



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

27 November 2023

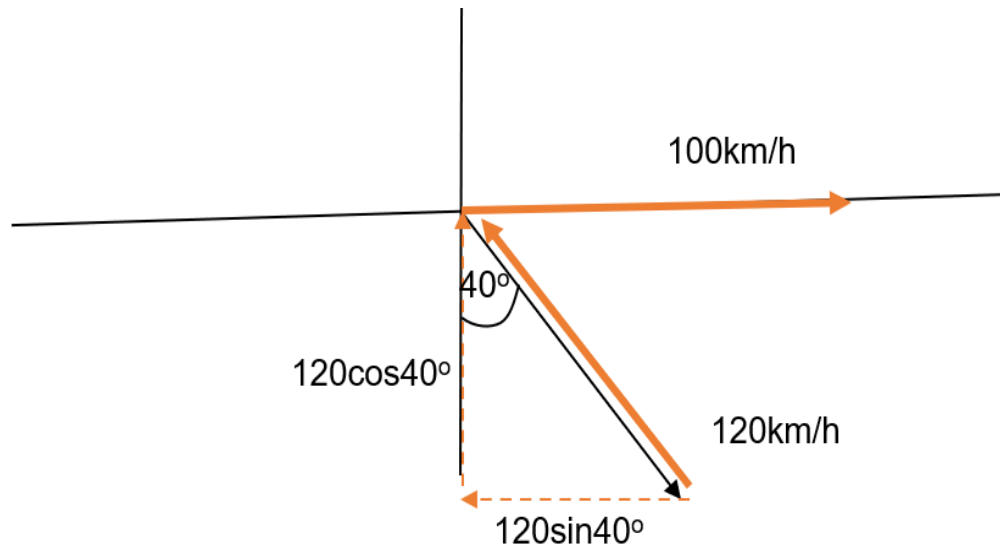
This marking guideline consists of 15 pages.

QUESTION 1

1.1 $v_g = v_i - v_j$
 $v_g = 19 - 1.9$ ✓
 $v_g = 17,1 \text{ m/s; North}$ ✓

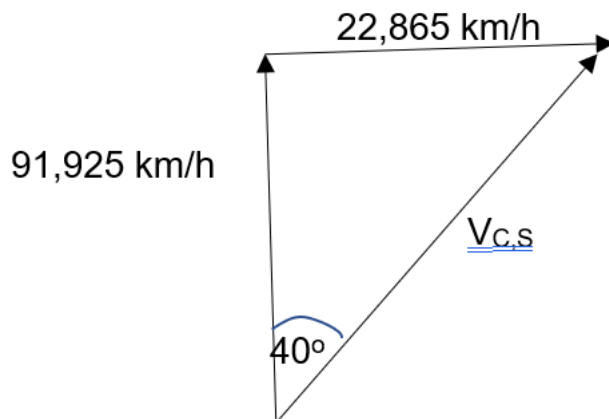
(2)

1.2



$$\Sigma V_c = 120 \cos 40^\circ = 91,925 \text{ km/h (N)} \checkmark$$

$$\Sigma H_c = -120 \sin 40^\circ + 100 = 22,865 \text{ km/h (E)} \checkmark \checkmark$$

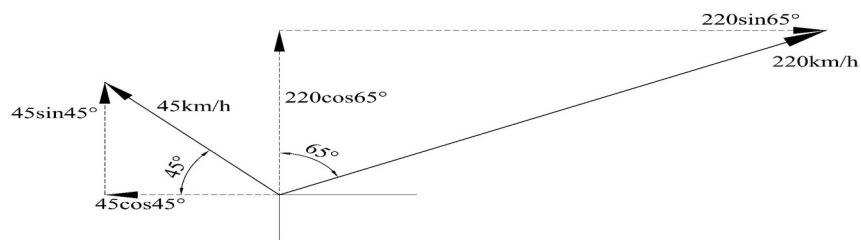


$$V_{C,S} = \sqrt{91,925^2 + 22,865^2} = 94,726 \text{ km/h} \checkmark$$

$$\text{Therefore } \theta = \tan^{-1} \left(\frac{22,865}{91,925} \right) = 13,97^\circ = \text{N } 13,97^\circ \text{ E} \checkmark$$

