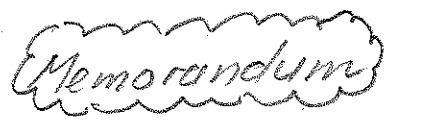


VAN en VOORLETTERS	HANDTEKENING	STUDENTENOMMER																
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SURNAME and INITIALS	SIGNATURE	STUDENT NUMBER																

STUDY DISCIPLINE STUDIERIGTING		TUITION LANGUAGE ONDERRIGTAAL	ENG or / of AFR
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Tyd / Time: 1½ ure / hours

20 April 2010

[illegible]

- ⇒ Answer all questions in the provided spaces.
- ⇒ The invigilators will supply no additional or loose pages.
- ⇒ Answers in pencil will not be marked.
- ⇒ Tippex or any other similar product may not be used.
- ⇒ No highlighter may be used.
- ⇒ Students may ask no questions for whatever reason during the exam or test. If you are of the opinion that you need additional information, make assumptions and state these assumptions.
- ⇒ The relevant units must substantiate all answers.
- ⇒ All aspects as described in the EXAMINATION REGULATIONS are applicable.
- ⇒ All calculations to reach an answer must be shown.

- ⇒ Beantwoord alle vrae in die spasies voorsien.
- ⇒ Die toesighouers sal geen addisionele of los bladsye voorsien nie.
- ⇒ Antwoorde in potlood word nie gemerk nie.
- ⇒ Tippex of enige soortgelyke produk mag nie gebruik word nie.
- ⇒ Geen glimpen ["highlighter"] mag gebruik word nie.
- ⇒ Studente mag nie tydens die eksamen vrae vra nie – om watter rede ookal. Indien u van mening is dat addisionele inligting benodig word, maak aannames en stel die aannames.
- ⇒ Alle antwoorde moet deur die nodige eenhede bevestig word.
- ⇒ Alle aspekte soos vervat in die EKSAMENREGULASIES is van toepassing.
- ⇒ Alle berekeninge om antwoorde te bepaal moet getoon word.

Dosente / Lecturers: Prof BWJ van Rensburg Mr F van Graan Prof L Maree

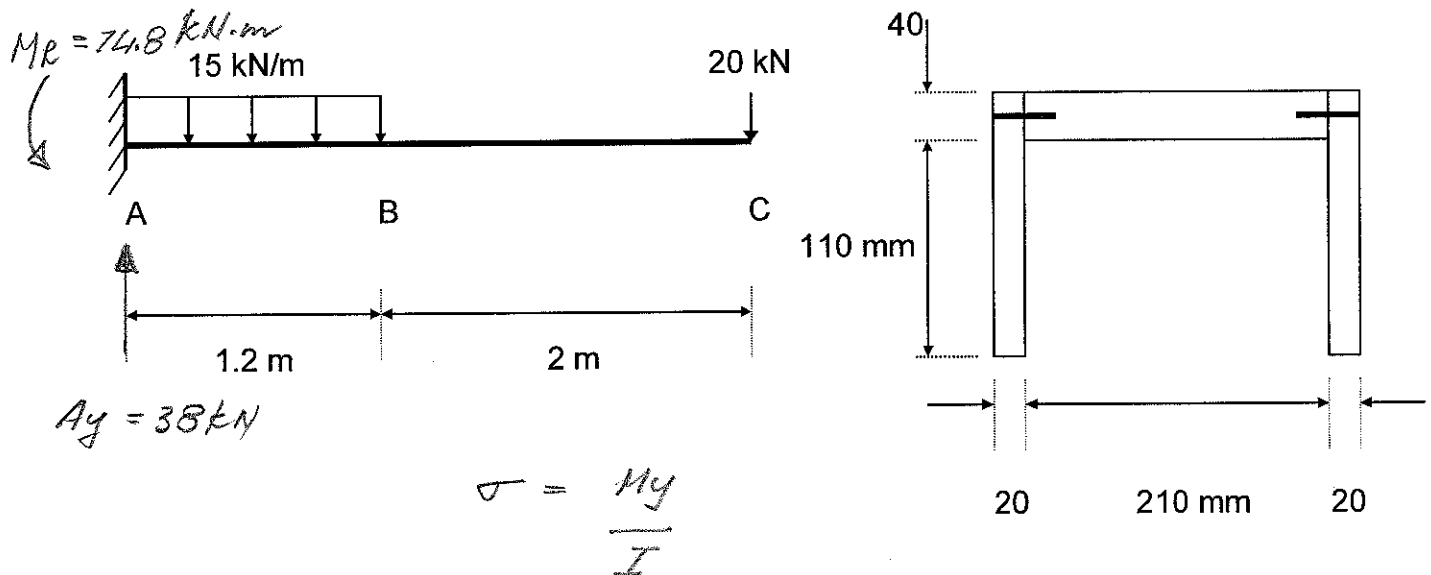
Eksterne Eksaminator / External Examiner: Prof WMG Burdzik

