higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

9 April 2021 (X-paper)
09:00–12:00

This question paper consists of 5 pages, 2 diagram sheets and a formula sheet of 2 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. Use only a black or blue pen.
6. Write neatly and legibly.

QUESTION 1: BRAKES

FIGURE 1, DIAGRAM SHEET 1 (attached), shows a band brake that is loaded with a known mass at the end of the lever at D. The diameter of the drum transmitting 16,965 kW is 320 mm when rotating at 16,667 r/s in an anticlockwise direction. The coefficient between the band and drum is 0,3. The lever is hinged at B and the band is perpendicular at A. AE = 330 mm, AB = 100 mm, BC = 150 mm and CD = 300 mm.

1.1 Prove that the angle of contact between the band and the drum is 192,6°. (7)

1.2 Calculate the magnitude of the mass required at the end of the lever to stop the drum. (12)

[19]

QUESTION 2: CLUTCHES

A centrifugal clutch has four shoes, each with a mass of 3,6 kg, that slide radially in a spider keyed to the driving shaft. The spring allows contact to be made at 75% of the operating speed. The centre of gravity of each shoe is 150 mm from the centre of the drive shaft. The drum diameter is 350 mm and the coefficient of friction is 0,3.

Calculate the power to be transmitted by the clutch at an operational speed of 600 r/min. **[9]**

QUESTION 3: LINE SHAFTS

FIGURE 2, DIAGRAM SHEET 1 (attached), shows a line shaft that is supported between two bearings that are 1,2 m apart. The line shaft transmits 12 kW when driven by a gear A with a PCD of 240 mm and a rotational speed of 600 r/min. Gear A meshes with gear B with a PCD of 300 mm and mounted at 600 mm from the left bearing. The two gears are meshing at an angle of 30° from the vertical and the pressure angle is 20°. The pulley with an effective diameter of 320 mm overhangs the left-hand bearing by 160 mm. The belts are vertical and parallel. The coefficient of friction between the belt and the pulley is 0,3 and the angle of contact is 180°. Neglect the mass of the pulley.

Calculate:

3.1 The rotational speed of the line shaft (2)

3.2 The torque transmitted by the line shaft (2)

3.3 The normal force of the vertical component (6)

3.4 The tension on the slack and tight sides of the belt (5)

3.5 The vertical reactions on the bearings (4)

[19]

QUESTION 4: FLYWHEELS

A cast-iron flywheel rim with an outside diameter of 400 mm, an inner diameter of 150 mm and a width of 120 mm must absorb 3,98 kJ of energy. The density of the cast-iron material is 7 500 kg/m³. During the absorption of energy, the flywheel accelerated uniformly from rest to an unknown rotational speed in 1,8 seconds. Neglect the moment of inertia of the boss and spoke of the flywheel as too small compared to the rim inertia.

Calculate:

4.1 The moment of inertia of the flywheel (6)

4.2 The uniform acceleration during the absorption of the 3,98 kJ of energy (4)
[10]

QUESTION 5: BALANCING

Four masses, A, B, C and D are mounted on a rotating shaft. The magnitude of the masses and radii are as follows: 8 kg at 120 mm, 10 kg at 100 mm, 7 kg at *r* mm and 9 kg at 90 mm. The axial spacing between AB is equal to CD. The axial spacing between BC is twice the spacing of AB.

Determine each of the following using a suitable scale:

5.1 The angle between A and B as well as between A and D (11)

5.2 The position of the 7 kg mass from the centre of the rotating shaft (6)
[17]

QUESTION 6: DYNAMICS

A locomotive with a mass of 30 tons pulls a train with a mass of 300 tons up a 4% incline at a constant speed of 72 km/h. The rolling resistance on the locomotive and the train is 25 N/ton and 30 N/ton respectively.

Calculate:

6.1 The tractive effort of the locomotive at constant speed (5)

6.2 The tractive effort of the locomotive required to accelerate it from rest to 72 km/s in 1,5 minutes (5)
[10]

QUESTION 7: KINEMATICS

FIGURE 3, DIAGRAM SHEET 2 (attached), shows a mechanism that is driven by a crank OA that is 100 mm in length and turning at 60 r/min clockwise. The connecting rod AB is 300 mm long. When the crank OA is at 30° from the horizontal, D would be the midpoint of AB. Block B slides horizontally and is on the same horizontal plain as O.

