basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2015

MARKS: 200

TIME: 3 hours

This question paper consists of 13 pages and a 4-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of TEN questions.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Start EACH question on a NEW page.
6. Show ALL calculations and units. Round off final answers to TWO decimal places.
7. Candidates may use non-programmable, scientific calculators and drawing instruments.
8. Take the value of gravitational force as 10 m/s^2.
9. All dimensions are in millimetres, unless stated otherwise in the question.
10. A formula sheet for your use is attached at the back of this question paper.
11. Write neatly and legibly.
12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME (minutes)
1	Multiple-choice questions	20	15
2	Safety	10	10
3	Tools and Equipment	12	10
4	Materials	13	10
5	Terminology	30	20
6	Joining Methods	25	25
7	Forces	30	30
8	Maintenance	15	15
9	Systems and Control	25	25
10	Turbines	20	20
	TOTAL	**200**	**180**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.20) in the ANSWER BOOK, for example 1.21 D.

1.1 Which ONE of the following safety rules applies to the spot welder?

A The area must be open to other workers.
B Make sure that the time and current settings are suitable for the type and thickness of material being welded.
C Oil the copper contact surfaces.
D Make sure that the copper tips operate at a high temperature. (1)

1.2 Which ONE of the following safety measures applies to a torsion tester?

A Stop the rotating test piece by hand.
B Be careful of metal particles coming off after the torsion.
C Use a hammer to remove the test piece from the tester.
D Use a strong lever to mount the test piece in the tester. (1)

1.3 Which ONE of the following pieces of equipment is used to test the compression in the cylinders of an internal combustion engine?

A Torsion tester
B Pressure tester
C Tensile tester
D Brinell tester (1)

1.4 Identify the engineering equipment shown in FIGURE 1.1.

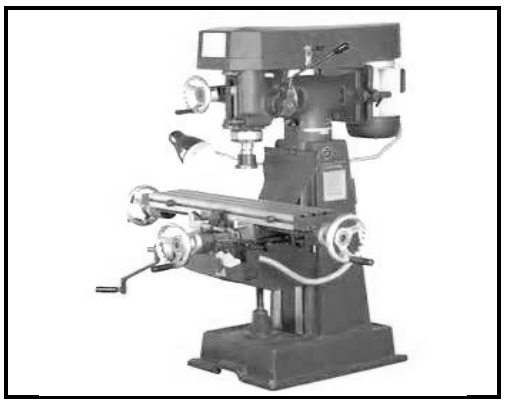

FIGURE 1.1

A Milling machine
B Gas analyser
C Brinell tester
D Lathe (1)

1.5 When carbon steel is heated at a constant rate, its temperature rises to 720 °C where the temperature then remains constant. This point is called the ...

A recalescence point.
B cooling point.
C decalescence point.
D lower critical point. (1)

1.6 Which structure of steel is characterised by an intensely hard and brittle characteristic?

A Austenite
B Cementite
C Pearlite
D Ferrite (1)

1.7 Identify the type of key shown in FIGURE 1.2.

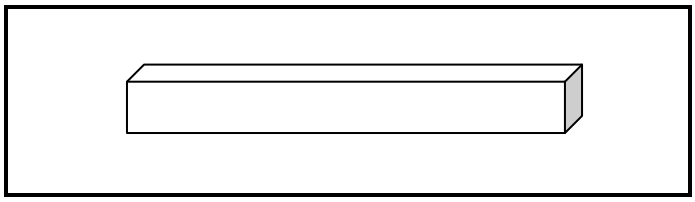

FIGURE 1.2

A Parallel key
B Gib head key
C Pratt and Whitney key
D Woodruff key (1)

1.8 Identify the milling process shown in FIGURE 1.3.

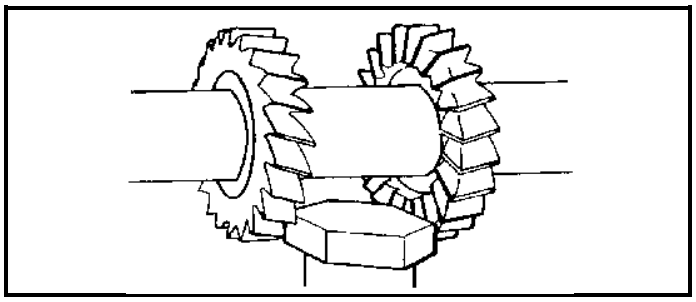

FIGURE 1.3

A Gang milling
B Slab milling
C Slot milling
D Straddle milling (1)

1.9 Which ONE of the following consumable parts is contained in the MIG/MAGS welding gun?

A Nozzle
B Shielding gas
C Electrode wire
D Earth cable (1)

1.10 Which ONE of the following non-destructive tests uses sound waves to detect defects in a welded joint?

A X-ray test
B Dye/Liquid penetration test
C Visual inspection
D Ultrasonic test (1)

1.11 Stress can be defined as an internal force in a material resisting a/an …

A internal load.
B spin load.
C moving load.
D external load. (1)

