



# **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)         |
|      |     | <b>[20]</b> |

**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<sub>2</sub> 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**

$$\begin{aligned}
 \text{Width} &= \frac{D}{4} \\
 &= \frac{120}{4} && \checkmark \\
 &= 30 \text{ mm} && \checkmark
 \end{aligned}$$

(2)

**5.1.2 The thickness of the key**

$$\begin{aligned}
 \text{Thickness} &= \frac{D}{6} \\
 &= \frac{120}{6} && \checkmark \\
 &= 20 \text{ mm} && \checkmark
 \end{aligned}$$

(2)

**5.1.3 The length of the key**

$$\begin{aligned}
 \text{Length} &= D \times 1.5 && \checkmark \\
 &= 120 \times 1.5 \\
 &= 180 \text{ mm} && \checkmark
 \end{aligned}$$

(2)

**5.2 Indexing**

$$\begin{aligned}
 \text{Indexing} &= \frac{40}{n} \\
 &= \frac{40}{124} \div \frac{2}{2} && \checkmark \\
 &= \frac{20}{62} && \checkmark
 \end{aligned}$$

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

(3)

**5.3 Height of screw the screw thread**

$$\begin{aligned}
 H &= 0.866P \\
 &= 0.866 \times 3 && \checkmark \\
 &= 2.6 \text{ mm} && \checkmark
 \end{aligned}$$

(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  $Module = \frac{PCD}{T}$   
 $PCD = m \times T$  ✓  
= 3 x 48 ✓  
= 144mm ✓ (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  $\pi$  ✓  
= 3 x  $\pi$   
= 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 ✓

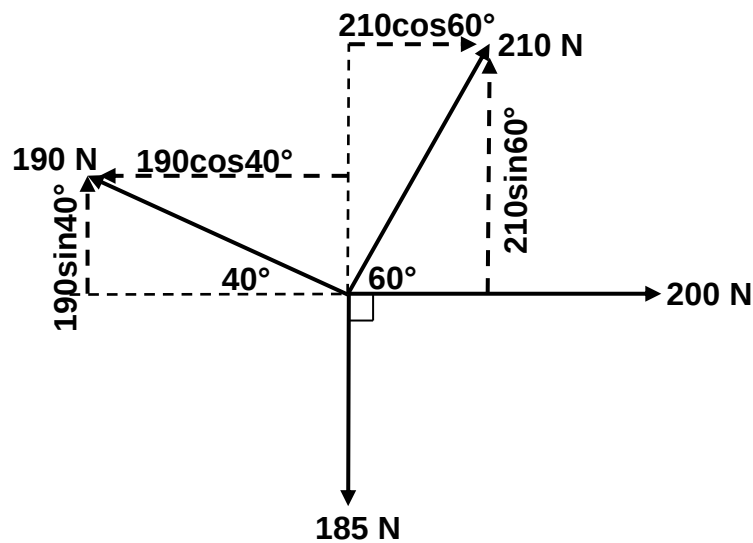
(1)

**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**

$$\begin{aligned}\Sigma HC &= 200 + 210 \cos 60^\circ - 190 \cos 40^\circ \\ &= 200 + 105 - 145,55 \\ &= 159,45 \text{ N}\end{aligned}$$

✓✓✓

✓

(4)

$$\begin{aligned}\Sigma VC &= 210 \sin 60^\circ + 190 \sin 40^\circ - 185 \\ &= 181,87 + 122,13 - 185 \\ &= 119 \text{ N}\end{aligned}$$

✓✓

✓

(3)

**OR**

| Horizontal components         | Magnitudes        | Vertical components           | Magnitudes     |
|-------------------------------|-------------------|-------------------------------|----------------|
| 200N                          | 200 N ✓           | $210 \text{ N Sin } 60^\circ$ | 181,87N ✓      |
| 210N                          | 105 N ✓           | $190 \text{ N Sin } 40^\circ$ | 122,13 N ✓     |
| $190 \text{ N Cos } 40^\circ$ | -145,45 N ✓       | -185 N                        | -185 N         |
| <b>TOTAL</b>                  | <b>159,45 N ✓</b> | <b>TOTAL</b>                  | <b>119 N ✓</b> |

$$E^2 = HC^2 + VC^2$$

$$E = \sqrt{159,45^2 + 119^2}$$

$$E = 198,96 \text{ N}$$

$$\tan \theta = \frac{VC}{HC}$$

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

$$= 36,73^\circ$$

$$E = 198,96 \text{ N } 36,73^\circ \text{ south of west}$$

OR

$$= 36^\circ 44' \text{ minutes south of west}$$

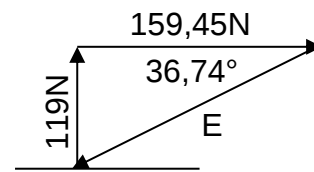
✓

✓

✓

✓

✓



(3)

