higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T530**(E)**(N18)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

18 November 2016 (X-Paper)
09:00–12:00

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

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. Subsections of questions should be kept together. Rule-off across the page after each section.
5. ALL formulae should be shown in the answers. Show ALL calculations.
6. Answers should be in blue or black ink.
7. ALL diagrams should be in pencil.
8. Take g = 9,8 m/s^2. Determine the answers correctly to THREE decimal digits where necessary.
9. Write neatly and legibly.

QUESTION 1

1.1 An express train travels from north to south at 103 km/h. A helicopter flies over the train at 187 km/h from the front.

Calculate the velocity of the helicopter relative to the velocity of the train in magnitude and direction. (3)

1.2 A stone is thrown at a velocity of 29 m/s at an angle of 35° to the horizontal.

Calculate the following:

1.2.1 The maximum height that the stone reaches

1.2.2 The horizontal displacement or range

(2 × 3) (6)

1.3 An aeroplane flies to its destination, 300 km directly east of its starting point. The pilot wants to complete the flight in 50 minutes. A wind blows in a north-eastern direction at 10 m/s.

Calculate the following:

1.3.1 The velocity of the aeroplane (4)

1.3.2 The direction of the flight (2)

[15]

QUESTION 2

2.1 Define *angular acceleration.* (2)

2.2 The spindle of a drilling machine rotating at 1 500 r/min slows down to 600 r/min while making 48 revolutions.

Calculate the following:

2.2.1 The angular retardation of the drilling machine in rad/s^2 (5)

2.2.2 The time taken to slow down (2)

[9]

QUESTION 3

3.1 Define *coefficient of friction.* (2)

3.2 A motorcar with a mass of 1,2 tonnes is at rest at the top of an incline of 1 : 30. The length of the incline is 62 metres. The frictional force of 200 N is constant (uniform). The brakes are released and the car moves downwards due to the gravitational force, and then onto a horizontal road.

Calculate the following:

3.2.1 The velocity of the car at the bottom of the incline (6)

3.2.2 The force applied by the motorcar on the horizontal road (1)

3.2.3 The distance where the car will come to rest if it continues to travel on the horizontal road (3)

[12]

QUESTION 4

A beam ABCDE, with A on the left-hand side, is 10 m long and simply supported at A and D. Point loads of 50 N and 30 N are at B and E respectively. AB = 2 m and DE = 2 m.
An evenly distributed load of 2 N/m is between A and D.

4.1 First draw the beam, then calculate the reaction forces of A and D. (5)

4.2 Calculate the bending moments at B and D and at a point C halfway between B and D. (3)

4.3 Draw the bending moment and shearing force diagrams with the main values indicated on the diagram. (7)

[15]

QUESTION 5

5.1 Define *Pascal's law.* (2)

5.2 Define the unit *pascal.* (2)

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

Cross-sectional area of the plunger piston	=	0,072 m^2
Force applied to the plunger piston	=	275 N
Cross-sectional area of the ram piston	=	0,624 m^2
Stroke length of plunger piston	=	0,148 m

Calculate the following:

5.3.1 The force exerted by the ram (2)

5.3.2 The volume of fluid displaced after 20 strokes of the plunger if there is a slip of 9% (3)

5.3.3 The distance moved by the ram piston after one stroke of the plunger if there is a slip of 9% (3)

5.3.4 The mechanical advantage of the lever system if an effort of 27,5 N is applied to the end of the lever (2)

5.4 Calculate the power required to pump 300 m^3 of water per hour to a reservoir 27 m above water level. The efficiency is 94%.

(HINT: 1 000 kg water = 1 m^3 = 1 000 litres) (6)

[20]

QUESTION 6

6.1 Name THREE types of stress that can be found in materials. (3)

6.2 Define *Hooke's Law.* (3)

6.3 A tensile force of 27 kN is applied to a steel bar with a rectangular cross-sectional area of 29 mm wide and 15 mm thick. The length of the bar is 2,8 m.
Young's modulus of elasticity for a steel bar is 208 GPa.

Calculate the following:

6.3.1 The stress of the steel bar (3)

6.3.2 The strain of the steel bar (2)

6.3.3 The change in length of the steel bar (3)
[14]

QUESTION 7

7.1 Define the *coefficient of linear expansion* of a substance. (2)

7.2 A square metal plate of 37 cm × 37 cm is at a temperature of 31 ˚C. The coefficient of linear expansion of the metal is 17 × 10 $^{-6}$/˚C.

