



MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 301: MECHANICS OF MACHINES 1

DATE: _____ **TIME:** _____

INSTRUCTIONS

1. *This paper contains FIVE questions.*
2. *Question ONE is compulsory and carries 30 marks.*
3. *Four remaining questions carry 20 marks each.*
4. *Attempt question ONE and any other TWO.*

QUESTION ONE (30 MARKS)

- a) Giving examples, highlight **FOUR** applications of screws with square threads
(4 Marks)
- b) Differentiate between the following
- (i) Machine and mechanism (2 Mark)
 - (ii) Kinematic constraint and kinematic inversion (2 Mark)
 - (iii) Rolling and spherical kinematic pairs (2 Marks)
- c) 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)

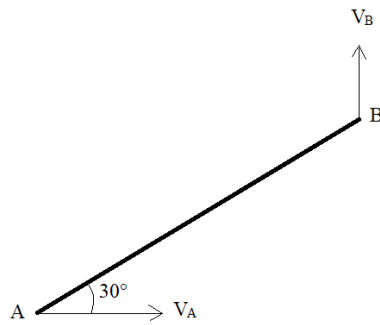


Figure Q1(e)

- d) Explain **THREE** advantages of using chain drives over belt drives in transmitting power between two shafts **(3 Marks)**
- e) Consider the slider-crank mechanism shown in Figure Q1(f) below. If the crank rotates clockwise with an angular velocity of 15 rad/s , use the instantaneous centres method to find:
- The angular velocity of link **AB**. **(4 Marks)**
 - The velocity of link **A** **(2 Marks)**

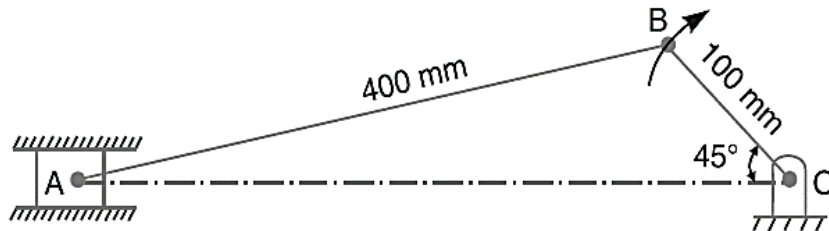


Figure Q1(f)

- f) Two pulleys, one 500 mm diameter and the other 220 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)**

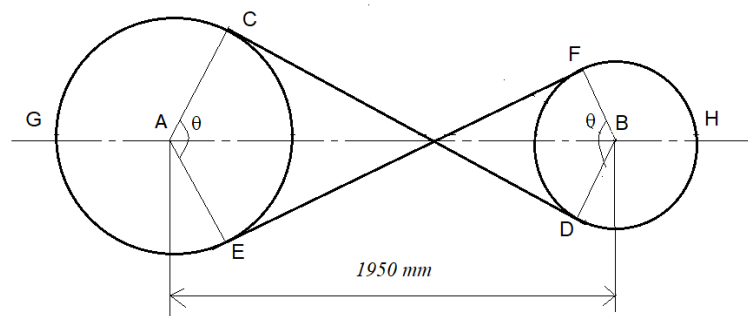


Figure Q1(g)

QUESTION TWO (20 MARKS)

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

$$\eta = \frac{1 + \sin \phi}{1 - \sin \phi}$$

(7 Marks)

- b) A 185 mm diameter valve is used to close a steam pipe carrying steam with a pressure of $2.3 \times 10^6 \text{ N/m}^2$. If the valve is operated via a handle with a square thread screw of pitch diameter 57 mm with 7 mm pitch, find the torque required to turn the handle. Take the coefficient of friction as 0.14. **(7 Marks)**
- c) A turnbuckle, with right- and left-hand single start threads, is used to couple two wagons. Its thread pitch is 15 mm and its mean diameter is 50 mm. The included angle of the v-thread is 55° and the coefficient of friction between the nut and screw is 0.17. Determine the torque required to overcome the friction between the screw and nut and turn the turnbuckle against a steady load of 3000 N **(6 Marks)**

