higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N5

(8090075)

1 April 2021 (X-paper)
09:00–12:00

OPENBOOK-EXAMINATION

Candidates may use textbooks, personal notes, calculators and mathematical tables.

This question paper consists of 6 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
MECHANICAL DRAWING AND DESIGN 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. Questions may be answered in any order, but subsections of questions must be kept together.
5. Show all the intermediate steps.
6. All the answers must be approximated accurately to THREE decimal numbers.
7. Where possible, standard size items must be used.
8. No exchange of notes, books or communication between candidates will be allowed during the examination.
9. Write neatly and legibly.

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QUESTION 1

A diesel truck transmission consists of a hub fitting over a splined shaft.

The following information is given:

Shaft diameter	80 mm
Outside diameter of splines	80 mm
Inside diameter of splines	70 mm
Length of the splines	55 mm
Shaft speed	133 r/min
Allowable shear stress in the splines	81 MPa
Number of splines	10

The width of each spline is equal to the gap between the splines.

Calculate:

1.1 The power that can be transmitted by the splines (9)

1.2 The force required to slide the hub axially under full load if the coefficient of friction is 0,12 (2)

1.3 The angle of twist of the solid shaft in degrees per metre length if the modulus of rigidity is 83 GPa (3)

[14]

QUESTION 2

2.1 A flat belt is used to drive two pulleys, each 450 mm in diameter. The driven pulley is situated directly below the driving pulley. The power transmitted is 16,5 kW and the belt speed is 18 metres per second. The belt tension ratio is 3:1 and the allowable stress in the belt material is 3,5 MPa. The belt is 8 mm thick.

Calculate:

2.1.1 The speed of the pulleys in revolutions per second (3)

2.1.2 The effective driving force of the belt (3)

2.1.3 The tension in the tight side and the slack side of the belt (4)

2.1.4 The width of the belt (3)

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2.2 The pulley mentioned in QUESTION 2.1 is keyed to a 50 mm diameter shaft midway between the two supporting bearings. The coefficient of friction between the shaft and the bearings is 0,04.

Calculate:

2.2.1 The reactive force on each bearing (2)

2.2.2 The total work done to overcome friction in joules per second (3)
[18]

QUESTION 3

3.1 Two 65 mm diameter shafts are coupled by means of a flanged coupling. Four hexagonal bolts on a pitch-circle diameter of 250 mm are used to secure the two halves of the coupling together. The ultimate shear stress in the shaft material and bolt material is 440 MPa. The shaft rotates at 90 revolutions per minute. Use a safety factor of 4.

Calculate:

3.1.1 The size of the bolts (4)

3.1.2 The torsion in the shaft due to the coupling bolts calculated in QUESTION 3.1.1 (3)

3.1.3 The power transmitted (3)

3.2 A rectangular key is used to key each coupling half, mentioned in QUESTION 3.1, to the shaft. The length of the key is 1,4 times the shaft diameter and the thickness of the key is 0,168 times the shaft diameter. The shear stress in the key is 110 MPa.

Calculate the size of the key. (4)
[14]

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QUESTION 4

The following information was given on a double-riveted lap joint:

Longitudinal joint efficiency	75%
Inside diameter of boiler	2,4 m
Steam pressure in the boiler	1,8 MPa
Allowable tensile stress for the plates	87 MPa
Allowable shear stress for the rivets	60 MPa
Allowable compressive stress for the rivets and the plates	108 MPa

Calculate:

4.1 The boiler plate thickness (4)

4.2 The rivet diameter. Use $d = 6\sqrt{t}$ (2)

4.3 The pitch of the rivets. Equate $F_t = F_s$ (4)

[10]

QUESTION 5

5.1 The 45 mm thick cover of a steam-engine cylinder with an internal diameter of 350 mm must resist a pressure of 1,45 MPa. The cover is secured to the 45 mm thick flange of the cylinder by means of 10 studs. The allowable tensile stress in the stud material is 38 MPa. The cylinder wall is 30 mm thick. Assume that core area = 0,85 nominal area (studs).

Calculate:

5.1.1 The diameter of the studs (6)

5.1.2 The pitch of the holes for the studs (3)

5.1.3 The outside diameter of the cover (1)

5.1.4 Test the cover for steam tightness on the cylinder flange (2)

5.2 A valve chest has a rectangular opening 320 mm wide and 410 mm long. The opening is covered with a rectangular cover plate using M24 bolts. The steam pressure in the valve chest is 1,5 MN/m². The allowable tensile stress in the bolts is 32 MPa. The bolts are in line and are positioned 35 mm from the edge of the opening. Assume that core area = 0,8 nominal area (bolts).

Calculate the following:

5.2.1 The total force exerted on the cover (4)

5.2.2 The number of bolts required for the cover to be steamtight (4)

[20]

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QUESTION 6

Two round rods, each with a 50 mm diameter, are joined by a parallel cotter joint.

The following safe stresses are given:

Tensile stress	130 MPa
Shear stress	80 MPa
Compressive stress	280 MPa

Calculate:

6.1	The tensile load on the rods away from the joints	(2)
6.2	The tensile load on the rod end at the cotter hole	(3)
6.3	The tensile load on the socket at the cotter hole	(3)
6.4	The shear load on the cotter	(2)
6.5	The crushing load between the cotter and the rod end	(2)
6.6	The crushing load between the cotter and the socket	(2)
6.7	The shear load on the collar of the rod end	(2)

[16]

QUESTION 7

A 60 mm diameter solid shaft is welded to a pulley by means of an 8 mm thick fillet weld. The shear stress of the weld is 78 MPa.

Calculate the force that the weld can withstand. **[8]**

TOTAL: 100

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