



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANOTECHNICS N5

16 April 2024

This marking guideline consists of 9 pages.

QUESTION 1

1.1

$$v = \frac{80}{60}$$

$$v = 1,333m/s \checkmark$$

$$v = \sqrt{g \cos \phi \times r}$$

$$r = \frac{v^2}{g \times \cos \phi}$$

$$r = \frac{1,333^2}{9,81 \times \cos 43^\circ} \checkmark$$

$$r = 0,248m \checkmark$$

$$r = 248mm$$

$$d = 248 \times 2$$

$$d = 496mm \checkmark \quad (4)$$

1.2

$$L = 2(\pi \times r) + 2C$$

$$L = 2(\pi \times 0,248) + (2 \times 90)$$

$$L = 1,558 + 180 \checkmark$$

$$L = 181,558m$$

$$\text{say } L = 182m \checkmark \quad (2)$$

1.3

$$B/s = \frac{v}{\text{spacing}}$$

$$B/s = \frac{1,333}{0,794} \checkmark$$

$$B/s = 1,679 \checkmark$$

Accept if rounded off to 2 buckets. (2)

1.4

$$m_s = \frac{1300 \times 10^3}{7,5 \times 3600}$$

$$m_s = 48,148kg/s \checkmark$$

$$m/b = \frac{m/s}{B/s}$$

$$m/b = \frac{48,148}{1,679} \checkmark$$

$$m/b = 28,677kg/b \checkmark$$

Accept if 2 buckets were used.

$$\text{Then } m/b = \frac{m/s}{B/s} = \frac{48,148}{2}$$

$$= 24,074 \text{ kg/b} \quad (3)$$

1.5

$$h = \frac{L}{2}$$

$$h = \frac{182}{2}$$

$$h = 91m \checkmark$$

Alternative to calculate h:

$$h = C + 2R$$

$$= 90 + 2(0,248)$$

$$= 90,5 \text{ m}$$

$$P_g = mgh$$

$$P_g = 48,148 \times 9,81 \times 91 \checkmark$$

$$P_g = 42,982 \text{ kW} \checkmark$$

Then when $h = 90,5 \text{ m}$

$$P_g = mgh$$

$$= 48,148 \times 9,81 \times 90,5$$

$$= 42,0746 \text{ kW}$$

$$P_i = \frac{P_g}{\eta}$$

$$P_i = \frac{42982,333}{0,76}$$

$$P_i = 56,556 \text{ kW} \checkmark$$

$$\text{Then } P_i = \frac{P_g}{\eta} = \frac{42,746 \times 1\,000}{0,76} = 56,245 \text{ kW}$$

(4)
[15]

QUESTION 2

2.1

$$T_A = 2T_P + T_S$$

$$= 2 \times 36 + 42 \checkmark$$

$$T_A = 114 \text{ teeth} \checkmark$$

(2)

2.2

Condition	Gear A	Gear P	Gear S	Arm L
Fix arm L and rotate Gear A + 1 rev	+1	$\frac{TA}{TP} = \frac{114}{36}$ $\frac{114}{36} = 3,167$	$\frac{TA}{TS} = \frac{114}{-42}$ $\frac{114}{-42} = 2,714$	0
Multiply by x and add y	$x + y$	$3,167x + y \checkmark$	$-2,714x + y \checkmark$	$+ y$
$N_L = 45$ $N_A = 0 \quad N_S = ?$	$0 \checkmark$		$N_S = ?$	$45 \checkmark$

$$N_S = -2,714x + y$$

$$y = 45 \checkmark$$

$$x + y = 0$$

$$x = -y$$

$$x = -45 \checkmark$$

$$N_S = -2,714x + y$$

$$N_S = -2,714(-45) + 45 \checkmark$$

$$N_S = 167,13 \text{ r/min} \checkmark$$

(8)
[10]

QUESTION 3

3.1

- Leather
- Rubber/Balata
- Plastic
- Cotton or fabric

(Any 3 × 1) (3)

3.2

3.2.1

$$\sin \alpha = \frac{R-r}{C}$$

$$\sin \alpha = \frac{0,375 - 0,15}{1,68}$$

$$\alpha = \sin^{-1}\left(\frac{0,225}{1,68}\right) \checkmark$$

$$\alpha = 7,697^\circ \checkmark$$

$$\theta = 180^\circ - 2\alpha$$

$$\theta = 180^\circ - (2 \times 7,697) \checkmark$$

$$\theta = 164,607^\circ$$

$$\text{say } \theta = 165^\circ \checkmark$$

(4)

