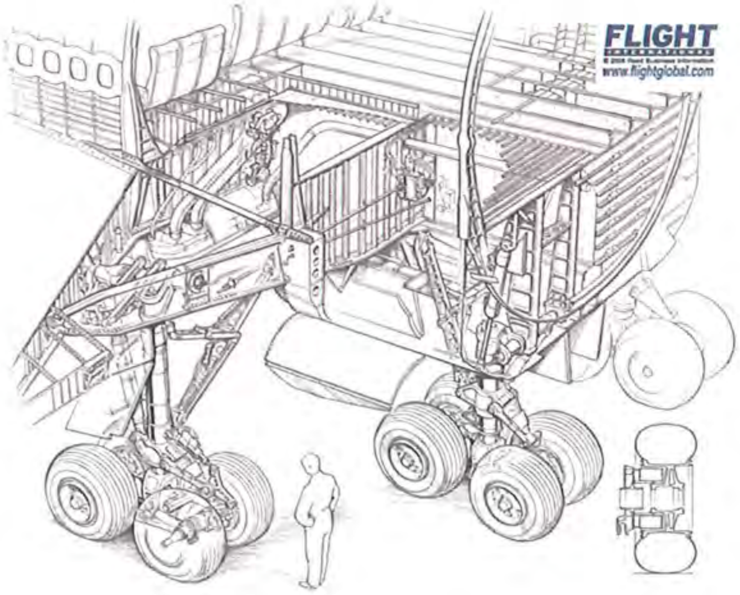
AE1103 - Statics



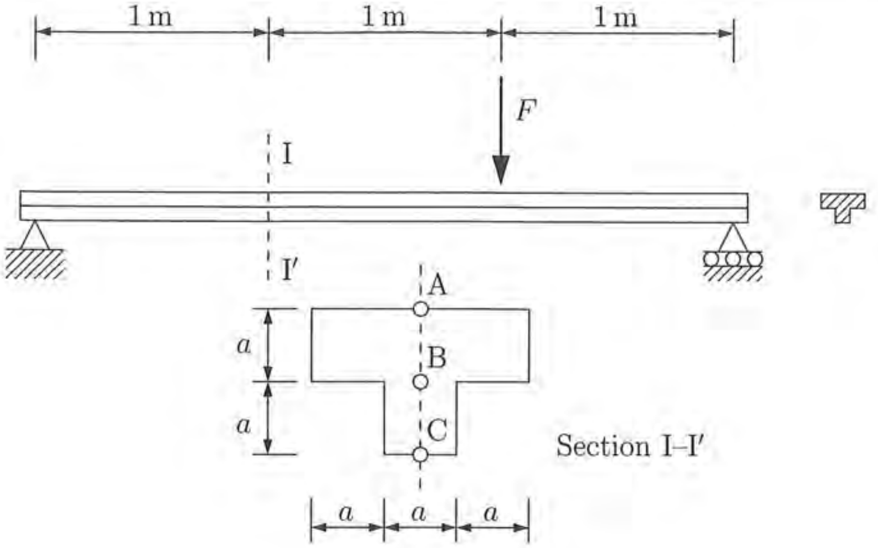
Assorted Exam Problems on Centroids & Area Moments of Inertia

23 September 2009

AE1-914 part III : 18 June 2002

Problem 3 (Weight 2, approx. 30 min.)

A simply supported T-beam is loaded by an unknown force F directed downwards. The normal stress at points A, B and C of section I–I′ is represented by σ_A, σ_B and σ_C respectively.



b) Calculate the position $\bar{y}$ of the centroid of the section with respect to point C and the central moment of inertia $\bar{I}$. Express these quantities as a function of distance a.

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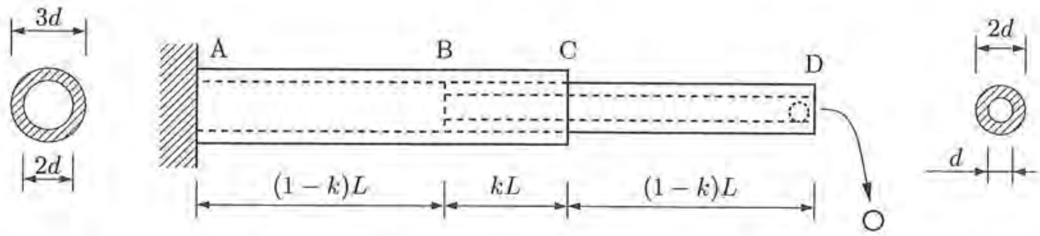
Answer sheets
Exam AE1-914 part III
June 18 2002, 14:00–17:00

Student id.:
Name:

Problem 4 (Weight 2.5, approx. 45 min.)

A work of art consists of two cylinders AC and BD fitted along a fraction k of their original length l, according to the figure. The left end A of the larger cylinder is fixed to the wall and a ball with weight W is placed in the right end D of the smaller cylinder. The exterior and interior diameter of each cylinder can be read from the figure and the elasticity modulus is E. The ball will fall down if the rotation of the right end D exceeds a threshold θ_0.



