higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

31 July 2017(X-Paper)
09:00–12:00

This question paper consists of 9 pages, 1 formula sheet and 1 information sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N4
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. Subsections of questions should be kept together.
5. Rule off across the page on completion of each question.
6. ALL formulae should be shown in the answer. Show ALL calculations.
7. Questions must be answered in blue or black ink.
8. ALL sketches and diagrams must be done in pencil.
9. Take g = 9,8 m/s^2.
10. Write neatly and legibly.

QUESTION 1: GENERAL

1.1 Define the following:

1.1.1 Angular velocity

1.1.2 Braking force

(2 × 1) (2)

1.2 Draw a neat, fully labelled stress-strain graph of a material subjected to a tensile force.

NOTE: The graph should start from no force applied to the material until the yield point. (4)

1.3 Explain Boyle's gas law showing the statement, the equation, and the sketch. (4)

1.4 State each of the following laws:

1.4.1 Hooke's law (1)

1.4.2 Newton's first law of motion (2)

1.5 Explain what is meant by the following characteristic of pressure in the volume of liquid:

Pressure is directly proportional to the depth of the liquid. (1)

1.6 Give an example to explain the characteristic of pressure stated in QUESTION 1.6. (2)

1.7 What is the function of a hydraulic accumulator? (2)

[18]

QUESTION 2: KINEMATICS

2.1 A jet takes off at a speed of 380 km/h in the direction N32°W. The plane is then blown off course by a 110 km/h wind from the direction W50°S.

2.1.1 Draw a detailed velocity vector diagram of the above. (2)

2.1.2 Determine the resultant velocity (with its direction). (4)

2.2 Two vehicles move simultaneously. Vehicle P moves at 210 km/h west while the velocity of P relative to Q 200 km/h east. Vehicle Q moves in an easterly direction.

Calculate the velocity of vehicle Q. (4)

2.3 A canon on the ground fires a rocket at 30° and hits a school which was horizontally 210 m away (on the ground).

Calculate the following:

2.3.1 The initial velocity of the rocket

2.3.2 The total time it took the rocket to travel and hit the school at the velocity calculated in QUESTION 2.3.1.

(2 × 2) (4)
[14]

QUESTION 3: ANGULAR MOTION

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (3.1.1–3.2.3) in the ANSWER BOOK.

A wheel with a diameter of 0,51m makes a constant rotational frequency of 880 r/min.

Determine the following:

3.1 The angular velocity at any moment:

A 3,74 rad/s^2
B 7,48 rad/s
C 224,4 rad/s
D 92,153 rad/s

3.2 The angular displacement during 3 seconds:

A 673,2 rad
B 11,22 rad
C 224,4 rad
D 276,460 rad

The flywheel rotates at 920 r/min and accelerates to 2 300 r/min in 63 revolutions.

Calculate the following:

3.3 The angular displacement:

A 2415,01 rad
B 395,841 rad
C 813,882 rad
D 240,855 rad

3.4 The angular acceleration:

A 25,414 rad/s^2
B 35,904 rad/s^2
C 45,714 rad/s^2
D 61,552 rad/s^2

(4 × 2) **[8]**

QUESTION 4: DYNAMICS

4.1 A vehicle with a mass of 820 kg moves at a kinetic energy of 800 kJ. It takes the vehicle 8 seconds to reduce its speed to 20 m/s within 95 m. The resistance to motion is 0,262 N/kg.

Calculate the following:

4.1.1 Deceleration of the vehicle (3)

4.1.2 Braking force of the vehicle (3)

4.1.3 Kinetic energy of the vehicle after 8 seconds (1)

4.1.4 Braking force of the vehicle if it were to brake ascending a slope of 10° in the same conditions as when on a horizontal road. (3)

[10]

