basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

EXEMPLAR 2014

MEMORANDUM

MARKS: 200

This memorandum consists of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

[20]

QUESTION 2: SAFETY

2.1 **Lathe**

- Check work frequently when it is being machined between centres. The work expands when it heats up and can damage the tailstock centre. ✓
- Stop the machine before making measurements or adjustments. ✓
- Don't attempt to remove chips with your hand when they become 'stringy' and build up on the tool post. Stop the machine and remove them with pliers. ✓
- Be careful not to run the cutting tool into the chuck or dog. Check out any readjustments of work or tool for ample clearance when the tool has been moved left to the farthest point that will be machine. ✓
- Stop the machine before making attempts to wipe down the machined surface. Keep cleaning and coolants away from the work when knurling. ✓
- If work has to be repositioned or removed from the lathe, move the cutting tool clear of the work to ensure prevention of accidental injuries. ✓
- Don't talk to anyone or permit others to fool around the machine while you are operating it. You are the only one who should turn the machine on or off, or make adjustments to the lathe while you are operating it. ✓
- Never attempt running the chuck on or off of the spindle using power. It is also a dangerous practice to stop the lathe by reversing the direction of rotation. The chuck could spin off and cause serious injuries and there is danger of damaging the machine. ✓
- You should always be aware of the direction of travel and speed of the carriage before engaging the automatic feed. ✓
- Tools must not be placed on the lathe ways. Use a tool board or place them on a lathe tray. ✓
- Files must not be used on the lathe unless they are fitted with handles. ✓
- Stop the machine immediately if some odd noise or vibration begins to develop while you are operating it. If you can't locate the trouble, get help from your instructor. Under no condition should the machine be operated unless the trouble has been corrected. ✓
- Remove sharp edges and burrs from the work before removing it from the machine. ✓

(Any 4 x 1) (4)

2.2 **Torsion Tester**

- Use safety goggles✓
- Make sure the work piece is properly tightened. ✓
- Be careful for metal particles coming off after the metal fractures. ✓
- Do not hold the test piece with your hands; it may be hot – use pliers✓

(Any 3 x 1) (3)

2.3 **Arc and gas welding**

- Make sure that the area has a safe floor to prevent the sparks from creating a fire.
- When welding or watching the welding operation, make sure that you always use a screen or helmet
- Use non-inflammable protective clothing that will prevent the welding sparks from entering through the sleeves and also at the collar.
- Welding must not be carried out in the vicinity of explosive and flammable liquids.
- Make sure that fire extinguishers are always available and in good working condition.
- Make sure the welding premises are properly ventilated because of hazardous fumes
- Use a fume extractor for toxic fumes given off when welding galvanised or zinc-coated materials. ✓ (Any 3 x 1) (3)

[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 **Causes of low compression:**

- Worn cylinders✓
- Worn inlet valves✓
- Worn outlet valves✓
- Worn compression rings ✓
- Worn piston ✓
- Worn head gasket ✓ (Any 2 x 1) (2)

3.2 **Brinell Hardness Tester:**

A = Diameter of impression or ball diameter or indentation ✓
B = Load✓
C = Hardened steel ball or ball✓
D = Test piece ✓ (4)

3.3 **Tests**

3.3.1 A gas analyser analyses the gas coming out of the exhaust of a motor car and determines the amount of carbon monoxide and/or carbon dioxide being produced. ✓✓ (2)

3.3.2 The purpose of the beam-bending test is to investigate the deflection of beams. ✓✓ (2)

3.4 **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 valve 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) ✓
- Look for bubbles in the radiator water. ✓
  (the cylinder head gasket is blown or the cylinder block is cracked) ✓

(Any 1 x 2) (2)
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QUESTION 4: MATERIALS

