higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

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This marking guideline consists of 12 pages.

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QUESTION 1: CLUTCHES

1.1 $$T = \frac{\mu \times F_A \times R_f}{\sin \alpha}$$

$$= \frac{0{,}3 \times 340 \times 0{,}11}{\sin(17)}$$ ✓✓

$$= 38{,}376\ N.m$$ ✓ (3)

1.2 $$I = m \times k^2$$
$$= 25 \times (0{,}21)^2$$
$$= 1{,}103\ kg.m^2$$ ✓

$$T = I \times \alpha$$

$$\alpha = \frac{T}{I} = \frac{38{,}376}{1{,}103}$$

$$= 34{,}792\ rad/s^2$$ ✓

$$t = \frac{\omega}{\alpha}$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 1100}{60}$$

$$= 115{,}191\ rad/s$$ ✓

$$\therefore t = \frac{115{,}191}{34{,}792}$$ ✓

$$= 3{,}31\ s$$ ✓

(5)
[8]

QUESTION 2: BRAKES

2.1 $$210^o \times \frac{\pi}{180}$$

$$= 3{,}67\ rads$$ ✓

$$\mu = \frac{\ln\left(\frac{T_1}{T_2}\right)}{\theta}$$

$$= \frac{\ln\left(\frac{450}{120}\right)}{3{,}67}$$ ✓

$$= 0{,}36$$ ✓ (3)

2.2 $\omega = \frac{2\pi N}{60}$

$= \frac{2\pi \times 200}{60}$

$= 20{,}9\ rad/s$ ✓

$P = T\omega$

$T = \frac{P}{\omega} = \frac{250}{20{,}9}$

$= 11{,}96\ N.m$ ✓

$WD = T \times \omega$

$= 11{,}96 \times \left(\frac{20{,}9 + 0}{2}\right)$

$= 125\ J/s$ ✓

$E_k = I \times \omega^2$

$= 12 \times (20{,}9)^2$

$= 5242\ J$ ✓

$t = \frac{E_{k\ (brake)}}{WD/s}$

$= \frac{5242}{125}$ ✓

$= 41{,}9\ s$ ✓ (6)

2.3 $\theta = \omega_{mean} \times t$

$= 10{,}45 \times 41{,}9$ ✓

$= 437{,}9\ rads$ ✓

$N = \theta \times \frac{180}{\pi} \times \frac{1}{360}$

$= 437{,}9 \times \frac{180}{\pi} \times \frac{1}{360}$ ✓

$= 69{,}69\ rev/s$ ✓ (4)

[13]

QUESTION 3: LINE SHAFTS

3.1 $$P = \frac{2\pi N_p T_p}{60}$$

$$\therefore T_p = \frac{P \times 60}{2\pi N_p} = \frac{26 \times 10^3 \times 60}{2\pi \times 1050}$$ ✓

$$= 236{,}459\ N.m$$ ✓ (2)

3.2 $$P = \frac{2\pi N_G T_G}{60}$$

$$\therefore T_G = \frac{P \times 60}{2\pi N_G} = \frac{26 \times 10^3 \times 60}{2\pi \times 480}$$

$$= 517{,}253\ N.m$$ ✓

$$T_G = (T_1 - T_2) \times R$$

$$\frac{T_1}{T_2} = 2{,}718^{\left(0{,}23 \times \frac{170^o}{57.3}\right)}$$ ✓

$$T_1 = 1.978T_2$$ ✓

$$517{,}253 = (1{,}978T_2 - T_2) \times 0{,}6$$

$$\therefore T_2 = \frac{517{,}253}{0{,}978 \times 0{,}6}$$ ✓

$$= 881{,}481\ N$$ ✓

And $T_1 = 1{,}978 \times 881{,}481$

$$= 1743{,}569\ N$$ ✓ (6)

3.3 $$F_t = \frac{Torque \times 2}{PCD} = \frac{236{,}459 \times 2}{0{,}1}$$ ✓

$$= 4729{,}18\ N$$ ✓ (2)

