basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

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GRADE 12

MECHANICAL TECHNOLOGY

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MEMORANDUM

MARKS: 200

This memorandum consists of 18 pages.

QUESTION 1: MULTIPLE CHOICE QUESTIONS

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

[20]

QUESTION 2: FORCES, SYSTEMS AND CONTROL

2.1 HYDRAULICS

2.1.1 Calculate the fluid pressure in the system:

$$A_B = \frac{\pi D}{4} \qquad or\ A_B = \pi r^2 \qquad \surd$$

$$= \frac{\pi(0.1)^2}{4} \qquad \surd$$

$$= 7{,}85 \times 10^{-3}\ m^2$$

$$P = \frac{F_B}{A_B} \qquad \surd$$

$$= \frac{150 \times 10^3}{7{,}85 \times 10^{-3}}$$

$$= 19{,}108\ MPa$$

$$= 19{,}11\ MPa \qquad \surd \quad (4)$$

2.1.2 Calculate the force on piston A:

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

$$= \frac{\pi(0{,}025)^2}{4}$$

$$= 0{,}49 \times 10^{-3}\ m^2 \qquad \surd$$

$$F_A = P \times A_A \qquad \surd$$

$$= \frac{150 \times 10^3}{7{,}85 \times 10^{-3}} \times 0{,}49 \times 10^{-3}$$

$$= 9363{,}9\ N$$

$$= 9{,}36kN \qquad \surd \quad (4)$$

2.1.3 Calculate force F:

$$F \times 0{,}48 = 9363{,}9 \times 0{,}08 \qquad \surd\surd$$

$$F = \frac{9363{,}9 \times 0{,}08}{0{,}48} \qquad \surd$$

$$= 1560{,}65\ N \qquad \surd \quad (4)$$

2.2 STRESS AND STRAIN

2.2.1 Calculate the maximum stress in part C:

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

$$= \frac{\pi(0,05)^2}{4} \quad \surd$$

$$= 1,96 \times 10^{-3}\, m^2 \quad \surd$$

$$\sigma_C = \frac{F}{A_C} \quad \surd$$

$$= \frac{12 \times 10^3}{1,96 \times 10^{-3}}$$

$$= 6,12 \times 10^6\, Pa$$

$$= 6,12MPa \quad \surd$$ (5)

2.2.2 Calculate the strain in part A:

$$E = \frac{\sigma_A}{\varepsilon_A}$$

$$\varepsilon_A = \frac{\sigma_A}{E} \quad \surd$$

$$BUT$$

$$\sigma_A = \frac{F}{A_A} \quad \surd$$

$$\sigma_A = \frac{F \times 4}{\pi(D_A)^2} \quad \surd$$

$$= \frac{12 \times 10^3 \times 4}{\pi(0,1)^2} \quad \surd$$

$$= 1,527 \times 10^6\, Pa \quad \surd$$

$$= 1,53\ MPa$$

$$\varepsilon_A = \frac{\sigma_A}{E} \quad \surd$$

$$= \frac{1,53 \times 10^6}{108 \times 10^9}$$

$$= 0,014 \times 10^{-3} \quad or \quad 0.00001414 \quad \surd$$ (7)

ALTERNATIVELY

2.2.2 **Calculate the strain in part A:**

$$\sigma_A \times A_A = \sigma_C \times A_C \quad \surd$$

$$\sigma_A = \frac{\sigma_C \times A_C}{A_A}$$

$$\sigma_A = \frac{\sigma_C \times (D_C)^2}{(D_A)^2} \quad \surd$$

$$= \frac{\sigma_C \times (50)^2}{(100)^2} \quad \surd$$

$$= \frac{\sigma_C}{2^2}$$

$$= \frac{6{,}12 \times 10^6}{4} \quad \surd$$

$$\sigma_A = 1{,}53 \times 10^6 \, Pa \quad \surd$$

$$\varepsilon_A = \frac{\sigma_A}{E}$$

$$= \frac{1{,}53 \times 10^6}{108 \times 10^9} \quad \surd$$

$$= 0{,}014 \times 10^{-3} \quad \surd \quad (7)$$

2.3 BELT DRIVE

Calculate power transmitted:

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

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

$$= \frac{300}{2,5} \quad \surd$$

$$T_2 = 120\ N \quad \surd$$

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

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

$$= 2442,9\ Watt \quad \surd$$

$$= 2,44\ kW$$

OR

$$OR$$

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

$$= (300 - 120)\pi \times 0,432 \times 10 \quad \surd\surd$$

$$= 2442,9\ Watt$$

$$= 2,44\ kW \quad \surd$$

(7)

2.4 GEAR DRIVE

2.4.1 Calculate the number of teeth on the final gear D:

$$\frac{Product\ of\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ number\ of\ teeth\ on\ driver\ gears} = \frac{N_{DR}}{N_{DN}} \quad \surd$$

$$\frac{80 \times T_D}{30 \times 20} = \frac{480}{90} \quad \surd$$

$$T_D = \frac{480 \times 30 \times 20}{90 \times 80} \quad \surd$$

$$= 40\ Teeth \quad \surd$$

(4)

