basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

MECHANICAL TECHNOLOGY

EXAMINATION GUIDELINES

GRADE 12

2021

These guidelines consist of 19 pages.

TABLE OF CONTENTS

1. INTRODUCTION

The Curriculum and Assessment Policy Statement (CAPS) for Mechanical Technology outlines the nature and purpose of the subject Mechanical Technology. This guides the philosophy underlying the teaching and assessment of the subject in Grade 12.

The purpose of these Examination Guidelines is to:

- Provide clarity on the depth and scope of the content to be assessed in the Grade 12 National Senior Certificate Examination in Mechanical Technology.
- Assist teachers to adequately prepare learners for the examinations.

This document deals with the final Grade 12 external examinations. It does not deal in any depth with the school-based assessment (SBA), performance assessment tasks (PATs) or final external practical examinations as these are clarified in a separate PAT document which is updated annually.

This guideline should be read in conjunction with:

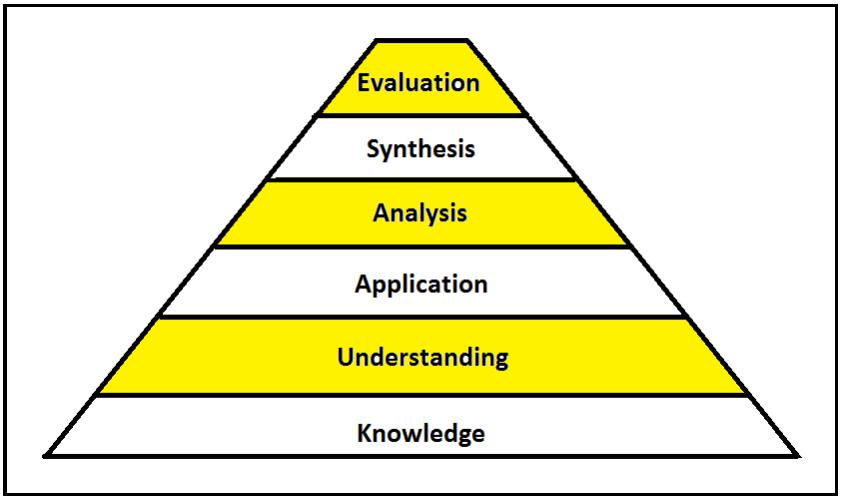
- *National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS)*: Mechanical Technology
- National Protocol of Assessment: *An addendum to the policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), regarding the National Protocol for Assessment (Grades R–12)*
- National policy pertaining to the programme and promotion requirements of the National Curriculum Statement, Grades R–12

These guidelines should be used in conjunction with the content outline per term and Section 4 of the CAPS document for Grade 12 Mechanical Technology specialisation. The duration of the final examination paper will be 3 hours with a maximum mark of 200. Summative assessment (examinations) will cater for a range of cognitive levels and abilities of learners.

THIS IS A GUIDELINE DOCUMENT AND NOT A WORK SCHEDULE.

2. COGNITIVE LEVELS

Blooms Taxonomy consists of six levels as shown below.



Bloom's Taxonomy	Bloom's Revised Taxonomy	Description
Evaluation	Creating	Generating, planning, producing
Synthesis	Evaluating	Critiquing, judging, justifying, recommending
Analysis	Analysing	Differentiating, organising, attributing, solving
Application	Applying	Executing, implementing, preparing, using
Understanding	Understanding	Interpreting, exemplifying, classifying, summarising, inferring, comparing, explaining
Knowledge	Remembering	Recognising, recalling, labelling, naming

The following cognitive levels and weighting thereof are applicable to the Mechanical Technology specialisations:

Cognitive Levels		Weighting
Lower order	**Knowledge:** memorise and recall information: arrange, define, label, list, outline, repeat, order	30%
	Comprehension: (understanding) interpret information in one's own words: describe, indicate, restate, review, summarise, classify	
Medium order	**Application:** apply knowledge to new situations: apply, calculate, draw, explain, identify, illustrate, prepare, operate, practise, solve, sketch, use	50%
	Analysis: break down knowledge into parts and show relationship among parts: analyses, categorise, compare, distinguish, discuss, examine, investigate, test	
Higher order	**Synthesis:** bring together parts of knowledge to form a whole; build relationships for new situation: arrange, compose, formulate, organise, plan, assemble, construct, problem-solving	20%
	Evaluation: make judgements on basis of criteria: appraise, assess, comment, critically analyse, evaluate, conclude, interrogate, judge, predict, compare, score	