QUESTION 1 / VRAAG 1

[14]

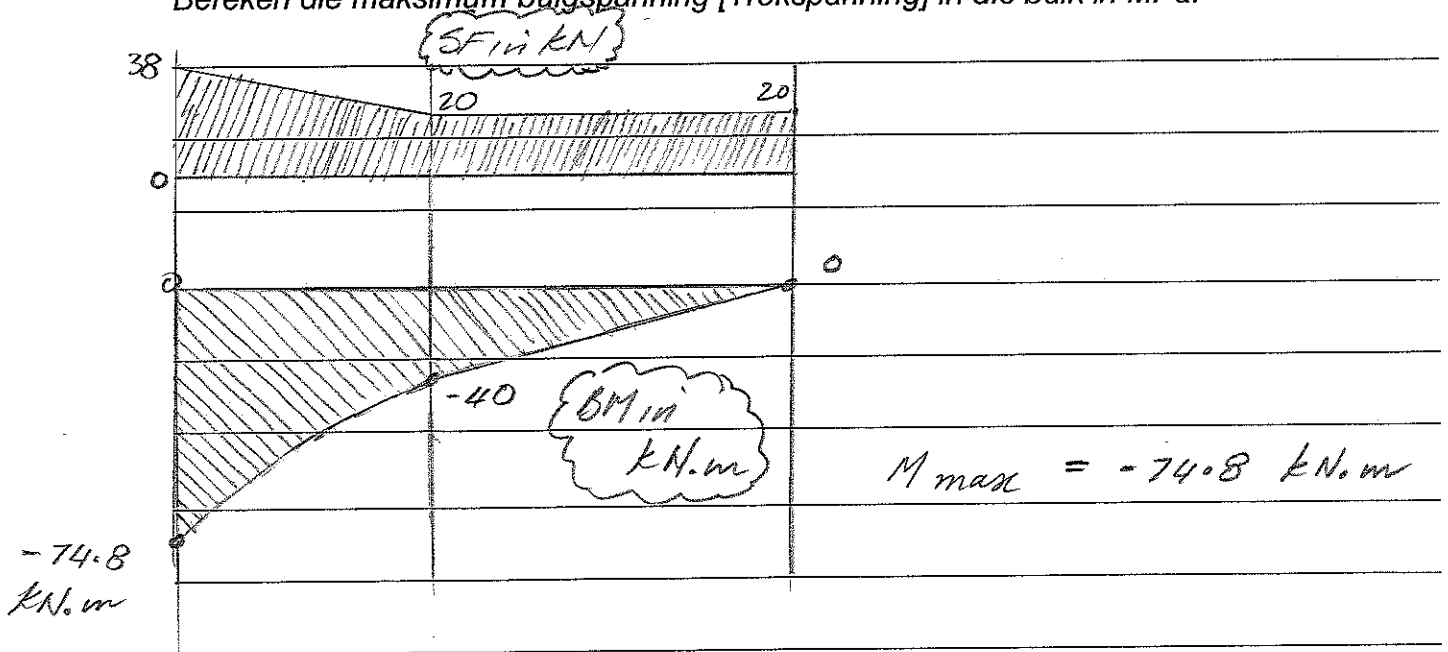
The figure shows a light beam ABC that is built-in at A and which supports a uniformly distributed load as well as a point load as shown.
The cross section of the beam is also shown.

Die figuur toon 'n ligte balk ABC wat ingebou is by A en wat 'n uniforme verspreide belasting asook 'n puntbelasting ondersteun soos getoon.
Die dwarsdeursnit van die balk word ook getoon.



1a. Calculate the maximum bending stress [Tension] in the beam in MPa
Bereken die maksimum buigspanning [Trekspanning] in die balk in MPa.