4.1 Iron-carbon properties

4.1.1 Ferrite: It is relatively soft, malleable and easy to work with when cold. ✓✓ (2)

4.1.2 Cementite: It is hard and brittle. ✓✓ (2)

4.1.3 Austenite: It is tough and has a high resistance to wear. ✓✓ (2)

4.2 Iron-carbon equilibrium diagram

4.2.1 Iron-carbon equilibrium diagram✓✓ (2)

4.2.2 A = Ferrite and pearlite✓
B = Pearlite and cementite✓
C = Ferrite and austenite✓
D = Austenite and cementite✓
E = Austenite✓ (5)
[13]

QUESTION 5: TERMINOLOGY

5.1 **Screw cutting – compound-slide method**

- Turn the part to be threaded to the major diameter of the thread. Set compound slide 30^0 to the right and set tool up accurately in the tool post. ✓
- Check index plate of the quick-change gearbox and move the levers for the necessary pitch of the thread.✓
- Start lathe and set cutting tool to touch work piece. Set dial to zero on cross feed and compound slide.✓
- Move the cutting tool a short distance off end of work piece and feed compound slide 0,06 mm inward. ✓
- With lathe turning, engage half-nuts in the correct line on the chasing dial, putting the first cut in progress. ✓
- Withdraw the cutting tool quickly and disengage the half-nut lever return the carriage to the starting point of thread. ✓
- Check with thread gauge to see if thread pitch is correct. Repeat with successive cut until thread is complete. ✓ (7)

5.2 **Calculation keyway:**

5.2.1

$$Width\ of\ keyway = \frac{Diameter\ of\ shaft}{4}$$
$$= \frac{84}{4} \quad ✓$$
$$= 21\ mm \quad ✓$$

(2)

5.2.2

$$Thickness\ of\ keyway = \frac{Diameter\ of\ shaft}{6}$$
$$= \frac{84}{6} \quad ✓$$
$$= 14\ mm \quad ✓$$

(2)

5.2.3

$$Length\ of\ keyway = 1{,}5 \times Diameter \quad ✓$$
$$= 1{,}5 \times 84$$
$$= 126\ mm \quad ✓$$

(2)

5.2.4

$$Taper = 1 : 100 = \frac{(126 - 14)}{100} \quad ✓$$
$$= \frac{112}{100} \quad ✓$$
$$= 1{,}12\ mm \quad ✓$$
$$Thickness\ on\ the\ small\ end\ of\ key = 14 - 1{,}12$$
$$= 13{,}88\ mm \quad ✓$$

(4)

5.3 **Milling operations:**

5.3.1 **Up-cut 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)

5.3.2 **Down-cut milling:**

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

5.4 **Indexing:**

$$Indexing = \frac{40}{A} \quad \checkmark$$

$$= \frac{40}{17} \quad \checkmark$$

$$= 2\frac{6 \times 2}{17 \times 2} \quad \checkmark$$

$$= \frac{12}{34} or \frac{18}{51}$$

2 full turns and 12 holes on the 34-hole circle or ✓
2 full turns and 18 holes on the 51-hole circle (4)

5.5 **Milling process**

5.5.1 Gang milling✓✓ (2)

5.5.2 A = Helical milling cutter✓
B = Side-and-face cutter✓
C = Work piece✓ (3)
[30]

QUESTION 6: JOINING METHODS

6.1 Weld defects

6.1.1 **Defect:** Porous weld✓
Cause:
- Speed too fast. ✓
- Current too low. ✓
- Faulty electrode. ✓
- Impurities in metal. ✓
- Contaminated work piece ✓
- Short arc ✓

(Any 1 x 1)

Preventive action:
- Use correct current. ✓
- Hold a longer arc✓
- Use correct electrodes. ✓
- Check for impurities in base metal. ✓

(Any 1 x 1) (3)

6.1.2 **Defect:** Slag inclusion✓
Causes:
- Included angle is too narrow. ✓
- Rapid chilling. ✓
- Weld temperature is too low. ✓
- High viscosity of molten metal. ✓
- Slag not removed from previous run weld. ✓

(Any 1 x 1)

Preventive action:
- Preheat metal. ✓
- Remove slag from previous run weld. ✓
- Increase included angle. ✓

(Any 1 x 1) (3)

