higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ENGINEERING SCIENCE N4

31 MARCH 2016

This marking guideline consists of 14 pages.

QUESTION 1

1.1 S (Horisontal) = 3 × S (vertical)

$$\frac{U^2 \text{Sin } 2\theta}{g} = \frac{3\ U^2 \text{Sin}^2\theta}{2g}$$

$$\frac{U^2 \text{Sin } 2\theta \times g}{g \times U^2} = \frac{3\ U^2 \text{Sin}^2\theta \times g}{g \times U^2}$$ ✓

$$\frac{3\ \text{Sin}\theta \times \text{Sin}\theta \times 2}{2 \times \text{Sin}2\theta \times 3} = \frac{\text{Sin}2\theta \times 2}{\text{Sin}2\theta \times 3}$$ ✓

But Sin2θ = 2 Sinθ Cosθ (from compound angles)

$$\frac{\text{Sin}\theta\ \text{Sin}\theta}{2\text{Sin}\theta\ \text{Cos}\theta} = \frac{2}{3}$$ ✓

$$\frac{\text{Sin}\theta}{\text{Cos}\theta} = \frac{2 \times 2}{3}$$

$$Tan\theta = \frac{4}{3}$$ ✓

θ = 53,13° ✓ (5)

OR

1.1 S (horisontal) = 270 Cos α(2)t

S (vertical) = 270sinαt + ½gt^2

S (horisontal) = 3 × S (vertical)

270 Cos α(2)t = 3(270 Sin αt + ½gt^2) ✓

270 Cosα(2) = 3(270sinα + ½gt)

540 Cos α = 810 Sin α – 14,7t ✓

540 Cos α = 810 Sin α – 14,7(27,55 Sin α) ✓

540 Cos α = 810 Sin α – 404,985 Sin α

540 Cos α = 405,015 Sin α

540/405,015 = Sin α/Cos α

540/405,015 = Tan α ✓

α = 53,129° ✓ (5)

t(max. height):

