higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

4 July 2022 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 6 pages, 1 formula sheet and 1 information sheet.

100Q1A2204

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE 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. Keep subsections of questions together.
5. Rule off across the page on completion of each section.
6. Show all formulae in answers.
7. Show all calculations.
8. Draw all diagrams in pencil.
9. Round off all answers to THREE decimal places.
10. Take g = 9,8 m/s^2.
11. Use only a black or a blue pen.
12. Write neatly and legibly.

QUESTION 1

1.1 A bus and a truck leave simultaneously from a fork in a road. The truck travels northeast at a velocity of 85 km/h. The bus travels directly east at 104 km/h.

Calculate the velocity of the truck relative to the velocity of the bus. (4)

1.2 An aeroplane flies to its destination 300 km directly east of its starting point. The pilot wants to complete the flight in 50 minutes. There is a southwesterly wind blowing at 10 m/s.

Calculate the velocity of the aeroplane and the direction of the flight. (6)

1.3 A bullet is fired at an angle of 33° to the horizontal at a velocity of 410 m/s.

Calculate the following:

1.3.1 The maximum height reached by the bullet (2)

1.3.2 The horizontal displacement when the bullet hits the ground (3)

[15]

QUESTION 2

The effective diameter on the tread of a car tyre is 405 mm.

Calculate the following:

2.1 The distance that a point on the tread of the tyre will cover if the tyre does ONE revolution (2)

2.2 The angular displacement of a point on the tread of the tyre after 10 revolutions (2)

2.3 The angular velocity of a point on the tread of the tyre when the car is travelling at 100 km/h (3)

2.4 The angular retardation if the vehicle is brought to rest with uniform reduction in speed from 100 km/h in 25 seconds (2)

[9]

QUESTION 3

3.1 Define the term *potential energy*. (1)

3.2 A cyclist with a mass of 120 kg accelerates uniformly from rest up a gradient of 1:35 and reaches a speed of 65 km/h after 2 minutes.

Calculate the following:

3.2.1 The acceleration of the bicycle (3)

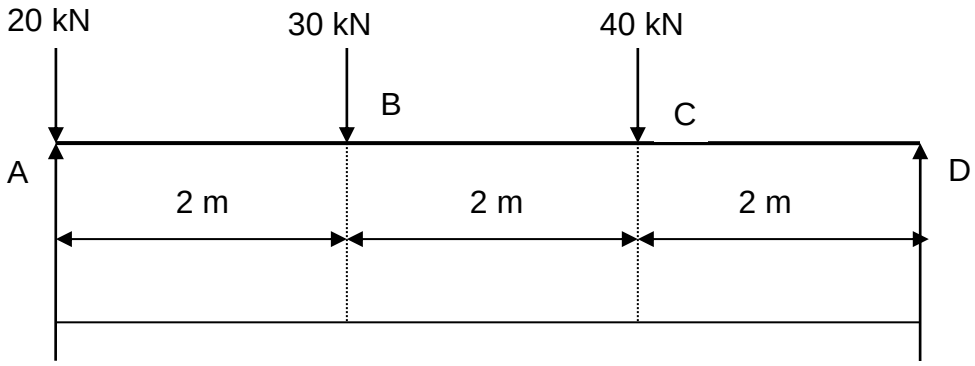
3.2.2 The kinetic energy that the bicycle possesses after 2 minutes (3)

3.2.3 The gain in potential energy (5)
[12]

QUESTION 4

4.1 Define the *law of moments.* (2)

4.2 Shown below is a simply supported light beam, ABCD.



4.2.1 Calculate the reaction forces at the support A and D, and test the answer. (4)

4.2.2 Calculate the bending moments at points A, B, C and D. (4)

4.2.3 Draw a bending-moments diagram. (2)

4.2.4 Draw a shear-force diagram. (3)
[15]

QUESTION 5

5.1 State TWO characteristics of liquids or fluids. (2)

5.2 A water pump with a piston diameter of 42 cm and a stroke length of 55 cm operates at a pressure of 857 kPa.

Calculate the following:

5.2.1 The volume of water delivered per stroke in m^3 (3)

5.2.2 The force exerted by the piston (2)

5.2.3 The work done per operation stroke (2)

5.3 Calculate the force exerted by the ram piston if an effort of 200 N is applied to the lever of a hydraulic press.

The mechanical advantage of the lever is 15 and the efficiency on the press is 93%. The diameter of the plunger is 0,1 times that of the diameter of the ram. (5)

5.4 The plunger of a three-cylinder pump has a diameter of 90 mm and a stroke length of 590 mm. The crankshaft speed is 240 r/min.

Calculate the quantity of water delivered in litres per second if the slip is 1,8%. (3)

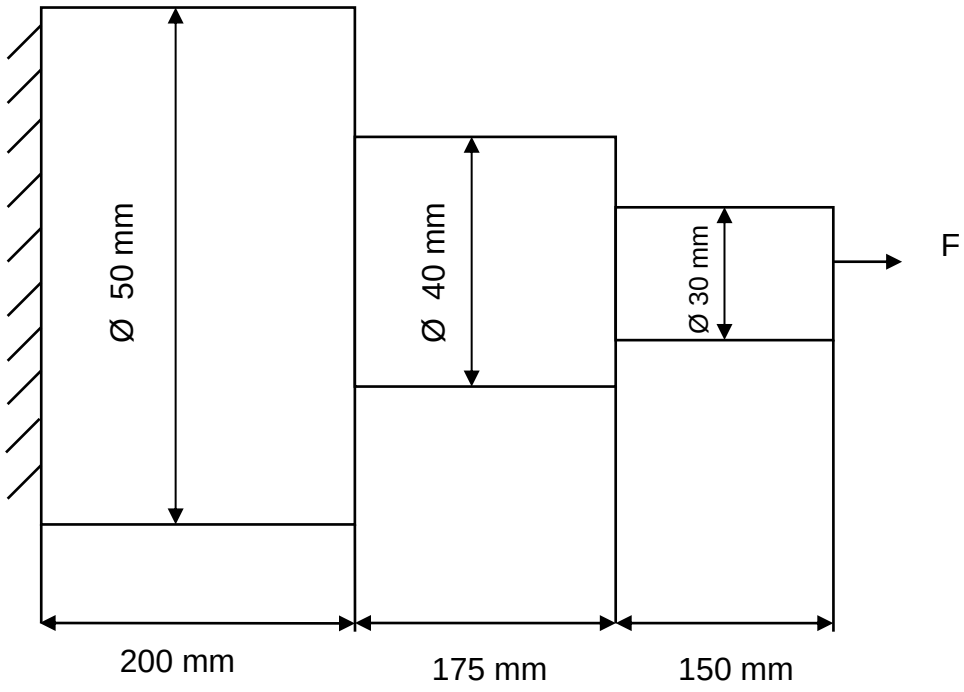
5.5 A borehole pumps water from a depth of 65 m at a rate of 320 ℓ/min. The installation efficiency of the borehole pump is 75%.

Determine the power of the driving pump of the electric motor. (3)
[20]

QUESTION 6

6.1 State *Hooke's law*. (2)

6.2 The figure below shows a mild-steel bar which is axially loaded by means of a tensile load so that the maximum induced stress is 120 MPa. Young's modulus is 200 GPa.



Calculate the total change in length. (5)

6.3 During a tensile test on a round bar of 25 mm diameter, a load of 80 kN causes an extension of 0,2 mm.

If the initial length was 250 mm, calculate:

6.3.1 The stress (3)

6.3.2 The strain (2)

6.3.3 Young's modulus (2)
[14]

QUESTION 7

7.1 Define *Pascal's law*. (3)

7.2 The piston of a single-acting water pump has a diameter of 100 mm and a delivery stroke of 80 mm. The water must be pumped to a vertical height of 20 m.

