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 manipulation 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 where ever 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 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 at least THREE decimal places.
12. Write neatly and legibly.

QUESTION 1

1.1 State the definition of acceleration. (1)

1.2 State the law of conservation of momentum. (2)

1.3 State the law of moments. (2)

1.4 State the definition of the resultant of forces. (2)

1.5 State the definition of a frictional force. (2)

1.6 Define the law of conservation of heat energy. (2)

1.7 State TWO advantages of steam. (1)

1.8 State the definition of the electromotive force (EMF) of a cell/battery. (2)

1.9 Name TWO gaseous non-metal elements. (1)

1.10 Explain what is meant by the term *oxidation*. (1)

1.11 Name the chemical composition of water. (2)

1.12 Make a neat, labelled sketch of a single-acting hydraulic press. (5)

[23]

QUESTION 2: MOTION, POWER AND ENERGY

2.1 A car accelerates at 2 m/s^2 from rest for two minutes.

Calculate the following:

2.1.1 The displacement after TWO minutes (2)
2.1.2 The velocity after TWO minutes (1)

2.2 A rifle with a mass of 3.5 kg fires a bullet with a mass of 120 g with a muzzle velocity of 420 m/s.

Calculate the following:

2.2.1 The momentum before the rifle was fired (1)

2.2.2 The velocity of the rifle after it was fired (3)

2.2.3 The kinetic energy of the rifle after the shot was fired (2)

2.3 A flat belt of a pulley has an effective tension of 200 N and a speed of 22,5 m/s. Calculate the power transmitted by the belt. (1)

[10]

QUESTION 3: MOMENTS

FIGURE 1 below shows a lever in equilibrium.

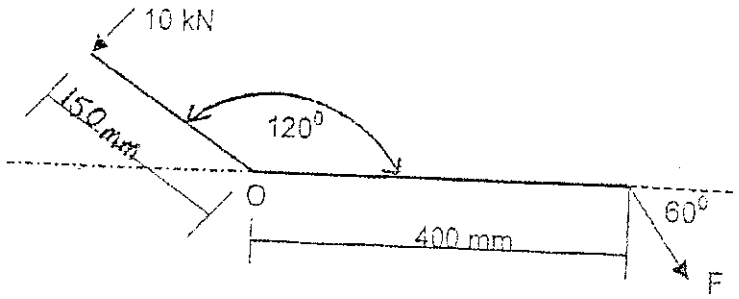

FIGURE 1

Calculate the following:

3.1 The magnitude of F (2)

3.2 The magnitude and direction of the reaction force of the support at point O (8)

[10]

QUESTION 4: FORCES

4.1 The following data refers to four forces acting at the same point:

420 kN East
200 kN South
320 kN West
300 kN North

Calculate the following:

4.1.1 The sum of the vertical components and the direction (2)
4.1.2 The sum of the horizontal components and the direction (2)
4.1.3 The magnitude of the resultant (2)
4.1.4 The direction of the resultant (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 CA:

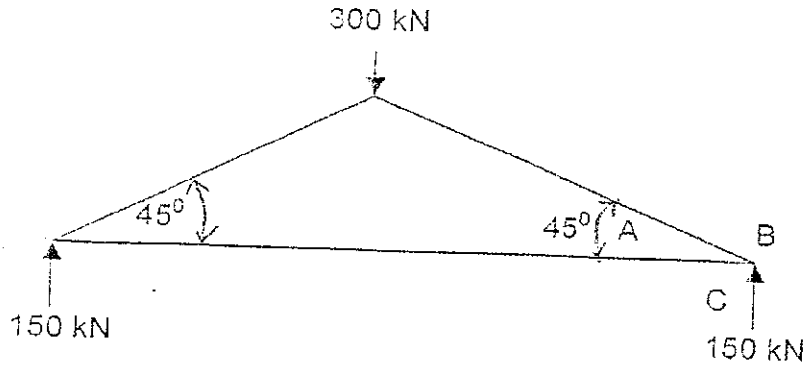

FIGURE 2

(5)
[13]

QUESTION 5: FRICTION

5.1 The mass of a truck is 5 000 kg and it is stationary on an inclined plane making an angle of 16° with the horizontal. The coefficient of friction is 0,387.

Calculate the following:

5.1.1 The weight of the truck (1)
5.1.2 The weight component parallel to the plane (2)
5.1.3 The static frictional force acting on the truck (2)

5.2 A body with a weight of 490 N is at rest on a horizontal plane. A pulling force of 800 N is applied at an angle of 8° with the horizontal plane, such that the body moves with a constant velocity.

5.2.1 Make a neat labelled drawing of the body on the horizontal plane showing ALL the forces and their components acting on it. (3)

5.2.2 Determine the kinetic frictional force opposing the motion. (2)

5.2.3 Determine the normal reactional force. (3)
[13]

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

QUESTION 6: HEAT

6.1 A hot steel ball with a mass of 5 kg raises the temperature of oil from 16 °C to 26 °C.

Calculate the following:

6.1.1 The quantity of heat lost by the ball if its initial temperature is 800 °C (3)

6.1.2 The mass of the oil (3)

6.2 Steam is generated in a boiler at a pressure of 1 450 kPa and a wet steam is generated with a dryness fraction of 0,9.

Calculate the enthalpy required for 1 kg of the following:

6.2.1 Wet steam (3)
6.2.2 Dry steam (1)
[10]

QUESTION 7: HYDRAULICS

7.1 A single-acting pump of 220 kPa delivers 3 000 m^3 of water per hour.

Calculate the following:

7.1.1 The work done per hour (2)
7.1.2 The power of the pump (2)

7.2 The following data refers to a single-acting hydraulic press:

Stroke length of the plunger	=	120 mm
Diameter of the plunger	=	100 mm
Force exerted on the plunger	=	230 N
Load lifted on the ram	=	4,8 kN

Calculate the following:

7.2.1 The diameter of the ram piston (2)
7.2.2 The distance that the ram will rise in 20 pumping strokes (2)
7.2.3 The fluid pressure in the system (2)
[10]

QUESTION 8: ELECTRICITY

8.1 A circuit consists of three cells connected in series each with EMF of 6 V. The internal resistance of each cell is 0,6 ohms and is connected to TWO parallel resistors of 6 ohms and 4 ohms.

Draw the circuit diagram of the components mentioned above. (2)

Calculate the following:

8.1.1 The total resistance of the circuit (3)
8.1.2 The current flowing in the circuit (2)
8.1.3 The potential difference of the parallel circuit (2)

8.2 An electric lamp is marked 240 V, 150 W. Calculate the cost to operate the lamp for 3 hours at a cost of 15 cent per unit. (2)

[11]

TOTAL: 100

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FORMULA SHEET

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

$W = F.s$

$W = \rho.V$

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

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

$F = m.a$

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

$\mu = \tan\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e . v$

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

$W_\mu = F_\mu . s$

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

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

$Q = I^2 . R . t$

$m = I . z . t$

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

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

$D_e = (D + t)$

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

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

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

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

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

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

$M = F . \perp s$