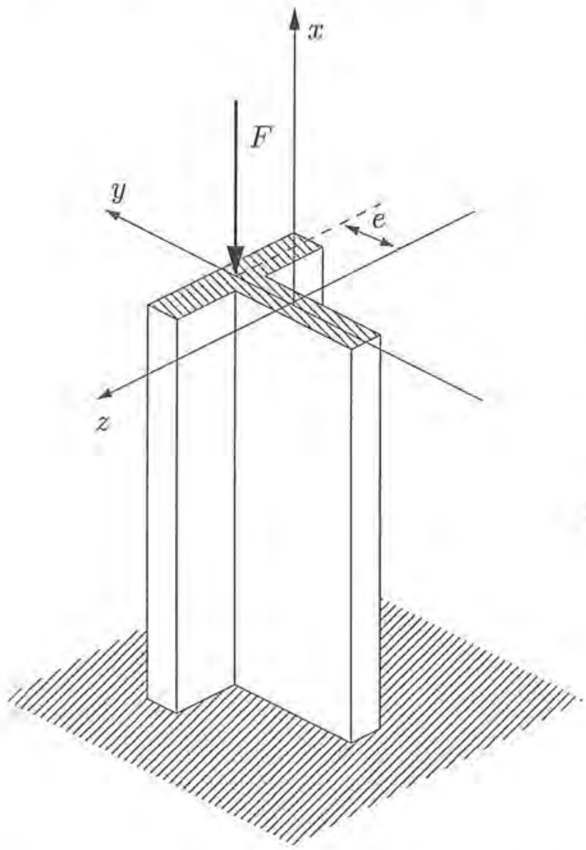
a) Calculate the central moment of inertia of the cross section of the work of art in segments AB, BC and CD. *Hint:* The central moment of inertia of a massive circular section of radius r is given by $\frac{\pi}{4}r^4$

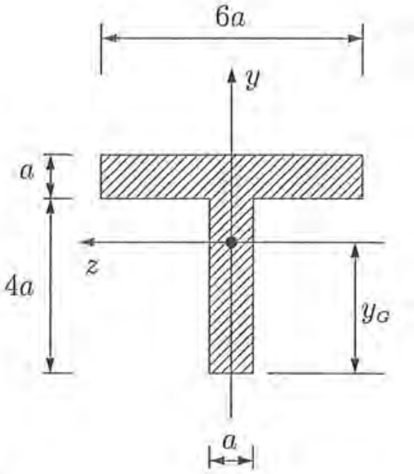
Answer sheets
Exam AE1-914 part III
August 22 2002, 14:00–17:00

Student id.:
Name:

Problem 2 (Weight 2.0, approx. 35 min.)

A single vertical force F with eccentricity e is applied to a short steel post with the represented T-section. The dimensions of the cross section can be read from the figure. The point of application of the force lays on the y-axis.





a) Calculate the position y_G of the centroid of the section with respect to the bottom of the section and the central moment of inertia I_z about the z-axis. Express these quantities as a function of distance a.

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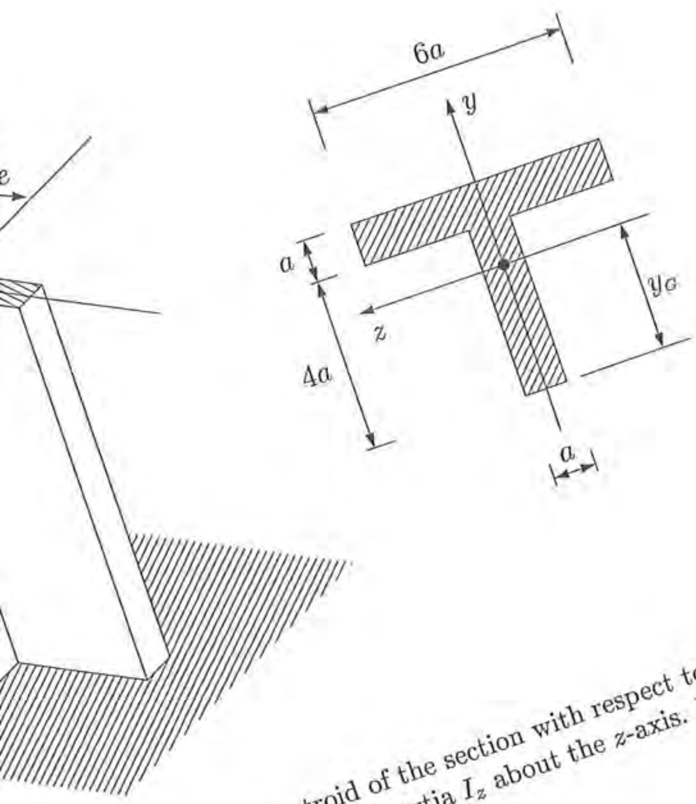
Student id.:
Name:

...e is applied to a short steel post with the
...he cross section can be read from the figure.
...on the y-axis.



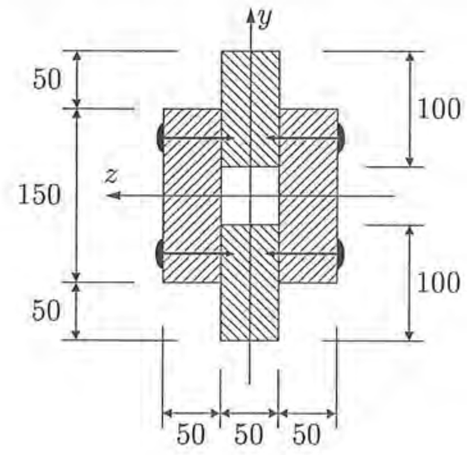
...the position y_G of the centroid of the section with respect to the bottom
...ction and the central moment of inertia I_z about the z-axis. Express these
...es as a function of distance a.

Answer sheets
Exam AE1-914 part III
August 22 2002, 14:00–17:00

Student id.:
Name:

Problem 3 (Weight 2.0, approx. 35 min.)

The built-up timber beam shown is subjected to a 6 kN vertical shear. The longitudinal spacing of the nails is $s = 60\,\text{mm}$. The dimensions are given in millimeters.



