higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

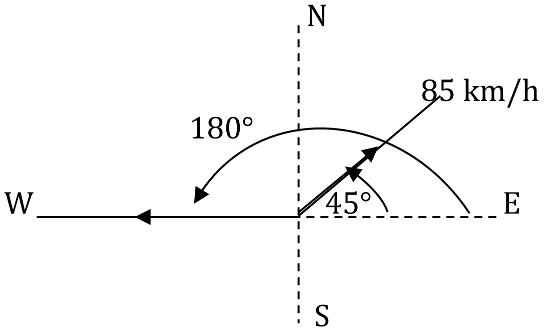
ENGINEERING SCIENCE N4

4 July 2022

This marking guideline consists of 12 pages.

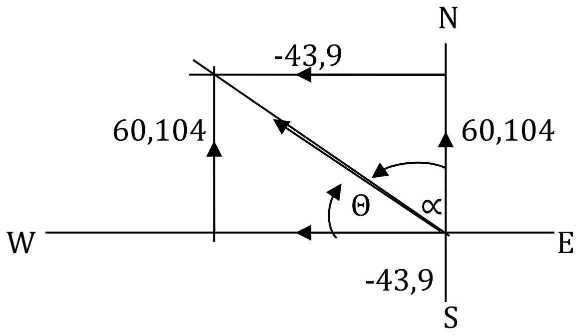
QUESTION 1

1.1



$\sum V = 85\sin 45° + 104\sin 180°$
$= 60{,}104$ km/h✓

$\sum H = 85\cos 45° + 104\cos 180°$
$= 43{,}9$ km/h



$\text{Resultant} = \sqrt{60{,}104^2 + 43{,}9^2}$

$= 74{,}429$ km/h✓

$tan\ \theta = \frac{60{,}104}{-43{,}9}$

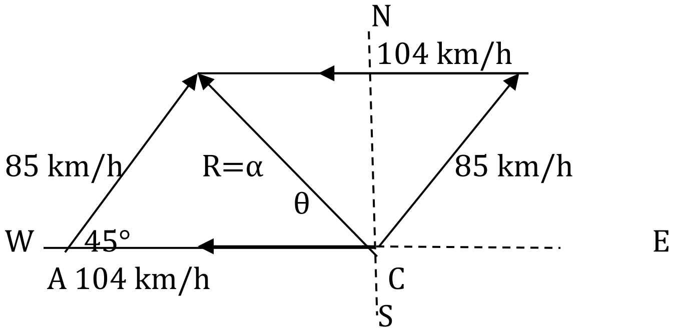
$\theta = 53{,}856°$✓

$_AV_B = 74{,}429$ km/h W 53,856° N✓

OR

${}_AV_B = 74{,}429\ \text{km/h N } 36{,}144°\ \text{W}$

Alternative method:



$a = \sqrt{b^2 + c^2 - 2 \times b \times c\cos A}$
$= 85^2 + 104^2 - 2 \times 85 \times 104\cos 45°$✓
$= 74{,}427\ \text{km/h}$✓

$\frac{\sin\theta}{85} = \frac{\sin 45°}{74{,}427}$ ✓
$\theta = 53{,}858°$
${}_AV_B = 74{,}427\ \text{km/h W } 53{,}856°\ \text{N}$✓

OR

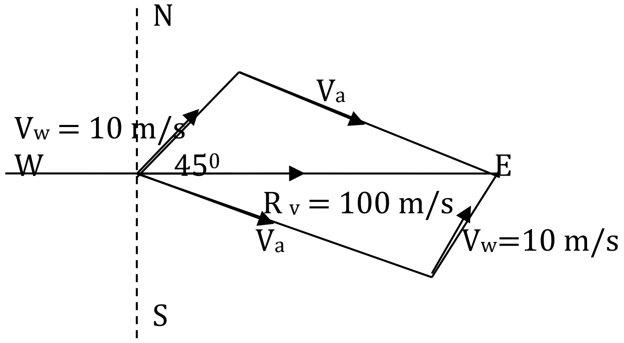
${}_AV_B = 74{,}427\ \text{km/h N } 36{,}144°\ \text{W}$✓

(4)

