higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

2 April 2020 (X-paper)
09:00–12:00

REQUIREMENTS: Properties of water and steam (BOE 173)

Calculators may be used

This question paper consists of 7 pages, a formula sheet of 2 pages and an information sheet of 2 pages.

066Q1A2002

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE
ENGINEERING SCIENCE N3
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 on completion of each question.
6. Answers must be rounded off to THREE decimals.
7. All calculations should consist of at least the following THREE steps:
   - Formula used or manipulation thereof
   - Substitution of given data in formula
   - Answer with correct SI unit
8. Drawing instruments must be used for all drawings. All drawings and diagrams must be fully labelled.
9. Use the constant values on the attached information sheet where applicable.
10. Use $g = 9{,}8\ m/s^2$.
11. Write neatly and legibly.

QUESTION 1: MOTION, ENERGY AND POWER

1.1 Define *acceleration*. (1)

1.2 The diagram in FIGURE 1 represents the motion of a train.

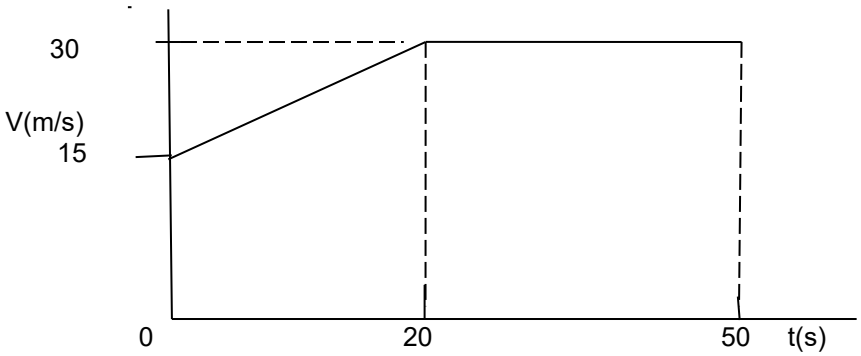

FIGURE 1

Determine each of the following:

1.2.1 Acceleration of the train during the first 20 seconds (2)

1.2.2 Total distance the train has travelled after 50 seconds (3)

1.3 A force of 250 N is exerted on a 20 cm long spanner to turn a nut through 120°.

Calculate each of the following:

1.3.1 Angle in radians (1)

1.3.2 Torque (2)

1.3.3 Work done (2)

1.4 A flat belt fits around a pulley with a diameter of 38 cm. The belt has a speed of 18,7 m/s and transmits 5 N per mm belt width. The effective pull in the belt is 420 N and the belt width is 21 cm.

Calculate each of the following:

1.4.1 Power transmitted by the belt in kW (2)

1.4.2 Tight-side force in the belt (1)

1.4.3 Pulley speed in r/s (2)

[16]

QUESTION 2: MOMENTS

2.1 Define *torque*. (2)

2.2 FIGURE 2 shows a simply supported loaded beam.

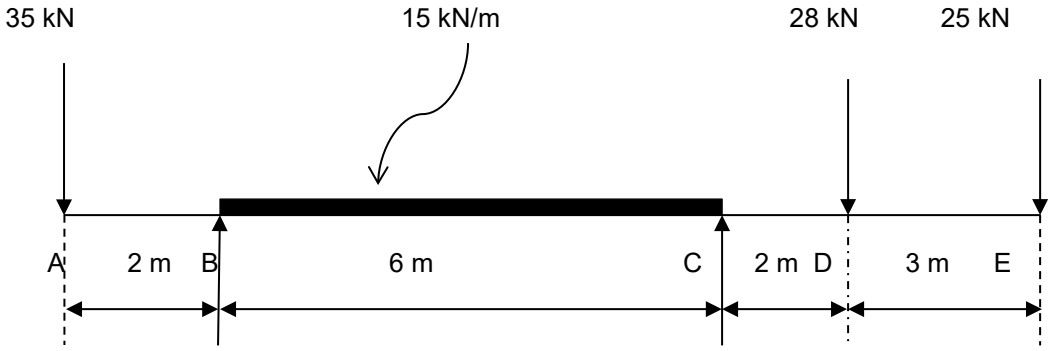

FIGURE 2

2.2.1 Calculate the magnitude of the reactions of supports B and C. (4)

2.2.2 Draw a shear-force diagram of the beam to suitable scale and indicate all the main values on the diagram. (6)
[12]

QUESTION 3: FORCES

3.1 Define *parallelogram of forces*. (2)

3.2 Determine the magnitude of the unknown forces shown in the system of forces in FIGURE 3.

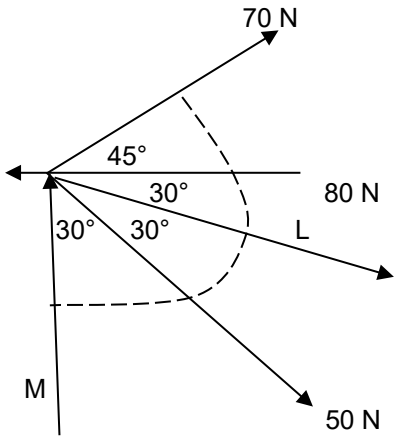

FIGURE 3 (6)

