higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

27 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 pages and formula sheet of 3 page.

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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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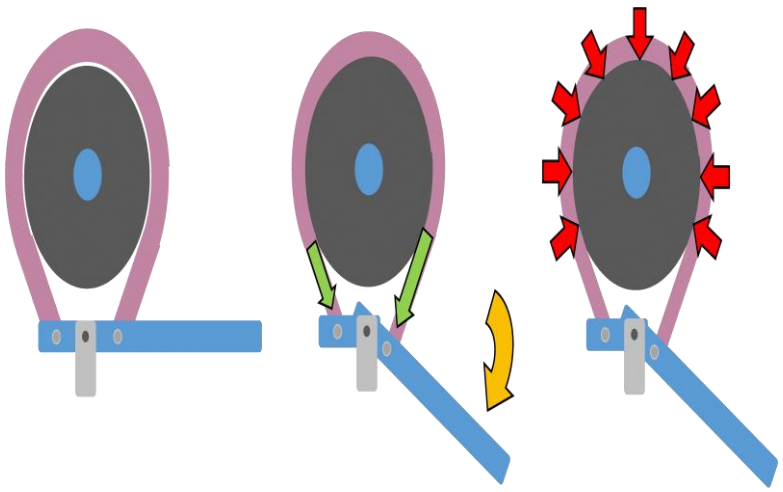
QUESTION 1: CLUTCHES

A flywheel with a mass of 28 kg and a radius of gyration of 210 mm is driven by an electric motor through a conical clutch. The operating speed of the motor is 1 100 r/min and the semi cone angle of the clutch is 19°; the mean diameter of the clutch lining is 220 mm; the coefficient of friction is 0,3; the axial force applied to the clutch is 350 N. Assume uniform wear theory and calculate the following

1.1 The torque required to engage the clutch (3)

1.2 The time taken for the clutch to attain full speed from rest (5)
[8]

QUESTION 2: BRAKES



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The band of a band brake has a contact angle of 210°. It has a tight side tension and slack side tension of 450 N, respectively. The drum rotates at a speed of 200 r/min at 250 W and brakes to a complete stop. The moment of inertia of the drum is 12 kg.m^2.

Calculate the following:

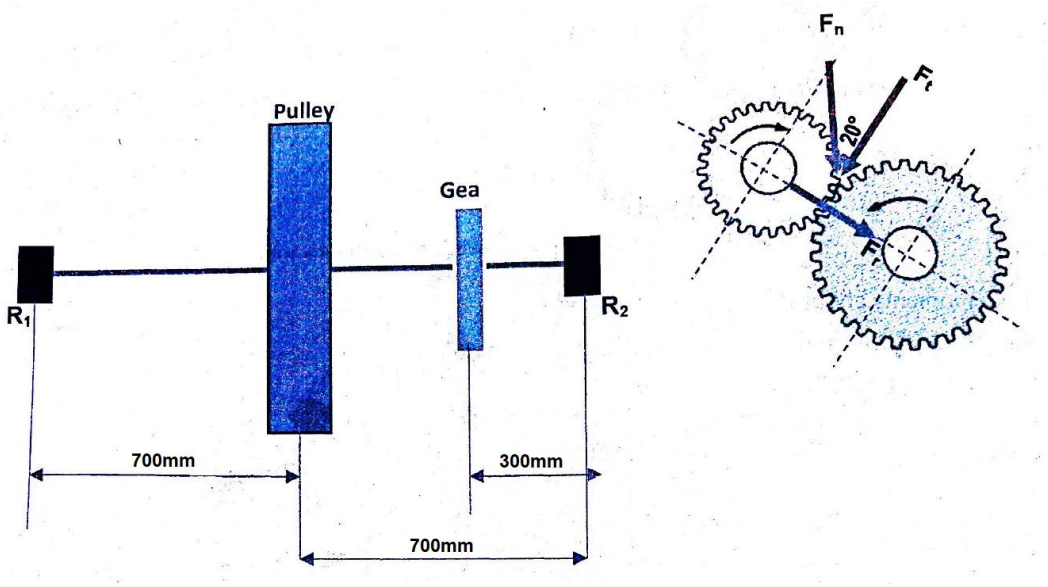
2.1 The coefficient of friction (3)

2.2 The braking time (6)

2.3 The number of revolutions (4)
[13]

QUESTION 3: LINE SHAFTS

A solid shaft transmits 26 kW at 480 r/min. The shaft is supported by two bearings, one at each end of the shaft 1,4 m apart. A pinion with a PCD of 100 mm rotates clockwise at 1 050 r/min and drives a shaft by means of a gear, which is mounted 300 mm from the right-hand bearing and situated above the shaft. The normal pressure acts vertically. A pulley with a diameter of 1 200 mm is mounted directly in the centre of the shaft. This pulley drives a machine horizontally to the shaft. Take the contact to be 170° and the coefficient of friction be 0,23.



