higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

4 April 2018 (X-Paper)
09:00–12:00

This question paper consists of 8 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 the steps in between your answers.
7. Use only BLUE or BLACK ink.
8. ALL the 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 displacement

1.1.2 Elasticity

(2 × 1) (2)

1.2 State the TWO characteristics of liquid. (2)

1.3 Name the THREE types of hydraulic accumulators. (3)

1.4 Discuss Boyle's gas law in detail (in your answer show the statement, equation, and the sketch). (4)

1.5 State the following laws in detail:

1.5.1 Pascal's law (1)

1.5.2 Newton's second law of motion (2)

1.6 In your own words, explain what is meant by the following:

'The efficiency of the hydraulic press is 95%'

Your answer should reflect the volumes in the hydraulic press. (1)

1.7 Write down the equation that explains Newton's second law of motion. (1)

1.8 Write down the combination of Charles's and Boyle's laws. (1)
[17]

QUESTION 2: KINEMATICS

2.1 An aircraft with an airspeed of 330 km/h takes off from the OR Tambo International Airport in the direction N35°W. The aircraft is blown off course by a wind of 90 km/h from the direction W42°S.

Calculate the resultant velocity of the aircraft. (5)

2.2 Two vehicles start moving simultaneously. Vehicle P moves at 200 km/h W44°N while vehicle Q moves at 200 km/h directly east.

Calculate the velocity of Q relative to P. (5)

2.3 A body is projected at such an angle that the maximum height is two-thirds of the range. The initial velocity is 350 m/s.

Calculate the angle of the projectile. (5)
[15]

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.

3.1 A blue racing car with a mass of 1,8 tons races around a circular path with a diameter of 120 m at a speed of 180 km/h and covers a distance of 35 m.

3.1.1 The angular displacement of the car is:

A 0,835 rad
B 0,524 rad
C 0,355 rad
D 0,583 rad (2)

3.1.2 The angular velocity of the car is:

A 0,535 rad/s
B 0,825 rad/s
C 0,582 rad/s
D 0,833 rad/s (2)

3.2 A machine has a torque of 228 Nm at its spindle. The diameter of the spindle is 68 cm and the rotational frequency of the spindle is 12,5 rad/s.

3.2.1 The power exerted is:

A 1,85 kW
B 2,55 kW
C 1,58 kW
D 2,85 kW (2)

3.2.2 If the efficiency of the machine is 94%, the input power of the machine is:

A 2,30 kW
B 3,30 kW
C 3,03 kW
D 2,30 kW (2)

3.2.3 The angular velocity of the machine is:

A 12,5 rad/s
B 10,5 rad/s
C 4,5 rad/s
D 7,5 rad/s (1)

[9]

QUESTION 4: DYNAMICS

4.1 A car with a mass of 1 ton is travelling on a horizontal road and increased its kinetic energy from 4,9 kJ to 9,3 kJ over a distance of 200 m on a smooth horizontal road.

Calculate the following:

4.1.1 The acceleration of the car on a smooth horizontal road (2)

4.1.2 The kinetic energy of the car when it has travelled 140 m. (3)

4.2 A soccer star is travelling in a car with a mass of 880 kg on a horizontal road at a velocity of 30 m/s; he immediately applies the brakes so as to stop 50 m away. The resistance to motion on the horizontal road is 295 N.

Calculate the following:

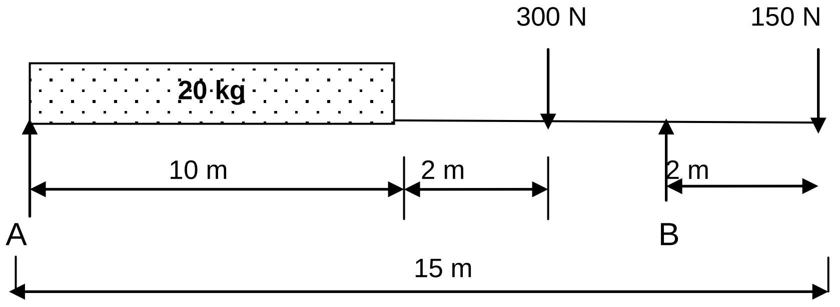
4.2.1 The deceleration of the car (2)

4.2.2 The braking force (4)

[11]