Alternative:

$$\begin{aligned}\cos \phi &= \frac{R-r}{C} \\ \cos \phi &= \frac{375-150}{1680} \checkmark \\ \phi &= \cos^{-1}(0,1339) \checkmark \\ \phi &= 82,3^\circ \checkmark \\ \text{Angle of wrap} &= 2 \times 82,3^\circ = 165^\circ \checkmark\end{aligned}$$

3.2.2 The belt mass per unit length:

$$\begin{aligned}m &= v \times \rho \\ m &= A \times \ell \times \rho \\ &= 595 \times 10^{-6} \times 1 \times 1185 \checkmark \\ &= 0,705 \text{ kg/m} \checkmark \\ T_C &= m \times v^2 \\ &= 0,705 \times \left(\frac{\pi \times 0,3 \times 1286}{60} \right)^2 \checkmark \\ &= 287,681 \text{ N} \checkmark\end{aligned} \quad (4)$$

3.2.3 $\frac{T_1 - T_C}{T_2 - T_C} = e^{\mu \theta \csc \beta}$

$$\begin{aligned}T_1 &= \sigma \times A \\ &= 8,85 \times 10^6 \times 595 \times 10^{-6} \checkmark \\ &= 5265,75 \text{ N} \checkmark\end{aligned} \quad (2)$$

3.2.4 $\frac{5265,75 - 287,681}{T_2 - 287,681} = e^{0,29 \times \frac{165 \times \pi}{180} \times \frac{1}{\sin 20^\circ}} \checkmark$

$$\begin{aligned}\frac{4978,069}{T_2 - 287,681} &= e^{2,442} \checkmark \\ 11,496 T_2 - 3\,306,467 &= 4\,978,069 \checkmark \\ T_2 &= \frac{826,25}{11,496}\end{aligned}$$

$$T_2 = 720,707 \text{ N} \checkmark \quad (4)$$

3.2.5 $P = (T_1 - T_2) \times v$

$$\begin{aligned}&= (5\,265,75 - 720,707) \times \left(\frac{\pi \times 0,3 \times 1286}{60} \right) \checkmark \\ &= 91\,811,872 \text{ W/belt} \checkmark \\ &= 91\,811,872 \times 3 \text{ W/belt} \\ &= 275,436 \text{ kW} \checkmark\end{aligned}$$

Alternative:

$$\begin{aligned} P &= n(T_1 - T_2)v \\ &= 3(5\,265,75 - 720,707) \checkmark \left[\frac{\pi \times 0,3 \times 12,86}{60} \right] \checkmark \\ &= 275,436 \text{ kW} \checkmark \end{aligned}$$

[20]

QUESTION 4

4.1 *Speed of worm gear N_E*

$$\text{One turn of worm moves worm gear} = \frac{3}{36} = \frac{1}{12} \checkmark$$

$$N_E = 1000 \times \frac{1}{12} \checkmark$$

$$N_E = 83,333 \text{ r/min} \checkmark$$

$$\therefore N_E = N_A = 83,333 \text{ r/min} \checkmark$$

OR

1 000 turns of worm shaft will displace $1\,000 \times 3 = 3\,000$ teeth ✓✓

$$N_E = 3\,000/36 = 83,333 \text{ r/min} \checkmark$$

$$N_E = N_A = 83,333 \text{ r/min} \checkmark$$

$$N_A \times T_A \times T_C = N_D \times T_B \times T_D$$

$$83,333 \times 20 \times 28 = N_D \times 40 \times 60 \checkmark \checkmark$$

$$N_D = \frac{46666,667}{2400} \checkmark$$

$$N_D = 19,444 \text{ r/min} \checkmark$$

(8)

4.2

$$V_R = \frac{N_{\text{worm}}}{N_D}$$

$$= \frac{1000}{19,444} \checkmark$$

$$= 51,428 \checkmark$$

(2)

[10]

QUESTION 5

5.1 It is used to prevent carts from running backwards. (1)

5.2 5.2.1

$$T_{tubs/min} = \frac{Ton_{/shift}}{60 \times running_{hours} \times ton_{/tub}}$$

$$= \frac{640}{60 \times 7,5 \times 1,2} \checkmark$$

$$= 1,185 \checkmark$$

$$spacing = \frac{v_{m/min}}{tubs_{/min}}$$

$$= \frac{50}{1,185} \checkmark$$

$$= 42,194m \checkmark$$

(4)

5.2.2

$$tubs_{/side} = \frac{l}{spacing}$$

$$= \frac{750}{42,194}$$

$$\checkmark = 17,775$$

$$say = 18 \checkmark$$

(3)

