higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANOTECHNICS N6

30 July 2021

This marking guideline consists of 13 pages.

QUESTION 1

1.1
- Uniform wear theory is based on the assumption that wear that takes place is uniform over the entire contacting surface✓ and resembles conditions of an old, worn-out clutch.√
- Uniform pressure theory is based on the assumption that the pressure is distributed uniformly across the contact surface✓ and resembles the condition of a new, unworn clutch.√ (2 × 1½) (3)

1.2.1

$$= \frac{2\pi NT}{60}$$

$$220 \times 1000 = \frac{2\pi \times 900 \times T}{60} ✓$$

$$T = 2334{,}272 N.m ✓$$

$$T = \frac{2334{,}272 N.m}{2}$$

$$T = 1167{,}136 N.m ✓$$ (3)

1.2.2

$$T = \mu \times p \times \frac{2}{3}\pi(R^3 - r^3)n$$

$$1167{,}136 = 0.3 \times 260000 \times \frac{2}{3}\pi(0.225^3 - r^3) ✓$$

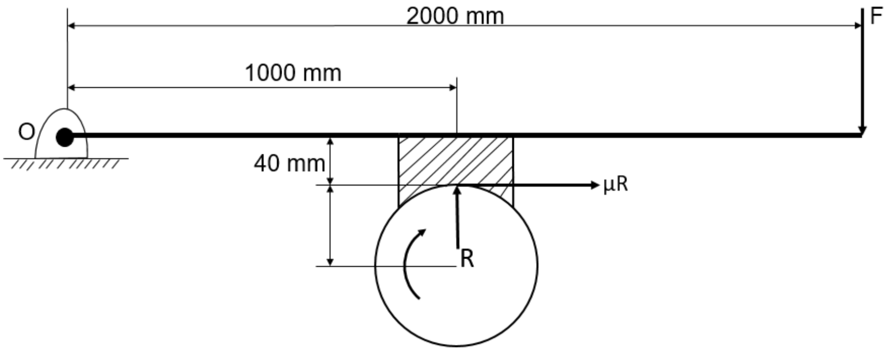
$$r^3 = 4.246 \times 0.001 ✓$$

$$r = 0.162 ✓$$

d = 324 mm✓ (4)

[10]

QUESTION 2



2.1 $D = 400mm = 0{,}4\ m$

$T = 200\ Nm$

$N = 600\ r/mm$

$\mu = 0{,}3$

$T = \mu R \times r$

$200 = 0.3R \times 0{,}2$✓

$R = 3333.333N$✓ (2)

2.2 Taking moments about O:

$\sum$ *clockwise moments* = $\sum$ *anti-clockwise moments*

$F \times 2 = 3333.333 \times 1) + (0{,}3 \times 3333{,}33) \times 0{,}04$✓

$F = \frac{3373{,}333}{2}$✓

$F = 1686{,}667N$✓ (3)

2.3 $P = \frac{2\times\pi\times N\times T}{60}$

$$P = \frac{2 \times \pi \times 600 \times 200}{60}$$

$Power = 12566{,}37\ N$ ✓

$= 12{,}566\ kN$ ✓

Alternative answer

$$v = \frac{\pi \times D \times N}{60}$$

$$= \frac{\pi \times 0{,}4 \times 600}{60}$$

$= 12{,}566\ m/s$ ✓

$Power = \mu R \times v = 1\ 000 \times 12{,}566$

$= 12{,}566\ kW$✓ (2)

2.4 Band brakes√

Block and Band√ (2 × ½) (1)

[8]

