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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

30 July 2018 (X-Paper)
09:00–12:00

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

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. Write neatly and legibly.

QUESTION 1

An electric motor drives a machine by means of a single-plate friction clutch which transmits 142 Nm during an engagement. The rotor of the motor has a mass of 22,8 kg and a radius of gyration of 75 mm. The machine has an equivalent mass of 63,5 kg and a radius of gyration of 140 mm. The motor speed is 1 500 r/min and the machine is at rest at the clutch engagement. The clutch plate has a mean diameter of 95 mm and a coefficient of friction of 0,3.

Assume uniform wear and calculate:

1.1 The power the clutch can transmit at 1 500 r/min (2)

1.2 The axial force required to transmit the 142 Nm (3)

1.3 The combined speed after engagement (5)

1.4 The time of slippage (4)

1.5 The loss of energy during the engagement period (3)
[17]

QUESTION 2

A bright steel shaft transmits 25 kW at 510 r/min. The shaft is supported at both ends by bearings, 1,75 m apart. A pinion with a PCD of 100 mm, rotating at 1 200 r/min, drives a spur gear mounted on the shaft, 250 mm from the right-hand bearing. The normal pressure between these gears is horizontal. A pulley for a flat vertical belt drive has a mass of 90 kg and a diameter of 850 mm and is mounted 500 mm from the left-hand bearing. The angle of contact between the belt and the pulley is 180° and the coefficient of friction is 0,27.

Calculate:

2.1 The belt tensions T_1 and T_2 (5)

2.2 The torque transmitted by the shaft (2)

2.3 The torque transmitted by the pinion (1)

2.4 The tangential force between the gears (F_t) (2)

2.5 The normal force between the gears (F_n) (2)

2.6 The reactions at the bearings in the vertical plane (6)
[18]

QUESTION 3

3.1 During a punching operation, the ram of the punching machine exerts an average force of 23 tons over a distance of 30 mm. The mechanical efficiency of the machine is 75%. The flywheel rotates at 296 r/min before the punching stroke and at 248 r/min at the completion of the punching stroke.

Calculate:

3.1.1 The moment of inertia of the flywheel (5)

3.1.2 The power of the motor required if a maximum of 10 punching strokes per minute has to be performed (2)

3.2 A brake consists of a flexible band applied on the outside periphery of a brake drum with a diameter of 400 mm to produce the braking action. The angle of contact between the band and the brake drum is 225° and the coefficient of friction is 0,3. One end of the band is attached to a fixed pin and the other end is subjected to a tension of 250 N.

Calculate the maximum braking torque transmitted by the brake. (6)

[13]