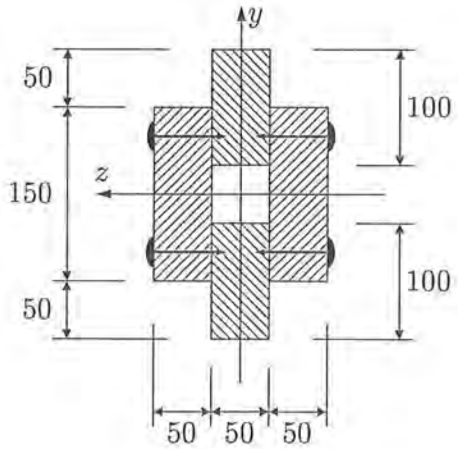
a) Calculate the central moment of inertia I_z.

Student id.:

Name:

Problem 3 (Weight 2.0, approx. 35 min.)

The built-up timber beam shown is subjected to a 6 kN vertical shear. The longitudinal spacing of the nails is $s = 60\,\text{mm}$. The dimensions are given in millimeters.

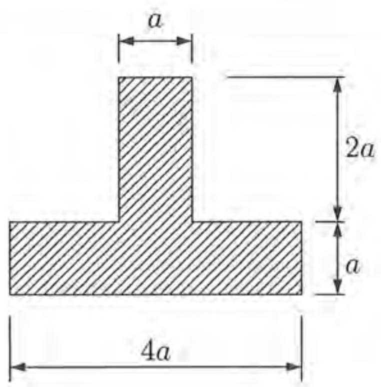


a) Calculate the central moment of inertia I_z.

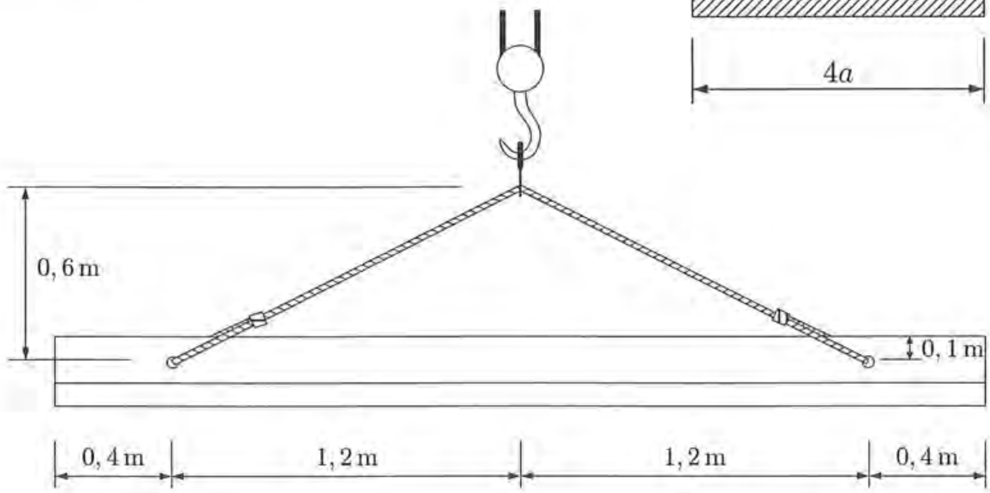
Student id.:

Name:

Problem 3 (Weight 3,5; approx. 70 min.)



A steel beam with the section represented in the right figure is being carried by a crane as shown below. The dimensions of the holes through which the cables are fastened can be neglected. The specific weight of the steel is $75\,\mathrm{kN/m^3}$.



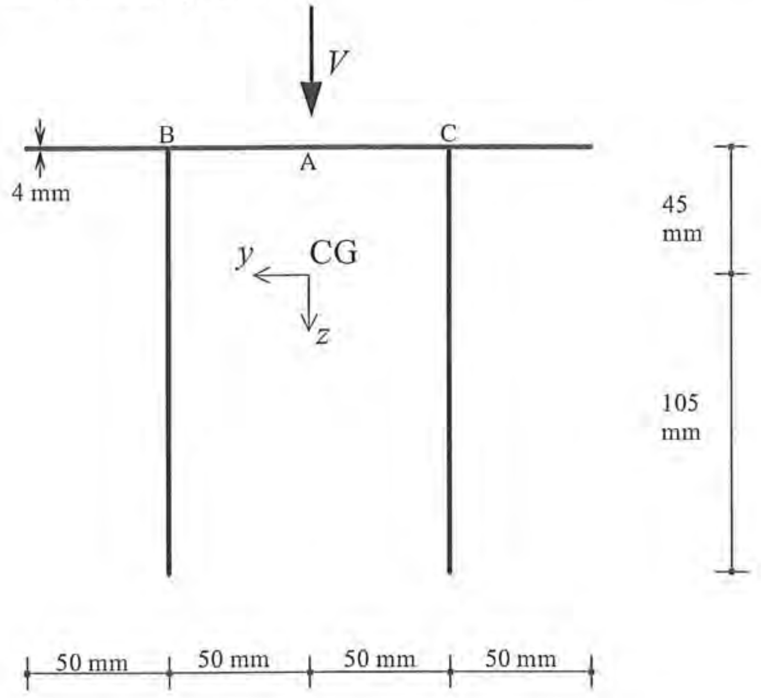
a) Calculate the cross-sectional area A of the section, the position $\bar{y}$ of the centroid with respect to the bottom and the central moment of inertia I_z for bending about a horizontal axis, as a function of a.

5

23/01/04

Answer sheets	Studyno:	
Exam Ae1-914 part III	Name:	

Problem 4 (Weight 2.5 – approx. 50 minutes)
The thin-walled profile represented below is loaded by a vertically downwards-acting shear force. The wall thickness is constant, t = 4 mm. The coordinate axis indicated goes through the centre of gravity, CG.



Questions:

a. Show that the position of the centre of gravity, CG is correct.

6

b. Show that the moment of inertia for bending is equal to: $I_y = 4950000\ \text{mm}^4$.

