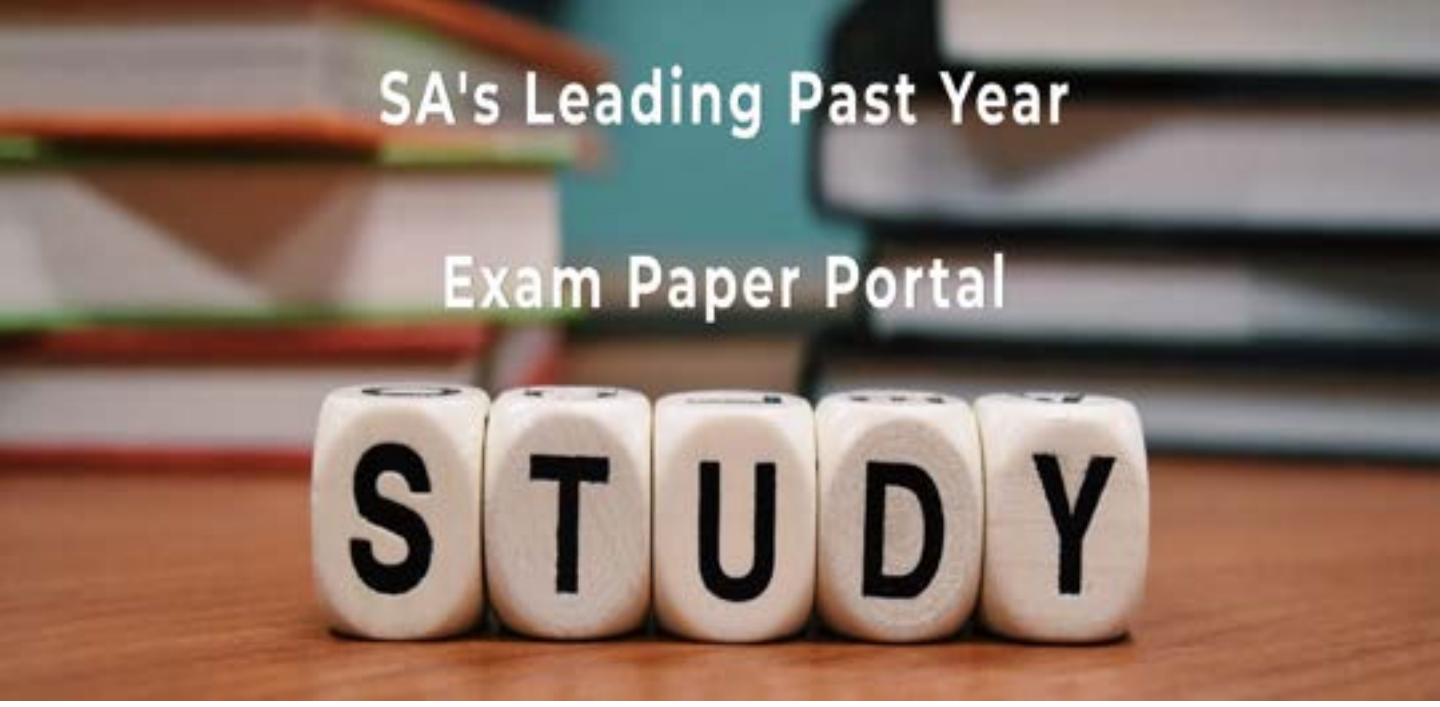

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GRADE 12

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 **AC_1 – 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 **AC_3 – 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 $\text{Circular pitch} = m \times \pi$

$$\text{module} = \frac{\text{circular pitch}}{\pi} \quad \checkmark$$

$$= \frac{12{,}567}{\pi} \quad \checkmark$$

$$= 4 \text{ mm} \quad \checkmark$$

(3)

5.1.2 $\text{Outside diameter} = PCD + 2m \quad \checkmark$

$$PCD = OD - 2m \quad \checkmark$$

$$= 112 - 2(4)$$

$$= 104 \text{ mm} \quad \checkmark$$

(3)

5.1.3

$\text{CuttingDepth} = 2{,}157m$	OR	$\text{CuttingDepth} = 2{,}25m$ ✓
$\text{CuttingDepth} = 2{,}157 \times 4$		$\text{CuttingDepth} = 2{,}25 \times 4$
$= 8{,}628 \text{mm}$		$= 9 \text{ mm}$ ✓
$= 8{,}63 \text{ mm}$		

(2)