1.2 R_v = Resultant velocity
V_w = Velocity of the wind
V_a = Velocity of the aeroplane

$R_v = \frac{300\ 000}{50 \times 60}$✓

$= 100\ \text{m/s}$



$V_a = \sqrt{V^2 + R^2 - 2 \times V_w \times R_v} \cos A$✓

$= \sqrt{10^2 + 100^2 - 2 \times 10 \times 100 \times \cos 45°}$

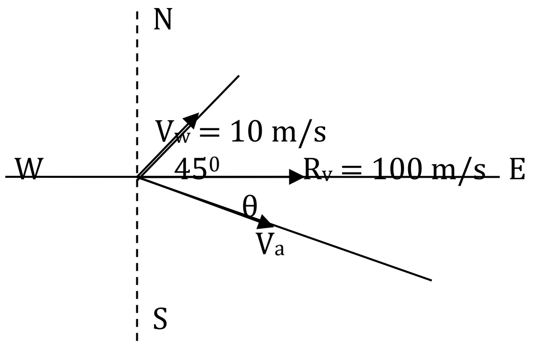
$= 93{,}198$ m/s✓

$\frac{\sin\theta}{10} = \frac{\sin 45°}{93{,}198}$✓

$\theta = 4{,}351°$✓

Direction: East 4,351° S✓

Alternative method:



$\sum V = V_w \sin 45° + V_a \sin(-\theta)$

$0 = 10\sin 45° + V_a \sin(-\theta)$✓

$V_a \sin\theta = 7{,}071$

$\sum H = V_w \cos 45° + V_a \cos\theta$

$100 = 7{,}071 + V \cos\theta$✓

$V_a \cos\theta = 92{,}929$

$V_a = \sqrt{(92,929)^2 + (7,071)^2}$

$= 93{,}198$ m/s✓

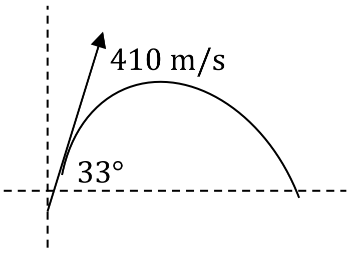
$\frac{v_a \sin\theta}{V_a \cos\theta} = \frac{7{,}071}{92{,}929}$✓

$\frac{\sin\theta}{\cos\theta} = \tan\theta = 0{,}0761$

$\theta = 4{,}351°$✓

Direction E 4,351° S✓ (6)

1.3



1.3.1 $S_v = \frac{u^2 \sin^2\theta}{2 \times g}$ ✓

$= \frac{410^2 \sin^2 33°}{2 \times 9{,}8}$ ✓

$= 2\ 544{,}071\ \text{m}$ ✓

OR

$U_v = 410 \times \sin 33°$ ✓
$= 223{,}302\ \text{m/s}$

$S_v = \frac{v^2 - u^2}{2 \times g}$ ✓

$= \frac{0^2 - 223{,}302^2}{2 \times -9{,}8}$

$= 2\ 544{,}071\ \text{m}$ (2)

1.3.2 $S_h = \frac{u^2 \sin 2\theta}{g}$ ✓
$= \frac{410^{g} \times \sin 2 \times 33°}{9{,}8}$ ✓

$= 15\ 670{,}101\ \text{m}$ ✓

OR

$U_h = 410 \times \cos 33°$ ✓
$= 343{,}855\ \text{m/s}$

$T_v = \frac{v - u}{g}$
$= \frac{0 - 223{,}302}{9{,}8}$ ✓
$= 22{,}786\ \text{s}\ (t_h - 2\ t_v)$

$S_h = u_h \times t_h$
$= 343{,}855 \times 2 \times 22{,}786$ ✓
$= 15\ 670{,}157\ \text{m}$ (3)
[15]

QUESTION 2

2.1 Distance $= \pi \times D \times n$
$= \pi \times 0{,}405 \times 1$✓
$S = 1{,}272$ m✓ (2)

2.2 Angular displacement: $\theta = 2\pi n$
$= 2 \times \pi \times 10$✓
$= 62{,}83$ rad✓ (2)

2.3 Angular velocity: $v = \omega R$

$$\omega = \frac{v}{R}$$

$$= \frac{100 \times 1\,000}{3\,600}$$

$$= 27{,}78 \text{ m/s}$$✓

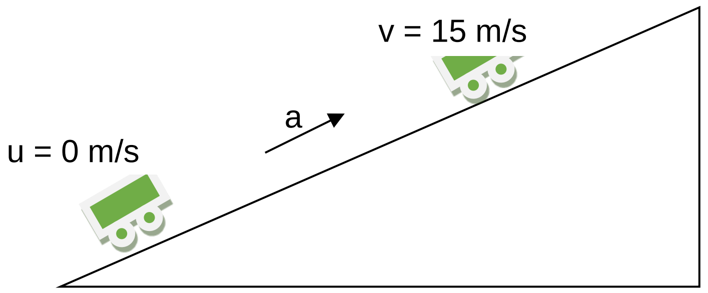
$R = \frac{405}{2} = \frac{202{,}5}{100} = 0{,}2025$ m✓
$= \frac{27{,}78}{0{,}2025}$
$= 137{,}185$ rad/s✓ (3)

