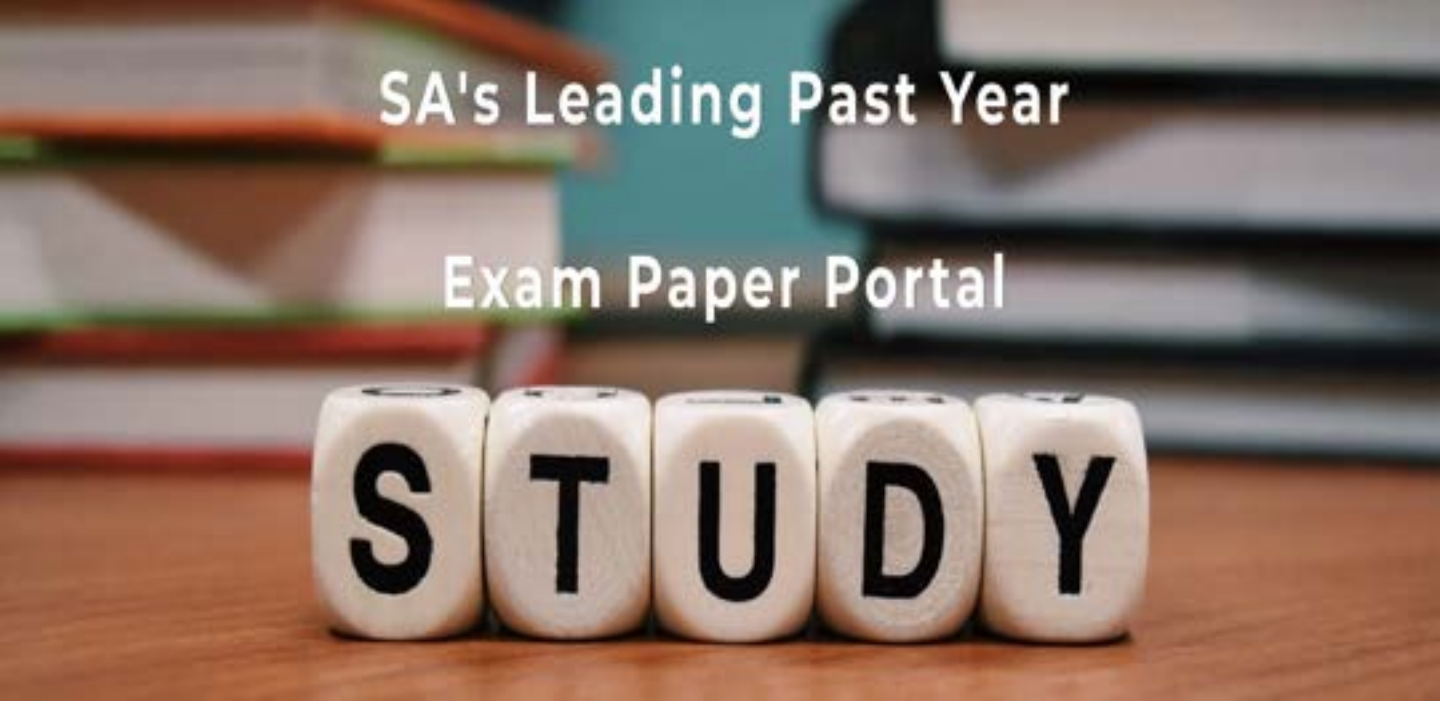

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GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2018

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

[20]

QUESTION 2: SAFETY

2.1 **Spring tester**

- Use correct attachments of the valve spring tester to compress the spring. ✓
- Do not exceed the prescribed pressure. ✓
- Ensure that the spring does not slip out. ✓

(ANY 2 x 1) (2)

2.2 **Welding helmet**

- To protect your eyes against the dangerous ultra-violet rays. ✓
- To protect your skin against the dangerous ultra-violet rays. ✓
- To protect your eyes against the sparks. ✓
- To protect your skin against the sparks. ✓

(ANY 1 x 1) (1)

2.3 **Spot welding**

- To prevent the electrodes from overheating. ✓ (1)