5.2.3

$$F_g = m_{load} \times no.of.tubs \times g \times \sin \theta$$

$$= 1200 \times 18 \times 9,81 \times \sin 15^\circ \checkmark$$

$$= 54842,72N \checkmark$$

$$M_T = m_{tubs} + m_{load} + m_{rope}$$

$$= (2 \times 18 \times 450) + (18 \times 1200) + (2 \times 750 \times 2,5) \checkmark \checkmark$$

$$= 41550kg \checkmark$$

$$F_R = ton_{in haulage} \times resis tan ce_{/ton}$$

$$= 41,55 \times 180 \checkmark$$

$$= 7479N \checkmark$$

$$T_E = F_R + F_g$$

$$= 7479 + 54842,72$$

$$= 62321,72N \checkmark$$

$$\begin{aligned}
 P_L &= T_{IE} \times v \\
 &= 62321,72 \times \frac{50}{60} \checkmark \\
 &= 51934,767W \checkmark \\
 P_i &= \frac{P_0}{\eta} = \frac{51934,767}{0,7} \checkmark = 74,192kW \checkmark
 \end{aligned}$$

(12)
[20]

QUESTION 6

$$a = \frac{v}{t} = \frac{2}{4} = 0,5 \text{ m/s}^2 \checkmark$$

$$\begin{aligned}
 T_1 &= m_1(g + a) \\
 &= 1\,500(9,81 + 0,5) \\
 &= 15\,465 \text{ N} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_2 &= m_2(g - a) \\
 &= 680(9,81 - 0,5) \\
 &= 4\,655 \text{ N} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_{load} &= (T_1 - T_2)R \\
 &= (15\,465 - 4\,655)0,4 \\
 &= 4\,324 \text{ N.m} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 I &= mk^2 \\
 &= 400 \times 0,3^2 \\
 &= 36 \text{ kg.m}^2 \checkmark
 \end{aligned}$$

$$\alpha = \frac{a}{r} = \frac{0,5}{0,4} = 1,25 \text{ rad/s}^2 \checkmark$$

$$\begin{aligned}
 T_{drum} &= I \times \alpha \\
 &= (36 \times 1,25) \\
 &= 45 \text{ N.m} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_{rope} &= m_r \times a \times r \\
 &= (200 \times 0,5 \times 0,4) \\
 &= 40 \text{ N.m} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_{total} &= T_L + T_D + T_r + T_\mu \\
 &= 4324 + 40 + 45 + 700 \\
 &= 5,109 \text{ kN.m} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P &= wT \\
 &= \frac{2}{0,4} \times 5,109 \\
 &= 5 \text{ kW} \checkmark
 \end{aligned}$$

QUESTION 7

$$\begin{aligned}
 7.1 \quad v &= u + at \\
 15 &= 0 + 240a \checkmark \\
 a &= 0,625 \text{ m/s}^2 \checkmark
 \end{aligned}
 \tag{2}$$

$$\begin{aligned}
 7.2 \quad F_a &= m \times a \\
 &= 100\,000 \times 0,625 \checkmark \\
 &= 6\,250 \text{ N} \checkmark
 \end{aligned}
 \tag{2}$$

$$\begin{aligned}
 7.3 \quad F_r &= R \times m \\
 &= 32 \times 1\,000 \checkmark \\
 &= 3\,200 \text{ N} \checkmark \\
 \\
 T_E &= F_r + F_a \\
 &= 3\,200 + 6\,250 \checkmark \\
 &= 9\,450 \text{ N} \checkmark \\
 \\
 P &= T_E \times V \\
 &= 9\,450 \times 15 \checkmark \\
 &= 14\,175 \text{ W} \checkmark
 \end{aligned}
 \tag{6}$$

[10]

QUESTION 8

$$\begin{aligned}
 8.1 \quad I &= mk^2 \\
 &= 2\,500 \times 1,25^2 \\
 &= 3\,906,25 \text{ kg.m}^2 \checkmark \\
 \\
 E_{K1} &= 0,5 \times I \times (2\pi N/60)^2 \\
 &= 0,5 \times 3\,906,25 \times (15,708)^2 \checkmark \\
 &= 481,914 \text{ kJ} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 8.2 \quad w_2 &= 2\pi N/60 \\
 &= 2\pi \times 140/60 \checkmark \\
 &= 14,661 \text{ rad/s} \\
 \\
 E_{K2} &= 0,5 \times I \times w^2 \\
 &= 0,5 \times 3\,906,25 \times 14,661^2 \\
 &= 419,801 \text{ kJ} \checkmark \\
 \\
 \text{Energy lost} &= E_{K1} - E_{K2} \\
 &= 481,914 - 419,801 \\
 &= 62,113 \text{ kJ} \checkmark
 \end{aligned}
 \tag{2}$$

[5]

TOTAL: 100