higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NATIONAL CERTIFICATE

# ENGINEERING SCIENCE N3

(15070413)

**20 August 2021 (X-paper)**
**09:00–12:00**

**Drawing instruments and nonprogrammable calculators may be used.**

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

070Q1G2128

# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N3
TIME: 3 HOURS
MARKS: 100

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**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.

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## QUESTION 1: MOTION, POWER AND ENERGY

1.1 Define the term *speed*. (1)

1.2 State the *law of conservation of energy*. (1)

1.3 A body of mass 5 kg is accelerated from 6 m/s to 15 m/s during a period of 20 s up an incline making an angle of 25° to the horizontal. The frictional force is 45 N.

Determine:

1.3.1 The acceleration (2)

1.3.2 The distance travelled (3)

1.3.3 The work done by the component of the gravitational force parallel to the plane (4)

1.3.4 The work done by the frictional force (2)

1.3.5 The power exerted by the total force (2)
**[15]**

## QUESTION 2: MOMENTS

2.1 Define the term *uniformly distributed load*. (2)

2.2 State the *law of moments*. (2)

2.3 A beam is 6 m long and supported 1 m from the left end and 2 m from the right end of the beam. There is a uniformly 12,243 kg/m placed between the two supports. A point load of 300 N is placed on both ends of the beam and a 200 N load is placed 1 m from the right end of the beam.

2.3.1 Calculate the reaction of the two supports. (4)

2.3.2 Draw a shear-force diagram showing all main values. (3)

2.3.3 Determine the maximum and minimum shear force from the diagram. (2)
**[13]**

 

**QUESTION 3: FORCES**

3.1 Give the similarities between the *resultant* and the *equilibrant force.* (2)

3.2 Draw a diagram indicating a tie and a strut on a single roof truss. (2)

3.3 The THREE forces in FIGURE 1 are in equilibrium and on the same plane.

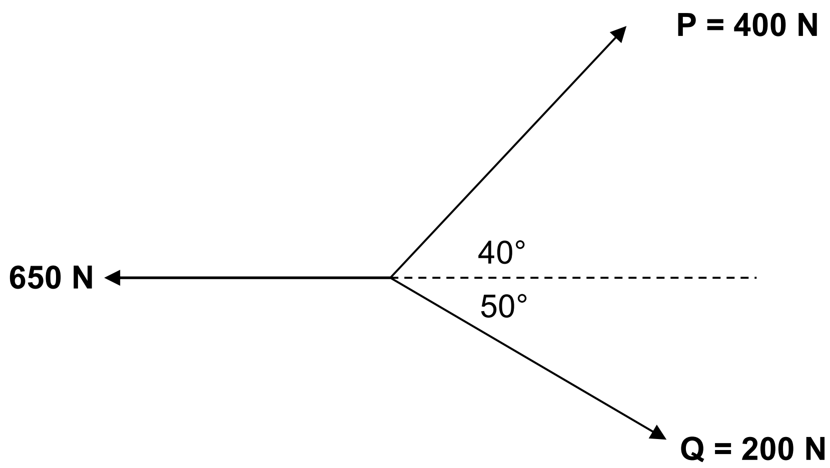


**FIGURE 1**

Determine:

3.3.1 The sum of the horizontal components (2)

3.3.2 The sum of the vertical components (2)

3.3.3 The resultant force that will keep the system in equilibrium (1)

 

3.4

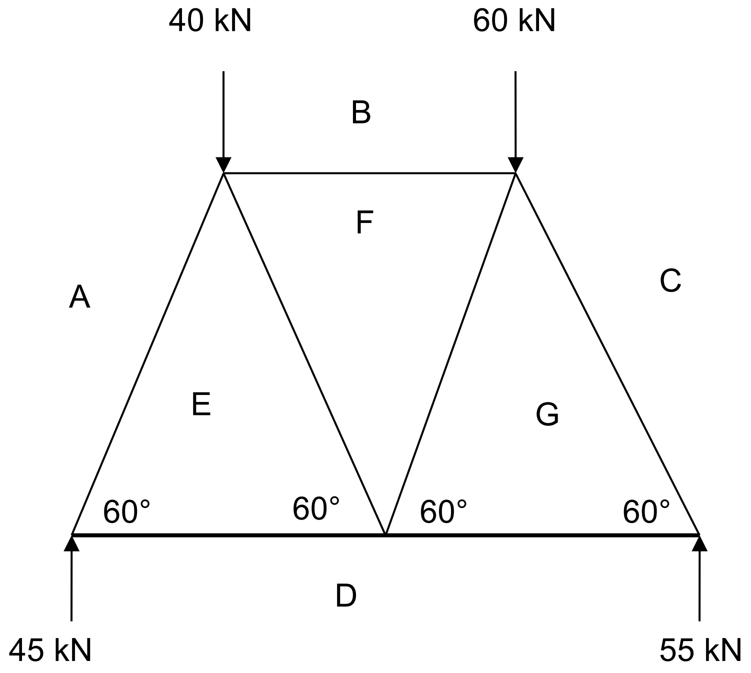


**FIGURE 2**

Determine the magnitude of the forces AE, ED and CG in FIGURE 2. (6)

**[15]**

## QUESTION 4: FRICTION

4.1 State FOUR principles of kinetic friction. (4)

4.2 A steel container full of copper strips is pulled downwards against an incline of 20° by a tractor. The mass of the steel container is 2 460 kg. The pulling force of the rope forms an angle of 25° with the incline. The coefficient of friction between the surfaces in contact is 0,46.

