higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1120(**E**)(A4)T

**NATIONAL CERTIFICATE**

# MECHANOTECHNICS N6

(8190236)

**4 APRIL 2018 (X-Paper)**
**09:00–12:00**

**This question paper consists of 7 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

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**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.

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## QUESTION 1

1.1 A cone clutch used on a farming implement has an included angle of 30° and transmits 25 kW at 1 200 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.

Calculate the following, assuming uniform wear:

1.1.1 Torque transmitted by the clutch (2)

1.1.2 Axial force applied to the clutch surface (3)

1.1.3 Force required to engage the clutch (2)

1.2 FIGURE 1 shows the layout of a band-and-block brake. There are 15 evenly spaced brake blocks, each subtending an angle of 10° at the centre of the brake drum. The brake drum has a diameter of 600 mm. The coefficient of friction between the band and the brake drum is 0,35.

Calculate the force required at the end of the lever to absorb 200 kW at 650 r/min

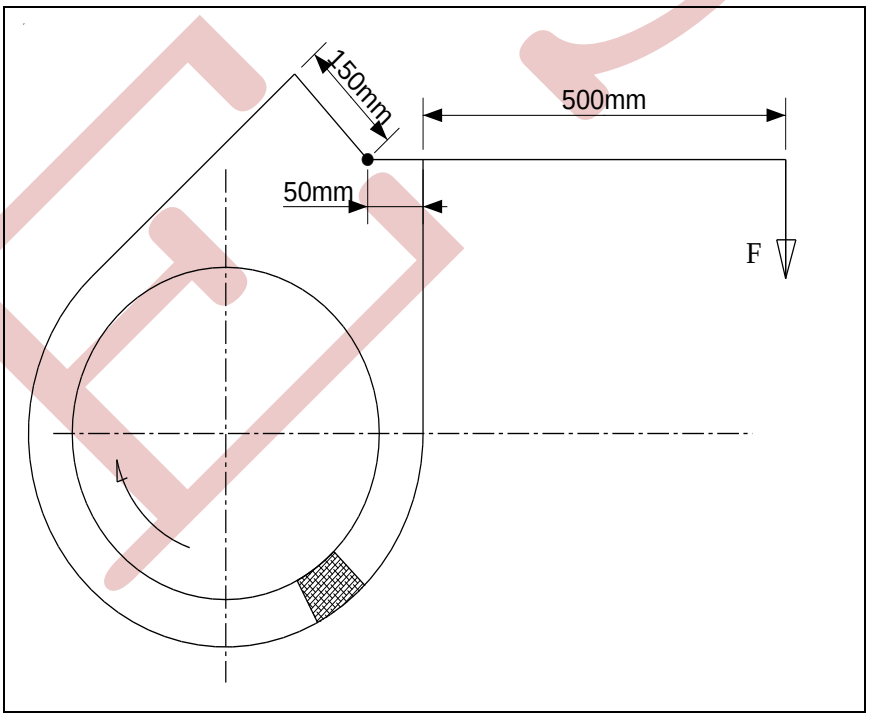


**FIGURE 1**

(10)
**[17]**

## QUESTION 2

2.1 A rotating shaft has four masses, A, B, C and D in that order, rigidly attached to it.

The mass of A is 6 kg at a 30 mm radius
The mass of C is 4 kg at a 40 mm radius
The mass of D is 3 kg at a 35 mm radius
The mass of B is to be placed at a 42 mm radius and is the reference plane.

The angle between A and C is 90° and the planes of revolution of A and B are 400 mm apart and those of B and C are 450 mm apart.

Draw the couple diagram to scale 1 mm = 1 kg.m$^2$ and determine the axial distance between planes C and D. (9)

2.2 A solid shaft is supported by two bearings, one at each end of the shaft. The shaft transmits 35 kW at 600 r/min. A pinion with a pitch-circle diameter of 120 mm rotates clockwise at 1 500 r/min and drives the shaft be means of a gear wheel having a pressure angle of 20°.

A pulley with a diameter of 900 mm drives a machine by means of a vertical flat-belt drive with a contact angle of 180° and a coefficient of friction of 0,25.

Calculate the following:

2.2.1 Belt tensions (4)

2.2.2 Torque transmitted by the shaft (2)

2.2.3 Torque transmitted by the pinion (1)

2.2.4 Normal force between the gears (3)

**[19]**

 

## QUESTION 3

A punching machine is equipped with a cast-iron flywheel. The flywheel has an outer diameter of 900 mm, an inner diameter of 600 mm, a width of 200 mm and a density of 7 300 kg/m$^3$.

The machine performs 12 punching operations per minute. During each punching operation the speed of the flywheel drops from 210 r/min to 132 r/min.