QUESTION 3

3.1

$$P = \frac{2\pi NT}{60}$$

$$20 \times 10^3 = \frac{2\pi \times 300 \times T}{60}$$

$T = 636{,}62\ N.m$ ✓

$T = (T_1 - T_2)r$

$T_1 = 2{,}5T_2$

$636{,}62 = 1{,}5T_2 \times 0{,}225$

$T_2 = 1886{,}28\ N$ ✓

$T_1 = 4715{,}70\ N$ ✓

Alternative answer

$$v = \frac{\pi \times D \times N}{60}$$

$$= \frac{\pi \times 0{,}45 \times 300}{60}$$

$= 7{,}0686\ m/s$ ✓

$20 \times 10^3 = (T_1 - T_2)v$

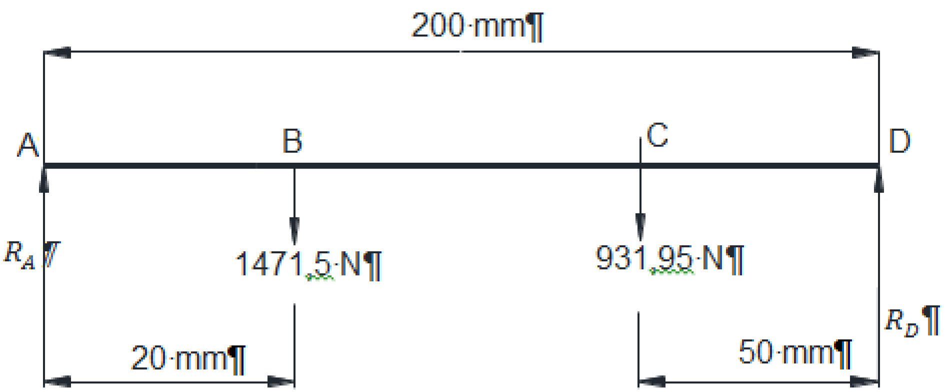
$20 \times 10^3 = 1{,}5T_2 \times 7{,}0686$

$T_2 = 1886{,}28\ N$ ✓

$T_1 = 4715{,}7\ N$ ✓

(3)

3.2



Taking moment about A:

$\sum$ *clockwise moments* = $\sum$ *anti-clockwise moments*

$(1\,471{,}5 \times 20) + (931{,}95 \times 150) = R_D \times 200$ ✓

$29\,430 + 139\,792{,}5 = R_D \times 200$ ✓

$$R_D = \frac{169\,222{,}5}{200}$$

$R_D = 846{,}113N$ ✓

(3)
[6]

QUESTION 4

4.1 $m = \rho \times v$

$m = 7500 \times \pi(1{,}2^2 - 0{,}9^2) \times 0{,}15$

$m = \frac{2226{,}604}{4} = 556{,}65\ kg$ ✓

$I = mk^2$

$I = 556{,}65\left(\frac{0{,}6^2 + 0{,}45^2}{2}\right)$

$I = 156{,}558\ kg.m^2$ ✓ (2)

4.2 $E_K = \frac{1}{2}I(\omega_f^2 - \omega_i^2)$

$E_K = \frac{1}{2}(156{,}558)[(2\pi \times 6)^2 - (2\pi \times 4{,}5)^2]$ ✓

$E_K = 48\ 672{,}714\ kJ$ ✓ (2)

4.3 $= E_K \times pressings(cycles)/s$

$P = \frac{48\ 672{,}714 \times 25}{60}$ ✓

$P = 20{,}280\ kW$ (2)

[6]

QUESTION 5

5.1 $Helix\ angle\ \ tan\theta = \frac{lead}{\pi \times mean\ diameter}$

$tan\theta = \frac{2 \times 15}{\pi \times 80} = 0{,}1194$

$\theta = 6{,}807^o$ ✓

$Angle\ of\ friction\ tan\ \phi = 0{,}045$

$\phi = tan^{-1}0{,}045 = 2{,}577^o$ ✓

The efficiency of the worm is given as:

$\eta_{worm} = \frac{\tan\theta}{\tan(\theta+\phi)} \times 100\% = \frac{\tan 6{,}807}{\tan(6{,}807+2{,}577)} \times 100\%$ ✓

$= \frac{0{,}1194}{0{,}1653} \times 100\% = 72{,}23\ \%$ ✓ (4)

5.2 $Power_{worm} = \frac{P_{out}}{\eta_{worm}} \times 100\%$

$= \frac{28000}{0{,}7223} = 39{,}457\ kW$ ✓ (1)