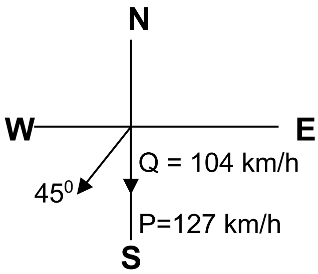
v = u + gt

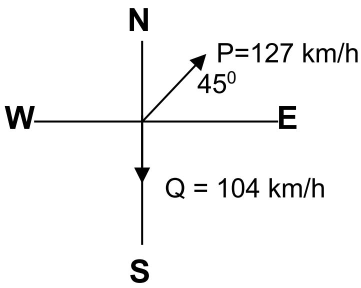
0 = 270sinα – 9,8t

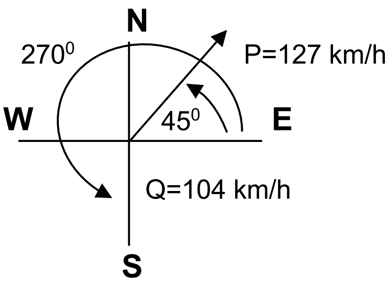
9,8t = 270sinα

t = 27,55sinα

1.2 Given:
Stop relative velocity and change its direction



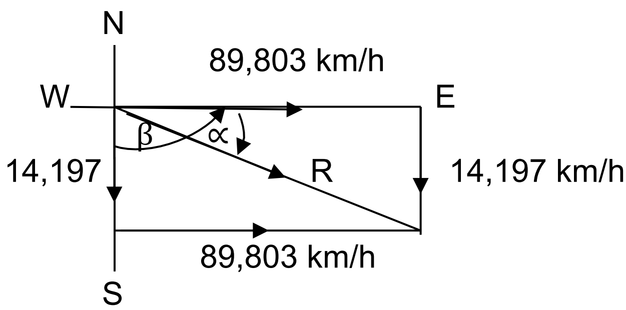




The sum of the vertical = 127 Sin 45^0 + 104 Sin 270^0
= -14,147 km/h ✓

The sum of the horisontal = 127 Sin45^0 + 104 Sin270^0
= 89,803 km/h ✓

Resultant velocity = $(-14,147^2 + 89,803^2)^{0,5}$
= 90,918 km/h ✓



$\theta = \tan^{-1} \frac{14,147}{89,803}$

$\theta = 8,984^0$ ✓

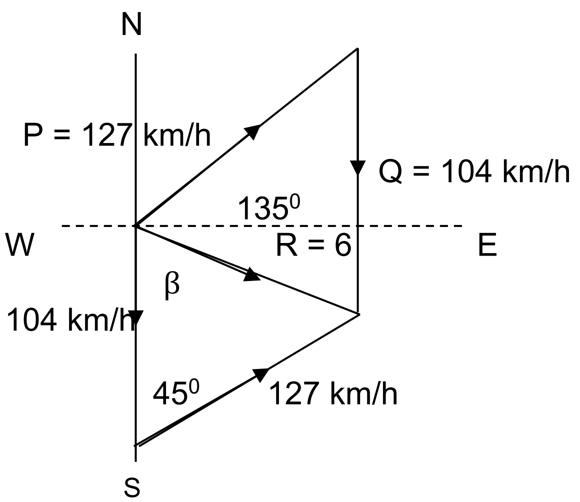
Relative velocity of Q to P = 90,918km/h E $8,984^0$ S

or

Relative velocity of Q to P = 90,918km/h S $81,016^0$ E ✓ (5)

OR

1.2



$R = b = (a^2 + c^2 - 2ac \text{ Cos B})^{0,5}$ ✓

$= (104^2 + 127^2 - 2 \times 104 \times 127 \text{ Cos } 45^0)^{0,5}$

$= 90,918$ km/h ✓

$\frac{\text{Sin A}}{a} = \frac{\text{Sin B}}{b} = \frac{\text{Sin C}}{c}$

$\frac{\text{Sin}\beta}{127} = \frac{\text{Sin}45^0}{90,918}$

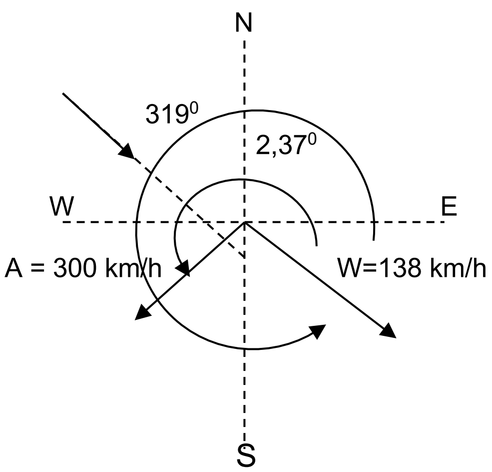
Sin β = 0,988 ✓

B = Sin^{-1} 0,988 ✓

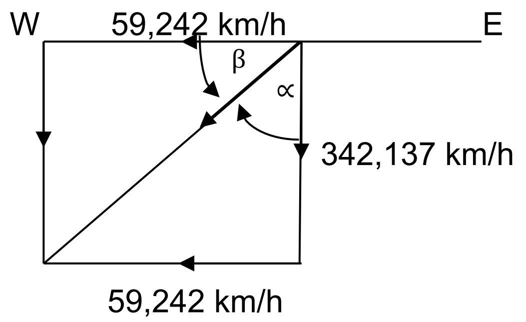
$= 81,016^0$

Relative velocity of Q to P = 90,918 km/h S $81,016^0$ E ✓ (5)

1.3



The sum of the vertical = 300 Sin 237^0 + 138 Sin319^0
= -342,137 km/h ✓
The sum of the horisontal = 300 Sin 237^0 + 138 Sin 319^0
= -59,242 km/h ✓



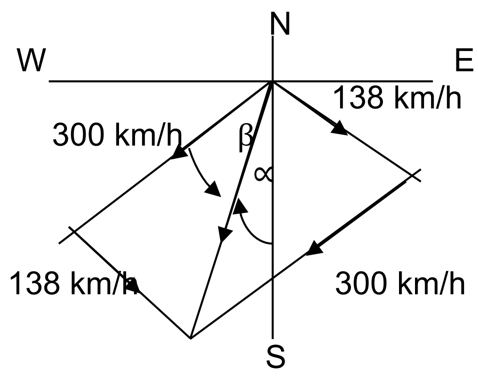
Resultant velocity = $(342,137^2 + 59,242^2)^{0,5}$
= 347,228 km/h ✓

