



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE MECHANOTECHNICS N6

(8190236)

**7 February 2022 (X-paper)
09:00–12:00**

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 3 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

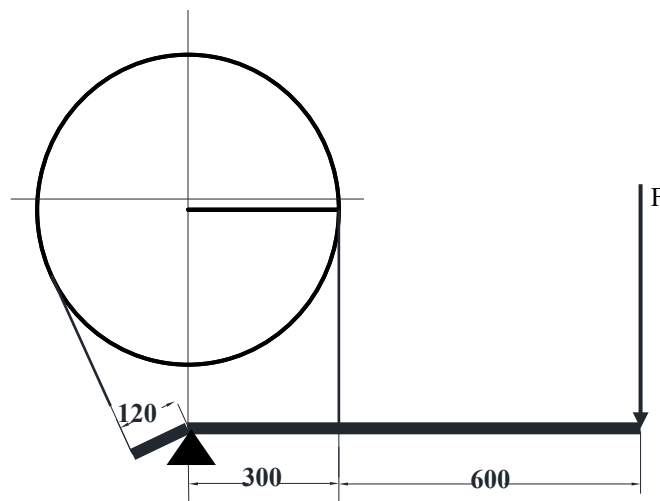
1. Answer all the questions.
 2. Read all the questions carefully.
 3. Number the answers according to the numbering system used in this question paper.
 4. Diagrams and drawings should be large, neat and may be done in pencil.
 5. Only use a black or blue pen for the questions and calculations.
 6. Write neatly and legibly.
-

QUESTION 1: CLUTCHES

- 1.1 Make a clear and neat drawing of a centrifugal clutch, sectional side view or front view, and label any THREE parts. * (3)
- 1.2 A conical clutch transmits 240 N.m at 1 240 r/min. The outside diameter of the clutch is 400 mm and the included cone angle is 24° . The clutch surface width is 64 mm and the coefficient of friction is 0,25. Assume uniform pressure. *
Calculate the following:
- 1.2.1 The axial force required to transmit 240 N.m (5)
- 1.2.2 The maximum pressure at the inner radius of the cone (2)
- [10]**

QUESTION 2: BRAKES

FIGURE 1 (below) shows a configuration of a band brake. A mass of 50 kg is attached at the end of the beam. The coefficient of friction is 0,3 and the angle of contact is 205° , the drum diameter is 600 mm. The drum rotates at 120 r/min. *

**FIGURE 1**

Determine the following: *

- 2.1 The tension on the band if the drum rotates clockwise (4)
- 2.2 The torque if the drum rotates clockwise (2)
- 2.3 The power generated (2)
- [8]**

QUESTION 3: LINE SHAFT

A shaft transmitting 27,5 kW rotates at 450 r/min. This shaft is supported at both ends by bearings 2 m apart. A spur gear mounted on the shaft 0,4 m from the right-hand side bearing is driven by a pinion with a PCD of 110 mm rotating at 1 220 r/min clockwise. The two gears engage at 30°.

Determine the following:



- 3.1 The tangential force (2)
- 3.2 Radial force between the gears (1)
- 3.3 The vertical reactions 

NOTE: A diagram may be drawn to assist with calculations.

(3)
[6]

QUESTION 4: FLYWHEELS

An electric motor is rotating at a speed of 750 r/min. The speed drops to 500 r/min in 1,2 s when a load is added. The moment of inertia of the flywheel attached the motor is 12 kg.m².



Determine the following:

- 4.1 The angular deceleration in rad/s^2
- 4.2 Angular displacement of the motor in rad 
- 4.3 The kinetic energy dissipated

(3 × 2)

[6]

QUESTION 5: REDUCTION GEARBOXES

- 5.1 FIGURE 2 (below) shows a compound gear train. There are two driving gears and two driven gears. Gear A has 20 teeth and rotates at 120 r/min. It is mounted on the driving shaft and is coupled to a motor with a power of 25 kW. Gear B has 30 teeth, gear C has 25 teeth and gear D has 35 teeth.

