higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

POWER MACHINES N6

9 APRIL 2013

This marking guideline consists of 11 pages.

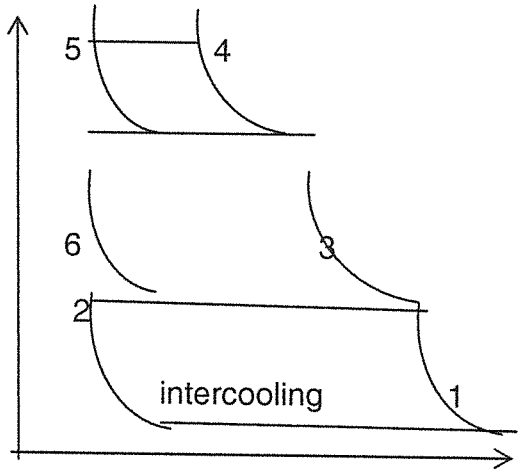
QUESTION 1

1.1 $$P_c = \frac{xn}{n-1} P_1 Ve_1 \left[(rp_s)^{\frac{n-1}{n}} - 1 \right] \times \frac{N}{60}$$ ✓

$$Ve_1 = \frac{(n-1)P_c \times 60}{xnP_1 \left[(rp_s)^{\frac{n-1}{n}} - 1 \right] N}$$ ✓ ✓

7 Perfect

$$= 0{,}038 \frac{m^3}{cycle}$$ ✓ (8)



(4)

1.2 $$V_{s1} = \frac{\pi}{4} D^2 L = \frac{\pi}{4} D^2 \times 1{,}24D = \frac{1{,}24\pi D^3}{4}$$ ✓ ✓ ✓

$$= \frac{1{,}24\pi}{4} \times 0{,}345^3 = \frac{0{,}04m^3}{cycle}$$ ✓ ✓ ✓

$$\eta_{vol1} = \frac{V_{s1}}{V_{s1}} = \frac{0{,}038}{0{,}04} \times 100 = 95\%$$ ✓ (4)

1.3 $$\frac{T_1}{T_2'} = \left(\frac{P_1}{P_2} \right)^{\frac{n-1}{n}}$$

$$\therefore T_1 1 = T_1 2^{Tr} (1/ [rp]_1 s)^{((n-1)/n)} = 378{,}002((1/3.4)^{(0{,}3/1{,}3)} = 285K($$

$$P_1 1 \ [Ve]_1 1 = [mRT]_1 1 \ ($$ ✓ ✓ ✓

$$\therefore R = \frac{P_1 V_{s1}}{mT_1} \times \frac{N}{60} = \frac{100 \times 0{,}038 \times 3600 \times 324}{900 \times 285 \times 60} = 0{,}288 \frac{kJ}{kg}$$ ✓ ✓ ✓ (5)

1.4 $$\eta_1 vol = \{1 - V_1 c/V_1 s \ [([rp]_1 s)^{T}(1/n) - 1] \}($$ ✓ ✓ ✓

$$\therefore V_c = \frac{(1 - \eta_{vol})V_s}{(rp_s)^{\frac{1}{n}} - 1} = \frac{(1 - 0{,}95) \times 0{,}04}{(3{,}4)^{(\frac{1}{1.3} - 1}} = 0{,}001 \frac{28m^3}{cycle}$$ ✓ ✓ ✓

$$V_1 = V_s + V_c = 0{,}04 + 0{,}001\,28 = 0{,}041\,28 \frac{m^3}{cycle}$$ (4)

1.5 $Q_{int} = 2[mC_p(T_2' - T_1)] = 2\left[\frac{900}{60 \times 60} \times 1{,}008(378{,}002 - 285)\right]$ ✓ ✓ ✓ ✓ ✓

$= 2[0{,}25 \times 1{,}008(93{,}002)]$

$Q_{int} = 46{,}873\ kW$ ✓ (3)

[20]

