

**NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY FEBRUARY/MARCH 2016**

**MEMORANDUM**

**MARKS: 200**

**This memorandum consists of 18 pages.**

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS**

1.1 C  (1)

1.2 B  (1)

1.3 D  (1)

1.4 D  (1)

1.5 A  (1)

1.6 C  (1)

1.7 D  (1)

1.8 D  (1)

1.9 B  (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 C  (1)

1.17 A  (1)

1.18 C  (1)

1.19 D  (1)

1.20 B  (1)

**[20]**

**QUESTION 2: SAFETY**

2.1 **Safety – Centre lathe**

• Look out for revolving work pieces 

• Do not remove shavings by hand 

• Be careful not to run the cutting tool into the chuck 

• Do not make any adjustments on the work piece while the machine is running 

• Do not leave tools on the machine while in operation 

**(Any 2 x 1)** (2)

2.2 **Safety – Tensile Tester**

• Use safety goggles 

• Do not apply excessive pressure 

• Test piece to be well secured for testing 

• Check hydraulic fluid level 

**(Any 2 x 1)** (2)

2.3 **Safety – Spring Tester**

• Spring tester should be in a good condition 

• Spring tester must be fitted correctly and firmly 

• Ensure that the spring cannot slip out of position before applying the load



• An uniform load must be applied 

• Release the load carefully and uniformly 

**(Any 2 x 1)** (2)

2.4 **Safety – Cylinder Leakage**

• Clean the area around the spark plug, before removing the spark plug 

 To prevent dirt from falling into the cylinder. 

• Be careful when removing radiator cap 

 The water may be hot and under pressure. 

• Do not exceed the specified pressure to test the cylinder 

 To prevent damage to the seals and tester. 

• The tester must fit properly and be well tightened in the spark hole or injector hole 

 To prevent damage to the tester and spark hole or injector hole. 

**Any 2 x 2** (4)

**[10]**

**QUESTION 3: TOOLS AND EQUIPMENT**

3.1 **Compression testing**

3.1.1 • Wet compression test 

• Dry compression test  (2)

3.1.2 • Worn cylinders 

• Worn piston rings 

• Worn piston 

• Leaking inlet valve 

• Leaking exhaust valve 

• Leaking cylinder head gasket 

**(Any 2 x 1)** (2)

|  |  |  |
| --- | --- | --- |
| 3.2 | **Oil pump**  • Oil pressure meter or oil pressure tester  | (1) |
| 3.3 | **Cooling system test**  • Remove the radiator cap and fit the tester   • Pump air at the prescribed pressure into the system   • Note the reading  and if the reading drops, it indicates a leaking |  |

system 

• To test for a leaking cylinder-head gasket,  the engine is started. 

• If the reading increases while the engine idles, it indicates on a leaking cylinder-head gasket  (7)

**[12]**

**QUESTION 4: MATERIALS**

4.1 **Iron-carbon properties**

4.1.1 **Pearlite:**

• Good ductility 

• Hard 

• Strong and tough 

• Resistant to deformation 

**(Any 2 x 1)** (2)

4.1.2 **Cementite:**

• Intensely hard 

• Brittle.  (2)

4.2 **Critical points**

4.2.1 **AC1 – lower critical point**

• The lowest temperature to which steel must be heated to be hardened. 

• The lowest temperature where the structure starts to change. 

**(Any 1 x 2)** (2)

4.2.2 **AC3 – high critical point**

• The highest temperature to which the steel can be heated to obtain maximum hardness. 

• The temperature where the steel completely loses its magnetic properties. 

• The temperature where the steel's structure is at its finest. 