QUESTION 5: STATICS

5.1

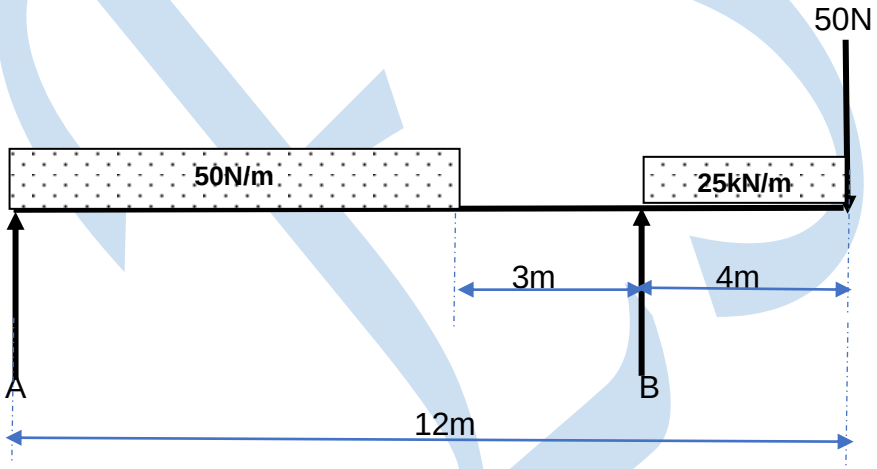

FIGURE 1

NOTE: The magnitude of A and B are 121,875 N and 278,125 N respectively.

Draw the following:

5.1.1 A detailed shear-force diagram of the above beam (2)

5.1.2 The magnitude of the bending moments at the principal points (4)

5.1.3 A detailed bending-moment diagram (4)

5.2

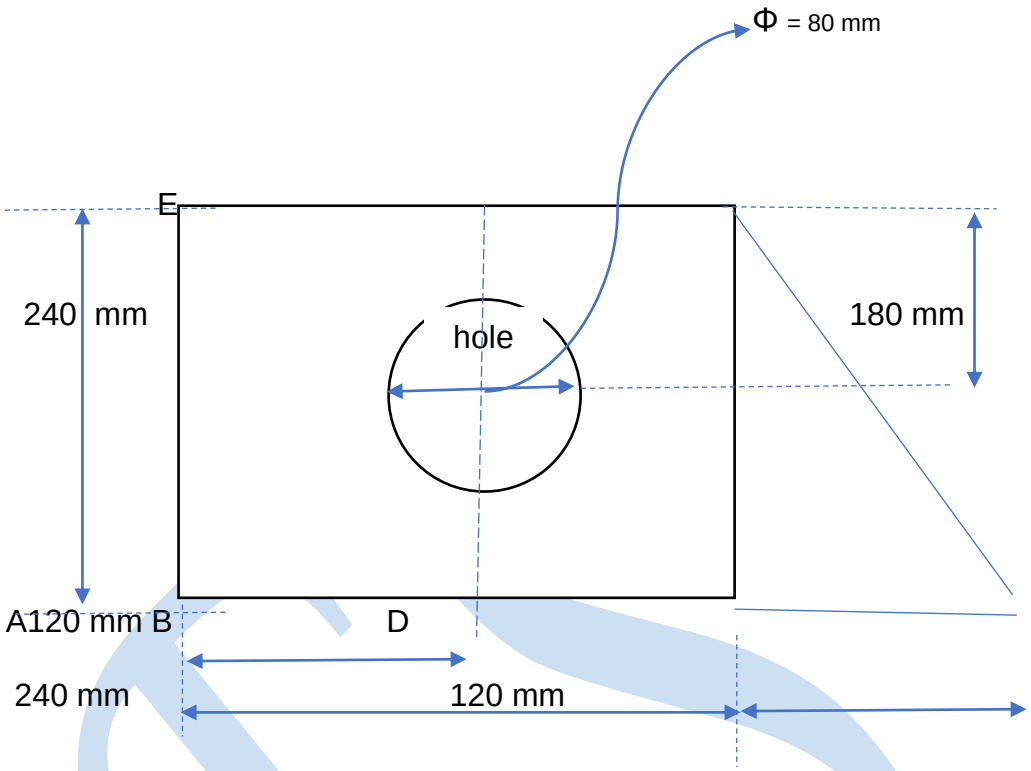

FIGURE 2

Use the information above and calculate the position of the centroids A–E or the x-coordinate. (6)
[16]

QUESTION 6: HYDRAULICS

6.1 The ratio of the diameter of the plunger of a hydraulic press to that of the ram is 2 : 5 while the stroke length of the plunger is 380 mm. The efficiency of the press is 95,6 % when the plunger makes 80 working strokes to lift the load of 2,1 tons.

Calculate the following:

6.1.1 The mechanical advantage of the press if the force on the handle is 311,4 N (5)

6.1.2 The distance the ram moved (2)

6.2 The plunger of a three-cylinder single-acting pump has a diameter of 280 mm and a stroke length of 390 mm. The crankshaft speed is 333,33 r/min.

