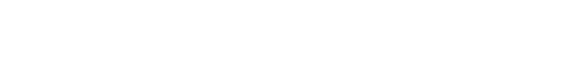


**NATIONAL SENIOR CERTIFICATE**

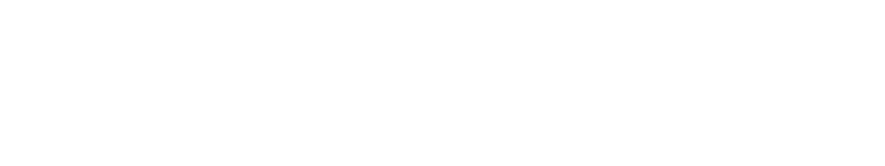


**GRADE 12**



**MECHANICAL TECHNOLOGY NOVEMBER 2015**

**MEMORANDUM**



**MARKS: 200**

**This memorandum consists of 19 pages.**

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS**

|  |  |  |
| --- | --- | --- |
| 1.1 | B  | (1) |
| 1.2 | B  | (1) |
| 1.3 | B  | (1) |
| 1.4 | A  | (1) |
| 1.5 | C / D | (1) |
| 1.6 | B  | (1) |
| 1.7 | A  | (1) |
| 1.8 | D  | (1) |
| 1.9 | A  | (1) |
| 1.10 | D  | (1) |
| 1.11 | D  | (1) |
| 1.12 | C  | (1) |
| 1.13 | B  | (1) |
| 1.14 | B  | (1) |
| 1.15 | A  | (1) |
| 1.16 | B  | (1) |
| 1.17 | A  | (1) |
| 1.18 | D  | (1) |
| 1.19 | A  B for Afrikaans only | (1) |

|  |  |  |
| --- | --- | --- |
| 1.20 | C  | (1) |
|  |  | **[20]** |

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**QUESTION 2: SAFETY**

2.1 **Personal Safety Angle grinder**

• Wear eye safety protection

• Wear ear plugs or muffs

• Wear safety boots with steel toe caps

• Wear overalls Leather apron

• Wear gloves

(Any 3 x 1) (3)

2.2 **Safety – Hydraulic Press**

• The predetermined pressure of the hydraulic press must not be exceeded

• Ensure the pressure gauges is in a 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 that securing pins for the platform are fitted properly

• Check on hydraulic pipes for leaks/ oil on floor

• Bearing need to be placed in a suitable jig

(Any 3 x 1) (3)

2.3 **Safety – Spring tester**

• Be very careful that the jaws/clamp of the spring tester does not slip out

• Use correct attachments of the valve spring tester to compress the spring. 

• Do not stretch or compress the spring more than indicated in the specification 

(Any 2 x 1) (2)

|  |  |  |
| --- | --- | --- |
| 2.4 | **Safety – Bearing and Gear puller**  • Make sure that the puller is the right one to use   • Do not use a hammer on the puller   • Use the correct spanner to tighten the clamps and to pull off the object   • Make certain that the puller is at a 90° to the work piece   • Legs of the puller must not be worn  • Use the slip cover to prevent injury  • When working with the puller do not work directly behind the puller in case it slips  (Any 2 x 1) | (2) |
|  |  | **[10]** |

**QUESTION 3: TOOLS AND EQUIPMENT**

3.1 **Tests**

3.1.1 A **cylinder leakage tester** is used to check whether gases leak

from the cylinder in the engine during compression stroke.  (2)

3.1.2 The purpose of the **fuel pressure tester** is to test the fuel operating pressure in the system  and fuel pressure in the fuel

line that runs to the direct injection.  (2)

3.1.3 The purpose of the **torsion tester** is to investigate the relationship between momentum or torque applied to material and influence of

material length and torsional deflection.  (2)

3.2 **Reasons to perform cylinder leakage test**

• Power loss

• Low compression

• To determine whether cylinder head gasket has blown

• Oil consumption due to excessive leakage past the piston rings

• To identify leaking valves as a cause of excessive smoking

(Any 2 x 1) (2)