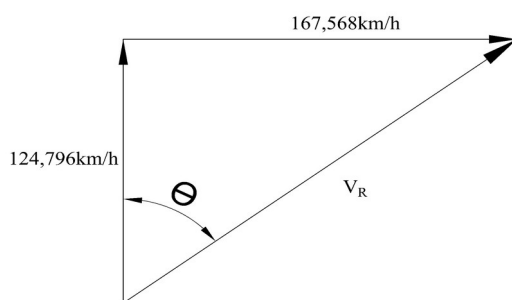
(5)

1.3



$$\Sigma V_c = 45 \sin 45^\circ + 220 \cos 65^\circ = 124,796 \text{ km/h (N)} \checkmark$$

$$\Sigma H_c = -45 \cos 45^\circ + 220 \sin 65^\circ = 167,568 \text{ km/h (E)} \checkmark$$



$$V_R = \sqrt{167,568^2 + 124,796^2} \checkmark$$

$$= 208,933 \text{ km/h} \checkmark$$

$$\theta = \tan^{-1} \frac{\Sigma H_c}{\Sigma V_c}$$

$$\theta = \tan^{-1} \frac{167,568}{124,796}$$

$$\theta = 53,232^\circ \checkmark$$

(5)

1.4

$$v = u + at$$

$$0 = 550 \sin \theta - 9,8 \frac{35}{2} \checkmark$$

$$\theta = \sin^{-1} \left(\frac{9,8 \times 35}{2 \times 550} \right) \checkmark$$

$$\theta = 22,4^\circ \checkmark$$

(3)

[15]

QUESTION 2

- 2.1 Given:
 $T_1 = 800 \text{ N}$
 $T_2 = 450 \text{ N}$
 $D = 0,07 \text{ m}$
 $N = 350 \text{ rpm}$

$$\begin{aligned} 2.1.2 \quad T &= F_e \times r \\ &= (800 - 450) \times 0,035 \checkmark \checkmark \\ &= 12,25 \text{ Nm} \checkmark \end{aligned} \quad (3)$$

$$\begin{aligned} 2.1.3 \quad P &= \frac{WD}{t} = \frac{T\theta}{t} = \frac{2 \times \pi \times N \times T}{60} \\ &= \frac{2 \times \pi \times 350 \times 12,25}{60} \checkmark \\ &= 448,986 \text{ W} \checkmark \end{aligned} \quad (2)$$

- 2.2 Given:
 $N = 3\,500 \text{ rpm}$
 $D = 0,08 \text{ m}$

$$\begin{aligned} 2.2.1 \quad N &= \frac{3\,500}{60} \\ N &= 58,333 \text{ r/s} \checkmark \\ \omega &= \pi \cdot D \cdot N \\ \omega &= \pi \times 0,08 \times 58,333 \checkmark \\ \omega &= 14,661 \text{ rad/s} \checkmark \end{aligned}$$

OR

$$\begin{aligned} \omega &= \frac{\pi \cdot D \cdot N}{60} \\ \omega &= \frac{\pi \times 3\,500 \times 0,08}{60} \\ \omega &= 14,661 \text{ rad/s} \end{aligned} \quad (3)$$

$$\begin{aligned} 2.2.2 \quad \Theta &= \omega t = 14,661 \times 15 \checkmark \\ &= 219,915 \text{ radians} \checkmark \end{aligned} \quad (2)$$