[12]



$$\textcircled{c} \bar{y} = \frac{2(20)(150)(75) + 210(40)(130)}{2(20)(150) + 210(40)}$$

$$= \frac{1542000}{14400} = 107.08 \text{ mm} \rightarrow$$

$$\begin{aligned} \textcircled{c} \bar{I}_{NA} &= \frac{1}{12}(250)(150)^3 + (250)(150)(32.08)^2 \\ &\quad - \frac{1}{12}(210)(110)^3 - (210)(110)(52.08)^2 \\ &= 108904740 - 85947240 = 22957500 \text{ mm}^4 \end{aligned}$$

$$\textcircled{c} \sigma = \frac{My}{I} = \frac{74.8 \times 10^6 \times 42.92}{22957500}$$

$$= 139.84 \text{ MPa} \rightarrow$$

1b. Calculate the maximum bending stress [Compression] in the beam in MPa. [2]
Bereken die maksimum buigspanning [Drukspanning] in die balk in MPa.

$$\textcircled{c} \sigma_c = \frac{My}{I} = \frac{74.8 \times 10^6 \times 107.08}{22957500}$$

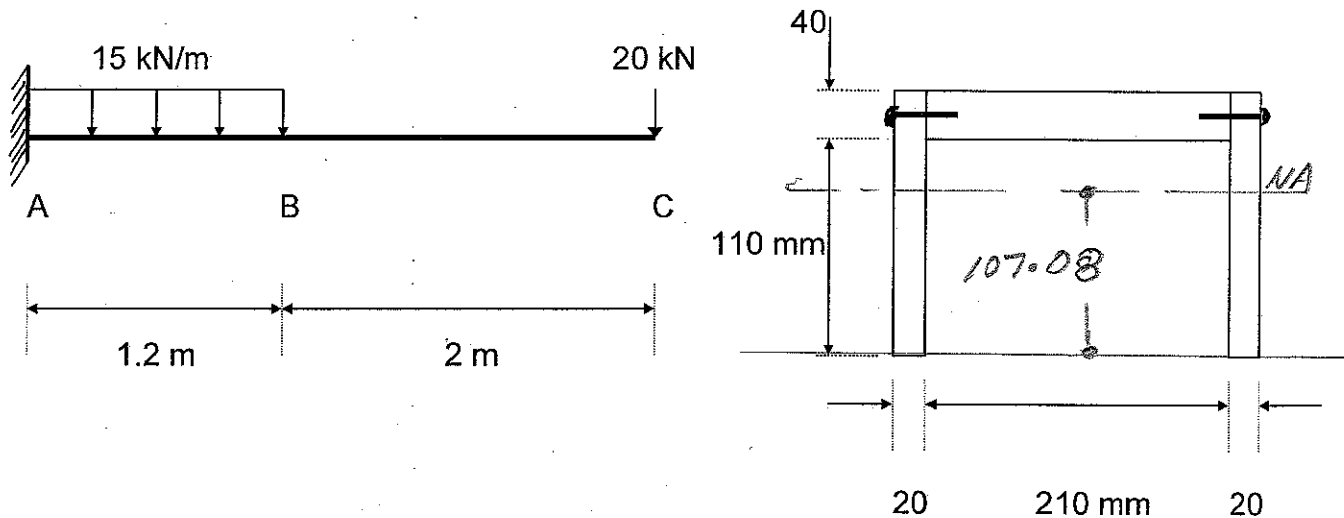
$$= 348.89 \text{ MPa} \rightarrow$$

CHECK QUESTION 1 / SIEN VRAAG 1

The figure shows a light beam ABC that is built-in at A and which supports a uniformly distributed load as well as a point load as shown.

The cross section of the beam is also shown.

Die figuur toon 'n ligte balk ABC wat ingebou is by A en wat 'n uniforme verspreide belasting asook 'n puntbelasting ondersteun soos getoon.
Die dwarsdeursnit van die balk word ook getoon.



2a. Calculate the maximum shear stress that will develop in the beam in MPa.
Bereken die maksimum skuifspanning wat in die balk sal voorkom in MPa.

