



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

5 December 2024

This marking guideline consists of 9 pages.

QUESTION 1

$$1.1 \quad P_1 V_1 = mRT_1 \quad \text{but} \quad P_{\text{density}} = \frac{m}{V}$$

$$\begin{aligned} \therefore R &= \frac{P_1}{P_{\text{density}} \times T_1} \checkmark \\ &= \frac{101,325}{1,3 \times 273} \checkmark \\ &= 0,286 \text{ kJ/kg.k} \checkmark \end{aligned} \quad (3)$$

$$1.2 \quad R = C_p - C_v$$

$$\begin{aligned} C_v &= C_p - R \\ &= 0,98 - 0,286 \checkmark \\ &= 0,694 \text{ kJ/kg.k} \checkmark \end{aligned}$$

$$\begin{aligned} \gamma &= \frac{C_p}{C_v} \\ &= \frac{0,98}{0,694} \checkmark \\ &= 1,4 \checkmark \end{aligned} \quad (4)$$

$$1.3 \quad P_1 V_1 = mRT_1$$

$$\begin{aligned} V_1 &= \frac{mRT_1}{P_1} \checkmark \\ &= \frac{1,5 \times 0,286 \times 273}{101,325} \checkmark \checkmark \\ &= 1,156 \text{ m}^3 \checkmark \end{aligned} \quad (4)$$

$$1.4 \quad V_2 = 0,1V_1 \quad P_2 = ?$$

$$\frac{V_2}{V_1} = 0,1$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1} \right)^\gamma$$

$$P_2 = \frac{P_1}{\left(\frac{V_2}{V_1} \right)^\gamma} \checkmark$$

$$\begin{aligned} &= \frac{101,325}{(0,1)^{1,4}} \checkmark \\ &= 2545,169 \text{ kPa} \checkmark \end{aligned}$$

$$1.5 \quad Q = WD + \Delta U \quad \text{but} \quad V_2 = 0,1 V_1 \\ = 0,1 \times 1,156 \\ = 0,1156 \, m^3 \checkmark$$

$$\begin{aligned} -WD = \Delta U &= \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} \\ &= \frac{(101,325)(1,156) - (2545,169)(0,1156)}{1,4 - 1} \checkmark \checkmark \\ &= -442,725 \, kJ \checkmark \end{aligned}$$

OR

$$\begin{aligned} -WD = \Delta U &= \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} \\ \text{but } T_2 &= T_1 \left(\frac{V_1}{V_2} \right)^{\gamma-1} \\ &= 273 \left(\frac{1,156}{0,1156} \right)^{1,4-1} \checkmark \\ &= 685,745 \, K \checkmark \end{aligned}$$

$$\begin{aligned} \therefore \Delta U &= \frac{mR(T_2 - T_1)}{\gamma - 1} \\ &= \frac{1,5 \times 0,286(685,745 - 273)}{1,4 - 1} \checkmark \\ &= 442,669 \, kJ \checkmark \end{aligned}$$

(4)

$$1.6 \quad Q = WD + \Delta U \\ Q = 0 \, kJ \text{ then } \checkmark$$

$$-WD = \Delta U \checkmark$$

(2)

[20]

QUESTION 2

2.1 2.1.1

$$\begin{aligned}\eta_{vol} &= 1 + \alpha - \alpha \left(\frac{P_2}{P_1} \right)^{1/\gamma} \times \frac{100}{1} \checkmark \\ &= 1 + 0.05 - 0.05 \left(\frac{650}{80} \right)^{\frac{1}{1.32}} \checkmark \checkmark \\ &= 80.55\% \checkmark\end{aligned}$$

OR

$$\begin{aligned}\eta_{vol} &= 1 - \alpha \left[\left(\frac{P_2}{P_1} \right)^{\frac{1}{n}} - 1 \right] \checkmark \\ &= 1 - 0.05 \left[\left(\frac{650}{80} \right)^{\frac{1}{1.32}} - 1 \right] \checkmark \checkmark \\ &= 80.55\% \checkmark\end{aligned}$$

OR

$$\begin{aligned}V_1 &= CV + SV \\ &= 0.05SV + SV \\ &= 1.05SV \\ V_3 &= 0.05SV \\ V_4 &= V_3 \left(\frac{P_3}{P_4} \right)^{\frac{1}{n}} \\ &= 0.05SV \left(\frac{650}{80} \right)^{\frac{1}{1.32}} \\ &= 0.2445SV \\ \eta_{vol} &= \left(\frac{V_1 - V_4}{V_1 - V_3} \right) \times 100 \checkmark \\ &= \left(\frac{(1.05 - 0.2445)SV}{(1.05 - 0.05)SV} \right) \times 100 \checkmark \checkmark \\ &= 80.55\% \checkmark\end{aligned}$$