Tan β = $\frac{342,127}{59,242}$
Β = $80,177^0$ ✓

Resultant velocity = 347,228 km/h W 80,177 ^{0}S ✓ (5)

OR

1.3



R = b = $(a^2 + c^2 – 2ac \text{ Cos B})^{0,5}$ ✓
= $(138^2 + 300^2 -2 \times 138 \times 300 \text{ Cos } 98^0)^{0,5}$
= 347,228 km/h ✓

$\frac{\text{Sin A}}{a} = \frac{\text{Sin B}}{b} = \frac{\text{Sin C}}{c}$
$\frac{\text{Sin}\beta}{138} = \frac{\text{Sin 98}}{347,22}$ ✓

Β = $23,204^0$ ✓
∝ = $33^0 – 23,204^0$
= $9,8^0$
Resultant = 347,228 km/h S $9,8^0$ W ✓ (5)
[15]

QUESTION 2

2.1 m = mass = 1 000 kg
r = radius = 37 m
v = 120 km/h
$v = \frac{120}{3,6}$
= 33,333 m/s

2.1.1 $\omega = \frac{V}{R}$ ✓
$= \frac{33,333}{37}$ ✓
= 0,901 rad/s ✓

(3)

2.1.2 $\theta = \frac{S}{R}$
$= \frac{47}{37}$ ✓
= 1,27 radians ✓ (2)

2.2 T = torque = 750 Nm
P = power = 75 kW

P = 2π NT ....(N)
$N = \frac{P}{2\pi T}$ ✓
$= \frac{75\ 000}{2 \times \Pi \times 750}$ ✓✓
= 15,916 rev/s ✓ (4)
[9]

QUESTION 3

3.1 U = initial velocity = 90 km/h
= 25 m/s

V = final velocity = 0 m/s ✓

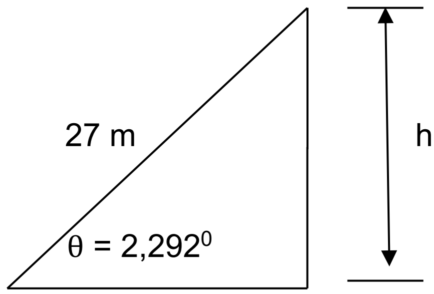
S = distance moved = 27 m ✓

Slope = $\sin^{-1}$ (1/25) = $2,292^0$

Kinetic energy horisontal = $\frac{1}{2} mv^2$

$= \frac{1}{2} \times m \times 25^2$

$= 312,5$ mass



h = height = 27 Sin $2,292^0$

= 1,08 m

Total energy at the top = Potential energy

E = (Potential) = mgh

= m x 9,8 x 1,08 ✓✓

= 10,584 mass

Kinetic energy when descending = $\frac{1}{2} mv^2$

$= 0,5 mv^2$ ✓

The total energy absorbed by the brakes is always kept constant.
Kinetic energy horisontal = Potential energy at the top + Kinetic energy when descending

312,5 mass = 10,582 mass + 0,5 mass.v^2 ✓

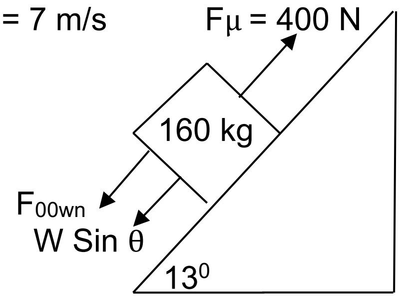
$$\frac{312,5 \text{ mass}}{\text{mass}} = \frac{10,582 \text{ mass}}{\text{mass}} + \frac{0,5 \text{ mass}.v^2}{\text{mass}}$$

$0,5\, v^2 = 312,5 - 10,582$

$v^2 = \frac{312,5-10,582}{0,5}$

$v = 24,573$ m/s ✓ (7)

