basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 26 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1	A ✓	(1)
1.2	B ✓	(1)
1.3	C ✓	(1)
1.4	D ✓	(1)
1.5	A ✓	(1)
1.6	C ✓	(1)
		[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Rated speed of a grinding wheel:**

- Because the wheel could burst/break if it turns faster than its revolution range. / Avoid an accident. ✓
- Effectiveness of the grinding process will be compromised. ✓ **(Any 1 x 1)** (1)

2.2 **Safety precautions of a band saw in operation:**

- Never leave the band saw unattended. ✓
- Use a push stick when cutting. ✓
- Hold the work piece firmly and flat on the table. ✓
- Don't adjust the machine while working. ✓
- Don't open any guard while the machine is on. ✓
- Make relief cuts before cutting tight curves. ✓
- Don't force the material into the blade. ✓
- Keep hands clear from the action point. ✓
- Keep hands braced against the table. ✓
- Keep your hands on either sides of the blade and not in line with the cutting line and the blade. ✓
- Keep loose clothing clear from action point. ✓ **(Any 2 x 1)** (2)

2.3 **Stages in which first aid is applied:**

- Examination ✓
- Diagnosis ✓
- Treatment ✓ (3)

2.4 **Causes of accidents:**

- Unsafe acts ✓
- Unsafe conditions ✓ (2)

2.5 **TWO advantages of the product layout:**

- Handling of material is kept to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- Control over operations is easier. ✓
- Greater use of unskilled labour is possible. ✓
- Less total inspection is required. ✓
- Less total floor space is needed per unit of production. ✓ **(Any 2 x 1)** (2)

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QUESTION 3: MATERIALS (GENERIC)

3.1 **Tempering:**

Tempering is a process generally applied to steel to relieve the strains/brittleness/improve ductility ✓ induced during the hardening process. ✓ (2)

3.2 **Annealing:**

- To relieve internal stresses ✓ that may have been set up during working of metal.
- To soften steel ✓ in order to facilitate the machining process.
- To refine their grain structure. ✓
- Reduce brittleness. ✓
- Make the steel ductile. ✓ **(Any 3 x 1)** (3)

3.3 **Normalising temperature:**

- Above ✓ higher/upper critical temperature ✓
- Above ✓ AC_3 line. ✓ **(Any 1 x 2)** (2)

3.4 **Spark pattern for carbon steels:**

3.4.1 High-carbon steel ✓ (1)

3.4.2 Low-carbon steel / Mild steel ✓ (1)

3.4.3 Cast-iron ✓ (1)

3.5 **Carbon diagram:**

A. Temperature range / °C ✓
B. AC_3 line / Higher/upper critical temperature line ✓
C. AC_1 line / Lower critical temperature line ✓
D. Carbon content / % carbon ✓ (4)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

4.1	B ✓	(1)
4.2	A ✓	(1)
4.3	A ✓	(1)
4.4	C ✓	(1)
4.5	C ✓	(1)
4.6	D ✓	(1)
4.7	B ✓	(1)
4.8	A ✓	(1)
4.9	C ✓	(1)
4.10	D ✓	(1)
4.11	B ✓	(1)
4.12	C ✓	(1)
4.13	A ✓	(1)
4.14	A ✓	(1)
		[14]

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 **Disadvantages of using compound slide method:**

- The automatic feed of the machine cannot be used. ✓
- Only short tapers can be cut. ✓
- It causes fatigue in the operator. ✓
- Poor finish. ✓
- Take longer time to cut. ✓

(Any 2 x 1) (2)

5.2 **Taper:**

5.2.1 **Length of taper:**

$$\tan\frac{\theta}{2} = \frac{D - d}{2 \times \ell}$$

$$\tan\frac{12}{2} = \frac{72 - 40}{2 \times \ell} \checkmark$$

$$2 \times \ell = \frac{32 \checkmark}{\tan 6^\circ \checkmark}$$

$$\ell = \frac{304{,}46}{2} \checkmark$$

$$\ell = 152{,}23\,\text{mm} \checkmark$$

(5)

