higher education
& training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

ENGINEERING SCIENCE N4

18 NOVEMBER 2016

This marking guideline consists of 8 pages.

QUESTION 1

1.1 $\uparrow V_H$ (+) 187 km/h

$\downarrow V_T$ (-) 103 km/h

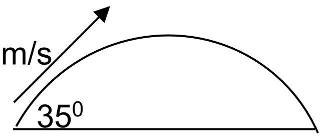
$_HV_T = V_H - V_T$ ✓
$= 187 - (-103)$ ✓
$= 187 + 103$ ✓
$= \underline{290\ km/h}$ (3)

1.2 1.2.1

$H_{max} = \frac{u^2 \sin^2 \alpha}{2g}$ ✓

$= \frac{29^2 \sin^2 35^0}{2\,(9{,}8)}$ ✓

$= \underline{14{,}116\ m}$ ✓



ALTERNATIVE SOLUTION:

$v_f^2 = v_i^2 + 2gs$
$0^2 = (29\sin 35°)^2 + 2(-9{,}8)s$
$s = 14{,}116\ m$ (3)

1.2.2

$S_H = L = \frac{u^2 \sin 2\alpha}{g}$ ✓

$= \frac{29^2 \sin 70^0}{9{,}8}$ ✓

$= \underline{80{,}641\ m}$ ✓

ALTERNATIVE SOLUTION:

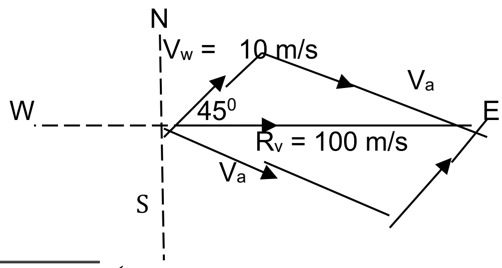
$v_f = v_i + at$
$0 = 29\sin 35° - 9{,}8t$
$t = 1{,}697\ s$
$s = v2t$
$s = (29\cos 35°)2(1{,}697)$
$s = 80{,}626\ m$ (3)

1.3 1.3.1

V_w = Velocity of the wind
V_a = Velocity of the aeroplane

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

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



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

$= \sqrt{10^2 + 100^2 - 2 \times 10 \times 100 \cos 45^0}$ ✓

$= \underline{93{,}198\ m/s}$ ✓ (4)

1.3.2 $\frac{\sin\theta}{10} = \frac{\sin 45^0}{93{,}198}$✓
$\theta = \underline{4.351^0}$✓ (2)

Direction: East $4{,}351^0$ South

[15]

QUESTION 2

2.1 Rate of change of angular velocity. (1 × 2) (2)

2.2 2.2.1 $\propto = ?$ ⟶ $\omega_2 = \omega_1 + \propto t$ $N_1 = 1500$ r/min
Need: $\omega_1 = 2\pi N_1/60 = 50\pi$ rad (157,08) $N_2 = 600$ r/min
$\omega_2 = 2\pi N_2/60 = 20\pi$ rad (62,832) $N_T = 48$ rev

$\therefore \omega_2^2 = \omega_1^2 + 2\propto \vartheta_T$✓
$\therefore (20\pi)^2 = (50\pi)^2 + 2\propto (96\pi)$✓
$\therefore = -\underline{34{,}361 \text{ rad/s}^2}$✓

$\therefore \vartheta_T = ?$✓
$\vartheta_T = 2\pi N$
$= 2\pi \times 48$
$= 96\pi$ rad✓
$= 301{,}593$ rad (5)

2.2.2 $\omega 2 = \omega 1 + \propto \tau$✓
$\therefore 20\pi = 50\pi - 34{,}361\,\tau$
$\therefore \tau = \underline{2{,}743 \text{ s}}$✓ (2)

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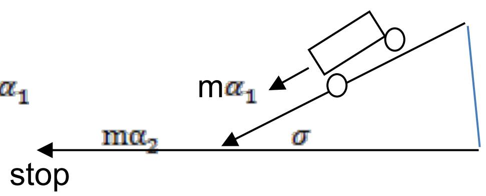
QUESTION 3

3.1 Coefficient of friction is the ratio of the friction force✓ and the normal reaction (weight).✓ (2)

3.2 3.2.1 $F_s - F\mu = m\alpha$✓
$\therefore mg\sin\theta - 200 = 1200\alpha_1$✓
$\therefore 1200(9{,}8)\left(\frac{1}{30}\right) - 200 = 1200\alpha_1$
$\therefore \alpha_1 = 0{,}16\ m/s^2$
✓



on the incline:
$v^2 = u^2 + 2a_1 s_1$✓
$\therefore v^2 = 0^2 + 2(0{,}16)(62)$✓
$\therefore v_1 = 4{,}454\ m/s$✓ (6)

