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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER 2010

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

17 November (X-Paper)
09:00 – 12:00

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

Calculators may be used.

This question paper consists of 7 pages, 1 information sheet and a 2-page formula sheet.

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. ALL the calculations must consist of, at least, the following THREE steps:
   - 3.1 The formula used or manupulation thereof
   - 3.2 Substitution of the given data in the formula
   - 3.3 The answer with the correct SI-unit
4. The constant values, as they appear on the attached information sheet, must be used wherever possible.
5. Number the answers correctly according to the numbering system used in this question paper.
6. Keep subsections of questions together.
7. Rule off across the page on completion of each question.
8. Drawing instruments must be used for ALL drawings/diagrams. ALL drawings/diagrams must be fully labelled.
9. One mark indicates one percentage point, that is 100 marks = 100%.
10. Use $g = 9{,}8\ m/s^2$.
11. Answers must be rounded off to THREE decimal places.
12. Write neatly and legibly.

QUESTION 1

1.1 Derive the formula $s = ut + \frac{1}{2}at^2$ from the formulae of motions: $s = \frac{1}{2}(u + v)t$ and $v = u + at$ (2)

1.2 State the law of conservation of momentum. (1)

1.3 State the law of moments. (2)

1.4 State the similarity and the difference between the *resultant force* and *equilibrant force* acting on a system of forces. (1)

1.5 Explain the term *heat value*. (1)

1.6 Express the static head of pressure in water in terms of delivery head and suction head. (1)

1.7 Make a neat sketch of a centrifugal pump with regard to the following:

1.7.1 Static head
1.7.2 Suction head
1.7.3 Delivery head
1.7.4 Water level (3)

1.8 Explain the term *alloy*. (1)

1.9 Give TWO examples of non-metals. (2)

1.10 Name the TWO elements that solder consists of. (2)

[16]

QUESTION 2: MOTION, POWER AND ENERGY

2.1 A racing car accelerates uniformly at 4 m/s^2 from rest. Calculate the displacement after 15 seconds. (2)

2.2 A truck with a mass of 8 tons travels at a velocity of 60 km/h and collides with a truck with a mass of 5 tons travelling in the same direction at 40 km/h. After the collision the two trucks move together.

Calculate the final common velocity of the TWO trucks in m/s after the collision. (3)

2.3 A belt drives a pulley with a diameter of 40 cm with a thickness of 1,2 mm. The tension in the tight side is 320,324 N and the slack side is 123,154 N. The belt velocity is 12 m/s.

Consider the belt thickness and calculate the following:

2.3.1 The rotational frequency of the pulley (2)
2.3.2 The power transmitted by the belt in kW (2)
[9]

QUESTION 3: MOMENTS

FIGURE 1 below shows a horizontal light beam ABCD with a uniform cross section loaded as shown in the diagram.

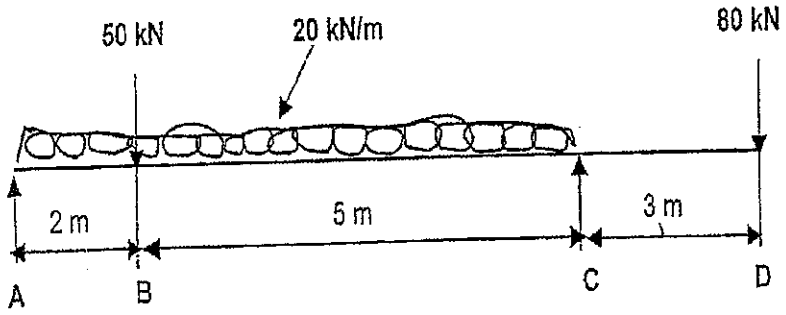

FIGURE 1

3.1 Calculate the reaction at the supports and test the answers. (5)

3.2 Draw a shear-force diagram by using a suitable scale. Show ALL the main values on the diagram. (5)
[10]

QUESTION 4: FORCES

4.1 Study the FOUR coplanar forces below, acting at the same point:

7 kN east
6 kN north
3 kN west
5 kN south

Calculate the following:

4.1.1 The sum of the vertical components and state the direction (2)

4.1.2 The sum of the horizontal components and state the direction (2)

4.1.3 The magnitude of the resultant (2)

4.1.4 The direction of the equilibrant (2)

4.2 FIGURE 2 below shows a structure of forces in equilibrium. Determine graphically or calculate the magnitude and nature of the members AB and AC.