Calculate the volume of water delivered per hour if the slip is 4,4%. (3)

6.3 A dam full of water has a diameter of 28 m and a height of 18 m and it is drained through irrigation sprinklers at a pressure of 1 200 Pa.

Calculate the following:

6.3.1 The work done to pump all the water from the dam (3)

6.3.2 The power required to empty the dam in 12 hours (2)
[15]

QUESTION 7: STRESS, STRAIN, AND YOUNG'S MODULUS OF ELASTICITY

7.1 A square bar with sides of 120 mm and 0,95 m is axially loaded by a tensile force of 300 kN. Young's modulus of elasticity for the bar is 110 GPa.

Calculate the following:

7.1.1 The stress in the bar

7.1.2 The total extension in the bar

(2 × 2) (4)

7.2 The diameter of the steel cable of a lift is 24,4 mm and Young's modulus of elasticity of steel is 209 GPa. The cable is 31 m long when the lift is at ground level.

Calculate the extension of the cable when a mass of 0,88 tons is loaded into the lift. (5)
[9]

QUESTION 8: HEAT

8.1 A cylinder contains 0,84 m^3 oxygen at a temperature of 20 °C and a pressure of 1 580 kPa. The temperature increases to 58 °C while the pressure remains constant.

8.1.1 Determine the final volume of the gas. (3)

8.1.2 State the gas law that is applied in the experiment in QUESTION 8.1.1. (1)

8.1.3 Give a reason for the answer in QUESTION 8.1.2. (1)

8.2 A certain gas has a mass of 0,19 kg and a volume of 54,772 liters at an absolute pressure of 220 kPa and a temperature of 31 °C.

Determine the constant of this gas. (2)

8.3 An air balloon at the bottom of a dip hole is filled with gas of a volume of 1.56 m^3 at a temperature of 11 °C and a pressure of 420 kPa. The balloon rises to the surface where the pressure is 101,3 kPa and the temperature is 31 °C.

Calculate the size of the balloon in m^3 when it reaches the surface. (3)
[10]

TOTAL: 100

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FORMULA SHEET

Any other applicable formula may also be used.

$$L = \frac{u^2}{g}\sin 2\theta$$

$$t_L = 2\frac{u}{g}\sin\theta$$

$$\overline{V} = \frac{s}{t}$$

$$\theta = 2\pi n$$

$$S = R\theta$$

$$\omega = 2\pi N$$

$$\omega = \frac{\theta}{t}$$

$$\omega_2 = \omega_1 + \alpha t$$

$$\omega_2^2 = \omega_1^2 + 2\alpha\theta$$

$$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$$

$$v = \omega R$$

$$v = \pi D n$$

$$a = \alpha R$$

$$\tau = FR$$

$$W_{ork} = \tau\theta = WD$$

$$P = 2\pi nT$$

$$v = u + at$$

$$P = T\omega$$

$$n = \frac{N}{60}$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

$$P = Fv$$

$$F_a = ma$$

$$E_p = mgh$$

$$E_k = \frac{1}{2}mv^2$$

$$v_{ave} = \frac{u+v}{2}$$

$$P = \frac{F}{A}$$

$$m = \rho \times vol$$

$$P = \rho gh$$

$$\frac{W_r}{F_p} = \frac{D^2}{d^2}$$

$$M.A = \frac{F_p}{F_h}.\frac{100}{\eta} = H.V$$

$$V_s = V_a.\frac{100}{\eta}$$

$$W_{ork}. = P_{ress} \times V_{ol} = A.V.$$

$$Q = mc\Delta t$$

$$\Delta l = l_o\alpha\Delta t$$

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$PV = mRT$$

$$\in = \frac{x}{l}$$

$$E = \frac{\sigma}{\in}$$

$$\sigma = \frac{F}{A}$$

$$E = \frac{Fl}{Ax}$$

$$\overline{y} = \frac{A_1y_1 \pm A_2y_2 \ldots}{A_1 \pm A_2 \ldots}$$

$$\overline{y} = \frac{v_1y_1 \pm v_2y_2 \ldots}{v_1 \pm v_2 \ldots}$$

Centroid of half a circle is 0,424r

Centroid of triangle is $C = \frac{h}{3}$

Centre of gravity of half a circle is $G = \frac{3}{8}r$

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^{-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