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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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APRIL EXAMINATION

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

(8060065)

10 April 2013 (X-Paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel sections BOE 8/2

Calculators may be used.

This question paper consists of 5 pages, a 3-page diagram sheet and a 2-page formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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STRENGTH OF MATERIALS AND STRUCTURES N5

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. Write neatly and legibly.

QUESTION 1

A steel rod is 4 m long with a diameter of 16 mm. A weight of 300 N is suddenly applied to the rod. E = 200 GPa.

Calculate the following:

1.1 The instantaneous extension (4)

1.2 The instantaneous stress (2)

1.3 The strain energy (2)
[8]

QUESTION 2

A compound shaft is formed by shrinking a bronze bush onto a solid steel shaft. The torque transmitted by the bush is twice that transmitted by the solid shaft. The shaft of the external diameter and the inside diameter of the bronze bush is 60 mm.

G_{steel} = 205 GPa, G_{bronze} = 82 GPa, T_{steel} = 85 MPa, T_{bronze} = 50 MPa.

Calculate the following:

2.1 The external diameter of the bush (7)

2.2 The torque transmitted by each material and also the total torque (7)

2.3 The power transmitted by the compound shaft when it is rotating at 1 450 r/min (2)
[16]

QUESTION 3

A water channel (FIGURE 1, DIAGRAM SHEET 1) is manufactured from plate metal with a thickness of 6 mm. The water channel is simply supported over a span of 12 m. The maximum bending stress is 120 MPa. Assume the density of water as 1 000 kg/m^3 and the density that of plate metal as 8 000 kg/m^3.

Calculate the maximum allowable depth of the water in the channel, taking the weight of the empty channel into consideration. **[19]**

QUESTION 4

A short strut comprises of two channel sections that are positioned back-to-back as shown in FIGURE 2, DIAGRAM SHEET 2. The composite strut has a height of 6 m and the critical stress of the strut is 300 MPa. Take $a = \frac{1}{7\,500}$ and the ends are hinged.

Calculate the following:

4.1 The second moment of area about the XX-axis. (4)

4.2 The second moment of area about the YY-axis (4)

4.3 The load that can be applied to the strut if the factor of safety is 2 and when using the Rankine formula (7)

[15]

QUESTION 5

A compound bar consists of a steel pipe and a copper rod that fits inside the steel pipe. The initial length of both the steel pipe and the copper rod is 840 mm and the cross-sectional area of the steel pipe and the copper rod is 500 mm^2 and 640 mm^2 respectively.

E_{steel} = 210 GPa; E_{copper} = 105 GPa; $\alpha_{steel} = 12\times10^{-6}$/°C; $\alpha_{copper} = 18\times10^{-6}$/°C.

Calculate the following:

5.1 The stress in the copper and steel if the temperature is increased by 50 °C (7)

5.2 The resultant stresses induced by both metals due to the rise in temperature and the application of an external compressive force of 40 kN (7)

5.3 The final length of the compound bar (4)

[18]

QUESTION 6

A pressure vessel with a diameter of 1,5 m is made from plate 16 mm thick. The joints are double-riveted butt joints with two cover plates, each 12 mm thick. The diameter of the rivets is 40 mm and the pitch of the rivets is 130 mm. The pressure vessel must withstand a pressure of 1,2 MPa.

Calculate the following:

6.1 The joint efficiency for tearing of the plate (1)

6.2 The tensile stress in the plate (3)

6.3 The shear stress in the rivets (3)

6.4 The crushing stress (3)
[10]

QUESTION 7

Determine graphically the magnitude and nature of forces in each member of the framework shown in FIGURE 3, DIAGRAM SHEET 3. **[14]**