5.2.2 **Tailstock set-over:**

$$\text{Set-over} = \frac{L(D - d)}{2\ell}$$

$$x = \frac{\overset{\checkmark}{(70 + 152{,}23)}\overset{\checkmark}{(72 - 40)}}{2(152{,}23)}$$

$$x = 23{,}36\,\text{mm} \checkmark$$

(3)

5.3 **Parallel key:**

5.3.1 **Width:**

$$\text{Width} = \frac{D}{4}$$

$$\text{Width} = \frac{102}{4} \checkmark$$

$$= 25{,}50 \text{ mm} \checkmark$$ (2)

5.3.2 **Thickness:**

$$\text{Thickness} = \frac{D}{6}$$

$$\text{Thickness} = \frac{102}{6} \checkmark$$

$$= 17 \text{ mm} \checkmark$$ (2)

5.3.3 **Length:**
Length = 1,5 x diameter of shaft

= 1,5 x 102 ✓

= 153 mm ✓

(2)

5.4 **Disadvantages of gang milling:**

- The gang of cutters place more stress on the machine spindle bearings. ✓
- The cutters make the milling machine work harder. ✓ (2)

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QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Spur gear:**

6.1.1 **Number of teeth:**

$$\text{Module} = \frac{PCD}{T}$$

$$\text{Module} = \frac{168}{42} \checkmark$$

$$\text{Module} = 4 \checkmark$$

(2)

6.1.2 **Circular pitch:**

$CP = m \times \pi$

$= 4 \times \pi \checkmark$

$= 12{,}57 \text{ mm} \checkmark$

OR

$$CP = \frac{PCD \times \pi}{T}$$

$$= \frac{168 \times \pi}{42} \checkmark$$

$$= 12{,}57 \text{ mm} \checkmark$$

(2)

6.1.3 **Outside diameter:**

$OD = PCD + 2(m)$

$= 168 + 2(4) \checkmark$

$= 176 \text{ mm} \checkmark$

OR

$OD = m(T + 2)$

$= 4(42 + 2) \checkmark$

$= 176 \text{ mm} \checkmark$

(2)

6.2 $W = 135 + 2(y)$

$m = W - (2x) - (2R)$

$m = W - 2(x + R)$

6.2.1 **Maximum width distance of dove tail (W):**

Calculate y:

$\text{Tan}\ \theta = \dfrac{h}{y}$

$y = \dfrac{h}{\tan\theta}$ ✓

$y = \dfrac{35}{\tan 60^\circ}$ ✓

$y = 20{,}21\,\text{mm}$ ✓

OR

$\tan\theta = \dfrac{y}{35}$

$y = \tan\theta \times h$ ✓

$y = \tan 30^\circ \times 35$ ✓

$= 20{,}21\,\text{mm}$ ✓

W = 135 + 2(y) ✓

= 135 + 2(20,21) ✓

= 135 + 40,42

= 175,42 mm ✓

(6)

6.2.2 **Distance between the rollers (m):**

Calculate x:

$$\text{Tan } \alpha = \frac{R}{x}$$

$$x = \frac{R}{\text{Tan}\alpha} \checkmark$$

$$x = \frac{12}{\text{Tan } 30°} \checkmark$$

$$x = \frac{12}{0,5774}$$

$$x = 20,78 \text{ mm} \checkmark$$

OR

$$\tan\theta = \frac{x}{12}$$

$$x = \tan\theta \times 12 \checkmark$$

$$x = \tan 60 \times 12 \checkmark$$

$$= 20,78 \text{ mm} \checkmark$$

m = W – (2x) – (2R) ✓

= 175,42 – (2 x 20,78) – (2 x 12) ✓

= 175,42 – 41,56 – 24

= 109,86 mm ✓

OR

m = W – 2(x +R) ✓

m = 175,42 – 2(20,78 + 12) ✓

m = 175,42 – 65,56

m = 109,86 mm ✓

(6)

