basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2012

MEMORANDUM

MARKS: 200

This memorandum consists of 17 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

QUESTION 2: TOOLS AND EQUIPMENT

2.1 **Causes of low compression:**

- Worn cylinders ✓
- Worn compression rings ✓
- Worn piston ✓
- Worn valves ✓
- Worn head gasket ✓

(Any 3 x 1) (3)

2.2 **Torsion:**

Torsion is the twisting action in a member ✓
caused by two opposing moments along the longitudinal axis. ✓ (2)

2.3 **Multimeter:**

A – LCD display screen ✓
B – Range selector switch ✓
C – 10 A DC terminal socket (Input terminal) ✓
D – VΩmA terminal socket (Input Terminal) ✓
E – Common terminal socket ✓ (5)

2.4 **Cylinder leakage tester:**

- Listen at the carburettor and/or inlet manifold for hissing noise. ✓
  (inlet valve is leaking) ✓
- Listen to the exhaust pipe or exhaust manifold for a hissing noise. ✓
  (exhaust pipe is leaking) ✓
- Listen for hissing noise in the dipstick hole. ✓
  (piston rings worn) ✓
- Remove the filler cap on the tappet cover and listen for hissing noise. ✓
  (rings are worn) ✓
- If you see bubbles in the radiator water, ✓
  (the cylinder head gasket is blown or the cylinder block is cracked) ✓

(Any 3 x 2) (6)

2.5 **MAGS/MIGS – meaning**

- MAGS: Metal Arc Gas Shielded ✓
- MIGS: Metal Inert Gas Shielded ✓ (2)

2. 6 **MAGS/MIGS gases**

- Argon ✓
- CO_2 ✓
- Helium ✓

(Any 2 x 1) (2)
[20]

QUESTION 3: MATERIALS

3.1 **Non-ferrous materials and composites:**

- Non-ferrous Metals are metallic and composites are non-metallic. ✓✓
- Non-ferrous metals are original substances and composites are combinations of two or more materials. ✓✓

(Any 1 x 2) (2)

3.2 **Compressive strength test:**

3.2.1 Material A has the highest compressive strength. ✓ (1)

3.2.2 The material that can resist a large compression force will have little deformation or compression, and has a higher compressive strength. ✓✓ (2)

3.3 **Carbon steel:**

- Low-carbon steel ✓
- Medium-carbon steel ✓
- High-carbon steel ✓ (3)

3.4 **Carbon steel – properties:**

- Greater hardness is obtained ✓
- Tensile strength is increased ✓
- Ductility is decreased ✓
- Welding ability is decreased ✓ (4)

3.5 **Uses and properties of engineering materials:**

3.5.1 **Uses of Duralumin:**

It is used to make the following:

- Bars ✓
- Sheets ✓
- Piston rods ✓
- Tubes ✓
- Rivets ✓
- Motorcar and aircraft parts ✓

(Any 2 x 1) (2)

Properties of Duralumin:

- o Lightweight ✓
- o High tensile strength ✓
- o Good resistance to corrosion ✓
- o Hardens with age ✓

(Any 2 x 1) (2)

3.5.2 **Uses of PVC:**

It is used to make:

- Pipes and fittings ✓
- Cable and services ducting ✓
- Roofing and ceiling systems and membranes ✓
- Healthcare materials ✓
- Automotive industry materials ✓

(Any 2 x 1) (2)

Properties of PVC:

- Lightweight ✓
- Weather resistant ✓
- Rigid or flexible ✓
- Clear or coloured ✓
- Good electrical insulator ✓
- Good resistance to corrosion ✓

(Any 2 x 1) (2)
[20]

QUESTION 4: SAFETY, TERMINOLOGY AND JOINING METHODS

4.1 **Beam bending tester:**

- Make sure that the object to be tested is firmly secured. ✓
- Make sure that all the holding devices are properly fitted. ✓
- Check components of tester for wear. ✓
- Check for leaks at the hydraulic pump ram and hose. ✓
- Make sure that the tester is clean and free from oil and grease. ✓

