



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2017

MEMORANDUM

MARKS: 200

This memorandum consists of 19 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

- | | | |
|------|-----|-----|
| 1.1 | B ✓ | (1) |
| 1.2 | D ✓ | (1) |
| 1.3 | C ✓ | (1) |
| 1.4 | C ✓ | (1) |
| 1.5 | B ✓ | (1) |
| 1.6 | D ✓ | (1) |
| 1.7 | A ✓ | (1) |
| 1.8 | B ✓ | (1) |
| 1.9 | A ✓ | (1) |
| 1.10 | B ✓ | (1) |
| 1.11 | B ✓ | (1) |
| 1.12 | B ✓ | (1) |
| 1.13 | D ✓ | (1) |
| 1.14 | D ✓ | (1) |
| 1.15 | A ✓ | (1) |
| 1.16 | C ✓ | (1) |
| 1.17 | A ✓ | (1) |
| 1.18 | B ✓ | (1) |
| 1.19 | B ✓ | (1) |
| 1.20 | A ✓ | (1) |
- [20]**

QUESTION 2: SAFETY**2.1 Safety – Coil spring compressor:**

- Make certain that the diameter of the compressor bolts can take the pressure of the coil spring. ✓
- Do not exceed the maximum pressure. ✓
- Make sure the compressors are clean and free from oil. ✓
- Ensure that the compressors are in a good working condition. ✓

(Any 2 x 1) (2)**2.2 Safety – Hydraulic Press:**

- Take notice of the predetermined pressure of the hydraulic press. ✓
- Ensure the pressure gauge is in a good working order. ✓
- Platform on which the work piece rests must be rigid and square with the cylinder of the press. ✓
- The prescribed equipment must be used. ✓
- Check for oil leaks. ✓

(Any 3 x 1) (3)**2.3 Safety – beam bender:**

- Ensure the beam is clamped parallel to the backboard. ✓
- Do not leave plastic beams loaded for any length of time, they tend to creep. ✓
- All the weight must be gently dropped onto the hanger as to reduce inaccuracies due to friction. ✓
- Do not exceed the tester's maximum load. ✓
- Make sure the tester is stable. ✓

(Any 2 x 1) (2)**2.4 Testers:****2.4.1 Brinell Tester:**

- The tester must be mounted rigidly on a worktable. ✓ (1)

2.4.2 Bearing and gear Puller:

- Make sure that the puller is at 90° to the work piece before you start to pull. ✓
- Ensure that the clamps are tight and will not slip from the work piece. ✓

(Any 1 x 1) (1)**2.4.3 Torsion tester:**

- Get specification (torsion) of the different materials and the size of rods you would like to test. ✓

**(1)
[10]**

QUESTION 3: TOOLS AND EQUIPMENT**3.1 Fuel pressure:**

- Faulty diaphragm ✓
- Clogged fuel filter ✓
- Faulty non return valves ✓
- Worn gasket ✓

(Any 2 x 1) (2)**3.2 Precision measuring instruments:**

- 3.2.1 Depth micro-meter ✓
Vernier calliper ✓

(Any 1 x 1) (1)

- 3.2.2 Screw-thread micro-meter ✓

(1)**3.3 Depth micro-meter reading:**

$$\begin{aligned} \text{Reading} &= 50 + 1,5 + 0,49 \checkmark \\ &= 51,99 \text{ mm. } \checkmark \end{aligned}$$

(2)**3.4 Multimeter measurements:**

- DC current measurement ✓
- DC voltage measurement ✓
- AC measurement ✓
- Resistance measurement ✓
- Diode measurement ✓
- Continuity measurement ✓

(Any 2 x 1) (2)**3.5 Trace the cylinder leakage in an engine:**

- Listen to at the carburettor for a hissing noise. ✓
- Listen at the exhaust pipe for a hissing noise. ✓
- Listen for hissing noise in the dipstick hole. ✓
- Listen to hissing noise by removing the filler cap on the tappet cover. ✓
- By checking whether there are bubbles in the radiator water for blown cylinder head gasket or cracked cylinder block. ✓