5.3 $1\,rev\ of\ worm = 2 \times 15 = 30\ mm\ on\ worm$

$Rotational\ speed\ of\ the\ worm\ in\ seconds = \frac{1680}{60} = 28\ r/s$✓

$Linear\ velocity\ of\ the\ worm, v = 0{,}03 \times 28 = 0{,}84\ m/s$✓

$P_{out} = F_{worm\ wheel} \times v$

$F_{worm\ wheel} = \frac{P_{out}}{v} = \frac{28000}{0{,}84} = 33{,}929\ kN$✓

(3)

5.4 $T_c = F_{worm} \times R \times \mu$

$T_c = 33{,}929 \times \frac{0.075}{2} \times 0{,}045$ ✓

$= 57{,}255\ n.m$ ✓

(2)

[10]

QUESTION 6

6.1.1 The banking angle θ

$Superelevation = sin\theta \times track\ width$

$$sin\theta = \frac{superelevation}{track\ width}$$

$$= \frac{0{,}1}{1{,}2}$$

$\theta = 4{,}78^o$✓

(1)

6.1.2 The maximum speed

$v = \sqrt{tan\theta \times rg}$

$v = 31km/h = \frac{31\times1000}{60\times60} = 8.611m/s$✓

$8{,}611 = \sqrt{\tan(4{,}78) \times r \times 9{,}81}$

$8{,}611^2 = \tan(4{,}78) \times r \times 9{,}81$✓

$r = \frac{8{,}611^2}{\tan(4{,}78)\times9{,}81} = 90{,}39\ m$✓

(3)

6.1.3 $F_g + mgsin\theta = F_c cos\theta$

$F_g = F_c cos\theta - mgsin\theta$

$$F_g = \frac{m \times v^2}{r} cos\theta - mgsin\theta$$

$v = \frac{72\times1000}{60\times60} = 20m/s$✓

$F_g = \frac{3000\times20^2}{90{,}39} cos4{,}78 - 3000 \times 9{,}81 \times sin4{,}78 = 10{,}78\ kN$✓✓✓

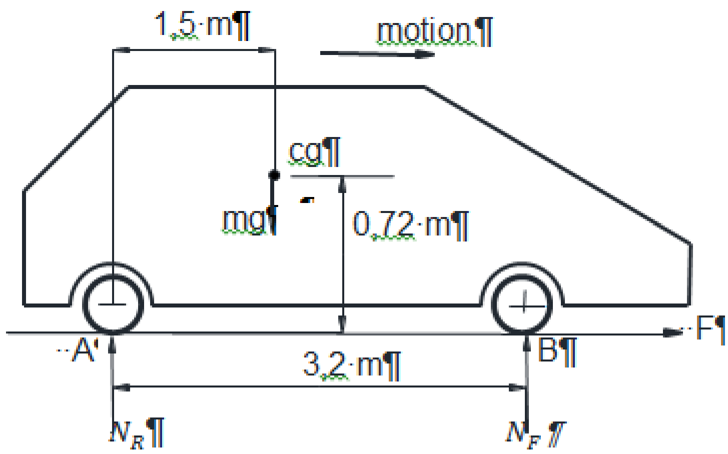
(4)

6.2 6.2.1 Locomotive tractive effort is the force that the locomotive must exert at its driving wheels to move itself and the trucks or train.

6.2.2 Draw bar pull is the force available at the rear end of the locomotive for pulling the trucks.

(2 × 1) (2)

6.3 6.3.1



Taking moments about A:

$$\sum clockwise\ moments = \sum anti\ clockwise\ moments$$

$$mg \times 1{,}5 = N_F \times 3{,}2$$

$$N_F = \frac{1{,}5 \times mg}{3{,}2} = 0{,}469\ mg\checkmark$$

$$F_{brake} = \mu N_F$$

$$ma = 0{,}35 \times 0{,}468\ mg$$

$$a = 0{,}35 \times 0{,}468 \times 9{,}81 = 1{,}607\ m/s^2$$

$$= -1{,}607\ m/s^2\checkmark$$

$$s = \frac{v^2 - u^2}{2a}$$

$$but\ \ u = \frac{97{,}2\ km}{h} = \frac{97{,}2 \times 1000}{60 \times 60} = 27\ m/s$$

The distance is given as:

$$s = \frac{0^2 - 27^2}{2 \times (-1{,}607)} = 226{,}82\ m\checkmark$$ (3)