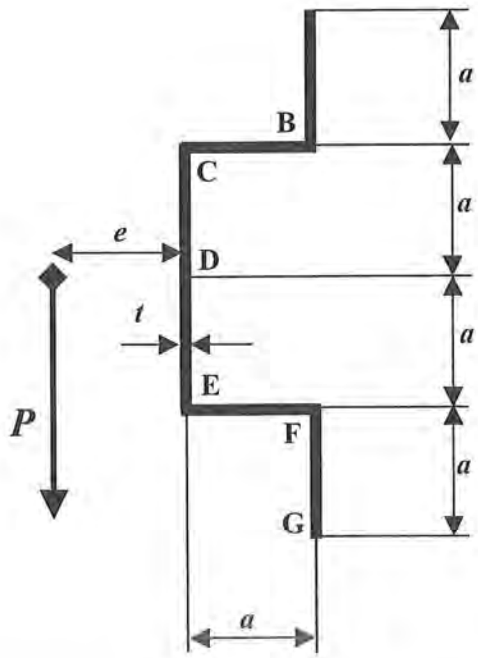
21/6/04

Answer sheets Studyno:

Exam Ae1-914 part III Name:

Problem 4 (Weight 2.5 - approx. 45 minutes)

The **thin-walled** ($t << a$) cross-section of a prismatic beam in the figure below has a constant wall thickness t. The cross-section is loaded by a shear force P which applies in the shear centre. The resulting shear force as a consequence of the shear stresses in part AB is F_{AB}, in part BC is F_{BC} and in part CE, F_{CE}. Given is that $F_{AB}=\frac{5}{44}P$.



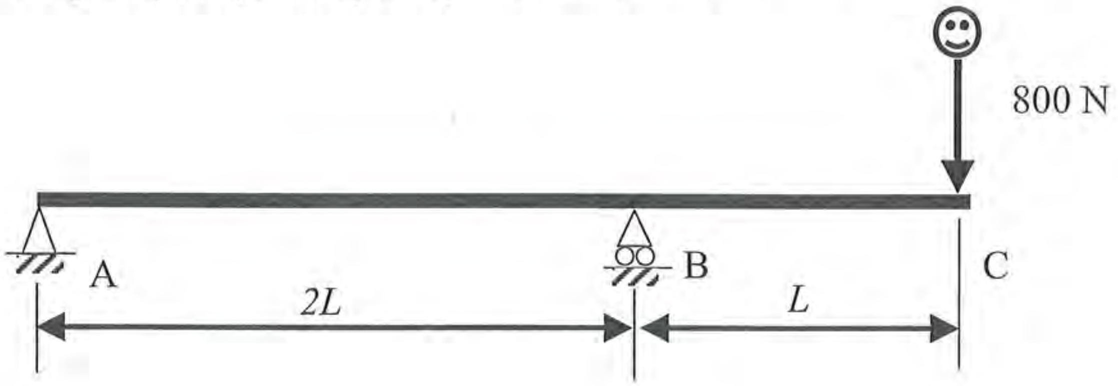
d. Show that the principal moment of inertia for bending due to the shear force P is equal to: $I=7\frac{1}{3}a^3t$

8

26/8/04

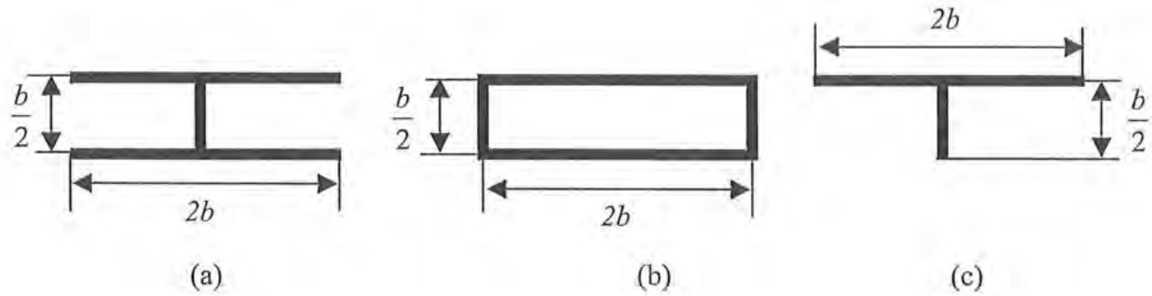
Problem 4 (Weight 2,5 – approx. 45 minutes)

Three **thin walled** cross-sections (a), (b) and (c) are being considered for use in diving boar ABC. All cross-sections have a constant wall thickness t. All other dimensions can be found in the figures below. We assume a static load of 800 N is applied in point C acting through the plane of symmetry of the cross-section.



The principal moment of inertia of cross-sections (a) and (b) are:

(a): $I = \frac{125}{480} b^3 t$ (b): $I = \frac{130}{480} b^3 t$



b) Show that the principal moment of inertia of cross-section (c) equals $I = \frac{17}{480} b^3 t$.

9

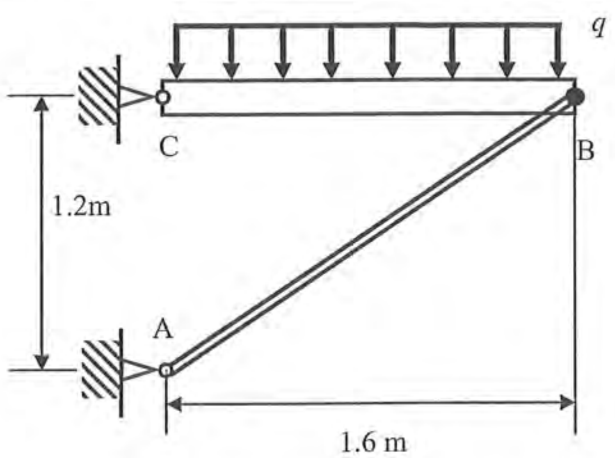
27/6/05

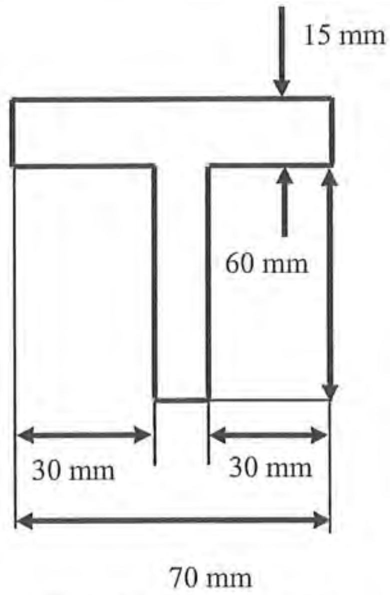
Answer sheets Studyno:

Exam Ae1-914 part III Name:

Problem 2 (Weight 2.5 - approx. 55 minutes)

The frame in the figure below supports a centrally applied distributed load of q = 18 kN/m. The hinges B and C are located in the centroid of the cross-section.





a. Show that the centroid of the cross-section lies at 21,14 mm from the top of the cross-section.

10

Answer sheets Studyno:

Exam Ae1-914 part III Name:

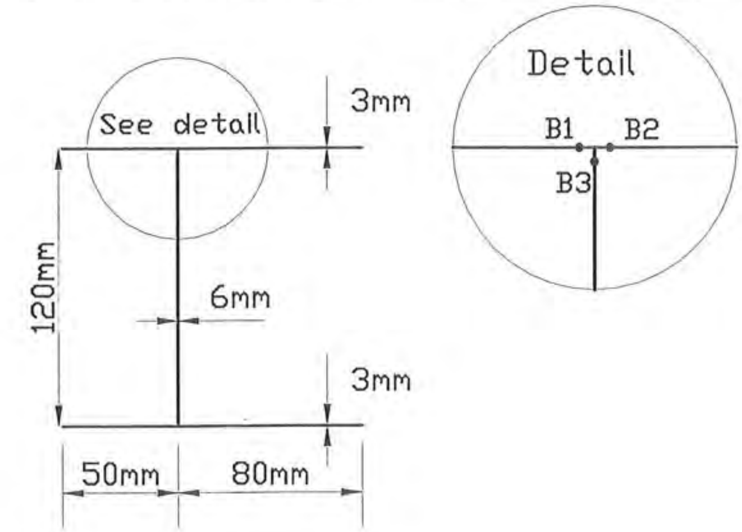
Problem 2 continued

b. Show that the principal moment of inertia for bending is equal to $I = 736619\ mm^4$.

3/4/06

Problem 4 (Weight 2.5 – approx. 45 minutes)

The **thin-walled** single-symmetric cross-section in the figure below is loaded by a vertical downwards acting shear force of 72 kN, which acts in the shear centre.



Questions:

c) Show that the principal moment of inertia for bending is equal to $I = 3.672 \times 10^6$ mm^4.

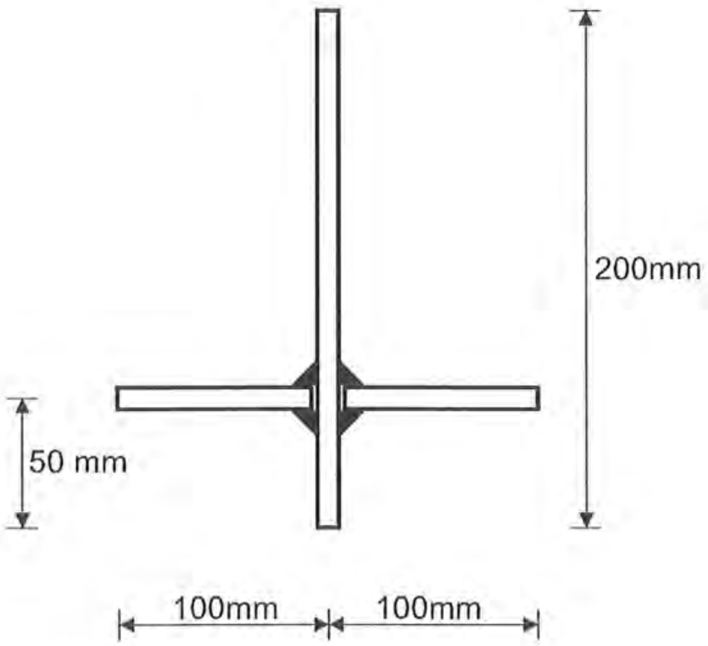
12

Antwoordformulier Studienummer:

Tentamen Ae1-914 deel III Naam:

Opgave 3 (gewicht 2.0 – ongeveer 35 minuten)

Een balk, waarvan in de figuur de dwarsdoorsnede is gegeven, is gemaakt van 3 met hoeklassen aan elkaar gelaste platen. Een hoeklas houdt in dat er alleen lasmateriaal aanwezig in de 4 getekende hoekjes en niet in de getekende spleet tussen een horizontale plaat en de verticale plaat. Elke plaat heeft een dikte van t = 12 mm. De dwarsdoorsnede mag als **dunwandig** worden opgevat. De dwarsdoorsnede wordt belast door een naar beneden gerichte dwarskracht gaande door het dwarskrachtmiddelpunt ter grootte van V = 100 kN.



a) Toon aan dat voor het relevante hoofdtraagheidsmoment I geldt: $I = 11 \times 10^6$ mm^4.