TOTAL: 100

DIAGRAM SHEET 1

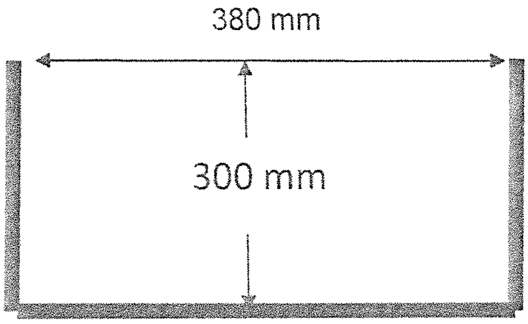


FIGURE 1

DIAGRAM SHEET 2

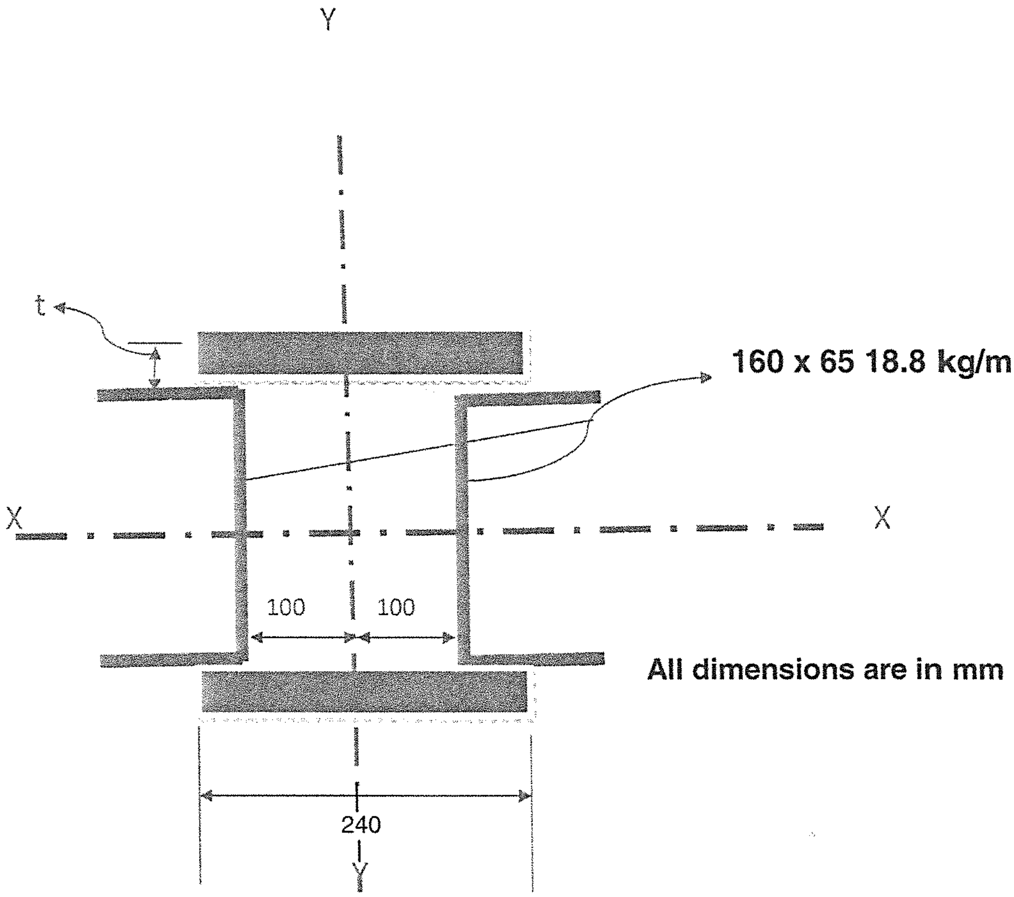
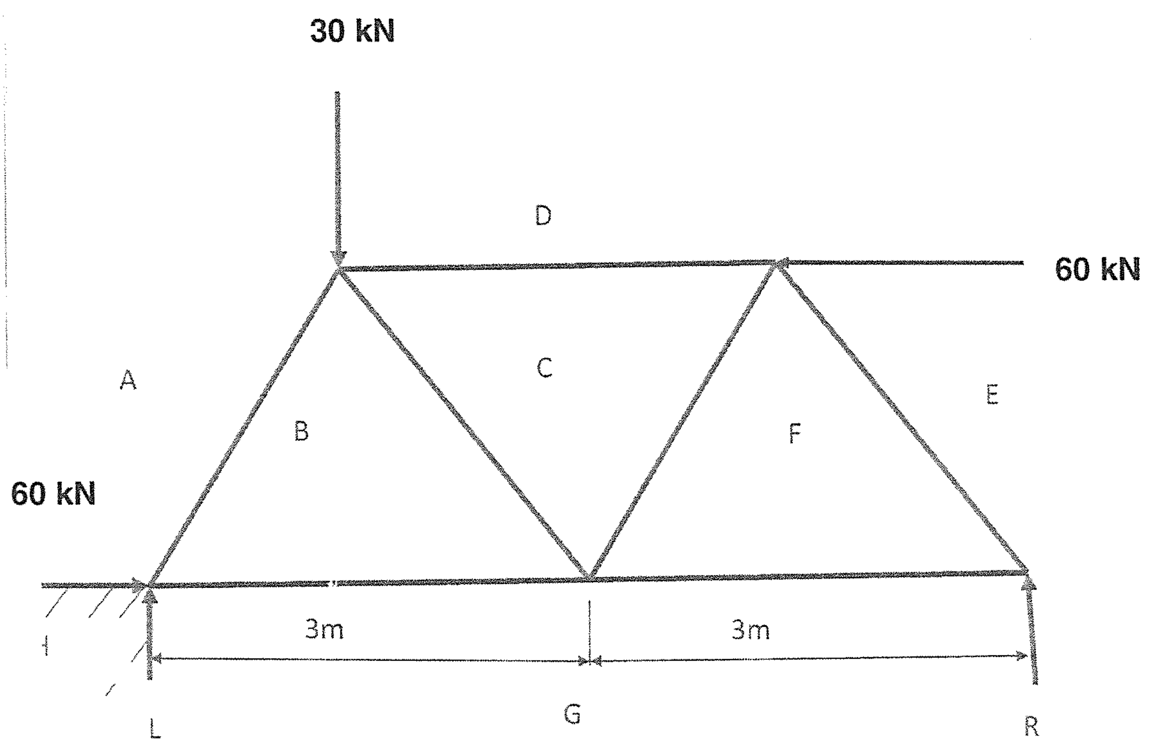