6.3.2

Rear wheels brake

Taking moments about B

$$\sum clockwise\ moments = \sum anti\ clockwise\ moments$$

$$N_R \times 3{,}2 = mg \times (3{,}2 - 1{,}5)$$

$$N_R = \frac{mg \times 1{,}7}{3{,}2} = 0{,}531mg \checkmark$$

$$F_{brake} = \mu N_R$$

$$ma = 0{,}35 \times 0{,}531 \times m \times 9{,}81$$

$$a = 0{,}35 \times 0{,}531 \times 9{,}81 = 1{,}823\ m/s^2$$

$$= -1{,}823\ m/s^2 \checkmark$$

The distance is given as:

$$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 27^2}{2 \times (-1{,}823)} = 199{,}945m \checkmark$$

(3)

6.3.3 Front and rear wheels brake:

$F_{brake} = \mu N_F + \mu N_R = \mu(N_F + N_R)$

$but \quad mg = N_F + N_R$

$ma = \mu mg$

$a = \mu g = 0{,}35 \times 9{,}81 = 3{,}435\ m/s^2$ ✓

$a = -3{,}435\ m/s^2$

The distance is given as:

$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 27^2}{2 \times (-3{,}435)} = 106{,}114\ m$ ✓ (2)

6.3.4 For ratio $N_F : N_R$

$F_{brake} = \mu(N_F + N_R)$

Taking moments about the centre of gravity:

$\sum clockwise\ moments = \sum anti\ clockwise\ moments$

$(F_{brake} \times distance\ from\ cg\ to\ the\ road) + (N_R \times 1{,}5) = (N_F \times 1{,}7)$

$\mu(N_F + N_R)0{,}72 + 1{,}5N_R = 1{,}7N_F$

$0{,}35(N_F + N_R)0{,}72 + 1{,}5N_R = 1{,}7N_F$ ✓

$0{,}252N_F + 1{,}752N_R = 1{,}7N_F$

$1{,}7N_F - 0{,}252N_F = 1{,}752N_R$

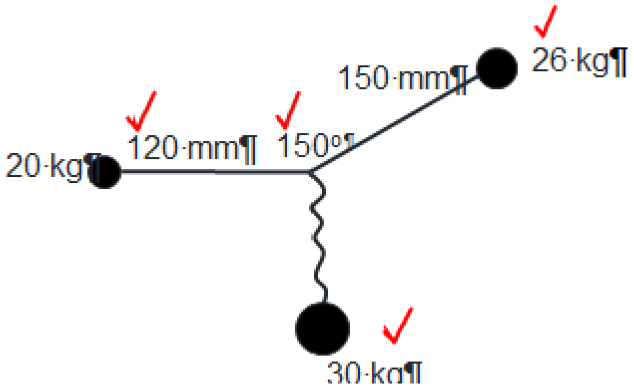
$1{,}5N_F = 1{,}752N_R$

$\frac{N_F}{N_R} = \frac{1{,}752}{1{,}5} = \frac{1{,}168}{1}$ ✓ (2)

[20]

QUESTION 7

7.1.



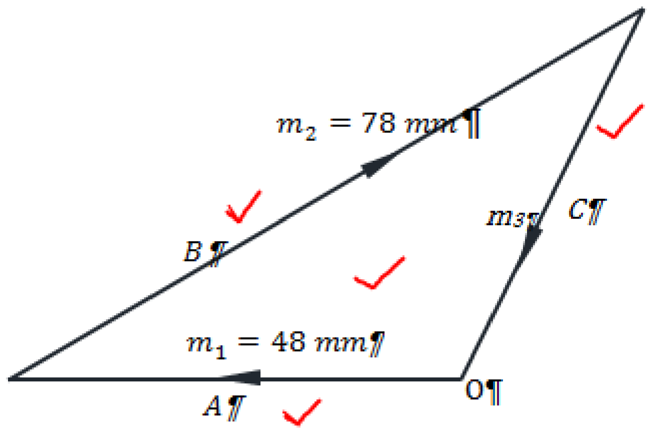
(4)

7.2

Plane	Mass (kg)	r(m)	mr(kg.m)	
A	20	0,12	2,4	✓
B	26	0,15	3,9	✓
C	30	x	30x	✓

(3)