Calculate:

4.2.1 The tensile force in the rope (4)

4.2.2 List THREE advantages of friction (3)

**[11]**

 

## QUESTION 5: HEAT

5.1 A heat-treatment process is applied to a 3 000 g steel hammer. The temperature of the hammer is 180 °C and it is placed in a 7 006 500 mg oil bath at 50 °C.

Calculate the final temperature of the steel hammer and the oil. (4)

5.2 A volume of 0,240 $m^3$ of water is heated from 300 °C to 540 °C by burning coal.

Determine:

5.2.1 The change in temperature (1)

5.2.2 The quantity of heat required (3)

5.2.3 The quantity of coal required (2)

5.3 State THREE advantages of steam (3)

5.4 State TWO disadvantages of steam (2)
**[15]**

## QUESTION 6: HYDRAULICS

6.1 Name TWO elementary experiments dealing with pressure in liquids. (2)

6.2 Sibusiso, Keka and Dimpho are three student engineers working on a single hydraulic pump and recorded the following information:

Force of the ram: 580 N
Force of the plunger: 125 N

Calculate:

6.2.1 The ratio of the diameters of the hydraulic pump (4)

6.2.2 The diameter of the ram if the plunger diameter is 0,45 cm (2)

6.3 Make a neat, labelled sketch to illustrate the application of Pascal's law and briefly explain its application. (3)
**[11]**

 

## QUESTION 7: ELECTRICITY

7.1 Explain Faraday's second law of electrolyses. (1)

7.2 Define *electrolysis.* (1)

7.3 Three cells, each with an emf of 3 V and internal resistance of 0,4 Ω per cell are connected in series to the circuit shown in FIGURE 3.

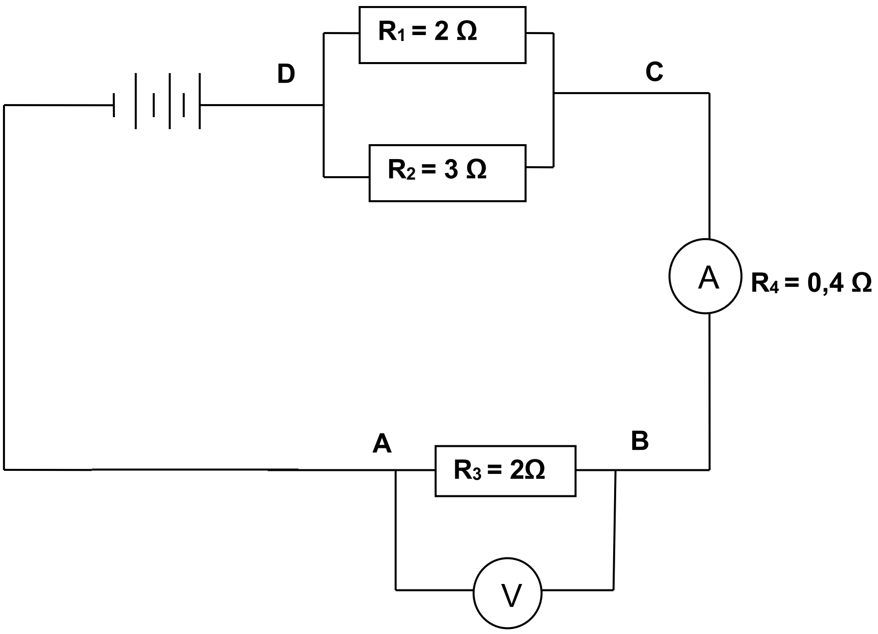


**FIGURE 3**

Calculate:

7.3.1 The total resistance of the circuit (4)

7.3.2 The ammeter reading (2)

7.3.3 The voltage across AB (2)

7.3.4 The current through the 3 Ω resistor (4)
**[14]**

## QUESTION 8: CHEMISTRY

8.1 List THREE properties of an atom. (3)

8.2 Name the THREE elements of a compound (limestone). (3)
**[6]**

**TOTAL: 100**

**FORMULA SHEET**

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

$W = F.s$

$W = \rho.V$

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

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

$F = m.a$

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

$\mu = tan\,\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e.v$

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

$W_\mu = F_\mu . s$

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

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

$Q = I^2 . R . t$

$m = I . z . t$

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

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

$D_e = (D + t)$

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

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

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

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

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

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

$M = F . \perp s$

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

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

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

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

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

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

$$V = I \times R$$

## 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 |