**(Any 1 x 2)** (2)

4.3 Carbon content determines the hardness of steel.  (1)

4.4 Cementite structure in steel determines the hardness.  (1)

4.5 Ferrite structure in steel determines the ductility.  (1)

4.6 Austenite is a solid solution of iron and carbon also called iron carbide. 

The structure is at its finest.  (2)

**[13]**

**QUESTION 5: TERMINOLOGY**

5.1 **Gear calculation**

5.1.1

5.1.2

Circular pitch = m× π

module = circular pitch 

π

= 12,567 

π

= 4 mm 

Outside diameter = PCD + 2m



PCD = OD − 2m 

=112 − 2(4)

=104 mm 

(3)

(3)

5.1.3

CuttingDepth = 2,157m

CuttingDepth = 2,157 × 4

CuttingDepth = 2,25m 

OR CuttingDepth = 2,25 × 4

= 8,628mm

= 9 mm 

= 8,63 mm

(2)

5.1.4

5.1.5

5.1.6

5.1.7

Addendum = m

= 4 mm

Dedendum =1,157m

=1,157 × 4

= 4,628mm

= 4,63 mm

Clearance = 0,157m

= 0,157 × 4

= 0,628 mm

= 0,63 mm

module = PCD Teeth

Teeth = PCD

m

= 104

4

= 26 teeth



Dedendum =1,25m 

OR Dedundum =1,25 × 4

= 5 mm 

Clearance = 0,25m 

OR = 0,25 × 4

=1 mm 







(1)

(2)

(2)

(3)

5.2 **Indexing**

Indexing = 40 n

= 40

26

= 40 ÷ 2

26 2 

= 20

13

=1 7 × 3

13 3

=1 21 

39

Indexing =1 full turn of the crank and 21 holes on the 39 hole circle 

(4)



|  |  |  |
| --- | --- | --- |
| 5.3 | **Screw thread cutting**  • Set up the work piece in the lathe and turn the part to be threaded to the major diameter of the thread.   • Set the compound slide to the correct angle (30°) to the right and set the tool up accurately in the post.   • Consult the index plate of the quick-change gearbox for 2 mm pitch and move the levers accordingly.   • Start the lathe and set the cutting tool so that it just touches the work piece. Set graduated dials to zero (cross feed and compound slide)   • Move cutting tool a short distance off end of work piece and feed compound slide say 0,06 mm inwards.   • With lathe turning, engage half nuts at 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 the thread.  **OR** Stop the machine, leave half nut engaged, back off slide past zero and return carriage to start position in reverse  |  |
|  | • Check with thread gauge to see if thread pitch is correct.   • Repeat with successive cuts until thread is complete. (Remember to bring cross-feed collar back to zero for each cut)   • Each successive cut is set by means of the compound slide. Check thread with ring gauge for correct fit.  | (10)  **[30]** |

**QUESTION 6: JOINING METHODS**

6.1 **MIG/MAGS welding equipment**

|  |  |  |
| --- | --- | --- |
| 6.1.1 | MIG/MAGS welding equipment  | (1) |
| 6.1.2 | **Labels**  A = Shielding gas cylinder   B = Regulator   C = Gas flow meter   D = Continuous wire reel   E = Welding gun   F = Arc   G = Earth clamp  | (7) |
| 6.1.3 | **Purpose**  Prevents oxygen  to come in contact with the molten metal. | (2) |

6.2 **Weld defects**

6.2.1 **Defect: Slag inclusion**

**Causes:**

• Included angle is too narrow. 

• Rapid chilling. 

• Weld temperature is too low. 

• High viscosity of molten metal. 

• Slag from previous run weld not removed. 

**(Any 2 x 1)** (2)

6.2.2 **Defect: Undercutting**

**Causes:**

• Faulty electrode manipulation. 

• Current too high. 

• Arc length too long. 

• Speed of weld too fast. 

**(Any 2 x 1)** (2)

6.3 **Welding defects**

6.3.1 **Defect: Lack of fusion**

**Preventions**:

• Adjust the electrode angle and prepare the V groove properly.

• Weave must be sufficient to melt sides of the joint. 

• Proper current will allow fusion. 

• Adjust welding speed to ensure fusion. 

**(Any 2 x 1)** (2)

6.3.2 **Defect: Weld craters**

**Preventions:**

• Use lower current. 

• Use proper welding technique. 

• Use correct electrode 

**(Any 2 x 1)** (2)

6.4 **Dye penetration test**

• Clean the weld that needs to be tested. 