(Any 2 x 1) (2)**3.6 Uses of cooling pressure tester:**

- To test if the pressure cap on the cooling system operates according to the prescribed pressure of the system. ✓
- To pump compressed air into the cooling system to determine whether they are any water leakage in the system. ✓

**(2)
[12]**

QUESTION 4: MATERIALS**4.1 Properties/characteristics:****4.1.1 Cementite:**

- Hard and brittle ✓✓

(2)

4.1.2 Pearlite:

- Good ductility ✓
- Very hard ✓
- Strong and tough ✓
- Resistance to deformation ✓

(Any 2 x 1) (2)**4.2 Iron –carbon equilibrium diagram**

4.2.1 Iron –carbon equilibrium diagram ✓

(1)

4.2.2 A – Ferrite + Pearlite ✓

B – Austenite + Ferrite ✓

C – Austenite ✓

D – Austenite + Cementite ✓

E – Ferrite + Cementite ✓

(5)

4.2.3 Austenite:

Soft, ✓ grain structure fine ✓

(2)

4.3 720 °C ✓

(1)

[13]

QUESTION 5: TERMINOLOGY

5.1 Indexing:

$$\begin{aligned} \text{Indexing} &= \frac{40}{n} \\ &= \frac{40}{118} \div \frac{2}{2} \\ &= \frac{20}{59} \end{aligned}$$

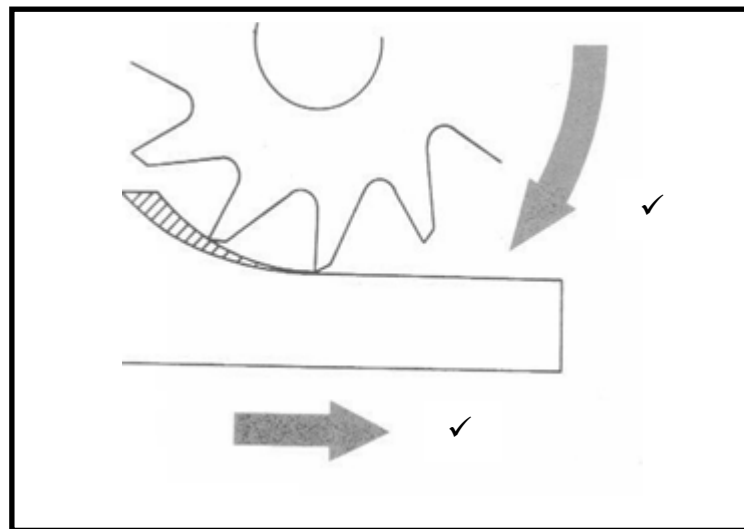
✓
✓
✓

No full turns and 20 holes in a 59-hole plate

(3)

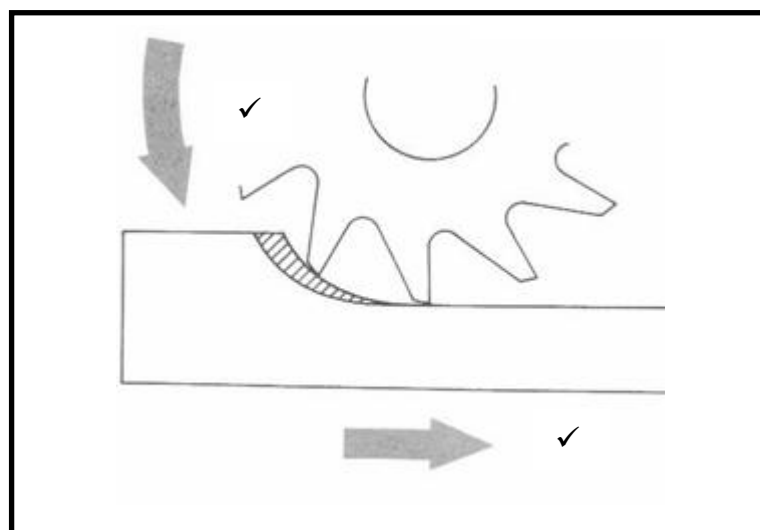
5.2 Milling processes:

- Up-cut milling



(2)

- Downcut milling



(2)