QUESTION 4

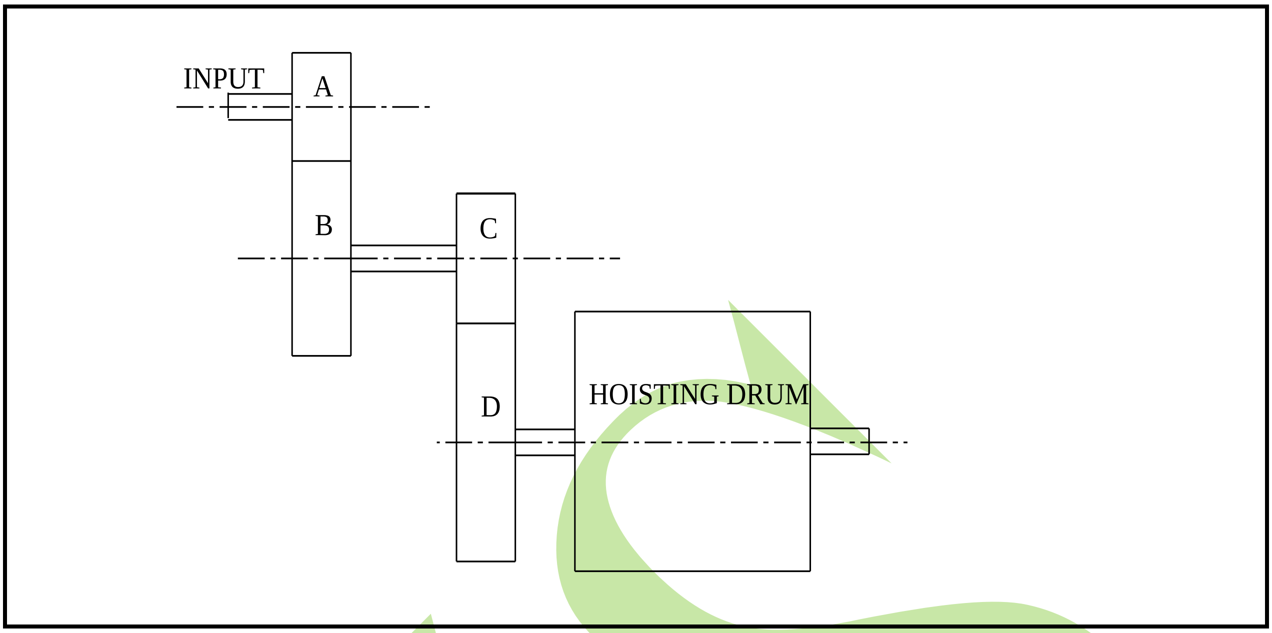

FIGURE 1

The layout of a double reduction gearbox is shown in FIGURE 1.
Gear A is the driving gear with 25 teeth and has a moment of inertia of 0,21 kg.m^2.
Gear B has 52 teeth and a moment of inertia of 0,65 kg.m^2.
Gear C has 30 teeth and a moment of inertia of 0,24 kg.m^2.
Gear D has 55 teeth and a moment of inertia of 0,9 kg.m^2.
The hoisting drum has a mass of 80 kg and a radius of gyration of 200 mm.

Calculate:

4.1 The moment of inertia of the hoisting drum (2)

4.2 The angular acceleration of the hoisting drum if a constant torque of 3,5 Nm is applied on the input shaft and the acceleration is from rest. Disregard all frictional losses. (14)
[16]

QUESTION 5

5.1 The weight of a vehicle is 14 kN. The wheel base is 3 m and the centre of gravity is 650 mm above the road surface. The track width of the vehicle is 1,5 m. The vehicle must negotiate a curve which is banked at 20° with a radius of 130 m. Assume a coefficient of friction between the wheels and the road surface of 0,6.

Determine the maximum speed in km/h at which the vehicle can travel around the curve safely.

(Hint: Compare maximum speed for skidding and overturning.) (6)

5.2 Two masses of 14,5 kg and 17,91 kg respectively are firmly attached to a rotating faceplate on a lathe. The 14,5 kg mass is attached at a radius of 91 mm and 17,91 kg mass at a radius of 101 mm from the centre O. The eccentricities of the 14,5 kg mass and the 17,91 kg mass are at an angle of 120° to one another.

Determine the distance where a 15 kg mass must be placed to balance the system. (12)
[18]

QUESTION 6

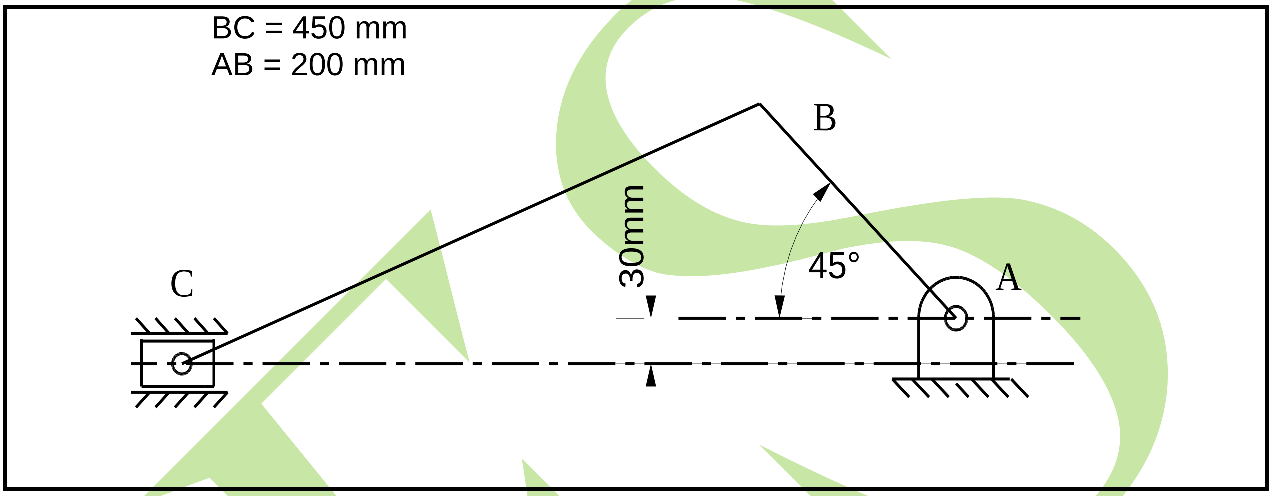

FIGURE 2

In the mechanism shown in FIGURE 2, A and C are fixed points. Crank AB rotates at 150 r/min clockwise. Point C can only move in a horizontal line.

6.1 Draw the space diagram using a scale of 4 mm = 1 mm. (3)

6.2 Calculate the velocity of B. (2)

6.3 Draw the velocity diagram using a scale of 1 mm = 0,04 m/s. (3)

6.4 Calculate:

8.4.1 The linear velocity of C (3)

8.4.2 The angular velocity of link BC in magnitude and direction (3)

8.4.3 The centripetal acceleration of B relative to C (2)

8.4.4 The centripetal acceleration of B relative to C (2)
[18]

TOTAL: 100

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. $v = T \times r$

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

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

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

61. $P = T \times T$

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

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

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

65. $P = Ke \times \text{operations/sec}$

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

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

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

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

77. $P_l = CmgL + mgh$