3.4 $$F_r = F_t \times tan\,\theta$$

$$F_r = 4729{,}18 \times tan(20^o)$$ ✓

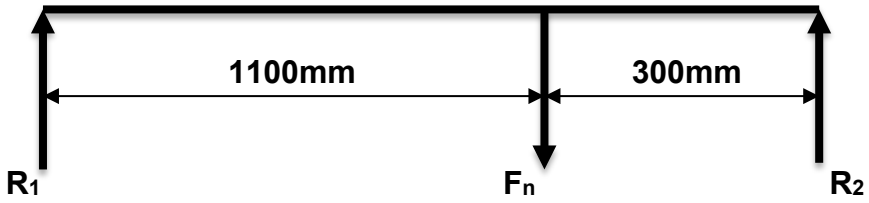
$$= 1721{,}281\ N$$ ✓ (2)

3.5 $F_n = F_t \times \sec\theta$

$F_n = 4729{,}18 \times \frac{1}{\cos(20^o)}$ ✓

$= 5032{,}688\ N$ ✓ (2)

3.6



Take moments about R_1

$\sum \circlearrowright M = \sum \circlearrowleft M$

$(F_n \times 1{,}1) = (R_2 \times 1{,}4)$

$\therefore R_2 = \frac{(F_n \times 1{,}1)}{1{,}4}$

$= \frac{(5032{,}688 \times 1{,}1)}{1{,}4}$ ✓

$= 3954{,}255\ N$ ✓

Take moments about R_2

$\sum \circlearrowleft M = \sum \circlearrowright M$

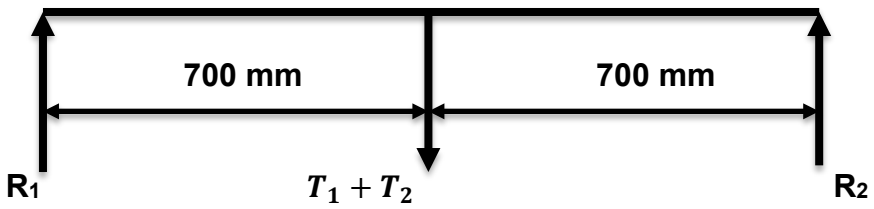
$(F_n \times 0{,}3) = (R_1 \times 1{,}4)$

$\therefore R_1 = \frac{(F_n \times 0{,}3)}{1{,}4}$

$= \frac{(5032{,}688 \times 0{,}3)}{1{,}4}$ ✓

$= 1078{,}433\ N$ ✓ (4)

3.7



Take moments about R_1

$$\sum \circlearrowright M = \sum \circlearrowleft M$$

$((T_1 + T_2) \times 0{,}7) = (R_2 \times 1{,}4)$

$\therefore R_2 = \dfrac{((T_1 + T_2) \times 0{,}7)}{1{,}4}$ ✓

$= \dfrac{((1743{,}569 + 881{,}481) \times 0{,}7)}{1{,}4}$ ✓

$= 1312.525\ N$ ✓

Take moments about R_2

$$\sum \circlearrowleft M = \sum \circlearrowright M$$

$((T_1 + T_2) \times 0{,}7) = (R_1 \times 1{,}4)$

$\therefore R_1 = \dfrac{((T_1 + T_2) \times 0{,}7)}{1{,}4}$ ✓

$= \dfrac{((1743{,}569 + 881{,}481) \times 0{,}7)}{1{,}4}$ ✓

$= 1312{,}525\ N$ ✓ (5)

[23]

QUESTION 4: FLYWHEELS

4.1 $P = \dfrac{W_D}{t}$

$E_K = Pmotor \times Operation\ time$

$E_{K(motor)} = 10\ X\ 0.7$ ✓

$E_{K(motor)} = 7\ kJ$ ✓ (2)