3.3 **Reasons for high CO reading**

• Rich mixture setting

• Incorrect idle speed

• Clogged air filter

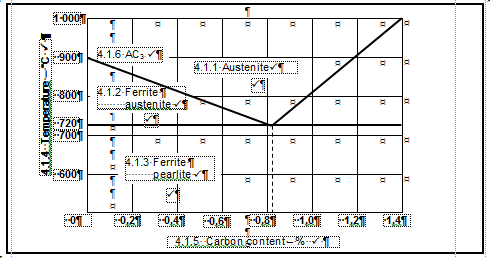
• Faulty choke

• Faulty injectors

(Any 2 x 1) (2)

|  |  |  |
| --- | --- | --- |
| 3.4 | **Tests that can be performed using a multi-meter**  • Current flow  • Voltage test Battery  • Resistance test  • Transistor test  • Continuity test  • Temperature  • Diode and capacitor testing  (Any 2 x 1) | (2) |
|  |  | **[12]** |

4.1 **Iron-carbon equilibrium diagram**



4.2 **Iron-carbon Structures**

(9)

4.2.1 **Pearlite** is the combination of ferrite and cementite  and it

contains 0,83% of carbon content before heat treatment  (2)

|  |  |  |
| --- | --- | --- |
| 4.2.2 | **Cementite** is formed when carbon content rises above 0,83%,   the carbon combines with pearlite crystals to form a very hard structure.  | (2) |
|  |  | **[13]** |

**QUESTION 5: TERMINOLOGY**

5.1 **Calculation – spur gear**

5.1.1

Module =

PCD T

= 108 



36

= 3 

(2)

5.1.2 OD = PCD + 2m

= 108 + 2(3) 

= 108 + 6 

= 114 mm  (3)

5.1.3 Cutting depth = 2,157 m or 2,25 m

= 2,157 x 3  2,25 x 3 

= 6,47 mm  6,75 mm 

(2)

5.1.4 Addendum = m

= 3 mm 

(1)

5.1.5 Dedendum = 1,157 m or 1,25 m

= 1,157 x 3  1,25 x 3 

= 3,47 mm  3,75 mm  (2)

5.1.6 Circular pitch = m x 𝜋

= 3 x 𝜋 

= 9,43 mm  or 9,42 mm 

(2)

5.1.7 Clearance = 0,157 m or 0,25m

= 0,157 x 3  0,25 x 3 

= 0,47 mm  0,75 mm 

5.2 **Advantages for compound slide:**

• The chips have a better chance of curling away, which prevents tearing of the thread. This results in a better finish. 

• The left edge of the cutting tool performs most of the work whilst the right edge helps to polish the thread. 

• The load on the tip of the cutting tool is less than the cross-slide method. 

• If the cutting tool has broken down, it is easy to pick up the thread 

• Faster than the cross slide method 

(2)

• Can cut a larger screw pitch (Any 2 x 1) (2)

5.3 **Disadvantages screw cutting – cross-slide method:**

• The point of the tool, which is the weakest part of the tool, does most of the cutting. 

• Because both edges of the tool do the cutting, two chips curl onto each other. This can result in a torn thread. 

• A large load can damage the cutting tool/cutting edge. 

• Slower method 

(Any 2 x 1) (2)

5.4 **Indexing:**

Indexing = 40 n

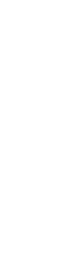
= 40

72

= 10 × 3



OR 5 × 6 



18 3 9 6

= 30

54 

No full turns and 30 holes in a 54 - hole plate 

(4)

5.5 **Advantages of Up-cut milling**

• A quick feed may be used 

• Vibration experienced is less 

• Less strain on the cutter and arbor 

• There is a positive pressure on the feed screw spindle and nuts because the direction of the cutter is against the direction of the feed 

• Metals with hard scale, start the cut under the scale where the metal is softer, this extends the life of the cutter 

• More accurate (precise) 

• Better finish 

(Any 2 x 1) (2)

5.6 **Disadvantages of Down-cut milling**

• A fine feed must be used 

• Vibration of the arbor is unavoidable 

• The cutter will come into contact with the hard scale of a scale material, which is harmful to the cutter teeth

• Cutter get blunt more easily 

• Poor finish 

• Slack on the table-feed must be eliminated 

(Any 2 x 1) (2)

5.7 **Calculate: parallel key**

5.7.1

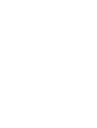
Width = D

4



= 42

4 



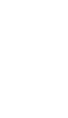
= 10,5 mm

(2)

5.7.2

Thickness = D

6



= 42 

6

= 7 mm 

(2)

**[30]**

**QUESTION 6: JOINING METHODS**

6.1 **Shielding gas**

It forms the arc plasma, stabilises the arc on the metal being welded, and shields the arc and molten weld pool.