3.2 V = 7 m/s



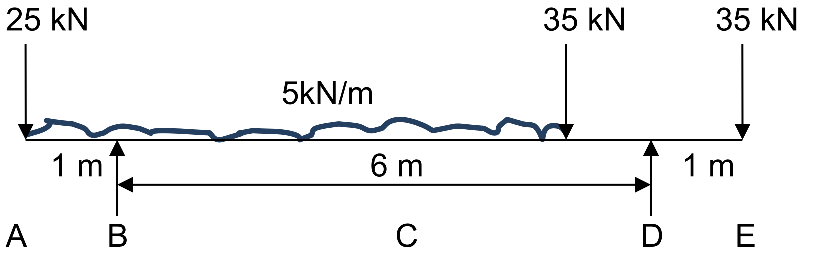
F (Total) = Frictional force – W sin θ
= 400 – 160 × 9,8 × Sin 13^0 ✓
= 47,277 N ✓

P = Power = force total × velocity ✓
= 47,277 × 7 ✓
= 330,939 W ✓ (5)

[12]

QUESTION 4

4.1



✓✓ (2)

4.2 Moments about D

Clockwise moments – Anti-clockwise moments
(B × 6) + (35 × 1) = (35 × 1) + (25 × 7) + (30 × 4)
B = 49,167 kN ✓✓

2. The sum of forces facing up = The sum of forces facing down
B + D = 35 + 35 + 25 + 30 ✓
49,167 + D = 125
D = 75,833 kN (3)

OR

2. Moments about B

Anti-clockwise moments = Clockwise moments
(D × 6) + (25 × 1) = (30 × 2) + (35 × 5) + (35 × 7) ✓
D = 75,833 kN (3)

4.3 1. Bending moment at B (from left hand side)
= (- 25 x 1) + (-5 x 1 x 0,5)
= - 27,5 kNm ✓

OR

1. Bending moment at B (from right hand side)
= (-5 × 5 × 2,5) + (-35 × 5) + (75,833 × 6) + (-35 × 7)
= - 27,5 kNm ✓

2. Bending moment at C (from the left hand side)
= (-25 × 6) + (49,167 × 5) + (-5 × 6 × 3) ✓
= 5,835 kNm

OR

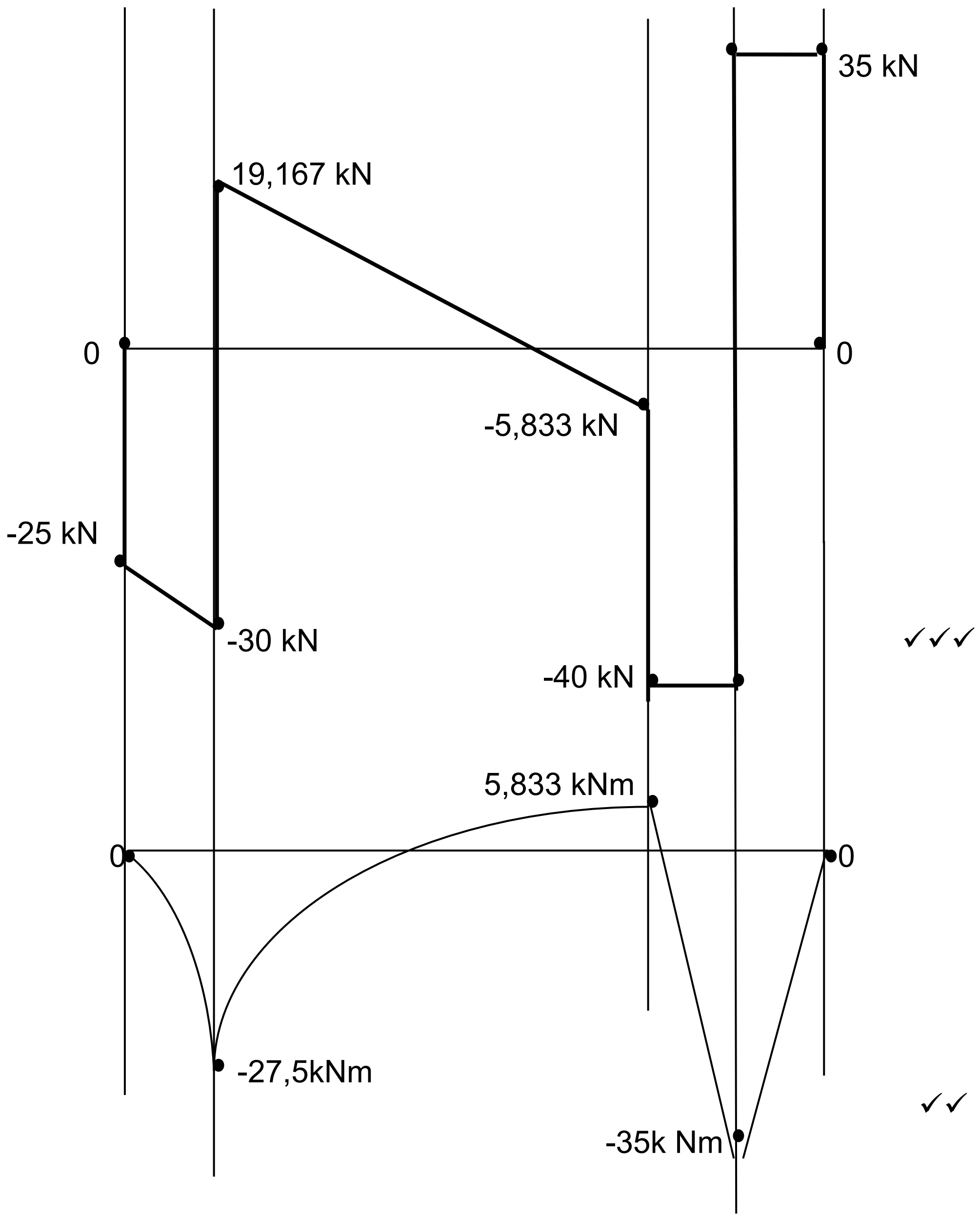
2. Bending moment at B (from the right hand side)
= (-35 × 2) + (75,8335 × 1) ✓
= 5, 833 kNm