5.1.4 $\text{Addendum} = m$

$$= 4 \text{ mm} \quad \checkmark$$

(1)

5.1.5

$\text{Dedendum} = 1{,}157m$		$\text{Dedendum} = 1{,}25m$ ✓
$= 1{,}157 \times 4$	OR	$\text{Dedundum} = 1{,}25 \times 4$
$= 4{,}628 \text{mm}$		$= 5 \text{ mm}$ ✓
$= 4{,}63 \text{ mm}$		

(2)

5.1.6

$\text{Clearance} = 0{,}157m$		$\text{Clearance} = 0{,}25m$ ✓
$= 0{,}157 \times 4$	OR	$= 0{,}25 \times 4$
$= 0{,}628 \text{ mm}$		$= 1 \text{ mm}$ ✓
$= 0{,}63 \text{ mm}$		

(2)

5.1.7 $\text{module} = \frac{PCD}{\text{Teeth}} \quad \checkmark$

$$\text{Teeth} = \frac{PCD}{m} \quad \checkmark$$

$$= \frac{104}{4}$$

$$= 26 \text{ teeth} \quad \checkmark$$

(3)

5.2 **Indexing**

$$\text{Indexing} = \frac{40}{n}$$
$$= \frac{40}{26} \quad \checkmark$$
$$= \frac{40}{26} \div \frac{2}{2} \quad \checkmark$$
$$= \frac{20}{13}$$
$$= 1\frac{7}{13} \times \frac{3}{3}$$
$$= 1\frac{21}{39} \quad \checkmark$$
$$\text{Indexing} = 1 \text{ full turn of the crank and } 21 \text{ holes on the } 39 \text{ hole circle} \quad \checkmark$$

(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)

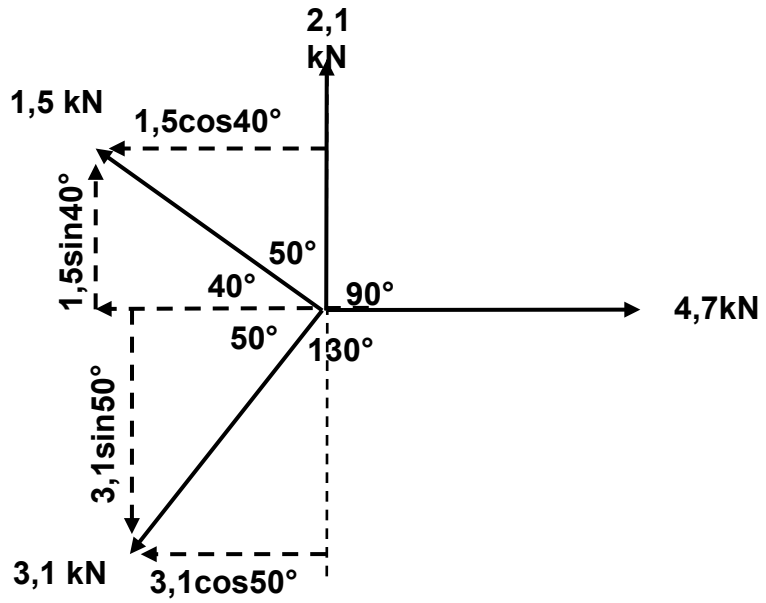
6.4 **Dye penetration test**

- 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**



7.1.1 $\sum HC = 4,7 - 3,1\cos 50° - 1,5\cos 40°$

$= 4,7 - 1,99 - 1,15$ ✓✓✓

$= 1,56 kN$ ✓

7.1.2 $\sum VC = 2,1 + 1,5\sin 40° - 3,1\sin 50°$

$= 2,1 + 0,96 - 2,37$ ✓✓✓

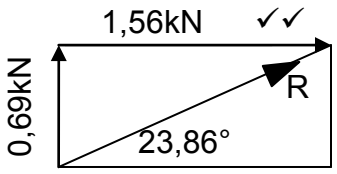
$= 0,69$ kN ✓

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**✓

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

$E = \sqrt{1,56^2 + 0,69^2}$ ✓

$E = 1,71\ kN$ ✓



✓✓

$\text{Tan}\,\theta = \dfrac{VC}{HC}$

$= \dfrac{0,69}{1,56}$ ✓

$\theta = 23,86^0$ ✓

$E = 1,71 kN$ at $23,86^0$ north from east ✓ (15)