2.4 **Testers**

2.4.1 **Brinell tester**

- The tester must be mounted on the rigid spot on a workbench ✓
- The force must be applied at an angle of 90° to the test piece ✓
- Do not exceed the prescribed load ✓
- Make sure the test piece is placed securely into position ✓

(ANY 1 x 1) (1)

2.4.2 **Tensile tester**

- Make sure all safety guards are in place ✓
- Do not exceed the prescribed load ✓
- See that the test piece is securely placed in position ✓
- Make sure the dial indicator is mounted properly ✓

(ANY 1 x 1) (1)

2.4.3 **Torsion tester**

- Fasten the tester to the workbench ✓
- When you add pieces of different mass, you should attach them very gently otherwise you could get a skew reading of the torsion on the rod ✓
- Get specification (torsion) of the different materials and of the size rods you would like test ✓

(ANY 1 x 1) (1)

2.5 **Bearing puller**

- Perpendicular or 90**°** to the bearing. ✓ (1)

2.6 Cylinder leakage tester

2.6.1
- To prevent damage to the seals and tester ✓
- To ensure the correct reading ✓

(ANY 1 x 1) (1)

2.6.2
- To prevent damage to the tester and spark plug hole or injector hole ✓
- To ensure the correct reading ✓

(ANY 1 x 1) (1)
[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Testers

3.1.1 Cylinder leakage tester

- Is used to determine a leakage in the cylinder✓.
- Determine the volume of leakage✓ (2)

3.1.2 Fuel pressure tester

- Is used to test the fuel operating pressure in the system ✓
- Is used to test the fuel pressure in the fuel line that runs to the direct injection. ✓ (2)

3.1.3 Torsion tester

- Is used to investigate the relationship between momentum or torque applied to material ✓
- Is used to investigate influence of material length on torsional deflection. ✓ (2)

3.2 Reasons for high CO_2 reading

- Lean fuel mixture setting ✓
- Low compression ✓
- Faulty high tension leads ✓

(ANY 2 x 1) (2)

3.3 MIGS/MAGS-welding

3.3.1 Reasons for using inert gas during MIGS/MAGS welding

- Stabilises the arc on the parent metal ✓
- Shields the arc and weld pool from atmospheric gases like oxygen ✓ (2)

3.3.2 Advantages of MIGS/MAGS welding

- Can weld in any position ✓
- Less operator skill required ✓
- Continuous welding can be done ✓
- Causes less deformation ✓
- Faster than arc welding ✓
- Minimal post weld cleaning ✓
- No slag removal is required ✓

(ANY 2 x 1) (2)
[12]

QUESTION 4: MATERIALS

4.1 **Characteristics of structures**

4.1.1 **Austenite**
- Soft ✓
- Coarse grain structure ✓
- Non-magnetic ✓

(ANY 2 x 1) (2)

4.1.2 **Ferrite**
- Soft ✓
- Ductile ✓
- Magnetic ✓

(ANY 2 x 1) (2)

4.2 **Iron-carbon equilibrium diagram**

4.2.1 **Lower critical point (AC_1) of steel**
- The structure starts to change ✓✓ (2)

4.2.2 **Higher critical point (AC_3) of steel**
- The structure turns into complete Austenite ✓✓
- The steel completely loses its magnetic properties ✓✓
- The structure turns into its finest grain size ✓✓

(ANY 1 x 2) (2)

4.3 **Reasons to enhance properties of a crankshaft**
- To produce a hard face with a tough core. ✓
- To induce toughness ✓ (2)

4.4 **Reasons for the tempering of a camshaft**
- To increase the lifespan of the camshaft ✓
- To eliminate brittleness caused by hardening. ✓

(ANY 2 x 1) (2)

4.5 **Heat treatment process on piston rings**
- Hardening ✓ (1)

[13]

QUESTION 5: TERMONOLOGY

5.1 Key dimensions

5.1.1 The width of the key

$$Width = \frac{D}{4}$$
$$= \frac{120}{4} \quad ✓$$
$$= 30\ mm \quad ✓$$

(2)

5.1.2 The thickness of the key

$$Thickness = \frac{D}{6}$$
$$= \frac{120}{6} \quad ✓$$
$$= 20\ mm \quad ✓$$

(2)