• Reduces atmospheric contamination

• It reduces excessive spatter and sparks any 1 x 2 (2)

|  |  |  |
| --- | --- | --- |
| 6.2 | **Relationship between voltage and wire feed** |  |
|  | Higher voltage results in a higher melt rate therefore you need a higher |
| 6.3 | feed rate.  **Weld defects (causes)** | (3) |

6.3.1 **Slag inclusion**

• Included angle too narrow

• Rapid chilling

• Welding temperature to low / current to low

• High viscosity of molten metal

• Slag not removed from previous weld run

• Current setting to low

• Correct welding technique

• Surface contamination (Any 2 x 1) (2)

|  |  |  |  |
| --- | --- | --- | --- |
| 6.3.2 | **Incomplete penetration** |  | |
|  | • Speed too fast  |
|  | • Joint design faulty |
|  | • Electrode too large |
|  | • Current too low |
|  | • Wrong welding technique | (Any 2 x 1) | (2) |

6.4 **Weld defects (preventative)**

|  |  |  |
| --- | --- | --- |
| 6.4.1 | **Porosity**  • Use correct current  • Hold a longer arc  • Use correct electrodes  • Check for impurities  • Must shield the weld  • Correct welding technique (Any 2 x 1) | (2) |
| 6.4.2 | **Lack of fusion**  • Use correct welding technique  • Use the correct size of electrode  • Use the correct current setting  • Prepare the plate bevel/V-groove accordingly  • Correct welding technique (Any 2 x 1) | (2) |

|  |  |  |
| --- | --- | --- |
| 6.7 | **Transceiver**  A unit that is used to send a sound wave (transmit)  and then act as a receiver to listen to the ultrasonic wave as it reflected through the metal.   • To determine defects  | (2) |
|  |  | **[25]** |

6.5 **Destructive tests**

6.5.1 **Free bend test**

• Measures the ductility of the weld deposit and the heat- affected area adjacent to the weld. 

• To determine the percentage of elongation of the weld.  (2)

6.5.2 **Nick break test**

• It determines the internal quality of the weld and can

reveal an internal defect if present.  (2)

6.5.3 **Machinability test**

• It is used to determine the weld's hardness and its strength. 

• To determine the machinability of the weld (2)

6.6 **Atmospheric contamination (MIGS/MAGS welding)**

• Inadequate shielding gas-flow

• Excessive shielding gas flow (this can cause aspiration of air into the gas stream)

• A severely blocked gas nozzle or a damaged gas supply system

(leaking hoses, fittings etc.) 

• Excessive wind in the welding area (this can blow away the gas

shield)  (4)

**QUESTION 7: FORCES**

7.1 **Equilibrant**

**280cos50°**

**280sin50°**

**280 N**



**300 N**

**200sin35°**

**300sin30°**

**300cos30°**

**30°**



**35°**

**50°**

**350 N**



**200 N**

**200cos35°**

7.1.1

7.1.2

∑ HC = 280cos50° - 200cos35 - 300cos30° − 350

= 179,98 - 163,83 - 259,81 − 350

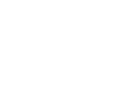
= - 593,66N

∑ VC = 280sin50° + 300sin30° − 200sin35°

= 214,49 + 150,0 − 114,72

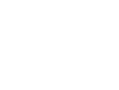
= 249,77 N

 





 





(5)

(4)

**OR**

|  |  |  |  |
| --- | --- | --- | --- |
| **7.1.1**  **Horizontal components** | **Magnitudes** | **7.1.2**  **Vertical components** | **Magnitudes** |
| 300NCos30 0 | -259,81 N  | 280NSin50 0 | 214,49N  |
| 200NCos35 0 | -163,83 N  | 300NSin30 0 | 150,0 N  |
| 350 N | -350 N  | 0 N | 0 N |
| 280NCos50 0 | 179,98 N  | 200Sin35 0 | -114,72N  |
| **TOTAL** | **-593,66 N**  | **TOTAL** | **249,77 N** |