7.2 **Stress and Strain**

Forces

$\text{Force} = \text{load} \times \text{gravity}$

$= 600 \times 10$

$= 6000N$ ✓

$\text{Area} = \dfrac{\pi D^2}{4}$

$= \dfrac{\pi \times 0,016^2}{4}$ ✓

$= 2,011 \times 10^{-4}\ m^2$ ✓

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

$= \dfrac{6000}{2,011 \times 10^{-4}}$ ✓

$= 29841551,83\ Pa$

$= 29,84\ MPa$ ✓

(6)

7.3 One Pascal (1 Pa) is equal to one Newton force (1 N) ✓ acting onto ✓ an area of one square metre (1 m^2) ✓ (3)

7.4 **Reactions**

Taking moments around A

$$\circlearrowleft = \circlearrowright$$

$$(B \times 3,5) + (1400 \times 0,7) = (350 \times 6,7)2,65 + (1600 \times 6) \quad \checkmark$$

$$3,5B + 980 = 6214,25 + 9600 \quad \checkmark$$

$$\frac{3,5B}{3,5} = \frac{6214,25 + 9600 - 980}{3,5} \quad \checkmark$$

$$B = 4238,36 \text{ N}$$

Taking moments around B

$$\circlearrowright = \circlearrowleft$$

$$(A \times 3,5) + (1600 \times 2,5) = (350 \times 6,7)0,85 + (1400 \times 4,2) \quad \checkmark$$

$$3,5A + 4000 = 1993,25 + 5880 \quad \checkmark$$

$$\frac{3,5A}{3,5} = \frac{1993,25 + 5880 - 4000}{3,5} \quad \checkmark$$

$$A = 1106,64 \text{ N}$$

(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 the oil gives off a vapour which will ignite. ✓✓ (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:

$$\frac{N_A}{N_D} = \frac{T_B \times T_D}{T_A \times T_C} \quad \checkmark$$

$$N_A = \frac{80 \times 63 \times 2}{30 \times 40} \quad \checkmark$$

$$N_A = \frac{10080}{1200} \quad \checkmark$$

$$N_A = 8{,}4\,\text{r/s} \quad \checkmark\checkmark \qquad (5)$$

9.1.2 Speed ratio of gear train:

$$\text{Speed ratio} = \frac{\text{Input}}{\text{Output}}$$

$$= \frac{8{,}4}{2} \quad \checkmark$$

$$= 4{,}2:1 \quad \checkmark$$

OR

$$\text{Speed ratio} = \frac{\text{Driven teeth}}{\text{Driver teeth}}$$

$$= \frac{80}{30} \times \frac{63}{40} \quad \checkmark$$

$$= 4{,}2:1 \quad \checkmark \qquad (2)$$

9.2 Belt drive

9.2.1 Diameter of the driven pulley

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

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

$$= \frac{7{,}2 \times 600}{800} \quad \checkmark$$

$$= 5{,}4\ \text{r/s} \quad \checkmark \qquad (3)$$

9.2.2 **Power transmitted:**

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

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

$$= 2442,90 \text{ Watt} \quad \checkmark$$

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

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

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

$$= 120 \text{ N}$$

OR

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

$$P = (300 - 120) \pi \times 0,8 \times 5,4 \quad \checkmark$$

$$= 2442,90 \text{ Watt} \quad \checkmark$$

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

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

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

$$= 120 \text{ N} \quad \checkmark$$

(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

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

$$= \frac{\pi 0{,}04^2}{4}$$

$$= 1{,}26 \times 10^{-3}\ m^2 \quad ✓$$

$$P_A = \frac{F}{A_A}$$

$$= \frac{80}{1{,}26 \times 10^{-3}} Pa \quad ✓$$

$$= 63661{,}98\ Pa$$

$$= 63{,}66\ kPa \quad ✓$$

(3)

9.5.2 Diameter of piston B

$$P_B = P_A$$

$$P_B = \frac{F_B}{A_B} \quad ✓$$

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

$$A_B = \frac{320}{63492{,}06}$$

$$A_B = 5{,}04 \times 10^{-3} \quad ✓$$

$$A = \frac{\pi D^2}{4} \quad ✓$$

$$D_B = \sqrt{\frac{A_B \times 4}{\pi}}$$

$$= \sqrt{\frac{5{,}04 \times 10^{-3} \times 4}{\pi}}$$

$$= 0{,}08\ m$$

$$= 80\ mm \quad ✓$$

(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)

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 into the cylinder ✓
- Exhaust gases leave system through the exhaust pipe ✓ (5)

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