higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

25 November 2024 (X-paper)
09:00–12:00

Drawing instruments and non-programmable calculators may be used

This question paper consists of 6 pages and a formula sheet of 3 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
MECHANOTECHNICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

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QUESTION 1: CLUTCHES

1.1 Name THREE types of clutches. (3)

1.2 A cone clutch has an included angle of 30° and transmits 30 kW at 1 100 r/min. The outer diameter of the cone is 200 mm and the inner diameter is 150 mm. The coefficient of friction is 0,28. Assume uniform wear.

Calculate the following:

1.2.1 The torque transmitted by the clutch (2)

1.2.2 The axial force applied to the clutch surface (3)

1.2.3 The force required to engage the clutch (2)
[10]

QUESTION 2: BRAKES

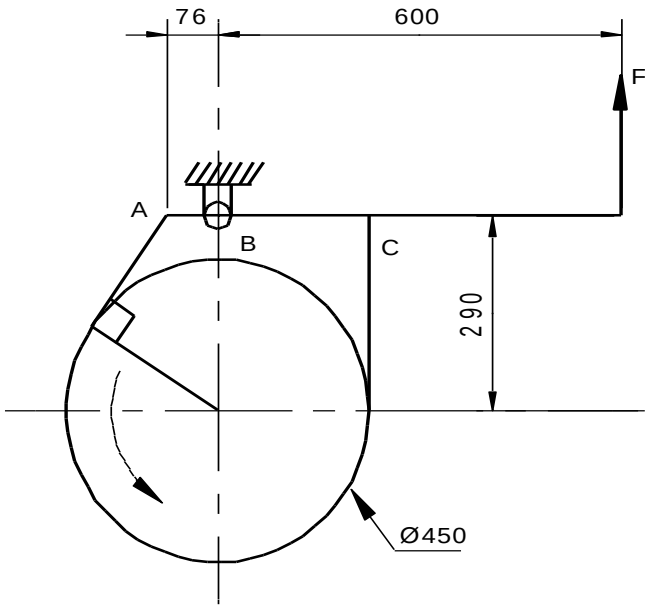


FIGURE 1

FIGURE 1 shows the layout of a band brake used on the brake drum of a hoist. The brake drum has a diameter of 450 mm, and the ends of the band are connected to points A and C on brake lever pivoted at B. The centre of the brake and the drum is 290 mm from B. A force of 250 N is applied to the brake lever, 600 mm from B. The coefficient of friction between the band and the brake is 0,25. Take BC = 22 mm and AB = 76 mm.

Calculate the following:

2.1 The angle of contact between the band and the brake drum (8)

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2.2 The tight side and slack side belt tensions (5)

2.3 The torque applied to the drum, which is rotating in an anti-clockwise direction (2)
[15]

QUESTION 3: LINE SHAFTS

A solid bright steel shaft is supported between two bearings and the centres are 1 m apart. Two pulleys are mounted between the two bearings. The driving pulley has a diameter of 560 mm, is 400 mm from the left-hand bearing and drives a machine by means of a vertical belt drive. The other pulley with a diameter of 320 mm is mounted 320 mm from the right-hand bearing and is driven by means of a horizontal belt drive from an electric motor. Assume an angle of contact of 180° and coefficient of friction of 0,3 for both pulleys. The maximum allowable belt tension on the driving pulley must not exceed 3 kN.

Calculate the following:

3.1 The slack side belt tension on the driving pulley (2)

3.2 The torque transmitted by the driving shaft (2)

3.3 The tight side and slack side belt tensions on the driven pulley (3)

3.4 The vertical reactions on the driving pulley (4)

3.5 The horizontal reactions on the driving pulley (4)
[15]

QUESTION 4: REDUCTION GEARBOXES AND FLYWHEELS

4.1 A worm drive has a worm with a three-start screw thread and a pitch diameter of 40 mm. The worm gear has 35 teeth. The module for the worm and worm-gear is 10 mm. The efficiency of the drive is 80%.

Calculate the following:

4.1.1 The pitch-circle diameter of the worm gear (2)

4.1.2 The centre distance between the shafts (2)

4.1.3 The coefficient of friction between the worm axis and the worm gear (8)

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4.2 A flywheel has a mass of 50 kg and a radius of gyration of 200 mm. The flywheel must be accelerated from 300 r/min to 720 r/min in 8 s. The friction torque is assumed constant at 0,6 N.m.