3.3 Name TWO conditions for static equilibrium if the forces acting on the framework or object are in equilibrium. (2)

3.4 FIGURE 4 below shows a structure. Determine the magnitude and nature of the forces in members AB and BC.

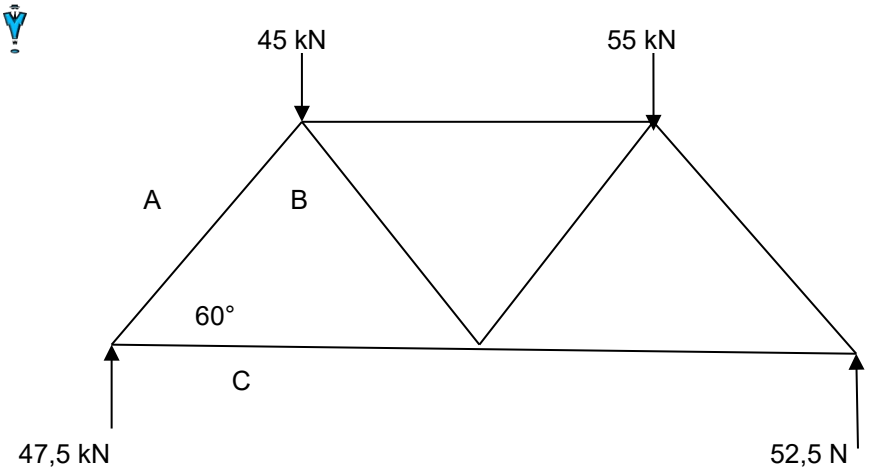

FIGURE 4

(4)
[14]

QUESTION 4: FRICTION

4.1 State THREE principles of kinetic friction. (3)

4.2 A casting with a mass of 0,2 tons rests on a sloping surface forming an angle of 25° with the horizontal. The co-efficient of friction is 0,36.

Calculate each of the following

4.2.1 Component of the weight of the object perpendicular to the surface (2)

4.2.2 Component of the weight of the object parallel to the surface (2)

4.2.3 Friction force between the *casting* and the *incline* (3)

4.2.4 Smallest force required to move the casting down the incline (2)
[12]

QUESTION 5: HEAT

5.1 Name THREE factors on which the increase in length depends if a metal rod is heated uniformly along its length. (3)

5.2 An aluminium strip with a length of 200 cm and a width of 10 cm is heated from 17 °C to 107 °C.

Calculate each of the following:

5.2.1 Change in temperature of the aluminium strip (1)

5.2.2 Change in length in mm of the aluminium strip (3)

5.2.3 Change in area of the aluminium strip in m^2 (3)

5.3 Describe the effect of the change in pressure on the saturation temperature of a substance. (1)

5.4 Calculate the total enthalpy in MJ required to produce 2 kg of wet steam with a dryness fraction of 0,9 at a pressure of 1450 kPa. (4)
[15]

QUESTION 6: HYDRAULICS

6.1 Write an equation of delivery head in terms of suction head and static head. (2)

6.2 The following data refers to a single-stroke pump driven by a diesel engine, which has to deliver water to a reservoir above the pump.

Working pressure	=	0,45 MPa
Volume of water delivered	=	45 m^3/h
Output power of the diesel engine	=	7350 W

Calculate each of the following:

6.2.1 Maximum height of the reservoir above the pump (3)

6.2.2 Work done by the pump per second (4)

6.2.3 Output power of the pump (1)

6.2.4 Efficiency of the pump (2)
[12]

QUESTION 7: ELECTRICITY

7.1 Explain *potential difference* of a cell. (1)

7.2 A battery has an internal resistance of 0,2 Ω and is connected in series with a 5 Ω resistor and an unknown resistor. When the circuit is closed, the potential difference across the 5 Ω resistor is 12,6 V and that across the unknown resistor is 11,4 V.