5.3 Calculate: Gib head key:

5.3.1

$$\begin{aligned} \text{Width} &= \frac{D}{4} \\ &= \frac{102}{4} && \checkmark \\ &= 25,5 \text{ mm} && \checkmark \end{aligned} \quad (2)$$

5.3.2

$$\begin{aligned} \text{Thickness} &= \frac{D}{6} \\ &= \frac{102}{6} && \checkmark \\ &= 17 \text{ mm} && \checkmark \end{aligned} \quad (2)$$

5.3.3

$$\begin{aligned} \text{Length} &= D \times 1.5 \\ &= 102 \times 1.5 && \checkmark \\ &= 153 \text{ mm} && \checkmark \end{aligned} \quad (2)$$

5.3.4

$$\begin{aligned} \text{Thickness at small end (t)} &= T - \frac{L}{100} && \checkmark \\ &= 17 - \frac{153}{100} && \checkmark \\ t &= 17 - 1,53 && \checkmark \\ &= 15,47 \text{ mm} && \checkmark \end{aligned} \quad (4)$$

5.4 Calculate – Spur gear:

5.4.1 Addendum = m
= 3 mm ✓ (1)

5.4.2 Dedendum = 1,157m or = 1,25m
= 1,157 x 3 ✓ = 1,25 x 3 ✓
= 3,47 mm ✓ = 3,75 mm ✓ (2)

5.4.3 Clearance = 0,157m or = 0,25m
= 0,157 x 3 ✓ = 0,25 x 3 ✓
= 0,47 mm ✓ = 0,75 mm ✓ (2)

5.4.4

$$\begin{aligned} \text{Module} &= \frac{\text{PCD}}{T} \\ \text{PCD} &= m \times T && \checkmark \\ &= 3 \times 60 && \checkmark \\ &= 180 \text{ mm} && \checkmark \end{aligned} \quad (2)$$

- 5.4.5 $OD = PCD + 2m$
 $= 180 + 2(3)$
 $= 180 + 6$ ✓
 $= 186 \text{ mm}$ ✓ (2)
- 5.4.6 Cutting depth = 2,157 m or = 2,25 m
 $= 2,157 \times 3$ ✓ $= 2,25 \times 3$ ✓
 $= 6,47 \text{ mm}$ ✓ $= 6,75 \text{ mm}$ ✓ (2)
- 5.4.7 Circular pitch = $m \times \pi$
 $= 3 \times \pi$ ✓
 $= 9,43 \text{ mm}$ ✓ (2)

[30]

QUESTION 6: JOINING METHODS

- 6.1 Slag inclusion ✓ (1)
- 6.2 **Visual inspection defects**
- Shape of profile ✓
 - Uniformity of surface ✓
 - Overlap ✓
 - Undercutting ✓
 - Penetration bead ✓
 - Root groove ✓
 - Crack free ✓
- (Any 4 x 1) (4)**
- 6.3 **Causes of incomplete penetration:**
- Weld speed too fast ✓
 - Joint design faulty ✓
 - Electrode too large ✓
 - Current too low ✓
- (Any 2 x 1) (2)**
- 6.4 **Prevention of lack of fusion**
- Adjust electrode size ✓
 - Correct preparation of joint ✓
 - Correct weld current ✓
 - Correct arc length ✓
 - Correct weld speed ✓
- (Any 2 x 1) (2)**
- 6.5 **Destructive test**
- 6.5.1 Machinability test ✓ (1)
- 6.5.2 Nick-break test ✓ (1)
- 6.5.3 Bend test ✓ (1)
- 6.6 **Dye penetration test**
- Clean the weld that needs to be tested. ✓
 - Spray dye onto the surface and leave to penetrate. ✓✓
 - Excess dye is cleaned away with a cleaning agent. ✓
 - Allow surface to dry. ✓
 - Spray a developer onto the surface to bring out the dye trapped in the crack. ✓
 - The dye will show all the surface defects. ✓ (7)

6.7 Functions of MIG/MAGS components**6.7.1 Wire feed controller**

Feeds the consumable electrode wire to the welding gun at a constant predetermined speed. ✓✓

(2)