5.1.3 The length of the key

$$Length = D \times 1.5 \quad ✓$$
$$= 120 \times 1.5$$
$$= 180\,mm \quad ✓$$

(2)

5.2 Indexing

$$Indexing = \frac{40}{n}$$
$$= \frac{40}{124} \div \frac{2}{2} \quad ✓$$
$$= \frac{20}{62} \quad ✓$$

No full turns and 20 holes in a 62 hole circle ✓

(3)

5.3 Height of screw the screw thread

$$H = 0.866P$$
$$= 0.866 \times 3 \quad ✓$$
$$= 2.6\,mm \quad ✓$$

(2)

5.4 Gear terminology

5.4.1 Addendum = m
= 3 mm ✓ (1)

5.4.2 Dedendum = 1,157 m or =1,25 m
= 1,157 x 3 ✓ =1,25 x 3 ✓
= 3,47 mm ✓ =3,75 mm ✓ (2)

5.4.3 Clearance = 0,157 m or =0,25m
= 0,157 x 3 ✓ =0,25 x 3 ✓
= 0,47 mm ✓ =0,75 mm ✓ (2)

5.4.4
$$Module = \frac{PCD}{T}$$
$$PCD = m \times T \quad \checkmark$$
$$= 3 \times 48$$
$$= 144mm \quad \checkmark$$
(2)

5.4.5 OD = PCD + 2m ✓
= 144 + 2(3)
= 144 + 6
= 150 mm ✓ (2)

5.4.6 Cutting depth = 2,157 m ✓ or =2,25m ✓
= 2,157 x 3 =2,25 x 3
= 6,47 mm ✓ =6,75 mm ✓ (2)

5.4.7 Circular pitch = m x π ✓
= 3 x π
= 9,42 mm ✓ (2)

5.5 Setting of the lathe and cutting tool to cut a metric V-screw thread:

- Set the lathe to the correct speed for screw cutting ✓
- Set the lead screw according to the required pitch ✓
- Set the dial gauge to position with the required worm gear ✓
- Set the compound slide to half the included angle of the thread (30°) ✓
- Set the cutting tool centre height and 90° to the work piece with the help of a centre gauge ✓
- Set cross slide and compound slide collars to zero with the tool touching the work piece ✓ (6)

[30]

QUESTION 6: JOINING METHODS

6.1 Welding defects

6.1.1 Slag inclusion

- Welding speed too fast ✓
- Not removing the slag from the previous weld run before welding the next run ✓
- Current too low ✓

(**ANY 2 x 1)** (2)

6.1.2 Incomplete penetrations

- Welding speed too fast ✓
- Faulty joint design ✓
- Electrode too large ✓
- Current too low ✓

(**ANY 2 x 1)** (2)

6.2 Atmospheric contamination during MIGS/MAGS welding

- Inadequate shielding gas flow ✓
- Excessive shielding gas flow ✓
- Severely clogged nozzle ✓
- Damaged gas supply system ✓
- Excessive wind in the welding area ✓

(**ANY 2 x 1)** (2)

6.3 Nick break test

- Make a hacksaw cut at both edges, through the centre of the weld ✓
- Place the saw-nicked specimen on two steel supports ✓
- Use a sledge hammer to break the specimen by striking it in the zone where you made the saw cuts ✓
- Defects like incomplete fusion, slag inclusion and brittleness will be exposed in the break ✓
- Any defects bring it to the attention to the welder to rectify it ✓ (5)

6.4 Reasons for destructive tests

6.4.1 Bend test

To determine the ductility/elongation ✓✓ of the weld metal. (2)

6.4.2 Machinability test

To determine the welds hardness ✓ and its strength. ✓ (2)

6.5 X-ray test

To detect internal defects in the weld metal✓✓ (2)

6.6 **Weld crater**

Forms where welding is resumed at the bottom of the previous weld instead of on the top ✓✓ (2)