• The dye is sprayed 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)

**[25]**

**QUESTION 7: FORCES**

7.1 **Resultant**

**1,5 kN**

**1,5sin40°**

**1,5cos40°**

**2,1 kN**

**40°**

**50°**

**90°**

**4,7kN**

**50°**

**130°**

**3,1 kN**

**3,1sin50°**

**3,1cos50°**

7.1.1 ∑ HC = 4,7 - 3,1cos50° - 1,5cos40°

= 4,7 - 1,99 - 1,15

= 1,56k N

7.1.2 ∑ VC = 2,1 + 1,5sin40° − 3,1sin50°

= 2,1 + 0,96 − 2,37

= 0,69 kN









|  |  |  |  |
| --- | --- | --- | --- |
| **7.1.3**  **Horizontal components** | **Magnitudes** | **7.1.4**  **Vertical components** | **Magnitudes** |
| 4,7 kN | 4,7 kN  | 2,1 kN | 2,1 kN  |
| 3,1 kN Cos50° | -1,99 kN  | 1,5 kN Sin40 0 | 0,96 kN  |
| 1,5 kN Cos40° | -1,15 kN  | 3,1 kN Sin50° | -2,37 kN  |
| **TOTAL** | **1,56 kN**  | **TOTAL** | **0,69 kN** |

E2 = HC 2 + VC 2

E = 1,56 2 + 0,69 2

 1,56kN 

E = 1,71 kN 

0,69kN

R

Tan

θ

= VC HC

= 0,69

1,56

= 23,86 0

θ

23,86°





E = 1,71k N

at 23,86 0 north from east 

(15)

7.2 **Stress and Strain**

**Forces**

Force = load× gravity

= 600 ×10

2

π

Area = ~~D~~

4

π

× 0,016 2



=

= 6000N 

4

= 2,011×10 − 4 m2 

Stress = Force 

Area

= 6000

2,011×10 −4 

= 29841551, 83 Pa

= 29,84 MPa 

(6)

7.3 One Pascal (1 Pa) is equal to one Newton force (1 N)  acting onto  an

area of one square metre (1 m2)  (3)

7.4 **Reactions**

Taking moments around A

=

(B × 3,5) + (1400 × 0,7) = (350 × 6,7)2,65 + (1600 × 6) 

3,5B + 980 =6214,25 + 9600 

3,5B = 6214,25 + 9600 − 980

3,5

B = 4238,36

3,5 

N

Taking moments around B

=

(A × 3,5) + (1600 × 2,5) = (350 × 6,7)0,85 + (1400 × 4,2) 

3,5A + 4000 =1993,25 + 5880 

3,5A = 1993,25 + 5880 - 4000

3,5

A =1106,64

3,5

N



(6)

**[30]**

**QUESTION 8: MAINTENANCE**

8.1 **Routine maintenance**.

• Tear on the belt.

• Misalignment of belt drive. 

• Overheating of components. 

• Belt slip. 

• Belt wear. 

• Pulley wear. 

• Financial loss due to the damage suffered.

• Loss of valuable production time. 

**(Any 2 x 1)** (2)

8.2 **Cutting fluid**

• To allow it to flow easily 

• Dissipate excess heat 

• Prevent excessive load on pump 

**(Any 2 x 1)** (2)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 8.3 | **Flash point**  Is the lowest temperature at which ignite.  | the | oil | gives | off | a | vapour | which | will | (2) |
| 8.4 | **'API'**  American Petroleum Institute  |  |  |  |  |  |  |  |  | (2) |

8.5 **Automatic transmission fluid**

• Transmit power in the torque convertor 

• Let hydraulic fluid transmit energy in order to move various parts such as the servo unit. 

• Acts as heat transfer medium to transfer heat within the transmission to outside and assist in cooling it down. 

• Acts as a lubricant for gears and bearings. 

(**Any 2 x 1)** (2)

8.6 **Replace belt in a drill press**

• Machine should be switched off the locked out. 

• Tension on the belt to be released by loosening an adjusting screw or releasing the belt tensioner. 

• Remove the belt. 

• Replace with new belt of the correct type and size. 