7.2



(4)

7.2. Force diagram

The centrifugal force of m_3 is given as

$20\ mm = 1\ kg.m$

$$43{,}9\ mm = \frac{43{,}9mm}{20\ mm} \times 1\ kg.m$$
$$= 2{,}195\ kg,m✓$$

The distance of m_3 from centre O of face plate:

$30x = 2{,}193$

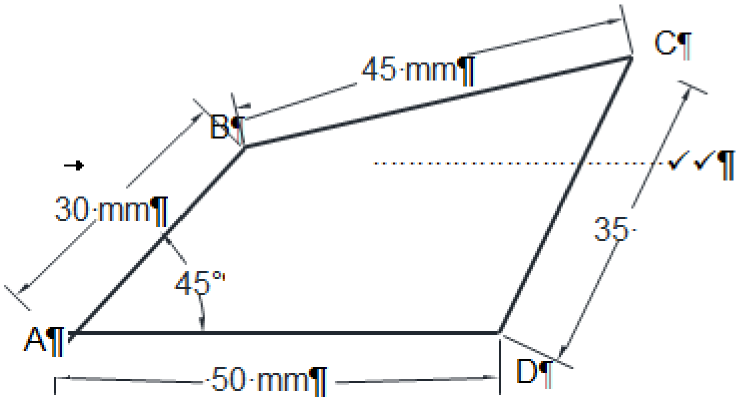
$x = \frac{2{,}193}{30} = 0{,}0731\ m = 73{,}1\ mm$✓✓

The position of m_3 to plane A is 244° clockwise and 116° to A.✓ (4)

[15]

QUESTION 8

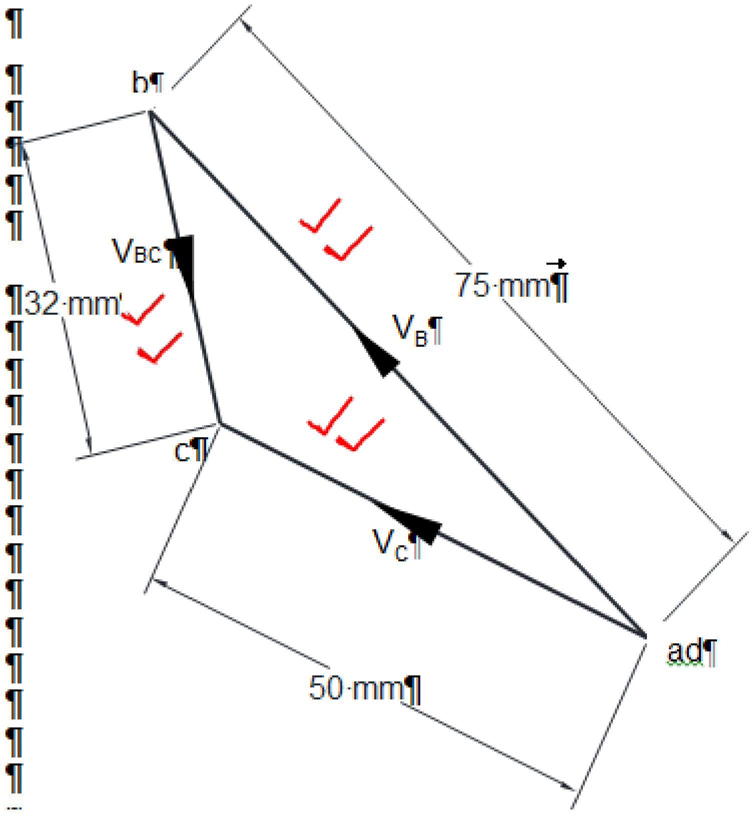
8.1 $AB = 30\ mm\ BC = 45\ mm\ \ CB = 30\ mm\ DA = 50\ mm$
$V_B = \omega_{AB} \times AB = 5 \times 0{,}03 = 0{,}15\ m/s$✓ (1)



(2)

Space diagram

Scale = 0,1 m/s = 50 mm



(6)

Velocity diagram:

$Scale \quad 0,1\ m/s = 5\ mm$

$ab = 75\ mm$

From the velocity diagram:

