higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

30 July 2021 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 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. Start each question on a new page.
5. Only use a black or blue pen.
6. Write neatly and legibly.

QUESTION 1: CLUTCHES

1.1 Differentiate between *uniform wear theory* and *uniform pressure theory.* (2 × 1½) (3)

1.2 220 kW of power is transmitted at 900 r/min by a single-plate clutch with contact surfaces on each side. The coefficient of friction is 0,3 and the outside diameter is 450 mm. Assume uniform surface pressure of 260 kPa.

Determine the following:

1.2.1 Torque per contact surface (3)

1.2.2 Inside diameter (4)

[10]

QUESTION 2: BRAKES

FIGURE 1 below shows a block brake of 400 mm diameter with a torque of 200 N·m being generated at 600 r/min. The coefficient of friction is taken to be 0,3. The block is made of wood and the drum is made of metal.

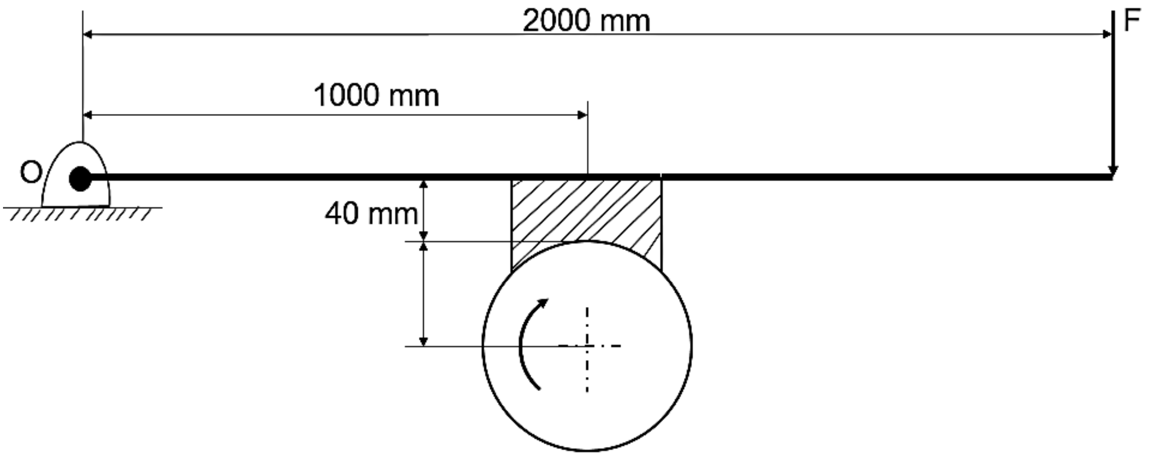

FIGURE 1

Determine the following:

2.1 Reaction force (2)

2.2 Force applicable at the lever (3)

2.3 Power transmitted by the brake (2)

2.4 List any TWO types of brakes other than block brakes. (1)

[8]

QUESTION 3: LINE SHAFTS

A shaft is supported by two bearings at both ends. The distance between the bearings is 200 mm. The shaft is rotating at 300 r/min and transmitting 20 kW of power. A pulley with a diameter of 450 mm and a mass of 95 kg is mounted 50 mm from the right-hand bearing, and this pulley is used in a horizontal belt drive. A flywheel with a mass 150 kg is mounted 20 mm from the left-hand bearing. The angle of contact between the belt and the pulley is 180° and the belt tension ratio is 2,5:1.

Determine the following:

3.1 Tensions T_1 and T_2 in the belt. (3)

3.2 The vertical reaction on the left bearing. (3)
[6]

QUESTION 4: FLYWHEELS

A punching machine has a flywheel with an outside diameter of 1 200 mm, inner diameter of 900 mm and width of 150 mm. The density of the flywheel is 7 500 kg/m^3. The machine performs punching operations and during these operations, the speed of the flywheel drops from 6 r/s to 4,5 r/s.

NOTE: Ignore the moment of inertia of the hub and spokes of the flywheel.

Determine the following:

4.1 The moment of inertia of the flywheel (2)

4.2 The kinetic energy absorbed during the deceleration period of the flywheel (2)

4.3 Motor power required for 25 pressings/min (2)
[6]

QUESTION 5: REDUCTION GEARBOXES

An electric motor drives a reduction gearbox which consists of a worm wheel and a two-start thread worm. The worm has a mean diameter of 80 mm and a pitch of 15 mm. The worm is driven at 1 680 r/min and the end thrust is taken up by a collar of 75 mm diameter. The worm wheel has an output power of 28,5 kW. The coefficient of friction between for the collar and the worm is 0,045.

Calculate the following:

5.1 The efficiency of the worm (4)

5.2 The power transmitted by the worm (1)

5.3 The end thrust on the worm wheel (3)

5.4 The frictional torque on the collar (2)
[10]

QUESTION 6: RAIL TRACTION AND VEHICLE DYNAMICS

6.1 A vehicle with a mass of 3 ton travels round a banked curve at a maximum speed of 31 km/h. The superelevation on the curve is 100 mm, the track width is 1,2 m and the centre of gravity of the vehicle is 800 mm above the road level.

