



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
MECHANOTECHNICS N4

(8190194)

23 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

070Q1E2323

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
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MECHANOTECHNICS N4
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. Use only a blue or black pen.
 5. Write neatly and legibly.
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QUESTION 1

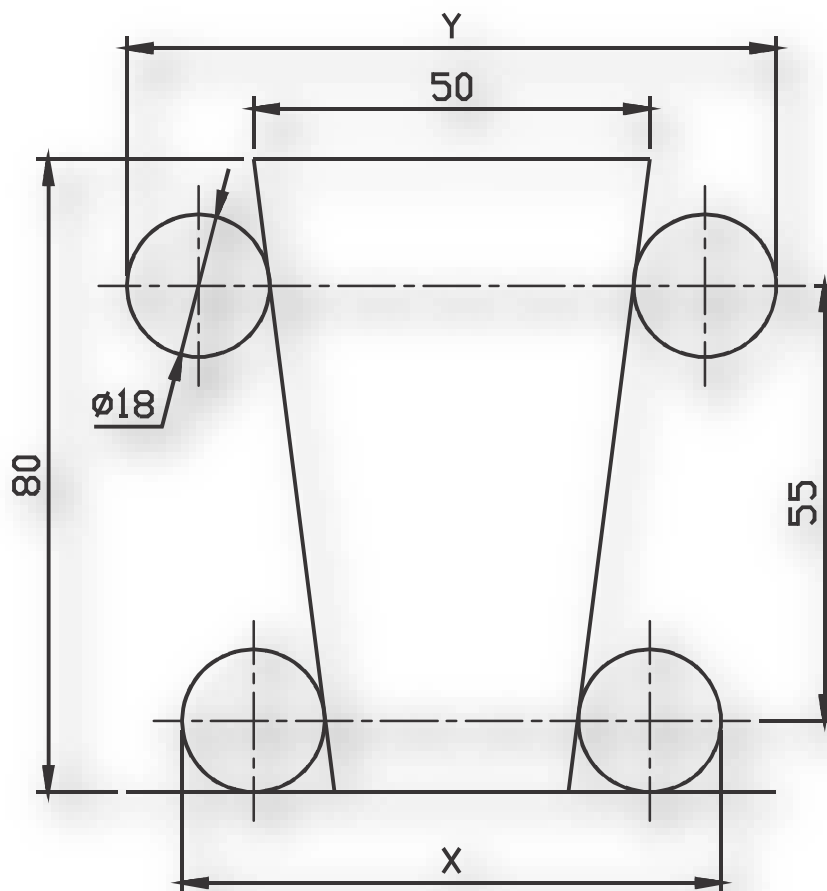
- 1.1 Give FIVE characteristics of batch production. (5)
- 1.2 Name FIVE advantages of airless spray painting. (5)
- 1.3 Make a neat labelled sketch of a needle feed lubricator. (5)

[15]

**QUESTION 2**

FIGURE 1 below shows a taper of 1-in-5 on the diameter that must be tested for correctness by using 18-mm diameter rollers. The centre distance between the top and bottom rollers is 55 mm. The taper is 80 mm long. The top diameter of the taper is 50 mm.

Calculate from a neat construction the distance across the top and bottom rollers.

**FIGURE 1**

[15]



QUESTION 3

An epicyclic gear train shown in FIGURE 2 below consists of annulus A having 60 teeth, sun gear B that is connected to the output shaft having 16 teeth and rotates at 120 r/min in a clockwise direction, and planetary gear D having 20 teeth and gear C having 24 teeth mounted on the same axis.

3.1 If arm E is fixed, calculate the speed and direction of annulus A. (8)

3.2 Determine the speed and direction of arm E, assuming that annulus A is fixed. (7)

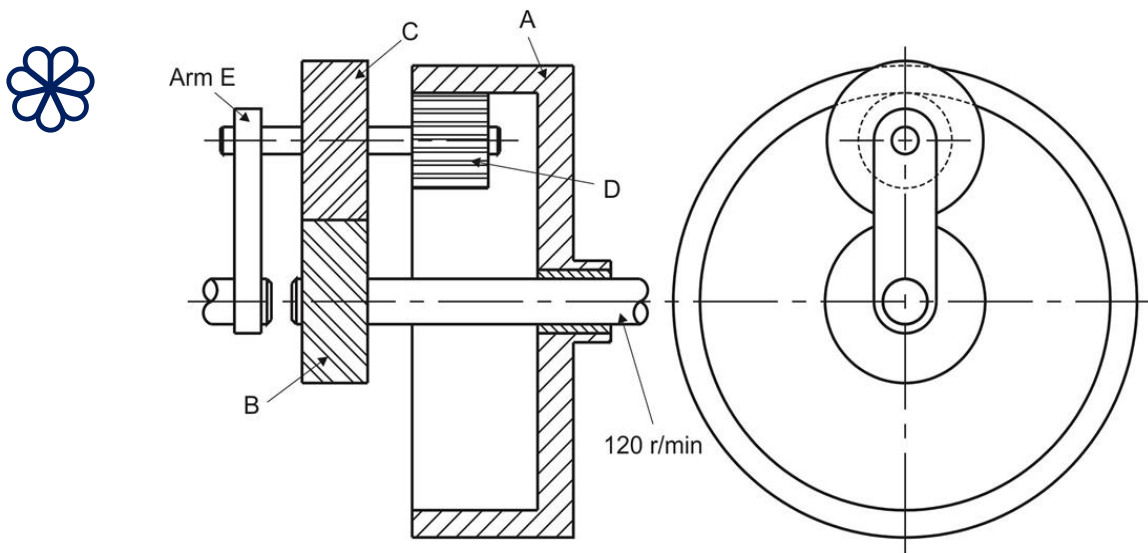


FIGURE 2

[15]