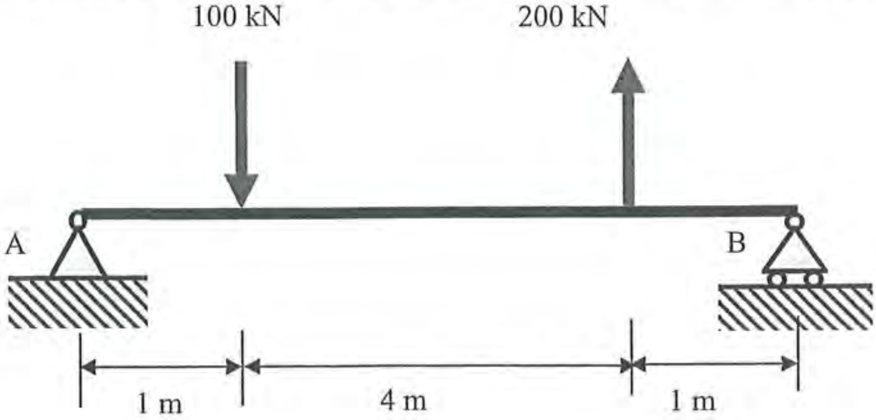
2/4/07

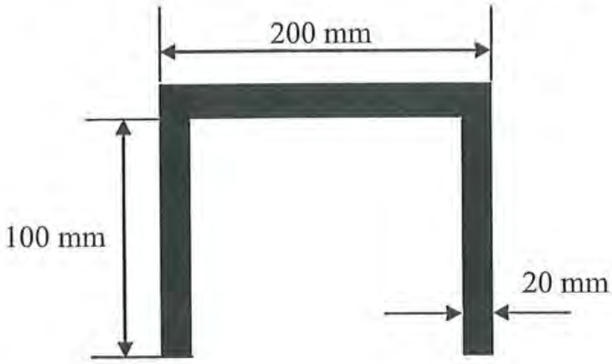
Answer sheets | Studyno:

Exam Ae1-914 part III | Name:

Problem 2 (Weight 2.0 - approx. 45 minutes)

The simply supported beam in the figure below is loaded by two forces, one of 100 kN and one of 200 kN, as shown. The beam has a cross-section as shown below. The cross-section is **NOT** thin-walled and has a constant wall thickness $t = 20$ mm.





Questions

a) Calculate the centre of gravity of the cross-section with respect to the top of the cross-section.

14

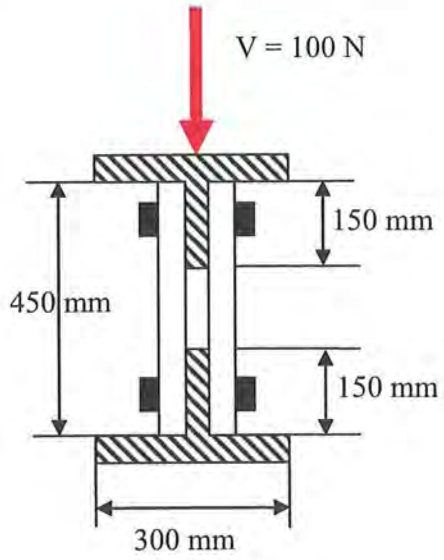
Answer sheets Studyno:

Exam Ae1-914 part III Name:

b) Calculate the principal moment of inertia for bending of the cross-section.

Problem 4 (Weight 2.0 - approx. 30 minutes)

The **thin-walled** structure in the figure below consists of two T-profile beams with wall thickness $t = 15$ mm bolted together by means of bolts and 2 thin webs each of thickness $t = 15$ mm. The structure is loaded by a vertical downwards directed shear force $V = 100$ N. All other dimensions are shown in the figure.



Questions

a) Show that the principal moment of inertia for bending of the cross-section is equal to $I = 793\ 125\ 000$ mm^4.

16

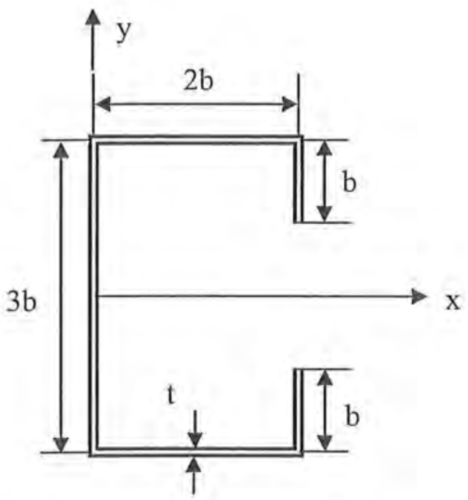
3/7/07

Answer sheets Studyno:

Exam Ae1-914 part III Name:

Problem 4 (Weight 2.0 - approx. 40 minutes)

The open **thin-walled** cross-section in the figure below is loaded by a vertical downwards acting shear force V which acts through the shear centre. All relevant dimensions are given in the figure below.
De open ***dunwandige*** *doorsnede in de onderstaande figuur wordt belast door een verticale naar beneden gerichte dwarskracht V die aangrijpt in het dwarskrachtencentrum (dwarskrachtmiddelpunt). Alle overige afmetingen staan in de figuur.*



b) Show that the principal moment of inertia for bending $I = \frac{161}{12} b^3 t$.

Toon aan dat het centrale hoofdtraagheidsmoment voor buiging $I = \frac{161}{12} b^3 t$.

17

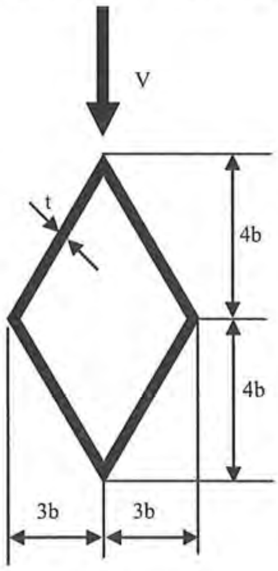
31/3/08

Answer sheets | Studyno: | [ ][ ][ ][ ][ ][ ][ ]

Exam Ae1-914 part III | Name:

Problem 4 (Weight 2.0 - approx. 30 minutes)

The **thin-walled** cross-section below is loaded by a vertical shear force V.
*De onderstaande **dunwandige** doorsnede wordt belast door een verticale dwarskracht V.*



Questions:

a) Show that the principal moment of inertia for bending is equal to $I = \frac{320}{3} b^3 t$.
Toon aan dat het centrale hoofdtraagheidsmoment voor buiging gelijk is aan $I = \frac{320}{3} b^3 t$.