1.12 What will Young's modulus of elasticity be for a metal if the strain value caused by 6 MPa stress is 2×10^{-3}?

A 3×10^{3} Pa
B 3×10^{6} Pa
C 3×10^{3} MPa
D 3×10^{6} MPa (1)

1.13 What is the unit of a turning moment?

A $N.m^{-2}$
B N.m
C $N.m^{2}$
D N.mm (1)

1.14 What is the definition of the *flash point* of engine oil?

A The lowest temperature at which a liquid will flow
B The lowest temperature at which oil gives off vapours which can ignite
C The lowest temperature at which oil converts from liquid to solid
D The lowest temperature at which oil converts from solid to liquid (1)

1.15 The definition of the viscosity index of oil is a measure of how much the oil's viscosity changes as the ... changes.

A temperature
B pressure
C flow
D resistance (1)

1.16 Which unit is used to measure power transmitted by a belt drive system?

A Pascal
B Watt
C Volt
D Joule (1)

1.17 Boyle's law regarding a given mass of gas is defined as follows:

A The volume is inversely proportional to the pressure, if the temperature remains constant.
B The volume is directly proportional to the pressure, if the temperature remains constant.
C The pressure is directly proportional to the volume, if the temperature remains constant.
D The volume is inversely proportional to the pressure, if the temperature increases. (1)

1.18 Which ONE of the following is a disadvantage of a flat belt drive system compared to a gear drive system?

A It needs no lubrication.
B It can only transmit power over a distance of more than one metre.
C It changes direction.
D It can slip on the pulley. (1)

1.19 How is a supercharger driven?

A Mechanical systems
B Exhaust systems
C Inlet systems
D Fuel systems (1)

1.20 A ... is a dynamic compressor in which air or gas is compressed by the mechanical action of an impeller which is spun by using the kinetic energy of moving air.

A supercharger
B gas turbine
C turbocharger
D steam turbine (1)

[20]

QUESTION 2: SAFETY

2.1 Name any THREE pieces of personal safety equipment that you need to wear when working with an angle grinder. (3)

2.2 State THREE safety precautions you should observe before pressing a bearing from a shaft on a hydraulic press. (3)

2.3 When assembling a cylinder head of a vehicle, the valve springs must be tested before installation. State TWO safety precautions you should observe when working with the spring tester. (2)

2.4 State any TWO safety precautions that you must consider when working with a bearing and gear puller. (2)
[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Tools are very important to complete different tasks in the workplace. Explain the function of EACH of the following testers:

3.1.1 Cylinder leakage tester (2)

3.1.2 Fuel pressure tester (2)

3.1.3 Torsion tester (2)

3.2 Give any TWO reasons why it is necessary to perform a cylinder leakage test on an engine. (2)

3.3 The gas analyser in FIGURE 3.1 is used to determine the CO and CO_2 readings of the exhaust gases of an internal combustion engine.

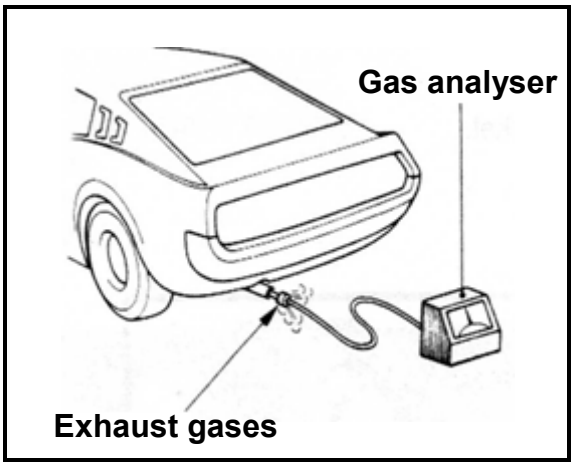

FIGURE 3.1

Give TWO reasons for a high CO reading. (2)

3.4 Name any TWO tests that can be performed with a multimeter. (2)
[12]

QUESTION 4: MATERIALS

4.1 Indicate the following by means of a neat iron-carbon equilibrium diagram:

4.1.1 Austenite structure (2)

4.1.2 Ferrite + Austenite structure (2)

4.1.3 Ferrite + Pearlite structure (2)

4.1.4 Temperature in degrees Celsius (1)

4.1.5 Percentages of carbon content (1)

4.1.6 AC_3 line (1)

4.2 Explain how the following structures are formed:

4.2.1 Pearlite (2)

4.2.2 Cementite (2)
[13]

QUESTION 5: TERMINOLOGY

5.1 A spur gear has a pitch-circle diameter of 108 mm and 36 teeth.

Calculate the following:

5.1.1 Module (2)

5.1.2 Outside diameter (3)

5.1.3 Cutting depth (2)

5.1.4 Addendum (1)

5.1.5 Dedendum (2)

5.1.6 Circular pitch (2)

5.1.7 Clearance (2)

5.2 State TWO advantages of using the compound slide method to cut an external V-thread on the centre lathe. (2)

5.3 State TWO disadvantages of using the cross-slide method to cut an external metric V-thread on the centre lathe. (2)

5.4 Calculate the indexing required to cut a 72-tooth gear. (4)

5.5 State TWO advantages of up-cut milling. (2)

5.6 State TWO disadvantages of down-cut milling. (2)

5.7 Calculate the following dimensions of a parallel key suitable for a 42 mm diameter shaft:

5.7.1 Width/Breadth (2)

5.7.2 Thickness (2)
[30]

QUESTION 6: JOINING METHODS

6.1 What is the purpose of the shielding gas in the MIG/MAGS welding process? (2)

6.2 Explain the relationship between the voltage (V) and the wire feed during the MIG/MAGS welding process. (3)

6.3 Name TWO causes of the following welding defects:

6.3.1 Slag inclusion (2)

6.3.2 Incomplete penetration (2)

6.4 Explain TWO preventative measures for EACH of the following weld defects:

6.4.1 Porosity (2)

6.4.2 Lack of fusion (2)

6.5 Give ONE reason for performing the following destructive tests:

6.5.1 Free-bend test (2)

6.5.2 Nick and break test (2)

6.5.3 Machinability test (2)

6.6 Name FOUR causes of atmospheric contamination during the MIG/MAGS welding process. (4)

6.7 What is the function of the transmitter-receiver unit as used in the ultrasonic test on a welded joint? (2)
[25]

QUESTION 7: FORCES

7.1 In FIGURE 7.1 four forces of 200 N, 300 N, 280 N and 350 N are acting on the same point.

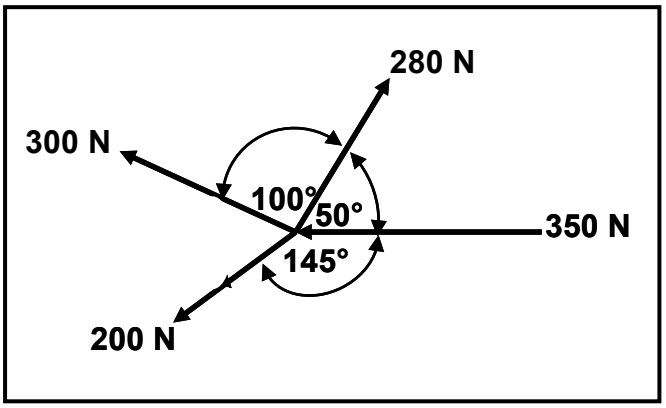

FIGURE 7.1

7.1.1 Calculate the resultant of the horizontal components. (5)

7.1.2 Calculate the resultant of the vertical components. (4)

7.1.3 Calculate the magnitude of the equilibrium force. (3)

7.1.4 Calculate the equilibrium angle with reference to the horizontal plane. (3)

7.2 An unknown force causes 3,5 MPa stress in a 25 mm round bar. Calculate the magnitude of the force. (4)

7.3 Study the stress-strain graph in FIGURE 7.2. Label points A–E as indicated on the graph.

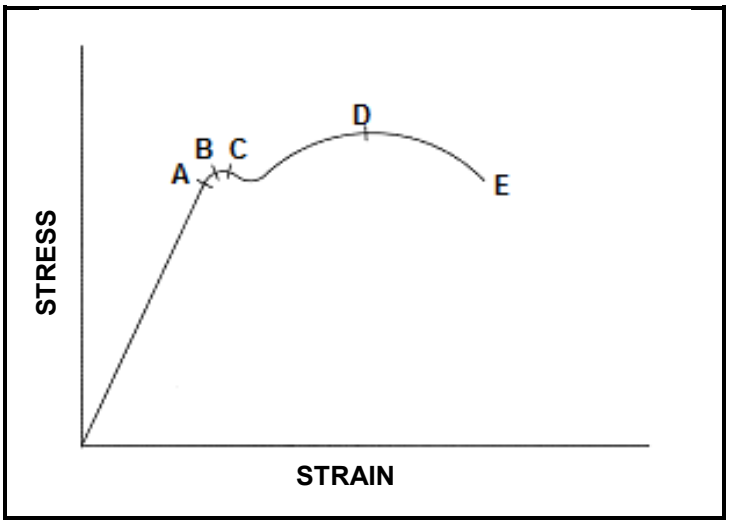

FIGURE 7.2 (5)

7.4 FIGURE 7.3 shows a uniform beam that is supported by two vertical supports, A and B. Two vertical point loads are exerted onto the beam, as well as a uniformly distributed force of 60 N/m, over the distance between the two vertical point loads.