(Any 3 x 1) (3)

4.2 **Gas cylinders:**

- Store full cylinders apart from empty cylinders. ✓
- Keep in cool, dry place away from sunlight. ✓
- Acetylene cylinders should be stored in an upright position. ✓
- Oxygen cylinders should be stored away from acetylene cylinders. ✓
- Do not allow cylinders to fall. ✓
- No oil and grease should come into contact with oxygen cylinders and fittings. ✓

(Any 3 x 1) (3)

4.3 **Milling operations:**

4.3.1 **Upcut milling:**

- Less vibration occurs. ✓
- Less strain on the cutter and arbor. ✓
- There is positive pressure on the feed screw spindle and its nuts because of the direction of the cutter. ✓
- A coarser feed may be used. ✓

(Any 2 x 1) (2)

4.3.2 **Down-cut milling:**

- Deeper cuts can be made because the force of the cutter is downwards. ✓
- A finer finish is obtained. ✓ (2)

4.4 **Indexing:**

4.4.1

$$\text{Indexing} = \frac{40}{A} \quad ✓$$

$$= \frac{40}{60} \quad ✓$$

$$= \frac{4 \times 4}{6 \times 4} \quad ✓$$

$$= \frac{16}{24} \text{ or } \frac{20}{30} \text{ or } \frac{26}{39} \text{ or } \frac{28}{42} \text{ or } \frac{34}{51} \text{ or } \frac{36}{54} \text{ or } \frac{44}{66} \quad ✓$$

16 holes on the 24-hole circle or
20 holes on the 30-hole circle or
26 holes on the 39-hole circle or
28 holes on the 42-hole circle or
34 holes on the 51-hole circle or
36 holes on the 51-hole circle or
44 holes on the 44-hole circle (4)

4.4.2

$$\frac{D_r}{D_v} = (A - n) \times \frac{40}{A} \quad OR \quad \frac{D_r}{D_v} = (N - n) \times \frac{40}{N} \quad ✓$$

$$\frac{D_r}{D_v} = (60 - 63) \times \frac{40}{60} \qquad \frac{D_r}{D_v} = (60 - 63) \times \frac{40}{60} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{-120}{60} \qquad \frac{D_r}{D_v} = \frac{-120}{60} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{-12 \times 4}{6 \times 4} \qquad \frac{D_r}{D_v} = \frac{-12 \times 4}{6 \times 4} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{-48}{24} \text{ or } \frac{56}{28} \text{ or } \frac{64}{32} \qquad \frac{D_r}{D_v} = \frac{-48}{24} \text{ or } \frac{56}{28} \text{ or } \frac{64}{32} \quad ✓$$ (5)

4.5 Cutting feed:

$V = \pi DN$ ✓

$N = \dfrac{V}{\pi D}$ ✓

$N = \dfrac{20}{\pi \times 0{,}08}$ ✓

$N = 79{,}577 \text{ r/min}$ ✓

$f = f_1 \times T \times N$ ✓

$f = 0{,}08 \times 14 \times 79{,}577$ ✓

$f = 89{,}13 \text{ mm/min}$ ✓ (7)

4.6 Ultrasonic test:

- A high frequency sound wave is send into the metal for a very short period of 1 to 3 microseconds. ✓
- The same unit which was used to send the sound wave then acts as a receiver to listen to the ultrasonic waves it reflected through the metal. ✓
- This cycle is repeated from one to five million times per second.
- The oscilloscope is calibrated only to pick up defects of a size that would be considered harmful. ✓
- The oscilloscope wave pattern is also calibrated to show the distance between the searching unit and any defects found. ✓

(5)

4.7 Weld defects:

4.7.1 Slag inclusion:

Causes:

- Included angle too narrow ✓
- Rapid cooling ✓
- Welding temperature too low ✓
- High viscosity of molten metal. ✓
- Welding second run without removing slag ✓

(Any 2 x 1) (2)

Prevention:

- Increase the included angle. ✓
- Let the welded metal cool slowly ✓
- Pre-heat the metal ✓
- Remove slag before welding a second run ✓

(Any 1 x 1) (1)

4.7.2 **Undercutting:**

Causes:

- Faulty electrode manipulation ✓
- Arc length too long ✓
- Current too high ✓
- Welding speed too fast ✓

(Any 2 x 1) (2)

Prevention:

- Use a uniform weaving movement in butt joint ✓
- Use the correct electrode ✓
- Use the correct current ✓
- Weld slowly ✓

(Any 1 x 1) (1)

4.8 **Milling Cutters:**

4.8.1 Spur gear – Involute cutter ✓
4.8.2 Groove – Side-and-face cutter or end mill or slot drill ✓
4.8.3 Rack – Involute cutter/Fly cutter ✓
4.8.4 Blind hole – Flute-end mill ✓ (4)

4.9 **Dividing head of a milling machine:**

A = Index plate ✓
B = Index crank ✓
C = Sector arms ✓
D = Single-start worm ✓
E = Wormwheel/gear ✓ (5)

4.10 **Classification of milling cutters:**

Arbor cutters ✓ (1)

Examples: Plain cutter , side cutter, staggered-tooth cutter, slitting-saw cutter, angular cutter, profile/form cutters, side-and-face cutter, helical cutter ✓

(Any 1 x 1) (1)

Shank cutters ✓ (1)

Examples: End mill; shell end mill; T-slot cutter and Woodruff keyseat cutter

(Any 1 x 1) (1)

[50]

QUESTION 5: MAINTENANCE AND TURBINES

5.1 Clutch

5.1.1 Parts:

A. Crankshaft ✓
B. Clutch plate ✓
C. Gearbox shaft ✓
D. Diaphragm spring ✓
E. Pressure plate ✓
F. Flywheel ✓ (6)

5.1.2 Functions:

- To provide friction between the clutch and pressure plate ✓✓
- To connect the flywheel to the gearbox shaft ✓✓ (4)

5.1.3 Causes of slip:

- Oil on the friction surfaces ✓
- Worn friction surfaces ✓
- Lack of compressive force on the friction surfaces caused by weak springs ✓
- Lack of compressive force on the friction surfaces caused by incorrect clutch settings ✓
- Uneven friction surfaces ✓
- Overheating ✓

(Any 3 x 1) (3)

5.1.4 Clutch types:

- Single-disc clutch ✓
- Multi-disc clutch ✓
- Centrifugal clutch ✓

(Any 2 x 1) (2)

5.2 Functions of lubricating oil:

- Provides lubrication between contact surfaces ✓
- Resists oxidation ✓
- Prevents rust ✓
- Avoids foaming ✓
- Resists carbon forming ✓
- Prevents corrosion ✓
- Resists extreme pressure ✓

(Any 3 x 1) (3)

5.3 **Cutting fluid:**

- Avoid contamination of the cutting fluid by draining and regularly replacing it. ✓
- Always clean metal cuttings from the machine's splash tray after use. ✓
- Regularly wipe cutting fluid splashes off machine parts when machine is stationary. ✓
- 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. ✓
- Check for correct ratio of cutting fluid to water. ✓

(Any 3 x 1) (3)

5.4 **Supercharger**

5.4.1 Centrifugal type ✓ (1)

5.4.2 **Parts:**

A. Inlet port ✓
B. Outlet port ✓
C. Rotor ✓
D. Vane ✓ (4)

5.4.3 **Operation:**

- The engine drives the rotor ✓
- Air is drawn in behind the rotor ✓
- The air is forced around into a decreasing volume ✓
- This raises the pressure of the air ✓
- The air is forced into the inlet manifold and into the cylinders ✓

