Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

MECHANICAL TECHNOLOGY: FITTING AND MACHINING MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 15 pages.

SECTION A: COMPULSORY

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 D ✓
1.2 B ✓
1.3 A ✓
1.4 C ✓
1.5 C ✓
1.6 B ✓

(6 x 1) **[6]**

QUESTION 2: SAFETY (GENERIC)

2.1 **Personal protective equipment**
- Welding helmet ✓
- Leather apron ✓
- Leather hand gloves ✓
- Overall/work suit ✓
- Safety boot ✓ (Any 3 x 1) (3)

2.2 **Arc welding safety precautions**
- Wear correct PPE ✓
- The welding cables and electrode holder must be well insulated ✓
- Your eyes must be protected with a welding helmet before attempting any strike ✓
- Ensure there is no water in the environment ✓
- Keep away combustible materials from the welding area ✓ (Any 3 x 1) (3)

2.3 **Reason why you must not force the drill bit into the workpiece**
- It can cause a broken drill bit and possible injuries. ✓ (1)

2.4 **Reason for clamping a small workpiece before drilling**
- To avoid slipping. ✓
- Prevent the drill bit from getting broken ✓
- To ensure smooth and straight drill ✓ (Any 1 x 1) (1)

2.5 **Safety precautions to be observed when handling gas cylinders**
- Store or transport cylinders in an upright position ✓
- Avoid oil or grease from coming in contact with oxygen fittings ✓
- Never stack cylinders on top of one another ✓
- Do not bang or work on cylinders ✓
- Never allow cylinders to fall ✓ (Any 2 x 1) (2)

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QUESTION 3: MATERIALS (GENERIC)

3.1 3.1.1 **Test required to determine the carbon content of a metal**
- Sound test ✓
- Spark test ✓ (Any 1 x 1) (1)

3.1.2 **Test required to determine the ductility of metal**
- Bending test ✓ (1)

3.2 **Cutting colour coded metals from unmarked end**
- In order to keep its identity ✓ (1)

3.3 **Types of case-hardening**
- Carburising ✓
- Nitriding ✓
- Cyaniding ✓ (3)

3.4 **Effect of medium or high carbon steel on case-hardening**
- The hardness will penetrate the core of the steel. ✓ (1)

3.5 **Heat treatment process of metal**
It has to do with heating metal to the required temperature, ✓ allow to soak in that temperature for a given period of time, ✓ then cool in the appropriate medium. ✓ (3)

3.6 **Factors that determine the hardness of steel during heat treatment**
- Work size ✓
- Quenching rate ✓
- Carbon content ✓ (3)

3.7 **Properties achieved from an annealed steel**
- Softness ✓
- Ductility ✓ (Any 1 x 1) (1)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

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

5.1 **Lathe Steadies turning**

5.1.1 Fixed Steady: It prevents the workpiece from bending away from the cutting tool when pressure is applied during machining. (2)

5.1.2 Travelling Steady:
- It moves with the saddle of the centre lathe
- The two soft face jaws does not damage the workpiece. (2)

5.2
- Compound slide method
- Tail-stock set-over method (2)

5.3 **Cutting Square Threads**

5.3.1 Lead = Pitch x Number of Starts
= 2 x 12 = 24 mm ✓✓ (2)

5.3.2 Mean Diameter = OD – 0,5 pitch
= 85 – 0,5 x 12 ✓
= 91 mm ✓ (2)

5.3.3 Tan θ = Lead / π x Dm
Tan θ = 24 / 91 ✓
θ = 14,77° ✓ (2)

5.4 **Keyway cutting procedure**

5.4.1 Side and face cutter ✓ (1)

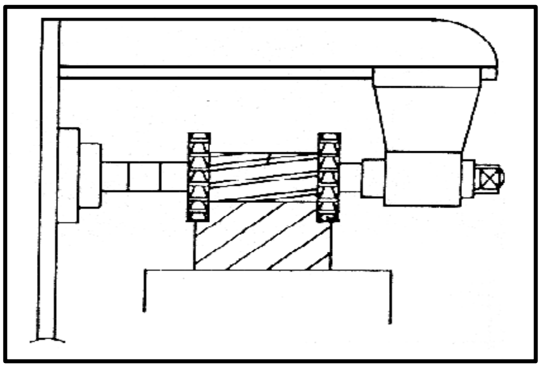
5.4.2 Labels

A – Workpiece ✓
B – Keyway ✓
C – Ruler ✓
D – Milling cutter ✓
E – Engineers Square ✓ (5)
[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