3. Bending moment at D (from the left hand side)
= (-35 × 1) + (-5 × 6 × 4) + (49,167 × 6) + (-25 × 7) ✓
= -35 kNm (3)

OR

3. Bending moment at D (from right hand side)
= -35 × 1 ✓
= -35 kNm (3)

4.4



(5)

4.5 Maximum bending moment = 35 kNm (sagging) ✓✓

or

Maximum bending moment = -35 kNm

Position = 1m from the right-hand side or at point D

or

Position = 7m from left hand-side or at point D (2)

[15]

QUESTION 5

5.1 The function of a hydraulic accumulator is to accumulate hydraulic energy and to store hydraulic energy until it is needed. (2)

5.2
- Mass-loaded/weight-loaded accumulator
- Spring-loaded accumulator
- Air/gas type accumulator (Any 2 × ½) (1)

5.3 d = 12,5% D
= 0,125 D
l = h = 100 mm = 0,1m
M.A. = 25
Slip = 15% = 0,15
Efficiency = 85% = 0,85

5.3.1 M = 6 tons = 6 000kg √

$$\frac{F}{d^2} = \frac{W}{D^2} \ldots\ldots\ldots\ldots\ldots (F) \quad √$$

$$F = \frac{W \times d^2}{D^2} \quad √$$

$$= \frac{6\,000 \times 9{,}8 \times 0{,}125D \times 0{,}125D}{D \times D} \quad √$$

$$= 918{,}75N \quad √$$ (2½)

$$M.A. = \frac{F}{Effort} \ldots\ldots\ldots\ldots\ldots (effort) \quad √$$

$$Effort = \frac{F}{M.A.}$$

$$= \frac{918{,}75}{25} \quad √$$

$$= 36{,}75N \quad √$$

85% = 36,75 √

100% = X √

$$X = \frac{100\% \times 36{,}75}{85\%} \quad √$$

$$= 43{,}235\ N \quad √$$ (3½)

5.3.2

$$n = \frac{\text{volume displaced by the ram}}{\text{volume displaced by plunger}}$$

$$n = \frac{D^2H}{d^2h}$$

$$= \frac{D \times D \times 400}{0{,}125D \times 0{,}125D \times 100} \quad ✓✓$$

$$= 256 \quad ✓$$ (3)

5.4 Force = F = 43 kN
Diameter = d = 22 cm = 220 mm = 0,22 m
Work done = W.D. = 15 kJ

5.4.1 W.D = F × s ....(s)

$S = \frac{W.D.}{F}$

$= \frac{15\ 000}{43\ 000}$ ✓

= 0,349m ✓ (2)