6.1.3 **Defect:** Undercutting✓
Causes:
- Faulty electrode manipulation. ✓
- Current too high. ✓
- Arc length too long. ✓
- Speed of weld too fast. ✓

(Any 1 x 1)

Preventive action:
- Do not use a too large electrode. ✓
- Current to be moderate and weld slowly. ✓
- Hold the electrode at a safe distance from the vertical plane when making a horizontal fillet weld. ✓

(Any 1 x 1) (3)

6.2 **Destructive tests**

- Nick break✓
- Nick bend✓
- Machinability test✓ (3)

6.3 **Dye penetration test**

- Clean the weld that needs to be tested. ✓
- Spray the dye onto the clean surface. ✓
- Allow the dye to penetrate the weld joint. ✓
- Excess dye is cleaned away with a cleaning agent. ✓
- Allow surface to dry thoroughly. ✓
- Spray a developer onto the surface to bring out the dye trapped in the crack. ✓
- The dye will show all the surface defects✓ (7)

6.4 MAGS/MIGS : Metal Arc Gas Shielded/Metal Inert Gas Shielded✓ (1)

6.5 **Components MAGS/MIGS welding machine**

- A inert gas cylinder and gas flow meter/regulator ✓
- A power unit ✓
- A wire-feed controller and wire ✓
- A weld pistol and accessories✓ 4 x $\frac{1}{2}$ = 2 (2)

6.6 **Advantages of MAGS/MIGs welding**

- Can weld in any position. ✓
- Higher disposition rate. ✓
- Less operator skill required. ✓
- Long welds can be made without stops and starts. ✓
- Minimal post weld cleaning is required. ✓ (3)

[25]

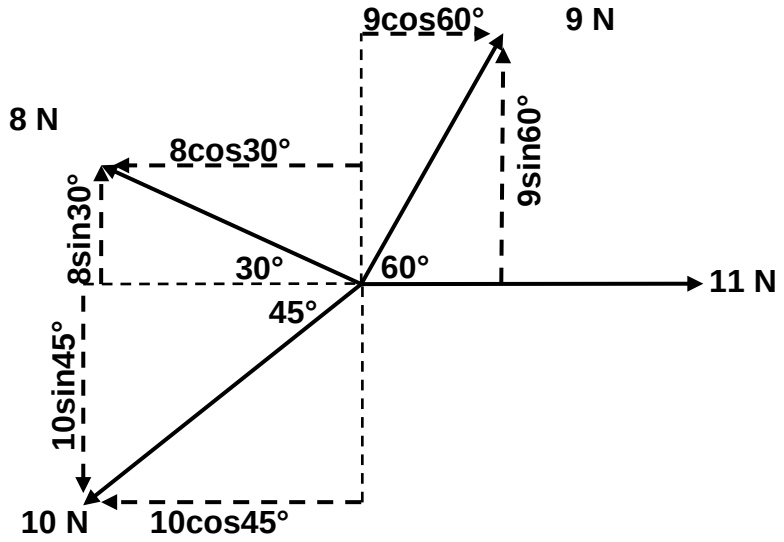
QUESTION 7: FORCES

7.1 Definition

7.1.1 **Stress:** An internal force in a material resisting a load. ✓ ✓ (2)

7.1.2 **Strain:** A measurement by the application of external force in order to produce a deformation and it is also determined by the ratio between deformation and original length. ✓ ✓ (2)

7.2 Resultant



$$\sum HK = 9\cos 60° - 10\cos 45 - 8\cos 30°$$ ✓
$$= 4{,}5 - 7{,}07 - 6{,}93$$ ✓
$$= -9{,}5\ N$$ ✓

$$\sum VK = 9\sin 60° - 10\sin 45 + 8\sin 30°$$ ✓
$$= 7{,}79 - 7{,}07 + 4$$ ✓
$$= 4{,}72\ N$$ ✓