FIGURE 2

DIAGRAM SHEET 3



All interior angles are equal

FIGURE 3

STRENGTH OF MATERIALS AND STRUCTURES N5

Any applicable equation or formula may be used.

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

$$\epsilon = \frac{X}{L}$$

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

$$F\left(\frac{1}{A_1E} + \frac{1}{A_2E}\right) = \Delta t(\alpha_2 - \alpha_1)$$

$$F\left(\frac{L_1}{A_1E} + \frac{L_2}{A_2E}\right) = L_1\alpha_1\Delta t + L_2\alpha_2\Delta t$$

$$U = \frac{1}{2}Fx$$

$$U = \frac{F^2L}{2AE}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$mg(h + \chi) = \frac{F^2L}{2AE}$$

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

$$J = \frac{\pi(D^4 - d^4)}{32}$$

$$T = \frac{\pi}{16}\tau\frac{(D^4 - d^4)}{D}$$

$$T = \frac{\pi}{16}\tau D^3$$

$$\theta = \frac{10{,}2\,TL}{GD^4}$$

$$\theta = \frac{10{,}2\,TL}{G(D^4 - d^4)}$$

$$P = 2\pi NT$$

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

$$M = \frac{WL}{8}$$

$$M = \frac{\omega L^2}{8}$$

$$M = \frac{WL}{4}$$

$$Z = \frac{I}{y}$$

$$M = \sigma Z$$

$$I = \frac{\pi}{64}(D^4 - d^4)$$

$$I = \frac{\pi}{64}D^4$$

$$I_{xx} = \frac{bd^3}{12}$$

$$F = \frac{\pi^2 EI}{L_e^2}$$

$$F = \frac{\sigma A}{1 + a\left(\frac{L_e}{k}\right)^2}$$

$$F = \frac{4\pi^2 EI}{L^2}$$

$$F = \frac{\sigma A}{1 + \frac{a}{4}\left(\frac{L}{k}\right)^2}$$

$$k = \sqrt{\frac{I}{A}}$$

$$S.v = \frac{L_e}{k}; \quad S.R = \frac{L_e}{k}$$

Hinged ends $L_e = L$

Fixed ends $L_e = \frac{L}{2}$

One end fixed, one end hinged $L_e = \frac{L}{\sqrt{2}}$

One end fixed, one end free $L_e = 2L$

$$\sigma = \frac{PD}{2 \, . \, t\eta}$$

$$\sigma = \frac{PD}{4 \, t\eta}$$

$$\eta = \frac{(p-d)\, t\sigma_t}{pt\sigma_t} \times 100$$

$$\eta = \frac{\frac{\pi d^2}{4} n\tau}{pt\sigma_t} \times 100$$

$$\eta = \frac{ndt\sigma_c}{pt\sigma_t} \times 100$$

$$\sigma_t (p-d)\, t = \frac{\pi d^2}{4} nt$$

$$(p-d)\, t\sigma_t = dtn\sigma_c$$