Calculate the following:

7.2.1 The volume of water being pumped per delivery stroke (3)

7.2.2 The mass of water pumped per delivery stroke (2)

7.3 The following data refer to a single-acting hydraulic press:

Plunger diameter = 80 mm
Plunger stroke = 120 mm
Ram diameter = 300 mm
Slip = 5%

Calculate the following:

7.3.1 The actual volume of liquid delivered to the ram per stroke (3)

7.3.2 The distance moved by the ram after FIVE pumping strokes of the plunger (4)
[15]

TOTAL: 100

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FORMULA SHEET

Any applicable formula may also be used.

$S = \frac{u + v}{2} \times t$

$a = \alpha R$

$MA = \frac{F_p}{F_h}$

$V = \frac{s}{t}$

$v = \pi DN$

$WD = mgh$

$v = u + at$

$T = FR$

$Q = mc\Delta t$

$s = ut + \frac{1}{2} at^2$

$WD = T\theta$

$\Delta l = {}_{lo}\alpha\Delta t$

$v^2 = u^2 + 2as$

$P = 2\pi NT$

$\beta = 2\alpha$

$v_g = \frac{u + v}{2}$

$P = T\omega$

$\gamma = 3\alpha$

$\omega = 2\pi N$

$P = Fv$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\omega = \frac{\theta}{t}$

$F_a = ma$

$PV = mRT$

$\theta = \frac{\omega_2 + \omega_1}{2} \times t$

$E_p = mgh$

$\epsilon = \frac{x}{l}$

$\omega_2 = \omega_1 + \frac{1}{2}\alpha t$

$E_k = \frac{1}{2} mv^2$

$E = \frac{\sigma}{\varepsilon}$

$v = \omega R$

$P = \frac{F}{A}$

$\sigma = \frac{F}{A}$

$\theta = 2\pi n$

$m = p \times vol$

$E = \frac{F\,l}{Ax}$

$S = R\theta$

$P = pgh$

$y = \frac{A_1 y_1 + A_2 y_2 + \ldots}{A_T}$

$\alpha = \frac{(\omega_2)^2 - (\omega_1)^2}{2\theta}$

$\frac{W_r}{F_p} = \frac{D^2}{d^2}$

$y = \frac{V_1 y_1 + V_2 y_2 + \ldots}{V_T}$

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INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS
Atmospheric pressure	101,3 kPa
Density of copper	8 900 kg/m^3
Density of aluminium	2 770 kg/m^3
Density of gold	19 000 kg/m^3
Density of alcohol (ethyl)	790 kg/m^3
Density of mercury	13 600 kg/m^3
Density of platinum	21 500 kg/m^3
Density of water	1 000 kg/m^3
Density of mineral oil	920 kg/m^3
Density of air	1,05 kg/m^3
Electrochemical equivalent of silver	1,118 mg/C
Electrochemical equivalent of copper	0,329 mg/C
Gravitational acceleration	9,8 m/s^2
Heat value of coal	30 MJ/kg
Heat value of anthracite	35 MJ/kg
Heat value of petrol	45 MJ/kg
Heat value of hydrogen	140 MJ/kg
Linear coefficient of expansion of copper	17 × 10^{-6}/°C
Linear coefficient of expansion of aluminium	23 × 10^{-6}/°C
Linear coefficient of expansion of steel	12 × 10^{-6}/°C
Linear coefficient of expansion of lead	54 × 10^{-6}/°C
Specific heat capacity of steam	2 100 J/kg.°C
Specific heat capacity of water	4 187 J/kg.°C
Specific heat capacity of aluminium	900 J/kg.°C
Specific heat capacity of oil	2 000 J/kg.°C
Specific heat capacity of steel	500 J/kg.°C
Specific heat capacity of copper	390 J/kg.°C