Determine the following:



5.1.1 The speed of the output shaft

5.1.2 Velocity ratio

5.1.3 Input torque



(3 × 2)

(6)

- 5.2 State FOUR functions of the reduction gearbox.

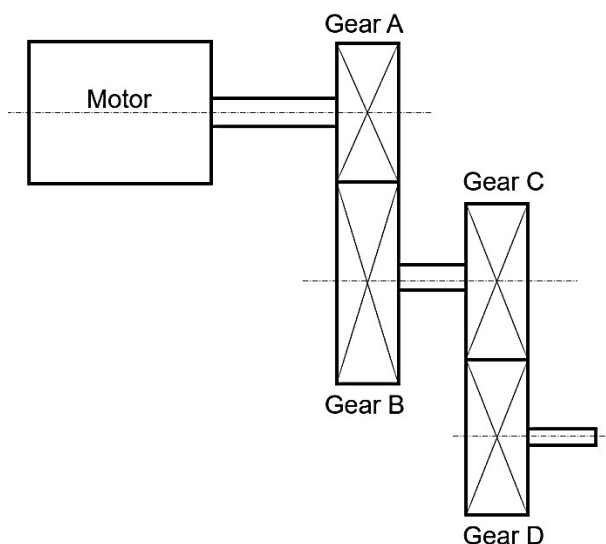


FIGURE 2

(4 × 1)

(4)

[10]

QUESTION 6: RAIL TRACTION AND VEHICLE DYNAMICS

- 6.1 A locomotive travels around an unbanked curve with a radius of 120 m. The centre of gravity of the locomotive is 900 mm above the rail surface which has a rail gauge of 1,2 m. Assume a coefficient of friction of 0,6 between the rails and the wheels.



Calculate the maximum speed in both m/s and km/h, at which the locomotive can travel around the curve:

6.1.1 Without skidding

6.1.2 Without overturning, assuming the friction is sufficient to prevent skidding



(6)

6.2 The same curve is now banked at an angle of 15° to the horizontal.

Calculate the maximum speed in both m/s and km/h, at which the locomotive can now travel around the curve:



6.2.1 Without skidding

6.2.2 Without overturning, assuming the friction is sufficient to prevent skidding

(2 × 4)

(8)

6.3 The following information applies to a diesel locomotive pulling a train:

Mass of the locomotive		:	20 t (ton)
Mass of the train		:	80 t
Percentage mass carried on the driving wheels		:	80%
Coefficient of friction between the driving wheels and rails		:	0,3
Total resistance		:	200 kN
Maximum incline		:	1 in 85

Determine the following:

6.3.1 The drawbar pull on the locomotive

6.3.2 The available acceleration force



6.3.3 The acceleration of the locomotive and the train

(3 × 2)

(6)

[20]

QUESTION 7: STATIC AND DYNAMIC BALANCING

Three discs, A, B and C are attached to a shaft. Discs B and C are 1,8 m and 2,7 m from A respectively. The eccentricities of A and C are at 90° to each other. The discs are out of balance to the extent of 0,05 kg.m, 0,078 kg.m and 0,06 kg.m respectively and these are keyed to the shaft so as to give static balance. The shaft is supported at bearings D and E, which are 2 m apart. Use the scale of 1 mm:0,005 kg.m for the force diagram and 1 mm:0,002 kg/m² for the couple diagram.



NOTE: A table and diagrams can be drawn to assist with calculations.

Determine the following:

7.1 The relative angular positions of the radii which define the imbalance

(9)

7.2 The dynamic load on the bearings when the shaft rotates at 500 r/min

(6)

[15]

QUESTION 8: KINEMATICS

The link AB in FIGURE 3 (below) is 650 mm long and is of uniform cross section. It has its ends joined with pins to the blocks which slide within the guides as indicated. For the instance given $OB = 410$ mm. A approaches O at a velocity of 8 m/s and a retardation of 150 m/s^2 . Use a scale of 1 : 10 to draw the space diagram.