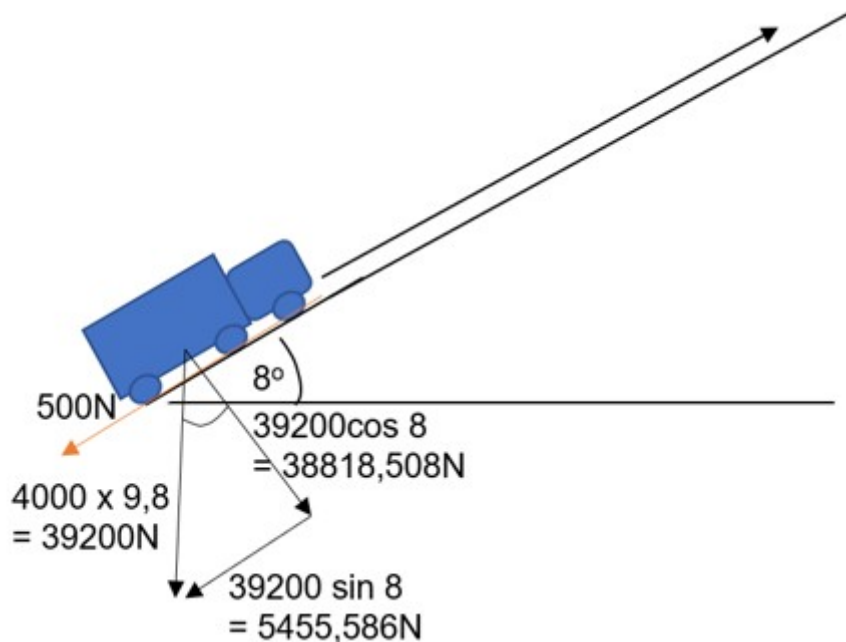
$$\begin{aligned} 2.2.3 \quad V &= \omega r = 14,661 \times 0,04 \checkmark \\ &= 0,587 \text{ m/s} \checkmark \end{aligned} \quad (2)$$

[12]

QUESTION 3

3.1 Newton's first law states that inertia is the property of an object to remain in a state of rest or uniform motion. (1)

3.2 Given:
 $u = 2 \text{ m/s}$
 $v = 10 \text{ m/s}$
 $t = 45 \text{ s}$
 $F_{\mu} = 500 \text{ N}$



3.2.1 $v = u + at$
 $a = \frac{10 - 2}{45} \checkmark$
 $a = 0.178 \text{ m/s}^2 \checkmark$ (2)

3.2.2 $v^2 - u^2 = 2as$
 $s = \frac{v^2 - u^2}{2a}$
 $s = \frac{10^2 - 2^2}{2 \times 0.178} \checkmark$
 $s = 269.663 \text{ m} \checkmark$

OR

$$s = \frac{u + v}{2} \times t$$

$$s = \frac{2 + 10}{2} \times 45$$

$$s = 270m$$

$$s = ut + \frac{1}{2}at^2$$

$$s = 2(45) + \frac{1}{2}(0,178)(45)^2$$

$$s = 270,225m$$

(2)

3.2.3

$$ma = 4000 \times 0,178$$

$$ma = 712N \checkmark$$

$$F_{\mu} = 500N$$

$$F_s = mg \sin \theta$$

$$F_s = 4000 \times 9,8 \times \sin 8^{\circ}$$

$$F_s = 5455,586N \checkmark$$

$$ma = F - F_s - F_{\mu}$$

$$F = ma + F_s + F_{\mu}$$

$$F = 712 + 5455,586 + 500$$

$$F = 6667,568N \checkmark$$

OR

$$ma = F - F_s - F_{\mu}$$

$$F = ma + F_s + F_{\mu}$$

$$F = (4000 \times 0,178) + (4000 \times 9,8 \times \sin 8^{\circ}) + 500$$

$$F = 6667,568N$$

(3)

3.2.4

$$P = \frac{Fs}{t}$$

$$P = \frac{6667,568 \times 270,225}{45} \checkmark$$

$$P = 40,039kW \checkmark$$

(2)

3.3 $M = 15 \text{ kg}$
 $V = 16,4 \text{ m/s}$

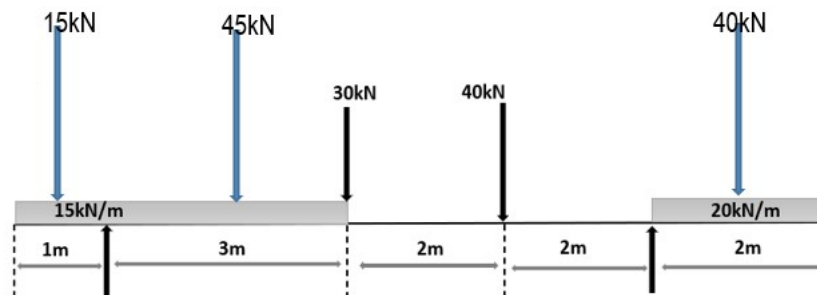
3.3.1 $E_p = E_k = \frac{1}{2} \times m \times v^2$ ✓
 $E_p = E_k = \frac{1}{2} \times 15 \times 16,4^2$ ✓
 $E_p = E_k = 2017,2 \text{ N}$ ✓