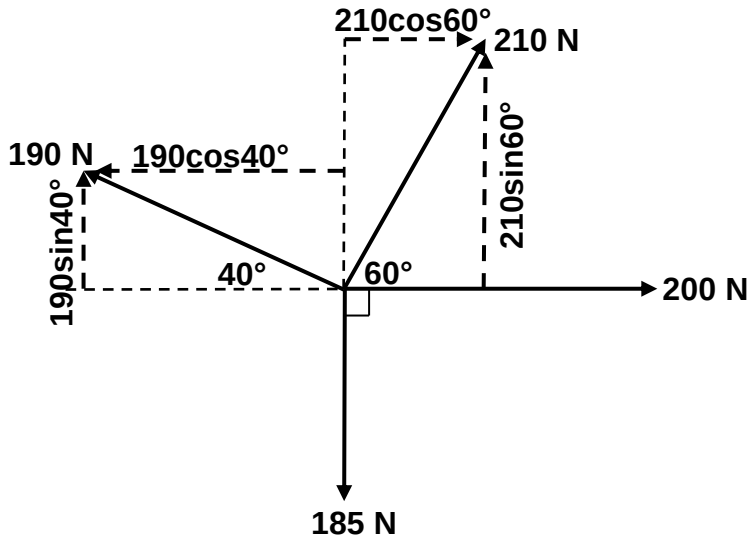
6.7 **MIGS/MAGS welding**

6.7.1 **Welding process**
MIGS/MAGS welding ✓ (1)

6.7.2 **Labelling**
A. Parent metal ✓
B. Arc ✓
C. Electrode wire ✓
D. Gas shroud ✓
E. Shielding gas ✓ (5)
[25]

QUESTION 7: FORCES

7.1 **Resultant**



$\Sigma HC = 200 + 210\cos 60 - 190\cos 40°$ ✓✓✓
$= 200 + 105 - 145.55$
$= 159{,}45\,N$ ✓ (4)

$\Sigma VC = 210\sin 60° + 190\sin 40° - 185$ ✓✓
$= 181{,}87 + 122{,}13 - 185$
$= 119\,N$ ✓ (3)

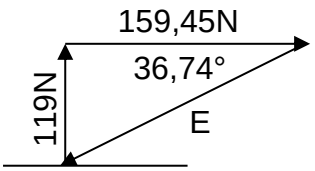
OR

Horizontal components	Magnitudes	Vertical components	Magnitudes
200N	200 N ✓	210NSin60^0	181,87N ✓
210N	105 N ✓	190NSin40^0	122,13 N ✓
190N Cos40^0	-145,45 N ✓	-185 N	-185 N
TOTAL	**159,45 N ✓**	**TOTAL**	**119 N ✓**

$E^2 = HC^2 + VC^2$

$E = \sqrt{159{,}45^2 + 119^2}$ ✓

$E = 198{,}96\ N$ ✓



(3)

$Tan\ \theta = \frac{VC}{HC}$ ✓

$= \frac{119}{159{,}45}$

$= 36{,}73°$ ✓

$E = 198{,}96N\ 36{,}73°\ south\ of\ west$

OR

$= 36°\ 44'\ minutes\ south\ of\ west$ ✓

(3)

7.2 Stress and Strain

7.2.1 Resistance area

$$A = \frac{\pi\left(D^2 - d^2\right)}{4} \quad ✓$$

$$= \frac{\pi\left(0{,}056^2 - 0{,}038^2\right)}{4}$$

$$= 1{,}33 \times 10^{-3} m^2 \quad ✓$$ (2)

7.2.2 Stress

$$Stress = \frac{force}{area} \quad ✓$$

$$Stress = \frac{20 \times 10^3}{1{,}33 \times 10^{-3}} \quad ✓$$

$$= 15037593{,}98\ Pa$$

$$Stress = 15{,}04 MPa \quad ✓$$ (3)

7.2.3 Strain

$$Strain = \frac{\Delta l}{OL} \quad ✓$$

$$Strain = \frac{50 - 49{,}975}{50} \quad ✓$$

$$Strain = \frac{0{,}025}{50}$$

$$= 0{,}5 \times 10^{-3} \quad ✓$$ (3)