QUESTION 5: STATICS

5.1



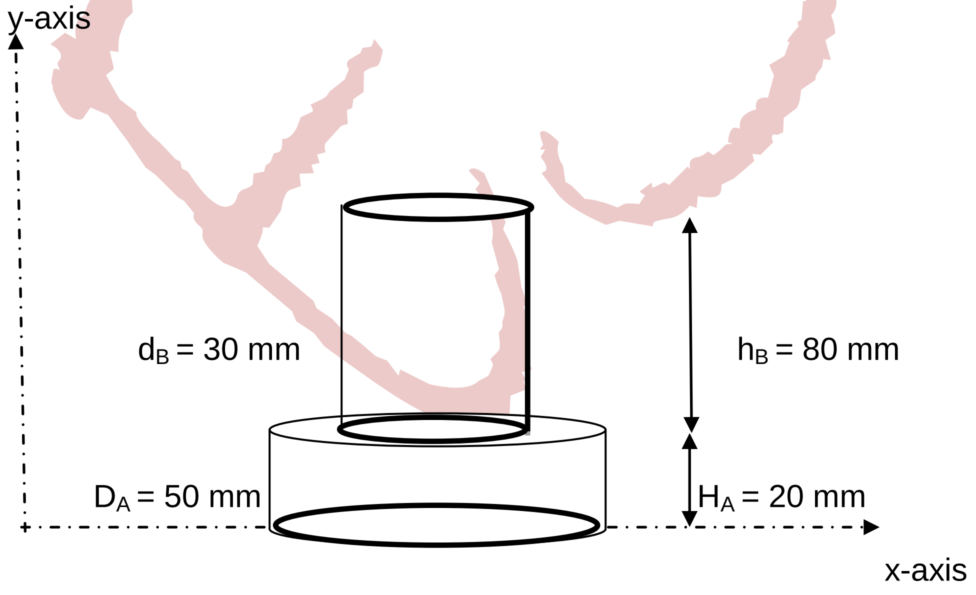
5.1.1 Calculate the magnitude of the supports. (2)

5.1.2 Draw the shear force diagram of the above beam in detail. (2)

5.1.3 Calculate the magnitude of the bending moments at the main principal points. (5)

5.1.4 Draw the bending moment diagram in detail. (2)

5.2



Calculate the position of the centre of gravity **y**. (4)

[15]

QUESTION 6: HYDRAULICS

6.1 The plunger of a hydraulic press has a diameter of 120 mm with a stroke length of 580 mm while the diameter of the ram is 220 mm. 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 and efficiency on the press is 94,6%. (5)

6.1.2 The distance the ram moved when the efficiency is 94,6%. (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 4,8%. (3)

6.3 The ram diameter of a hydraulic accumulator is 444 mm and the load is 1 200 000 N.

Calculate the following:

6.3.1 The operating pressure

6.3.2 The energy stored if the ram is lifted 1,8 m

(2 × 2) (4)

[14]

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

7.1 A square bar of sides 120 mm and the length of 0,95 m is axially loaded on the square sides by a force of 300 kN. Young's modulus of elasticity of the material of 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 the 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 0,880 tons is loaded into the lift. (5)

[9]

QUESTION 8: HEAT

8.1 A metal ball has a volume of 0,77 m^3. The coefficient of cubic expansion for this metal is 17×10^{-6}/K.

Calculate the volume if the temperature of the ball is raised by 233 K. (3)

8.2 A 2 m^3 cylinder containing air at 25 °C and 550 kPa is connected by means of a valve to another cylinder contacting 6 kg of air at 35 °C and 220 kPa. When the valve is opened, the entire system is allowed to reach a thermal equilibrium with the surroundings at 20 °C. The gas constant of the air is 287 J/kg.K.

Calculate the following:

8.2.1 The volume of the second cylinder before the valve was opened (3)

8.2.2 The final equilibrium pressure of the air (4)
[10]

TOTAL: 100

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FORMULA SHEET (Useful information)

Any applicable formula may also be used.

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

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

$$\theta = 2\pi n$$

$$S = R\theta$$

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

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

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

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

$$v = \omega R$$

$$v = \pi D n$$

$$a = \alpha R$$

$$\tau = FR$$

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

$$P = 2\pi n T$$

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

$$P = T\omega$$

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

$$v = u + at$$

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

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

$$P = Fv$$

$$F_a = ma$$

$$E_p = mgh$$

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

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

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

$$m = \rho \times vol$$

$$P = \rho g h$$

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

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

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

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

$$Q = mc\Delta t$$

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

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$PV = mRT$$

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

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

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

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

$$\bar{y} = \frac{A_1 y_1 \pm A_2 y_2 \ldots}{A_1 \pm A_2 \ldots}$$

$$\bar{y} = \frac{v_1 y_1 \pm v_2 y_2 \ldots}{v_1 \pm v_2 \ldots}$$

Centroid of half circle 0.424r

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

Centre of gravity half 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