18

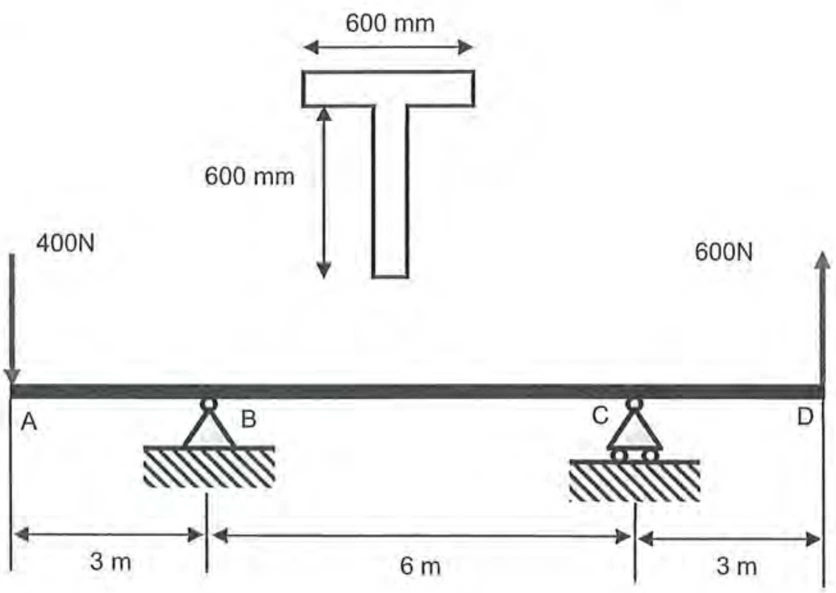
30/3/09

Answer sheets Studyno:

Exam Ae1-914 part III Name:

Problem 2 (Weight 2.0 - approx. 40 minutes)

A beam, simply supported in B and C, is loaded by two forces in A and D as shown in the figure below. The beam is a T-profile and is thick-walled with a thickness $t = 100$ mm. All relevant dimensions can be found in the figure below.
Een balk die scharnierend is opgelegd in B en C wordt belast door twee krachten in A en D zoals afgebeeld in de onderstaande figuur. De balk is een dikwandig T-profiel met een dikte t = 100 mm. Alle overige dimensies staan in de figuur.



Questions:

b) Show that the principal moment of inertia for bending is equal to $I = 5525 \times 10^6$ mm^4.
Toon aan dat het centrale hoofdtraagheidsmoment voor buiging gelijk is aan $I = 5525 \times 10^6\ mm^4$.

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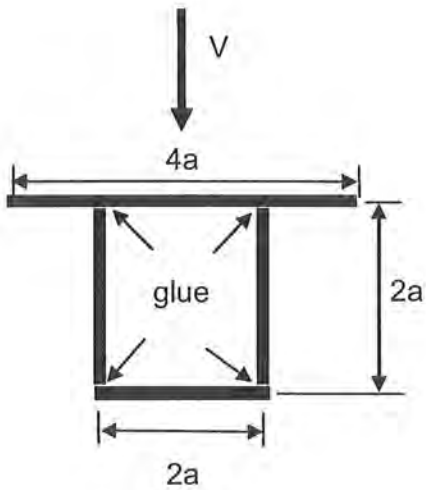
Problem 3 (Weight 2.0 - approx. 35 minutes)

The **thin-walled** cross-section in the figure below is loaded by a downwards acting shear flow V. The cross-section consists of 4 planks which have been glued together as shown. The wall thickness t = constant. All other relevant dimensions can be found in the figure.
*De **dunwandige** doorsnede in de onderstaande figuur wordt belast door een verticaal naar beneden gerichte dwarskracht V. De doorsnede bestaat uit 4 aan elkaar gelijmde planken zoals aangegeven in de figuur. De wanddikte t is constant. Alle overige dimensies staan in de figuur.*



Questions

a) Show that the principal moment of inertia for bending is equal to $I = \frac{104}{15} a^3 t$.
Toon aan dat het centrale hoofdtraagheidsmoment voor buiging gelijk is aan $I = \frac{104}{15} a^3 t$.

20

29/6/09

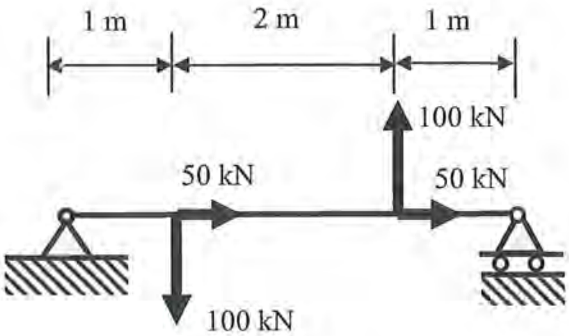
Answer sheets Studyno:

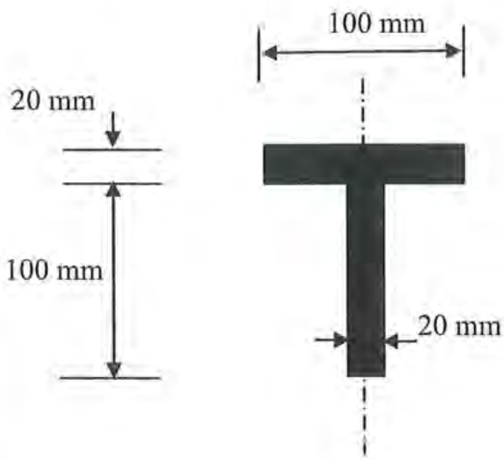
Exam Ae1-914 part III Name:

Problem 2 (Weight 2.5 - approx. 45 minutes)

The simply supported beam in the figure below is loaded by two forces of 100 kN and two forces of 50 kN, applied at a quarter and three-quarter of the beam length, as shown. The horizontal forces are applied in the normal centre (centre of gravity) of the cross section, and at the supports, forces are introduced through the normal centre. The beam has a cross-section as shown below. The cross-section is **NOT** thin-walled and has a constant wall thickness $t = 20$ mm.

