![basic education Department: Basic Education REPUBLIC OF SOUTH AFRICA]

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2018

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

[20]

QUESTION 2: SAFETY

2.1 **Spring tester**
- Use correct attachments of the valve spring tester to compress the spring. ✓
- Do not exceed the prescribed pressure. ✓
- Ensure that the spring does not slip out. ✓

(ANY 2 x 1) (2)

2.2 **Welding helmet**
- To protect your eyes against the dangerous ultra-violet rays. ✓
- To protect your skin against the dangerous ultra-violet rays. ✓
- To protect your eyes against the sparks. ✓
- To protect your skin against the sparks. ✓

(ANY 1 x 1) (1)

2.3 **Spot welding**
- To prevent the electrodes from overheating. ✓ (1)

2.4 **Testers**

    2.4.1 **Brinell tester**
- The tester must be mounted on the rigid spot on a workbench ✓
- The force must be applied at an angle of 90° to the test piece ✓
- Do not exceed the prescribed load ✓
- Make sure the test piece is placed securely into position ✓

(ANY 1 x 1) (1)

    2.4.2 **Tensile tester**
- Make sure all safety guards are in place ✓
- Do not exceed the prescribed load ✓
- See that the test piece is securely placed in position ✓
- Make sure the dial indicator is mounted properly ✓

(ANY 1 x 1) (1)

    2.4.3 **Torsion tester**
- Fasten the tester to the workbench ✓
- When you add pieces of different mass, you should attach them very gently otherwise you could get a skew reading of the torsion on the rod ✓
- Get specification (torsion) of the different materials and of the size rods you would like test ✓

(ANY 1 x 1) (1)

2.5 **Bearing puller**
- Perpendicular or 90° to the bearing. ✓ (1)

2.6   **Cylinder leakage tester**

    2.6.1
- To prevent damage to the seals and tester ✓
- To ensure the correct reading ✓

                                                       (ANY 1 x 1)   (1)

    2.6.2
- To prevent damage to the tester and spark plug hole or injector hole ✓
- To ensure the correct reading ✓

                                                       (ANY 1 x 1)   (1)
                                                              [10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 **Testers**

3.1.1 **Cylinder leakage tester**
- Is used to determine a leakage in the cylinder✓.
- Determine the volume of leakage✓ (2)

3.1.2 **Fuel pressure tester**
- Is used to test the fuel operating pressure in the system ✓
- Is used to test the fuel pressure in the fuel line that runs to the direct injection. ✓ (2)

3.1.3 **Torsion tester**
- Is used to investigate the relationship between momentum or torque applied to material ✓
- Is used to investigate influence of material length on torsional deflection. ✓ (2)

3.2 **Reasons for high CO_2 reading**
- Lean fuel mixture setting ✓
- Low compression ✓
- Faulty high tension leads ✓

(ANY 2 x 1) (2)

3.3 **MIGS/MAGS-welding**

3.3.1 **Reasons for using inert gas during MIGS/MAGS welding**
- Stabilises the arc on the parent metal ✓
- Shields the arc and weld pool from atmospheric gases like oxygen ✓ (2)

3.3.2 **Advantages of MIGS/MAGS welding**
- Can weld in any position ✓
- Less operator skill required ✓
- Continuous welding can be done ✓
- Causes less deformation ✓
- Faster than arc welding ✓
- Minimal post weld cleaning ✓
- No slag removal is required ✓

(ANY 2 x 1) (2)
[12]

QUESTION 4: MATERIALS

4.1 **Characteristics of structures**

    4.1.1 **Austenite**
- Soft ✓
- Coarse grain structure ✓
- Non-magnetic ✓

    (ANY 2 x 1) (2)

    4.1.2 **Ferrite**
- Soft ✓
- Ductile ✓
- Magnetic ✓

    (ANY 2 x 1) (2)

4.2 **Iron-carbon equilibrium diagram**

    4.2.1 **Lower critical point (AC_1) of steel**
- The structure starts to change ✓✓ (2)

    4.2.2 **Higher critical point (AC_3) of steel**
- The structure turns into complete Austenite ✓✓
- The steel completely loses its magnetic properties ✓✓
- The structure turns into its finest grain size ✓✓

    (ANY 1 x 2) (2)

4.3 **Reasons to enhance properties of a crankshaft**
- To produce a hard face with a tough core. ✓
- To induce toughness ✓ (2)

