higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

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

REQUIREMENTS: Properties of water and steam (BOE 173)

This question paper consists of 7 pages, 1 information sheet and 1 formula sheet.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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. Start each question on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.
7. Steam tables to be provided by examination centre

QUESTION 1: MOTION, POWER AND ENERGY

1.1 Differentiate between *uniform velocity* and *average velocity*. (2)

1.2 An object with a mass of 60 kg moves in a straight line with uniform acceleration according to the law v = 5 + 3t, where v is the final velocity in m/s and t is the time in seconds.

Calculate:

1.2.1 The initial velocity of the body (1)

1.2.2 The acceleration of the body (1)

1.2.3 The displacement after 5 seconds (2)

1.2.4 The kinetic energy after 5 seconds (4)

1.2.5 The change in momentum (2)

1.3 A flat belt drive transmits 36 kW from one shaft to another shaft. The belt speed is 72 km/h. The belt, which has a width of 22 cm, transmits 12,5 N per mm of its width.

Calculate:

1.3.1 The effective force in the belt

1.3.2 The slack force

(2 × 2) (4)

[16]

QUESTION 2: MOMENTS

2.1 State the *law of moments*. (1)

2.2 FIGURE 1 shows a light horizontal beam ABCDE of a uniform cross section loaded as shown.

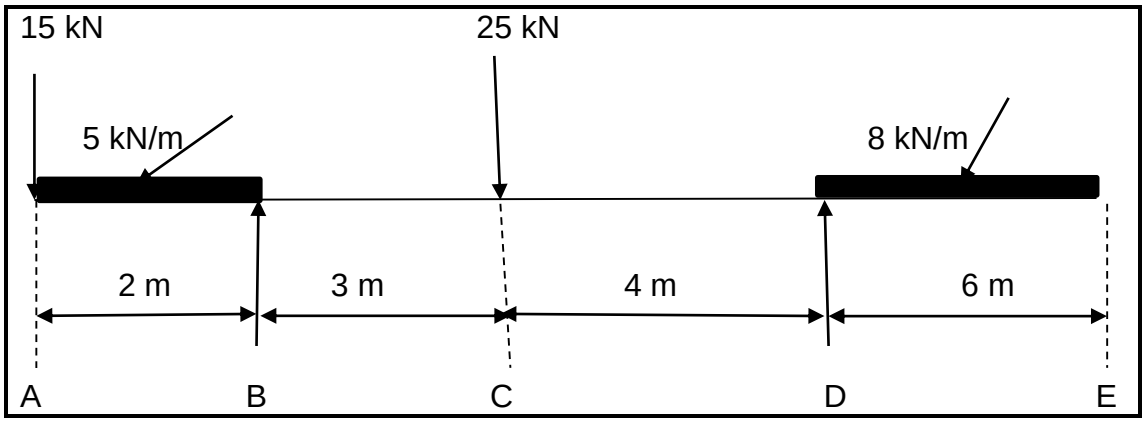

FIGURE 1

2.2.1 Calculate the magnitude of the reactions at the supports. (6)

2.2.2 Draw, to a suitable scale, a shear-force diagram. (5)
[12]

QUESTION 3: FORCES

3.1 Define the term *equilibrant*. (1)

3.2 Consider the following forces that act on the same point:

25 kN west
35 kN east
100 kN directly north
60 kN directly south
20 kN northeast at 45°

Calculate:

3.2.1 The sum of the vertical and horizontal forces and state the directions (6)

3.2.2 The magnitude and direction of the resultant (4)

3.2.3 The magnitude of the equilibrant (1)
[12]

QUESTION 4: FRICTION

4.1 Define the term *angle of rest*. (2)

4.2 FIGURE 2 shows a body of mass of 50 kg that is placed on an incline forming an angle of 30° with the horizontal. The coefficient of friction is 0,36. A force Q, making an angle of 20° upwards with the plane, is required to pull the body up the plane.