(5)

5.4.4 **Advantages of a supercharger:**

- More power is developed compared to a similar vehicle without a supercharger ✓
- Supercharged engines are more economical per given kilowatt output ✓
- Less fuel is used compared to engine mass ✓
- Power loss above sea level is eliminated ✓

(Any 3 x 1) (3)

5.5 **Steam turbines:**

- Condensing turbines ✓
- Non-condensing turbines ✓
- Reheat turbines ✓
- Extracting turbines ✓
- Induction turbines ✓

(Any 3 x 1) (3)

5.6 **Advantages of gas turbine:**

- High power output from a given weight of engine. ✓
- The torque output permits a notable simplification of the transmission system. ✓
- Smooth vibrationless running due to absence of reciprocating parts. ✓
- No rubbing parts such as piston so that internal friction and wear are almost eliminated. ✓
- Easy starting. ✓
- Can use a wide range of fuels without expensive anti-knock additives. ✓
- Low lubricating oil consumption. ✓
- No water cooling system needed. ✓
- Non-poisonous exhaust gases gives very little trouble with pollution. ✓
- Requires little routine maintenance. ✓

(Any 3 x 1) (3)
[40]

QUESTION 6: FORCES, SYSTEMS AND CONTROL

6.1 Hydraulics:

6.1.1 Fluid pressure:

Rounded off

$$A_A = \frac{\pi D^2}{4}$$ ✓

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

$$= 1,13 \times 10^{-3}\, m^2$$ ✓

$$P = \frac{F_A}{A_A}$$ ✓

$$P = \frac{300}{1,13 \times 10^{-3}}$$ ✓

$$= 0,27\ MPa$$ ✓

Fully extended

$$A_A = \frac{\pi D^2}{4}$$ ✓

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

$$= 0,001134114\, m^2$$ ✓

$$P = \frac{F_A}{A_A}$$ ✓

$$P = \frac{300}{0,001134114}$$ ✓

$$= 264523,45\ Pa$$ ✓

(5)

6.1.2 Load lifted by piston B:

Rounded off

$$A_B = \frac{\pi D^2}{4}$$ ✓

$$= \frac{\pi \times (0,175)^2}{4}$$

$$= 24,05 \times 10^{-3}\, m^2$$ ✓

$$P = \frac{F_B}{A_B}$$ ✓

$$F_B = A_B \times P$$ ✓

$$= (24,05 \times 10^{-3}) \times 0,27 \times 10^6$$ ✓

$$= 6,49\ kN$$ ✓

Fully extended

$$A_B = \frac{\pi D^2}{4}$$ ✓

$$= \frac{\pi \times (0.175)^2}{4}$$

$$= 0,024052818\, m^2$$ ✓

$$P = \frac{F_B}{A_B}$$ ✓

$$F_B = A_B \times P$$ ✓

$$= (0,024052818 \times 264523,45$$ ✓

$$= 6362,54\ N$$ ✓

(6)

6.2 **Stress and Strain:**

Tensile force:

Rounded off

$\varepsilon = \frac{\Delta L}{OL}$ ✓

$= \frac{0,2}{300}$

$= 0,66 \times 10^{-3}$ ✓

$E = \frac{\sigma}{\varepsilon}$ ✓

$\sigma = E \times \varepsilon$

$= 245 \times 10^{9} \times 0.66 \times 10^{-3}$ ✓

$= 161.7 \times 10^{6}\ Pa$ ✓

$\sigma = \frac{F}{A}$ ✓

$F = \sigma \times A$ ✓

$= 161,7 \times 10^{6} \times 2,2 \times 10^{-6}$ ✓

$= 355,74\ N$ ✓

Fully extended

$\varepsilon = \frac{\Delta L}{OL}$ ✓

$= \frac{0,2}{300}$

$= 0,0006666$ ✓

$E = \frac{\sigma}{\varepsilon}$ ✓

$\sigma = E \times \varepsilon$

$= 245 \times 10^{9} \times 0,000666666$ ✓

$= 163333333,3\ Pa$ ✓

$\sigma = \frac{F}{A}$ ✓

$F = \sigma \times A$ ✓

$= 163333333,3 \times 2,2 \times 10^{-6}$ ✓

$= 359,33\ N$ ✓

(9)