4.4 **Reasons for the tempering of a camshaft**
- To increase the lifespan of the camshaft ✓
- To eliminate brittleness caused by hardening. ✓

    (ANY 2 x 1) (2)

4.5 **Heat treatment process on piston rings**
- Hardening ✓ (1)

[13]

QUESTION 5: TERMONOLOGY

5.1 **Key dimensions**

5.1.1 **The width of the key**

$$Width = \frac{D}{4}$$
$$= \frac{120}{4} \quad ✓$$
$$= 30 \ mm \quad ✓$$

(2)

5.1.2 **The thickness of the key**

$$Thickness = \frac{D}{6}$$
$$= \frac{120}{6} \quad ✓$$
$$= 20 \ mm \quad ✓$$

(2)

5.1.3 **The length of the key**

$$Length = D \times 1.5 \quad ✓$$
$$= 120 \times 1.5$$
$$= 180 \ mm \quad ✓$$

(2)

5.2 **Indexing**

$$Indexing = \frac{40}{n}$$
$$= \frac{40}{124} \div \frac{2}{2} \quad ✓$$
$$= \frac{20}{62} \quad ✓$$

No full turns and 20 holes in a 62 hole circle ✓

(3)

5.3 **Height of screw the screw thread**

$$H = 0.866P$$
$$= 0.866 \times 3 \quad ✓$$
$$= 2.6 \ mm \quad ✓$$

(2)

5.4   **Gear terminology**

5.4.1   Addendum   = m
                        = 3 mm ✓   (1)

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

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

5.4.4
$$Module = \frac{PCD}{T}$$
$$PCD = m \times T \quad ✓$$
$$= 3 \times 48$$
$$= 144 mm \quad ✓$$
                                                                                                    (2)

5.4.5   OD = PCD + 2m   ✓
               = 144 + 2(3)
               = 144 + 6
               = 150 mm   ✓   (2)

5.4.6   Cutting depth = 2,157 m ✓   or   =2,25m   ✓
                        = 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
                         = 9,42 mm ✓   (2)

5.5   **Setting of the lathe and cutting tool to cut a metric V-screw thread:**
- Set the lathe to the correct speed for screw cutting ✓
- Set the lead screw according to the required pitch ✓
- Set the dial gauge to position with the required worm gear ✓
- Set the compound slide to half the included angle of the thread (30°) ✓
- Set the cutting tool centre height and 90° to the work piece with the help of a centre gauge ✓
- Set cross slide and compound slide collars to zero with the tool touching the work piece ✓   (6)

[30]

QUESTION 6: JOINING METHODS

6.1 **Welding defects**

    6.1.1 **Slag inclusion**
- Welding speed too fast ✓
- Not removing the slag from the previous weld run before welding the next run ✓
- Current too low ✓

                                                                 (ANY 2 x 1) (2)

    6.1.2 **Incomplete penetrations**
- Welding speed too fast ✓
- Faulty joint design ✓
- Electrode too large ✓
- Current too low ✓

                                                                 (ANY 2 x 1) (2)

6.2 **Atmospheric contamination during MIGS/MAGS welding**
- Inadequate shielding gas flow ✓
- Excessive shielding gas flow ✓
- Severely clogged nozzle ✓
- Damaged gas supply system ✓
- Excessive wind in the welding area ✓

                                                                 (ANY 2 x 1) (2)

6.3 **Nick break test**
- Make a hacksaw cut at both edges, through the centre of the weld ✓
- Place the saw-nicked specimen on two steel supports ✓
- Use a sledge hammer to break the specimen by striking it in the zone where you made the saw cuts ✓
- Defects like incomplete fusion, slag inclusion and brittleness will be exposed in the break ✓
- Any defects bring it to the attention to the welder to rectify it ✓ (5)

6.4 **Reasons for destructive tests**

    6.4.1 **Bend test**
To determine the ductility/elongation ✓✓ of the weld metal. (2)

    6.4.2 **Machinability test**
To determine the welds hardness ✓ and its strength. ✓ (2)

6.5 **X-ray test**
To detect internal defects in the weld metal ✓✓ (2)

6.6   **Weld crater**

Forms where welding is resumed at the bottom of the previous weld instead
of on the top ✓✓   (2)