QUESTION 2

2.1

$Q_{in}\left(\frac{kJ}{kg}\right)$	$Q_{out}\left(\frac{kJ}{kg}\right)$	%
$CV = \frac{Q_{econ}}{\eta_{econ}}$ $= (2476{,}8" (" \times 100)/8{,}256($ $= 30\,000($	Economiser $= 2476{,}8$ Evaporator = 30 000 x 0,65684 (= 19 705,2) Superheater = 30 000 x 0,0862 (= 2 586) Moisture = 30 000 x 0,0525(= 1 575) Dry flues = 30 000 x 0,0635(= 1 905) Unaccounted = 30 000 x 0,0525(= 1 752)	8,256 65,684 8,62 5,25 6,35 5,84✓
30 000	$= 30\,000$	100

(7)

2.2 2.2.1 $\eta_{plant} = \eta_{econ} + \eta_{evap} + \eta_{super} = 8{,}256 + 65{,}634 + 8{,}62 = 82{,}56\%$ ✓ ✓ ✓ ✓

$\eta_1 th = (m_1 s\ (h_1 ss - h_1 fw1))/(m_1 f \times CV)$ (✓ ✓ ✓

$\therefore h_1 fw1 = h_1 ss - (\eta_1 th \times m_1 f \times CV)/m_1 s = 3010 - (0{,}8256 \times 975 \times 30\,000)/8385 (= 3010 - 2880 = 130 kJ/kg$

At 130 kJ/kg from steam tables: $t_1 fw1 = 31°C($

$t_1 fw2 = 31°C + 68{,}6°C = 99{,}6°C($

And $h_1 fw2 = 418\ kJ/kg($

(6)

2.2.2 At 2 550 kPa: $h_f = 967\frac{kJ}{kg}; h_{fg} = 1834\frac{kJ}{kg}; h_g = \frac{2801kJ}{kg}; t_s = 225℃$

$Q_1evap = m_1s/m_1f\ (h_1f + [\![xh]\!]_1fg - h_1fw2\ )($

$\therefore xh_{fg} = \frac{Q_{evap} \times m_f}{m_s} - h_f + h_{fw2}$

✓ ✓ ✓ ✓ ✓

$1834x = (19705,2 \times 975)/8385(-967 + 418 = 1742,3023$

$\therefore x = \frac{1742,3023}{1834} = 0,95$ ✓ (4)

2.2.3 $h_{ss} = h_g + C_p(t_{ss} - t_s)$ ✓

✓ ✓ ✓

$\therefore t_1ss = (h_1ss - h_1g)/C_1p + t_1s = (3010 - 2801)/2,75(+225 = 76 + 225$
$= 301℃($ (3)

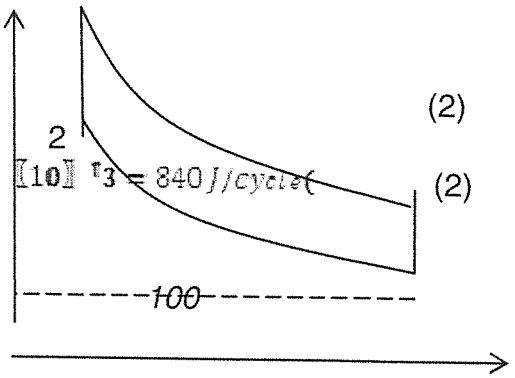
[20]

QUESTION 3

3.1 $IP = BP(/\eta = 11,9(/0,85(= 14\ kW($ (2)

3.2 $WD = (IP \times 60 \times 2)/N = (14"\ (" \times 60 \times 2"\ (")/2000(\times$ $[\![10]\!]^{\uparrow}3 = 840\ J/cycle($ (2)
4

3.3 $IP = PLANE/60\ (= (P \times V_1s \times NE)/60$
1



$\therefore\ V_1s = (60 \times IP)/PNE = (60 \times 14"\ (" \times 2"\ (")/(1000"\ (" \times 2000"\ (" \times 1) = 0,000\ 84\ m^{\uparrow}3\ ($
$V\ (m^3)$

$V_1s = \pi/4\ D^{\uparrow}2 \times L = \pi/4\ D^{\uparrow}2 \times 1,25D(= \pi/4\ D^{\uparrow}3$