Neglect the moment of inertia of the spokes and the hub and calculate the following:

| | | |
|---|---|---|
| 3.1 | Mass of the flywheel | (3) |
| 3.2 | Moment of inertia of the flywheel | (3) |
| 3.3 | Kinetic energy absorbed during the acceleration period of the flywheel | (4) |
| 3.4 | Torque required to accelerate the flywheel between punching operations if the duration of each operation is 1,2 seconds | (5) |
| 3.5 | Motor power required for 12 punching operations per minute | (2) |

**[17]**

## QUESTION 4

An electric motor drives a hoist through a worm reduction gearbox. The worm has a double start thread with a pitch of 15 mm and a mean diameter of 75 mm. The worm wheel has 40 teeth and a module of 5. The power output on the wheel is 20 kW at 1 200 r/min.

Use a coefficient of friction of 0,03 between the worm and the wheel and calculate the following:

| | | |
|---|---|---|
| 4.1 | Efficiency of the worm drive | (7) |
| 4.2 | Power output of the motor | (2) |
| 4.3 | End thrust on the worm shaft | (6) |

**[15]**

 

## QUESTION 5

A vehicle has a mass of 1,5 tons and a wheel base of 2,8 m with the centre of gravity 800 mm above road level. The centre of gravity is 1,2 m behind the front axle. The vehicle ascends an incline of 20° at uniform speed.

Calculate the following:

5.1 Minimum coefficient of friction between the rear wheels and the road (12)

5.2 Power required by the vehicle to ascend the incline at a speed of 25 km/h and a transmission efficiency of 52% (3)

**[15]**

## QUESTION 6

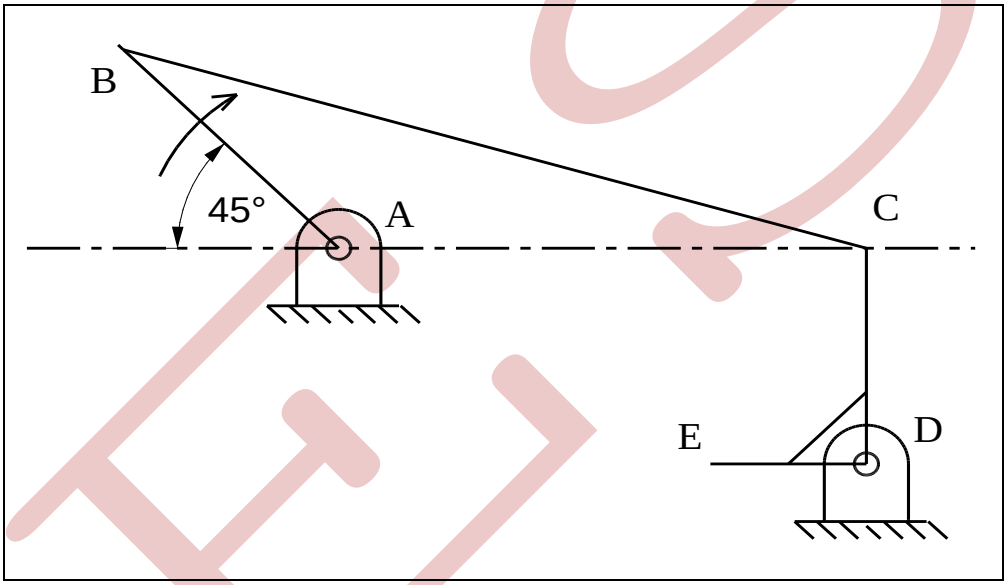


**FIGURE 2**

A and D are fixed points in the mechanism shown in FIGURE 2. When crank AB is at 45° the horizontal point C is on the same horizontal line. Crank AB rotates at 240 r/min in a clockwise direction.

The lengths of the links are as follows:

AB = 100 mm; BC = 300 mm; CD = 100 mm; DE = 50 mm

6.1 Draw the space diagram to scale 4 mm = 1 mm. (3)

6.2 Calculate the velocity of B. (1)

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

 

6.4 Calculate the following:

| | | |
|---|---|---|
| 6.4.1 | Angular velocity of link BC in magnitude and direction | (3) |
| 6.4.2 | Angular velocity of link CD in magnitude and direction | (3) |
| 6.4.3 | Centripetal acceleration of B relative to C | (2) |
| 6.4.4 | Centripetal acceleration of C relative to D | (2) |
| | | **[17]** |

**TOTAL: 100**

**MECHANOTECHNICS N6**

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

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

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

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

61. $P = T \times T$

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

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

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

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

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

67. $\mu = Tan\ \theta$

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

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

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

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

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

74. *Tractive effort = mass on driving wheels × μ × g*

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

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

77. $P_l = CmgL + mgh$