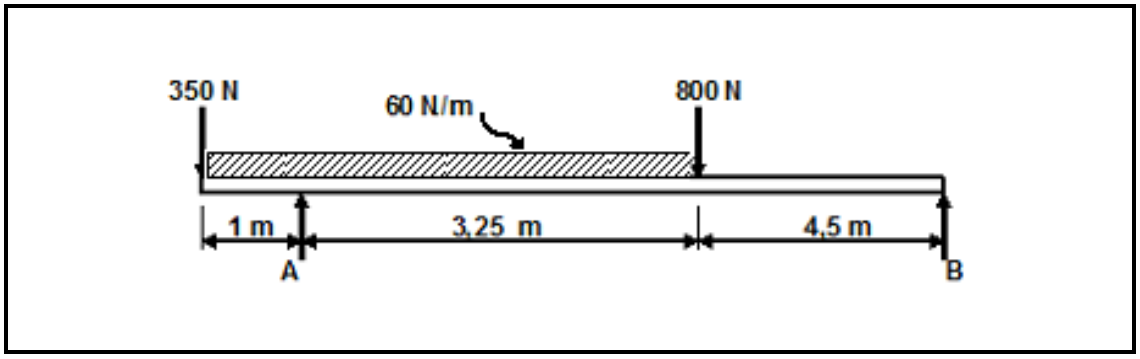

FIGURE 7.3

Determine, by means of calculations, the magnitudes of the reactions in support A and support B. (6)
[30]

QUESTION 8: MAINTENANCE

8.1 Why is it important to use oil with a higher viscosity in a manual transmission? (2)

8.2 What is the reason for using SAE20W50 viscosity oil or other multigrade oil in an internal combustion engine? (2)

8.3 Define the term *pour point* of a lubricant. (1)

8.4 State THREE ways in which cutting fluid should be maintained. (3)

8.5 Explain the importance of maintaining a belt drive system. (2)

8.6 Explain the reason for skimming the flywheel before installing a new clutch plate. (3)

8.7 Give TWO reasons for using grease on bearings. (2)
[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1 The gear system in FIGURE 9.1 is used to control a mechanical gate. The driver gear has 46 teeth and rotates at 500 r/min. The idler gear that is used to change the direction of rotation rotates at 1 000 r/min. The driven gear has 60 teeth.

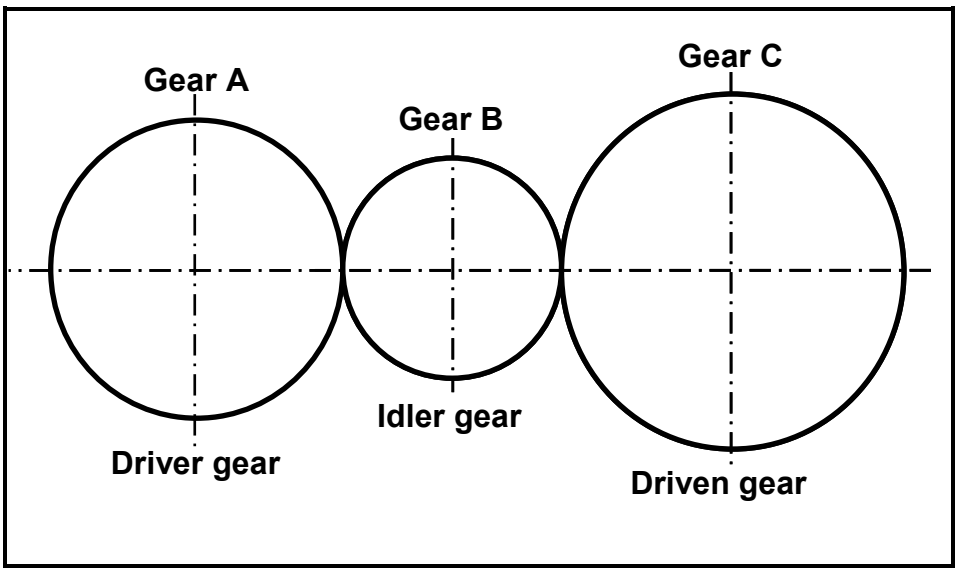

FIGURE 9.1

Determine by means of calculations:

9.1.1 The number of teeth on the idler gear (3)

9.1.2 The rotation frequency of the driven gear in revolutions per minute (3)

9.2 A machine must be driven at a speed of 12 r/s from a pulley with a diameter of 600 mm which rotates at a speed of 7,2 r/s. The tensile force in the tight side of the belt is 300 N. The ratio between the tensile force in the tight side and the tensile force in the slack side is 2,5 **:** 1.

Determine by means of calculations:

9.2.1 The diameter of the pulley that must be fitted to the machine (3)

9.2.2 The power that can be transmitted (3)

9.3 A hydraulic system is used in a hydraulic press. The specifications of the system are presented diagrammatically in FIGURE 9.2.