OR

Horizontal components	Magnitudes	Vertical components	Magnitudes
$8N\cos 30^0$	- 6,93 N	$8N\sin 30^0$	4N
$9N\cos 60^0$	4,5	$9N\sin 60^0$	7,79 N
11 N	11 N	0 N	0 N
$10N\cos 45^0$	- 7,07 N	$10\sin 45^0$	- 7,07N
TOTAL	**-9,5 N** ✓✓✓	**TOTAL**	**4,72 N**✓✓✓

$R^2 = HC^2 + VC^2$ ✓

$R = \sqrt{9.5^2 + 4,72^2}$ ✓

$R = 10,61\,N$

$Tan\theta = \frac{VC}{HC}$ ✓

$= \frac{4,72}{9.5}$ ✓

$\theta = 26,42^0$

$R = 10,61\,N \ at\ 26,42^0\ north\ from\ west$ ✓✓✓ (13)

7.3 Stress and Strain

7.3.1 Strain

$Strain = \frac{Change\ in\ length}{Original\ lenth}$ ✓

$Strain = \frac{14.4 \times 10^{-3}}{80}$ ✓

$= 1.8 \times 10^{-4}$ ✓ (3)

7.3.2 Young's modulus

$E = \frac{Stress}{Strain}$ ✓

$E = \frac{16 \times 10^6}{1,8 \times 10^{-4}}$ ✓

$= 88,9\ GPa$ ✓ (3)

7.4 D = Maximum stress ✓ (1)

7.5 Reactions

Take reactions RL and RR

RL x 6 = (600 x 4) + (400 x 3) + (500 x 2) ✓
= 2 400 + 1 200 + 1 000
= 4 600/6 ✓
L = 766,67 N ✓

RR x 6 = (500 x 4) + (400 x 3) + (600 x 2) ✓
= 2 000 + 1 200 + 1 200
= 4 400/6 ✓
R = 733,33 N ✓ (6)

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QUESTION 8: MAINTENANCE

8.1 **Properties of oil:**

8.1.1 **Viscosity:** The resistance of oil to flow ✓ (1)

8.1.2 **Pour point:** The lowest temperature at which a liquid will flow. ✓ (1)

8.2 **Timing chain:**

8.2.1 A = Timing Chain✓
B = Camshaft Pulley✓
C = Chain Guide✓
D = Crankshaft Pulley✓
E = Tensioner✓ (5)

8.2.2 **Chain Replacement**

- Align crankshaft and camshaft pulleys before removing the timing chain. ✓
- Locate link in chain and remove the spring retainer and pin of link plate. ✓
- The chain will break and remove it. ✓
- Select the correct length and size. ✓
- Fit new chain and run over sprocket. ✓
- Insert the chain link and tension the chain.✓ (6)

8.3 **SAE:** Society of Automotive Engineering✓✓ (2)
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QUESTION 9: SYSTEMS AND CONTROL

9.1 Gear drives

9.1.1 Rotation frequency of the output shaft:

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

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

$$N_{INPUT} = \frac{20 \times 18 \times 42}{38 \times 46 \times 80} \times 1\,440 \quad ✓$$

$$= 155{,}7\ r/min \quad ✓$$

(3)

9.1.2 Velocity Ratio

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

$$= \frac{1\,440}{155{,}7}$$

$$= 9{,}25 : 1 \quad ✓$$

(2)

9.2 Belt Drives

9.2.1 Rotation frequency of the driven pulley

$$N_1 \times D_1 = N_2 \times D_2$$

$$N_2 = \frac{N_1 \times D_1}{D_2} \quad ✓$$

$$= \frac{1\,100 \times 0{,}24}{0{,}36}$$

$$= 733{,}33\ r/min \quad ✓$$

(2)

9.2.2 Power transmitted:

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

$$P = \frac{(200 - 90)\pi \times 0{,}24 \times 1100}{60} \quad ✓$$

$$= 1\,520{,}53\ Watts$$

$$= 1{,}52\ kW \quad ✓$$

(2)