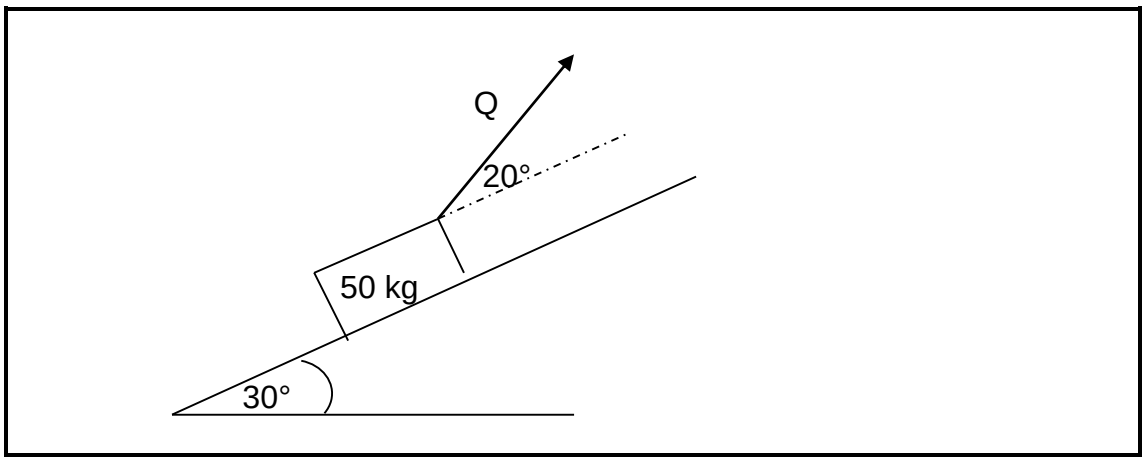

FIGURE 2

Calculate:

4.2.1 The component Q parallel to the plane (1)

4.2.2 The gravity component parallel to the plane (2)

4.2.3 The gravity component perpendicular to the plane (2)

4.2.4 The magnitude of Q (5)
[12]

QUESTION 5: HEAT

5.1 State the *law of the conservation of heat energy*. (2)

5.2 Sixty copper sheets are cooled down in 15 litres of water. The initial temperature of the plates is 200 °C and that of the water 25 °C. Each plate has a mass of 1,2 kg.

Calculate the final temperature of the mixture. The SHC of copper is 390 J/kg.°C and that of water 4 187 J/kg.°C. (4)

5.3 An aluminium door with a width of 1,4 m and a height of 2,4 m is manufactured at 25 °C.

Given that the temperature increases to 45,5 °C and the coefficient of linear expansion for aluminium is equal to 23×10^{-6}/°C, calculate:

5.3.1 The change in temperature in K (2)

5.3.2 The change in height in mm with this change in temperature (3)

5.3.3 The change in width in cm with this change in temperature (3)

[14]

QUESTION 6: HYDRAULICS

6.1 State *Pascal's law* in words. (1)

6.2 The diameter of a ram on a hydraulic press is 600 mm and the diameter of the plunger is 240 mm.

Calculate the ratio of the forces of the hydraulic press. (3)

6.3 A pump needs to pump all the water from a circular dam with a diameter of 1 500 cm. The depth of the water in the dam is 500 cm. The water must also be pumped through a height of 450 cm.

Calculate:

6.3.1 The work done by the pump (4)

6.3.2 The power required to empty the dam within six hours (3)

6.4 Illustrate, by means of sketch, the following terms with reference to a centrifugal pump: *suction head*, *static head* and *delivery head*. (3)

[14]

QUESTION 7: ELECTRICITY

7.1 Give THREE advantages of a standard transformer. (3)

7.2 An electric kettle consumes 100 kJ electrical energy from a 210 V supply in 5 minutes.

Calculate:

7.2.1 The current flowing through the kettle element (3)

7.2.2 The resistance of the heating element (2)

7.3 A single-phase transformer has a supply voltage of 220 V and a primary current of 8 A at full load. The secondary current is 0,8 A and there are 300 turns on the primary coil.

Calculate:

7.3.1 The turns ratio

7.3.2 The number of turns on the secondary coil

7.3.3 Secondary voltage

(3 × 2) (6)
[14]

QUESTION 8

8.1 Define the term *element*. (1)

8.2 List FOUR factors that affect the rate of corrosion. (4)

8.3 Write down the formula of hydrogen peroxide. (1)
[6]

TOTAL: 100

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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

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FORMULA SHEET

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

$W = F.s$

$W = \rho.V$

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

$\eta = \frac{\text{Output}}{\text{Input}} \times 100\%$

$F = m.a$

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

$\mu = tan\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e \ . \ v$

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

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

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

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

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

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

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

$\Sigma \ CWM = \Sigma ACWM$

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

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

$M = F \ . \perp s$

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

$D_e = (D + t)$

$h_{wet} = h_f \ + x.h_{fg}$

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

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

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

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

$F_X \ = Fcos\theta$

$F_Y \ = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

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

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

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

$V = I \times R$