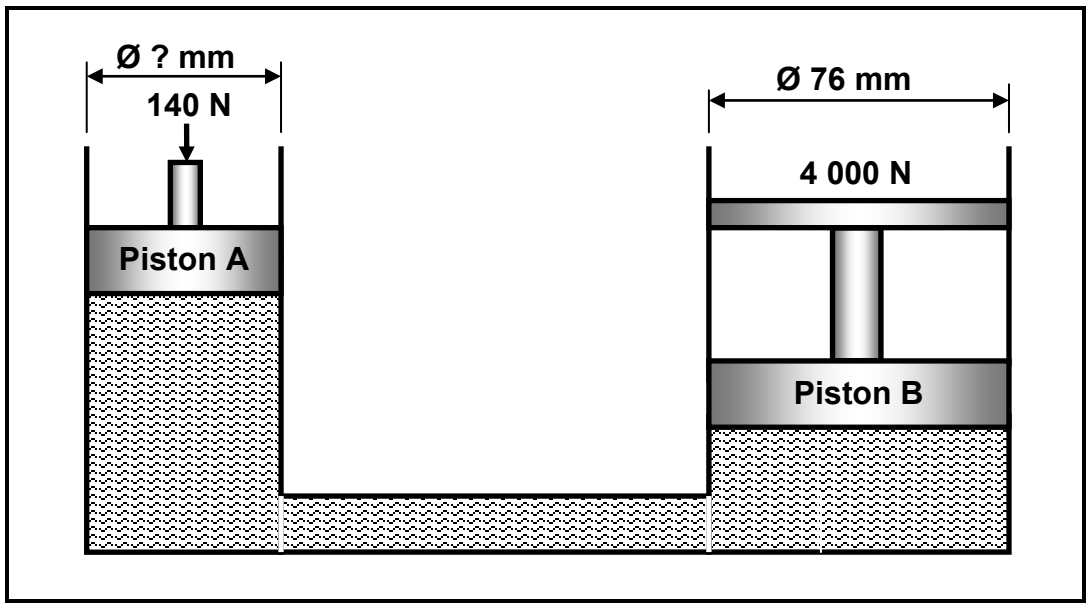

FIGURE 9.2

Determine by means of calculations:

9.3.1 The fluid pressure in the hydraulic system when in equilibrium (4)

9.3.2 The diameter of piston A (5)

9.4 What is the purpose of traction control in the driving system of a motor vehicle? (2)

9.5 Why are air bags in a motor vehicle seen as a passive safety feature? (2)
[25]

QUESTION 10: TURBINES

10.1 Name TWO types of reaction turbines. (2)

10.2 Explain the operation of the water impulse turbine. (6)

10.3 Why is it important to control the speed of a steam turbine? (2)

10.4 State THREE advantages of a gas turbine. (3)

10.5 Name TWO uses of auxiliary power units. (2)

10.6 State TWO functions of a supercharger when used on a motor vehicle engine. (2)

10.7 What effect does a high altitude have on the performance of a motor vehicle engine? (2)

10.8 State ONE advantage of a turbocharger when compared to a supercharger. (1)
[20]

TOTAL: 200

FORMULA SHEET

1. BELT DRIVES

1.1 $\text{Belt speed} = \dfrac{\pi DN}{60}$ where N is in r/min

1.2 $\text{Belt speed} = \dfrac{\pi (D + t) \times N}{60}$ (t = belt thickness)

1.3 Belt mass = area × length × density (A = thickness × width)

1.4 $\text{Speed ratio} = \dfrac{\text{diameter of driven pulley}}{\text{diameter of driver pulley}}$

1.5 $N_1 D_1 = N_2 D_2$

1.6 $\text{Open-belt length} = \dfrac{\pi(D + d)}{2} + \dfrac{(D - d)^2}{4c} + 2c$

1.7 $\text{Crossed-belt length} = \dfrac{\pi(D + d)}{2} + \dfrac{(D + d)^2}{4c} + 2c$

1.8 $\text{Ratio of tight side to slack side} = \dfrac{T_1}{T_2}$

1.9 $\text{Power (P)} = \dfrac{(T_1 - T_2)\,\pi\, D\, N}{60}$ where N is in r/min

T_1 = force in the tight side
T_2 = force in the slack side
$T_1 - T_2$ = effective force (T_e)

1.10 $\text{Power (P)} = (T_1 - T_2) \times V$ where V = belt speed in m/s

1.11 $\text{Power (P)} = \dfrac{2\,\pi\, N\, T}{60}$ where N is in r/min

1.12 $\text{Width} = \dfrac{T_1}{\text{permissible tensile force}}$

2. STRESS AND STRAIN

2.1 $\text{Stress} = \frac{\text{force}}{\text{area}}$ or $(\sigma = \frac{F}{A})$

2.2 $\text{Strain}\ (\varepsilon) = \frac{\text{change in length}\ (\Delta L)}{\text{original length}\ (L)}$

2.3 $\text{Young's modulus}\ (E) = \frac{\text{stress}}{\text{strain}}$ or $(\frac{\sigma}{\varepsilon})$

