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:**

Reading = 50 + 1,5+ 0,49 ✓
= 51,99 mm. ✓ (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:**

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

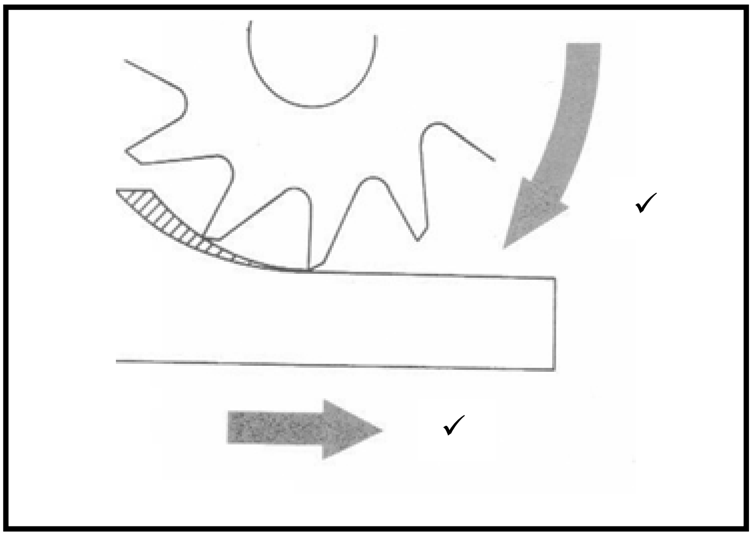
$$= \frac{40}{118} \div \frac{2}{2} \quad ✓$$

$$= \frac{20}{59} \quad ✓$$

No full turns and 20 holes in a 59-hole plate ✓ (3)

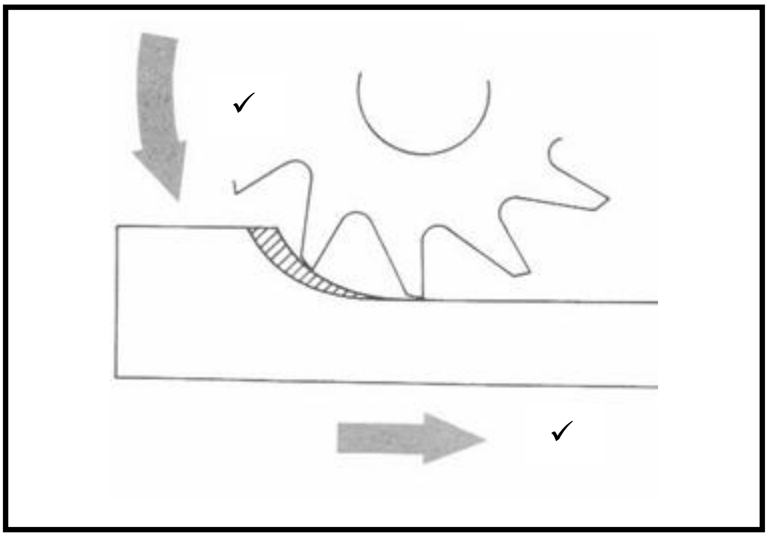
5.2 **Milling processes:**

- Up-cut milling



(2)

- Downcut milling



(2)

5.3 **Calculate: Gib head key:**

5.3.1

$$\text{Width} = \frac{D}{4}$$
$$= \frac{102}{4} \checkmark$$
$$= 25{,}5 \text{ mm} \checkmark$$
(2)

5.3.2

$$\text{Thickness} = \frac{D}{6}$$
$$= \frac{102}{6} \checkmark$$
$$= 17 \text{ mm} \checkmark$$
(2)

5.3.3

$$\text{Length} = D \times 1.5$$
$$= 102 \times 1.5 \checkmark$$
$$= 153 \text{ mm} \checkmark$$
(2)

5.3.4

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

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

5.4.5 OD = PCD + 2m
= 180 + 2(3)
= 180 + 6 ✓
= 186 mm ✓ (2)

5.4.6 Cutting depth = 2,157 m or = 2,25 m
= 2,157 x 3 ✓ = 2,25 x 3 ✓
= 6,47 mm ✓ = 6,75 mm ✓ (2)

5.4.7 Circular pitch = m x π
= 3 x π ✓
= 9,43 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**

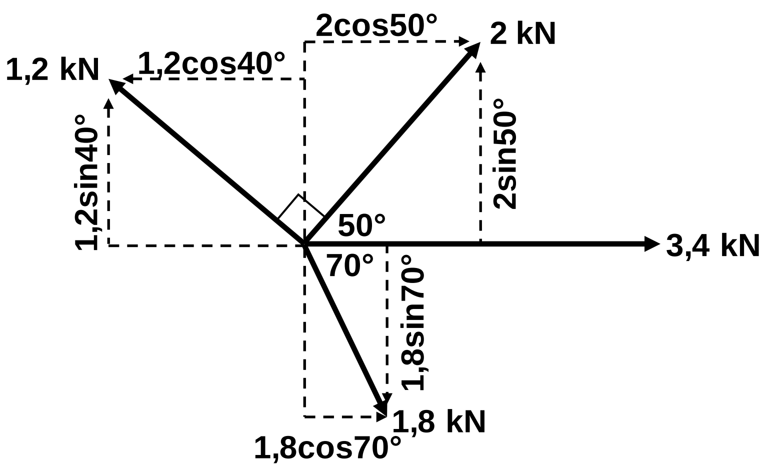
6.7.1 **Wire feed controller**
Feeds the consumable electrode wire to the welding gun at a constant predetermined speed. ✓✓ (2)

