higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# MARKING GUIDELINE

## NATIONAL CERTIFICATE

## MECHANOTECHNICS N5

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**This marking guideline consists of 10 pages.**

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## QUESTION 1

1.1 $T_C = 2T_B + T_A$

$120 = 2T_B + 18$ ✓

$T_B = 51\ teeth$ ✓ (2)

1.2

| Condition | Gear A | Gear B | Gear C | Gear D | Gear E | Arm F |
|---|---|---|---|---|---|---|
| *Fix arm F and rotate Gear C +1rev* | $N_A = \frac{N_B \times T_B}{T_A}$<br>$N_A = \frac{2{,}353 \times 51}{-18}$<br>$N_A = -6{,}667$ | $N_B = \frac{N_B \times T_B}{T_A}$<br>$N_B = \frac{1 \times 120}{51}$<br>$N_B = 2{,}353$ | +1 | $N_D = 2{,}353$ | $N_E = \frac{N_D \times T_D}{T_E}$<br>$N_E = \frac{2{,}353 \times 40}{100}$<br>$N_E = 0{,}941$ | *0* |
| *Multiply by x and add y* | $-6{,}667x + y$ ✓ | $2{,}353x + y$ ✓ | $x + y$ | $2{,}353x + y$ ✓ | $0{,}941x + y$ ✓ | $+ y$ |
| $N_C = 0$<br>$N_A = 1500r/\text{mi}$<br>$N_E = ?$ | $N_A = 1500$ | | *0* | | $N_E = ?$ | |

$N_E = 0{,}941x + y$

$-6{,}667x + y = 1500$.....1

$x + y = 0$

$x = -y$.....2

*sub*.....2..*in*....1

$-6{,}667x + y = 1500$

$-6{,}667(-y) + y = 1500$

$y = \frac{1500}{7{,}667}$

$y = 195{,}644$ ✓

*but* $x = -y$

$\therefore x = -195{,}644$ ✓

$N_E = 0{,}941x + y$

$N_E = 0{,}941(-195{,}644) + 195{,}644$ ✓

$N_E = 11{,}543r/\text{min}$ ✓

(8)
**[10]**

## QUESTION 2

2.1
- Layout space is minimised.
- There is no scattering, leakage and dropping of materials.
- Long life structure with good fatigue resistance and elasticity.
- Material is closed up in pipe and no foreign material comes in from outside.
- Layout is easy and economical since transportation line is easily designed and layout cost is low.
- It prevents deposits on belt from dropping.
- New design gives proper bending rigidity. (Any 3 × 1) (3)

2.2 2.2.1

$$W_{D_\mu} = F_\mu \times v$$
$$= 4200 \times \frac{95}{60} \checkmark$$
$$= 6650J$$
$$= 6{,}650kJ \checkmark$$ (2)

2.2.2

$$\sin\varphi = \frac{h}{l}$$
$$h = 124 \times \sin 16° \checkmark$$
$$= 34{,}179m \checkmark$$
$$W_{D_L} = F_{/s} \times S$$
$$= \frac{290 \times 10^3 \times 9{,}81}{3600} \times 34{,}179 \checkmark$$
$$= 27009{,}955J$$
$$= 27{,}010kJ \checkmark$$ (4)

2.2.3

$$W_{D_{TOTAL}} = (T_1 - T_2) \times v$$
$$(T_1 - T_2) = (6650 + 27009{,}955) \times \frac{60}{95} \checkmark$$
$$= 21258{,}919N$$
$$= 21{,}259kN \checkmark$$ (2)

2.2.4

$$\frac{T_1}{T_2} = e^{\mu\theta}$$
$$\frac{T_1}{T_2} = e^{0,3\times\frac{220°}{57,3}} \checkmark$$
$$T_1 = 3,164T_2 \checkmark$$

$$T_1 - T_2 = 21258,919$$
$$3,164T_2 - T_2 = 21258,919 \checkmark$$
$$T_2 = \frac{21258,919}{2,164} \checkmark$$
$$T_2 = 9823,900N \checkmark$$

$$T_1 = 3,164 \times T_2$$
$$= 3,164 \times 9823,9 \checkmark$$
$$= 31082,820N$$
$$T_1 = 31,083kN \checkmark$$ (7)

2.2.5

$$P = W_{D/S}$$
$$P = W_{D_\mu} + W_{D_L}$$
$$P = 6650 + 27009,955 \checkmark$$
$$P = 33659,995W$$
$$P = 33,660kW \checkmark$$ (2)

