Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2023

MECHANICAL TECHNOLOGY: FITTING AND MACHINING
MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 16 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 C ✓ (1)

1.2 D ✓ (1)

1.3 C ✓ (1)

1.4 C ✓ (1)

1.5 A ✓ (1)

1.6 B ✓ (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Arc welding safety precautions:**

- Wear correct PPE ✓
- Ensure the electrode holder is well insulated ✓
- The environment must be free of water and combustible materials ✓
- Ensure the environment is well ventilated ✓ (Any 3 x 1) (3)

2.2 **Pedestal drilling machine safety precautions:**

- Wear correct PPE ✓
- Make sure all guards are in place ✓
- Clamp the workpiece securely ✓
- Use the correct drill bit ✓
- Do not make any adjustment while the machine is in motion ✓
- Use the correct speed ✓
- Do not remove chips by hand ✓ (Any 2 x 1) (2)

2.3 Manual guillotine maximum cutting thickness is 1,20 mm ✓ (1)

2.4 2.4.1 **Advantages of product layout:**

- Handling of material is limited to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- 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)

2.4.2 **Advantages of the process layout:**

- High machine utilisation because more than one product is manufactured. ✓
- Better supervision as a result of subdivision of processes. ✓
- Less interruption in flow of work when machines become defective. ✓
- Lower equipment cost, since one machine can produce more than one product. ✓
- Better control of total manufacturing cost. ✓
- Greater flexibility in the production process. ✓ (Any 2 x 1) (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Purpose of case hardening:**
- To produce a hard case over ✓ and tough core. ✓ (2)

3.2 **Using high carbon steel for case hardening:**
- The hardness will penetrate the core ✓ (1)

3.3 **Factors of hardness:**
- Work piece size ✓
- Quenching rate ✓
- Carbon content ✓ (3)

3.4 **Types of quenching mediums:**
- Water and salt (brine) ✓
- Tap water ✓
- Liquid salts ✓
- Molten lead ✓
- Soluble oil and water ✓
- Oil ✓ (Any 3 x 1) (3)

3.5 **Colour coding of engineering materials:**
- To identify the type of materials as well as the carbon content of steel ✓ (1)

3.6 **Types of test:**

3.6.1
- Filing test ✓
- Machining test ✓ (Any 1 x 1) (1)

3.6.2
- Sound test ✓
- Spark test ✓ (Any 1 x 1) (1)

3.6.3
- Bending test ✓ (1)

3.7 **Machine for spark test:**
- Pedestal grinding machine ✓ (1)

[14]

QUESTION 4: MULTIPLE CHOICE QUESTION (SPECIFIC)

4.1 D √

4.2 D √

4.3 B √

4.4 A √

4.5 A √

4.6 B √

4.7 C √

4.8 B √

4.9 D √

4.10 B √

4.11 C √

4.12 B √

4.13 D √

4.14 B √ (14 x 1) **[14]**

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

5.1 **Cutting depth:**

Cutting depth = 0,866 x P ✓
= 0,866 X 2,5 ✓
= 2,17 mm ✓ (3)

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
= 100 – 0,5 x 12 ✓
= 94 mm ✓ (2)

5.3.3 Tan θ = Lead / π x Dm
Tan θ = 24 / 94 ✓
θ = 14,32° ✓ (2)

5.4 **Milling Terminology**

5.4.1 Universal horizontal milling machine ✓ (1)

5.4.2 **Labels**

A – Arbor ✓
B – Milling cutter ✓
C – Workpiece ✓
D – Parallels ✓
E – Machine vice ✓
F – Machine table (5)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Advantages of gang milling:**

- Several surfaces can be milled simultaneously.
- This method is a time saver.
- It makes production work more effective (Any 2 x 1) (2)

6.2 **Uses of cutters:**

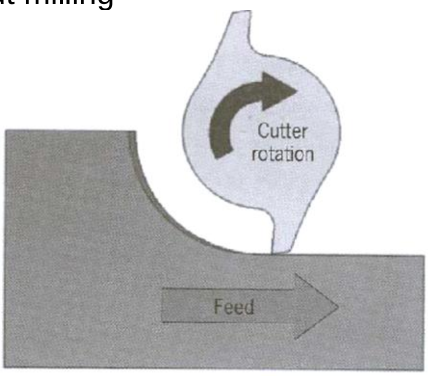
6.2.1 T-slot milling cutters are designed for cutting T-slots in machine tables and similar applications. ✓ (1)

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. ✓

6.3 Module is the unit of size that indicates how big or how small a gear is. ✓ (1)

6.4 Milling methods
Up-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:

$$\text{Indexing} = \frac{40}{A} \quad ✓$$
$$= 40/160$$
$$= \frac{1}{4} \times \frac{7}{7} \quad ✓$$
$$= 7/28$$