$Measure\ bc = 32\ mm = 0,064\ m/s$

$\omega_{BC} = \frac{0,064}{0,046} = 1.422\ rad/s$✓

$Measure\ cd = 35\ mm = 0,07\ m/s$

$\omega_{CD} = \frac{0,07}{0,035} = 2\ rad/s$✓ (2)

8.2 $Centripetal\ acc\ of\ A\ relative\ to\ B = \omega_{AB}{}^2 \times AB$
$= 5^2 \times 0,03 = 0,75\ m/s^2$✓

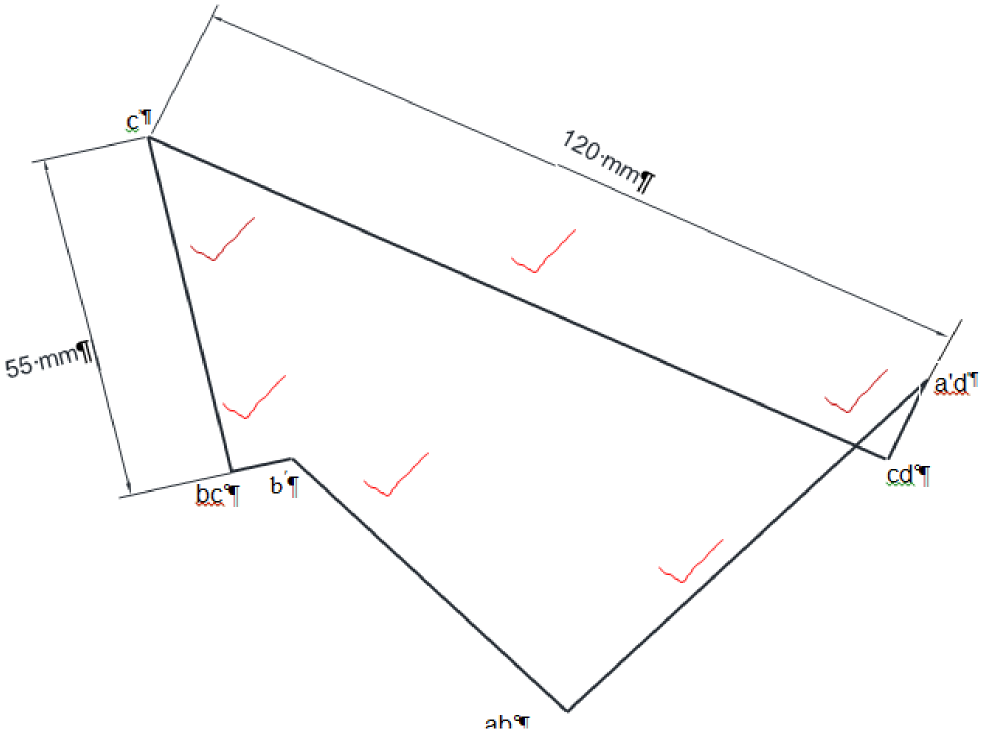
$Tangential\ acc\ of\ A\ relative\ to\ B = \alpha_{AB} \times B$
$= \alpha_{AB} \times B = 19 \times 0,03 = 0,57 m/s^2$✓

$Scale\ 0,75 \frac{m}{s^2} = 75\ mm$

$Centripetal\ acc\ B\ relative\ to\ C = \omega_{BC}{}^2 \times BC$
$= 1,422 \times 0,045 = 0,09o\ \ m/s^2$✓

$Centripetal\ acc\ of\ C\ relative\ to\ D = \omega_{CD}{}^2 \times CD$
$= 2^2 \times 0,035 = 0,14\ m/s^2$

From the acceleration diagram:
$Measure\ c'bc = 55\ mm = \frac{0,75}{75} \times 55 = 0,55\ m/s^2$✓
$Measure\ c'dc = 120\ mm = \frac{0,75}{75} \times 120 = 1,2\ m/s^2$✓
$\alpha_{BC} = \frac{0,55}{0,045} = 12,22\ rad/s^2$✓
$\alpha_{CD} = \frac{1,2}{0,035} = 34,29\ rad/s^2$✓ (7)



(7)
(14)
[25]

TOTAL: 100