• The belt should be re-tensioned and aligned. 

(5)

**[15]**

**QUESTION 9: SYSTEMS AND CONTROL**

9.1 **Gear drive**

9.1.1 **Rotational frequency of the electric motor:**

NA = TB × TD 

ND TA × TC

N = 80 × 63 × 2

A 30 × 40 

10080

NA =



1200

NA = 8,4 r/s  

(5)

9.1.2 **Speed ratio of gear train:**

Speed ratio = Input Output

Speed ratio = Driven teeth

Driver teeth

= 8,4

 **OR**

= 80 × 63 

2 30 40 

= 4,2 : 1 

= 4,2 : 1

(2)

9.2 **Belt drive**

9.2.1 **Diameter of the driven pulley**

N1 × D1 = N2 × D2

N = N2 × D2

1

D1 

= 7,2 × 600 

800

= 5,4 r/s 

(3)

9.2.2 **Power transmitted:**

P = (T1 − T2 )

π

Dn

π

P =( 300 −120)

× 0,6 × 7,2 

T1 = 2,5

T2

T = 300 

2

= 2442,90 Watt

= 2,44 kW

2,5

 = 120 N

**OR**

P = (T1 − T2 )

π

Dn

π

P =( 300 −120)

× 0,8 × 5*,*4 

T1 = 2,5

T2

T = 300

2

= 2442,90 Watt

= 2,44 kW

 2,5 

= 120 N

(3)

9.3 **The volume of gas can be changed by the altering of ...**

• its pressure 

• its temperature 

• both its pressure and temperature 

(**Any 2 x 1)** (2)

9.4 **Definition of Boyle's law**

The volume of a given mass of gas is inversely proportional to the pressure on it, if the temperature remains constant (3)

9.5 **Hydraulics**

9.5.1 **Fluid pressure**

2

π

A A = ~~D~~

4

π

2

= ~~0,04~~

4

= 1,26 × 10 -3 m2 

P = F A A

A

= 80 Pa 

1,26 ×10 -3

= 63661,98 Pa

= 63,66 kPa 

(3)

9.5.2 **Diameter of piston B**

PB = PA

P = FB

B

A B 

A = FB

B

PB

A = 320

B 63492,06

A = 5,04 × 10 -3 

B

2

π

A = ~~D~~

4 

DB =

π

AB × 4

5,04 × 10 −3 × 4

π

=

= 0,08 m

= 80 mm 

(4)

**[25]**

**QUESTION 10: TURBINES**

10.1 **Water turbine blades**

To supply water pressure  to the turbine  (2)

10.2 **Reverse flow**

• Deriaz 

• Francis  (2)

10.3 **Supercharger**

• Roots

• Twin screw

• Centrifugal 

• Vane 

**(Any 2 x 1)** (2)

into the cylinder 

|  |  |  |
| --- | --- | --- |
| 10.4 | **Turbocharger**  • Exhaust gases drive the turbine   • The turbine drives a compressor via a common shaft  • The compressor forces  compressed air above atmospheric pressure | (5) |
|  | • Exhaust gases leave system through the exhaust pipe  |
| 10.5 | **Supercharger over turbocharger** |
|  | • Do not suffer lag  |
|  | • More efficient at low revolution per minute.  |
|  | • Does not require extensive exhaust modification. |
|  | • No special shutdown procedure is required.   **(Any 2 x 1)** | (2) |
| 10.6 | **Lag** |  |
|  | Lag is the delay  between pressing the accelerator pedal  and feeling the  pressure building up. | (3) |
| 10.7 | **Supercharger drive** |  |
|  | • Belt drive  |  |
|  | • Gear drive  |  |
|  | • Chain drive   **(Any 2 x 1)** | (2) |

10.8 **Gas turbine disadvantages**

• Cost is much greater than for a similar-sized reciprocating engine since the materials must be stronger and more heat resistant. 

• Manufacturing operations are also more complex. 

• Usually less efficient than reciprocating engines, especially at idling speed. 

• Delayed response to changes in power settings. 

**(Any 2 x 1)** (2)

**[20]**

**TOTAL: 200**