QUESTION THREE (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:
- (i) Use the Aronhold-Kennedy theorem to locate all the instantaneous centres **(4 Marks)**
 - (ii) Find the angular velocity of link BC **(4 Marks)**
 - (iii) Find the angular velocity of link CD **(4 Marks)**

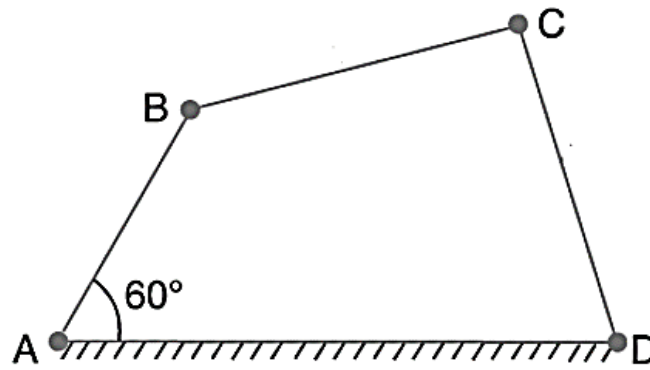


Figure Q2(a)

- b) Consider the 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.

- i) Find the velocity of point **A** with respect to point **O** (2 Mark)
- ii) Plot a velocity diagram of the mechanism (3 Marks)
- iii) Find the velocity of point **C** with respect to point **O** (2 Marks)
- iv) Find the angular velocity of link **BP** (2 Marks)

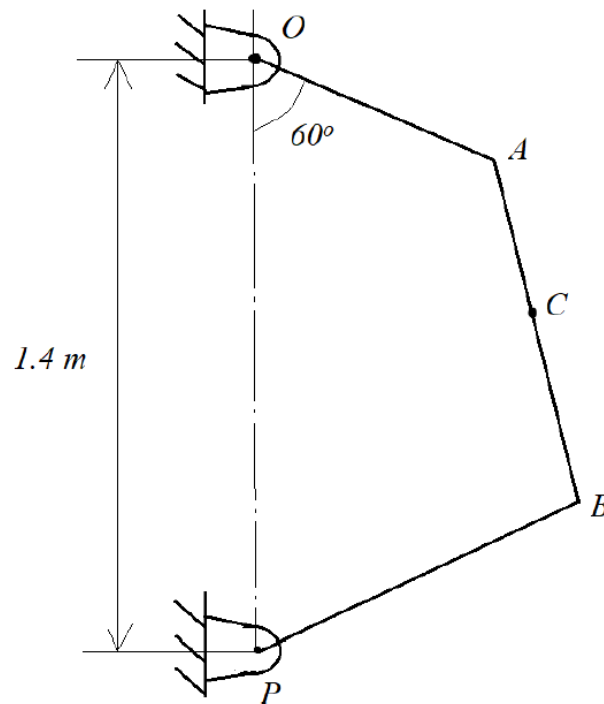


Figure Q2(b)

QUESTION FOUR (20 MARKS)

- a) Find the power transmitted by a belt running over a pulley of 910 mm diameter at 310 rpm. The coefficient of friction between the belt and the pulley is 0.23, angle of lap 152° and maximum tension in the belt is 3600 N. **(10 Marks)**
- b) A chain drive is used for reduction of speed from 320 rpm to 160 rpm. The number of teeth on the driving sprocket is 40. If the pitch circle diameter of the driven sprocket is 950 mm and centre to centre distance between the two sprockets is 1300 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)**

QUESTION FIVE (20 MARKS)

- a)
- (i) Show that the torque on a plate clutch under uniform pressure is given by:
$$T = \frac{2}{3} \mu W \frac{r_1^3 - r_2^3}{r_1 - r_2}$$
 (8 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 250 mm external diameter and a 125 mm internal diameter. Assuming uniform pressure, find the total spring load pressing the plates together to transmit 30 kW at 1600 rev/min. Take $\mu = 0.32$.
(4 Marks)
- b) A single plate clutch, with both sides effective to form two pairs of contact surfaces, has outer and inner diameters 300 mm and 200 mm respectively. The maximum intensity of pressure at any point in the contact surface is not to exceed 100000 N/m^2 . If the coefficient of friction is 0.3, determine the power transmitted by a clutch at a speed 2500 rpm. **(8 Marks)**