2.4 Area of a round bar $A = \frac{\pi d^2}{4}$

2.5 Area of a pipe $A = \frac{\pi(D^2 - d^2)}{4}$

3. HYDRAULICS

3.1 $\text{Pressure}\ (P) = \frac{\text{force}\ (F)}{\text{area}\ (A)}$

3.2 Volume = cross-sectional area × stroke length

3.3 Work done = force × distance

4. KEYS

4.1 $\text{Width of key} = \frac{\text{diameter of shaft}}{4}$

4.2 $\text{Thickness of key} = \frac{\text{diameter of shaft}}{6}$

4.3 $\text{Length of key} = 1{,}5 \times \text{diameter of shaft}$

4.4 Standard taper for taper key: 1 in 100 or 1 **:** 100

5. LEVERS

5.1 $\text{Mechanical advantage}\ (MA) = \frac{\text{load}\ (W)}{\text{effort}\ (F)}$

5.2 $\text{Velocity ratio} = \frac{\text{input movement}}{\text{output movement}}$

5.3 Input movement (IM) = effort × distance moved by effort

5.4 Output movement (OM) = load × distance moved by load

6. GEAR DRIVES

6.1 $\text{Power (P)} = \dfrac{2\pi N T}{60}$

6.2 $\text{Gear ratio} = \dfrac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driver gears}}$

6.3 $\dfrac{N_{input}}{N_{output}} = \dfrac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driver gears}}$

6.4 Torque = force × radius

6.5 Torque transmitted = gear ratio × input torque

6.6 $\text{Module (m)} = \dfrac{\text{pitch-circle diameter (PCD)}}{\text{number of teeth (T)}}$

6.7 $N_1T_1 = N_2T_2$

6.8 $\text{Pitch-circle diameter (PCD)} = \dfrac{\text{circular pitch (CP)} \times \text{number of teeth (T)}}{\pi}$

6.9 Outside diameter (OD) = pitch-circle diameter (PCD) + 2 module

6.10 Addendum = module (m)

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

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

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

6.14 $\text{Circular pitch (CP)} = m \times \pi$

7. SCREW THREADS

7.1 Pitch diameter = outside diameter – ½ pitch

7.2 Pitch circumference = π × pitch diameter

7.3 Lead = pitch × number of starts

7.4 Height of screw thread = 0,866 × pitch

7.5 Depth of screw thread = 0,613 × pitch

8. INDEXING

8.1 Cincinnati dividing head table for milling machine

Hole circles											
Side 1	24	25	28	30	34	37	38	39	41	42	43
Side 2	46	47	49	51	53	54	57	58	59	62	66

8.2 $\text{Indexing} = \frac{40}{n}$ (where n = number of divisions)

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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]

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)

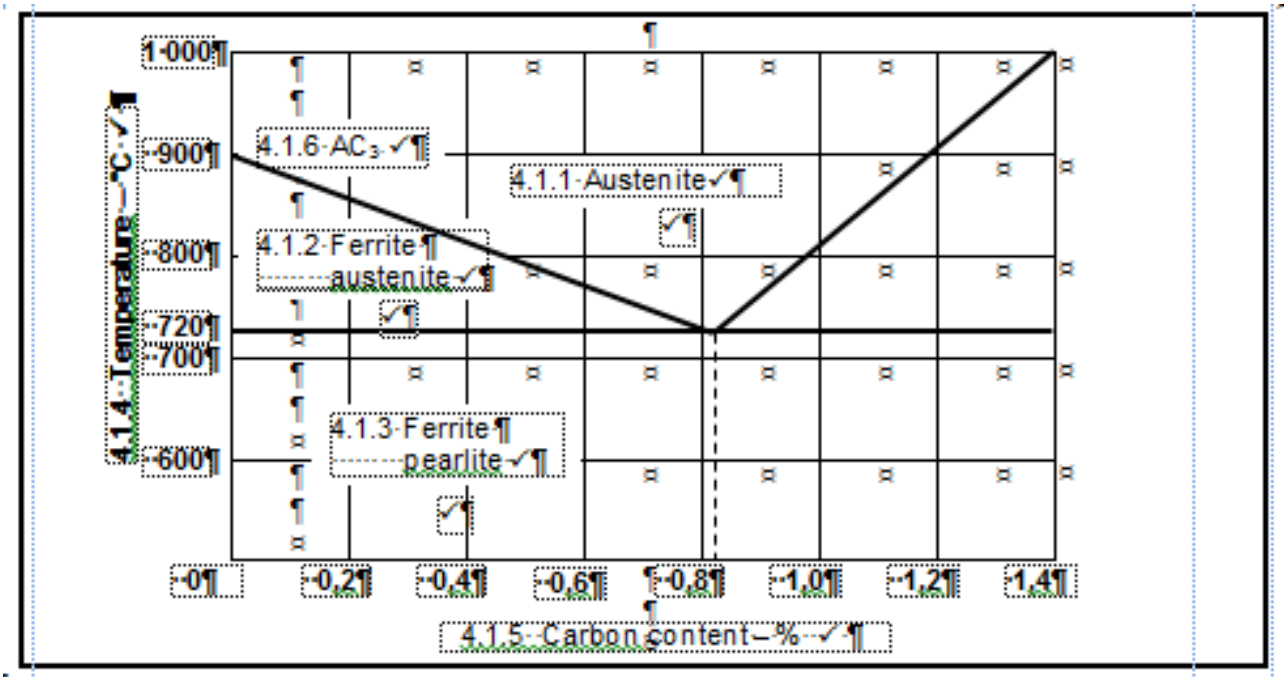
3.4 Tests that can be performed using a multi-meter