5.4.2 Pressure = P = $\frac{FORCE}{AREA}$

$= \frac{43\ 000 \times 4}{\Pi \times 0{,}22 \times 0{,}22}$ ✓

= 1 131,184 kPa ✓ (2)

5.4.3 W.D. = Pressure x Volume …........(Volume)

Volume = V = $\frac{Work\ done}{Pressure}$

$= \frac{15}{1\ 131{,}184}$ ✓

= 0,0133m^3 ✓

Volume/second = volume x N/60

= 0,088403 m^3/s ✓

But 1 000 litres of pure water = 1 m^3

Volume in l/s = 88,403 l/s ✓ (4)

[20]

QUESTION 6

6.1 β : γ = 2 : 3 or 1 : 1,5 ✓✓ (2)

6.2

	Mercury	**Flask/glass**
Volume (original)	400 mm^3	400 mm^3
Temperature (original)	16 °C	16 °C
Temperature (final)	51 °C	51 °C
	7 x 10^{-5}/^{0}C	10 x 10^{-6}/°C

6.2.1 Change in volume of mercury = V (original) × 3∝ ($t_2 - t_1$)

= 400 × 3 x 7 × 10^{-5} (51 – 16) ✓

= 2,94 mm^3 ✓ (2)

6.2.2 Change in volume of flask = 400 × 3 × 10 × 10^{-6}(51 -16) ✓

= 0,42 mm^3 ✓

Overflow = Change in volume of mercury - Change in volume of flask

= 2,94 – 0,42 ✓

= 2,52mm^3 ✓ (4)

6.3 T = 5 °C = 5 + 273 = 278° K ✓
$P_1 = P_2$ = 185 kPa
V_1 (original) = 0,26m^3

6.3.1 T_2 = -28 + 5 = -23 °C ✓ (1)

OR

6.3.1 T_2 = 250 – 273 = -23 °C ✓ (1)

6.3.2 $\frac{V_2}{T_2} = \frac{V_1}{T_1}$ ....(V_2)

$V_2 = \frac{T_1 \times V_2}{T_2}$

$= \frac{0{,}26 \times 250}{278}$ ✓✓

= 0,234 m^3 ✓ (3)

6.3.3 $P_1 V_1 = m RT_1$ ....(m)

$m = \frac{P_1 V_1}{RT_1}$

$= \frac{185 \times 0{,}26}{0{,}288 \times 278}$ ✓✓

= 0,601 kg ✓ (3)

OR

6.3.3 $P_2 V_2 = m RT_2$ ....(m)

$m = \frac{P_2 V_2}{RT_2}$

$= \frac{185 \times 0{,}234}{0{,}288 \times 250}$ ✓✓

= 0,601kg ✓ (3)

[15]

QUESTION 7

7.1 For an elastic object the strain is (directly) proportional to the stress producing it. ✓✓

OR

For an elastic object the extension is (directly) proportional to the load producing it. (2)

7.2 D = 3,2 d
L (original) = 720 mm = 0,72 m
F = 312 kN
X = 0,138 mm (0,138 x 10^{-3} m)
E = 200 GPa

$E = \frac{F \times L}{A \times X}$ ………… (A)
$A = \frac{F \times L}{E \times X}$
$= \frac{312\ 000 \times 0,72}{200 \times 10^{9} \times 0,138 \times 10^{-3}}$ ✓✓
= 8,138 x 10^{-3} m^2

Area of a pipe (A) $= \frac{\Pi(D^2 - d^2)}{4}$
$= \frac{\Pi\,[(3,2d)^2 - (d^2)]}{4}$ ✓
$\frac{4(8,139 \times 10^{-3})}{\pi} = 9,24\ d^2$ ✓
d^2 = 1,122 x 10^{-3} ✓
d = 0,033 m ✓
D = 3,2d
D = 0,106 m ✓ (7)

7.3 F = 10 kN
S = 194 mm (0,194 m)
L_1 (Original) = 5 m (5 000 mm)
X = 0,231 mm

7.3.1 Stress = force/area
= 10 000/0,194 x 0,194 ✓
= 265,703 kPa ✓ (2)

7.3.2 Strain = x/l
= 0,231/5 000 ✓
= 4,62 x 10^{-5} ✓ (2)

7.3.3 E = 265 703/4,62 x 10^{-5}
= 5,751 GPa ✓ (1)
[14]

TOTAL: 100