higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N3

(15070413)

19 November 2019 (X-Paper)
09:00–12:00

REQUIREMENTS: **Properties of water and steam (BOE 173)**

Calculators may be used.

This question paper consists of 6 pages, a formula sheet of 2 pages and 1 information sheet.

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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. Answers must be rounded off to THREE decimal places.
5. ALL the calculations should consist of at least the following THREE steps:
   a. The formula used or the manipulation thereof
   b. Substitution of the given data in the formula
   c. The answer with the correct SI unit
6. Drawing instruments must be used for all drawings/diagrams. ALL drawings/diagrams must be fully labelled.
7. The constant values, as they appear on the attached information sheet, must be used wherever possible.
8. Keep subsections of questions together.
9. Rule off on completion of each question.
10. Use $g = 9{,}8\ m/s^2$.
11. Write neatly and legibly.

QUESTION 1: MOTION, ENERGY AND POWER

1.1 Name ONE difference and ONE similarity between *speed* and *velocity*? (2)

1.2 A BMW motor car with a mass of 1,2 ton accelerates uniformly from rest up a gradient of 1 in 20 and reaches a speed of 15,5 m/s after 3 minutes.

Calculate:

1.2.1 The acceleration of the BMW (2)

1.2.2 The kinetic energy the BMW possesses after 3 minutes (2)

1.2.3 The gain in potential energy (4)

1.3 A flat belt has a speed of 72 km/h. The tension in the tight side is 600 N and the tension ratio 4:1.

Calculate:

1.3.1 Tension in the slack side (1)

1.3.2 Effective tensile force (1)

1.3.3 Power transmitted (2)

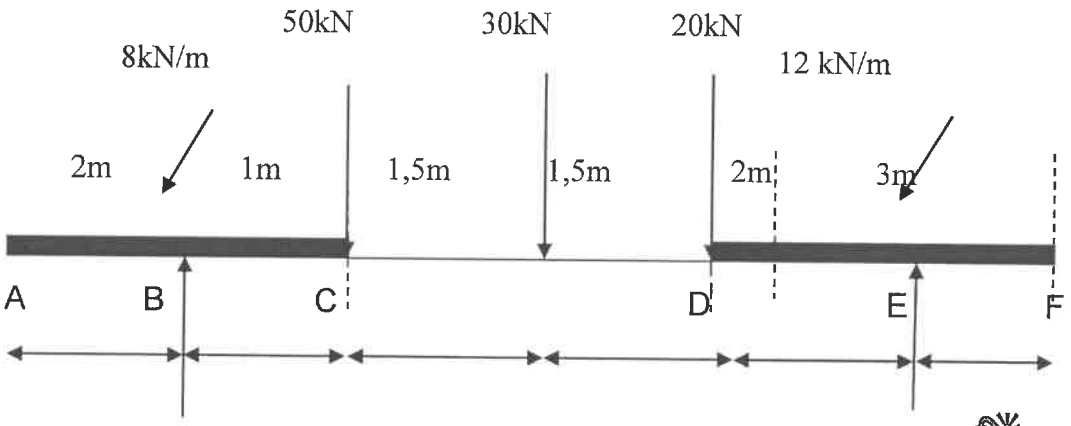
1.3.4 The velocity ratio if the diameter of the driver pulley is 20 cm and the diameter of the driven pulley is 0.12 m. (2)

[16]

QUESTION 2: MOMENTS

2.1 State TWO conditions for equilibrium for a number of coplanar forces acting on the same point. (2)

2.2 Given a light horizontal beam ABCDEF of a uniform cross-section, loaded as shown:



2.2.1 Calculate the reaction of the supports B and E. (4)

2.2.2 Draw a shear force diagram, using a suitable scale. Show ALL the main values on the diagram. (6)

[12]

QUESTION 3: FORCES

3.1 What is the relationship between the *resultant force* and the *equilibrant* of a system of forces? (2)

3.2 The following data refer to four forces acting on a point:

40N North
25N West
35N East 30° North
30N East 60° South

Calculate:

3.2.1 The sum of the vertical components and state their direction

3.2.2 The sum of the horizontal components and state their direction

3.2.3 The magnitude of the resultant force

(3 × 3) (9)

3.3 The direction of the resultant force of a system of forces acting on a point is west 42,7° south, while the sum of the vertical components equals 300N.

