basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

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✓

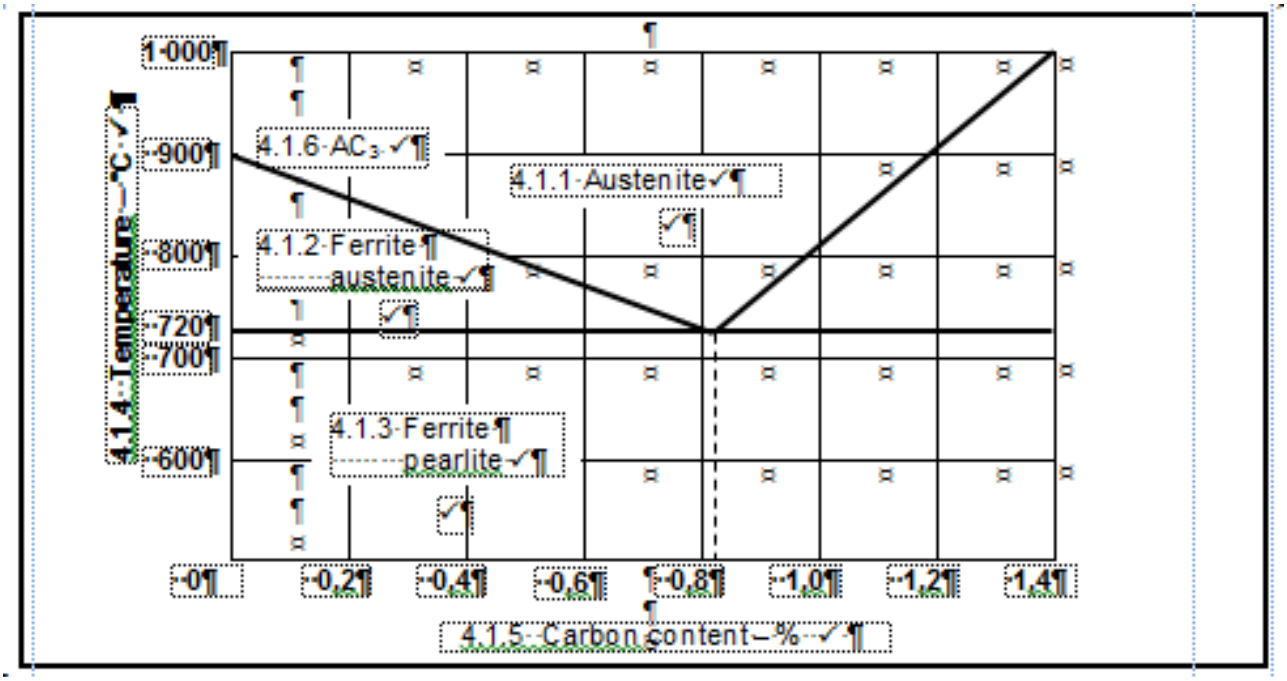
(Any 2 x 1) (2)

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

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

$$= \frac{42}{4} \quad ✓$$

$$= 10{,}5 \text{ mm} \quad ✓$$

(2)

5.7.2

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

$$= \frac{42}{6} \quad ✓$$

$$= 7 \text{ mm} \quad ✓$$

(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**

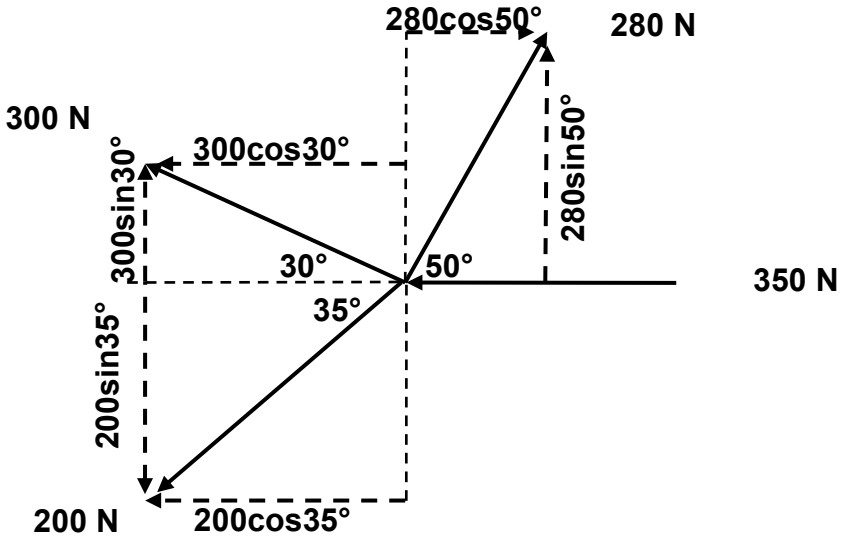
A unit that is used to send a sound wave (transmit) ✓ and then act as a receiver to listen to the ultrasonic wave as it reflected through the metal. ✓

- 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)

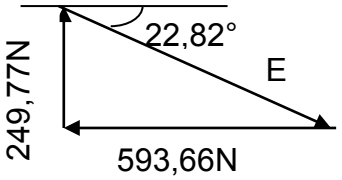
OR

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:

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

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

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

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

OR

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

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

$$= 120 \text{ N}$$

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

$P = (300 - 120)\pi \times 0,36 \times 12$ ✓

$= 2\,442,9$ Watts ✓

$= 2,44$ kW

$\frac{T_1}{T_2} = 2,5$ ✓

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

$= 120$ N

(3)

9.3 Hydraulics

9.3.1 Fluid pressure

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

$= \frac{\pi \times 0,076^2}{4}$ ✓ ✓

$= 4,536459792 \times 10^{-3}\ m^2$

$P_B = \frac{F}{A_B}$

$= \frac{4000}{4,536459792 \times 10^{-3}}$ Pa ✓

$= 881744,837$ Pa ✓

$= 881,74$ 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