



higher education & training

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NATIONAL CERTIFICATE

MECHANOTECHNICS N6

(8190236)

21 November 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

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

A machine is driven by means of a centrifugal clutch that has four shoes, each with a mass of 2 kg. The stationary tension in each retraction spring is 400 N while the clearance between the shoes and the drum is 3 mm. When the clutch is stationary, the centre of gravity of each shoe is 35 mm from the contact surface of the drum.

The internal diameter of the drum is 270 mm, and the coefficient of friction between the shoes and the drum is 0,28. The spring stiffness is 150 N/mm.

Calculate the following:

1.1 The maximum power that the clutch can transmit at 1 200 r/min (8)

1.2 The maximum power that the clutch can transmit at 1 200 r/min if the drum diameter increases to 275 mm because of wear. The spring stiffness remains unaltered. (8)

[16]

QUESTION 2

Study the layout of a line shaft in FIGURE 1 below and answer the questions.

The shaft in FIGURE 1 is driven by means of a pinion which transmits 40 kW at 900 r/min. The pinion, which has a pitch-circle diameter of 160 mm, is mounted 250 mm from the right-hand bearing and drives a gear with a pitch-circle diameter of 350 mm. The gears have a pressure angle of 20° . Pulley A, 150 mm from the left-hand bearing, has a weight of 1 kN and a diameter of 450 mm. The coefficient of friction between the belt and the pulley is 0,3 and the angle of contact is 180° .

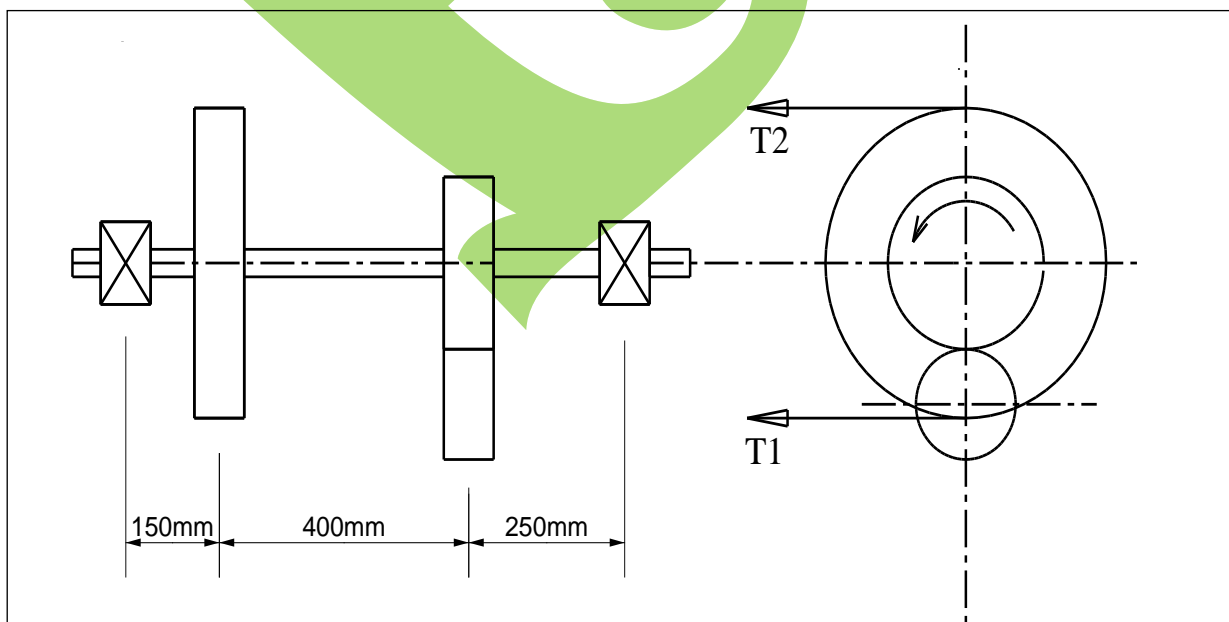


FIGURE 1

Calculate the following:

- 2.1 The torque transmitted by the pinion (2)
- 2.2 The torque transmitted by the shaft (2)
- 2.3 The tangential force between the gears (1)
- 2.4 The radial force between the gears (1)
- 2.5 The belt tensions T_1 and T_2 (3)
- 2.6 The reactions at the bearings in the vertical plane (4)
- 2.7 The reactions at the bearings in the horizontal plane (4)
- [17]

QUESTION 3

Study the flywheel in FIGURE 2 below and answer the questions.