4.2 $E_{K(reduction)} = E_{K(per\ stroke)} - E_{K(motor)}$

$E_{K(per\ stroke)}$ @ $25\%loss = \left(\frac{9}{0.8}\right)$ ✓

$E_{K(per\ stroke)} = 11.25\ kJ$ ✓

$E_{K(reduction)} = 11.25 - 7 = 4.25kJ$ ✓ (3)

4.3 $E_k = \frac{1}{2}\ \mathrm{I} \times \omega^2$

$E_K = 0.5 \times 60 \times 28.274^2 = 23{,}983kJ$ ✓✓ (2)

4.4 $E_{k(2)} = \frac{1}{2}\ \mathrm{I} \times {\omega_2}^2$

$\omega_2 = \sqrt{\frac{2 \times E_{k(2)}}{\mathrm{I}}}$

$\omega_2 = \sqrt{\frac{2 \times 19{,}733 \times 10^3}{60}} = 25.647\ \mathrm{rad/s}$ ✓

But:

$N_2 = \frac{\omega_2 \times 60}{2\pi}$

$= \frac{25{,}647 \times 60}{2\pi}$ ✓

$= 244.911\ \mathrm{r/min}$ ✓ (3)

4.5 $\mathrm{n} = \frac{\mathrm{p}}{E_{K(per\ stroke)}}$

$= \frac{10}{11.25}$ ✓

$= 0{,}889\ \mathrm{stroke/sec} = 53.34\ \mathrm{strokes/min}$ ✓ (2)

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4.6 $E_{K(per\ stroke)} = F_{(AVERAGE)} \times stroke\ length(S)$

$$F_{(AVERAGE)} = \frac{E_{K(per\ stroke)}}{S}$$

$$= \frac{11{,}25 \times 10^3}{0{,}045} \checkmark$$

$$= 250\ \text{kN} \checkmark$$ (2)

[16]

QUESTION 5: REDUCTION GEARBOXES

5.1
- Planetary gearboxes✓
- Worm gear reducers✓
- Gear train gear reducers✓
- Bevel gear reducers✓

(Any 3) (3)

5.2 5.2.1

$$\omega_2 = \frac{N_B \times 2\pi}{60}$$

$$= \frac{450 \times 2\pi}{60}$$

$$= 43{,}982\ rad/s \checkmark$$

$$\alpha_B = \frac{\omega_2 - \omega_1}{t}$$

$$= \frac{43{,}982 - 0}{35}$$

$$= 1{,}257 rad/s^2 \checkmark$$

$$\therefore T_B = I_B \times \alpha_B$$

$$= 500 \times 1{,}257 \checkmark$$

$$= 628{,}5\ N.m \checkmark$$ (2)

5.2.2 $\frac{N_A}{N_B} = \frac{\alpha_A}{\alpha_B}$

$\alpha_A = \frac{1{,}257 \times 1200}{420}$

$= 3{,}591 rad/s^2$ ✓

$I_A = I_A \times \alpha_A$

$= 215 \times 3{,}591$

$= 772\ N.m$ ✓ (2)

5.2.3 To find the equivalent moment of inertia

$k = \frac{0{,}6}{2} = 0{,}3\ m$

Determine the moment of inertia of the mass raised by the drum

$I = m \times k^2$

$= 300 \times 0{,}3^2$

$= 27\ kg.m^2$ ✓

Determine the velocity ratio

$V_R = \frac{N_B}{N_A}$

$= \frac{420}{1200}$ ✓ $= 0{,}35$

Determine I_{Tot}

$\mathrm{I}_{Tot} = I_A + (I_B + I)VR^2$

$= 215 + (500 + 27) \times 0{,}35^2$

$= 279{,}558\ kg.m^2$ ✓ (2)

5.2.4 $E_{k\,(Tot)} = 0{,}5 I_{Tot} \omega^2$

$= 0{,}5 \times 279{,}558 \times 125{,}664$ ✓

$= 2207\ kJ$ ✓ (2)

