higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T560**(E)**(J30)T

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

30 July 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. Questions must be answered in 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 Resultant velocity

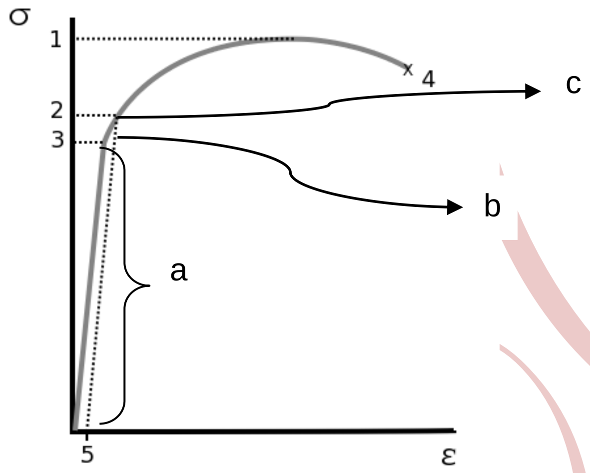
1.1.2 Shear force

(2 × 1) (2)

1.2 State Newton's second law of motion. (2)

1.3

Stress-strain graph of tensile test on a steel rod



Answer the following questions referring to the stress strain graph of a tensile test on a steel rod (above).

1.3.1 What is the meaning of the straight line with reference to the steel rod? (1)

1.3.2 Point 'b' represents elastic limit.

Explain what happens to the steel rod at the point. (2)

1.4 What is the direction of the north-westerly wind that is blown at 95 m/s? (1)

1.5 Explain the following:

1.5.1 'The percentage slip of hydraulic press is 5%'. Your answer should reference the volumes in the press.

1.5.2 'Pressure is directly proportional to the depth of the volume'. This is one of the characteristics of pressure in the volume.

(2 × 1) (2)

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

1.7 Discuss Charles' gas law in detail (in your answer show the statement, equation and the sketch) (4)
[16]

QUESTION 2: KINEMATICS

2.1 A Rooivalk fighter jet flies at a velocity of 300 km/h. It takes off from Waterkloof Air Base in a direction North 40° West. It is then blown off course by a wind of 100 km/h from a direction West 20° South.

Answer the following:

2.1.1 Draw the velocity vector diagram in detail. (2)

2.1.2 Calculate the resultant velocity. (3)

2.1.3 Determine the direction of flight. (1)

2.2 Two vehicles move simultaneously, vehicle P moves at 220 km/h east while vehicle Q moves at 220 km/h in a direction W30° N.

Calculate the velocity of vehicle P relative to Q. (4)

2.3 During a forensic investigation of the State vs Jack The Sniper', it was found that Jack shot the mayor with a gun from the ground at an angle. The mayor was 210 m above the ground on a building. The speed of the bullet was 230 m/s. It took three seconds to hit the mayor after shooting.

Calculate the angle of projection that was used. (3)
[13]

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 (3.1–3.4) in the ANSWER BOOK.

The minute arm of a tower clock is 1,8 m long. It took 35 minutes to move from 2 to 9.

3.1 The angular displacement of the minute arm is …

A 2,345 rad.
B 3,665 rad.
C 3,345 rad.
D 2,665 rad.

3.2 The arc length produced by the tip of the minute arm is …

A 4,835 m.
B 5,524 m.
C 6,597 m.
D 4,524 m.

3.3 The angular velocity of the minute arm is …

A $2,327 \times 10^{-3}$ m.
B $1,745 \times 10^{-3}$ m.
C $2,117 \times 10^{-3}$ m.
D $1,227 \times 10^{-3}$ m.

3.4 The linear velocity/tangential velocity of the minute arm is:

A $2,447 \times 10^{-3}$ m/s.
B $4,189 \times 10^{-3}$ m/s.
C $4,447 \times 10^{-3}$ m/s.
D $3,141 \times 10^{-3}$ m/s.

(4 × 2) **[8]**

QUESTION 4: DYNAMICS

4.1 A priest is in a rested motorcar, with a mass of 780 kg, at the top of a slope of 80%. When he releases the brakes of the motorcar, it moves freely down for 25 m due to gravitational force to the bottom of the slope and then immediately onto a horizontal road until it comes to a rest at the bottom of the slope.

Calculate the following:

4.1.1 The velocity of the motorcar at the bottom of the slope. (3)

4.1.2 The deceleration of the motorcar on the horizontal road, if it took 12 seconds to travel on the horizontal road. (2)

4.1.3 What is the kinetic energy of the motorcar after 12 seconds on the horizontal road? (1)

4.2 A car of 1,8 ton is travelling on a horizontal road at 20 m/s. There is a frictional force of 110 N/ton. When the brakes are applied the car comes to a standstill after 35 m.