NOTE: Use $1 \text{ mm} = 3 \text{ m/s}^2$ to draw the acceleration diagram.

Determine the following:

- | | | |
|-----|--------------------------------|------|
| 8.1 | The velocity of B | (15) |
| 8.2 | The angular velocity of AB | (2) |
| 8.3 | The acceleration of B | (4) |
| 8.4 | The angular acceleration of AB | (4) |

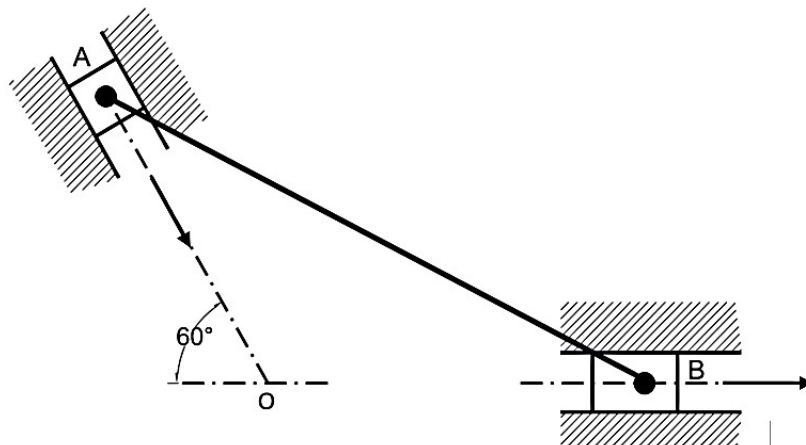


FIGURE 3

[25]

TOTAL: 100

FORMULA SHEET

$$1. \quad m = \frac{PCD}{T}$$

$$2. \quad DO = m \times (T + 2)$$

$$3. \quad C = \frac{m}{2} \times (TA + TB)$$

$$4. \quad Ke = \frac{1}{2}mv^2$$

$$5. \quad VR = \frac{TA}{TB}$$

$$6. \quad VR = \frac{\text{PCD of gear}}{\text{PCD of pinion}}$$

$$7. \quad VR = \frac{NB}{NA}$$

$$8. \quad NA \times TA = NB \times TB$$

$$9. \quad Ft = \frac{2 \times T}{PCD}$$

$$10. \quad Fr = Ft \times \tan \phi$$

$$11. \quad Fn = Ft \times \sec \phi$$

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

$$13. \quad T\alpha = Ie \times \alpha$$

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

$$15. \quad \frac{NB}{NA} = \frac{\omega B}{\omega A} = \frac{\alpha B}{\alpha A} = \frac{IA}{IB}$$

$$16. \quad T_{\text{OUTPUT}} = T_{\text{INPUT}} \times \text{GR} \times \eta$$

$$17. \quad P = \frac{\pi \times PCD}{n}$$

$$18. \quad Ti + To + Th = 0$$

$$19. \quad TA = TS + 2TP$$

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

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

$$22. \quad P = Te \times v$$

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

$$24. \quad TI = \alpha \times A$$

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

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

$$27. \quad L = \frac{\pi}{2} \times (D + d) + \frac{(D \pm d)^2}{4 \times C} + 2C$$

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

$$29. \quad v = \omega \times r$$

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

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

$$34. \frac{T_1}{T_2} = \left[\frac{1 + \mu \tan \theta}{1 - \mu \tan \theta} \right]^n$$

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

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

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

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

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

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

$$47. \frac{p_1}{\rho} + \frac{(v_1)^2}{2} + gh_1 = \frac{p_2}{\rho} + \frac{(v_2)^2}{2} + gh_2$$

$$48. V_w (V_a) = \sqrt{\frac{gx^2}{2y}}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$57. Self-weight = \frac{m_1 \times g \times S^2}{8 \times h}$$

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

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

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

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

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

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

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

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

$$66. (I_1 + I_2)\square_3 = I_1\square_1 + I_2\square_2$$

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

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

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

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

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

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

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

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

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

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

$$77. P_l = CmgL + mgh$$