$\therefore D = \sqrt[3]{(\ [\![4V]\!]_1s/1,25\pi)} = \sqrt[3]{((4 \times 0,00084 \times [\![10]\!]^{\uparrow}9\ "\ (")/(1,25 \times \pi"\ ("))} = 94,935\ mm($
✓ ✓

$L = 1,25D = 1,25 \times 94,935 = 118,669\ mm$ (6)

3.4 $V_s = 0,00084 \times 10^6 = 840\ cm^3$

$V_1c = V_12 = V_13 = V_1s(/r = 840(/7,5(= 112\ [\![cm]\!]^{\uparrow}3\ ($
✓ ✓

$V_1 = V_s + V_c = 840 + 112 = 952\ cm^3$ *OR* $V_1 = rV_c = 8,5 \times 112 = 952\ cm^3$ (3)

3.5 ✓ ✓ ✓

$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^n = 100(8,5)^{1,31}$$

$= 1\,650{,}208\ kPa$(

$P_1 4 = (P_1 1\ V_1 1\ T_1 4)/(T_1 1\ V_1 4\ ) = (P_1 1\ T_1 4)/T_1 1\ = (100 \times 2{,}8^{n}\ (^{n})/1($

$= 280\ kPa$ ✓

✓ ✓

$$P_3 = P_4\left(\frac{V_4}{V_3}\right)^n = 280(8,5)^{1,31}$$

$= 4\,620{,}584\ kPa$ ✓ (5)

3.6 ✓

$ASE = [1 - (1/r)^{\dagger}(\gamma - 1)\ ] \times 100\% = [1 - (1(/8,5)^{\dagger}0{,}4($] $\times\ 100\%$

$= 57{,}515\%$ ✓ (2)

[20]

QUESTION 4

4.1 ✓ ✓

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{n-1} = 305(16)^{0,35}$$

$= 804{,}9\ K($

✓ ✓

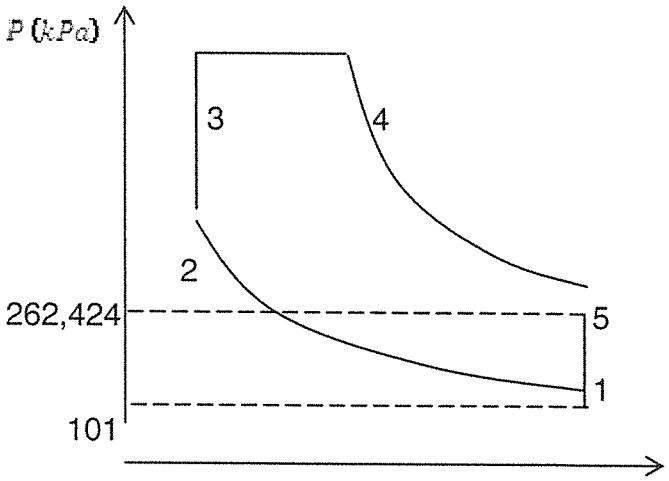
$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^n = 101(16)^{1,35}$$

$= 4\,264{,}65\ kPa($

✓ ✓

$P_3 = P_4 = 1{,}4P_2 = 1{,}4 \times 4264{,}65$

$= 5\,970{,}51\ kPa($



✓ ✓

$T_1 3 = (P_1 3\ T_1 2)/P_1 2\ = (5970{,}51 \times 804{,}9)/4264{,}65($

$V(m^3)$

$= 1\,126{,}86\ K($

✓ ✓

$$T_4 = \frac{V_4 T_3}{V_3} = \frac{V_2 \times 1126{,}86 \times 15}{10 \times V_2\ (}$$

where ✓ ✓ ✓

$$V_4 = V_3 + \frac{V_2}{30} = \frac{V_2}{15} + \frac{V_2}{30} = \frac{V_2}{10}$$

$= 1\,690{,}29\ K$ ✓

✓ ✓

$T_1 5 = (P_1 5\ T_1 1)/P_1 1\ = (262{,}424 \times 305)/101($

$= 792{,}469\ K($ (12)