*De opgelegde balk in onderstaande figuur wordt belast door twee krachten van 100 kN en twee krachten van 50 kN, aangebracht op een kwart en driekwart van de balklengte, zoals aangegeven. De horizontale krachten worden aangebracht in het normaalcentrum (zwaartepunt) van de doorsnede, en bij de ondersteuningen worden krachten via het normaalcentrum ingeleid. De balk heeft een doorsnede zoals onder getoond. De doorsnede is **NIET** dunwandig en heeft een constante wanddikte $t = 20$ mm.*





v

21

Answer sheets Studyno: | | | | | | | |

Exam Ae1-914 part III Name:

Questions

a) Calculate the centre of gravity of the cross-section with respect to the top of the cross-section.
Bereken het zwaartepunt van de doorsnede ten opzichte van de bovenzijde van de doorsnede.

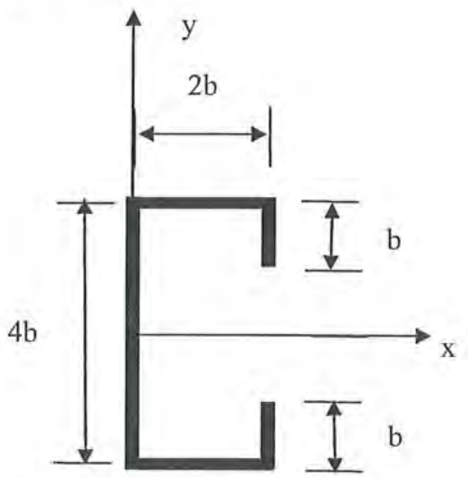
b) Calculate the principal moment of inertia for bending of the cross-section.
Bereken het hoofdtraagheidsmoment voor buiging van de doorsnede.

Answer sheets Studyno:

Exam Ae1-914 part III Name:

Problem 4 (Weight 2.0 - approx. 35 minutes)

The open **thin-walled** cross-section in the figure below is loaded by a vertical downwards acting shear force V which acts through the shear centre. The walls have a thickness *t*. All other dimensions are given in the figure below.
De open ***dunwandige*** *doorsnede in de onderstaande figuur wordt belast door een verticale naar beneden gerichte dwarskracht V die aangrijpt in het dwarskrachten-centrum (dwarskrachtmiddelpunt). De wanden hebben een dikte t. Alle overige afmetingen staan aangegeven in de figuur.*



Questions

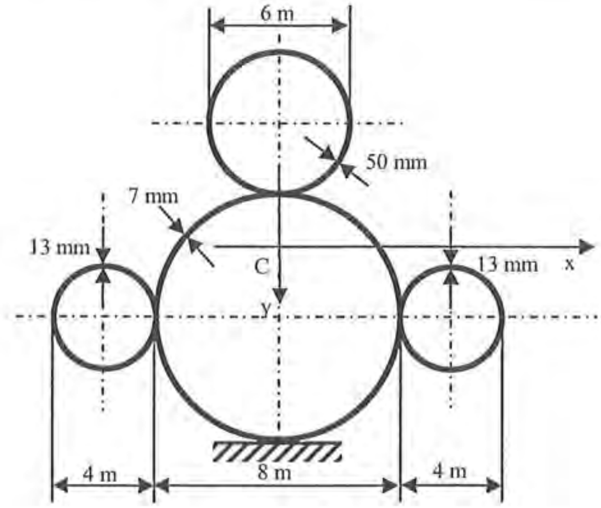
b) Calculate the principal moment of inertia for bending *I*.
Bereken het centrale hoofdtraagheidsmoment voor buiging I.

23

Answer sheets Student no:

TRIAL Exam AE1103 Statics Name:

Problem 1 (Weight 1.5 - approx. 30 minutes)
Consider the space shuttle in its launch configuration with its booster rockets and its extra tank (as pictured on the left below). A cross-section of the front fuselage space shuttle in launch configuration consists of 4 **thin-walled** circles as shown in the figure below on the left. All relevant dimensions are given in the figure below.
Beschouw de space shuttle in haar lanceerconfiguratie met haar booster raketten en extra tank links in de onderstaande figuur. De dwarsdoorsnede van het voorste deel van de romp van de space shuttle in lanceerconfiguratie bestaat uit 4 ***dunwandige*** *cirkels zoals afgebeeld in de onderstaande figuur. Alle relevante dimensies staan in de figuur.*



Questions

a) Show that the centroid lies at a distance of 8.6 m from the bottom of the cross-section.
Toon aan dat het zwaartepunt op een afstand van 8.6 m van de onderkant van de doorsnede ligt.

24

(Problem 1 continued)

b) Calculate the principle area moment of inertia about the x-axis, I_x.
Bereken het centrale hoofdtraagheidsmoment om de x-as, I_x.

c) Why is the polar moment of inertia $J_O \neq 2I_x$ for this composite cross-section? Motivate your answer.
Waarom is het polaire traagheidsmoment $J_O \neq 2I_x$ voor deze samengestelde doorsnede? Motiveer uw antwoord.