7.2.4 Young's Modulus of Elasticity

$$Youngs\ Modulus\ of\ Elasticity = \frac{Stress}{Strain} \quad ✓$$

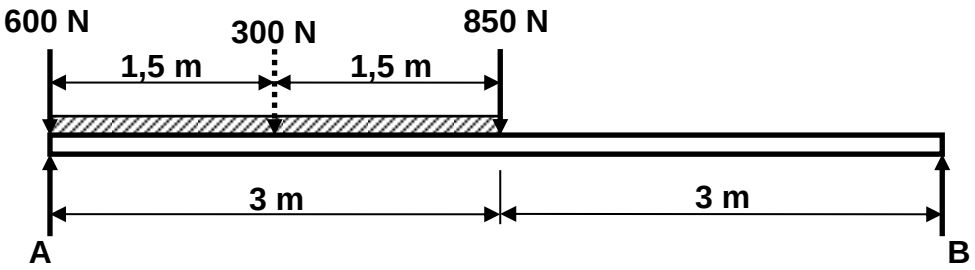
$$E = \frac{15{,}04 \times 10^6}{0{,}5 \times 10^{-3}} \quad ✓$$

$$= 30{,}08 \times 10^9\ Pa$$

$$= 30{,}08 GPa \quad ✓$$ (3)

7.3 Moments

7.3



Calculate B. Moments about A:

$\sum LHM = \sum RHM$ ✓

$(B \times 6) = (300 \times 1{,}5) + (850 \times 3)$ ✓

$\frac{6B}{6} = \frac{3000}{6}$

$B = 500\ N$ ✓

Calculate A. Moments about B:

$\sum RHM = \sum LHM$ ✓

$(A \times 6) = (850 \times 3) + (300 \times 4{,}5) + (600 \times 6)$ ✓

$6A = 2550 + 1350 + 3600$

$\frac{6A}{6} = \frac{7500}{6}$

$A = 1250\ N$ ✓

(6)
[30]

QUESTION 8: MAINTENANCE

8.1 **Reason using SAE 20W50**

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)

8.2 **Maintain V-belt drive systems**

- Check the contact surfaces of the pulley to prevent the belt from being damaged.✓
- Check the belt condition and replace if it is worn. ✓
- Correct installation procedure must be followed. ✓
- Belt drives should be well guarded to prevent foreign objects to come into contact with the belts and pulleys. ✓
- Keep guard mesh free of papers, rags, etc. that can cause insufficient air flow. ✓
- Check that the belt deflection is according to specification. ✓
- Store replacement belts in a cool, well ventilated place. ✓
- Correct alignment of pulleys. ✓

(ANY 2 x 1) (2)

8.3 **Flash point**

It is the lowest temperature ✓ at which the oil gives off vapours ✓ which can ignite. ✓ (3)

8.4 **Maintaining 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. ✓

(ANY 2 x 1) (2)

8.5 **Functions of the clutch plate**

- It provides friction between the flywheel and pressure plate. ✓
- It serves as a link between the clutch and the gearbox main shaft. ✓ (2)

8.6 **Reasons for skimming the flywheel**

- To remove the grooves caused by the clutch plate. ✓
- To ensure a full contact surface between the flywheel and the clutch plate. ✓
- To prolong the life of the clutch plate. ✓

(ANY 2 x 1) (2)

8.7 **Properties of grease**

- It must be water resistant, it must not mix with water ✓
- Prevents rust/corrosion ✓
- Good for load pressures ✓
- High melting point ✓
- Low freezing point ✓
- Prevent gumming ✓
- Be able to lubricate ✓
- High viscosity ✓

(ANY 2 x 1) (2)
[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1 Gear drives

9.1.1 Rotation frequency of input shaft

$$\frac{N_A}{N_F} = \frac{T_B \times T_D \times T_F}{T_A \times T_C \times T_E}$$

$$N_A = \frac{T_B \times T_D \times T_F \times N_F}{T_A \times T_C \times T_E} \quad ✓$$

$$= \frac{36 \times 46 \times 80 \times 160}{20 \times 18 \times 42} \quad ✓$$

$$= 1401{,}90\ r/\min \quad ✓$$

(3)