3.2.2 $F = -F\mu = -200$ N✓ only friction force (1)

3.2.3 On the horizontal Road
$v^2 = u^2 + 2a_2 s_2$✓
$\therefore 0^2 = (4{,}454)^2 + 2(-0{,}167)S_2$
$\therefore s_2 = 59{,}396m$ ✓

NOTE: $-F\mu = m a_2$✓
$\therefore -200 = 1200\, a_2$
$\therefore a_2 = -0{,}167_{m/s}2$ (3)

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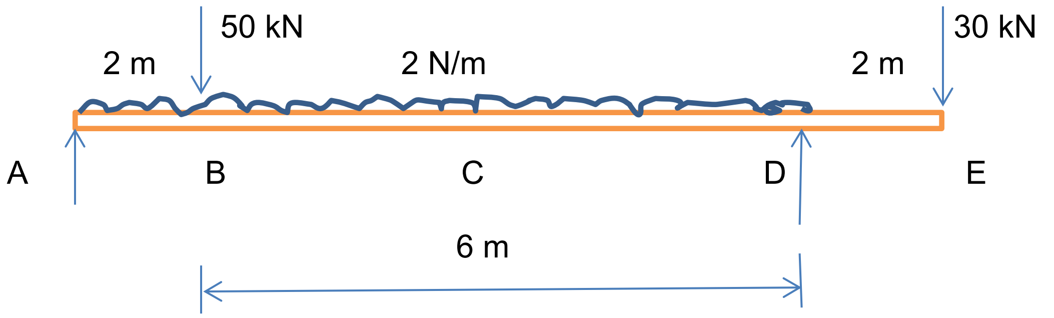
QUESTION 4

4.1



✓

Taking moments about A
For equilibrium: $\in ACM = \in CM$

$\therefore (DX8) = (4 \times 1) + (50 \times 2) + (12 \times 5) + (30 \times 10)$
$\therefore 8D = 4 + 100 + 60 + 300$
$\therefore 8D = 464$ ✓✓
$\therefore D = 58\ N$

Taking moments about D
For equilibrium: $\in ACM = \in CM$

$\therefore (4 \times 7) + (50 \times 6) + (12X3) = (A \times 8) + (30 \times 2)$
$\therefore 28 + 300 + 36 = 8A + 60$
$\therefore 8A = 304$ ✓✓
$\therefore A = 38\ N$

Check:
$\uparrow F = 58N + 38N = 96N$
$\downarrow F = 4 + 50 + 12 + 30 = 96N$
$\uparrow F = \downarrow F$ *and equilibrium exists* (5)