(3)

2.1.2

$$\frac{P_a \eta_{air}}{T_a} = \frac{P_1 \eta_{vol}}{T_1} \checkmark$$

$$\eta_{air} = \frac{80 \times 0,8055 \times 289}{301 \times 101,3} \checkmark \checkmark$$

$$\eta = 61,08\% \checkmark$$

(3)

2.1.3

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

$$T_2 = 301 \left(\frac{650}{80} \right)^{\frac{1,32-1}{1,32}} \checkmark$$

$$T_2 = 500,184 \text{ K} \checkmark$$

(3)

2.1.4

$$V_s = \frac{\pi \times d^2}{4} \times L \times N$$

$$V_s = \frac{\pi \times 0,205^2}{4} \times 0,250 \times 18 \times 60 \checkmark$$

$$V_s = 8,91 \text{ m}^3 / \text{min} \checkmark$$

$$\eta_{vol} = \frac{V_e}{V_s} \times 100$$

$$V_e = 8,91 \times 0,8055 \checkmark$$

$$V_e = 7,177 \text{ m}^3 / \text{min} \checkmark$$

(4)

2.2 Is to change the atmosphere into compressed air making use of the least amount of power to do so. $\checkmark \checkmark$

(2)

[15]

QUESTION 3

- 3.1 3.1.1 $m_f = ?$
- $h_2 = 3264 \text{ kJ/kg @ } 1000 \text{ kPa} \text{ \& } t_{ss} = 250^\circ \text{C} \checkmark$
- $h_1 = 112 \text{ kJ @ } 26,7^\circ \text{C} \checkmark$
- $$\eta = \frac{m_s(h_2 - h_1)}{m_f \cdot H_v} \times 100\%$$
- $$m_f = \frac{m_s(h_2 - h_1)}{\eta \cdot H_v} \times 100\%$$
- $$= \frac{2200(3264 - 112)}{68 \times 32,5 \times 10^3} \times 100\% \checkmark \checkmark \checkmark \checkmark$$
- $$= 313,774 \text{ kg/h} \checkmark \quad (7)$$
- 3.1.2 $E.E = \frac{m_s(h_2 - h_1)}{m_f \cdot 2257}$
- $$= \frac{2200(3264 - 112)}{313,774 \times 2257} \checkmark \checkmark$$
- $$= 9,792 \text{ kg}_{steam}/\text{kg}_{fuel} \checkmark \quad (3)$$
- 3.2 3.2.1 Primary loop✓ – Heat is transferred from the water and nuclear fuel in the reactor to the tubes in the steam generators and the water is then pumped back to the reactor. This loop is a closed system.✓✓ (3)
- 3.2.2 Secondary loop✓ – The water is pumped into the steam generators, and it is heated to form steam. The steam is used to drive the turbines which in turn drives the generators.✓✓ Once through the turbines, the steam is condensed, and the water is returned to the steam generator in order to start the process again.✓ (4)
- 3.2.3 Tertiary loop✓ – cold water is pumped through the condensers at a rate of tons per second, and it cools the steam in condensers with a certain capacity and the water is returned to the original source.✓✓ (3)
- 3.3 3.3.1 Uranium✓✓ (2)
- 3.3.2 U (1)
- 3.3.3 238,03 g/mole✓✓ (2)

[25]

QUESTION 4

$$\begin{aligned}
 P_T &= (B_r - M_r) \cdot 0,1333 \\
 &= (750 - 665) \cdot 0,1333 \checkmark \\
 &= 11,33 \text{ kPa} \checkmark
 \end{aligned}$$

By interpolation from steam table:

P	h_f	h_{fg}
11	200	2388
12	207	2384
1	+7	-4
0,33	+2,31	-1,32
11,33	202,31 ✓✓	2386,68 ✓✓

For q ?

$$Q_{\text{lost by steam}} = Q_{\text{gained by water}}$$

$$m_s(h_f + q \cdot h_{fg} - h_c) = m_w \times C_{pw}(t_2 - t_1)$$

$$h_f + q \cdot h_{fg} = \frac{m_w \times C_{pw}(t_2 - t_1) + h_c}{m_s}$$

$$q \cdot h_{fg} = \frac{m_w \times C_{pw}(t_2 - t_1) + h_c - h_f}{m_s}$$

$$q = \frac{\frac{m_w \times C_{pw}(t_2 - t_1) + h_c - h_f}{m_s}}{h_{fg}} \checkmark$$

$$= \frac{\frac{230 \times 10^3 \times 4,187(30 - 20)}{4200} + 163 - 202,31}{2386,68} \checkmark \checkmark$$