4.2.1 Calculate the total torque required (3)

4.2.2 Calculate the power at 720 r/min (2)

[17]

QUESTION 5: RAIL TRACTION AND VEHICLE DYNAMICS

5.1 The following data is available for a vehicle:

Height up to centre of gravity	750 mm
Track width	1,2 m
Radius	22 m
Coefficient of friction	0,45

Calculate the following:

5.1.1 The maximum speed without skidding in km/h

5.1.2 The maximum speed without overturning in km/h

(2 × 3) (6)

5.2 Calculate the forces exerted on the front and rear wheels of a vehicle when all four wheels are braked and on the point of skidding. The vehicle has a mass of 1 400 kg. The wheel base is 3 m. The centre of gravity is 1,2 m behind the front wheels and 600 mm above the road surface. Assume a coefficient of friction between the wheels and the road surface of 0,5. (7)

[13]

QUESTION 6: DYNAMIC BALANCING

Two masses of 15 kg and 19 kg respectively are firmly attached to a rotating-face plate of a lathe machine. The 15 kg mass is attached to a radius of 80 mm and 19 kg mass at a radius of 90 mm from the centre, O. The eccentricities of the 15 kg mass and the 19 kg mass are at an angle of 120° to one another.

Determine the distance at which a 20 kg mass must be placed to balance system. **[12]**

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QUESTION 7: KINEMATICS

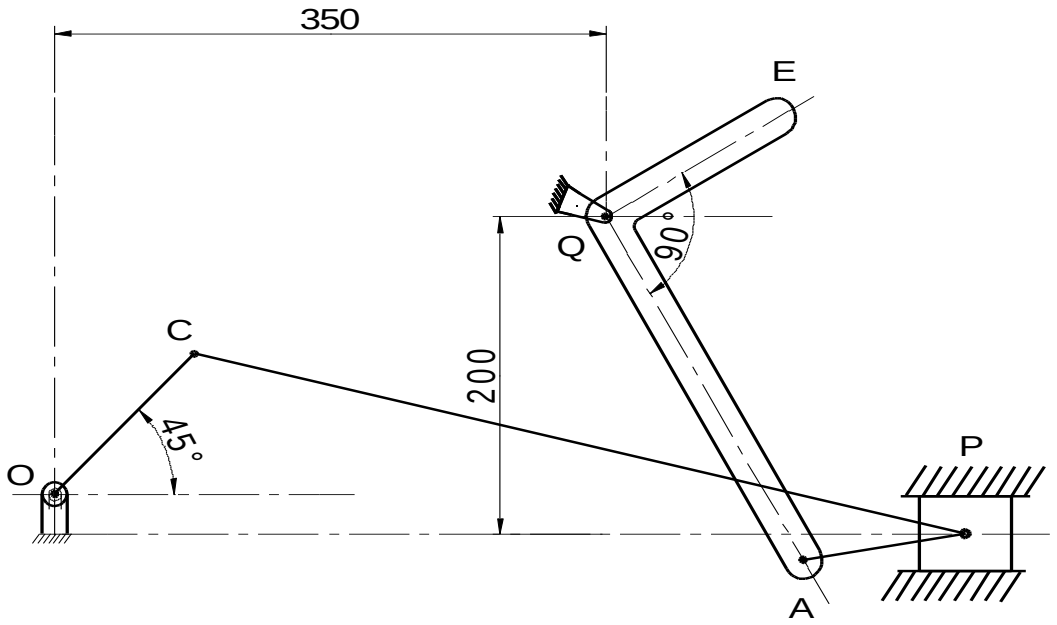


FIGURE 2

In a mechanism shown in FIGURE 2, the various dimensions are: OC = 125 mm; CP = 500 mm: PA = 125 mm: AQ = 250 mm and QE = 125 mm. The slider P moves horizontally along an axis which is 25 mm vertically below point O. The crank OC rotates uniformly at 120 r/min in an anti-clockwise direction. The bell crank lever AQE rocks about fixed centre Q.

7.1 Calculate the velocity of C (2)

7.2 Draw the space diagram (4)

7.3 Draw the velocity diagram (4)

7.4 Calculate the following:

7.4.1 The velocity of A

7.4.2 The centripetal acceleration of C relative to O

7.4.3 The centripetal acceleration of the link CP

7.4.4 The centripetal acceleration of link AQ

(4 × 2) (8)
[18]