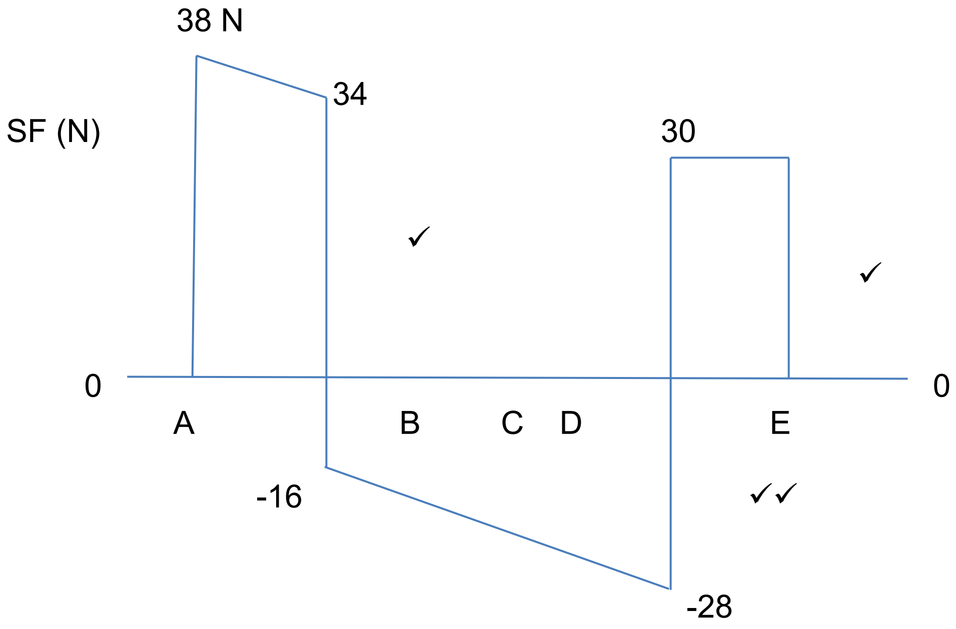
4.2 $BM_A = 0$ Nm

$BM_B = (38 \times 2) - (4 \times 1) = 72\ Nm$ ✓

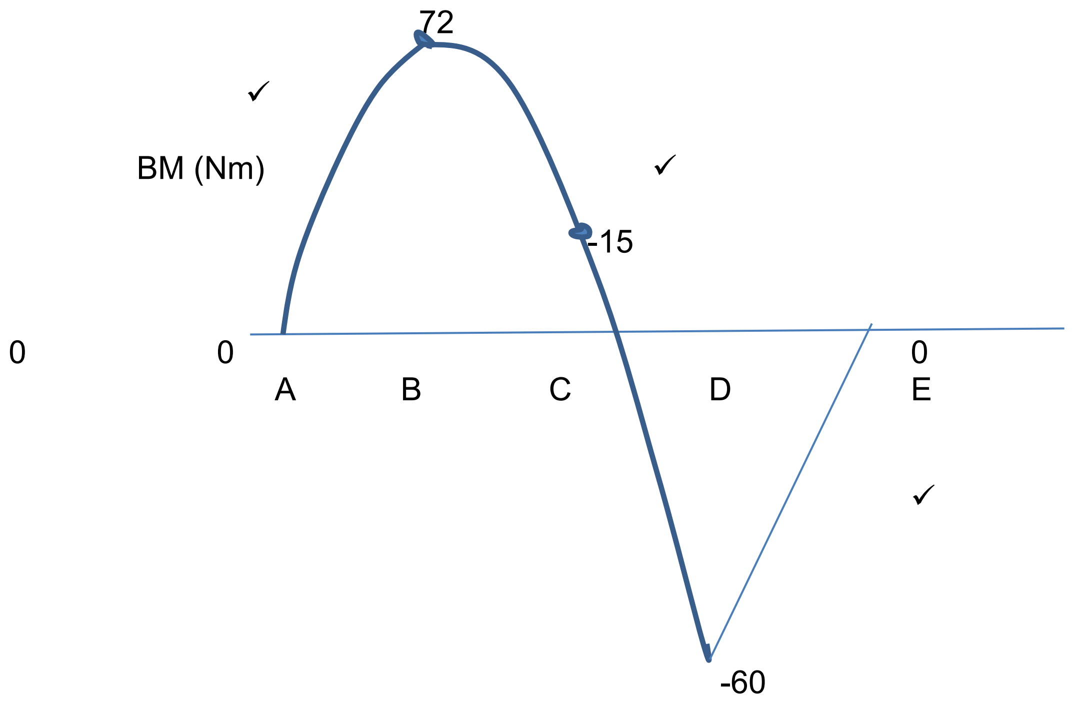
$BM_c = (38 \times 5) - (50 \times 3) = (10 \times 2{,}5)$
$\therefore BM_c = 190 - 150 - 25 = 15\ Nm$ ✓

$BM_D = (38 \times 8) - (50 \times 6) - (16 \times 4) = 304 - 300 - 64 = -60\ Nm$ ✓
$BM_E = O\ \ Nm$ (3)

4.3



(4)



(3)
[15]

QUESTION 5

5.1 When a pressure is exerted on the surface of a liquid, this force is transmitted with the same intensity through the liquid in all directions. (1 × 2) (2)

5.2 1 Pascal is the pressure when a force of 1 Newton acts perpendicularly and evenly over a cross-sectional area of 1 m^2. (1 × 2) (2)

5.3 5.3.1

$\frac{F_R}{A_R} = \frac{F_P}{A_P}$ $A_p = 0{,}072\ m^2$

$\therefore \frac{F_R}{0{,}624} = \frac{275}{0{,}072}$✓ $F_P = 275N$

$\therefore F_{RAM} = 2\ 383{,}333\ N$✓ $A_R = 0{,}624\ m^2$

$= \underline{2{,}383\ kN}$ $L = 0{,}148\ m$

Slip = 9% (2)

5.3.2

$V_P = A_P \times L \times n \times 0{,}91$✓ $n = 20$ strokes

$= 0{,}072 \times 0{,}148 \times 20 \times 0{,}91$✓

$= \underline{0{,}194\ m^3}$✓ (3)

5.3.3

$V_P = V_R$

$A_P \times L \times 1 \times 0{,}91 = A_R \times h$✓ (0,194÷ 20 for 1 stroke)

$\therefore 9{,}7 \times 10^{-3} = 0{,}624 \times h$✓

$\therefore h = \underline{0{,}0156\ m}$✓ (3)

5.3.4

$MA = \frac{F_P}{F_H}$ F_H = effort = 27,5 N

$MA = \frac{275}{27{,}5}$✓

$= \underline{10}$✓ (2)