9.1.2 Velocity ratio

$$VR = \frac{N_A}{N_F} \quad ✓$$

$$VR = \frac{1401{,}90}{160}$$

$$= 8{,}76{:}1 \quad ✓$$

(2)

9.2 Belt drives

9.2.1 Rotation frequency of driver pulley

$$N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$$

$$N_{DR} = \frac{N_{DN} \times D_{DN}}{D_{DR}} \quad \checkmark$$

$$= \frac{733{,}33 \times 0{,}36}{0{,}24} \quad \checkmark$$

$$= 2000 r/\min \quad \checkmark$$

(3)

9.2.2 Power transmitted

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

$$P = \frac{(360 - 90)\pi \times 0{,}36 \times 733{,}33}{60} \quad \checkmark$$

$$= 3732{,}20 Watts$$

$$= 3{,}73\ kW \quad \checkmark$$

(2)

9.2.3 Belt speed

$$Belt\ speed = \frac{\pi DN}{60}$$

$$= \frac{\pi \times 0{,}36 \times 733{,}33}{60} \quad \checkmark$$

$$= 13{,}83 m.s^{-1} \quad \checkmark$$

(2)

9.3 Hydraulics

9.3.1 Fluid pressure

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

$$= \frac{\pi 0{,}04^2}{4} \quad ✓$$

$$= 1{,}26\times10^{-3}\ m^2 \quad ✓$$

$$P_B = \frac{F}{A_B} \quad ✓$$

$$= \frac{275}{1{,}26\times10^{-3}} \quad ✓$$

$$= 218253{,}97\ Pa$$

$$or \quad ✓$$

$$= 218{,}25\ kPa$$

(5)

9.3.2 Diameter of piston B

$$P_B = P_A$$

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

$$A_B = \frac{F_B}{P_B} \quad ✓$$

$$A_B = \frac{5{,}56\times10^3}{218{,}25\times10^3}$$

$$A_B = 25{,}48\times10^{-3}\ m^2 \quad ✓$$

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

$$D_B = \sqrt{\frac{A_B\times4}{\pi}}$$

$$= \sqrt{\frac{25{,}48\times10^{-3}\times4}{\pi}} \quad ✓$$

$$= 0{,}18\ m$$

$$or \quad ✓$$

$$= 180\ mm$$

(4)

9.4 **ABS**

ABS prevents wheels from skidding ✓ when breaking hard ✓ in difficult conditions. (2)

9.5 **ECU**

Electronic Control Unit ✓ (1)

9.6 **Traction Control**

- Prevent wheels from spinning. ✓
- Improves road holding ✓

(ANY 1 x 1) (1)

[25]

QUESTION 10: TURBINES

10.1 **Reaction turbines**
- Francis ✓
- Kaplan ✓
- Tyson ✓
- Gorlov ✓ **(ANY 2 x 1)** (2)

10.2 **Supercharger boost**
Boost refers to the increase in intake manifold pressure ✓ that exceeds normal atmospheric pressure✓ (2)

10.3 **Blowers**
- Roots ✓
- Centrifugal ✓
- Vane-type ✓
- Twin screw type ✓

(ANY 2 x 1) (2)

10.4 **Gas turbine**
A = Clean air inlet ✓
B = Compression ✓
C = Combustion ✓
D = Exhaust ✓
E = Turbine ✓
F = Combustion chamber ✓ (6)

10.5 **Application of a gas turbine**
- Jet engines ✓
- Naval ships ✓
- Hi-performance vehicles and boats ✓
- Generating electricity ✓

(ANY 2 x 1) (2)

10.6 **Advantages of a gas turbine**
- Less complex than internal combustion piston engines ✓
- Only one moving part (Common shaft for: compressor and turbine) ✓
- Operate at higher revolutions per minute ✓ **(ANY 2 x 1)** (2)

10.7 **Waste gate**
A waste gate is a valve that diverts exhaust gases away from the turbine wheel ✓ to regulate the turbine/compressor speed and boost.✓ (2)

10.8 **Oil cooler**
To cool the oil ✓ that lubricates the turbocharger bearings and shaft. ✓ (2)
[20]

TOTAL: 200