3. ELABORATION OF CONTENT FOR GRADE 12 (CAPS)

BASIC SKILLS LINKED TO THE SUBJECT:

The following skills are measured in the question paper. The visibility of these skills gives an indication of the overall skills required in the subject:

- Ability to follow instructions
- Identifying labels/labelling/making drawings/diagrams/schematic representations
- Plotting and interpretation of graphs/data
- Working out and interpreting calculations
- Organising/Recording and categorising data
- Extraction and/or manipulation and/or evaluation of data

NOTE:

Calculations
Generally, the criteria used for calculations is as follows: • Correct formula (Manipulation) • Substitution of values • Simplifying of values • Answer and correct units

4. STRUCTURE OF THE QUESTION PAPER

This examination guidelines document is compiled with reference to the Mechanical Technology CAPS document that focuses on specialisation.

The INSTRUCTIONS AND INFORMATION part is the same for all three specialisations and this must be brought to the attention of the candidates.

The GENERIC questions for each of the specialisations are the same and have the same weighting.

The SPECIFIC questions focus only on content applicable for that specialisation.

Use the following FORMULA SHEET ANNEXURES for the specific specialisation:

4.1.1 ANNEXURE A (Fitting and Machining)
4.1.2 ANNEXURE B (Automotive)
4.1.3 ANNEXURE C (Welding and Metalwork)

4.1 FITTING AND MACHINING

QUESTION	CONTENT	MARKS	TIME IN MINUTES
	Generic		
1	Multiple-choice questions	6	6
2	Safety	10	10
3	Materials	14	14
	Specific		
4	Multiple-choice Questions	14	14
5	Terminology (Lathe and Milling Machine)	18	15
6	Terminology (Indexing)	28	24
7	Tools and Equipment	13	12
8	Forces	33	31
9	Maintenance	18	15
10	Joining Methods	18	15
11	Systems and Control (Drive Systems)	28	24
	TOTAL	**200**	**180**

ANNEXURE A (Fitting and Machining)

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: FITTING AND MACHINING

1. BELT DRIVES

1.1 $\text{Belt speed} = \frac{\pi DN}{60}$

1.2 $\text{Belt speed} = \frac{\pi(D + t) \times N}{60}$ (t = belt thickness)

1.3 $\text{Belt mass} = \text{Area} \times \text{Length} \times \text{Density}$ (A = thickness × width)

1.4 $\text{Speed ratio} = \frac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

1.5 $\text{Belt length (flat)} = [(D + d) \times 1{,}57] + (2 \times \text{centre distance})$

1.6 $\text{Open belt length} = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$

1.7 $\text{Crossed belt length} = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$

1.8 $\text{Power } (P) = \frac{(T_1 - T_2)\pi DN}{60}$

Where:

T_1 = force in the tight side
T_2 = force in the slack side
$T_1 - T_2$ = effective tensile force (T_e)

1.9 $\text{Ratio between tight side and slack side} = \frac{T_1}{T_2}$

1.10 $\text{Power } (P) = \frac{2\pi NT}{60}$

1.11 $\text{Width} = \frac{T_1}{\text{Permissable tensile force}}$

1.12 $N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$

2. STRESS AND STRAIN

2.1 $A_{shaft} = \frac{\pi d^2}{4}$

2.2 $A_{pipe} = \frac{\pi(D^2 - d^2)}{4}$

2.3 $\text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$

2.4 $\text{Stress} = \frac{\text{Force}}{\text{Area}}$ OR $\sigma = \frac{F}{A}$

2.5 $\text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$ OR $\varepsilon = \frac{\Delta L}{L}$

2.6 $\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$ OR $E = \frac{\sigma}{\varepsilon}$

3. HYDRAULICS

3.1 $\text{Pressure} = \frac{\text{Force}}{\text{Area}}$ OR $P = \frac{F}{A}$

3.2 $\text{Volume} = \text{Area} \times \text{Stroke length}$ $(l \text{ or } s)$

3.3 $\text{Work done} = \text{Force} \times \text{Distance}$

3.4 $P_A = P_B$

3.5 $\frac{F_A}{A_A} = \frac{F_B}{A_B}$

4. GEAR DRIVES

4.1 $\text{Power } (P) = \frac{2\pi N T}{60}$

4.2 $\text{Gear ratio} = \frac{\text{Product of teeth on driven gear}}{\text{Product of teeth on driver gear}}$ OR $\text{Speed ratio} = \frac{N_{input}}{N_{output}}$