2.4 Angular retardation: $\alpha = \frac{\omega_2 - \omega_1}{t}$
$\omega_1 = 137{,}185$ rad/s
$\omega_2 = 0$ rad/s
$\alpha = \frac{0 - 137{,}185}{25}$✓
$\alpha = -5{,}487$ rad/s^2✓ (2)
[9]

QUESTION 3

3.1 The potential energy of a particle is the work which the forces acting on it could do if it moved from its given position to some standard position. (1)

3.2



A gradient of 1 in 35 means that: $\tan\theta = \frac{1}{35}$

$$\theta = \tan^{-1}\frac{1}{35}$$
$$= 1{,}637°$$

3.2.1 $a = \frac{v_2 - v_1}{t}$

$a = \frac{18{,}06 - 0}{2 \times 60}$ ✓✓

$= 0{,}150 \text{ m/s}^2$ ✓ (3)

3.2.2 E_k after 2 minutes:

$2 \text{ min} = 18{,}06 \text{ m/s}$

$E_k = ½ mv^2$ ✓

$= ½ \times 120 \times (18{,}06)^2$ ✓

$= 19\ 569{,}816 \text{ J}$ ✓

$= 19{,}570 \text{ kJ}$ (3)

3.2.3 E_P after 2 minutes:

$S = ut \times ½at^2$

$S = 0 + (½ \times 0,150 \text{ m/s}^2 \times (120)^2)$

$= 1\ 080 \text{ m}$ ✓

$\sin 1{,}637° = \frac{h}{1\ 080}$ ✓

$h = 1\ 080 \sin 1{,}637°$

$h = 30{,}85 \text{ m}$ ✓

$E_P = mgh$

$= 120 \text{ kg} \times 9{,}8 \times 30,85$ ✓

$= 36\ 279{,}60 \text{ J}$

$= 36{,}28 \text{ kJ}$ ✓ (5)

[12]

QUESTION 4

4.1 The law of moments states that a system of forces is in equilibrium when the sum of the clockwise moments about any turning point equals the sum of anticlockwise moments about the same turning point. (2)

4.2 4.2.1 R_A = Take the moments about D

$\Sigma \curvearrowright \text{moments} = \Sigma \curvearrowleft \text{moments}$

$R_A \times 6 = (20 \times 6) + (30 \times 4) + (40 \times 2)$ ✓

$= 320 \div 6$

$R_A = 53{,}33 \text{ kN}$ √

R_D = Take the moments about A

$\Sigma \curvearrowleft \text{moments} = \Sigma \curvearrowright \text{moments}$

$R_D \times 6 = (30 \times 2) + (40 \times 4)$ ✓

$= 220 \div 6$

$R_D = 36,67 \text{ kN}$ √

TEST: $\Sigma \downarrow \text{forces} = \Sigma \uparrow \text{forces}$

$(20 + 30 + 40) \text{ kN} = (36,67 + 53,33) \text{ kN}$

$90 \text{ kN} = 90 \text{ kN}$ ✓ (4)