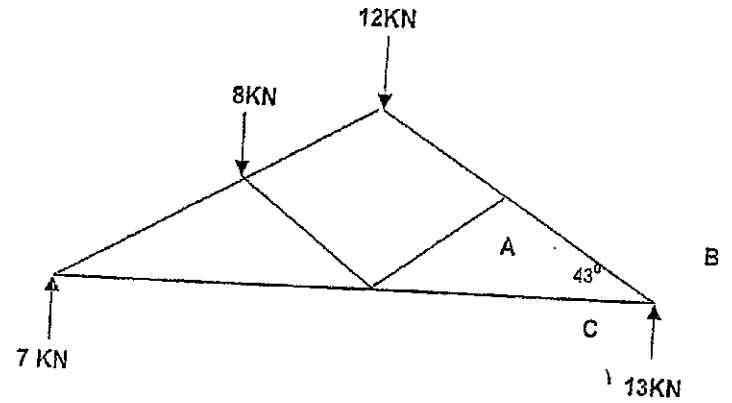

FIGURE 2

(6)
[14]

QUESTION 5: FRICTION

5.1 A granite stone with a mass of 50 kg rests on an inclined plane making an angle of 20° with the horizontal. A force of 290 N parallel to the plane is required to pull the granite stone up the inclined plane at a constant velocity.

Calculate the coefficient of friction. (3)

5.2 A body with a mass of 40 kg rests on a horizontal plane. The coefficient of friction is 0,36. A force T with angle of 22° to the horizontal pulls the body at a constant velocity.

Calculate the magnitude of force T. (4)
[7]

QUESTION 6: HEAT

6.1 A mass of 265,841 × 10^{-3} kg of fuel is burnt for 30 minutes to heat 100 litres of water from 18°C to 30°C. Only 54% of the energy of the fuel was dissipated to the water.

Calculate the following:

6.1.1 The heat energy required for the temperature change (2)

6.1.2 The heat energy given off by the fuel (2)

6.1.3 The heat value of the fuel (2)

6.1.4 Refer to the information sheet and name this fuel (1)

6.1.5 The power transmitted by the fuel (2)

6.2 An aluminium rectangular plate at 23°C with a dimension of 25 cm by 10 cm is heated and the temperature increases to 65°C.

Calculate the change in the area of the plate. (2)

6.3 Steam is generated in a boiler at a pressure of 270 kPa to a dryness fraction of 0,94.

Calculate the following:

6.3.1 The enthalpy of the dry saturated steam (1)
6.3.2 The enthalpy required to convert 2 kg of water into wet steam (3)
[15]

QUESTION 7: HYDRAULICS

7.1 A diesel generator with an output power of 5 kW drives a single-acting pump. The pump delivers 80 000 litres of water per hour. The tank is 20 m vertically above the pump.

Calculate the following:

7.1.1 The pressure exerted by the pump in kPa (2)
7.1.2 The work done by the pump per hour (2)
7.1.3 The efficiency of the pump (3)

7.2 The following data refers to a hydraulic press:

Diameter of the plunger	= 50 mm
Diameter of ram	= 0,2 m
Stroke length of plunger	= 70 cm
Effort on the plunger	= 310 kN

Calculate the following:

7.2.1 The force exerted by the ram (2)

7.2.2 The distance moved by the ram per stroke of the plunger (2)

7.2.3 The number of pumping strokes required by the plunger to lift the load to a height of 46 m (2)

7.2.4 The volume of liquid received by the ram cylinder (2)
[15]

QUESTION 8: ELECTRICITY

8.1 An electrical circuit consists of a battery with 2 cells each with EMF 12 volts and an internal resistance of 0,4 ohm each and connected in parallel. An ammeter with an internal resistance of 0,15 ohm is connected in series with a resistor R_a = 2 ohms and a resistor R_b = 4 ohms and the battery.

Calculate the following:

8.1.1 The total resistance of the circuit (2)
8.1.2 The reading on the ammeter (2)
8.1.3 The potential difference in the circuit (1)

8.2 An electrical motor produces a current of 8 A for 4 hours per day from a voltage supply of 240 volts. The cost is 16 cent per kW/h.

Calculate the total cost after FIVE days of operating the motor. (3)

8.3 A single-phase transformer has a supply voltage of 240 V and a primary current of 20 A at full load. There are 50 primary turns and 300 secondary turns on the transformer.

Calculate the following:

8.3.1 The secondary voltage (2)
8.3.2 The secondary current (2)

8.4 Calculate the magnitude of the current which flows for 30 minutes through a copper sulphate solution. The mass of the copper deposited is 7,46 gram. (2)
[14]

TOTAL: 100

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

FORMULA SHEET

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

$W = F.s$

$W = \rho.V$

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

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

$F = m.a$

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

$\mu = \tan\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e . v$

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

$W_\mu = F_\mu . s$

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

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

$Q = I^2 . R . t$

$m = I . z . t$

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

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

$D_e = (D + t)$

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

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

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

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

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

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

$M = F . \perp s$

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

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

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

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

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

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

$$V = I \times R$$