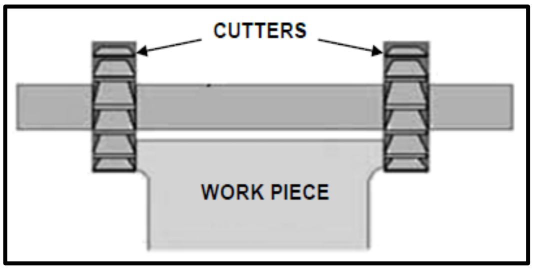
6.1 **Milling operations**

6.1.1 Gang milling:



✓✓ (2)

6.1.2 Straddle milling:



✓✓ (2)

6.2 **Uses of cutters:**

6.2.1 T-slot milling cutters are designed for cutting T-slots in machine tables and similar applications. ✓ (1)

6.2.2 End mill cutters are used for machining slots, keyways, pockets, facing narrow faces and cutting profiles. ✓ (1)

6.2.3 Slitting saw cutters are used for parting off and slitting thin sections and the cutting of deep and narrow slots. ✓ (1)

6.3 **Definition of *indexing***
Is the process of evenly dividing the circumference of a circular workpiece into equally spaced divisions, such as in cutting gear teeth, cutting splines, milling grooves in the reamers and taps. ✓ (1)

6.4 **Milling methods:**
- Up-cut milling ✓
- Down-cut milling ✓ (2)

6.5 Differential indexing

Hole circles											
Side 1	24	25	28	30	34	37	38	39	41	42	43
Side 2	46	47	49	51	53	54	57	58	59	62	66

Standard change gears										
24 x 2	28	32	40	44	48	56	64	72	86	100

6.5.1 Indexing required:

$\text{Indexing} = \frac{40}{A}$ ✓

$= 40/120$

$= \frac{1}{3} \times \frac{22}{22}$ ✓

$= 22/66$

Indexing is 22 holes in a 66-hole circle. ✓ (3)

6.5.2 Change of gears

Gear ratio: $\frac{\text{Driver}}{\text{Driven}} = \frac{A-N}{A} \times \frac{40}{1}$ ✓

$= \frac{120-113}{120} \times 40$ ✓

$= +\frac{7}{3} \times \frac{8}{8}$ ✓

$= 56/24$ ✓

The driver gear has 56 teeth.
The driven gear has 24 teeth. ✓ (4)

6.5.3 The direction of motion is clockwise.
The crank handle will turn the same direction as index plate. ✓✓ (2)

6.6 **Dove tail calculations**

"x" = 150 + 2(AB) – 2(CD) – 2r

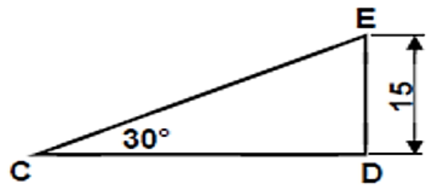
$\tan\theta = \frac{BC}{AB}$ ✓

$AB = \frac{BC}{\tan\theta}$

$= \frac{35}{\tan 60^\circ}$ ✓

= 20,207 mm

= 20,21 mm ✓



$\tan\theta = \frac{DE}{CD}$ ✓

$CD = \frac{15}{\tan\theta}$ ✓

$= \frac{15}{\tan 30^\circ}$

= 25,98 mm ✓

"x" = 150 + 2(AB) – 2(CD) – 2r ✓
= 150 + 2(20,21) – 2(25,98) – 2(15)
= 150 + 40,42 – 51,93 – 30 ✓
= 108,454 mm
= 108,45 mm ✓ (9)

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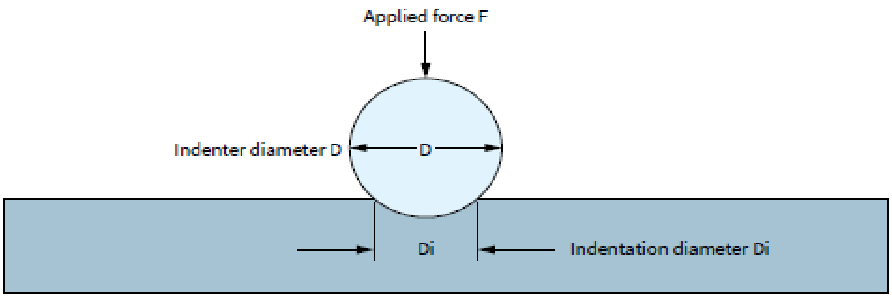
QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Hardness testers**