6.3 **Milling of spur gear:**

6.3.1 **Indexing:**

$$\text{Indexing} = \frac{40}{n}$$

$$\text{Indexing} = \frac{40}{113}$$

$$\text{Indexing} = \frac{40}{110} \checkmark$$

$$\text{Indexing} = \frac{40}{110} \div \frac{5}{5}$$

$$\text{Indexing} = \frac{8}{22} \times \frac{3}{3} \checkmark$$

$$\text{Indexing} = \frac{24}{66} \checkmark$$

Approximate indexing: 24 holes on a 66-hole circle ✓ (4)

6.3.2 **Change gears:**

$$\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$$

$$\frac{Dr}{Dn} = (110 - 113) \times \frac{40}{110} \checkmark$$

$$\frac{Dr}{Dn} = -\frac{-3 \times 40}{110}$$

$$\frac{Dr}{Dn} = -\frac{-120}{110} \div \frac{5}{5}$$

$$\frac{Dr}{Dn} = \frac{-24}{22} \times \frac{2}{2} \checkmark$$

$$\frac{Dr}{Dn} = \frac{48\checkmark}{44\checkmark}$$

(4)

6.4 **Unbalanced work piece:**

- Unnecessary bearing loads ✓
- Excessive vibration ✓
- A bad finish ✓
- Work that is not perfectly round ✓
- Danger to the operator ✓
- Clatter on the gear teeth ✓
- A tendency to bend the spindle ✓

(Any 2 x 1) (2)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Tensile tester:**

- Yield stress ✓
- Ultimate tensile stress / Maximum stress ✓
- Elongation percentage / Ductility ✓
- Limit of proportionality ✓
- Limit of elasticity ✓
- Break stress ✓

(Any 3 x 1) (3)

7.2 **Brinell hardness tester:**

A - Work piece / Test piece ✓
B - Steel Carbide ball / Indenter ✓
C - Indentation diameter ✓ (3)

7.3 **Calculate cutting depth:**

Cutting depth = 0,613 x pitch
= 0,613 x 1,75 ✓
= 1,07 mm ✓ (2)

7.4 **Depth micrometer reading:**

✓ ✓
17,36 mm (2)

7.5 **Function of moment tester:**

To determine the reactions ✓ on either side ✓ of a simply loaded ✓ beam. (3)
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QUESTION 8: FORCES (SPECIFIC)

8.1 **System of forces:**

HORIZONTAL COMPONENT:

$$\sum HC = 50\cos30^\circ - 85\cos0^\circ + 75\cos70^\circ$$

$$\sum HC = \overset{✓}{43{,}30} \; \overset{✓}{-85} + \overset{✓}{25{,}65}$$

$$\sum HC = -16{,}05 \text{ N} ✓$$

VERTICAL COMPONENT:

$$\sum VC = 50\sin30^\circ - 25\sin90^\circ - 75\sin70^\circ$$

$$\sum VC = \overset{✓}{25} - \overset{✓}{25} - \overset{✓}{70{,}48}$$

$$\sum VC = -70{,}48 \text{ N} ✓$$

OR

Force	θ	VC/y = Fsinθ		HC/x = Fcosθ	
50 N	30º	VC = 50sin30º	25 N ✓	HC = 50cos30º	43,30 N✓
85 N	180º	VC = 85sin180º	0 N	HC = 85cos180º	-85 N ✓
25 N	270º	VC = 25sin270º	-25 N ✓	HC = 25cos270º	0 N
75 N	290º	VC = 75sin290º	-70,48 N✓	HC = 75cos290º	25,65 N✓
		Total	**-70,48 N**✓		**-16,05 N**✓