7.1.3

E2 = HC2 + VC2 

E = − 593,66 2 + 249,77 2 

E = 644,06 N

 22,82°

249,77N

E

7.1.4

Tanθ = VC HC

= 249,77

593,66

593,66N





(3)

θ = 22,820 

E = 644,06 N at 22,820 south of east 

OR

= 22

0 49

minutes

south of east

(3)

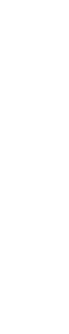
7.2 **Stress and Strain**

**Stress = Pa Diameter = m Force = N**

**Force**

Stress = force area

Force = Stress × Area 



2

Force

= 3500 000 × π × 0,025 

4

Force

= 3,5×106

× 4,90873852 *x* 10−4 

=1718,06 N

Force

= 1,72 kN 

(4)

7.3 **Stress and Strain**

A = Limit of proportionality 

B = Elastic limit 

C = Yield point 

D = Maximum stress 

E = Break stress / Break point (5)

|  |  |  |
| --- | --- | --- |
| 7.4 | **Reactions**  Taking moments around A  =  (255 x 1,125) + (800 x 3,25) = (B x 7,75) + (350 x 1)  286,88 + 2600 = 7,75B + 350  B = 2536,88/7,75  B = 327,34 N  Taking moments around B  =  A x 7,75 = (800 x 4,5) + (255 x 6,625) + (350 x 8,75)  A x 7,75 = 3600 + 1689,38 + 3062,5  A = 8351,88/7,75  A = 1077,66 N | (6) |
|  |  | **[30]** |

|  |  |  |
| --- | --- | --- |
| 8.7 | **Grease**  • Grease has a very high viscosity to ensure that it coats and sticks to the bearing surface it is lubricating.  • To reduce rust   • To reduce noise   • Helps cool the bearings   • Increases the lifespan of the bearings   • Reduces friction  | (2) |
|  |  | **[15]** |

**QUESTION 8: MAINTENANCE**

|  |  |  |
| --- | --- | --- |
| 8.1 | **Viscosity**  To ensure that the gears are well coated with oil and do not lose the barrier of lubrication between them.  | (2) |
| 8.2 | **Reason using SAE20W50**  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) |
| 8.3 | **Pour point**  Pour point is the lowest temperature at which a liquid remains pourable.  | (1) |
| 8.4 | **Maintain 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. 

• Filter oil on a regular basis

• Ensure that the correct soluble oil to water ratio is correct 

|  |  |  |
| --- | --- | --- |
| 8.5 | (Any 3 x 1)  **Belt drive maintenance** | (3) |
|  | Belt tends to stretch with prolonged use therefore they will need to be |  |
|  | tightened periodically and checked for correct alignment. |  |
|  | To transmit maximum torque without slippage | (2) |
| 8.6 | **Reason skimming flywheel** |  |
|  | The clutch plate presses against the flywheel. Due to friction between the  clutch and flywheel it creates grooves/cracks in the flywheel. The grooves will need to be removed by a precision machining process known as |  |
|  | skimming before the new clutch plate is fitted. |  |
|  | To ensure that the co-efficient of friction the surfaces are at its maximum.  |  |
|  | To reduce wear and protect the new clutch plate.  | (3) |

**QUESTION 9: SYSTEMS AND CONTROL**

9.1 **Gear drives**

9.1.1 **Number of teeth idler**

NA × TA = NB × TB

N × T

T = A A 

B

NB

= 500 × 46 

1000

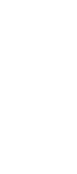
= 23 teeth 

(3)

9.1.2 **Rotation frequency of the output shaft**



NB × TB = NC × TC



NA × TA = NC × TC

N = NB × TB 

C

TC **OR**

= 1000 × 23 

60

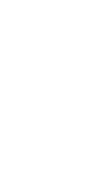
= 383,33 r/min 

N = NA × TA 

TC

C

= 500 × 46 



60

= 383,33 r / min 

(3)