Calculate the following:

6.1.1 The angle θ at which the curve is banked (1)

6.1.2 The radius of the curve in metres (3)

6.1.3 The side thrust between the outer wheel and the track at a speed of 72 km/h (4)

6.2 Explain the meaning of the following terms:

6.2.1 Locomotive tractive effort

6.2.2 Draw bar pull

(2 × 1) (2)

6.3 A vehicle shown in FIGURE 2 below has a wheel base of 3,2 m and its centre of gravity is 720 mm above road level. The centre of gravity is 1,5 m in front of the rear axle. The vehicle travels at a constant speed of 97,2 km/h on a level road. The coefficient of friction between the wheels and the road is 0,35.

NOTE: Neglect load transfer.

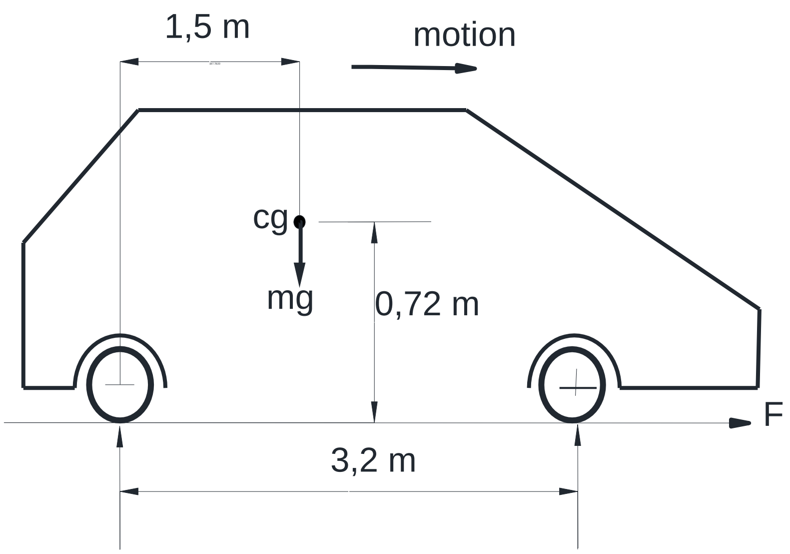

FIGURE 2

Calculate the minimum distance in which the vehicle can be stopped when brakes are applied under the following circumstances:

6.3.1 Only on the front wheels (3)

6.3.2 Only on the rear wheels (3)

6.3.3 On both front and rear wheels (2)

6.3.4 Find the ratio of the front axle reaction (N_F) to the rear axle reaction (N_R) when all four wheels brake [N_F:N_R]. (2)

[20]

QUESTION 7: STATIC AND DYNAMIC BALANCING

Two bodies of masses m_1 = 20 kg and m_2 = 26 kg respectively are attached firmly to a rotating face plate on a lathe. Mass m_1 is attached at a radius of 120 mm and mass m_2 at a radius of 150 mm from centre O of the face plate. The eccentricities of the two masses are at an angle of 150°. Mass m_3 = 30 kg is to be placed on the face plate to balance the two masses.

7.1 Draw a space diagram for the arrangement of the masses. (4)

7.2 Determine the distance and position where m_3 must be placed to balance the system.

NOTE: Use a scale of 1 kg.m = 20 mm. (11)

[15]

QUESTION 8: KINEMATICS

The position shown on the four-bar chain in FIGURE 3 below indicates the angular velocity of 5 rad/s and the angular acceleration of 19 rad/s^2. The lengths of the links are AB = 30 mm; BC = 45 mm; CD = 35 mm and DA = 50 mm.

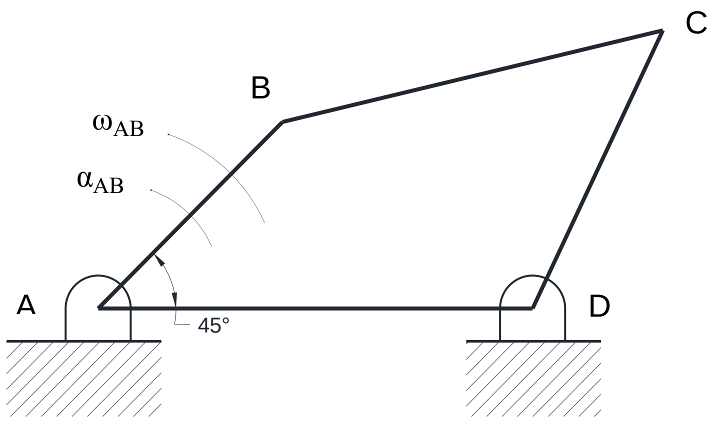

FIGURE 3

8.1 Draw the velocity diagram of the mechanism to determine the angular velocity of links BC and CD.

NOTE: Use a scale of 0,1 m/s:50 mm. (11)

8.2 Draw the acceleration diagram to determine the angular acceleration of links BC and CB.

NOTE: Use a scale of 0,75 m/s^2:75 mm. (14)
[25]

TOTAL: 100

FORMULA SHEET

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. $v = T \times r$

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

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

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

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

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

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

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

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

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

39. $P = Pg + P\mu$

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

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

42. $T = F \times r$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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. $P_l = CmgL + mgh$