3.3.2 $E_p = E_k = m \times g \times h$
 $h = \frac{E_p}{mg}$
 $h = \frac{2017,2}{15 \times 9,8}$ ✓
 $h = 13,722 \text{ m}$ ✓

(2 × 2) (4)
[14]

QUESTION 4

4.1



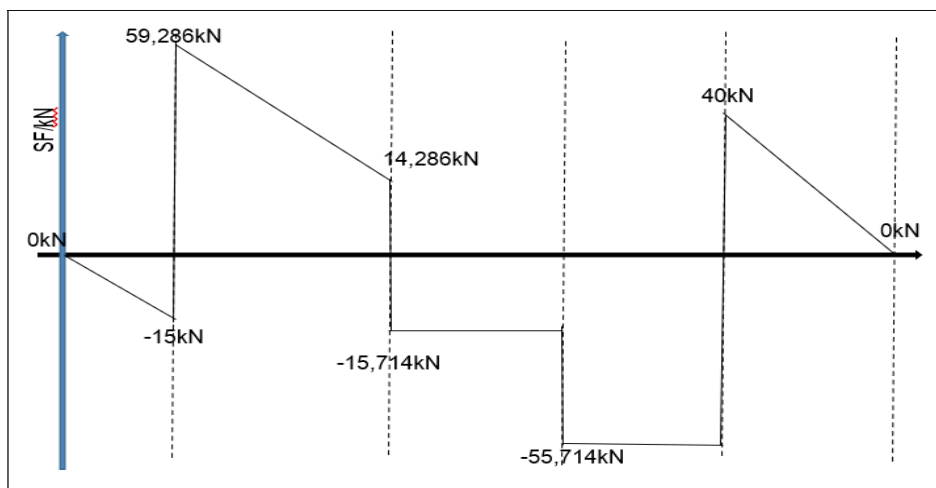
4.1.1 Taking moments about B
 $\Sigma CM = \Sigma ACM$
 $(45 \times 1,5) + (30 \times 3) + (40 \times 5) + (40 \times 8) = (15 \times 0,5) + (E \times 7)$ ✓
 Therefore, $E = 95,714 \text{ kN}$ ✓

Taking moments about E
 $\Sigma CM = \Sigma ACM$
 $(B \times 7) + (40 \times 1) = (40 \times 2) + (30 \times 4) + (45 \times 5,5) + (15 \times 7,5)$ ✓
 Therefore, $B = 74,286 \text{ kN}$ ✓

Check: $\Sigma \uparrow F = \Sigma \downarrow F$
 $95,714 + 74,286 = 15 + 45 + 30 + 40 + 40$
 $170 \text{ kN} = 170 \text{ kN} \dots \dots \dots \text{balanced}$

(3)

4.1.2



✓✓✓✓✓ for every correct value
✓ for the shape

(3)

4.1.3 Bending moments at principal points:

$$BM_A = 0 \text{ kNm} \checkmark$$

$$BM_B = -(15 \times 1) = -15 \text{ kNm} \checkmark$$

$$BM_C = (74,286 \times 3) - (15 \times 3,5) - (45 \times 1,5) = 102,858 \text{ kNm} \checkmark$$

$$BM_D = (95,714 \times 2) - (40 \times 3) = 71,428 \text{ kNm} \checkmark$$

$$BM_E = -(40 \times 1) = -40 \text{ kNm} \checkmark$$

$$BM_F = 0 \text{ kNm} \checkmark$$

(4)

4.2

SHAPE	AREA/mm	CENTROID/mm	MOM/mm ³
	250×380 $= 95\,000 \checkmark$	$\frac{380}{2}$ $= 190 \checkmark$	$18\,050\,000 \checkmark$
	$0,5 \times 180 \times 100$ $= 9\,000 \checkmark$	$200 + 120$ $= 320 \checkmark$	$2\,880\,000 \checkmark$
	$95\,000 - 9\,000$ $= 86\,000 \checkmark$	$\bar{x}$	$15\,170\,000 \checkmark$

$$\bar{x} = \frac{1517000}{86000} = 176,395 \text{ mm} \checkmark$$

(5)
[19]