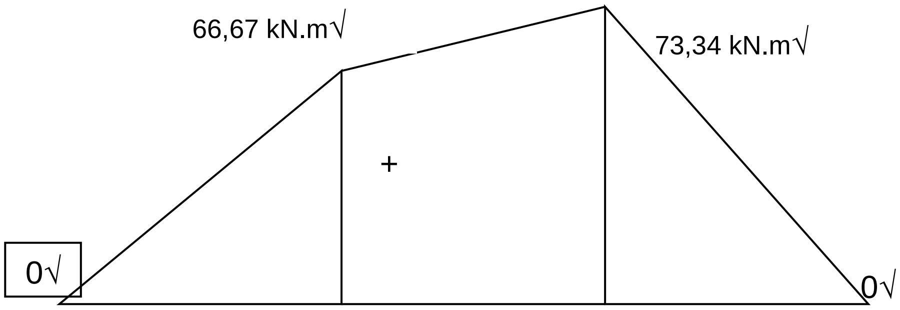
4.2.2 BM at A $= 0$✓

BM at B $= (53{,}33 \times 2) - (20 \times 2)$ kN.m
$= 66{,}67$ kN.m✓

BM at C $= 36{,}67 \times 2$
$= 73{,}34$ kN✓

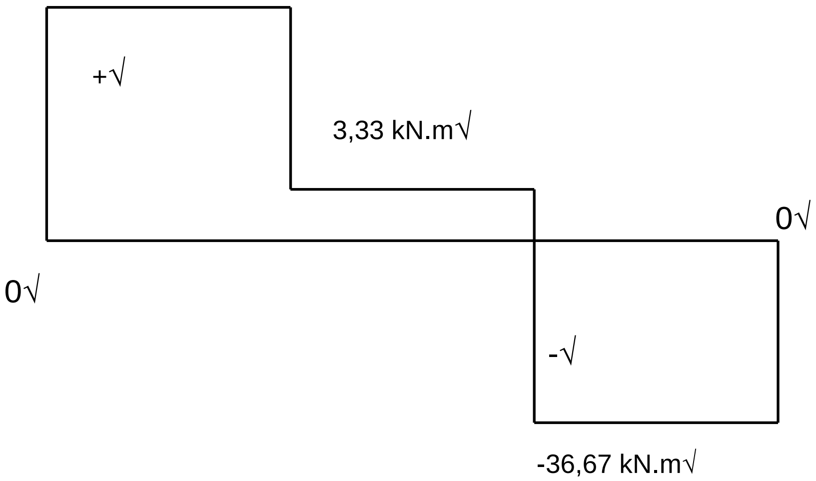
BM at D $= 0$✓ (4)

4.2.3



(2)

4.2.4



(3)
[15]

QUESTION 5

5.1
- A liquid has definite volume.
- A liquid takes the shape of its container.
- Liquids such as water and hydraulic fluid can be used to do work and can be used repeatedly. (Any 2 × 1) (2)

5.2 $D = 42 \text{ cm} = 0{,}42 \text{ m}$
$L = H = 55 \text{ cm} = 0{,}55 \text{ m}$
$P = 857 \text{ kPa}$

5.2.1
$$V = \frac{\pi D^2 \times L}{4} ✓$$
$$= \frac{\pi\ 0{,}42^2 \times 0{,}55}{4} ✓$$
$$= 0{,}076 \text{ m}^3 ✓$$
(3)

5.2.2
$$F = P \times A$$
$$= \frac{857 \times \pi\ 0{,}42^2}{4} ✓$$
$$= 118{,}732 \text{ kN} ✓$$
(2)

5.2.3
$$WD = F \times S$$
$$= 118{,}732 \times 0{,}55 ✓$$
$$= 65{,}303 \text{ J} ✓$$

OR

$$WD = P \times V ✓$$
$$= \frac{857 \times \pi\ 0{,}42^2 \times 0{,}55}{4}$$
$$= 65{,}303 \text{ J} ✓$$
(2)

5.3 $d = 0{,}1\ D$
$MA = 5$
$\text{Efficiency} = 93\%$

$$F = MA \times \text{effort}$$
$$= 15 \times 200 ✓$$
$$= 3\ 000 \text{ N}$$

$$W = \frac{F \times D^2}{d \times d} ✓$$
$$= \frac{3\ 000 \times D^2}{(0{,}1\ D)^2} ✓$$
$$= 300\ 000 \text{ N}$$

$$100\% = 300\ 000$$
$$93\% = X$$
$$X = \frac{93\% \times 300\ 000}{100\%} ✓✓$$
$$= 279\ 000 \text{ N } (279\text{kN})$$
(5)

5.4 N = 240 r/min
d = 90 mm
S_l = 590 mm
C = 3

V_a (actual volume in ℓ/s), slip% = 1,8%, η = 100 slip%

$$V_s = \frac{\pi . d^2 sl. n. C.}{4} . \frac{N}{60}$$

$$= \frac{\pi .(0{,}09\ m)^2 .0{,}59\ m.1.(3)}{4} . \frac{240\ \text{r/min}}{60} ✓$$

$$= 0{,}045041\ \text{m}^3$$

$$V_a = V_s . \frac{\eta}{100}$$

$$= 0{,}045041\ \text{m}^3/\text{s}. \frac{98.2}{100} ✓$$

$$= \frac{0{,}044230275\ \text{m}^3}{s} (1\ 000\ \ell/\text{m}^3)$$

$$= 44{,}230\ \ell/\text{s} ✓$$ (3)