7.1.1 Brinell Hardness tester

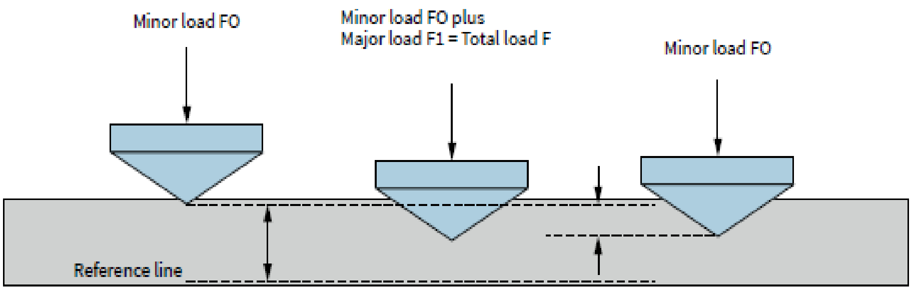
The Brinell Hardness Test involves indenting the test material with a piece of 10 mm hardened steel or carbide ball. The diameter of the indentation left in the test material is measured with a low-powered microscope.



✓✓✓ (3)

7.1.2 Rockwell Hardness tester

Rockwell Hardness Test method involves indenting the test material with a diamond cone or hardened steel-ball indenter.



✓✓✓ (3)

7.2 **Hardness** is the materials ability to resist plastic deformation, usually by penetration. ✓✓ (2)

7.3 Study diagram

7.3.1 Tensile tester (1)

7.3.2 A – Hand wheel ✓
B – Test specimen / Workpiece ✓
C – Dial Indicator ✓ (3)

7.4 A depth micrometer is used to measure the depth of a workpiece accurately. ✓✓ (1)

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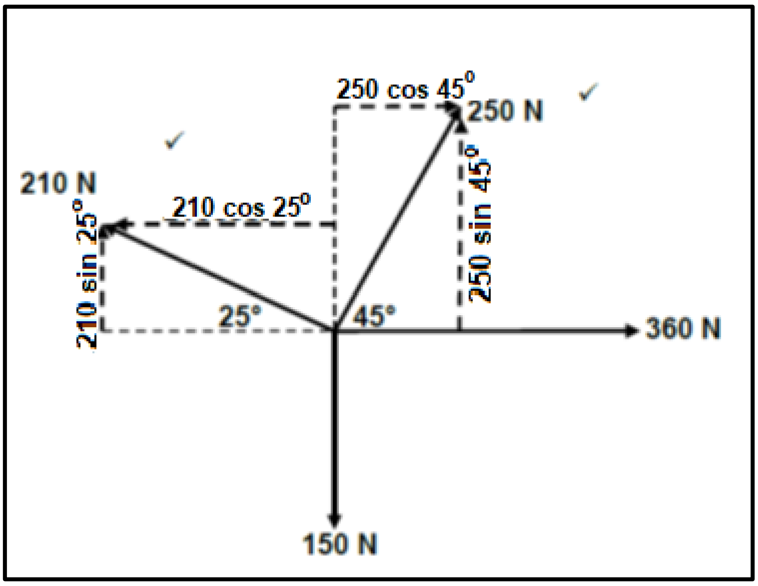
QUESTION 8: FORCES (SPECIFIC)

8.1 **Resultant Force Calculations:**



Xcom = 360 + 250 cos 45 – 210 cos 25 ✓
= **346,45 N** ✓

Ycom = 250 sin 45 + 210 sin 25 – 150 ✓
= **115,53 N** ✓

R = $\sqrt{(X^2 + Y^2)}$
R = 365,21 N ✓ (5)

Tan θ = y/x ✓
Tan Θ = 115,53 / 345,45
Θ = 18,44° ✓

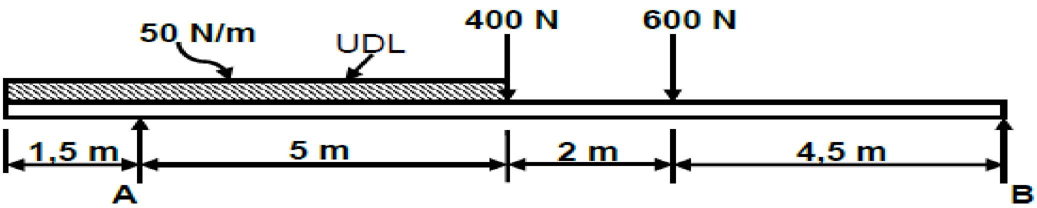
Equilibrant = Resultant BUT IN THE OPPOSITE DIRECTION

Equilibrant = 365,21 N at 18,44° ✓ (3)

8.2 **Moments**

Converting the UDL to point load

5,6 x 50 = 40 kN @ 3,25 m from left-hand end



Calculate the reactions by Taking moments:

Calculate A
Take moments about 'B'

A x 11,5 = (600 x 4,5) + (400 x 6,5) + (325 x 9,75) ✓✓
= 2 700 + 2 600 + 3 168,75
= 8 468,75 N

$A = \frac{8\,468{,}75}{11{,}5}$ ✓

A = 736,41 N ✓

Calculate B
Take moments about 'A'

B x 11,5 = (325 x 1,75) + (400 x 5) + (600 x 7) ✓
= 568,75 + 2 000 + 4 200
= 6 768,75 N ✓

$B = \frac{6\,768{,}75}{11{,}5}$

B = 588,59 N ✓ (7)

8.3 **Stress and strain calculations**

8.3.1 Tensile stress calculations

A = 2,2 mm² F = ? kN; D = 98, d= 67mm: L = 300 mm : E= 245 PGa:

Rounded off		**Fully extended**	
$\varepsilon = \frac{\Delta L}{OL}$	✓	$\varepsilon = \frac{\Delta L}{OL}$	✓
$= \frac{0{,}2}{300}$		$= \frac{0{,}2}{300}$	
$= 0{,}66 \times 10^{-3}$	✓	$= 0{,}0006666$	✓
$E = \frac{\sigma}{\varepsilon}$	✓	$E = \frac{\sigma}{\varepsilon}$	✓
$\sigma = E \times \varepsilon$		$\sigma = E \times \varepsilon$	
$= 245 \times 10^{9} \times 0{,}66 \times 10^{-3}$	✓	$= 245 \times 10^{9} \times 0{,}0006666$	✓
$= 161{,}7 \times 10^{6}$ Pa	✓	= 163 333 333,3 Pa	✓
$\sigma = \frac{F}{A}$	✓	$\sigma = \frac{F}{A}$	✓
$F = \sigma \times A$	✓	$F = \sigma \times A$	✓
$= 161{,}7 \times 10^{6} \times 2{,}2 \times 10^{-6}$	✓	$= 163\,333\,333{,}3 \times 2{,}2 \times 10^{-6}$	✓
= 355,74 N	✓	= 359,33 N	✓

(9)

8.4 **Stress/Strain diagram**

8.4.1 A – Limit of Proportionality: Up to this point the stress is directly proportional to the strain it causes, the furthest point it can be stretched while able to return to its previous shape ✓✓

B – Elastic limit: maximum stress or force per unit area within a solid material that can arise before the onset of permanent deformation. When stresses up to the elastic limit are removed, the material resumes its original size and shape. ✓✓

E – Point of Fracture: also known as breaking strength, is the stress at which a specimen fails via fracture. ✓✓ (6)

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QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Material Classifications**

9.1.1 PVC – Thermoplastic ✓ (1)

9.1.2 Glass fibre – Thermo-setting plastic ✓ (1)

9.1.3 Nylon – Thermoplastic ✓ (1)

9.2 **Reasons for using cutting fluid when working on the centre lathe.**

- It prolongs the life of a cutting tool. ✓
- It prevents the shavings or metal chips from sticking and fusing to the cutting tool. ✓
- It will carry away the heat generated by the turning process.
- It flushes away shavings/metal chips. ✓
- It improves the quality of the finish of the turned surface. (Any 2 x 1) (2)

9.3 **Consequences for failure to maintain equipment.**

- Risk of injury. ✓
- Financial loss due to long breakdown. ✓
- Loss of production time. ✓ (3)

9.4 **Reasons for use of carbon fibre**

- It is light in weight. ✓
- It is tougher and stronger. ✓
- It can be bent to any shape when heated above 150 ˚C. ✓ (Any 2 x 1) (2)

9.5 **ONE property and ONE use of each composites**

Composite	Property	Uses
9.5.1 PVC	- Resistant to Water, grease, heat and corrosion ✓ - Flexible, rubberlike, tough and easy to bond (Any 1)	Electrical cables, Artificial leather, cling wrap, credit and phone cards ✓ (Any 1)
9.5.2 Glass Fibre	- Withstands high temperatures - self lubrication ✓ - high strength, durable. (Any 1)	Furniture, Ornaments roof sheeting laminated, swimming pools. ✓ (Any 1)
9.5.3 Nylon	- Toughness, no lubrication ✓ - Hardwearing, cheap, light (Any 1)	Bushes, pulleys, toys, Curtain hooks ✓ (Any 1)

(6)

9.6 **Preventative maintenance**

- Inspection ✓
- Measuring ✓
- Cleaning ✓
- Lubricating ✓
- Adjusting and replacement of parts ✓ (Any 2 x 1) (2)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Square thread calculations:**
T = 48 mm ; m = 3