- 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



(9)

4.2 Iron-carbon Structures

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
$$\text{Module} = \frac{\text{PCD}}{\text{T}}$$
$$= \frac{108}{36} \quad \checkmark$$
$$= 3 \quad \checkmark$$
(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 ✓
(2)

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 ✓
- 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:**

$$\text{Indexing} = \frac{40}{n}$$

$$= \frac{40}{72} \quad ✓$$

$$= \frac{10}{18} \times \frac{3}{3} \quad \text{OR} \quad \frac{5}{9} \times \frac{6}{6} \quad ✓$$

$$= \frac{30}{54} \quad ✓$$

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

$$\text{Width} = \frac{D}{4}$$

$$= \frac{42}{4} \quad \checkmark$$

$$= 10{,}5 \text{ mm} \quad \checkmark$$

(2)

5.7.2

$$\text{Thickness} = \frac{D}{6}$$

$$= \frac{42}{6} \quad \checkmark$$

$$= 7 \text{ mm} \quad \checkmark$$

(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 feed rate.✓ (3)

6.3 **Weld defects (causes)**

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)

6.5 **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)

6.7 **Transceiver**

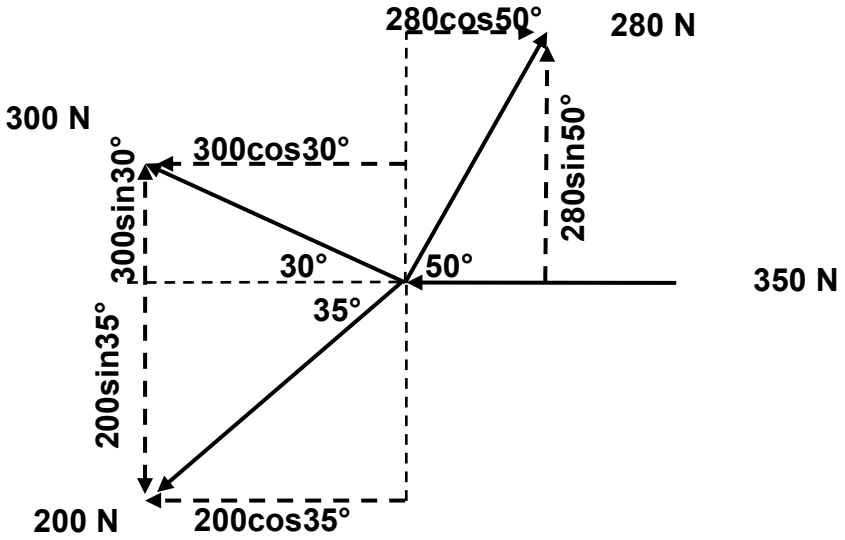
A unit that is used to send a sound wave (transmit) ✓ and then act as a receiver to listen to the ultrasonic wave as it reflected through the metal. ✓

- To determine defects ✓✓

(2)
[25]

QUESTION 7: FORCES

7.1 **Equilibrant**



7.1.1 $\sum HC = 280\cos 50° - 200\cos 35 - 300\cos 30° - 350$

$= 179,98 - 163,83 - 259,81 - 350$ ✓✓ ✓✓ ✓

$= -593,66\,N$ (5)

7.1.2 $\sum VC = 280\sin 50° + 300\sin 30° - 200\sin 35°$

$= 214,49 + 150,0 - 114,72$ ✓✓ ✓ ✓

$= 249,77\ N$ (4)

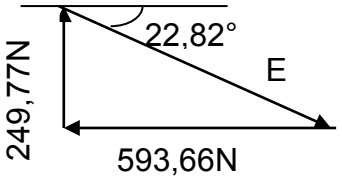
OR

7.1.1 Horizontal components	**Magnitudes**	**7.1.2 Vertical components**	**Magnitudes**
$300N\cos 30^0$	-259,81 N ✓	$280N\sin 50^0$	214,49N ✓
$200N\cos 35^0$	-163,83 N ✓	$300N\sin 30^0$	150,0 N ✓
350 N	-350 N ✓	0 N	0 N
$280N\cos 50^0$	179,98 N ✓	$200\sin 35^0$	-114,72N ✓
TOTAL	**-593,66 N** ✓	**TOTAL**	**249,77 N**✓

7.1.3 $E^2 = HC^2 + VC^2$ ✓

$E = \sqrt{-593,66^2 + 249,77^2}$ ✓

$E = 644,06\,N$ ✓



7.1.4 $\text{Tan}\theta = \frac{VC}{HC}$

$= \frac{249,77}{593,66}$ ✓

$\theta = 22,82^0$ ✓

$E = 644,06\,N$ at $22,82^0$ south of east ✓

OR

$= 22\ ^0\ 49$ minutes south of east (3)