QUESTION 5

5.1

Given:

$$f = 185 \text{ N}$$

$$\eta = 0,82$$

$$MA = 12$$

$$\frac{D}{d} = \frac{8}{1}$$

$$MA = \frac{f_p}{f} \times \frac{1}{\eta}$$

$$f_p = MA \times f \times \eta$$

$$f_p = 12 \times 185 \times 0,82 \checkmark$$

$$f_p = 1820,4 \text{ N} \checkmark$$

$$\frac{f_p}{d^2} = \frac{F}{D^2}$$

$$F = \frac{D^2}{d^2} \times f_p \checkmark$$

$$F = \frac{8^2}{1^2} \times 1820,4 \checkmark$$

$$F = 116,506 \text{ kN} \checkmark$$

(5)

5.2

Given:

Three cylinders = x 3

$$d = 0,125 \text{ m}$$

$$l = 0,4 \text{ m}$$

$$\eta = 0,8$$

$$\rho = 500 \text{ kPa}$$

$$n = 500 \text{ rpm}$$

Vol / stroke :

$$V_{stroke} = \frac{\pi D^2}{4} \times l$$

$$V_{stroke} = \frac{\pi \times 0,125^2}{4} \times 0,4$$

$$V_{stroke} = 0,00491 \text{ m}^3 \checkmark$$

$$n = \frac{500}{60}$$

$$n = 8,333 \text{ r / s} \checkmark$$

Vol/s three pistons:

$$Vol / \text{sec}(3) = V_{\text{stroke}} \times n \times 3$$

$$Vol / \text{sec}(3) = 0,00491 \times 8,333 \times 3$$

$$Vol / \text{sec}(3) = 0,123 \text{ m}^3 / \text{s} \checkmark$$

$$P_{in} = \frac{P_{out}}{\eta}$$

$$P_{in} = \frac{\rho \times \frac{V}{s}}{\eta}$$

$$P_{in} = \frac{500 \times 10^3 \times 0,123}{0,8} \checkmark$$

$$P_{in} = 76,875 \text{ kPa}$$

OR

$$P_{in} = \frac{P_{out}}{\eta}$$

$$P_{in} = \frac{\rho \times V}{\eta \times t}$$

$$P_{in} = \frac{\rho \times 3 \left(\frac{\pi D^2}{4} \times l \times n \right)}{\eta}$$

$$P_{in} = \frac{500 \times 10^3 \times 3 \left(\frac{\pi \times 0,125^2}{4} \times 0,4 \times \frac{500}{60} \right)}{0,8}$$

$$P_{in} = 76,696 \text{ kPa}$$

(4)

5.3 D = 200 mm
m = 900 kg
l = 2 200 mm

5.3.1 $F = mg$
 $F = 900 \times 9,8$
 $F = 8820 \text{ N} \checkmark$

$$A = \frac{\pi D^2}{4}$$

$$A = \frac{\pi 0,2^2}{4}$$

$$A = 0,0314 \text{ m}^2 \checkmark$$

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

$$\rho = \frac{8820}{0,0314}$$

$$\rho = 280,892 \text{ kPa} \checkmark$$

(3)

OR

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

$$\rho = \frac{mg}{\frac{\pi \cdot D^2}{4}}$$

$$\rho = \frac{900 \times 9,8}{\frac{\pi \times 0,2^2}{4}}$$

$$\rho = 280,749 \text{ kPa}$$

5.3.2 $V = A \times l$

$$V = \frac{\pi \cdot D^2}{4} \times l$$

$$V = \frac{\pi \cdot 0,2^2}{4} \times 2,2 \checkmark$$

$$V = 0,069115 \times 1000 \checkmark$$

$$V = 69,115 \ell \checkmark$$

(3)