9.2 **Pulley Drives**

9.2.1 **Diameter of the driven pulley**

N1 × D1 = N2 × D2

D = N1 × D1 



2

N2

= 7,2 × 600 

12

= 360 mm 

(3)

9.2.2 **Power transmitted:**

P = (T1 − T2 )πDn

T1 = 2,5

T2

P = (300 −120) π × 0,6 × 7,2 



= 2 442,9 Watts



= 2,44 kW

T = 300 

2 2,5



= 120 N

**OR**

P = (T1 − T2 )πdn

P = (300 −120) π × 0,36 ×12 

= 2 442,9 Watts 

T1 = 2,5 

T2

= 2,44 kW

T = 300

2 2,5

= 120 N

(3)

9.3 **Hydraulics**

9.3.1 **Fluid pressure**

2

π

A B = ~~D~~

4 

π

2

= x 0,076

4 

= 4,536459792 ×10-3 m2

P = F A B

B





= 4000 Pa

4,536459792 ×10-3

= 881744,837 Pa 

= 881,74 kPa

(4)

9.3.2 **Diameter of piston A**

PA = PB

P = FA

B

A A

A = FA

A

PB

A = 140 N

A 881744,837N/m2 

A = 1,5877609 × 10 − 4

A

A = 1,59 × 10 − 4 

A

πD2

= 

4

D = A A × 4

π





1,59 × 10 − 4 × 4

=

π

= 0,0142182 m

= 14,22 mm 

(5)

9.4 **Traction Control**

• Prevent wheel from spinningif the torque transmitted to any other wheel which exceeds the minimum traction

• Safety feature 

(2)

|  |  |  |
| --- | --- | --- |
| 9.5 | **Air Bags**  It is seen as a passive safety feature because the driver and passengers in the vehicle do not need to activate the air bags or do anything to be protected by air bags.  | (2) |
|  |  | **[25]** |

**QUESTION 10: TURBINES**

10.1 **Reaction Turbine**

• Francis

• Kaplan 

• Tyson

• Gorlov 

(Any 2 x 1) (2)

10.2 **Impulse Turbine**

• Impulse turbine changes the velocity of a water jet. 

• The jet pushes on the turbine's curved blades which changes the direction of the flow

• The resulting change in momentum (impulse) causes a force on the turbine blades. 

• Since the turbine is spinning the force acts through a distance and the diverted water flow is left with diminished energy. 

• Prior to hitting the turbine blades the water's pressure is converted to kinetic energy by a nozzle and focused on the turbine. 

• No pressure change occurs at the turbine blades.  (6)

10.3 **Control of speed of steam turbine**

To prevent the turbine rotor leading to an over-speed trip. This causes the

nozzle valves that control the flow of steam to the turbine to close.  (2)

10.4 **Advantages of gas turbine**

• Smooth 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. 

• No water cooling system required. 

• Non-poisonous exhaust giving very little trouble with pollution

• Require little routine maintenance. 

• Very high power-to-weight ratio, compared to reciprocating engines.

• Moves in one direction only, with far less vibration than a reciprocating engine. 

• Low operating pressures. 

• High operation speeds.

• Low lubricating oil cost and consumption. 

(Any 3 x 1) (3)

10.5 **Auxiliary power units**

• To supply auxiliary power for larger machines. 

• To supply compressed air for aircraft ventilation. 

• Start power for larger jet engines, electrical and hydraulic power units.

(Any 2 x 1) (2)

10.6 **Purpose of supercharger**

• To fill the cylinder with an increased pressure that is higher than atmospheric pressure. 

• To increase the compression pressure in the cylinder. 

• To increase the volumetric efficiency of the engine.

• To produce more engine power

• Eliminates power loss above sea level

(Any 2 x 1) (2)

10.7 **High altitude**

At high altitude less oxygen is available for combustion.

Loss of power  (2)

|  |  |  |
| --- | --- | --- |
| 10.8 | **Advantage turbocharger**  Uses the exhaust gases to operate the turbo charger. No loss of power - needed to drive supercharger | (1) |
|  |  | **[20]** |

**TOTAL: 200**