4.2 $P_4V_4^{\,n} = P_5V_5^{\,n}$ ✓

$$\left(\frac{V_5}{V_4}\right)^n = \frac{P_4}{P_5}$$ ✓ ✓

$$n.\frac{\ln V_5}{V_4} = \frac{\ln P_4}{P_5}$$

$n = (\ln P_14/P_15)/(\ln V_15/V_14) = (\ln 59/0.51(/262,424()/(\ln [16V_1{}_5/15 \times 10(/(V_1S^{-}(^{-}))) = (\ln 59/0.51/262,424)/(\ln 160/15)$

$n = 1,32($ (4)

4.3 $\eta = [1 - (T_15 - T_11)/((T_13 - T_12) + \gamma(T_14 - T_13))](\times 100\%$

$$= \left[1 - \frac{792,469\,(-305\,(}{(1126,86\,(-804,9\,() + 1,4(1690,29\,(-1126,86\,()}\right] \times 100\%$$

$$= \left[1 - \frac{487,469}{1110,762}\right] \times 100\%$$

= 56,114% (4)

[20]

QUESTION 5

5.1 $C_c = \sqrt{2000(h_1 - h_c)} = \sqrt{2000(135,2)}$ ✓ ✓

$= 520\frac{m}{s}$ ✓

At 3 000 kPa and 300°C: $h_{ss} = h_1 = 2\,995\frac{kJ}{kg}$

$\Delta h = h_1 - h_c$ ✓ ✓ ✓ ✓

$h_c = h_1 - \Delta h = 2\,995 - 135,2 = 2\,859,8\frac{kJ}{kg}$

At 1 600 kPa: $h_g = 2\,792\ kJ/kg$ *and* $t_s = 201,4$°C

$h_c = h_{gc} + C_{p_c}(t_c - t_s)$ ✓ ✓ ✓

$\therefore t_1c = (h_1c - h_1(g_1c))/C_1(p_1c) + t_1s = (2859,8 - 2792)/2,825(+201,4 = 24 + 201,4$

$= 225,4$°C ✓

✓ ✓

$\frac{2859,8 - 1941}{1600(\square]}$

$= 0,1325\frac{m^3}{kg}$ ✓

✓ ✓ ✓

$A_1c = [\![mV]\!]_1c/C_1c = (5,2 \times 0,1325)/520(\times [\![10]\!]^{\uparrow}6 = 1\,325\ [\![mm]\!]^{\uparrow}2($

$d = \sqrt{((}[\![4A]\!]_1c\ ^{"}(")/\pi) = \sqrt{((4 \times 1325^{"}(")/\pi)} = 41,074\ mm($ (12)