The flywheel has SIX elliptically shaped spokes and is keyed to a shaft with a diameter of 100 mm and a length of 1 m. Assume the density of the flywheel material is $7\,200\text{ kg/m}^3$.

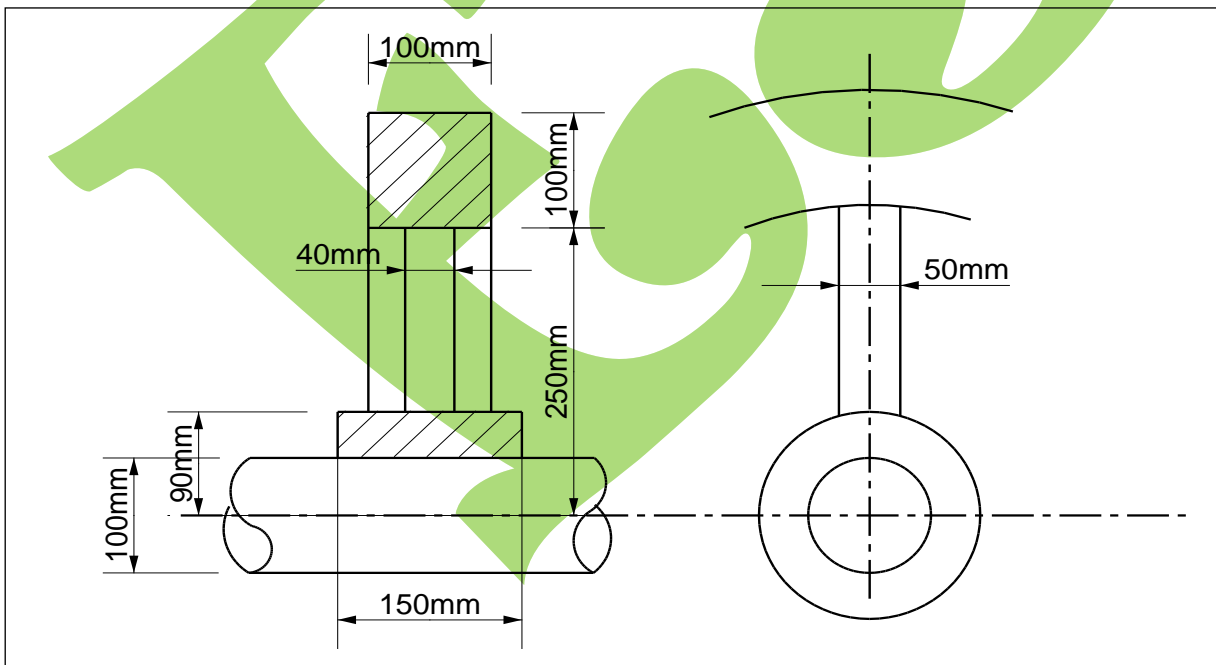


FIGURE 2

Calculate the following:

- 3.1 The moment of inertia of the flywheel and shaft assembly around the axis of rotation (15)
- 3.2 The radius of gyration of the whole system (2)
- [17]

QUESTION 4

- 4.1 The winding drum of a crane has an effective diameter of 460 mm. A brake drum with a diameter of 1,2 m is attached to it. The contact angle of the brake band is 270° , and the coefficient of friction between the band and the drum is 0,3. The maximum allowable tension in the band is 15 kN.

Calculate the following:

- 4.1.1 The angle of contact between the band and the brake drum (3)
- 4.1.2 The tension in the tight side and slack side (3)
- 4.2 A train has 12 trucks, each with a mass of 28 tonnes. The train is hauled up an incline of 1 in 80 at a constant speed of 42 km/h. The locomotive and trucks maintain a constant speed as they move around a curve, up the incline. At this speed, the rolling resistance of the locomotive is 60 N/ton, and the curve resistance is 80 N/ton of the mass of the locomotive.