[5]

$$\odot Q = 2(107.08)(20)\left(\frac{107.08}{2}\right)$$

$$= 229\,323 \text{ mm}^3 \rightarrow$$

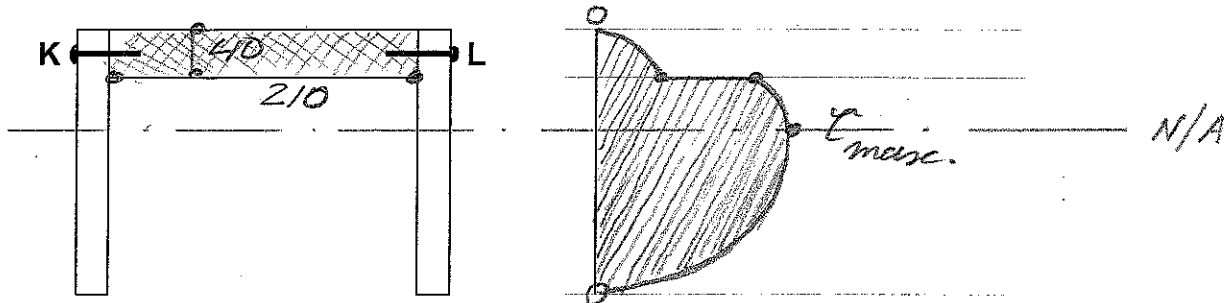
$$\odot \tau_{\max} = \frac{VQ}{It}$$

$$= \frac{38 \times 10^3 \times 229\,323}{22\,957\,500 \times 2(20)}$$

$$= 9.5 \text{ MPa} \rightarrow$$

2b. Draw a diagram [without values] that will depict the distribution of vertical shear stress from the top to the bottom of the beam at a cross section at A. [3]

Teken 'n diagram [sonder waardes] wat die verspreiding van die verikale skuifspanning van die bokant tot die onderkant by 'n dwarsdeursnit van die balk by A sal weergee.



2c. A row of bolts at K and L is used to fix the webs to the flange of the beam. [6]
Check the figure above. Calculate the spacing of the bolts necessary to fix the flange to the webs for section BC of the beam if a single bolt can resist 20 kN in shear. Give your answer in millimetres.

'n Ry boute by K en L word gebruik om die webbe aan die flens te heg.
Beskou bostaande figuur. Bereken die spasiëring van die boute nodig om die flens aan die webbe te heg vir gedeelte BC van die balk indien 'n enkele bout 20 kN in skuif kan weerstaan. Gee u antwoord in millimeters.

$$\odot \frac{q}{I} = \frac{VQ}{I} = \frac{20 \times 10^3 \times (210 \times 40 \times 22.92)}{22\,957\,500}$$