9.2.3 Belt speed

$$V = \frac{\pi DN}{69}$$ ✓

$$= \frac{\pi \times 0,24 \times 1100}{60}$$

$$= 13,82\ ms^{-1}$$ ✓ (2)

9.3 Hydraulics

9.3.1 Fluid pressure

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

$$= \frac{\pi 0.04^2}{4}$$

$$= 1,2566 \times 10^{-3}\ m^2$$ ✓

$$P_A = \frac{F}{A_A}$$

$$= \frac{275}{1,2566 \times 10^{-3}}\ Pa$$ ✓

$$= 218\,844\ Pa$$

$$= 218,85\ kPa$$ ✓ (3)

9.3.2 Load lifted by piston B

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

$$= \frac{\pi \times 0,18^2}{4}$$

$$= 0,0254\ m^2$$ ✓

$$P_B = \frac{F}{A}$$ ✓

$$F = P \times A$$

$$= 218\,844 \times 0,0254$$

$$= 5\,558,63\ N$$ ✓

$$= 5,56\ kN$$ ✓ (4)

9.4 **Abbreviations:**

9.4.1 **ABS:** Anti-lock Braking System✓ (1)

9.4.2 **ECU:** Engine Control Unit✓ (1)

9.5 **Traction Control**

- Traction control prevents wheel spin by applying brakes on the drive wheel that is losing traction reducing engine torque. ✓
- The difference between ABS and TCS is that ABS only comes into play when braking while TCS only comes into play while accelerating although they both use the braking system. ✓ (2)

9.6 **Central Locking:**

- Central locking is the mechanism through which all doors of a car are locked simultaneously with or without a remote control unit.
- In the interior of the car door there is the door-lock actuator which uses either vacuum or an electromagnet mechanism that controls the door lock.
- When the actuator is in operation, it moves the door locking latch either up or down.
- When the latch is in the unlocked position, the door handle outside of the car is connected to the opening mechanism.
- This makes the door to open and close at will.
- When the door locking latch is in the locked position, you will find that the door handle outside is disconnected from the opening mechanism.
- There is usually a master control unit in the driver's door while the rest of the doors act like slave units. (6 x ½) (3)

[25]

QUESTION 10: TURBINES

10.1 Water turbine

10.1.1 Labels

A = Turbine generator shaft✓
B = Water flow✓
C = Turbine blades✓
D = Wicket gate ('Waste gate')✓
E = Rotor✓
F = Stator✓ (6)

10.1.2 Operation

- Flowing water is directed onto the blades of a turbine, creating a force on the blades. ✓
- Since the turbine is spinning, the energy is transferred from the water flow to the turbine. ✓
- This causes the rotor to rotate inside the stator generating electricity. ✓ (3)

10.2 Supercharger

10.2.1 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 ✓
- Eliminates lag ✓
- No shut-down procedure. ✓ (Any 2 x 1) (2)

10.2.2 Disadvantages of a supercharger

- A small amount of power is lost in order to drive the supercharger ✓
- Higher fuel consumption results if the power generated is not fully used, as in the case of passenger vehicles. ✓
- Owing to the compression of the air, this results in an increase in temperature causing a decrease in the density of the inlet charge. ✓
- The lifespan of the engine is decreased because of higher cylinder pressure, which increases the load on the engine components. ✓ (Any 1 x 1) (1)

10.3 **Advantages of gas turbine:**

- High power output from a given weight of engine. ✓
- The torque output characteristic permits a notable simplification of the transmission system. ✓
- Smooth less vibration 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 wide range of fuels and does not require expensive anti-knock additives. ✓
- Low lubricating oil consumption. ✓
- No water cooling system needed. ✓
- Non-poisonous exhaust giving very little trouble with pollution. ✓
- Requires little routine maintenance. ✓

(Any 3 x 1) (3)

10.4 **Turbocharger**

Labels

A = Clean air inlet ✓
B = Compressor housing ✓
C = Compressor wheel ✓
D = Exhaust gas inlet ✓
E = Exhaust outlet ✓
F = Turbine wheel ✓ (6)

[20]

TOTAL: 200