The rolling resistance of the trucks is 24 N/ton, and the curve resistance is 50 N/ton of the mass of the trucks. 70% of the mass of the locomotive is carried on the driving wheels, and the coefficient of friction between the wheels of the locomotive and the rails is 0,26.

Calculate the number of drive axles if the load per drive axle is 8 tonnes.

(11)
[17]

QUESTION 5

Study the rotating shaft in FIGURE 3 below and answer the questions.

The shaft carries four masses, A, B, C and D, which are rigidly attached to it. The mass centres are at 130 mm, 110 mm, 160 mm and 210 mm respectively from the axes of rotation. The axial distance between the masses is 450 mm. Masses B, C and D are 12 kg, 6 kg and 3 kg respectively.

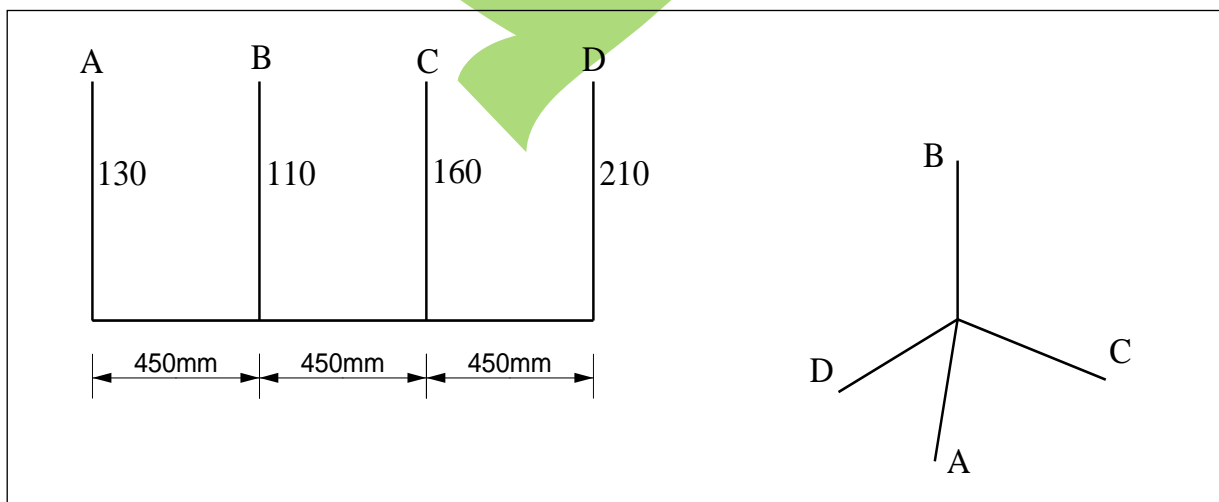


FIGURE 3

- 5.1 Choose plane A as reference plane. Use the given data to compile the required table and draw the couple polygon to scale $5 \text{ mm} = 0,1 \text{ kg.m}^2$ (6)
- 5.2 Draw a force diagram. (3)
- 5.3 Calculate the minimum value of mass A. (4)
- 5.4 Use the end view to indicate the relative angular positions of the centre of the masses A and D to ensure complete dynamic balance of the rotating shaft. Indicate the angular positions of the masses with respect to mass B. (4)
- [17]**

QUESTION 6

Study the instantaneous configuration of a slider-crank mechanism in FIGURE 4 below and answer the questions.

The crank AB rotates clockwise at 120 r/min about the fixed centre A. The slide block E is driven by link DE, which is attached at midpoint D to the connection rod BC. The slide block C reciprocates horizontally, and the slide Block E reciprocates vertically. For the given position, link AB makes a 30° angle with the horizontal.