[15]**QUESTION 6**

6.1 Given:

$$\sigma = 65 \text{ MPa}$$

$$l = 1,9 \text{ m}$$

$$D = 60 \text{ mm}$$

$$d = 52 \text{ mm}$$

$$E = 210 \text{ GPa}$$

6.1.1 $\sigma = \frac{F}{A}$

$$F = 4 \times \sigma \times A$$

$$F = 4 \times 65 \times 10^6 \times \left(\frac{\pi \cdot 0,06^2}{4} - \frac{\pi \cdot 0,052^2}{4} \right) \checkmark$$

$$F = 182966,356 \text{ N} \checkmark$$

$$m = \frac{F}{g}$$

$$m = \frac{182966,356}{9,8}$$

$$m = 18670,036 \text{ kg}$$

$$m = 18,67 \text{ ton} \checkmark$$

(3)

6.1.2

$$\varepsilon = \frac{\Delta x}{l}$$

$$\Delta x = \varepsilon \times l$$

$$E = \frac{\sigma}{\varepsilon}$$

$$\varepsilon = \frac{\sigma}{E}$$

$$\Delta x = \frac{\sigma}{E} \times l$$

$$\Delta x = \frac{65 \times 10^6}{210 \times 10^9} \times 1,9$$

$$\Delta x = 0,000588m$$

$$\Delta x = 0,588mm$$

OR

$$E = \frac{\sigma}{\varepsilon}$$

$$E = \frac{\frac{F}{A}}{\frac{\Delta x}{l}}$$

$$\Delta x = \frac{F}{A} \times \frac{l}{E}$$

$$\Delta x = \frac{\frac{182966,356}{4} \times 1,9}{\left(\frac{\pi 0,06^2}{4} - \frac{\pi 0,052^2}{4} \right) \times 210 \times 10^9}$$

$$\Delta x = 0,000588m$$

$$\Delta x = 0,588mm$$

(3)

6.2

6.2.1

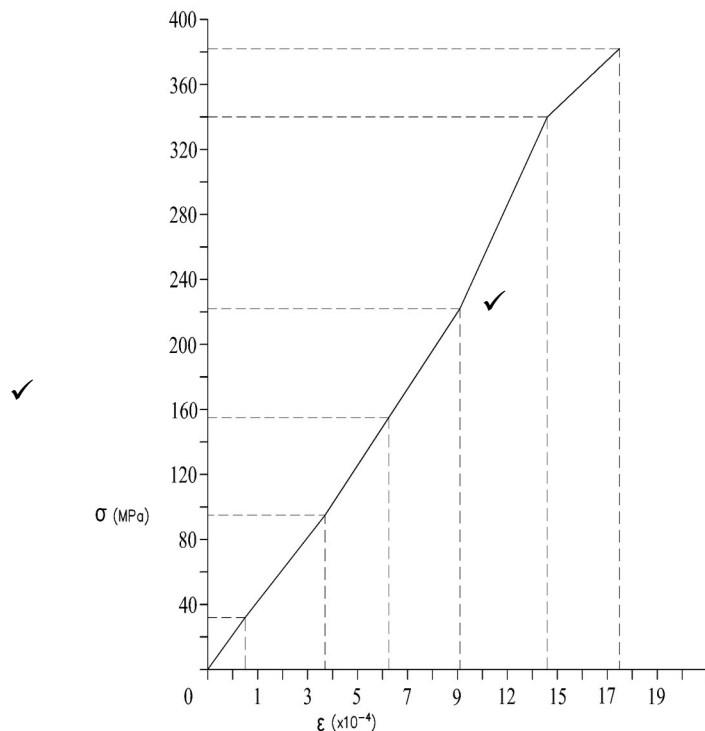
$\sigma = \frac{F}{A}$ $\sigma = \frac{10 \times 10^3}{\frac{\pi 0,02^2}{4}}$ $\sigma = 31,831MPa$	$\varepsilon = \frac{\Delta x}{l}$ $\varepsilon = \frac{15 \times 10^{-6}}{0,2}$ $\varepsilon = 0,75 \times 10^{-4}$	✓
$\sigma = \frac{F}{A}$ $\sigma = \frac{30 \times 10^3}{\frac{\pi 0,02^2}{4}}$ $\sigma = 95,943MPa$	$\varepsilon = \frac{\Delta x}{l}$ $\varepsilon = \frac{67,5 \times 10^{-6}}{0,2}$ $\varepsilon = 3,375 \times 10^{-4}$	✓
$\sigma = \frac{F}{A}$ $\sigma = \frac{50 \times 10^3}{\frac{\pi 0,02^2}{4}}$ $\sigma = 159,155MPa$	$\varepsilon = \frac{\Delta x}{l}$ $\varepsilon = \frac{125 \times 10^{-6}}{0,2}$ $\varepsilon = 6,25 \times 10^{-4}$	✓
$\sigma = \frac{F}{A}$ $\sigma = \frac{70 \times 10^3}{\frac{\pi 0,02^2}{4}}$ $\sigma = 222,817MPa$	$\varepsilon = \frac{\Delta x}{l}$ $\varepsilon = \frac{183 \times 10^{-6}}{0,2}$ $\varepsilon = 9,15 \times 10^{-4}$	✓
$\sigma = \frac{F}{A}$ $\sigma = \frac{90 \times 10^3}{\frac{\pi 0,02^2}{4}}$ $\sigma = 286,479MPa$	$\varepsilon = \frac{\Delta x}{l}$ $\varepsilon = \frac{237 \times 10^{-6}}{0,2}$ $\varepsilon = 11,85 \times 10^{-4}$	✓