10.1.1 PCD = T x m
= 48 x 3 = **144 mm** ✓✓ (2)

10.1.2 Add = Module = **3 mm** ✓ (1)

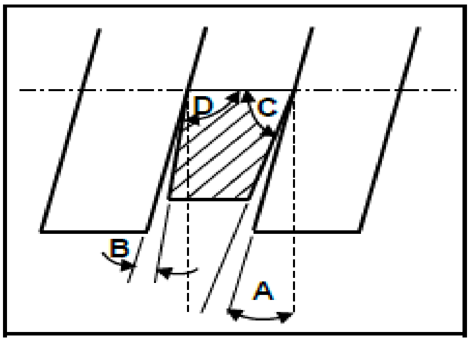
10.1.3 Clearance = 0,157 x 3
= 0,471 mm ✓✓ (2)

10.1.4 Ded = 1,157 x 3
= 3,471 mm ✓✓ (2)

10.1.5 OD = PCD + 2 x 3
= 150 mm ✓✓ (2)

10.1.6 Circular pitch
= π x m
= π x 3 = **9,424 mm** ✓ (1)

10.2 Left-hand square screw thread



✓

A – Leading angle ✓
B – Following or trailing angle ✓
C – Clearance ✓
D – Helix angle ✓ (4)

10.3 A multi-start thread allows for a faster travel or movement and is more efficient as it lose less power to friction compared to single start thread. ✓✓ (2)

10.4 International Standards Organisation ✓✓ (2)
[18]

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

11.1 Pressure is the action of putting force onto a body. ✓✓ (2)

11.2 **Hydraulic system calculations**

11.2.1 **Calculate the fluid pressure.**

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

$$= \frac{\pi (0,04)^2}{4}$$

$$A_A = 1,257 \times 10^{-3}\ m^2$$

$$P = \frac{F_A}{A_A}$$

$$= \frac{0,9 \times 10^3}{1,257 \times 10^{-3}}$$

$$= 715\ 990,45\ Pa$$

$$= 715\ 990\ Pa$$ ✓✓✓✓ (4)

11.2.2 **Number of strokes**

The volume of the system stays the same

$A_B = \frac{\pi D^2}{4}$ ✓

$= \frac{\pi (0{,}240)^2}{4}$

$= 45{,}24 \times 10^{-3}\ m^2$ ✓

Volume displayed by A = Volume displayed by B

$V_A = V_B$ ✓

$A_A \times L_A = A_B \times L_B$

$L_A = \frac{A_B \times L_B}{A_A}$ ✓

$= \frac{(45{,}24 \times 10^{-3})\ (35 \times 10^{-3})}{(1{,}257 \times 10^{-3})}$ ✓

$= 1{,}26$ m ✓

Number of strokes by piston A $= \frac{L_A}{\text{One stroke lenght}}$ ✓

$= \frac{1{,}26}{0{,}126}$ ✓

= 10 strokes ✓ (9)

11.3 Hydraulics refers to the transmission and control of forces and movement by means of fluid. Fluid (generally oil) is used to transmit energy. ✓✓ (2)

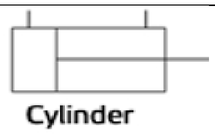
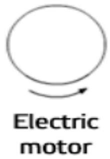
11.4 **Belt drive calculations**

Nmotor x Dmotor = Nblade x Dblade

130 x 1 205 = 385 x Dblade ✓

Dblade = 406,883 pm ✓ (2)

11.5 **Pneumatic symbols**

11.5.1	Cylinder	 ✓
11.5.2	Accumulator	 ✓
11.5.3	Electric motor	 ✓

(3)

11.6 **Gear-drive system calculations:**

Data:

11.6.1 Rotational frequency of the output shaft:

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

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

$$\frac{N_F}{N_A} = \frac{24 \times 20 \times 42 \times 1\,440}{40 \times 48 \times 90}$$

$$= 168 \text{ r/min}$$

OR

$$\frac{N_F}{N_A} = \frac{\text{Product of driven gears}}{\text{Product of driver gears}} \checkmark$$

$$= \frac{24 \times 20 \times 42 \times 1\,440}{40 \times 48 \times 90} \checkmark$$

$$= 168 \text{ r/min} \checkmark$$

(3)

11.6.2 Velocity ratio

$$\textbf{VR} = \frac{N_A}{N_F} \checkmark$$

$$\textbf{VR} = \frac{1\,440}{168}$$

VR = 8,57 : 1 ✓ (2)

11.6.3 Driven will rotate clockwise ✓ (1)

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TOTAL: 200