5.2

$$At\ 860\ kPa\text{:}\ h_f = \frac{734kJ}{kgand} h_{fg} = 2036\frac{kJ}{kg}$$

✓ ✓ ✓

$$h_2 = h_f + xh_{fg} = 734 + 0{,}98(2036)$$

$$= 2\,729{,}28\frac{kJ}{kg}\checkmark$$

✓ ✓

$$x_i = 99{,}286\ of\ x_a = 0{,}99286 \times 0{,}98 = 0{,}973$$

✓

$$h_2' = h_f + x_i h_{fg} = 734 + 0{,}973(2036)$$

$$= 2\,715{,}028\ kJ/kg($$

✓

$$\Delta h_{actual} = h_1 - h_2 = 2995 - 2729{,}28$$

$$= 265{,}72\frac{kJ}{kg}\checkmark$$

✓

$$\Delta h_{isen} = h_1 - h_2' = 2995 - 2715{,}028$$

$$= 279{,}972\frac{kJ}{kg}\checkmark$$

✓

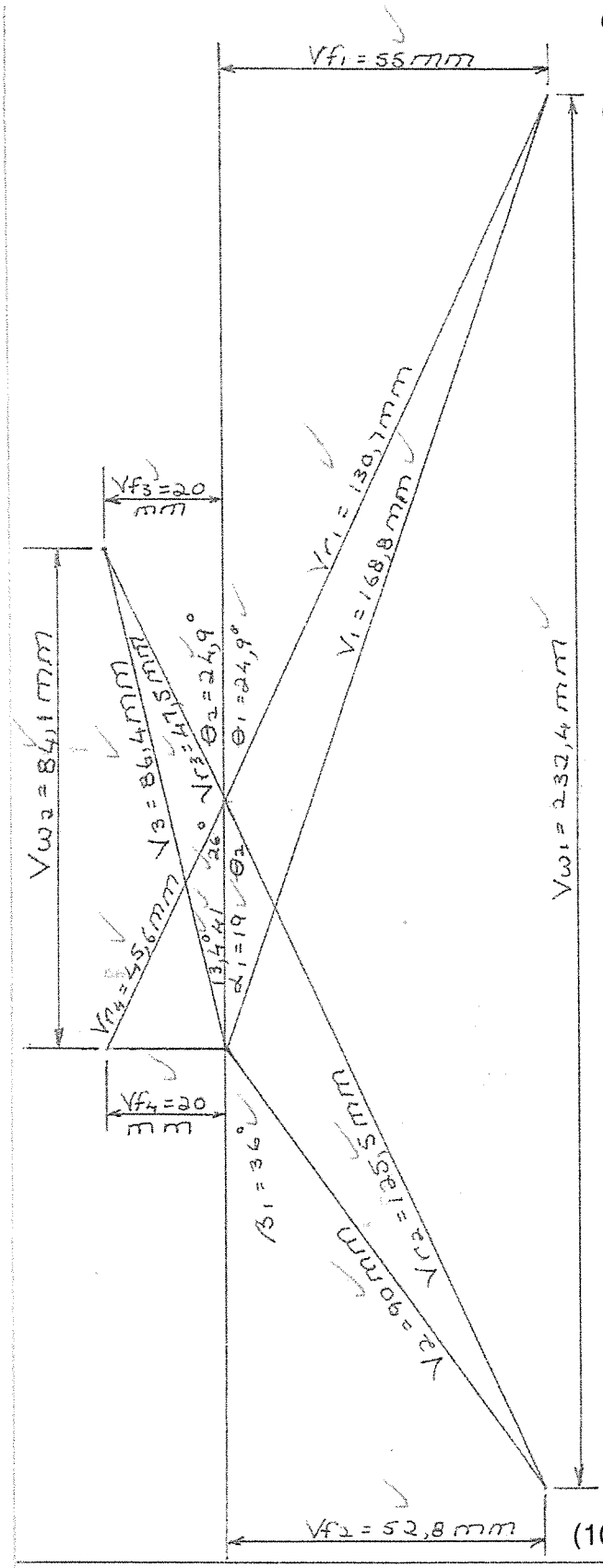
$$\eta_{nozzle} = [\Delta h]_{act} / [\Delta h]_{isen} = 265{,}72 / 279{,}972 \times 100\%$$

$$= 94{,}909\% \quad \checkmark$$

(8)
[20]

QUESTION 6

6.1



6.2.1 $\alpha_1 = 19^\circ$ ✓

6.2.2 $\alpha_2 = 13,4^\circ$ ✓

6.2.3 $\theta_1 = \theta_2 = \theta_3 = 24,9^\circ$ ✓

6.2.4 $\beta_1 = 36^\circ$ ✓

6.2.5 $U = 41 \times 4 = 164 \text{ m/s}$ ✓

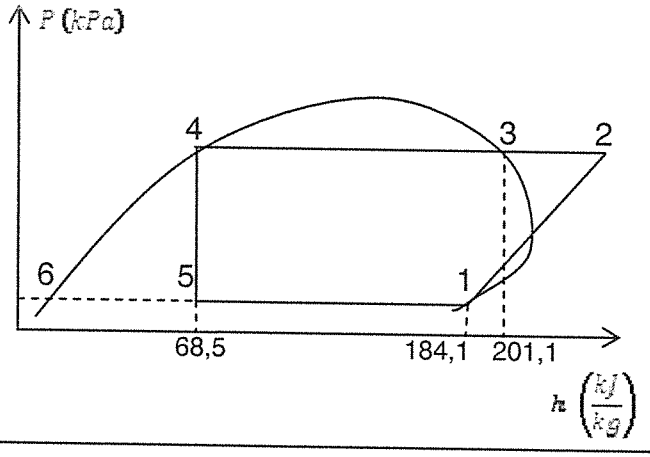
6.2.6 $V_1 = 168,8 \times 4 = 675,2 \text{ m/s}$ ✓