4.3 $\frac{N_{input}}{N_{output}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driver gears}}$

4.4 $N_A \times T_A = N_B \times T_B$

4.5 Torque = Force × Radius

4.6 Torque transmitted = Gear ratio × Input torque

4.7 $\text{Module} = \frac{\text{Pitch circle diameter}}{\text{Number of teeth}}$ OR $m = \frac{PCD}{T}$

4.8 $\text{Pitch circle diameter} = \frac{\text{Circlular pitch} \times \text{Number of teeth}}{\pi}$ OR $PCD = \frac{CP \times T}{\pi}$

4.9 $\text{Outside diameter } (OD) = PCD + 2(m)$

4.10 Addendum = Module OR $a = m$

4.11 $\text{Dedendum } (b) = 1{,}157(m)$ OR $\text{Dedendum } (b) = 1{,}25(m)$

4.12 $\text{Cutting depth } (h) = 2{,}157\,(m)$ OR $\text{Cutting depth } (h) = 2{,}25\,(m)$

4.13 $\text{Clearance } (c) = 0{,}157\ (m)$ OR $\text{Clearance } (c) = 0{,}25\ (m)$

4.14 $\text{Circular pitch } (CP) = m \times \pi$

4.15 $\text{Working depth } (WD) = 2 \times m$

5. PULLEYS

5.1 $N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$

5.2 $\text{Power (P)} = \dfrac{2\pi NT}{60}$

5.3 $\text{Velocity ratio} = \dfrac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

6. KEYWAYS

6.1 $\text{Width of key} = \dfrac{\text{Diameter of shaft}}{4}$

6.2 $\text{Thickness of key} = \dfrac{\text{Diameter of shaft}}{6}$

6.3 Length of key = 1,5 × Diameter of shaft

6.4 Standard taper for taper key : 1 in 100 or 1 : 100

7. CINCINNATI DIVIDING HEAD TABLE FOR MILLING MACHINE

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
Change gears											
Gears	24 x 2	28	32	40	44	48	56	64	72	86	100

7.1 $\text{Indexing} = \dfrac{40}{n}$ (n = number of divisions)

7.2 $\dfrac{Dr}{Dn} = \dfrac{A-n}{A} \times \dfrac{40}{1}$ OR $\dfrac{Dr}{Dn} = (A-n) \times \dfrac{40}{A}$

Where:

A = chosen number of divisions
n = real number of divisions

8. DOVETAILS

Where:

R = Radius of precision roller
y = Distance from top edge of dovetail in relation to bottom corner of dovetail
x = Distance from middle of precision roller to bottom corner of dovetail
θ = Dovetail included angle (normally 60°)
h = Height of dovetail
w = Minimum width distance of dovetail
W = Maximum width distance of dovetail
m = Distance between rollers
M = Distance over rollers

9. TAPERS

9.1 $\tan\frac{\theta}{2} = \frac{D - d}{2 \times l}$ (l = Taper length)

9.2 $\tan\frac{\theta}{2} = \frac{L(D - d)}{2 \times l}$ (L = Distance between centres)

10. SCREW THREADS

10.1 Mean diameter = Outside diameter $-(\frac{1}{2} \times \text{Pitch})$ OR $D_m = OD - \frac{P}{2}$

10.2 Effective diameter (D_{eff}) = Pitch diameter (D_p) = Mean diameter (D_m)

10.3 Lead = Pitch × Number of starts

10.4 Height of screw thread = 0,866 × Pitch (P)

10.5 Depth of screwthread = 0,613 × Pitch (P)

10.6 Helix angle : $\text{Tan}\theta = \frac{\text{Lead}}{\pi \times D_m}$

10.7 Leading angle = 90º – (Helix angle + Clearance angle)

10.8 Following angle = 90º + (Helix angle – Clearance angle)

4.2 AUTOMOTIVE

QUESTION	CONTENT	MARKS	TIME IN MINUTES
	Generic		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	Specific		
4	Multiple-choice questions	14	10
5	Tools and Equipment	23	20
6	Engines	28	25
7	Forces	32	25
8	Maintenance	23	20
9	Systems and Control (Automatic Gearbox)	18	20
10	Systems and Control (Axles, Steering Geometry and Electronics)	32	30
	TOTAL	**200**	**180**