$\sigma = \frac{F}{A}$	$\epsilon = \frac{\Delta L}{L}$
$\sigma = \frac{110 \times 10^3}{\frac{\pi \times 0,02^2}{4}}$	$\epsilon = \frac{292 \times 10^{-6}}{0,2}$
$\sigma = 350,141 \text{ MPa}$	$\epsilon = 14,6 \times 10^{-4}$

✓

(6)

6.2.2



✓

(2)
[14]

QUESTION 7

7.1

Given:

$$L_0 = 2 \text{ m}$$

$$L_F = 2032,5 \text{ mm}$$

$$\Delta t = 300 \text{ K}$$

7.1.1

$$\Delta l = L_0 \times \alpha \times \Delta t$$

$$\alpha = \frac{\Delta l}{L_0 \times \Delta t}$$

$$\alpha = \frac{2,0325 - 2}{2 \times 300} \checkmark$$

$$\alpha = 54,167 \times 10^{-6} / \text{K} \checkmark$$

(2)

7.1.2

Lead

(1)

7.2 $\Delta V_p = \gamma_p \times V_p \times \Delta t$
 $\Delta V_p = 76,4 \times 10^{-5} \times 45 \times (45 - 21) \checkmark$
 $\Delta V_p = 0,825 \text{ cm}^3 \checkmark$

$$\Delta V_G = \gamma_G \times V_G \times \Delta t$$

$$\Delta V_G = 3(8,6 \times 10^{-6}) \times 45 \times (45 - 21) \checkmark$$

$$\Delta V_G = 0,0279 \text{ cm}^3 \checkmark$$

$$V_{\text{Overflow}} = \Delta V_p - \Delta V_G$$

$$V_{\text{Overflow}} = 0,825 - 0,0279 \checkmark$$

$$V_{\text{Overflow}} = 0,7971 \text{ cm}^3 \checkmark$$

(6)

7.3 Given:

$$V_1 = 80 \times 10^{-6} \text{ m}^3$$

$$P_1 = 250 \text{ kPa}$$

$$P_2 = 400 \text{ kPa}$$

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2} \checkmark$$

$$V_2 = \frac{(250 \times 10^3) \times (80 \times 10^{-6})}{400 \times 10^3} \checkmark$$

$$V_2 = 50 \times 10^{-6} \text{ m}^3 \checkmark$$

(3)

7.4 Given:

$$T_O = 278 \text{ K}$$

$$T_F = 302 \text{ K}$$

$$P_O = 490 \text{ kPa}$$

$$P_F = 101,3 \text{ kPa}$$

$$V_O = 0,5 \text{ m}^3$$

$$\frac{P_O \cdot V_O}{T_O} = \frac{P_F \cdot V_F}{T_F}$$

$$V_F = \frac{P_O \cdot V_O \cdot T_F}{T_O \cdot P_F} \checkmark$$

$$V_F = \frac{(490 \times 10^3) \times 0,5 \times 302}{278 \times (101,3 \times 10^3)} \checkmark$$

$$V_F = 2,627 \text{ m}^3 \checkmark$$

(3)

[15]**TOTAL: 100**