6.7   **MIGS/MAGS welding**

6.7.1   **Welding process**
        MIGS/MAGS welding ✓   (1)

6.7.2   **Labelling**
        A.   Parent metal ✓
        B.   Arc ✓
        C.   Electrode wire ✓
        D.   Gas shroud ✓
        E.   Shielding gas ✓   (5)
                                                                        [25]

QUESTION 7: FORCES

7.1   **Resultant**
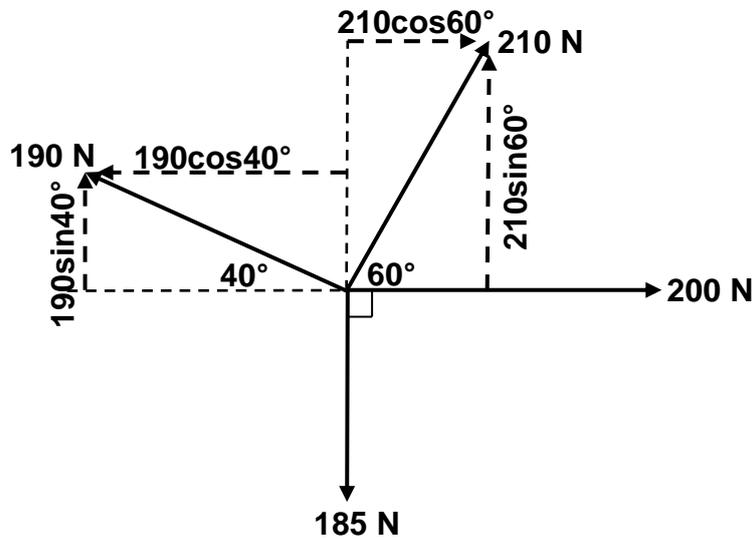
$$\Sigma HC = 200 + 210\cos 60 - 190\cos 40°$$ ✓✓✓
$$= 200 + 105 - 145.55$$
$$= 159,45\,N$$ ✓   (4)

$$\Sigma VC = 210\sin 60° + 190\sin 40° - 185$$ ✓✓
$$= 181,87 + 122,13 - 185$$
$$= 119\,N$$ ✓   (3)

OR

Horizontal components	Magnitudes	Vertical components	Magnitudes
200N	200 N ✓	210NSin60^0	181,87N ✓
210N	105 N ✓	190NSin40^0	122,13 N ✓
190N Cos40^0	-145,45 N ✓	-185 N	-185 N
TOTAL	**159,45 N** ✓	**TOTAL**	**119 N** ✓

$$E^2 = HC^2 + VC^2$$
$$E = \sqrt{159{,}45^2 + 119^2}$$ ✓
$$E = 198{,}96 \ N$$ ✓

(3)

$$Tan \ \theta = \frac{VC}{HC}$$ ✓

$$= \frac{119}{159{,}45}$$

$$= 36{,}73°$$ ✓

$$E = 198{,}96N \ 36{,}73° \ south \ of \ west$$

OR

$$= 36° \ 44' \ minutes \ south \ of \ west$$ ✓
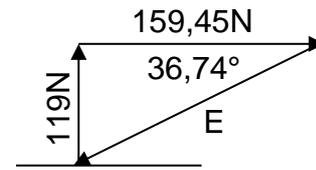
(3)

7.2 **Stress and Strain**

7.2.1 **Resistance area**

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

$$= \frac{\pi(0.056^2 - 0.038^2)}{4}$$

$$= 1.33 \times 10^{-3} \, m^2 \qquad \checkmark \tag{2}$$

7.2.2 **Stress**

$$Stress = \frac{force}{area} \qquad \checkmark$$

$$Stress = \frac{20 \times 10^3}{1.33 \times 10^{-3}} \qquad \checkmark$$

$$= 15037593.98 \, Pa$$

$$Stress = 15.04 \, MPa \qquad \checkmark \tag{3}$$

7.2.3 **Strain**

$$Strain = \frac{\Delta l}{OL} \qquad \checkmark$$

$$Strain = \frac{50 - 49.975}{50} \qquad \checkmark$$

$$Strain = \frac{0.025}{50}$$

$$= 0.5 \times 10^{-3} \qquad \checkmark \tag{3}$$

7.2.4 **Young's Modulus of Elasticity**

$$Youngs \, Modulus \, of \, Elasticity = \frac{Stress}{Strain} \qquad \checkmark$$