Indexing is 7 holes in a 28-hole circle. ✓ (3)

6.5.2 **Change of gears:**

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

$= \frac{160-163}{120} \times 40$ ✓

$= -\frac{3}{4} \times \frac{8}{8}$ ✓

= - 24/32

The driver gear has 24 teeth.
The driven gear has 32 teeth. ✓ (4)

6.5.3 The direction of motion is anti-clockwise ✓
The crank handle will turn the opposite direction as index plate (-) ✓ (2)

6.6 **Dove tail calculations**

6.6.1 Calculate Y and X

Y = 180 – 2(DE)
X = 180 – 2(DE) + 2(AC) + 2 (Radius) ✓

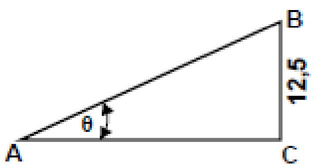
Calculating AC:

$\text{Tan}\ \theta = \frac{BC}{AC}$ ✓

$AC = \frac{BC}{\text{Tan}\ \theta}$ ✓

$= \frac{12,5}{\text{Tan}\ 30^\circ}$

$= 21,65\ mm$ ✓



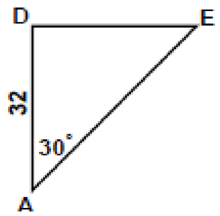
Calculating BE

$\text{Tan}\ \theta = \frac{DE}{AD}$ ✓

$DE = \text{Tan}\ \theta \times AD$ ✓

$= \text{Tan}30^\circ \times 32$

$= 18,48\ mm$ ✓



Calculating Y

Y = 180 – 2(DE)
= 180 – 2(18,48) ✓
= 143,04 mm ✓

X = 180 – 2(DE) + 2(AC) + 2 (Radius)
= 143,04 + 2 (21,65) + 2 (12,5) ✓
= 211,34 mm ✓ (11)

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QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Brinell Hardness test procedure**

- The desired load in kilograms is selected on the dial by adjusting the air regulator. ✓
- The specimen is placed on the anvil. Ensure that the specimen is clean and free from burrs. It should be smooth enough so that an accurate measurement can be taken of the impression. ✓
- The specimen is raised to be in contact with Brinell ball by turning the hand wheel. ✓
- The load is then applied by pulling out the plunger control. Maintain the load for 30 seconds for non-ferrous metals and 14 seconds for steel. ✓
- Remove the specimen from the tester and measure the diameter of the impression. ✓ (5)

7.2 **The THREE ways that hardness is measured:**

- Resistance to penetration ✓
- Elastic hardness ✓
- Resistance to abrasion ✓ (3)

7.3 **Study Engineering Apparatus**

7.3.1 Rockwell hardness tester ✓ (1)

7.3.2 A – Hardness Indicator ✓
B – Platform ✓
C – Height Adjuster ✓
D – Activating knob ✓ (4)

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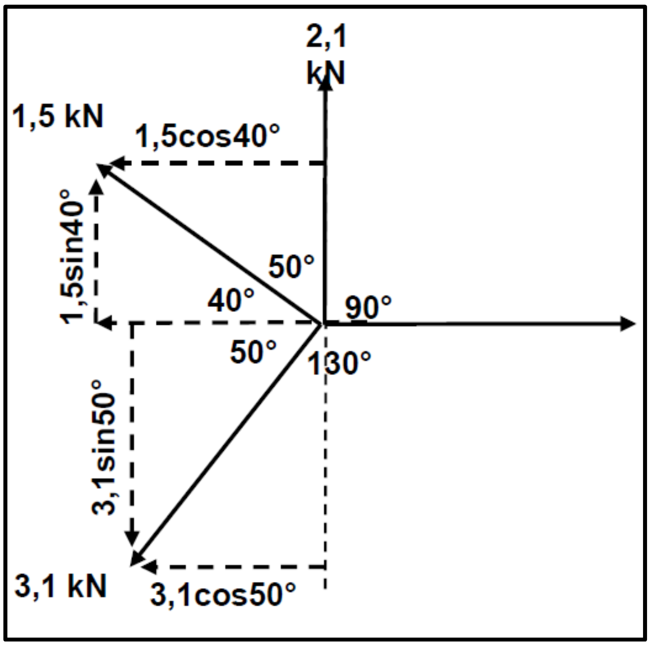
QUESTION 8: FORCES (SPECIFIC)

8.1 **Resultant Force Calculations:**



8.1.1 $\sum X_{com}$ = 4,7 – 3,1 cos 50 – 1,5 cos 40 ✓✓
= **3,856 kN** ✓ (3)