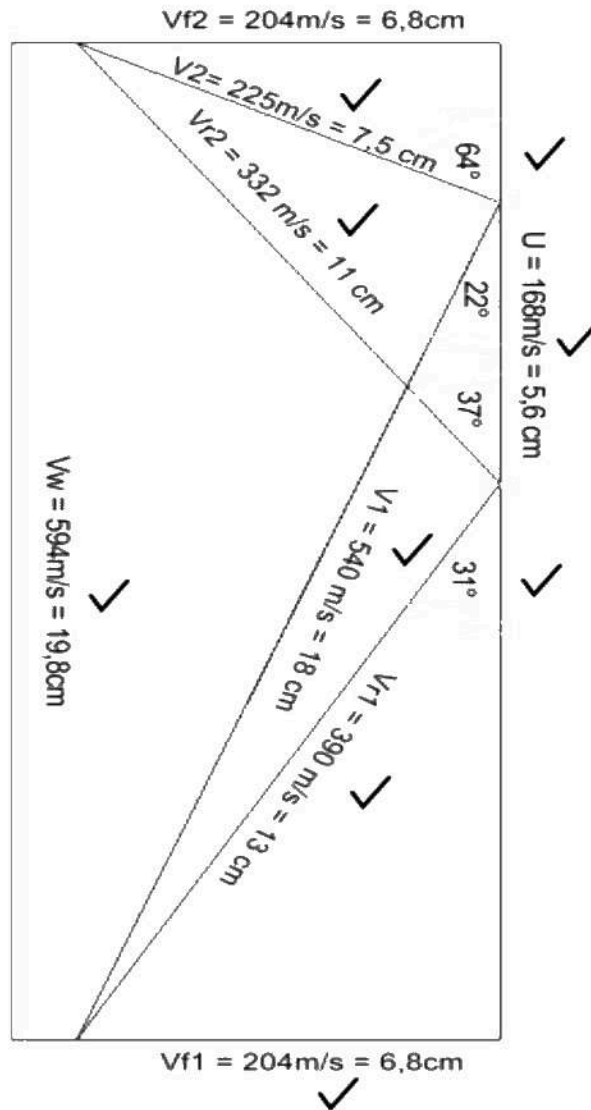
$$= 0,944 \checkmark$$

[10]

QUESTION 5

5.1 5.1.1 $U = \pi D \times N$

$$= \frac{\pi \times 0,46 \times 6976}{60} \checkmark = 168 \text{ m/s } \checkmark$$



(11)

5.2 5.2.1 $P = MUV_w$

$$= 1 \times 168 \times 594 \checkmark$$

$$= 99792 \text{ W } \checkmark \text{ or } 99,792 \text{ kW}$$

$$\begin{aligned}
 5.2.2 \quad KE &= \frac{1}{2} MV^2 \\
 &= 0.5 \times 1 \times 225^2 \checkmark \\
 &= 25312,5 \text{ W/kg} \checkmark
 \end{aligned}$$

(2 × 2) (4)

- 5.3
- Mechanical
 - Electronic
 - Electronic Control Units

(3)

$$\begin{aligned}
 5.4 \quad h &= \frac{g}{\omega^2} \\
 &= \frac{9.8}{1,5} \checkmark \\
 &= 6.533 \text{ m} \checkmark
 \end{aligned}$$

(2)
[20]

QUESTION 6

6.1 Renewable energy – is the harnessing of naturally occurring non-depletable sources of energy, including solar, wind, biomass, hydro, tidal wave, ocean current and geothermal, to produce electricity, gaseous and liquid fuels, heat or combination of these energy types.✓✓

(2)

- 6.2
- Photovoltaic✓ – is used to produce electricity from direct sunlight using photovoltaic cells.✓
 - Concentrated solar power✓ – is used to produce very high temperatures, for heating to temperatures above 100 °C. The heat can also be used to produce steam that can be used to produce electricity using steam turbines.✓
 - Solar thermal✓ – for domestic solar water heater, heating temperature below 100 °C.✓

(3 × 2) (6)

6.3 The basic principle of solar thermal heating is to utilize the sun's energy and convert it into heat which is then transferred into your home or business heating system in the form of hot water and space heating.✓✓

(2)
[10]

TOTAL: 100