201208T130

higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T660(**E**)(J27)T
AUGUST 2012

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

27 July (X-Paper)
09:00 – 12:00

This question paper consists of 6 pages, 1 formula sheet and 1 information sheet.

QUESTION 1

1.1 A light aircraft is flying at 250 km/h in calm weather. A wind is blowing from the north-west at 30 km/h. Calculate the direction in which the pilot has to steer in order to fly due south, as well as the resultant velocity of the aircraft in relation to the ground. (4)

1.2 A train is travelling in an easterly direction at 100 km/h. A passenger notices an aeroplane appearing to fly at 150 km/h north. Calculate the actual velocity and direction of the aeroplane. (4)

1.3 A stone is projected vertically upwards at a velocity of 50 m/s.

Calculate:

1.3.1 The time it takes the stone to reach the ground again (2)

1.3.2 The maximum height reached by the stone (2)

1.4 A bullet is fired at such an angle that the horizontal displacement is three times the maximum height reached by the bullet. The initial velocity of the bullet is 150 m/s.

Calculate the angle of projection. (5)

[17]

QUESTION 2

2.1 Define *angular displacement.* (2)

2.2 The wheel of a motorbike has a diameter of 40 cm and accelerates from 4 rad/s to 10 rad/s in 20 seconds.

Calculate the following:

2.2.1 The angular acceleration of the wheel (2)

2.2.2 The angular displacement of the wheel in radians (2)

2.2.3 The number of revolutions completed by the wheel during this time (2)

2.3 The wheel of a belt drive has a diameter of 36 cm and rotates at 500 r/min. The belt is subjected to an effective force of 400 N. Calculate the power transmitted by the belt. (4)

[12]

QUESTION 3

3.1 Define *Newton's Third Law.* (1)

3.2 A locomotive is pulling a train with a mass of 150 ton up a hill with an incline of 10° at a constant velocity of 72 km/h. The train experiences a frictional force of 8 000 N.

Calculate the power required by the engine of the locomotive to pull the train. (3)

3.3 A toy car with a mass of 1 kg is projected up an incline of 1 : 5 at an initial velocity of 1,5 m/s. Calculate the distance that the car will move up the incline before coming to rest. Ignore all losses due to friction. (5)

[9]

QUESTION 4

4.1 A light, horizontal beam ABCDE is 7 metres long. It is supported at two points, B and D, each 1 metre from the ends of the beam. The beam carries the following loads:

A concentrated load of 30 kN at the left end, point A
A concentrated load of 40 kN, 2 metre from the right end at point C
A concentrated load of 40 kN, at the right end, point E
A uniformly distributed load of 5 kN/m over the first 5 metres from the left

4.1.1 Make a neat, labelled diagram of the beam as described above. (1)

4.1.2 Calculate the reactions of the supports at points B and D. (3)

4.1.3 Calculate the bending moments at the supports and also at a point 5 metres from the left. (3)

4.1.4 Draw a shear force diagram and a bending moment diagram and show all the main values on the diagrams. (5)

4.1.5 Calculate the magnitude of the maximum bending moment and its position. (4)

4.2 Write down the positions of the following:

4.2.1 The centroid of a triangular plate with a perpendicular height *h*, resting on one of its sides and measured from this baseline (1)

4.2.2 The centre of gravity of a cone with a perpendicular height *h* and radius *r*, resting on its circular base (1)

[18]

QUESTION 5

5.1 Define the term *density*. (1)

5.2 Name TWO important facts relating to the pressure exerted by liquids. (2)

5.3 The information below refers to a single-acting hydraulic press:

Cross-sectional area of the plunger	= 30% of that of the ram cross-sectional area
Stroke length of the plunger	= 0,2 m
Force exerted on the plunger	= 600 N
Cross-sectional area of the ram	= 0,2 m²

Ignore all losses and calculate:

5.3.1 The volume of liquid displaced after 12 pumping strokes of the plunger (2)

5.3.2 The distance moved by the ram, in mm, after 1 stroke of the plunger (2)

5.3.3 The force exerted by the ram (2)

5.3.4 The mechanical advantage of the press (2)

5.3.5 The pressure in the liquid (2)

5.4 The plungers of a two-cylinder, single-acting pump have diameters of 8 cm each and stroke lengths of 30 cm each. The pressure during the delivery stroke is 1 MPa.

Calculate the following:

5.4.1 The power required to drive the pump at 200 r/min if the efficiency of the motor is 85% (4)

5.4.2 The volume of water delivered per minute if there is no slip (3)

[20]

QUESTION 6

6.1 Explain the difference between *tensile stress* and *compressive stress*. (2)

6.2 A concrete pillar with a diameter of 60 cm is used in a construction. The pillar is subjected to a compressive stress of 5 MPa. Calculate the maximum load allowed on the pillar. (3)

6.3 A bar with a square profile of 25 mm x 25 mm is subjected to a tensile test. A load of 100 kN causes an extension of 0,3 mm. The initial length of the bar was 330 mm.

Calculate the following:

6.3.1 The stress in the bar (2)

6.3.2 The strain (2)

6.3.3 Young's modulus of elasticity of the material (2)
[11]

QUESTION 7

7.1 Define *Boyle's law* using a brief definition, writing down an equation and drawing a graph to illustrate the law. (5)

7.2 A piece of thin solder wire (an alloy of lead) with an original length of 10 cm is used during a demonstration to illustrate the concept of linear expansion. It is established that the change in temperature of the wire is 60 °C. The final length of the wire is 10,01722 cm. Calculate the linear expansion coefficient of the solder wire. (3)

7.3 Nitrogen gas is contained in a closed cylinder with a volume of 10 ℓ at a temperature of 15 °C. The pressure inside the cylinder is 1 600 kPa. The temperature decreases to 5 °C.

Calculate:

7.3.1 The pressure at the lower temperature (3)

7.3.2 The mass of the nitrogen gas contained in the cylinder if the gas constant of nitrogen gas is 260 J/kg.K (2)
[13]

TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

$S = \frac{u+v}{2} \times t$

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

$v = u + at$

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

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

$v_g = \frac{u+v}{2}$

$\omega = 2\pi N$

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

$\theta = \frac{\omega_2 + \omega_1}{2} \times t$

$\omega_2 = \omega_1 + \alpha t$

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

$v = \omega R$

$\theta = 2\pi n$

$S = R\theta$

$\alpha = \frac{\omega_2^2 - \omega_1^2}{2\theta}$

$a = \alpha R$

$v = \pi DN$

$T = FR$

$AV = T\theta = WD$

$P = 2\pi NT$

$P = Fv$

$P = T\omega$

$F_a = ma$

$E_p = mgh$

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

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

$m = \rho \times vol$

$P = \rho gh$

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

$W.D. = P \times V = A.V.$

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

$AV = mgh = WD$

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

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

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

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