**7.2 Stress and Strain****7.2.1 Resistance area**

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

$$= \frac{\pi(0,056^2 - 0,038^2)}{4}$$

$$= 1,33 \times 10^{-3} m^2 \quad \checkmark \quad (2)$$

**7.2.2 Stress**

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

$$Stress = \frac{20 \times 10^3}{1,33 \times 10^{-3}} \quad \checkmark$$

$$= 15037593,98 Pa$$

$$Stress = 15,04 MPa \quad \checkmark \quad (3)$$

**7.2.3 Strain**

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

$$Strain = \frac{50 - 49,975}{50} \quad \checkmark$$

$$Strain = \frac{0,025}{50}$$

$$= 0,5 \times 10^{-3} \quad \checkmark \quad (3)$$

**7.2.4 Young's Modulus of Elasticity**

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

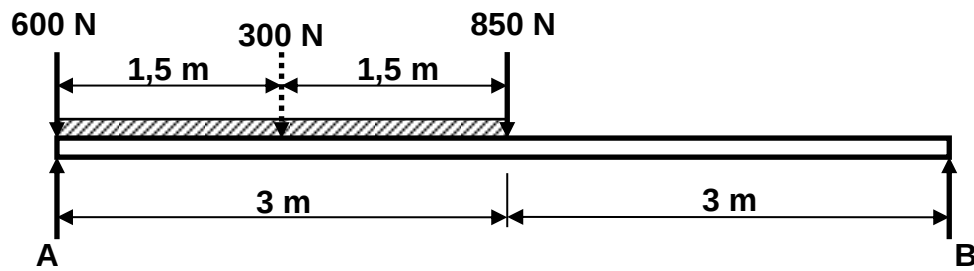
$$E = \frac{15,04 \times 10^6}{0,5 \times 10^{-3}} \quad \checkmark$$

$$= 30,08 \times 10^9 Pa$$

$$= 30,08 GPa \quad \checkmark \quad (3)$$

## 7.3 Moments

7.3

**Calculate B. Moments about A:**

$$\sum LHM = \sum RHM \quad \checkmark$$

$$(B \times 6) = (300 \times 1,5) + (850 \times 3) \quad \checkmark$$

$$\frac{6B}{6} = \frac{3000}{6}$$

$$B = 500 \text{ N} \quad \checkmark$$

**Calculate A. Moments about B:**

$$\sum RHM = \sum LHM \quad \checkmark$$

$$(A \times 6) = (850 \times 3) + (300 \times 4,5) + (600 \times 6) \quad \checkmark$$

$$6A = 2550 + 1350 + 3600$$

$$\frac{6A}{6} = \frac{7500}{6}$$

$$A = 1250 \text{ N} \quad \checkmark$$

(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**

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

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

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

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

**9.1.2 Velocity ratio**

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

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

$$= 8,76:1 \quad \checkmark \quad (2)$$

**9.2 Belt drives****9.2.1 Rotation frequency of driver pulley**

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

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

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

$$= 2000 \text{ r/min} \quad \checkmark$$

(3)

**9.2.2 Power transmitted**

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

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

$$= 3732,20 \text{ Watts}$$

$$= 3,73 \text{ kW} \quad \checkmark$$

(2)

**9.2.3 Belt speed**

$$\text{Belt speed} = \frac{\pi D N}{60}$$

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

$$= 13,83 \text{ m.s}^{-1} \quad \checkmark$$

(2)

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

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

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

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

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

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

$$= 218253,97 \text{ Pa}$$

$$\text{or} \quad \checkmark$$

$$= 218,25 \text{ kPa} \quad (5)$$

**9.3.2 Diameter of piston B**

$$P_B = P_A$$

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

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

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

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

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

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

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

$$= 0,18 \text{ m}$$

$$\text{or} \quad \checkmark$$

$$= 180 \text{ mm} \quad (4)$$

- 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**