5.2.5 $T = I_{Tot} \times \alpha$

$= 279{,}558 \times 1{,}257$ ✓

$= 351{,}4\ N.m$ ✓ (2)

[13]

QUESTION 6: RAIL TRACTION AND VEHICLE DYNAMICS

6.1 $T_E = F_R - F_g$

$= 200 - 50$✓

$= 150\ kN$✓ (2)

6.2 Acceleration

$F_a = T_E - F_R + F_g$

$= 150 - 120 + 330$✓

$= 360\ kN$✓

Deceleration

$F_a = T_E - F_g + F_R$

$= 150 - 330 + 120$✓

$= -60kN$✓ (4)

6.3 **Step 1:** Calculate the total locomotive torque.

$T = T_E \times radius\ of\ the\ driving\ wheels$

$= 150 \times 10^3 \times 300 \times 10^{-1}$

$= 45\ 000\ Nm$✓

Step 2: Calculate the torque of the driving wheels.

$$T_{\text{wheels}} = \frac{T}{n_{\text{wheels}}}$$

$$= \frac{45000}{8}$$ ✓

$= 5\ 625$ Nm per wheel✓ (3)

6.4 $$\text{Wheel speed} = \frac{\text{engine speed}}{\text{gear ratio}}$$

$$= \frac{1800}{4} \checkmark$$

$$= 450 \text{ r/min} \checkmark$$ (2)

[11]

QUESTION 7: BALANCING

7.1 $F_C = m_a \omega^2 r_a$

$= 7 \times 252 \times 0{,}09 \checkmark$

$= 393{,}75\ N \checkmark$ (2)

7.2 $m_b r_b = m_a r_a$

$1{,}5 \times r_b = 7 \times 0{,}09 \checkmark$

$r_b = 0{,}42 = 420\ mm \checkmark$

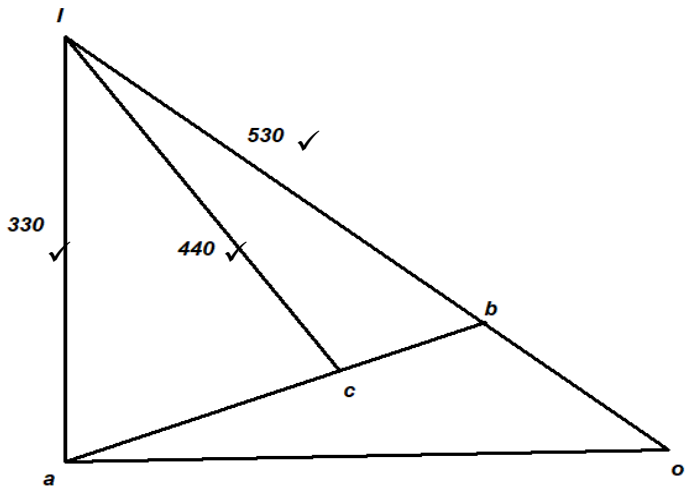
The balance mass of 1,5 kg must be placed diametrically opposite to the casting at 420 mm from the centre of rotation. (2)

7.3 Where two links of a machine are in contact with each other. (2)

7.4
- Low pair
- Higher pair (2)

[8]

QUESTION 8: KINEMATICS



$V_B = wr$

$= \left(\frac{2\pi(100)}{60}\right) \times (0{,}12)$

$= 1{,}257\ m/s$ ✓

$V_A = \frac{V_B}{I_B} \times I_A$

$= \frac{1{,}257}{530} \times 330$ ✓

$= 0{,}783\ m/s$ ✓

$V_C = \frac{V_B}{I_B} \times I_C$

$= \frac{1{,}257}{530} \times 440$ ✓

$= 1{,}044\ m/s$ ✓

OR

$V_C = \frac{V_A}{I_A} \times I_C$

$= \frac{0{,}783}{330} \times 440$ ✓

$= 1{,}044\ m/s$ ✓ **[8]**

TOTAL: 100

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