

**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

POWER MACHINES N6

28 July 2014

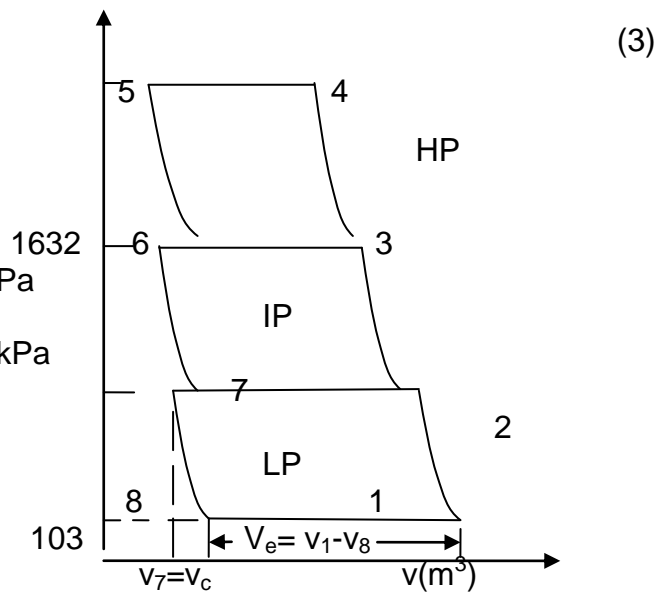
This marking guideline consists of 9 pages.

QUESTION 1

$$1.1.1 \quad k = \sqrt{\frac{P_3}{P_1}} = \sqrt{\frac{1632}{103}} = 3,98$$

$$P_2 = P_1 \times k = 103 \times 3,98 = 409,94 \text{ kPa}$$

$$P_4 = P_3 \times k = 1632 \times 3,98 = 6495,36 \text{ kPa}$$



$$1.1.2 \quad V_1 = V_s + V_c = V_s + 0,04V_1$$

$$0,96 V_1 = V_s$$

$$\therefore V_1 = \frac{0,0084}{0,96} = 0,00875 \text{ m}^3$$

$$V_c = 0,04 V_1 = 0,04 \times 0,00875 = 0,00035 \text{ m}^3$$

$$V_8 = V_c \left(\frac{P_7}{P_8}\right)^{\frac{1}{n}} = 0,00035 \left(\frac{409,94}{103}\right)^{\frac{1}{1,32}} = 0,00099 \text{ m}^3$$

$$\therefore V_e = V_1 - V_8 = 0,00875 - 0,00099 = 0,00776 \text{ m}^3 \quad (6)$$

$$1.1.3 \quad P = \frac{\gamma n}{n-1} P_1 V_e [(P_2/P_1)^{n-1/n} - 1] \times 2 \times \frac{N}{60}$$

$$= \frac{3 \times 1,32 \times 103 \times 0,00776}{0,32} \left[\left(\frac{409,94}{103}\right)^{\frac{0,3}{1,32}} - 1 \right] \times 2 \times \frac{340}{60}$$

$$= 44,586 \text{ W} \quad (3)$$

$$1.1.4 \quad T_2 = T_1 (P_2/P_1)^{n-1/n} = 302 (3,98)^{0,32/1,32} = 422,12 \text{ K} \quad (2)$$

$$1.1.5 \quad Q_{\text{intercooler}} = m C_p (T_2 - T_1) = \frac{336}{3600} \times 1,005 (422,12 - 302)$$

$$= 11,267 \text{ kJ/s} \quad (2)$$

$$1.1.6 \quad Q_{\text{waterjacket}} = \frac{P}{3} - Q_{\text{intercooler}} = \frac{41,34}{3} - 11,267 = 2,513 \text{ kJ/s} \quad (2)$$

2.2

Q _{in} (kJ/kg)	Q _{out} (kJ/kg)		%
33 075	Economiser	2548	7,704
	Evaporator	22923,67	69,308
	Superheater	988,33	2,988
	Unaccounted	33075 – 26460 = 6615	20
33 075		33 075	100

(5)
[20]**QUESTION 3**

$$3.1.1 \quad V_s = \frac{\pi}{4} D^2 L = \frac{\pi}{4} (0,07515)^2 \times 0,09018$$

$$= 0,0004 \text{ m}^3$$

$$BP = \frac{PLACE}{60} = \frac{1250 \times 0,0004 \times 4800 \times 4}{60 \times 2}$$

$$= 80 \text{ kW}$$

$$P_{im} = \frac{P_{bm}}{\eta} = \frac{1250}{0,8}$$

$$= 1562,5 \text{ kPa}$$

(6)

$$3.1.2 \quad BP = \frac{2\pi TN}{60}$$

$$T = \frac{60 \times BP}{2\pi N} = \frac{60 \times 80 \times 10^3}{2 \times \pi \times 4800}$$