QUESTION 4

A belt drive consists of three V-belts on grooved pulleys of 40° . The cross-sectional area of each belt is 300 mm^2 and the maximum tensile stress induced in the belt may not exceed 7 MPa. The coefficient of friction between the pulley and the belt is 0,2. Each belt pulley is 400 mm in diameter and rotates at 300 r/min.

Calculate the power that can be transmitted by each belt if the contact angle between the pulley and the belt is 180° . [5]

QUESTION 5

- 5.1 A pipeline conveying water is equipped with a Venturi meter with the following specifications:

Diameter of water pipes	=	80 mm
Throat diameter of Venturi meter	=	30 mm
Mercury reading in manometer	=	25 mm
Coefficient of delivery	=	0,95 mm



Calculate the delivery of the pipeline in litres per hour.

(7)

- 5.2 Determine the coefficient of discharge (C_d) for an orifice of diameter 60 mm in the inside of a tank containing water under a constant head of 4 m. The actual discharge of water from the orifice is 54 000 litres per hour.

(5)

- 5.3 Water with a density of 1 000 kg/m³ flows through a tapered pipe, which has a large diameter of 400 mm and a small diameter of 200 mm. The pressure on the pressure gauge at the small diameter of the pipe is 16 kPa and the velocity of flow at the small diameter is 20 m/s.

Find the pressure at the large diameter of the pipe.

(8)

[20]

**QUESTION 6**

- 6.1 Name FOUR mean fluctuating loads in bearings.

(4)

- 6.2 Calculate the tensile force on each bearing if a single V-belt drive transmits 140 kW at 1 500 m/min and the belt tension is ($T_1 = 15T_2$).

(7)

HINT: Total tensile force on each bearing = $\frac{T_1 + T_2}{2}$



- 6.3 A deep groove ball bearing has a radial load of 4 500 N applied to it. The rotational speed of the bearing is 1 200 r/m. The basic dynamic load rating obtained from the bearing manufacturer's table is 48,2 kN. The dynamic equivalent bearing load is 4 500 N.

Calculate the expected service life of the bearing in hours.

(4)

[15]



QUESTION 7

- 7.1 A shaft with diameter 80 mm rotates at 400 r/min within a bearing. The coefficient of friction between the contact surfaces is 0,04. The radial force exerted by the shaft on the bearing is 30 kN, which results in a frictional loss.



Calculate the following:

- 7.1.1 The circumferential speed in m/s (v) (3)
- 7.1.2 The frictional force (2)
- 7.1.3 The power loss due to friction (2)

- 7.2 Calculate the power consumed by the following:



- 7.2.1 A shaper operation in which the cutting force by 850 N and a stroke length of 150 mm takes 6 s to complete (4)
- 7.2.2 A lathe operation in which the cutting force applied to the tool is 750 N and the rotational speed of the workpiece with a diameter of 300 mm is 250 r/min (4)

[15]

TOTAL: 100



MECHANOTECHNICS N4**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. $VR = \frac{PCD \text{ of gear}}{PCD \text{ of pinion}}$
7. $VR = \frac{NB}{NA}$
8. $NA \times TA = NB \times TB$
9. $F_t = \frac{2 \times T}{PCD}$
10. $F_r = F_t \times \tan \phi$
11. $F_n = F_t \times \sec \phi$
12. $l_e = IA + (VR)^2 IB + (VR)^2 IC + (VR)^2 ID$
13. $T\alpha = l_e \times \alpha A$
14. $T\alpha = TA + \frac{(NB)}{(NA)} \frac{TBC}{\eta_1} + \frac{(ND)}{(NA)} \frac{TD}{\eta_1 \eta_2}$
15. $\frac{NB}{NA} = \frac{\omega_B}{\omega_A} = \frac{\alpha_B}{\alpha_A} = \frac{IA}{IB}$
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. $P = T_e \times v$
23. $\frac{T_1}{T_2} = e^{\mu\theta}$
24. $T_1 = \delta \times A$
25. $T_c = m \times v^2$
26. $\frac{T_1 - TC}{T_2 - TC} = e^{\mu\theta \csc \alpha}$
27. $L = \frac{\pi}{2} \times (D + d) + \frac{(D \pm d)^2}{4 \times C} + 2C$

$$28. Tg = m \times g \times \sin \phi$$

$$29. v = T \times r$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$77. P_l = CmgL + mgh$$

$$78. P_r = X.F_r + Y.F_a$$

$$79. L_0 = \left(\frac{1 \times 10^6}{60 \times n} \right) \times \left(\frac{C_r}{P_r} \right)^p$$

$$80. L_0 = \left(\frac{C_r}{P_r} \right)^p$$

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

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

$$66. (I_1 + I_2)\omega_3 = I_1\omega_1 + I_2\omega_2$$

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

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

$$72. Fc = m \times \omega^2 \times \frac{\gamma}{7}$$