Calculate the following:

3.1	The torque transmitted by the pinion	(2)
3.2	The belt tensions T_1 and T_2	(6)
3.3	The tangential force between the gears	(2)
3.4	The radial force between the gears	(2)
3.5	The normal force between the gears	(2)
3.6	The vertical reactions at the bearings	(4)
3.7	The horizontal reactions at the bearings	(5)

[23]

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QUESTION 4: FLYWHEELS

A 10 kW motor drives a flywheel of a punching machine with a stroke length of 45 mm. At the beginning of the punching stroke, the flywheel rotates at 270 r/min. Each punching operation takes 0,7 s and requires 9 kJ of energy. The flywheel assembly has a moment of inertia of 60 kg.m^2. Assume 20% of the energy loss in the machine.

Calculate the following:

4.1 The energy supplied by the motor during the punching operation (3)

4.2 The energy reduction of the flywheel before each punching operation (3)

4.3 The energy of the flywheel before each punching operation (3)

4.4 The rotational frequency of the flywheel after each punching operation (3)

4.5 The maximum number of punching operations that the machine can perform per minute (2)

4.6 The average force exerted by the ram during each punching operation (2)
[16]

QUESTION 5: REDUCTION GEARBOXES

5.1 Name THREE types of reduction gearboxes. (3)

5.2 The following information is available for an electric motor driving the drum of a host through a reduction gearbox.

Pinion A and driven gear B keyed on parallel shafts	
I_A =215 kg.m^2	$I_{B + drum}$ = 500 kg.m^2
N_A = 1 200 r/min	N_B = 420 r/min
D_{drum} = 600 mm	$M_{raised\ by\ drum}$ = 300 kg

Calculate:

5.2.1 The torque required to accelerate gear B from rest to its current speed in 3s (2)

5.2.2 The torque required to accelerate the pinion (2)

5.2.3 The equivalent moment of inertia of the whole system with reference to the pinion (2)

5.2.4 The total kinetic energy of the whole system (2)

5.2.5 The input torque required to accelerate the drum from rest to its speed (2)

[13]

QUESTION 6: RAIL TRACTION AND VEHICLE DYNAMICS

A locomotive travels down an incline. The tractive resistance is 200 kN. The incline resistance is 50 kN when the train travels at a constant speed. During acceleration, the train has a tractive effort of 150 kN, a tractive resistance of 120 kN and an incline resistance of 330 kN. The locomotive has eight driving wheels with radius of 300 mm and the engine has a speed of 1 800 r/min and a gear ratio of 4:1.

Calculate:

6.1 The tractive effort of the locomotive at a constant speed (2)

6.2 The acceleration force when accelerating and when decelerating (4)

6.3 The torque of the driving wheels (3)

6.4 The wheel speed (2)

[11]

QUESTION 7: BALANCING

A casting with a mass of 7 kg is to be machined on a lathe and is fixed to the face plate so that its centre of gravity is 90 mm from the centre of rotation.

Calculate the following:

7.1 The out of balance centrifugal force at an angular velocity of 25 rad/s.

7.2 The radius where a 1,5 kg balance mass must be placed.

7.3 Define the term, *kinematics pair.*

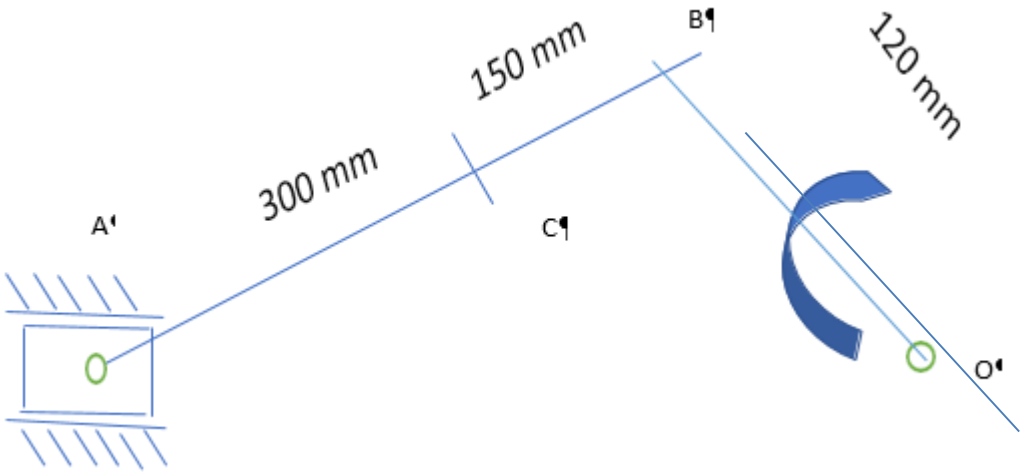
7.4 Provide TWO classifications of kinematics pairs.

(4 × 2) **[8]**

QUESTION 8: KINEMATICS

A part of a mechanism with a sliding block, A, is shown below where AB = 450 mm and OB = 120 mm. The crank OB rotates clockwise at 100 r/min.

Calculate the velocities at point B and C using the instantaneous-centre method from the given position.



[8]

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

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* $= Fc\mathrm{Cos}\,\theta - mg\ \mathrm{Sin}\theta$

76. $\mu = \frac{Fc\mathrm{Cos}\theta - mg\mathrm{Sin}\theta}{mg\mathrm{Cos}\theta + Fc\mathrm{Sin}\theta}$

77. $P_l = CmgL + mgh$

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