Calculate the following:

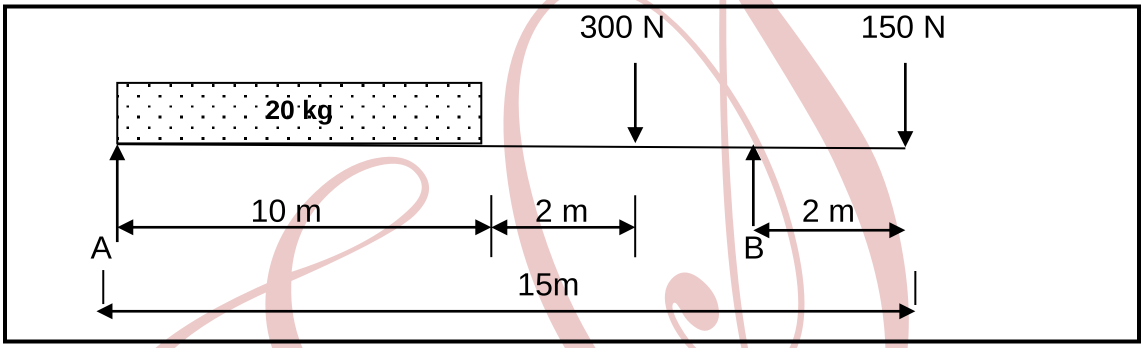
4.2.1 Deceleration of the car

4.2.2 The braking force

(2 × 3) (6)
[12]

QUESTION 5: STATICS

5.1



Calculate:

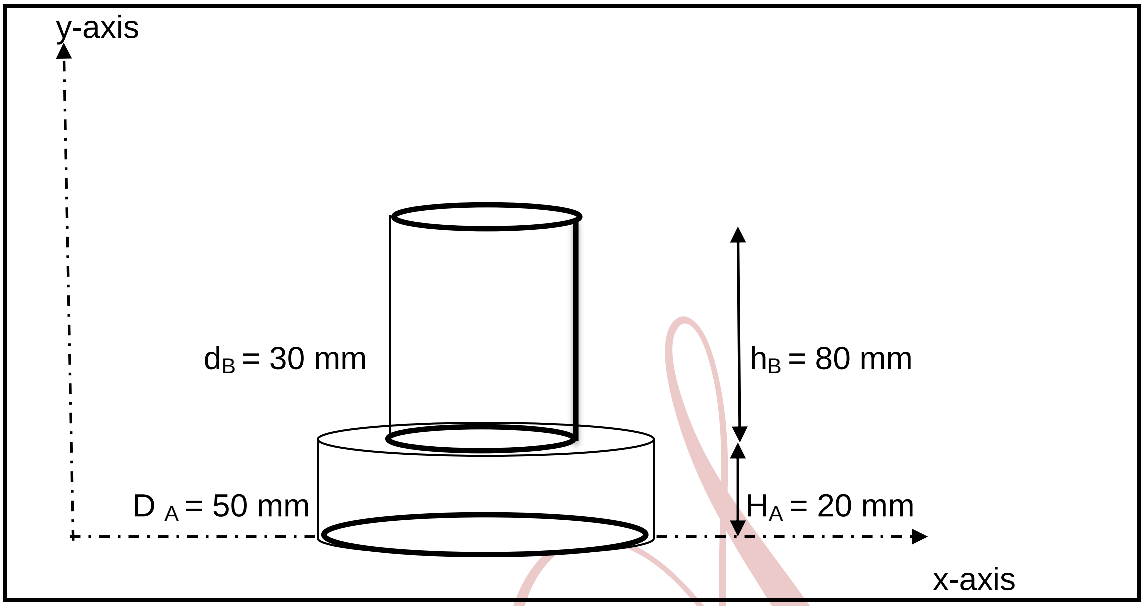
5.1.1 The magnitude of the supports. (2)

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

5.1.3 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 position of the Centre of gravity, y. (4)
[15]

QUESTION 6: HYDRAULICS

6.1 The plunger of a hydraulic press has a diameter of 90 mm with a stroke length of 480 mm while the diameter of the ram is 180 mm. The mechanical advantage of the plunger is 18.

Calculate:

6.1.1 The force to be applied to the leaver to lift a load of 4,2 Mg if efficiency is 96% (5)

6.1.2 The number of the pumping strokes needed to lift the load of 220 mm at efficiency of 96%. (3)

6.2 The plunger of a two-cylinder pump has a diameter of 150 mm and a stroke length of 250 mm.

Calculate:

6.2.1 The volume delivered in *l*/s. (4)

6.2.2 The slip% if the volume delivered in 16.789 *l*/s. (2)
[14]

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

7.1 The ratio of external diameter to internal diameter of a steel pipe is 3:1. A compressive force of 620 kN is applied and the length decreases by 0,771 mm. Young's modulus of elasticity of the material is 209 Gpa. The initial length of the pipe is 3 m.

Calculate the external and the internal diameter of the pipe. (6)

7.2 A steel wire of 4 m length and 8 000 mm^2 cross-sectional area hangs vertically. A load of 38 kN is applied to the end of the wire and it extends by 0,51 mm.

Calculate:

7.2.1 The stress

7.2.2 The strain

7.2.3 The Young's modulus of elasticity of the steel

(3 × 2) (6)
[12]

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:

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.

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

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

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

$\theta = 2\pi n$

$S = R\theta$

$\omega = 2\pi N$

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

$\omega_2 = \omega_1 + \alpha t$

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

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

$v = \omega R$

$v = \pi D n$

$a = \alpha R$

$\tau = FR$

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

$P = 2\pi n T$

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

$P = T\omega$

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

$v = u + at$

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

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

$P = Fv$

$F_a = ma$

$E_p = mgh$

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

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

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

$m = \rho \times vol$

$P = \rho g h$

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

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

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

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

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

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

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

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