6.7.2 Welding gun

Activates the supply of gas, power and wire feed ✓✓

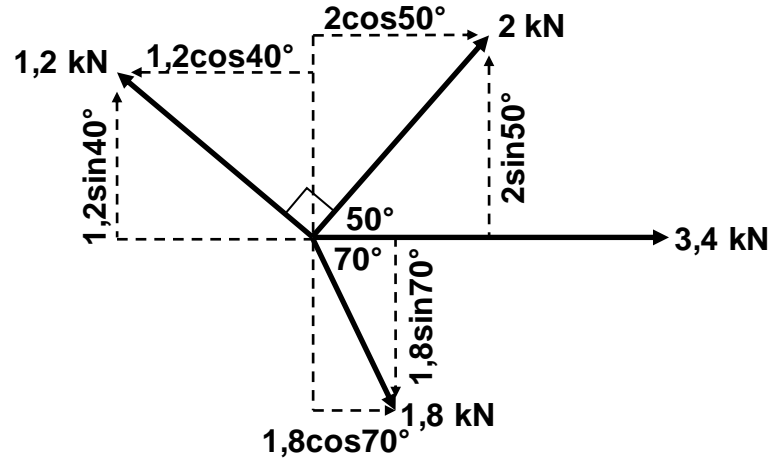
(2)

6.8 Purpose of inert gas

The inert gas shields the molten pool from the atmospheric gases. ✓✓

(2)

[25]

QUESTION 7: FORCES**7.1 Forces**

$$\begin{aligned}\Sigma HC &= 3,4 (\checkmark) + 1,8 \cos 70^\circ (\checkmark) - 1,2 \cos 40^\circ (\checkmark) + 2 \cos 50^\circ (\checkmark) \\ &= 3,4 + 0,62 - 0,92 + 1,29 \\ &= 4,39 \text{ kN } (\checkmark)\end{aligned}$$

$$\begin{aligned}\Sigma VC &= 1,2 \sin 40^\circ (\checkmark) + 2 \sin 50^\circ (\checkmark) - 1,8 \sin 70^\circ (\checkmark) \\ &= 0,77 + 1,53 - 1,69 \\ &= 0,61 \text{ kN } (\checkmark)\end{aligned}$$

OR

Horizontal component	Magnitudes	Vertical component	Magnitudes
$-1,2 \cos 40^\circ \checkmark$	-0,92 kN	$1,2 \sin 40^\circ \checkmark$	0,77
$3,4 \checkmark$	3,4 kN	0	0
$2 \cos 50^\circ \checkmark$	1,29 kN	$2 \sin 50^\circ \checkmark$	1,53
$1,8 \cos 70^\circ \checkmark$	0,62 kN	$-1,8 \sin 70^\circ \checkmark$	1,69
TOTAL	4,39 kN \checkmark	TOTAL	0,61 kN \checkmark

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

$$R = \sqrt{4,39^2 + 0,61^2} \quad \checkmark$$

$$R = 4,43\text{kN} \quad \checkmark$$

$$\begin{aligned} \tan \theta &= \frac{VC}{HC} \\ &= \frac{0,61}{4,39} \quad \checkmark \\ \theta &= 7,91^\circ \end{aligned}$$

$$R = 4,43 \text{ N at } 7,91^\circ \text{ north of east} \quad \text{.....}\checkmark \quad (13)$$

7.2 Stress and Strain

7.2.1 Stress:

$$A = \frac{\pi(D^2 - d^2)}{4} \quad \checkmark$$

$$\begin{aligned} A &= \frac{\pi(0,098^2 - 0,067^2)}{4} \\ &= 4,02 \times 10^{-3} \text{ m}^2 \quad \checkmark \end{aligned}$$

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

$$\sigma = \frac{40000}{4,02 \times 10^{-3}} \quad \checkmark$$

$$\sigma = 9950248,76\text{Pa}$$

$$\sigma = 9,95 \text{ MPa} \quad \checkmark \quad (5)$$

7.2.2 Strain:

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

$$\varepsilon = \frac{9,95 \times 10^6}{90 \times 10^9} \quad \checkmark$$

$$= 0,11 \times 10^{-3}$$

$$\text{or } 1,11 \times 10^{-4} \quad \checkmark \quad (3)$$

7.2.3 **Change in length**

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

$$\Delta l = \varepsilon \times l$$

$$= (0,11 \times 10^{-3}) \times 0,08$$

$$= 8,8 \times 10^{-6} \text{ m}$$

$$= 8,8 \times 10^{-3} \text{ mm}$$

✓

✓

✓

(3)