$$= 159,155 \text{ N.m}$$

(2)

$$3.1.3 \quad BSFC = \frac{mf/h}{BP}$$

$$mf/s = \frac{BSFC \times BP}{60 \times 60} = \frac{0,288 \times 80}{60 \times 60}$$

$$= 0,0064 \text{ kg/s}$$

$$\eta_B = \frac{BP}{mf/s \times CV} = \frac{80}{0,0064 \times 39062,5} \times 100\%$$

$$= 32\%$$

$$\eta_{IT} = \frac{\eta_{BT}}{\eta_m} = \frac{32}{0,8} = 40\%$$

(6)

$$3.1.4 \quad r = \frac{vs+vc}{vc} = \frac{vs+0,05vs}{0,05vs} = \frac{1,05vs}{0,05vs} = 21$$

$$A S E = [1 - (1/r)^{\gamma-1}] \times 100 \% = [1 - (1/21)^{0.41}] \times 100 \% \\ = \underline{71,3\%}$$

$$\text{Ind. } \eta \text{ ratio} = \frac{\eta_{IT}}{ASE} \times 100\% = \frac{0,4}{0,713} \times 100\%$$

$$= \underline{56,1\%}$$

(6)
[20]**QUESTION 4**

$$4.1.1 \quad C_c = \sqrt{2000 C_p (T_1 - T_2)}$$

$$T_1 = \frac{C_c^2}{2000 C_p} + T_c = \frac{398,801^2}{2000 \times 1,008} + 404,11 = 78,89 + 404,11$$

$$= \underline{483K}$$

$$\frac{P_c}{p_1} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

$$P_1 = P_c \left(\frac{\gamma+1}{2}\right)^{\frac{\gamma}{\gamma-1}} = 475,454 \left(\frac{2,4}{2}\right)^{\frac{1,4}{0,4}} = \underline{900kPa}$$

(5)

$$4.1.2 \quad T'_c = T_1 \left(\frac{2}{\gamma+1}\right) = 483 \left(\frac{2}{2,4}\right) = 402,5K$$

$$A_c = \frac{m V_c}{C_c}$$

$$V_c = \frac{A_c C_c}{m} = \frac{1534,6 \times 10^{-6} \times 398,801 \times 60}{150} = \underline{0,2448 \text{ m}^3/\text{kg}}$$

$$\eta = \left(1 - \frac{T_1 - T_c}{T_1 - T'_c}\right) \times 100\%$$

$$= \left(1 - \frac{78,89}{80,5}\right) \times 100\% = \underline{2\%}$$

(6)

$$4.1.3 \quad T_2' = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 483 \left(\frac{237,26}{900}\right)^{\frac{0,4}{1,4}} = 330K$$

$$T_2 = T_1 - \eta (T_1 - T_2') = 483 - 0,92(153)$$

$$= \underline{342,24K}$$

$$C_2 = \sqrt{2000 C_p (T_1 - T_2)}$$

$$= \sqrt{2000 \times 1,008 (483 - 342,24)}$$

$$= \underline{532,703 \text{ m/s}}$$

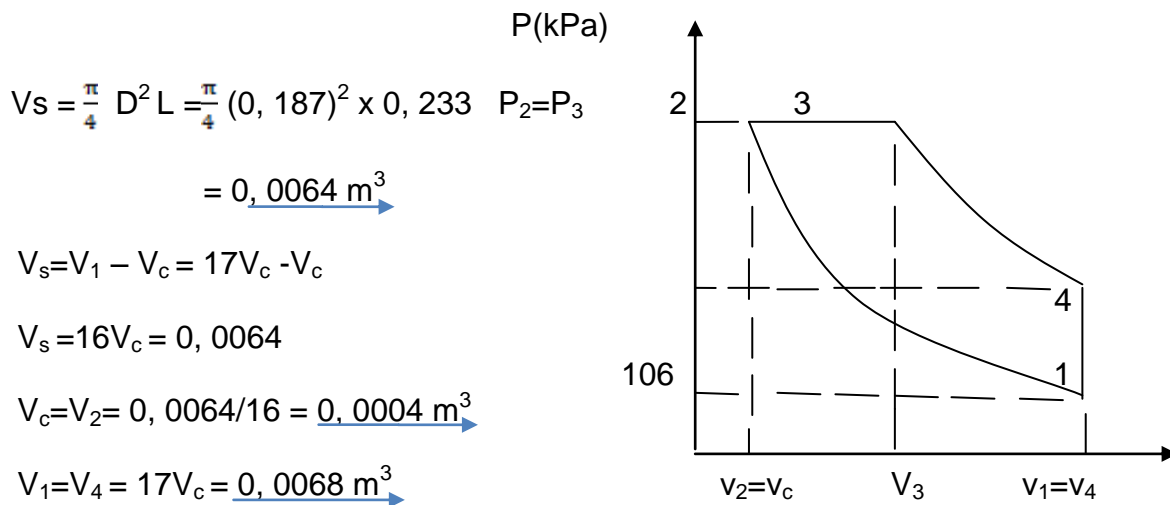
$$A_2 = \frac{mV_2}{C_2} = \frac{150 \times 0,4154 \times 106}{60 \times 532,703} = 1949,492 \text{ mm}^2 \quad (8)$$

$$4.1.4 \quad \text{Mach no} = \frac{C_2}{C_c} = \frac{532,703}{398,801} = 1,336 \quad (1)$$