7.1 Draw the space diagram. (3)

7.2 Calculate the velocity of the crank OA. (2)

7.3 Draw the velocity diagram at the given position. (5)

7.4 Determine the vertical velocity of DE. (2)

7.5 Calculate the centripetal accelerations of:

7.5.1 The crank OA

7.5.2 The connecting rod AB

(2 × 2) (4)
[16]

TOTAL: 100

DIAGRAM SHEET 1

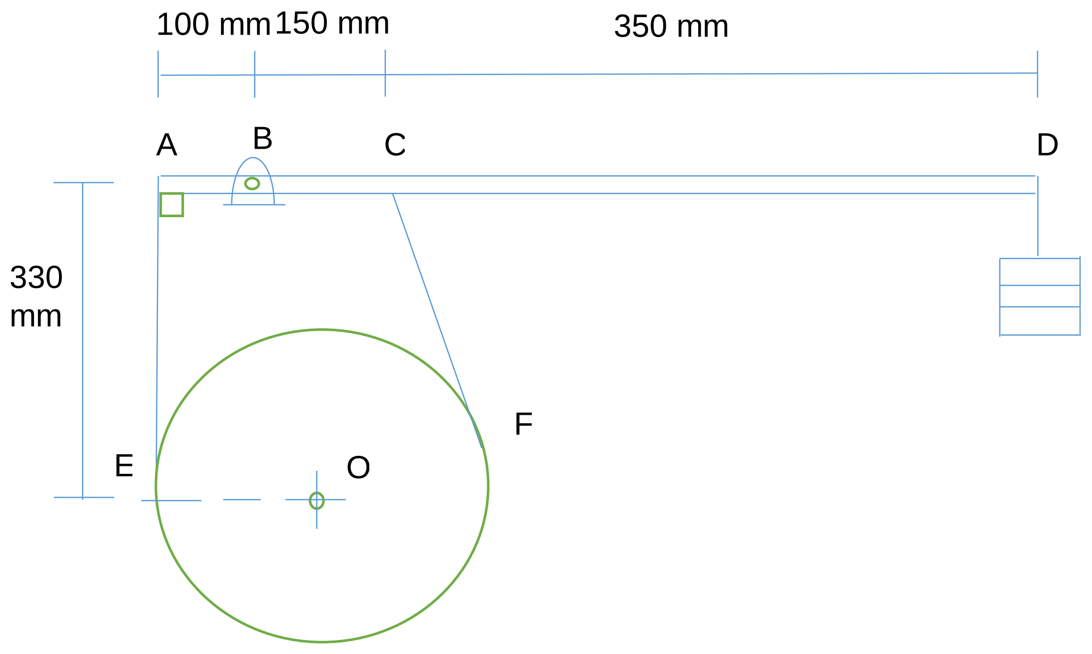

FIGURE 1

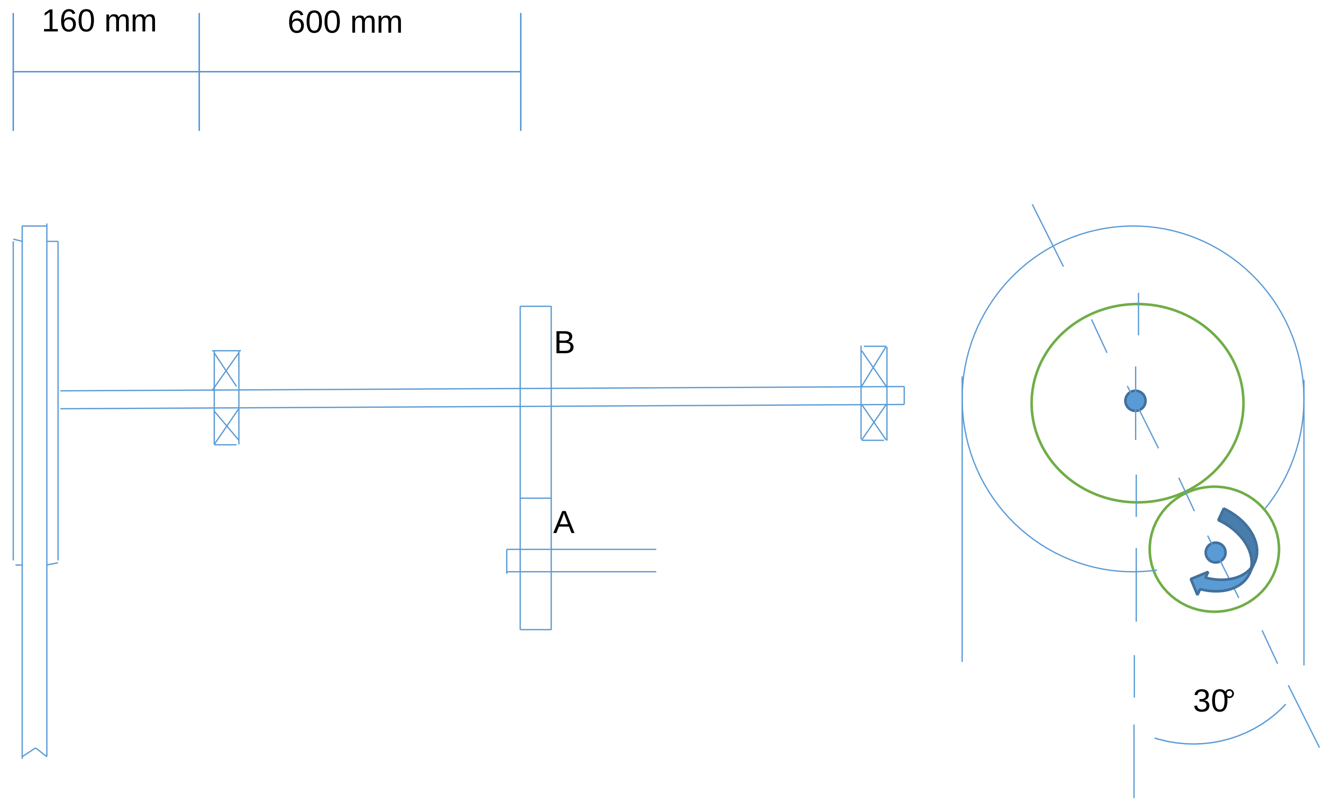

FIGURE 2

DIAGRAM SHEET 2

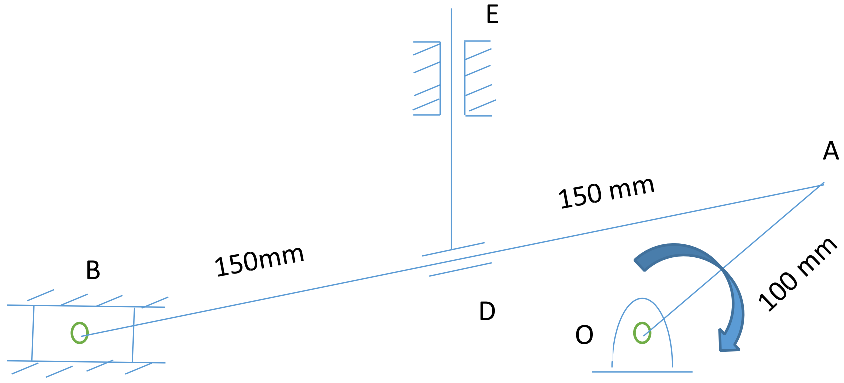

FIGURE 3

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. $Fr = Ft \times \tan \emptyset$

11. $Fn = Ft \times \sec \emptyset$

12. $Ie = IA + (VR)^2 IB + (VR)^2 IC + (VR)^2 ID$

13. $T \propto = Ie \times \alpha A$

14. $T\alpha = TA + \frac{(NB)}{(NA)} \frac{TBC}{\eta 1} + \frac{(ND)}{(NA)} \frac{TD}{\eta 1 \eta 2}$

15. $\frac{NB}{NA} = \frac{wB}{wA} = \frac{\alpha B}{\alpha A} = \frac{IA}{IB}$

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. $T1 = \delta \times A$

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. $Tg = m \times g \times \sin \emptyset$

29. $v = w \times r$

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

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

32. $v = \sqrt{gr[\frac{\mu + \tan\theta}{1 - \mu \tan\theta}]}$

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

34. $\frac{T1}{T2} = [\frac{1 + \mu \tan\theta}{1 - \mu \tan\theta}]^n$

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

36. $\cos\frac{\emptyset}{2} = \frac{R + r}{C}$

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

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

39. $P = Pg + P\mu$

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

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. $h = m[1 - \frac{\pi}{4}(\sin \theta \cos \theta)]$

47. $\frac{P1}{Rho} + \frac{(v1)^2}{2} + gh1 = \frac{P2}{R} + \frac{(v2)^2}{2} + gh2$

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

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

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

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

61. $P = w \times T$

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

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

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

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

66. $(I_1 + I_2)w_3 = I_1 w_1 + I_2 w_2$

67. $\mu = \tan \theta$

68. $\eta = \frac{\tan \theta}{\tan(\theta + \emptyset)}$

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. $Fc = m \times w^2 \times y$

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

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

75. $Side\ thrust = Fc \cos \theta - mg \sin \theta$

76. $\mu = \frac{Fc \cos \theta - mg \sin \theta}{mg \cos \theta + Fc \sin \theta}$

77. $P_l = CmgL + mgh$