5.4 Power input =?

W = Pressure × V✓

Power (out) = $W_{/sec} = P\ V_{/sec}$ $V_{/sec} = \frac{300\ m^3}{1\ hour}$

$= 264\ 600 \times 0{,}083$✓ $= \frac{300 m^3}{3600\ sec}$✓

$= 21961{,}8\ W$✓ $= 0{,}083\ m^3/s$

$\therefore$ Power required (input) ✓ Pressure = ρgh✓

$= 21\ 961{,}8 \times \frac{100}{94}$ $= 1\ 000 \times 9{,}8 \times 27$

$= 23363{,}617\ W$ $= 264\ 600\ Pa$ (6)

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QUESTION 6

6.1
- Compressive stress
- Shear stress
- Tensile stress (3)

6.2 Within the elastic limit, the stress is directly proportional to the strain (3)

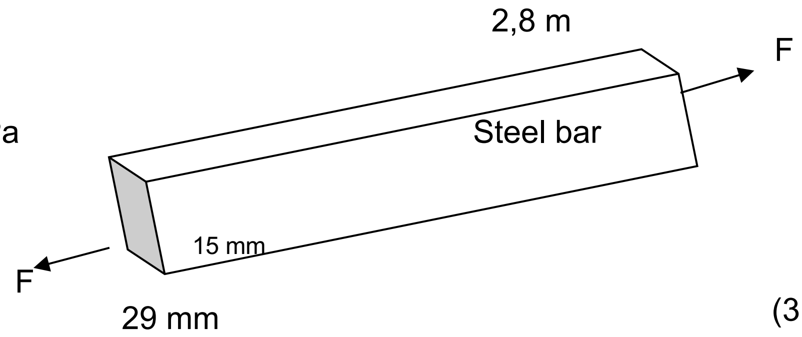
6.3 6.3.1 $\sigma = \frac{F}{A}$

$= \frac{27 \times 10^3}{(0{,}029 \times 0{,}015)}$ ✓✓

= 62 068965,52 Pa

= 62,069 MPa✓

→



(3)

6.3.2 $E = \frac{\sigma}{\varepsilon}$

$\therefore 208 \times 10^9 = \frac{62{,}069 \times 10^6}{\varepsilon}$ ✓

$\therefore \varepsilon = 2{,}984 \times 10^{-4}$ ✓

→ (2)

6.3.3 $\varepsilon = \frac{\Delta \ell}{\ell_0}$ ✓

$\therefore 2{,}984 \times 10^{-4} = \frac{\Delta \ell}{2800}$ ✓

$\therefore \Delta \ell = 0{,}836$ mm✓ → (3)

[14]

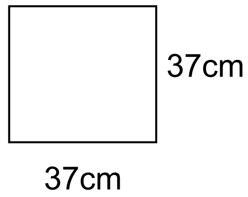
QUESTION 7

7.1 Linear expansion coefficient is the change✓ in length per unit length per 1 ^{0}C change in temperature.✓ (2)

7.2 $\Delta A = A_0 .2 \propto \Delta t$

$= (37 \times 37)(2)(17 \times 10^{-6})(67)$✓

$= 3{,}119$ cm^2✓



→ (2)

7.3 $\rho_1 = 1{,}07 \times 10^4 \text{kg/m}^3$

$\rho_1 = 0^0\text{C}$ $m_1 = 1{,}07 \times 10^4$ kg

$= 273$ K $V_1 = 1$ m^3 ✓

$\gamma = 200 \times 10^{-6}/^0\text{C}$

$\rho_2 = ?$ $V_2 = ?$

$T_2 = 70^0\text{C} = 273$

$\frac{70}{343\text{K}}$

$\Delta V = V_1 \gamma \Delta t$

$= 1 \times 200 \times 10^{-6} \times 70$✓

$= 0{,}014$ m^3✓

$\therefore V_2 = 1{,}014\ m^3$

$\rho_2 = \frac{m}{v_2}$

$= \frac{1{,}07 \times 10^4 \text{kg}}{1{,}014\text{m}^3}$✓

$= 1{,}055 \times 10^4$ kg/m^3✓ → (5)

7.4 7.4.1 $P_1V_1 = m_1RT_1$✓

$\therefore 410 \times 10^3 \times 0{,}184 = m_1(273)(334)$✓

$\therefore m_1 = 0{,}827$ kg✓ → (3)

7.4.2 $P_2V_2 = m_2RT_2$

$\therefore 300 \times 10^3 \times 0{,}184 = m_2(273)(305)$✓

$\therefore m_2 = 0{,}663$ kg✓

$\therefore \Delta m = 0{,}827 - 0{,}663$

$= 0{,}164$ kg that leaked out✓ → (3)

[15]

TOTAL: 100