[20]

QUESTION 5

$$5.1.1 \quad (5)$$



$$V_3 = 10\%V_s + V_c$$

$$= 0,1(0,0064) + 0,0004 = 0,00104 \text{ m}^3$$

$$5.1.2 \quad P_2 = P_3 = P_1 \left(\frac{V_1}{V_2}\right)^n = 106(17)^{1,32} = 4461,68 \text{ kPa}$$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{n-1} = 295,5(17)^{0,32} = 731,646 \text{ K}$$

$$T_3 = \frac{V_3 T_2}{V_2} = \frac{0,00104 \times 731,646}{0,0004} = 1902,28 \text{ K}$$

$$P_4 = P_3 \left(\frac{V_3}{V_4}\right)^n = 4461,68 \left(\frac{0,00104}{0,0068}\right)^{1,32} = 374,171 \text{ kPa}$$

$$T_4 = T_3 \left(\frac{V_3}{V_4}\right)^{n-1} = 1902,28 \left(\frac{0,00104}{0,0068}\right)^{0,32} = 1043,091 \text{ K} \quad (8)$$

$$5.1.3 \quad m = \frac{P_1 V_1}{RT_1} = \frac{106 \times 0,0068}{0,287 \times 295,5} = 0,0085 \text{ kg/cycle}$$

$$= 0,0085 \times \frac{300}{60} = 0,0425 \text{ kg/s} \quad (3)$$

$$\begin{aligned}
 5.1.4 \quad WD &= mR[(T_3 - T_2) + \frac{T_3 - T_4 - T_2 + T_1}{n-1}] \\
 &= 0,0425 \times 0,287[(1902,28 - 731,646) \\
 &\quad + \frac{1902,28 - 1043,091 - 731,646 + 295,5}{0,32}] \\
 &= 0,0425 \times 0,287[1170,634 + 1322,009] \\
 &= 30,404 \text{ kW}
 \end{aligned}$$

(4)
[20]

QUESTION 6

6.1.1 (5)

T

$$\begin{aligned}
 S_2 &= S_1 = S_3 + C_p \ln \frac{T_2}{T_3} \\
 &= 0,922 + 2,5261 \ln \frac{325,8}{301} \\
 &= 1,122 \text{ kJ/kg}
 \end{aligned}$$

$$x_1 = \frac{s_1 - s_7}{s_8 - s_7} = \frac{1,122 - 0,312}{1,183 - 0,312} = 0,93$$

6.1.2 $h_1 = h_7 + x_1(h_8 - h_7)$

$$\begin{aligned}
 &= 81,4 + 0,93(318,6 - 81,4) \\
 &= 81,4 + 220,6
 \end{aligned}$$