7.3 **Moments****Calculate A. Moments about B**

$$\sum \text{RHM} = \sum \text{LHM}$$

$$(A \times 11,6) = (200 \times 5,8) + (928 \times 5,8) + (600 \times 2,8)$$

$$11,6A = 1160 + 5382,4 + 1680$$

$$\frac{11,6A}{11,6} = \frac{8222,4}{11,6}$$

$$A = 708,83 \text{ N}$$

✓

✓

✓

Calculate B. Moments about A

$$\sum \text{LHM} = \sum \text{RHM}$$

$$(B \times 11,6) = (600 \times 8,8) + (928 \times 5,8) + (200 \times 5,8)$$

$$11,6B = 5280 + 5382,4 + 1160$$

$$\frac{11,6B}{11,6} = \frac{11822,40}{11,6}$$

$$B = 1019,17 \text{ N}$$

✓

✓

✓

(6)
[30]

QUESTION 8: MAINTENANCE

- 8.1 **Preventative maintenance**
Can be described as maintenance of equipment or system before a fault occurs. ✓✓ (2)
- 8.2 **Lock out**
Locking out means that the machine's start switch cannot be activated without the knowledge of a servicing technician otherwise an accident would occur. ✓✓ (2)
- 8.3 **Clutch free-play**
The distance the pedal moves before the slack is taken from the linkage and release bearing. ✓✓ (2)
- 8.4 **Viscosity index**
Viscosity index is a measure of how much the oil's viscosity changes as temperature changes. ✓ (1)
- 8.5 **Replace clutch plate:**
 - Worn friction linings. ✓
 - Weak or broken springs. ✓
 - Glazed friction linings due to overheating. ✓
 - Oil on friction linings. ✓

(Any 2 x 1) (2)
- 8.6 **Grease – high viscosity**
To ensure that the grease coats and sticks ✓ to the bearing surfaces it is lubricating. ✓ (2)
- 8.7 **Cutting fluid**
Mixture of soluble oil ✓ and water. ✓ (2)
- 8.8 **Viscosity of cutting fluid**
Has a low viscosity to allow easy flow ✓ and effective dissipation of excess heat. ✓ (2)
- [15]**

QUESTION 9: SYSTEMS AND CONTROL**9.1 Gear drives****9.1.1 Rotation frequency of the output shaft**

$$\frac{N_{\text{INPUT}}}{N_{\text{OUTPUT}}} = \frac{T_B \times T_D}{T_A \times T_C}$$

$$N_{\text{OUTPUT}} = \frac{T_A \times T_C}{T_B \times T_D} \times N_{\text{INPUT}} \quad \checkmark$$

$$N_{\text{OUTPUT}} = \frac{18 \times 16}{36 \times 46} \times 1660 \quad \checkmark$$

$$= 288,70 \text{ r/min} \quad \checkmark \quad (3)$$

9.2.2 Velocity Ratio

$$VR = \frac{N_{\text{INPUT}}}{N_{\text{OUTPUT}}}$$

$$= \frac{1660}{288,70} \quad \checkmark$$

$$= 5,75 : 1 \quad \checkmark \quad (2)$$

9.2 Belt Drives**9.2.1 Rotation frequency of the driver pulley**

$$V = \frac{\pi(D + t) \times N}{60} \quad \checkmark$$

$$N = \frac{V \times 60}{\pi(D + t)} \quad \checkmark$$

$$N = \frac{36 \times 60}{\pi(230 + 12) \times 10^{-3}} \quad \checkmark$$

$$= 2841,11 \text{ r/min} \quad \checkmark \quad (4)$$

9.2.2 **Power transmitted**

$$\frac{T_1}{T_2} = 2,5 \quad \checkmark$$

$$\begin{aligned} T_1 &= 2,5 \times T_2 \\ &= 2,5 \times 110 \\ &= 275 \text{ N} \quad \checkmark \end{aligned}$$

$$P = (T_1 - T_2)V \quad \checkmark$$

$$\begin{aligned} P &= (275 - 110) \times 36 \\ &= 5940 \text{ W} \\ &= 5,94 \text{ kW} \quad \checkmark \end{aligned}$$