6.3 **Belt drives:**

6.3.1 **Rotation frequency of the driven pulley:**

$N_A \times D_A = N_B \times D_B$ ✓

$N_B = \frac{N_A \times D_A}{D_B}$

$= \frac{1000 \times 0,25}{0,35}$ ✓

$= 714,29\ r/min$ ✓

(3)

6.3.2 **Power transmitted:**

$$P=\frac{(T_1-T_2)\pi DN}{60} \quad \checkmark$$

$$P=\frac{(200-90)\times\pi\times 0{,}25\times 1000}{60} \quad \checkmark$$

$$P=1439{,}90\ Watts$$

$$P=1{,}44\,kW \quad \checkmark$$

(3)

6.3.3 **Belt speed:**

$$v=\frac{\pi DN}{60} \quad \checkmark$$

$$=\frac{\pi\times 0{,}25\times 1000}{60} \quad \checkmark$$

$$v=13{,}09\,m.s^{-1} \quad \checkmark$$

(3)

6.4 **Gears:**

6.4.1 **Rotation frequency of the output shaft:**

$$\frac{N_F}{N_A}=\frac{T_A\times T_C\times T_E}{T_B\times T_D\times T_F} \quad or \quad \frac{N_F}{N_A}=\frac{Product\ of\ driven\ gears}{Product\ of\ driver\ gears} \quad \checkmark$$

$$N_F=\frac{T_A\times T_C\times T_E\times N_A}{T_B\times T_D\times T_F} \qquad =\frac{24\times 20\times 42\times 1440}{40\times 48\times 90} \quad \checkmark\checkmark$$

$$N_F=\frac{24\times 20\times 42\times 1440}{40\times 48\times 90} \qquad =168\ r/min$$

$$=168\ r/min \quad \checkmark$$

(4)

6.4.2 **Velocity ratio:**

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

$$VR=\frac{1440}{168}$$

$$VR=8.57:1 \quad \checkmark$$

(2)

6.5 **Differential wheel and axle:**

6.5.1 **Mechanical advantage:**

$$MA = \frac{W}{F} \quad ✓$$

$$MA = \frac{2400}{400}$$

$$MA = 6 \quad ✓$$

(2)

6.5.2 **Velocity ratio:**

$$VR = \frac{2D}{d_1 - d_2} \quad ✓$$

$$VR = \frac{2(210)}{160 - 140} \quad ✓$$

$$VR = \frac{420}{20}$$

$$VR = 21 : 1 \quad ✓$$

(3)

6.5.3 **Mechanical efficiency:**

$$\eta_{mech} = \frac{MA}{VR} \times 100\% \quad ✓$$

$$= \frac{6}{21} \times 100\%$$

$$= 28.57\% \quad ✓$$

(2)

6.6 Clutches:

6.6.1 Diameter of clutch plate:

$T = \mu W n R$ ✓

$R = \dfrac{T}{\mu W n}$ ✓

$R = \dfrac{336}{0{,}4 \times 3500 \times 2}$ ✓

$R = 0{,}12\, m$

$D = 2 \times 0{,}12$ ✓

$D = 0{,}24\, m$

$= 240\, mm$ ✓

(5)

6.6.2 Power transmitted at 3500 rpm in kW:

$P = \dfrac{2\, \pi\, N\, T}{60}$ ✓

$P = \dfrac{2 \times \pi \times 3200 \times 336}{60}$ ✓

$P = 112{,}59 kW$ ✓

(3)

[50]

TOTAL: 200