TOTAL: 100

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MECHANOTECHNICS N6

FORMULAE

1. $m = \frac{PCD}{T}$
2. $DO = m \times (T + 2)$
3. $C = \frac{m}{2} \times (TA + TB)$
4. $Ke = \frac{1}{2} mv^2$
5. $VR = \frac{TA}{TB}$
6. $VR = \frac{PCD\ of\ gear}{PCD\ of\ pinion}$
7. $VR = \frac{NB}{NA}$
8. $NA \times TA = NB \times TB$
9. $Ft = \frac{2 \times T}{PCD}$
10. $Fr = Ft \times Tan\phi$
11. $Fn = Ft \times Sec\phi$
12. $Ie = IA + (VR)^2\ IB + (VR)^2\ IC + (VR)^2\ ID$
13. $T\forall = Ie \times \forall A$
14. $T\alpha = TA + \frac{(NB)}{(NA)} \frac{TBC}{\eta 1} + \frac{(ND)}{(NA)} \frac{TD}{\eta 1 \eta 2}$
15. $\frac{NB}{NA} = \frac{\omega B}{\omega A} = \frac{\alpha B}{\alpha A} = \frac{IA}{IB}$
16. $T_{OUTPUT} = T_{INPUT} \times GR \times \eta$
17. $P = \frac{\pi \times PCD}{n}$
18. $Ti + To + Th = 0$
19. $TA = TS + 2TP$
20. $\frac{Input\ speed}{Output\ speed} = \frac{Teeth\ on\ driven\ gears}{Teeth\ on\ driving\ gears}$
21. $v = \pi \times (d + t) \times N$
22. $P = Te \times v$
23. $\frac{T1}{T2} = e^{\mu\theta}$
24. $T1 = * \times A$
25. $Tc = m \times v^2$
26. $\frac{T1 - TC}{T2 - TC} = e^{\mu\theta cosec\ \alpha}$
27. $L = \frac{\pi}{2} \times (D + d) + \frac{(D \pm d)^2}{4 \times C} + 2C$
28. $Tg = m \times g \times sin\phi$
29. $v = T \times r$

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30. $v = \sqrt{\mu \times g \times r}$

31. $v = \sqrt{\frac{g \times b \times r}{2 \times h}}$

32. $v = \sqrt{gr\left[\frac{\mu + Tan\,\theta}{1 - \mu Tan\,\theta}\right]}$

33. $v = \sqrt{gr\left[\frac{hTan\theta + b/2}{h - b/2\,tan\,\theta}\right]}$

34. $\frac{T1}{T2} = \left[\frac{1 + \mu Tan\,\theta}{1 - \mu Tan\,\theta}\right]^n$

35. $Cos\,\frac{\theta}{2} = \frac{R - r}{C}$

36. $Cos\,\frac{\phi}{2} = \frac{R + r}{C}$

37. $m = w \times t \times L \times \Delta$

38. $T1 = w \times n \times ft$

39. $P = Pg + P\mu$

40. $t = \frac{I \times \omega}{T}$

41. $P = \frac{2 \times \pi \times N \times T}{60}$

42. $T = F \times r$

43. $w = do + 3d - 1{,}5155P$

44. $do = de + 0{,}65P$

45. $w = \frac{\pi \times m}{2}(cos^2\,\theta)$

46. $h = m\left[1 - \frac{\pi}{4}\left(sin\,\theta\,Cos\theta\right)\right]$

47. $\frac{p1}{Rho} + \frac{(v1)^2}{2} + gh1 = \frac{p2}{Rho} + \frac{(v2)^2}{2} + gh2$

48. $Vw\,(Va) = \sqrt{\frac{gx^2}{2y}}$

49. $v = C\sqrt{mi}$

50. $hf = \frac{4 \times f \times \ell \times v^2}{2 \times g \times d}$

51. $hf = \frac{f \times \ell \times O^2}{3{,}026 \times d^5}$

52. $Q = \frac{Cd \times A \times a \times \sqrt{(2gh)}}{\sqrt{(A^2 - a^2)}}$

53. $Q = Cd \times A \times \frac{\sqrt{(2gh)}}{\sqrt{(m^2 - 1)}}$

54. $V = \sqrt{(g \times R \times Cos\theta)}$

55. $Vol.\ bucket = \frac{m \times s}{\rho \times v}$

56. $L = 2C + \pi D$

57. $Self\text{-}weight = \frac{m1 \times g \times S^2}{8 \times h}$

58. $One\ load = \frac{m2 \times g \times S}{4 \times h}$

59. $T\ (acc\ load) = (T1 - T2)R$

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60. $T\ (acc\ drum) = I \times \alpha = mk^2 \times \frac{a}{R}$

61. $P = T \times T$

62. $T = 2\pi \times N$

63. $Ke = \frac{1}{2} I \times \omega^2$

64. $Ke = \frac{work\ done}{efficiency}$

65. $P = Ke \times operations/sec$

66. $(I_1 + I_2) T_3 = I_1 T_1 + I_2 T_2$

67. $\mu = Tan\ \theta$

68. $\eta = \frac{Tan\ \theta}{Tan\ (\theta + \phi)}$

69. $T = \mu \times F \times Re \times n$

70. $T = \frac{\mu \times F \times Re}{sin\ \theta}$

71. $T = \mu \times n \times (Fc - S)R$

72. $Fc = m \times T^2 \times \gamma$

73. $\mathrm{Fc} = \frac{\mathrm{mv}^2}{\gamma}$

74. *Tractive effort = mass on driving wheels* $\times \mu \times g$

75. $Side\ thrust = FcCos\theta - mg\ Sin\theta$

76. $\mu = \frac{FcCos\theta - mgSin\theta}{mgCos\theta + FcSin\theta}$

77. $P_l = CmgL + mgh$

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