8.1.2 $\sum Y_{com}$ = 2,1 + 1,5 sin40 – 3,1 sin 50 ✓✓
= **0,69 kN** ✓ (3)

8.1.3 R $= \sqrt{(X^2 + Y^2)}$
R $= \sqrt{[(3{,}856)^2} + (0{,}69)^2]$
R = 3,92 kN ✓

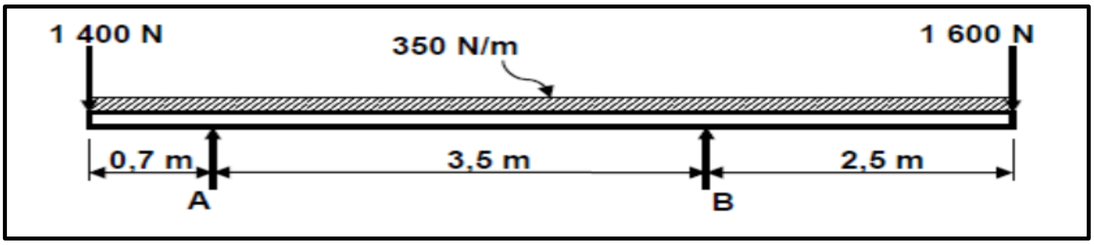
Tan θ = y/x ✓
Tan Θ = 0,69/3,856
Θ = 10,145° ✓

Equilibrant = Resultant BUT IN THE OPPOSITE DIRECTION

Equilibrant = 3,92 kN at 190,145º ✓ (4)

8.2 Moments

Converting the UDL to Point Load
350 x 6,7 = 2345 kN @ 3,35 m from Left hand end ✓



Calculation the Reactions by Taking moments:

Taking moments around A

$$\circlearrowleft = \circlearrowright$$

$$(B \times 3{,}5) + (1400 \times 0{,}7) = (350 \times 6{,}7)2{,}65 + (1600 \times 6) \quad ✓$$

$$3{,}5B + 980 = 6214{,}25 + 9600 \quad ✓$$

$$\frac{3{,}5B}{3{,}5} = \frac{6214{,}25 + 9600 - 980}{3{,}5} \quad ✓$$

$$B = 4238{,}36 \text{ N}$$

Taking moments around B

$$\circlearrowright = \circlearrowleft$$

$$(A \times 3{,}5) + (1600 \times 2{,}5) = (350 \times 6{,}7)0{,}85 + (1400 \times 4{,}2) \quad ✓$$

$$3{,}5A + 4000 = 1993{,}25 + 5880 \quad ✓$$

$$\frac{3{,}5A}{3{,}5} = \frac{1993{,}25 + 5880 - 4000}{3{,}5} \quad ✓$$

$$A = 1106{,}64 \text{ N}$$

(7)

8.3 Stress and Strain Calculations

8.3.1 Calculate the diameter of the pin.
Dia = ? F = 100 kN; E= 210 PGa:

$$\text{Stress } (\sigma) = \frac{\text{Force } (F)}{\text{Area } (A)}$$

$$A = \frac{100 \times 10^3}{204 \times 10^6} \quad ✓$$

$$= 0{,}49 \times 10^{-3} \text{ m}^2 \quad ✓$$

$$\text{But Area} = \frac{\pi d^2}{4} \quad ✓$$

$$d = \sqrt{\frac{4A}{\pi}} \quad ✓$$

$$= \sqrt{\frac{4 \times 0{,}49 \times 10^{-3}}{\pi}} \quad ✓$$

$$= \sqrt{0{,}624 \times 10^{-3}}$$

$$= 0{,}025 \text{ m}$$

$$d = 25 \text{ mm} \quad ✓$$

(6)

8.3.2 **Strain in the pin**

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

$$\varepsilon = \frac{\sigma}{E}$$ ✓

$$= \frac{204 \times 10^6}{210 \times 10^9}$$ ✓

$$= 0{,}97 \times 10^{-3}$$ ✓

(3)

8.3.3 **Change in length**

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

$$\Delta L = \varepsilon \times OL$$

$$= (0{,}97 \times 10^{-3}) \times (110)$$ ✓

$$= 0{,}11\, mm$$ ✓ (3)

8.3.4 Compressive Stress. ✓ (1)

8.4 **Stress/Strain diagram labels**

A – Limit of Proportionality ✓
B – Elastic limit: ✓ (2)
C – Yield Point ✓ (1)
[33]

QUESTION 9: MAINTENANCE

9.1 **Properties of nylon:**

- Needs no lubrication ✓
- Can withstand a lot of shock ✓
- No maintenance ✓
- Light in weight ✓
- Easy to machine ✓ (Any 3 x 1) (3)