(4)

9.3 **Hydraulics**9.3.1 **Fluid pressure**

$$A_B = \frac{\pi D^2}{4} \quad \checkmark$$

$$\begin{aligned} &= \frac{\pi \times 0.075^2}{4} \\ &= 4.42 \times 10^{-3} \text{ m}^2 \quad \checkmark \end{aligned}$$

$$P_B = \frac{F}{A_B} \quad \checkmark$$

$$\begin{aligned} &= \frac{700 \times 10}{4.42 \times 10^{-3}} \text{ Pa} \\ &= 1583710,41 \text{ Pa} \\ &= 1583,71 \text{ kPa} \quad \checkmark \end{aligned}$$

(4)

9.3.2 Effort on piston A

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

$$= \frac{\pi \times 0.04^2}{4} \quad \checkmark$$

$$= 1,256 \times 10^{-3} \text{ m}^2 \quad \checkmark$$

$$P_A = \frac{F_A}{A_A} \quad \checkmark$$

$$F_A = P_A \times A_A$$
$$= (1583,71 \times 10^3) \times (1,256 \times 10^{-3})$$
$$= 1990,10 \text{ N} \quad \checkmark$$

$$= 1,99 \text{ kN} \quad (4)$$

9.4 ABS

Prevents wheel from locking during heavy breaking. ✓✓ (2)

9.5 Seat belt

A seat belt has to be activated for its safety to be functional. ✓✓ (2)
[25]

QUESTION 10: TURBINES**10.1 Impulse Turbine**

- Waterwheel ✓
- Pelton ✓
- Turgo ✓
- Michell – Banki/Crossflow/Ossberger ✓
- Jonval turbine ✓
- Reverse overshot waterwheel ✓
- Archimedes' screw turbine ✓

(Any 2 x 1) (2)**10.2 Water turbine**

- 10.2.1
- Water turbine ✓
 - Kaplan-turbine ✓
 - Reaction turbine ✓

(Any 1 x 1) (1)**10.2.2 Parts**

- A – Wicket gate ✓
- B – Rotor ✓
- C – Stator ✓
- D – Shaft ✓
- E – Water-flow ✓
- F – Blades ✓

(6)**10.2.3 Advantages of water turbine**

- Low maintenance ✓
- No need for lubrication ✓
- Fewer moving parts ✓
- Environmental friendly ✓
- Cost effective ✓

(Any 2 x 1) (2)**10.3 Turbines****10.3.1 Advantage of supercharger:**

- Increases the output power of the engine. ✓
- A smaller engine fitted with a centrifugal blower delivers the same power as a larger engine. ✓
- It eliminates lack of oxygen above sea level. ✓
- Increases the volumetric efficiency of the engine. ✓
- With the aid of the intercooler both the power and the torque output of the engine are increased. ✓

(Any 2 x 1) (2)

10.3.2 Advantages of steam turbines:

- It is compact. ✓
- No lubrication is required. ✓
- Steam turbine speeds can be more accurately regulated. ✓
- A variety of fuels can be used to obtain steam. ✓
- Steam turbines are more economical. ✓
- Higher speeds can be obtained as compared to internal combustion engine. ✓
- Convert heat energy into mechanical energy. ✓

(Any 2 x 1) (2)**10.3.3 Advantages of gas turbines:**

- Very high power to weight ratio ✓
- Smaller than most reciprocating engines of the same power rate ✓
- Moves in one direction only, with far less vibration ✓
- Low operating pressures ✓
- High operating speeds ✓
- Low lubricating oil cost and consumption ✓

(Any 2 x 1) (2)**10.4 Turbo lag**

- It is a delay ✓ between pushing on the accelerator ✓ and feeling turbo kick in. ✓

**(3)
[20]****TOTAL: 200**