Calculate each of the following:

7.2.1 Current through the 5 Ω resistor

7.2.2 Resistance of the unknown resistor

(2 × 2) (4)

7.3 A current of 10 A flows through a silver nitrate solution for one hour to electroplate an object. The electrochemical equivalent for silver is 0,001118 g/C.

Calculate each of the following:

7.3.1 Amount of electric charge required

7.3.2 Mass of silver deposited

(2 × 2) (4)

7.4 A single-phase transformer has a supply voltage of 230 V and a primary current of 6 A at full load. The secondary current is 0,4 A and there are 600 turns on the primary coil.

Calculate each of the following:

7.4.1 Turns ratio

7.4.2 Number of turns in the secondary

(2 × 2) (4)
[13]

QUESTION 8: CHEMISTRY

8.1 Give the number of valence electrons for alkali earth metals. (1)

8.2 Name the TWO main groups into which elements in the periodic table are divided. (2)

8.3 Name ONE property of brass. (1)

8.4 Give the chemical formulae for limestone and hydrochloric acid. (2)
[6]

TOTAL: 100

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FORMULA SHEET

All the formulae needed are not necessarily included.
Any applicable formula may also be used.

$W = F.s$

$W = \rho.V$

$P = \frac{W}{t}$

$\eta = \frac{Uitset/Output}{Inset/Input}\ 100\%$

$F = m.a$

$\mu = \frac{F_\mu}{N_R}$

$\mu = \tan\Phi$

$N_R = F_C \pm F_T sin\alpha \ ... \ a = 0$

$F_S = wsin\theta$

$F_C = wcos\theta$

$F_T cos\alpha = F_\mu \pm F_S \ ... \ a = 0$

$F_e = T_1 - T_2$

$\frac{T_1}{T_2} = tension\ ratio$

$P = F_e \ . \ v$

$v = \pi \ . \ d \ . \ n \ ... \ n = \frac{N}{60}$

$W_\mu = F_\mu \ . \ s$

$\Delta E_p = m.g.\Delta h$

$\Delta E_K = \frac{1}{2}.m.\Delta v^2$

$Q = I^2 \ . \ R \ . \ t$

$m = I \ . \ z \ . \ t$

$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$

$m_1.u_1 \pm m_2.u_2 = m_1.v_1 \pm m_2.v_2$

$D_e = (D + t)$

$h_{nat/wet} = h_f + x.h_{fg}$

$P = 2.\pi.T.n \ ... \ T = F.r$

$P = \frac{F_{RAM}}{A_{RAM}} = \frac{F_{PL}}{A_{PL}} \ ... \ A = \frac{\pi D^2}{4}$

$V_{RAM} = V_{PL} \times n$

$A_{RAM} \ . \ H_{RAM} = A_{PL} \ . \ L_{PL}$

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

$\Sigma F_X = F_1 cos\theta_1 + ... + F_n cos\theta_n$

$\Sigma F_y = F_1 sin\theta_1 + ... + F_n sin\theta_n$

$R = \sqrt{\Sigma F_X^2 + \Sigma F_Y^2}$

$tan\varphi = \frac{\Sigma F_Y}{\Sigma F_X}$

$Q = m \ . \ c \ . \ \Delta t \ ... \ t_F = to \pm \Delta t$

$m.ww = Q = m.hv$

$P = \frac{Q}{t}$

$\Delta L = Lo \ . \ \alpha \ . \ \Delta t \ ... \ L_f = Lo \pm \Delta L$

$\Delta A = A_0 \ . \ \beta \ . \ \Delta t \ ... \ A_f = A_0 \pm \Delta A$

$2.a.s = v^2 - u^2$

$s = u.t + \frac{1}{2}.a.t^2$

$v = u + a.t$

$\Sigma \uparrow F = \Sigma \downarrow F$

$M = F \ . \perp s$

$$\Sigma\ CWM = \Sigma ACWM$$

$$P_{ABS} = P_{ATM} + P_{MET}$$

$$P = \delta \times g \times h$$

$$\frac{1}{R_{PAR}} = \frac{1}{R_1} + ... + \frac{1}{R_n}$$

$$R_{SER} = R_1 + ... R_n$$

$$V_1 - V_2 = - e(U_1 - U_2)$$

$$V = I \times R$$

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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 alkohol (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	Elektrocherniese 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	$23 \times 10^{-6}/°C$	Lineêre uitsettingskoëffisiënt van aluminium
Linear coefficient of expansion of steel	$12 \times 10^{-6}/°C$	Lineêre uitsettingskoëffisiënt van staal
Linear coefficient of expansion of lead	$54 \times 10^{-6}/°C$	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