$$R^2 = VC^2 + HC^2$$

$$\sqrt{R^2} = \sqrt{(-70{,}48)^2 + (-16{,}05)^2} ✓$$

$$\sqrt{R^2} = \sqrt{5225{,}033}$$

$$R = 72{,}28 \text{N} ✓$$

$$\tan\theta = \frac{VC}{HC}$$

$$\theta = \tan^{-1}\left(\frac{-70{,}48}{-16{,}05}\right) ✓$$

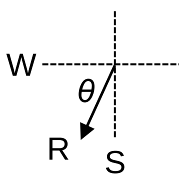
$$\theta = \tan^{-1}(4{,}39)$$

$$\theta = \overset{✓}{77{,}17^\circ} \text{ OR } 77^\circ 10' 12'' ✓$$

$$R = \overset{✓}{72{,}28 \text{ N}} \; \overset{✓}{77{,}17^\circ} \; \overset{✓}{\text{South from West}}$$

✓ **OR**

$$R = 72{,}28 \text{ N} \; \overset{✓}{12{,}83^\circ} \; \overset{✓}{\text{West from South}}$$



(15)

8.2 **Moments:**

8.2.1 **Point load for UDL:**

6 x 11 = 66 kN ✓ (1)

8.2.2 **Calculate A**
Take moments about B:
∑ RHM = ∑LHM

$$(A \times 11) = (12 \times 2{,}5) + (66 \times 5{,}5) + (75 \times 11) ✓$$

$$11A = 30 + 363 + 825$$

$$A = \frac{1218}{11} ✓$$

$$A = 110{,}73 \text{ kN} ✓$$

(3)

8.2.3 **Calculate B**
Take moments about A:
∑ LHM = ∑RHM

$$B \times 11) = (75 \times 0) + (66 \times 5{,}5) + (12 \times 8{,}5) ✓$$

$$11B = 0 + 363 + 102$$

$$B = \frac{465}{11} ✓$$

$$B = 42{,}27 \text{ kN} ✓$$

OR

$$A + B = 75 + 66 + 12 ✓$$

$$B = 153 - 110{,}73 ✓$$

$$B = 42{,}27 \text{ kN} ✓$$ (3)

8.3.1 **The resistance area:**

$$A = \frac{\pi D^2}{4}$$

$$A = \frac{\pi(0,05)^2}{4} \checkmark$$

$$A = 0,00196\text{m}^2 \text{ or } 1,96\times10^{-3}\ \text{m}^2 \checkmark$$ (2)

8.3.2 **The stress in the material in MPa:**

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

$$\sigma = \frac{50\times10^3 \checkmark}{1,96\times10^{-3} \checkmark}$$

$$\sigma = 25510204,082\ \text{Pa}$$

$$\sigma = 25,51\ \text{MPa} \checkmark$$ (3)

8.3.3 **Strain in material:**

$$\varepsilon = \frac{\Delta L}{L}$$

$$\varepsilon = \frac{0,005}{3} \checkmark$$

$$\varepsilon = 0,0017 \ \textbf{OR}\ 1,67\times10^{-3} \checkmark$$

(***No unit! If unit indicated, answer is wrong***) (2)

8.4 **Label stress and strain diagram:**

A – Limit of proportionality ✓

B – Elastic limit ✓

C – Yield point ✓

D – Maximum stress ✓

(4)
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QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Main purpose of maintenance:**
To ensure that the machinery always operates at an optimal level. ✓ (1)

9.2 **Preventative maintenance:**

9.2.1 **Chain drives:**
- Cleaning uncovered drives. ✓
- Check sprocket teeth and link plate wear. ✓
- Check lubricants. ✓
- Checking the functioning of tensioning devices. ✓
- Inspecting chains regularly for elongation. ✓

(Any 2 x 1) (2)

9.2.2 **Belt drives:**
- Checking the wear and tear on belt. ✓
- Checking belt alignment. ✓
- Checking the tension setting. ✓
- Checking the tensioning devices. ✓