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



$$\sum HC = 3{,}4(\surd) + 1{,}8\cos 70° (\surd) - 1{,}2\cos 40° (\surd) + 2\cos 50° (\surd)$$
$$= 3{,}4 + 0{,}62 - 0{,}92 + 1{,}29$$
$$= 4{,}39 \text{ kN } (\surd)$$

$$\sum VC = 1{,}2\sin 40 (\surd) + 2\sin 50° (\surd) - 1{,}8\sin 70° (\surd)$$
$$= 0{,}77 + 1{,}53 - 1{,}69$$
$$= 0{,}61 \text{ kN } (\surd)$$

OR

Horizontal component	Magnitudes	Vertical component	Magnitudes
-1,2cos40° ✓	-0,92 kN	1,2sin40✓	0,77
3,4 ✓	3,4kN	0	0
2cos50° ✓	1,29kN	2sin50° ✓	1,53
1,8cos70° ✓	0,62kN	-1,8sin70°✓	1,69
TOTAL	**4,39kN** ✓	**TOTAL**	**0,61kN** ✓

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

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

$$R = 4{,}43\,kN \quad ✓$$

$$\text{Tan}\,\theta = \frac{VC}{HC}$$

$$= \frac{0{,}61}{4{,}39} \quad ✓$$

$$\theta = 7{,}91°$$

.......✓

$$R = 4{,}43\ N\ \text{at}\ 7{,}91°\ \text{north of east}$$

(13)

7.2 Stress and Strain

7.2.1 **Stress:**

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

$$A = \frac{\pi\left(0{,}098^2 - 0{,}067^2\right)}{4}$$

$$= 4{,}02 \times 10^{-3}\ m^2 \quad ✓$$

$$\sigma = \frac{F}{A} \quad ✓$$

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

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

$$\sigma = 9{,}95\ MPa \quad ✓$$

(5)

7.2.2 **Strain:**

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

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

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

$$\text{or}\ 1{,}11 \times 10^{-4} \quad ✓$$

(3)

7.2.3 **Change in length**

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

$$\Delta l = \varepsilon \times ol \checkmark$$

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

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

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

(3)

7.3 **Moments**

Calculate A. Moments about B

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

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

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

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

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

Calculate B. Moments about A

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

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

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

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

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

(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

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

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

$$N_{IOUTPUT} = \frac{18 \times 16}{36 \times 46} \times 1660 \quad ✓$$

$$= 288{,}70 \text{ r/min} \quad ✓$$

(3)

9.2.2 Velocity Ratio

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

$$= \frac{1660}{288{,}70} \quad ✓$$

$$= 5{,}75 : 1 \quad ✓$$

(2)

9.2 Belt Drives

9.2.1 Rotation frequency of the driver pulley

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

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

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

$$= 2841{,}11 \text{r/min} \quad ✓$$

(4)

9.2.2 **Power transmitted**

$$\frac{T_1}{T_2} = 2,5 \quad ✓$$

$$T_1 = 2,5 \times T_2$$
$$= 2,5 \times 110$$
$$= 275\ \text{N} \quad ✓$$

$$P = (T_1 - T_2)V \quad ✓$$
$$P = (275 - 110) \times 36$$
$$= 5940\ \text{W}$$
$$= 5,94\ \text{kW} \quad ✓$$

(4)

9.3 **Hydraulics**

9.3.1 **Fluid pressure**

$$A_B = \frac{\pi D^2}{4} \quad ✓$$
$$= \frac{\pi \times 0.075^2}{4}$$
$$= 4.42 \times 10^{-3}\ \text{m}^2 \quad ✓$$

$$P_B = \frac{F}{A_B} \quad ✓$$
$$= \frac{700 \times 10}{4.42 \times 10^{-3}}\ \text{Pa}$$
$$= 1583710,41\text{Pa}$$
$$= 1583,71\ \text{kPa} \quad ✓$$

(4)

9.3.2 **Effort on piston A**

$$A_A = \frac{\pi D^2}{4} \checkmark$$
$$= \frac{\pi \times 0.04^2}{4}$$
$$= 1,256 \times 10^{-3}\ m^2 \checkmark$$

$$P_A = \frac{F_A}{A_A} \checkmark$$
$$F_A = P_A \times A_A$$
$$= (1583,71 \times 10^3) \times (1,256 \times 10^{-3})$$
$$= 1990,10\ N \checkmark$$
$$= 1,99\ kN$$

(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 – Wicked 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