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 (2)

9.4 **Reasons for using of carbon fibre**

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

9.5 **TWO property and TWO uses of PVC**

COMPOSITE	PROPERTY/CHARACTERISTICS	USES
PVC	- Resistant to water, grease, heat and corrosion ✓ - Flexible, rubberlike, tough and easy to bond ✓ (Any 2)	- Electrical cables, artificial leather, cling wrap, credit and phone cards ✓✓ (Any 2)

(4)

9.6 **Preventative Maintenance**

- Inspection ✓
- Measuring ✓
- Cleaning ✓
- Lubricating ✓
- Adjusting and Replacement of parts ✓ (Any 3 x 1) (3)

[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)

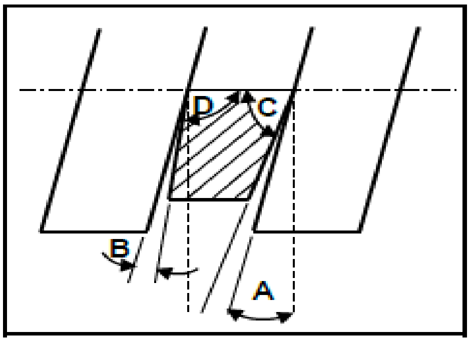
10.1.3 Clearance = 0,157 x 3
= 0,471 mm ✓✓ (2)

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 at it lose less power to friction compare to single start thread. ✓✓ (2)

10.4 International Standards Organization ✓✓ (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 diameter of Piston A**

First calculate the volume of cylinder B. ✓

$$V_B = Area_B \times Stroke\ length_B$$

$$= \frac{\pi \times D_B^2}{4} \times L_B$$

$$= \frac{\pi \times (0{,}18)^2}{4} \times 0{,}012 \checkmark$$

$$= 0{,}305 \times 10^{-3} m^3 \checkmark$$

$$But,\ V_A = V_B$$

$$\therefore A_A \times L_A = V_B \checkmark$$

$$A_A \times 0{,}06 = 0{,}305 \times 10^{-3} \checkmark$$

$$A_A = \frac{0{,}305 \times 10^{-3}}{0.06}$$

$$= 5{,}08 \times 10^{-3} m^2 \checkmark$$

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

$$D_A^2 = \frac{5{,}08 \times 10^{-3} \times 4}{\pi} \checkmark$$

$$D_A = \sqrt{6{,}47 \times 10^{-3}} \checkmark$$

$$D_A = 0{,}80\ m$$

$$= 80\ mm \checkmark$$

(9)

11.2.2 **Calculate the pressure exerted on Piston A**

$$Pressure\ at\ A = \frac{F_A}{A_A}$$

$$P_A = \frac{550}{5{,}08 \times 10^{-3}} \checkmark$$

$$= 108{,}268 \times 10^3\ Pa$$

$$= 108{,}27\ kPa \checkmark$$

(2)

11.2.3 Calculate the force exerted on Piston B

NOTE: Pressure at A is equal to Pressure at B ✓

$$P_B = P_A$$

$$P_B = \frac{F_B}{A_B} \quad ✓$$

$$F_B = 108{,}268 \times 10^3 \times A_B \quad ✓$$

$$= 108{,}268 \times 10^3 \times 25{,}45 \times 10^{-3} \quad ✓$$

$$= 2755{,}42\ N$$

$$= 2{,}76\ kN$$

(4)

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**

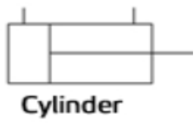
$N_{motor} \times D_{motor} = N_{blade} \times D_{blade}$

$130 \times 1205 = 385 \times D_{blade}$ ✓

$D_{blade} = 406{,}883$ pm ✓ (2)

11.5 **Pneumatic symbols**

11.5.1 Cylinder

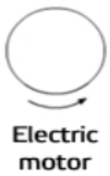


✓ (1)

11.5.2 Accumulator

✓ (1)

11.5.3 Electric Motor



✓ (1)

11.6 **Gear-Drive system calculations:**
Data:

11.6.1 Rotational frequency of the output shaft:

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

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

$$= \frac{36 \times 46 \times 80 \times 160}{20 \times 18 \times 42} \quad ✓$$

$$= 1401{,}90\ r/\min \quad ✓$$

(3)

11.6.2 Velocity ratio

$$VR = \frac{N_A}{N_F} \quad ✓$$

$$VR = \frac{1401{,}90}{160}$$

$$= 8{,}76{:}1 \quad ✓$$

(2)

11.6.3 Driven will rotate Clockwise: ✓ (1)
[28]

TOTAL: 200