(Any 2 x 1) (2)

9.3 **Properties of EACH of the following nylon products:**

9.3.1 **Polyethylene (PET):**
- Stiff ✓
- Strong ✓
- Hard ✓
- Chemical resistance ✓

(Any 2 x 1) (2)

9.3.2 **Polypropylene (PP):**
- Good fatigue resistance ✓
- Heat resistance ✓
- Tough ✓
- Semi rigid ✓
- Good chemical resistant ✓

(Any 2 x 1) (2)

9.3.3 **Polystyrene (PS):**
- Good insulation properties ✓
- Water resistant ✓
- Odourless properties ✓
- Light weight ✓

(Any 2 x 1) (2)

9.4 **Factors influencing coefficient of friction:**

- Surface roughness/texture ✓
- Temperature ✓
- Type of lubricant ✓
- Type of friction ✓

(Any 3 x 1) (3)

9.5 **Thermo-hardened composites:**
This type of plastic goes through a chemical change during moulding that prevents reheating. ✓ (1)

9.6 **Types of belt drive systems:**

- V-belt ✓
- Wedge belt / Cog belt ✓
- Flat belt ✓
- Multi-groove belt ✓
- Toothed / Timing belt ✓
- Circular belt / Round belt ✓
- Poly V-belt ✓

(Any 3 x 1) (3)
[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Square Thread:**

10.1.1 **Pitch:**

$$\text{Lead} = \text{Pitch} \times \text{Number of starts}$$

$$\text{Pitch} = \frac{\text{Lead}}{\text{Number of starts}} \checkmark$$

$$\text{Pitch} = \frac{36}{3} \checkmark$$

$$\text{Pitch} = 12 \text{ mm} \checkmark$$

(3)

10.1.2 **Pitch diameter:**

$$D_p = OD - \frac{P}{2}$$

$$D_p = 70 - \frac{12}{2} \checkmark$$

$$D_p = 64 \text{ mm} \checkmark$$

(2)

10.1.3 **Helix angle of the thread:**

$$\text{Tan}\,\theta = \frac{\text{Lead}}{\pi \times \text{PD}}$$

$$\text{Tan}\,\theta = \frac{36 \checkmark}{\pi \times 64 \checkmark}$$

$$\text{Tan}\,\theta = 0{,}179049311$$

$$\theta = 10{,}15^\circ \text{ OR } 10^\circ 9' \checkmark$$

(3)

10.1.4 **Leading angle:**

Leading angle = 90° - (helix angle + clearance angle)
= 90° - (10°9’ + 3°) ✓
= 76°51’ **or** 76,85º ✓ (2)

10.1.5 **Following angle:**

Following angle = 90° + (helix angle - clearance angle)
= 90° + (10°9’ - 3°) ✓
= 97°9’ **or** 97,15º ✓ (2)

10.2 **Square thread cutting tool angles:**

10.2.1 Square thread ✓ (1)

10.2.2 A - Clearance angle ✓
B - Leading angle ✓
C - Following angle ✓
D - Helix angle ✓ (4)

10.3 **Included angle of Metric V-thread:**

60° ✓ (1)
[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 **Hydraulic calculations:**

11.1.1 **The fluid pressure in the hydraulic system in MPa:**

$$A_{RAM} = \frac{\pi d^2}{4}$$

$$A = \frac{\pi(0,120)^2}{4} \quad ✓$$

$$A = 11,31 \times 10^{-3}\ m^2 \quad ✓$$

NOTE: Force of Ram = 4 500 kg x 10 m/s^2
= 45 x 10^3 N

$$P = \frac{F}{A}$$

$$P = \frac{\overset{✓}{45 \times 10^3}}{11,3 \times 10^{-3}}$$

$$P = 3,98\ N \quad ✓$$

(4)