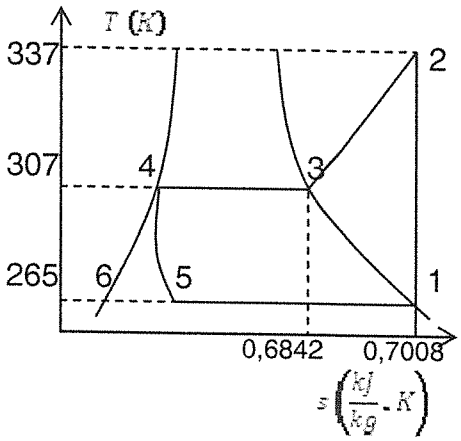
6.2.7 $V_2 = 90 \times 4 = 360 \text{ m/s}$ ✓

6.2.8
$$\eta = \frac{2U(V_{w1} + V_{w2})}{V_1^2} \times 100\%$$
$$= \frac{2 \times 164 (232,4 \times 84,1) 4}{675,2^2}$$
$$= \frac{2 \times 164 (929,6 + 336,4)}{675,2^2}$$
$$= \frac{2 \times 164 (1266)}{675,2^2} \times 100\%$$
$$= 91,084\% \text{ ✓}$$

6.2.9
$$P = mU(V_{w1} + V_{w2})$$
$$= 45 \times 164 (929,6 + 336,4)$$
$$= 45 \times 164 (1266) \times 10^{-6}$$
$$= 9,343 \text{ MW} \text{ ✓} \quad (10)$$

(10) **[20]**





7.1 $s_1 1 = s_1 2 = s_1 3 + C_1 p \ln T_1 2/T_1 3$ (

$C_1 p = (s_1 2 - s_1 3)/(\ln T_1 2/T_1 3) = (0{,}7008" (" - 0{,}6842" (")/(\ln 337(/307() = 0{,}178\ kJ/kg.K($ (

✓ ✓ ✓ ✓ ✓

$h_2 = h_2 + C_p(T_2 - T_2) = 201{,}1 + 0{,}178(337 - 307) = 201{,}1 + 0{,}178(30)$

$= 206{,}44 \frac{kJ}{kg}$ ✓

(6)

7.2 ✓ ✓ ✓ ✓

$V_s = \frac{\pi}{4} D^2 L \times \frac{N}{60} = \frac{\pi}{4}(0{,}12)^2 \times 0{,}1415 \times \frac{360}{60} = 0{,}009\,6 \frac{m^3}{s}$ ✓

$\eta_{vol} = \frac{V_r}{V_s}$ ✓ ✓ ✓ ✓

$V_r = V_s \times \eta_{vol} = 0{,}0096 \times 0{,}9 = 0{,}008\,64 \frac{m^3}{s}$

✓ ✓ ✓

$m_r = \frac{V_r}{V_g} = \frac{0{,}00864}{0{,}072} = 0{,}12 \frac{kg}{s}$

(6)

7.3 ✓ ✓ ✓ ✓

$P_c = m_r(h_2 - h_1) = 0{,}12(206{,}44 - 184{,}1) = 0{,}12(22{,}34) = 2{,}6808\ kW$

✓ ✓ ✓ ✓

$P_{ice} = m_r(h_1 - h_5) = 0{,}12(184{,}1 - 68{,}5) = 0{,}12(115{,}6) = 13{,}872\ kW$

$COP = RE/WD\ (= 13{,}872(/2{,}6808(= 5{,}175($

OR $COP = \frac{h_1 - h_5}{h_2 - h_1} = \frac{184{,}1 - 68{,}5}{206{,}44 - 184{,}1} = \frac{115{,}6}{22{,}35} = 5{,}175$

(6)

7.4 $Q_{econ} = m_w(h_2 - h_4) = 0,12(206,44 - 68,5) \times 60 = 0,12(137,94) \times 60$ ✓ ✓ ✓

$= 993,168 \frac{kJ}{\min}$ ✓

(2)
[20]

$$Persentasie \frac{}{Percentage} = \frac{Punte \frac{}{Marks}}{2}$$

TOTAL: 100