$$= 167.73 \text{ N/mm} = 167.73 \text{ kN/m}$$

$$= 83.86 \text{ kN/m per side.}$$

$$\odot \text{ Bolt spacing} = \frac{20}{83.86} = 0.238 \text{ m}$$

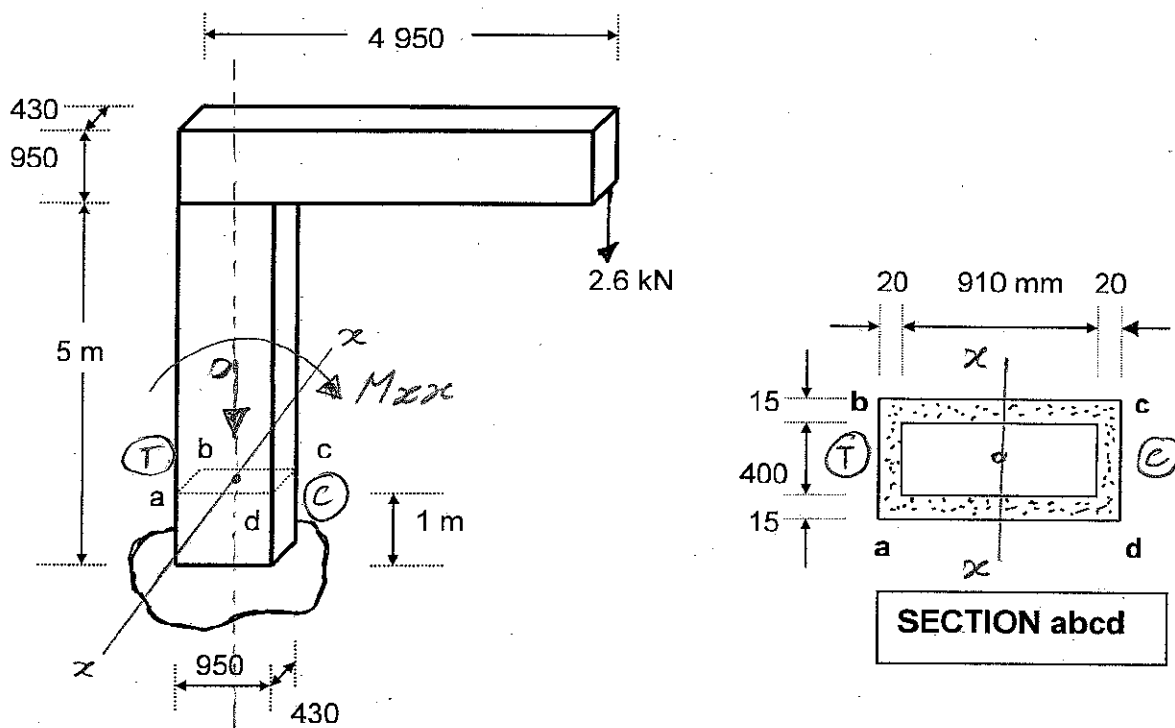
$$= 238.5 \text{ mm} \rightarrow$$

QUESTION 3 / VRAAG 3

[10]

The figure shows a structure that supports a power line for the Gautrain. The power line weighs 2.6 kN. The structure is manufactured from a box beam that weighs 1.4 kN/m and the cross section of the box beam is also shown.

Die figuur 'n toon 'n struktuur wat 'n kraglyn vir die Gautrein ondersteun. Die kraglyn weeg 2.6 kN. Die struktuur is vervaardig van 'n kisbalk wat 1.4 kN/m weeg en die dwarsdeursnit van die kisbalk word ook getoon.



3a. Determine the state of stress at level abcd.
Bepaal die spanningstoestand op vlak abcd.

[8]

$$\odot I_{xx} = \frac{1}{12}(430)(950)^3 - \frac{1}{12}(400)(910)^3$$

$$= 5\,603\,570\,833 \text{ mm}^4 \rightarrow$$

$$\odot A = 950(430) - (910)(400) = 44\,500 \text{ mm}^2 \rightarrow$$

$$\odot \text{At abcd: } P = 2.6 + (4 + 4.95)(1.4) = 15.13 \text{ kN} \rightarrow$$

$$\odot M_{xx} = 2.6(4.475) + 1.4(4)(2.475) = 25.495 \text{ kN.m} \rightarrow$$

$$\odot \text{ At ab: } \sigma_T = -\frac{P}{A} + \frac{My}{I}$$

$$= -\frac{15.13 \times 10^3}{44300} + \frac{25.495 \times 10^3 \times 475}{5603570833}$$