Calculate the increase in area of the metal plate in cm^2 if its temperature rises to 98 ˚C. (2)

7.3 The density of 1 m^3 mercury at 0 ˚C is 1,07 × 10^4 kg/m^3 and the volumetric coefficient of expansion is 200 × 10 $^{-6}$/^{0}C.

Calculate the density of mercury at 70 ˚C. (5)

7.4 A container has a capacity of 0,184 m^3 and is filled with nitrogen gas at a pressure of 410 kPa and a temperature of 61 ˚C. Later it is found that the pressure has dropped to 300 kPa and the temperature has decreased to 32 ˚C as the result of a leak.

Calculate the following:

7.4.1 The mass of nitrogen gas that was initially in the container if the gas constant is 273 J/kgK

7.4.2 The mass of nitrogen gas that leaked out

(3 × 2) (6)
[15]

TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

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

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

$v = u + at$

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

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

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

$\omega = 2\pi N$

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

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

$\omega_2 = \omega_1 + \alpha t$

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

$v = \omega R$

$\theta = 2\pi n$

$S = R\theta$

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

$a = \alpha R$

$v = \pi DN$

$T = FR$

$AV = T\theta = WD$

$P = 2\pi NT$

$P = Fv$

$P = T\omega$

$F_a = ma$

$E_p = mgh$

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

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

$m = \rho \times vol$

$P = \rho gh$

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

$W.D. = P \times V = A.V.$

$H.V. = \frac{F_p}{F_h} = M.A.$

$AV = mgh = WD$

$Q = mc\Delta t$

$\Delta l = l_o \alpha \Delta t$

$\beta = 2\alpha$

$\gamma = 3\alpha$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$PV = mRT$

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

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

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

$E = \frac{Fl}{Ax}$

$\overline{y} = \frac{A_1y_1 \pm A_2y_2 \ldots}{A_1 \pm A_2 \ldots}$

$\overline{y} = \frac{v_1y_1 \pm v_2y_2 \ldots}{v_1 \pm v_2 \ldots}$

INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS KONSTANTE	HOEVEELHEID
Atmospheric pressure	101,3 kPa	Atmosferiese druk
Density of copper	8 900 kg/m^3	Digtheid van koper
Density of aluminium	2 770 kg/m^3	Digtheid van aluminium
Density of gold	19 000 kg/m^3	Digtheid van goud
Density of alcohol (ethyl)	790 kg/m^3	Digtheid van alcohol (etiel)
Density of mercury	13 600 kg/m^3	Digtheid van kwik
Density of platinum	21 500 kg/m^3	Digtheid van platina
Density of water	1 000 kg/m^3	Digtheid van water
Density of mineral oil	920 kg/m^3	Digtheid van minerale olie
Density of air	1,05 kg/m^3	Digtheid van lug
Electrochemical equivalent of silver	1,118 mg/C	Elektrochemiese ekwivalent van silwer
Electrochemical equivalent of copper	0,329 mg/C	Elektrochemiese ekwivalent van koper
Gravitational acceleration	9,8 m/s^2	Swaartekragversnelling
Heat value of coal	30 MJ/kg	Warmtewaarde van steenkool
Heat value of anthracite	35 MJ/kg	Warmtewaarde van antrasiet
Heat value of petrol	45 MJ/kg	Warmtewaarde van petrol
Heat value of hydrogen	140 MJ/kg	Warmtewaarde van waterstof
Linear coefficient of expansion of copper	17 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van koper
Linear coefficient of expansion of aluminium	23 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van aluminium
Linear coefficient of expansion of steel	12 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van staal
Linear coefficient of expansion of lead	54 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van lood
Specific heat capacity of steam	2 100 J/kg.°C	Spesifieke warmtekapasiteit van stoom
Specific heat capacity of water	4 187 J/kg.°C	Spesifieke warmtekapasiteit van water
Specific heat capacity of aluminium	900 J/kg.°C	Spesifieke warmtekapasiteit van aluminium
Specific heat capacity of oil	2 000 J/kg.°C	Spesifieke warmtekapasiteit van olie
Specific heat capacity of steel	500 J/kg.°C	Spesifieke warmtekapasiteit van staal
Specific heat capacity of copper	390 J/kg.°C	Spesifieke warmtekapasiteit van koper