ANNEXURE B (Automotive)

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: AUTOMOTIVE

1. $F = m \times a$

   Where:

   m = mass
   a = acceleration

2. $\text{Work done} = \text{Force} \times \text{Displacement}$ OR $W = F \times s$

3. $\text{Power} = \frac{\text{Force} \times \text{Displacement}}{\text{Time}}$ OR $P = \frac{F \times s}{t}$

4. $\text{Torque} = \text{Force} \times \text{Radius}$ OR $T = F \times r$

5. $IP = P \times L \times A \times N \times n$

   Where:

   IP = Indicated power
   P = Mean effective pressure
   L = Stroke length
   A = Area of piston crown
   N = Number of power strokes per second
   n = Number of cylinders

6. $BP = 2\pi N T$

   Where:

   BP = Brake power
   N = Revolutions per second
   T = Torque

7. $\text{Brake power with Prony brake} = 2 \times \pi \times N \times F \times R$

   Where:

   BP = Brake power
   N = Revolutions per second
   F = Force
   R = Brake arm length

8. $$\text{Mechanical efficiency} = \frac{BP}{IP} \times 100\%$$

9. $$\text{Compression ratio} = \frac{SV + CV}{CV}$$

Where:

SV = Swept volume
CV = Clearance volume

10. $$SV = \frac{\pi D^2}{4} \times L$$

Where:

D = Bore diameter
L = Stroke length

11. $$CV = \frac{SV}{CR-1}$$

12. $$\text{Gear ratio} = \frac{\text{Product of teeth on driven gears}}{\text{Product of teeth on driver gears}}$$

4.3 WELDING AND METALWORK

QUESTION	CONTENT	MARKS	TIME IN MINUTES
	Generic		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	Specific		
4	Multiple-choice questions	14	10
5	Terminology (Templates)	23	20
6	Tools and Equipment	18	15
7	Forces	45	42
8	Joining Methods (Inspection of Weld)	23	20
9	Joining Methods (Stresses and Distortion)	18	15
10	Maintenance	8	8
11	Terminology (Development)	21	20
	TOTAL	**200**	**180**

ANNEXURE C (Welding and Metalwork)

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: WELDING AND METALWORK

1. STRESS AND STRAIN

1.1 $$A_{shaft} = \frac{\pi d^2}{4}$$

1.2 $$A_{pipe} = \frac{\pi (D^2 - d^2)}{4}$$

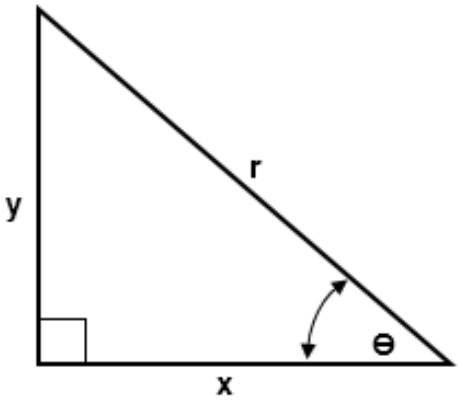
1.3 $$\text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$$

1.4 $$\text{Stress} = \frac{\text{Force}}{\text{Area}} \quad \text{OR} \quad \sigma = \frac{F}{A}$$

1.5 $$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}} \quad \text{OR} \quad \varepsilon = \frac{\Delta L}{L}$$

1.6 $$\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}} \quad \text{OR} \quad E = \frac{\sigma}{\varepsilon}$$

2. PYTHAGORAS THEOREM AND TRIGONOMETRY



2.1 $$\text{Sin}\,\theta = \frac{y}{r}$$

2.2 $$\text{Cos}\,\theta = \frac{x}{r}$$

2.3 $$\text{Tan}\,\theta = \frac{y}{x}$$

2.4 $$r^2 = x^2 + y^2$$

3. TEMPLATES AND DEVELOPMENTS

3.1 Mean Ø = Outside Ø – Plate thickness

OR

Mean Ø = Inside Ø + Plate thickness

3.2 Mean circumference = π x Mean Ø

(where Ø = diameter)

5. CONCLUSION

This Examination Guidelines document is meant to articulate the assessment aspirations espoused in the CAPS document. It is therefore not a substitute for the CAPS document which teachers should teach to.

Qualitative curriculum coverage as enunciated in the CAPS cannot be over-emphasised.