$$E = \frac{15.04 \times 10^6}{0.5 \times 10^{-3}} \qquad \checkmark$$

$$= 30.08 \times 10^9 \, Pa$$

$$= 30.08 \, GPa \qquad \checkmark \tag{3}$$

7.3 **Moments**

7.3
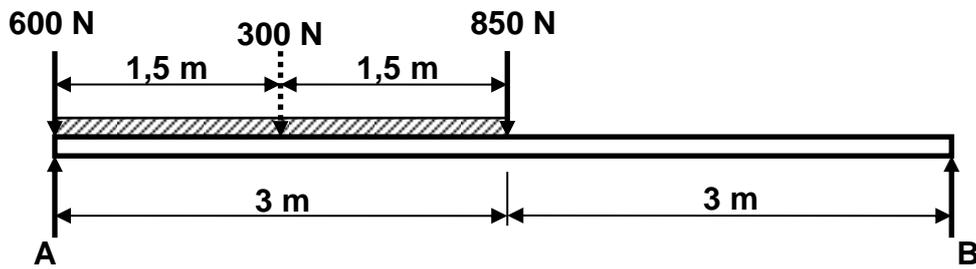
Calculate B. Moments about A:

$$\sum LHM = \sum RHM \qquad \checkmark$$
$$(B \times 6) = (300 \times 1{,}5) + (850 \times 3) \qquad \checkmark$$
$$\frac{6B}{6} = \frac{3000}{6}$$
$$B = 500\,N \qquad \checkmark$$

Calculate A. Moments about B:

$$\sum RHM = \sum LHM \qquad \checkmark$$
$$(A \times 6) = (850 \times 3) + (300 \times 4{,}5) + (600 \times 6) \qquad \checkmark$$
$$6A = 2550 + 1350 + 3600$$
$$\frac{6A}{6} = \frac{7500}{6}$$
$$A = 1250\,N \qquad \checkmark$$

(6)
[30]

QUESTION 8: MAINTENANCE

8.1 **Reason using SAE 20W50**
This to ensure that the oil is able to satisfy the operational ✓ requirements over a range of temperature ✓ from start-up to running hot. (2)

8.2 **Maintain V-belt drive systems**
- Check the contact surfaces of the pulley to prevent the belt from being damaged.✓
- Check the belt condition and replace if it is worn. ✓
- Correct installation procedure must be followed. ✓
- Belt drives should be well guarded to prevent foreign objects to come into contact with the belts and pulleys. ✓
- Keep guard mesh free of papers, rags, etc. that can cause insufficient air flow. ✓
- Check that the belt deflection is according to specification. ✓
- Store replacement belts in a cool, well ventilated place. ✓
- Correct alignment of pulleys. ✓

(ANY 2 x 1) (2)

8.3 **Flash point**
It is the lowest temperature ✓ at which the oil gives off vapours ✓ which can ignite. ✓ (3)

8.4 **Maintaining cutting fluid**
- Avoid contamination of the cutting fluid by draining and regularly replacing it. ✓
- Always clean the machine's splash tray of metal cutting after use. ✓
- Regularly wipe cutting fluid splashes of machine parts. ✓
- Ensure that the sump is topped up from time to time and check that there is sufficient flow of cutting fluid to the cutting tool. ✓

(ANY 2 x 1) (2)

8.5 **Functions of the clutch plate**
- It provides friction between the flywheel and pressure plate. ✓
- It serves as a link between the clutch and the gearbox main shaft. ✓ (2)

8.6 **Reasons for skimming the flywheel**
- To remove the grooves caused by the clutch plate. ✓
- To ensure a full contact surface between the flywheel and the clutch plate. ✓
- To prolong the life of the clutch plate. ✓

(ANY 2 x 1) (2)

8.7   **Properties of grease**
   - It must be water resistant, it must not mix with water ✓
   - Prevents rust/corrosion ✓
   - Good for load pressures ✓
   - High melting point ✓
   - Low freezing point ✓
   - Prevent gumming ✓
   - Be able to lubricate ✓
   - High viscosity ✓

(ANY 2 x 1)   (2)
[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1 **Gear drives**