5.5 H = 65 m
V_a = 320 ℓ/min
η_l = 75%

$$P_{rr}. = \rho . g . h$$
$$= 1\ 000\ \text{kg/m}^3 (9{,}8\ \text{m/s}^2).65\ \text{m}$$
$$= 637\ \text{kPa} ✓$$

$$Va = 320\ 000\ \text{m}^3/\text{min}$$
$$= 320\ 000\ \text{m}^3/\ \text{min}. \frac{1\ \text{min}}{60\ \text{s}}$$
$$= 5\ 333.333\ \text{m}^3/\text{s} ✓$$

$$P_{out} = (637\ 000\ \text{Pa}) 5\ 333.333\ \text{m}^3/.\text{s}$$
$$= 3\ 397\ 333\ 333\ \text{W}$$

$$\eta = . \frac{P_{out}}{P_{in}} .100$$

$$P_{in} = . \frac{P_{out}}{\eta} .100$$

$$= \frac{3\ 397\ 333{,}333\ \text{kW}}{75} .100$$
$$= 4\ 529\ 777.778\ \text{kW} ✓$$ (3)

[20]

QUESTION 6

6.1 Hooke's law states that within the elastic limit of any body, the ratio of stress to strain produced is constant. (2)

6.2
$$\sigma = \frac{F}{A}$$
$$F = \sigma \times A$$
$$= 120° \times 10^6 \times \frac{\pi \times (0{,}030)^2}{4}✓$$
$$= 84\,823 \text{ N}$$
$$= 84{,}823 \text{ kN}✓$$

$$x_T = x_1 + x_2 + x_3$$

$$x_T = \frac{F \times L}{A \times E} + \frac{F \times L}{A \times E} + \frac{F \times L}{A \times E}$$

$$x_T = \frac{84{,}82 \times 10^3 \times 0{,}2}{\frac{\pi \times (0{,}050)^2}{4} \times 200 \times 10^2} + \frac{84{,}82 \times 10^3 \times 0{,}175}{\frac{\pi \times (0{,}040)^2}{4} \times 200 \times 10^2} + \frac{84{,}82 \times 10^3 \times 0{,}150}{\frac{\pi \times (0{,}030)^2}{4} \times 200 \times 10^2}✓$$

$$x_T = 4{,}319 \times 10^{-5} + 5{,}90 \times 10^{-5} + 8{,}99 \times 10^{-5}✓$$
$$x_T = 1{,}92 \times 10^{-4} \text{ m}$$
$$x_T = 0{,}192 \text{ m}✓$$
(5)

6.3 6.3.1
$$\sigma = \frac{F}{A}$$
$$= \frac{80 \times 10^3 \times 4}{\pi \times (0{,}025)^2}✓✓$$
$$= 162{,}975 \text{ MPa}✓$$
(3)

6.3.2
$$\varepsilon = \frac{x}{L}$$
$$\varepsilon = \frac{0{,}2}{250}✓$$
$$= 0{,}0008✓$$
(2)

6.3.3
$$\in = \frac{\sigma}{\varepsilon}$$
$$= \frac{162{,}975 \times 10^6}{0{,}8 \times 10^{-3}}✓$$
$$= 203{,}719 \text{ GPa}✓$$
(2)

[14]

QUESTION 7

7.1 Pascal's law states that the pressure exerted on the surface of a liquid in a closed system is transmitted with the same intensity through the liquid and in all directions. (3)

7.2 d = 100 mm
L= 80 mm
h = 20 m

7.2.1
$$V = A \times s\ell$$
$$= \frac{\pi d^2}{4} \times sl$$
$$= \frac{\pi(0,1)^2}{4} \times 0,08 ✓✓$$
$$= 6,283 \times 10^{-4}\ \text{m}^3 ✓$$
(3)

7.2.2
$$m = \rho \times V$$
$$= 1\,000 \times 6,283 \times 10^{-4}\ \text{kg} ✓$$
$$= 0,628\ \text{kg} ✓$$
(2)

7.3 7.3.1
$$V_{ACT} = A \times s\ell \times 0,95$$
$$= \frac{\pi d^2}{4} \times sl \times 0,95 ✓$$
$$= \frac{\pi(0,08)^2}{4} \times 0,12 \times 0,95 ✓$$
$$= 5,73 \times 10^{-4}\ \text{m}^3 ✓$$
(3)

7.3.2
$$V_{ACT} = A \times h$$
$$(5)(5,73 \times 10^{-4}) = \frac{\pi d^2}{4} \times h ✓$$
$$h = \frac{(5)(5,73 \times 10^{-4}) \times 4}{\pi(0,08)^2} ✓✓$$
$$h = 0,570\ \text{m} ✓$$
(4)
[15]

TOTAL: 100