7.2 **Stress and Strain**

Stress = Pa
Diameter = m
Force = N

Force

$\text{Stress} = \frac{\text{force}}{\text{area}}$

$\text{Force} = \text{Stress} \times \text{Area}$ ✓

$\text{Force} = 3500000 \times \frac{\pi \times 0,025^2}{4}$ ✓

$\text{Force} = 3,5 \times 10^6 \times 4,90873852x10^{-4}$ ✓

$= 1718,06\ \text{N}$

$\text{Force} = 1,72\ \text{kN}$ ✓ (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

$\circlearrowright = \circlearrowleft$

$(255 \times 1{,}125) + (800 \times 3{,}25) = (B \times 7{,}75) + (350 \times 1)$✓

$286{,}88 + 2600 = 7{,}75B + 350$

$B = 2536{,}88/7{,}75$✓

$B = 327{,}34$ N✓

Taking moments around B

$\circlearrowright = \circlearrowleft$

$A \times 7{,}75 = (800 \times 4{,}5) + (255 \times 6{,}625) + (350 \times 8{,}75)$✓

$A \times 7{,}75 = 3600 + 1689{,}38 + 3062{,}5$

$A = 8351{,}88/7{,}75$✓

$A = 1077{,}66$ N✓ (6)

[30]

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 ✓

(Any 3 x 1) (3)

8.5 **Belt drive maintenance**
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)

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 9: SYSTEMS AND CONTROL

9.1 Gear drives

9.1.1 Number of teeth idler

$$N_A \times T_A = N_B \times T_B$$

$$T_B = \frac{N_A \times T_A}{N_B} \quad \checkmark$$

$$= \frac{500 \times 46}{1000} \quad \checkmark$$

$$= 23 \text{ teeth} \quad \checkmark$$

(3)

9.1.2 Rotation frequency of the output shaft

$$N_B \times T_B = N_C \times T_C$$

$$N_C = \frac{N_B \times T_B}{T_C} \quad \checkmark$$

$$= \frac{1000 \times 23}{60} \quad \checkmark$$

$$= 383{,}33 \text{ r/min} \quad \checkmark$$

OR

$$N_A \times T_A = N_C \times T_C$$

$$N_C = \frac{N_A \times T_A}{T_C} \quad \checkmark$$

$$= \frac{500 \times 46}{60} \quad \checkmark$$

$$= 383{,}33 \text{ r/min} \quad \checkmark$$

(3)

9.2 Pulley Drives

9.2.1 Diameter of the driven pulley

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

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

$$= \frac{7{,}2 \times 600}{12} \quad \checkmark$$

$$= 360 \text{ mm} \quad \checkmark$$

(3)

9.2.2 Power transmitted:

$$P = (T_1 - T_2)\pi Dn$$

$$P = (300 - 120)\pi \times 0{,}6 \times 7{,}2 \quad \checkmark$$

$$= 2\,442{,}9 \text{ Watts}$$

$$= 2{,}44 \text{ kW} \quad \checkmark$$

$$\frac{T_1}{T_2} = 2{,}5$$

$$T_2 = \frac{300}{2{,}5} \quad \checkmark$$

$$= 120 \text{ N}$$

OR

$$P = (T_1 - T_2)\pi dn$$
$$P = (300 - 120)\pi \times 0,36 \times 12 \quad \checkmark$$
$$= 2\,442,9 \text{ Watts} \quad \checkmark$$
$$= 2,44 \text{ kW}$$

$$\frac{T_1}{T_2} = 2,5 \quad \checkmark$$
$$T_2 = \frac{300}{2,5}$$
$$= 120 \text{ N}$$

(3)

9.3 Hydraulics

9.3.1 Fluid pressure

$$A_B = \frac{\pi D^2}{4} \quad \checkmark$$
$$= \frac{\pi \times 0,076^2}{4} \quad \checkmark$$
$$= 4,536459792 \times 10^{-3} \text{ m}^2$$

$$P_B = \frac{F}{A_B} \quad \checkmark$$
$$= \frac{4000}{4,536459792 \times 10^{-3}} \text{ Pa}$$
$$= 881744,837 \text{ Pa} \quad \checkmark$$
$$= 881,74 \text{ kPa}$$

(4)

9.3.2 **Diameter of piston A**

$$P_A = P_B$$

$$P_B = \frac{F_A}{A_A}$$

$$A_A = \frac{F_A}{P_B}$$

$$A_A = \frac{140\ N}{881744{,}837 N/m^2} \quad \checkmark$$

$$A_A = 1{,}5877609 \times 10^{-4}$$

$$A_A = 1{,}59 \times 10^{-4} \quad \checkmark$$

$$= \frac{\pi D^2}{4} \quad \checkmark$$

$$D = \sqrt{\frac{A_A \times 4}{\pi}}$$

$$= \sqrt{\frac{1{,}59 \times 10^{-4} \times 4}{\pi}} \quad \checkmark$$

$$= 0{,}0142182\ m$$

$$= 14{,}22\ mm \quad \checkmark$$

(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