**[20]**

## QUESTION 3

3.1 Tensioning devices compensate for variation in length of chain or belt due to temperature changes, atmospheric conditions or wear. (1)

3.2 3.2.1

$$v = \frac{80}{60}$$
$$v = 1,333\ m/s$$
$$v = \sqrt{g\cos\phi \times r}$$
$$r = \frac{v^2}{g \times \cos\phi}$$
$$r = \frac{1,333^2}{9,81 \times \cos 43^\circ} \checkmark$$
$$r = 0,248m \checkmark$$
$$r = 248mm$$
$$d = 248 \times 2$$
$$d = 496\ mm \checkmark$$ (3)

3.2.2
$$L = 2(\pi \times r) + 2C$$
$$L = 2(\pi \times 0{,}248) + (2 \times 90)$$
$$L = 1{,}558 + 180 \checkmark$$
$$L = 181{,}558m$$
$$say\ L = 182m \checkmark$$
(2)

3.2.3
$$B/_s = \frac{v}{spacing}$$
$$B/_s = \frac{1{,}333}{0{,}794} \checkmark$$
$$B/_s = 1{,}679 \checkmark$$
(2)

3.2.4
$$m_s = \frac{1300 \times 10^3}{7{,}5 \times 3600}$$
$$m_s = 48{,}148kg/s \checkmark$$
$$m/_b = \frac{m/_s}{B/_s}$$
$$m/_b = \frac{48{,}148}{1{,}679} \checkmark$$
$$m/_b = 28{,}677kg/b \checkmark$$
(3)

3.2.5
$$h = \frac{L}{2}$$
$$h = \frac{182}{2}$$
$$h = 91m \checkmark$$

$$P_g = mgh$$
$$P_g = 48{,}148 \times 9{,}81 \times 91 \checkmark$$
$$P_g = 42{,}982kW \checkmark$$

$$P_i = \frac{P_g}{\eta}$$
$$P_i = \frac{42982{,}333}{0{,}76}$$
$$P_i = 56{,}556kW \checkmark$$
(4)
**[15]**

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## QUESTION 4

4.1
- Aerial ropeways could be more economical than the building of roads or railways.
- It is more efficient since loading and unloading can be fully automatic.
- Transportation is possible where no tracks or railway lines can be provided.
- Aerial ropeways do not interfere with other forms of transport such as road or rail.
- It is independent of terrain difficulties.
- The shortest route between terminals can be taken. (Any 5 × 1) (5)

4.2 4.2.1

$$\sigma = \frac{strength}{A_{rope}}$$

$$\sigma = \frac{strength}{0{,}55D^2}$$

$$D^2 = \frac{strength}{0{,}55 \times \sigma}$$

$$D = \sqrt{\frac{720 \times 10^3}{0{,}55 \times 1465 \times 10^6}} \checkmark$$

$$= 0{,}02989\ m \checkmark$$

$$= 29{,}89\ mm \checkmark$$

$$say\ D = 30\ mm \checkmark$$ (4)

4.2.2

$$M_{r/m} = \frac{d^2}{195}$$

$$= \frac{(30)^2}{195} \checkmark$$

$$= 4{,}615 kg/m \checkmark$$ (2)

4.2.3

$$T_{weight} = \frac{m_1 \times g \times s^3}{8 \times h}$$

$$= \frac{4{,}615 \times 9{,}81 \times (115)^2}{8 \times 2{,}2} \checkmark$$

$$= 34019{,}171N \checkmark$$ (2)

4.2.4

$$T_{load} = \frac{m_2 \times g \times s}{4 \times h} \checkmark$$

$$= \frac{660 \times 9{,}81 \times 115}{4 \times 2{,}2} \checkmark$$

$$= 84611{,}25N \checkmark$$ (3)

4.2.5 $$f.o.s = \frac{\sigma}{T_{weight} + T_{load}}$$

$$= \frac{720 \times 10^3}{34019{,}171 + 84611{,}25} \checkmark\checkmark$$

$$= \frac{720 \times 10^3}{118630{,}421} \checkmark$$

$$= 6{,}069 \checkmark$$

(4)
**[20]**

## QUESTION 5

5.1 $$F_R = F_\mu \times m \times g$$

$$= \frac{0{,}9}{100} \times 330 \times 10^3 \times 9{,}81 \checkmark$$

$$= 29135{,}7N \checkmark$$

(2)