AB = 90 mm ; BC = 200 mm ; DE = 185 mm

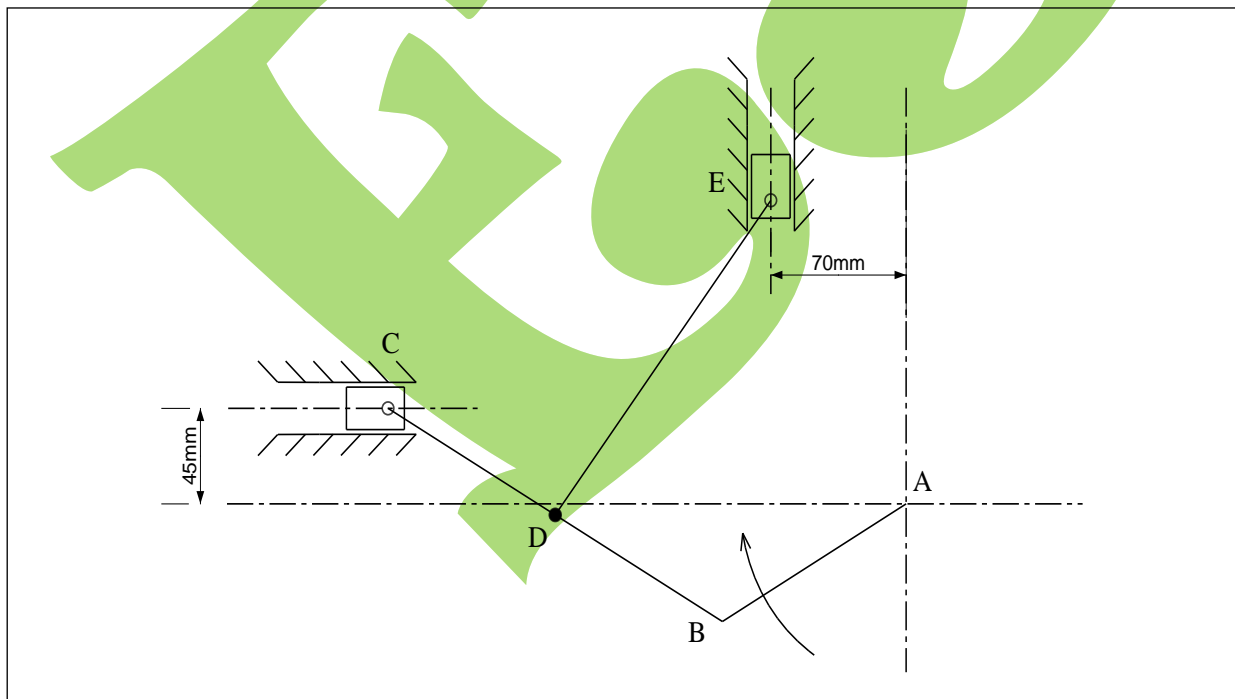


FIGURE 4

- 6.1 Draw the space diagram using a scale of $5 \text{ mm} = 1 \text{ mm}$. (3)
- 6.2 Calculate the velocity of B relative to A. (2)
- 6.3 Draw the velocity diagram to scale $25 \text{ m/s} = 1 \text{ cm}$. (3)

6.4 Calculate the following:

6.4.1 The angular velocity of crank AB

6.4.2 The velocity of C relative to B

6.4.3 The velocity of E relative to D

6.4.4 The centripetal acceleration of B relative to A

(4 x 2) (8)

[16]

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. $VR = \frac{PCD \text{ of gear}}{PCD \text{ of pinion}}$

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. $F_n = F_t \times \sec \phi$

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

13. $T \forall = I_e \times \forall A$

14. $T\alpha = TA + \frac{(NB) TBC}{(NA) \eta_1} + \frac{(ND) TD}{(NA) \eta_1 \eta_2}$

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. $T_i + T_o + T_h = 0$

19. $TA = TS + 2TP$

20. $\frac{\text{Input speed}}{\text{Output speed}} = \frac{\text{Teeth on driven gears}}{\text{Teeth on driving gears}}$

21. $v = \pi \times (d + t) \times N$

22. $P = Te \times v$

23. $\frac{T_1}{T_2} = e^{\mu\theta}$

24. $Tl = * \times A$

25. $Tc = m \times v^2$

26. $\frac{T_1 - TC}{T_2 - TC} = e^{\mu\theta \csc \alpha}$

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. $v = T \times r$

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

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

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

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

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

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

$$42. T = F \times r$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$$39. P = Pg + P\mu$$

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

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

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

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

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

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

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

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

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

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

$$61. P = T \times T$$

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

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

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

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

$$66. (I_1 + I_2)T_3 = I_1T_1 + I_2T_2$$

$$67. \mu = \tan \theta$$

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

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

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

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

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

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

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

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

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

$$77. P_1 = CmgL + mgh$$