) Consider a 4-bar mechanism shown in Figure Q2(b). $AC = CB = 0.45$ m, $OA = 0.5$ m, $PB = 0.65$ m and crank OA rotates clockwise at 24.83 rpm.

- Find the velocity of point A with respect to point O (2 marks)
- Plot a velocity diagram of the mechanism (3 marks)
- Find the velocity of point C with respect to point O (2 marks)
- Find the angular velocity of link BP (1 mark)

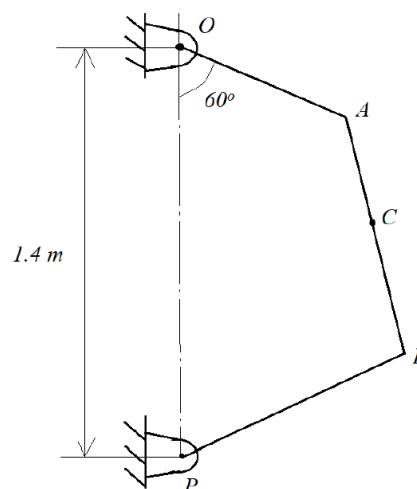


Figure Q2(b)

QUESTION THREE (20 MARKS)

- a) Show that the maximum efficiency of a square screw thread is given by:

$$\eta = \frac{1 + \sin \phi}{1 - \sin \phi} \quad (7 \text{ marks})$$

- b) A 150 mm diameter valve is used to close a steam pipe carrying steam with a pressure of $2 \times 10^6 \text{ N/m}^2$. If the valve is operated via a handle with a square thread screw of pitch diameter 47 mm with 6 mm pitch, find the torque required to turn the handle. Take the coefficient of friction as 0.12. (7 marks)
- c) A turnbuckle, with right- and left-hand single start threads, is used to couple two wagons. Its thread pitch is 12 mm and its mean diameter is 40 mm. The included angle of the v-thread is 55° and the coefficient of friction between the nut and screw is 0.16. Determine the torque required to overcome the friction between the screw and nut and turn the turnbuckle. (6 marks)

QUESTION FOUR (20 MARKS)

- a) i. Show that the torque on a plate clutch under uniform pressure is given by:

$$T = \frac{2}{3} \mu W \frac{r_1^3 - r_2^3}{r_1^2 - r_2^2} \quad (8 \text{ marks})$$

- ii. A plate clutch has 3 discs on the driving shaft and 2 discs on the driven shaft, providing four pairs of contact surfaces, each plate has a 240 mm external diameter and a 120 mm internal diameter. Assuming uniform pressure, find the total spring load pressing the plates together to transmit 25 kW at 1575 rev/min. Take $\mu = 0.3$. (4 marks)
- iii. Determine the maximum, minimum and average pressure in plate clutch when the axial force is 20 kN. The inside radius of the contact surface is 100 mm and the outside radius is 200 mm. Assume uniform wear of the plate clutch (8 marks)

QUESTION FIVE (20 MARKS)

- a) Find the power transmitted by a belt running over a pulley of 900 mm diameter at 300 rpm. The coefficient of friction between the belt and the pulley is 0.22, angle of lap 150° and maximum tension in the belt is 3500 N. (10 marks)
- b) A chain drive is used for reduction of speed from 300 rpm to 150 rpm. The number of teeth on the driving sprocket is 30. If the pitch circle diameter of the driven sprocket is 900 mm and centre to centre distance between the two sprockets is 1200 mm, find;
- i. The number of teeth on the driven sprocket. (2 marks)
 - ii. The pitch of the chain. (3 marks)
 - iii. The length of the chain (5 marks)