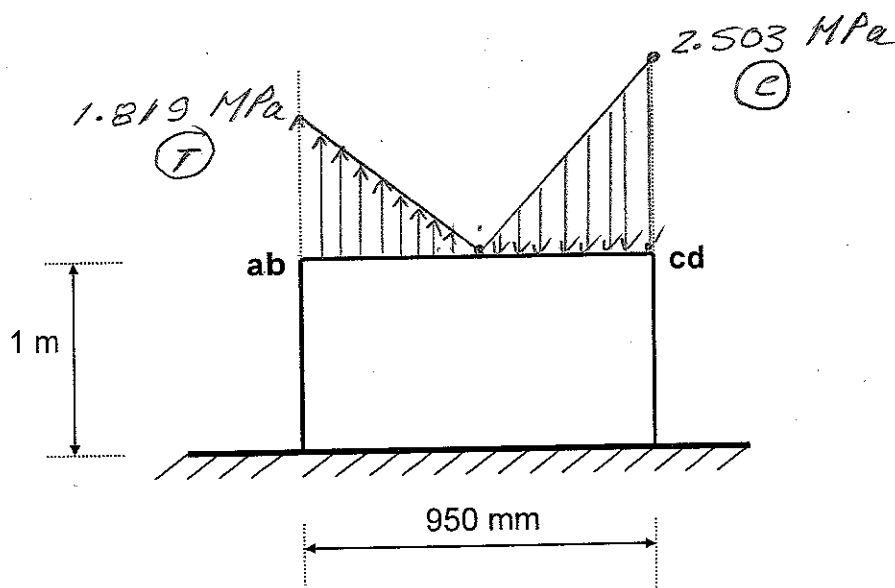
$$= -0.342 + 2.161$$

$$= 1.819 \text{ MPa} \rightarrow$$

$$\odot \text{ At cd: } \sigma_c = 0.342 + 2.161$$

$$= 2.503 \text{ MPa} \rightarrow$$

3b. Draw a diagram, with captions and values, that will depict the state of stress at cross section **abcd** of the given structure. [2]
Teken 'n diagram, met byskrifte en waardes, wat die spanningstoestand op vlak **abcd** sal weergee.

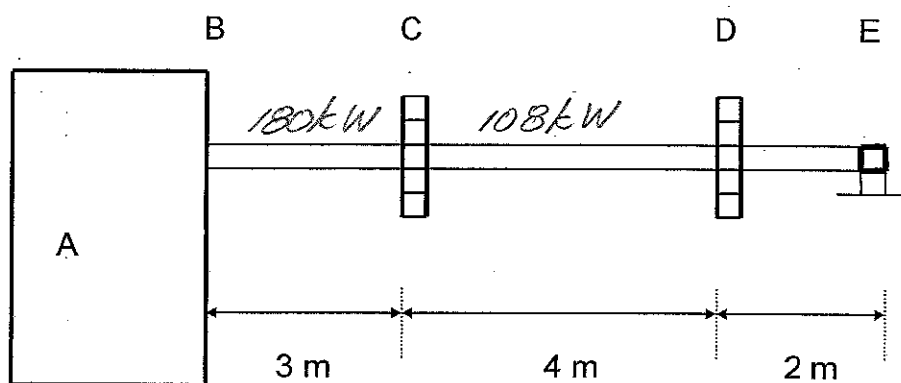


QUESTION 4 / VRAAG 4

[12]

The figure shows a turbine A that generates 180 kW of power which is transmitted to the gears such that C receives 60 % and D receives 40% of the generated power. The steel shaft rotates at 900 revs / minute, it is 100% in-line and there is therefore no friction losses at the thrust bearing at E. The shaft diameter is 120 mm and $G_{\text{STEEL}} = 75 \text{ GPa}$.

Die figuur toon 'n turbine A wat 180 kW krag opwek en die krag word oorgedra na die ratte op so 'n wyse dat rat C 60 % en rat D 40% van die krag ontvang. Die staal as draai teen 900 omwentelinge / minuut, dit is 100% in-lyn en daar is dus geen wrywingsverliese by die druklaer by E nie. Die as diameter is 120 mm en $G_{\text{STAAL}} = 75 \text{ GPa}$.



4a. Determine the maximum shear stress in the shaft in MPa.
Bepaal die maksimum skuifspanning in die as in MPa.

[6]

$$\textcircled{a} J = \frac{\pi}{2} r^4 = \frac{\pi}{2} (60)^4 = 20\,357\,520 \text{ mm}^4 \rightarrow$$

$$\textcircled{b} P = 2\pi f T :$$

$$180 \times 10^6 = 2\pi \frac{900}{60} \times T \therefore T = 1\,909\,859 \text{ N}\cdot\text{mm} \rightarrow$$

$$\textcircled{c} \tau_{\max} = \frac{Tc}{J} = \frac{1\,909\,859 \times 60}{20\,357\,520}$$

$$= 5.629 \text{ MPa} \rightarrow$$

4b. Determine the angle of twist [in degrees] of end E relative to B.
Bepaal die wringhoek [in grade] van end E relatief tot B.

[6]

② For CD: $P = 2\pi fT$

$$\therefore 0.4 \times 180 \times 10^6 = 2\pi \frac{900}{60} \times T$$

$$\therefore T_{CD} = 763\,944 \text{ N}\cdot\text{mm} \rightarrow$$

① $\phi_{BE} = \sum \left[\frac{TL}{GJ} \right]$

$$= \frac{1909859 \times 3000}{GJ} + \frac{763\,944 \times 4000}{GJ}$$

$$= \frac{8\,785\,353 \times 10^3}{(75 \times 10^3) \times \left(\frac{\pi}{2} \times 60^4 \right)}$$

$$= 0.005\,754 \text{ rad}$$

$$= 0.329\,682^\circ \rightarrow$$