Calculate the magnitude of the resultant force. (3)

[14]

QUESTION 4: FRICTION

4.1 Give THREE advantages of friction. (3)

4.2 A body with a mass of 0,6 ton is placed on an incline plane making an angle of 25° with the horizontal. The co-efficient of friction is 0,36. A force P, at an angle of 30° to the plane, is required to pull the body UP the plane.

Calculate:

4.2.1 Component of P parallel to the plane (1)

4.2.2 Gravitational component parallel to the plane (2)

4.2.3 Gravitational component perpendicular to the plane (2)

4.2.4 Magnitude of P (5)

[13]

QUESTION 5: HEAT

5.1 Define the term *specific heat capacity* of a substance. (1)

5.2 6 kg steel is cooled down in oil and the temperature drops from 900 °C to 27 °C. The specific heat capacity of steel is 0,46kJ/kg °C and that of oil is 1,5kJ/kg °C.

Calculate the:

5.2.1 Quantity of heat lost by the steel (3)

5.2.2 Mass of the oil required if the original temperature of the oil is 20 °C (3)

5.3 A fuel with a heat energy value of 32MJ/kg is used in an engine that develops 13kW. The test lasted 30 minutes and a thermal efficiency of 35% was obtained.

Calculate:

5.3.1 The equivalent power of the fuel (3)

5.3.2 The heat energy dissipated by the fuel in MJ (2)

5.3.3 The mass of the fuel used (2)
[14]

QUESTION 6: HYDRAULICS

6.1 State Pascal's principle in words. (2)

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

Force exerted on a ram piston 5200N
Force exerted to plunger 365N
Diameter of the plunger 8cm
Stroke length of plunger piston 0,1m

Calculate the following:

6.2.1 Diameter of the ram piston (3)

6.2.2 Distance moved by the ram (in mm), after 30 pumping strokes of the plunger piston (4)

6.2.3 Liquid pressure in the system (3)
[12]

QUESTION 7: ELECTRICITY

7.1 Define Faradays's first law of electrolysis. (2)

7.2 Four cells, each with an EMF of 3V and internal resistance of 0,5 Ω per cell are connected in series. The battery is then connected to two parallel connected resistors 4Ω and 6Ω and a 5Ω resistor in series.

Calculate:

7.2.1 The total resistance of the circuit (3)

7.2.2 The total current flow (2)

7.2.4 The current through the 4 Ω resistor (2)

7.3 The resistance of the heating element of a heater is 60 Ω. The current flowing through the heater is 10 A for 5 hours.

Calculate:

7.3.1 The quantity of heat released

7.3.2 The cost if the tariff is 27 cents per kWh

(2 × 2) (4)
[13]

QUESTION 8: CHEMISTRY

8.1 Explain the term *reduction* as it applies to a chemical reaction (1)

8.2 Name THREE methods to combat corrosion. (3)

8.3 Give the chemical formula for sodium hydroxide and sulphuric acid. (2)
[6]

TOTAL: 100

ENGINEERING SCIENCE N3

FORMULA SHEET

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

$W = F.s$

$W = \rho.V$

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

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

$F = m.a$

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

$\mu = \tan\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e \,.\, v$

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

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

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

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

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

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

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

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

$D_e = (D + t)$

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

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

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

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

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

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

$M = F \,.\, \perp s$

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

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

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

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

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

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

$$V = I \times R$$

(15070413)

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^{-5}/°C
Linear coefficient of expansion of aluminium	23×10^{-5}/°C
Linear coefficient of expansion of steel	12×10^{-5}/°C
Linear coefficient of expansion of lead	54×10^{-5}/°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