11.1.2 **Force to be applied on the plunger:**

$$A_{Plunger} = \frac{\pi d^2}{4}$$

$$A = \frac{\pi(0{,}032)^2}{4} \quad \checkmark$$

$$A = 0{,}80 \times 10^{-3} \ m^2 \quad \checkmark$$

$$P = \frac{F}{A}$$

$$F = P \times A \quad \checkmark$$

$$F = 3{,}98 \times 10^6 \times 0{,}80 \times 10^{-3} \quad \checkmark$$

$$F = 3184\,N \quad \checkmark$$

OR

$$\frac{F_A}{A_A} = \frac{F_B}{A_B}$$

$$\frac{F_A}{\underset{\checkmark}{0{,}8 \times 10^{-3}}} = \frac{45 \times 10^3 \ \checkmark}{11{,}31 \times 10^{-3}} \quad \checkmark$$

$$F_A \overset{\checkmark}{=} \frac{(45 \times 10^3)(0{,}8 \times 10^{-3})}{11{,}31 \times 10^{-3}}$$

$$= 3184\,N \quad \checkmark$$

(5)

11.2 **Function hydraulic non-return valve:**
Used to provide one-directional oil flow and the fluid is not allowed to flow back. ✓ (1)

11.3 **Spring-loaded double-action control valve is used in a water line:**
- Protect water supplies from back flow. ✓
- Prevent water contamination. ✓
- Safety device if one valve is jammed. ✓

(Any 2 x 1) (2)

11.4 **Pressure gauges:**
- Bourdon tube gauge. ✓
- Schrader gauge. ✓ (2)

11.5 **Belt drive:**

11.5.1 **The rotational frequency:**

$$N_{DN} \times D_{DN} = N_{DR} \times D_{DR}$$

$$N_{DN} = \frac{N_{DR} \times D_{DR}}{D_{DN}} \quad ✓$$

$$N_{DN} = \frac{1320 \times 0{,}085}{0{,}375} \quad ✓$$

$$N_{DN} = \frac{299{,}2}{60} \quad ✓$$

$$N_{DN} = 4{,}99 \text{ r/sec} \quad ✓$$

(4)

11.5.2 **Power transmitted in Watt:**

$$P = \frac{(T_1 - T_2)\,\pi DN}{60}$$

$$P = (275 \checkmark - 120)\,\pi \times 0{,}375 \times 4{,}99 \checkmark$$

$$P = 911{,}199 \text{ Watt } \checkmark$$

OR

$$P = (T_1 - T_2)\pi DN$$

$$= \frac{(275 \checkmark - 120) \times \pi \times 0{,}085 \checkmark \times 1320}{60}$$

$$= 910{,}59 \text{ Watt } \checkmark$$

(3)

11.6 **Gear drive:**

11.6.1 **Number of teeth on T_A:**

$$\frac{N_{input}}{N_{output}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$\frac{N_F}{N_A} = \frac{T_A \times T_C \times T_E}{T_B \times T_D \times T_F}$$

$$\frac{720}{320} = \frac{T_A \times 45 \times 50}{20 \times 25 \times 20} \checkmark \checkmark$$

$$2{,}25 = \frac{2250 \times T_A}{10000} \checkmark$$

$$2250 \times T_A = 2{,}25 \times 10000$$

$$T_A = \frac{22500}{2250}$$

$$T_A = 10 \checkmark$$

(4)

11.6.2 **Gear ratio:**

$$\text{Gear ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$\text{Gear ratio} = \frac{20 \times 25 \times 20}{10 \times 45 \times 50} \checkmark \checkmark$$

$$\text{Gear ratio} = 0{,}44 : 1 \checkmark$$

OR

$$\text{Speed Ratio} = \frac{N_A}{N_F}$$

$$= \frac{320}{720} \checkmark \checkmark$$

$$= 0{,}44 : 1 \checkmark$$

(3)
[28]

TOTAL: 200