$$h_2 = h_g + C_p(T_2 - T_3) = 263,8 + 2,5261(325,8 - 301)$$

$$= 263,8 + 62,447$$

$$= 326,447 \text{ kJ/kg}$$

6.1.3 $h_6 = h_4 - C_p(T_4 - T_5) = 178,6 - 5,42(301 - 296)$

$$= 178,6 - 27,1$$

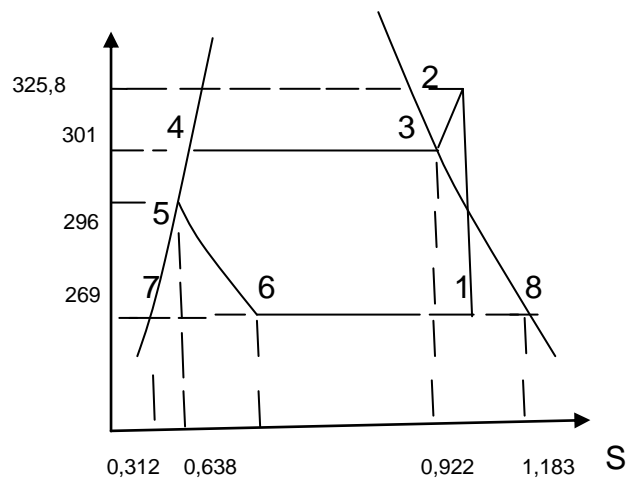
$$= 151,5 \text{ kJ/kg}$$

$$RE = h_1 - h_6 = 302 - 151,5 = 150,5 \text{ kJ/kg}$$

$$WD = h_2 - h_1 = 326,447 - 302 = 24,447 \text{ kJ/kg}$$

$$COP = \frac{RE}{WD} = \frac{150,5}{24,447} = 6,156$$

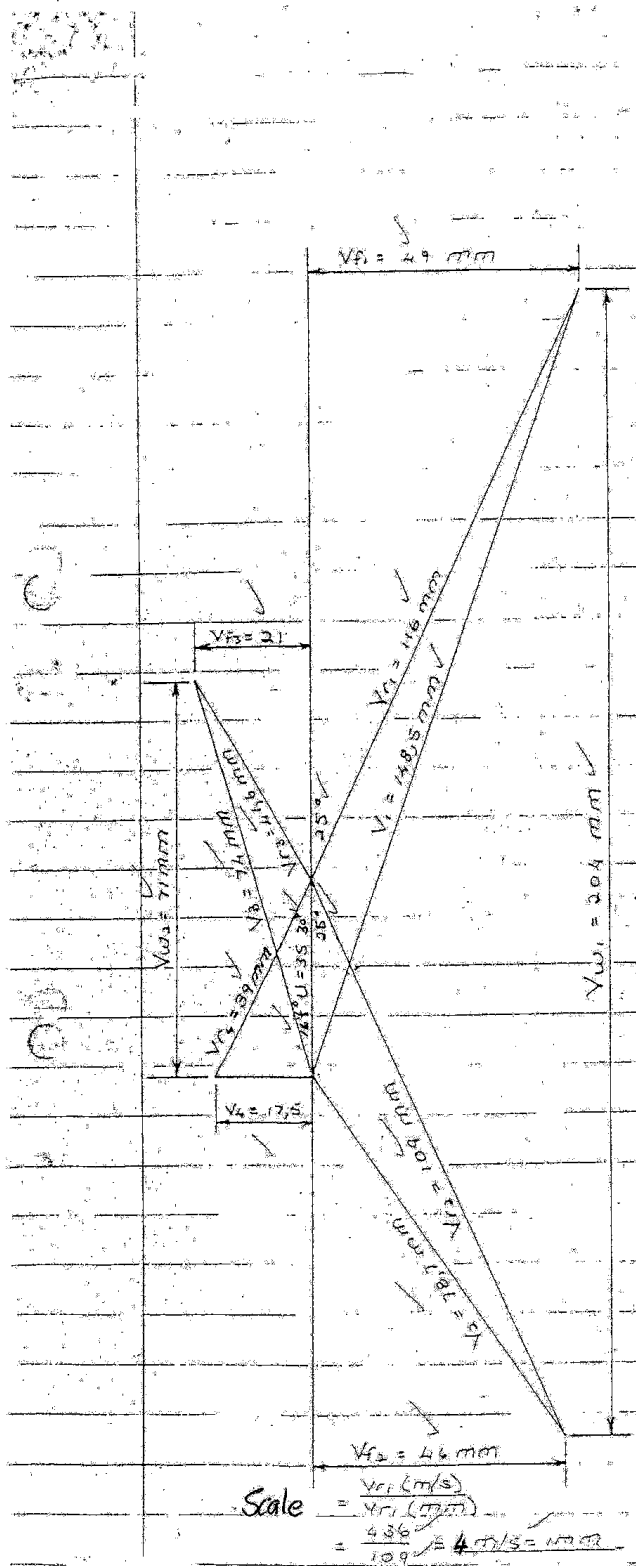
(7)



$$\begin{aligned} 6.1.4 \quad P_m &= \frac{m r (h_2 - h_1)}{\eta} \\ &= \frac{18(24,447)}{60 \times 0,83} \\ &= 8,836 \text{ kW} \end{aligned}$$

(2)
[20]

QUESTION 7



- 7.2 7.2.1 $U = 35 \times 4 = 140 \text{ m/s}$
- 7.2.2 $V_1 = 148,5 \times 4 = 594 \text{ m/s}$
- 7.2.3 $V_2 = 78,7 \times 4 = 314,8 \text{ m/s}$
- 7.2.4 $V_3 = 74 \times 4 = 296 \text{ m/s}$
- 7.2.5 $V_4 = 17,5 \times 4 = 70 \text{ m/s}$
- 7.2.6 $\alpha_1 = 19,3^\circ$
- 7.2.7 $P = \mu (Vw_1 + Vw_2)$
 $= 1 \times 140(204 + 71) \times 4$
 $= 154 \text{ kJ/kg}$
- 7.2.8 $\eta = 2UVw_T / V_1^2 \times 100\%$
 $= 2 \times 140 \times 1100 / 594^2 \times 100\%$
 $= 87,3\%$

(10)
[20]

TOTAL: 100