9.1.1 **Rotation frequency of input shaft**

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

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

$$= \frac{36 \times 46 \times 80 \times 160}{20 \times 18 \times 42} \qquad \checkmark$$

$$= 1401{,}90 \, r/\min \qquad \checkmark \qquad\qquad (3)$$

9.1.2 **Velocity ratio**

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

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

$$= 8{,}76{:}1 \qquad \checkmark \qquad\qquad (2)$$

9.2 **Belt drives**

9.2.1 **Rotation frequency of driver pulley**

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

$$N_{DR} = \frac{N_{DN} \times D_{DN}}{D_{DR}} \qquad \checkmark$$

$$= \frac{733,33 \times 0,36}{0,24} \qquad \checkmark$$

$$= 2000\, r/\min \qquad \checkmark \qquad (3)$$

9.2.2 **Power transmitted**

$$P = \frac{(T_1 - T_2)\pi Dn}{60}$$

$$P = \frac{(360 - 90)\pi \times 0,36 \times 733,33}{60} \qquad \checkmark$$

$$= 3732,20\, Watts$$

$$= 3,73\, kW \qquad \checkmark \qquad (2)$$

9.2.3 **Belt speed**

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

$$= \frac{\pi \times 0,36 \times 733,33}{60} \qquad \checkmark$$

$$= 13,83\, m.s^{-1} \qquad \checkmark \qquad (2)$$

9.3   **Hydraulics**

9.3.1   **Fluid pressure**

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

$$= \frac{\pi 0,04^2}{4} \qquad \checkmark$$

$$= 1,26 \times 10^{-3} \, m^2 \qquad \checkmark$$

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

$$= \frac{275}{1,26 \times 10^{-3}} \qquad \checkmark$$

$$= 218253,97 \, Pa$$

$$or \qquad \checkmark$$

$$= 218,25 \, kPa \qquad \qquad (5)$$

9.3.2   **Diameter of piston B**

$$P_B = P_A$$

$$P_B = \frac{F_B}{A_B}$$

$$A_B = \frac{F_B}{P_B} \qquad \checkmark$$

$$A_B = \frac{5,56 \times 10^3}{218,25 \times 10^3}$$

$$A_B = 25,48 \times 10^{-3} m^2 \qquad \checkmark$$

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

$$D_B = \sqrt{\frac{A_B \times 4}{\pi}}$$

$$= \sqrt{\frac{25,48 \times 10^{-3} \times 4}{\pi}} \qquad \checkmark$$

$$= 0,18 \, m$$

$$or \qquad \checkmark$$

$$= 180 \, mm \qquad \qquad (4)$$

9.4 **ABS**
ABS prevents wheels from skidding ✓ when breaking hard ✓ in difficult
conditions. (2)

9.5 **ECU**
Electronic Control Unit ✓ (1)

9.6 **Traction Control**
- Prevent wheels from spinning. ✓
- Improves road holding ✓

(ANY 1 x 1) (1)
[25]

QUESTION 10: TURBINES

10.1 **Reaction turbines**
- Francis ✓
- Kaplan ✓
- Tyson ✓
- Gorlov ✓ **(ANY 2 x 1)** (2)

10.2 **Supercharger boost**
Boost refers to the increase in intake manifold pressure ✓ that exceeds normal atmospheric pressure ✓ (2)

10.3 **Blowers**
- Roots ✓
- Centrifugal ✓
- Vane-type ✓
- Twin screw type ✓

(ANY 2 x 1) (2)

10.4 **Gas turbine**
A = Clean air inlet ✓
B = Compression ✓
C = Combustion ✓
D = Exhaust ✓
E = Turbine ✓
F = Combustion chamber ✓ (6)

10.5 **Application of a gas turbine**
- Jet engines ✓
- Naval ships ✓
- Hi-performance vehicles and boats ✓
- Generating electricity ✓

(ANY 2 x 1) (2)

10.6 **Advantages of a gas turbine**
- Less complex than internal combustion piston engines ✓
- Only one moving part (Common shaft for: compressor and turbine) ✓
- Operate at higher revolutions per minute ✓ **(ANY 2 x 1)** (2)

10.7 **Waste gate**
A waste gate is a valve that diverts exhaust gases away from the turbine wheel ✓ to regulate the turbine/compressor speed and boost. ✓ (2)

10.8 **Oil cooler**
To cool the oil ✓ that lubricates the turbocharger bearings and shaft. ✓ (2)

[20]

TOTAL: 200