5.2 $$F_g = m \times g \times h$$

$$= 330 \times 10^3 \times 9{,}81 \times {}^{1}\!/_{125} \checkmark$$

$$= 25898{,}4N \checkmark$$

(2)

5.3 $$F_a = m \times a$$

$$= 330 \times 10^3 \times 0{,}065 \checkmark$$

$$= 21450N \checkmark$$

(2)

5.4 $$T_E = F_R + F_g + F_a$$

$$= 29135{,}7 + 25898{,}4 + 21450 \checkmark$$

$$= 76484{,}1N \checkmark$$

$$P_L = T_E \times v$$

$$= 76484{,}1 \times \frac{65 \times 10^3}{3600} \checkmark$$

$$= 1380{,}963kN \checkmark$$

(4)
**[10]**

## QUESTION 6

6.1

$$w_1 = \frac{2 \times \pi \times N_1}{60}$$
$$= \frac{2 \times \pi \times 95}{60}$$
$$= 9{,}948 rad/s \checkmark$$
$$w_2 = \frac{2 \times \pi \times N_2}{60}$$
$$= \frac{2 \times \pi \times 120}{60}$$
$$= 12{,}566 rad/s \checkmark$$
$$\alpha = \frac{w_2 - w_1}{t}$$
$$= \frac{12{,}566 - 9{,}948}{25}$$
$$= 0{,}105 rad/s^2 \checkmark$$

(3)

6.2

$$T = m \times \alpha \times k^2$$
$$= 825 \times 0{,}105 \times 0{,}5^2 \checkmark$$
$$= 21{,}656 N.m \checkmark$$

(2)
**[5]**

## QUESTION 7

7.1 500 turns of worm shaft will displace $500 \times 2 = 1000$ teeth ✓

$$Revolutions\ of\ worm\ wheel = \frac{1000}{No\ teeth\ of\ worm\ gear} \checkmark$$

$$Revolutions\ of\ worm\ wheel, N_A = \frac{1000}{50} \checkmark$$
$$= 20\ r/min \checkmark$$

$$\frac{Input\ speed}{Output\ speed} = \frac{No\ of\ teeth\ of\ drivengears}{No\ of\ teeth\ of\ driving\ gears}$$

$$\frac{20}{N_E} = \frac{55 \times 80}{20 \times 25} \checkmark$$

$$\frac{20}{N_E} = \frac{55 \times 80}{20 \times 25} \checkmark$$

$$N_E = \frac{20 \times 20 \times 25}{55 \times 80}$$

$$N_E = 2{,}27\ r/min \checkmark$$

(7)

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7.2

$$velocity\ ratio = \frac{worm\ speed}{delivery\ speed} \checkmark$$
$$= \frac{500}{2{,}27} \checkmark$$

$$= 220{,}26:1 \checkmark$$ (3)

**[10]**

## QUESTION 8

8.1

$$T_1 = m_1(g + a) + F_\mu$$
$$= 1500(10 + 2) + 500$$
$$= 18500\ N \checkmark$$

$$T_2 = m_2(g - a) - F_\mu$$
$$= 600(10 - 2) - 500$$
$$= 4300\ N \checkmark$$ (2)

8.2 Torque to hold dead load

$$T_{load} = (T_1 - T_2) \times r$$
$$= (18500 - 4300) \times 0{,}8$$
$$= 11360\ N \checkmark$$

Torque to accelerate drum

$$T_{rope} = I \times \alpha = m \times k^2 \times \frac{a}{r}$$
$$= 800 \times 0{,}5^2 \times \frac{2}{0{,}8}$$
$$= 500\ N.m \checkmark$$ (2)

8.3 Motor power

$$T_{total} = (T_{load} + T_{rope})$$
$$= 11360 + 500$$
$$= 11860\ N.m \checkmark$$
$$T_{rope} = I \times \alpha = m \times k^2 \times \frac{a}{r} \checkmark$$
$$= 11860 \times \frac{2{,}8}{0{,}8}$$
$$= 41510\ W \checkmark$$ (3)

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8.4 $$a = \frac{u^2 - v^2}{2 \times s} = \frac{0 - 4^2}{2 \times 2} = -4\ m/s^2$$ ✓

$$T_1 = m_1(g + a) + F_\mu$$
$$= 1500(10 - 4) + 500$$
$$= 9500\ N$$ ✓

$$T_2 = m_2(g - a) - F_\mu$$
$$= 600(10 + 4) - 500$$
$$= 8900$$ ✓

(3)
**[10]**

**TOTAL: 100**

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