2.4.2 **The gear ratio of the system:**

$$Gear\ ratio = \frac{Product\ of\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ number\ of\ teeth\ on\ driver\ gears}$$ √

$$= \frac{80 \times 40}{30 \times 20}$$ √

$$= 5,3 : 1$$ √

OR **OR**

$$Gear\ ratio = \frac{N_{input}}{N_{output}}$$ √

$$= \frac{480}{90}$$ √

$$= 5,3 : 1$$ √ (3)

2.5 **WHEEL AND AXLE**

2.5.1 **Calculate the mechanical advantage of the system:**

$$MA = \frac{Load}{Effort}$$ √

$$= \frac{1800}{100}$$ √

$$= 18$$ √ (3)

2.5.2 **Calculate the velocity ratio of the system:**

$$VR = \frac{2D}{d_2 - d_1}$$ √

$$= \frac{2 \times 0,3}{0,15 - 0,12} \quad or \quad VR = \frac{600}{30}$$

$$= 20 : 1$$ √ (2)

2.5.3 **Calculate the mechanical efficiency of the system:**

$$\eta = \frac{MA}{VR} \times 100$$

$$= \frac{18}{20} \times 100$$ √

$$= 90\%$$ √ (2)

2.6 CLUTCH

2.6.1 Calculate the torque transmitted by the clutch:

$$T = \mu WnR \quad \surd$$

$$= 0,4 \times 3 \times 10^3 \times 2 \times \left(\frac{0,25}{2}\right) \quad \surd$$

$$= 300Nm \quad \surd \quad (3)$$

2.6.2 Calculate the power transmitted:

$$P = \frac{2\pi N T}{60} \quad \surd$$

$$= \frac{2\pi \times 3000 \times 300}{60}$$

$$= 94,247 \times 10^3\ W \quad or \quad 94247,78\ Watt$$

$$= 94,25kW \quad \surd \quad (2)$$

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QUESTION 3: TOOLS AND EQUIPMENT

3.1 **VOLTMETER** is connected in parallel with a circuit. √
AMMETER is connected in series with a circuit. √ (2)

3.2 Metal Arc Gas Shielded/Metal Inert Gas Shielded √√ (2)

3.3 **USES OF A MULTI-METER:**

- Direct current measurement (DC) √
- Alternating current measurement (AC) √
- Diode and continuity measurement √
- Battery measurement √
- Resistance measurement √
- Temperature measurement √
- Transistor test √
- Direct current voltage measurement √ (2)

(Any 2 x 1)

3.4 **COMPRESSION TEST**

3.4.1 **Reasons for compression test**:

- **Valve clearances** √
- Leaking exhaust valve √
- Leaking cylinder head gasket √
- Worn rings √
- Worn cylinders √
- Worn piston √
- Leaking inlet valve. (4)
- **Loose cylinder head bolt**
- **Cracked cylinder head**
- **Cracked piston**

(Any 4 x 1)

3.4.2 **Dry compression test**:

- Run engine until normal operating temperature is reached. √√
- Air cleaner to be removed and jam the choke and throttle valve in the open position, to allow maximum air to enter the combustion chamber. √√
- Disconnect the primary coil lead to prevent spark. √
- Clean area around spark plug and the screw the pressure gauge into the spark plug hole. √√ √
- Crank the engine until the gauge stops rising.
- Test all the cylinders and compare the readings to the manufacturer's specifications. √√ (10)

[20]

QUESTION 4: MATERIALS

4.1 PROPERTIES OF STAINLESS STEEL:

- It has a shiny appearance due to chromium oxide film applied to the surface √
- It has good resistance to corrosion due to a high chrome content. √ (2)

4.2 SCREW DRIVER:

Reason: The material is too brittle. √

Support: A brittle material is the one that fractures with little or no deformation √ (2)

4.3 HAMMER:

Material B is the toughest. √√

Reason: Toughness is measured by the amount of energy needed to break the material. The higher the swing height of the hammer the higher the toughness of the material. √√ (4)

4.4 ELECTRICAL CABLE:

Polyvinylchloride (PVC) and Polythene (Polyethylene) √√

Reasons: They soften on heating and can be moulded into shape. √
On cooling they harden. √ (4)

4.5 NON-FERROUS ALLOYS:

A non-ferrous alloy is a metal that has a combination of two or more non-ferrous metals which are melted together to form one non-ferrous alloy. √
Example: Brass; Bronze; White metal; duralumin and solder (only one example) √ (2)

4.6

Process	Composition	Uses
Silver soldering	They are alloys of copper, zinc and silver, **tin and lead** √	They are used to produce strong ductile joints in copper, brass and in jewellery work √
Brazing	They make use of zinc copper alloys	They are used to produce strong ductile joints in ferrous metals. √

(4)

4.7 CARBON STEEL:

Low carbon steel – 0,25% carbon or
Medium carbon steel – 0,5 % carbon or
High carbon steel – 1% carbon Select only ONE answer (2 x 1) (2)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

5.1 **BEAM BENDING TESTER**:

- Make sure the object to be tested is firmly secured √
- Make sure that all the holding devices are fitted properly √
- Check components of a tester for wear √
- Check for leaks at the hydraulic pump ram. √
- Make sure the area around tester is clean and free from oil and grease √

(Any 4 x 1) (4)

5.2 **CENTRE LATHE:**

- **Personal safety**
- Do not operate the machine until you are certain you know the procedures √√
- Make sure that the machine is clean and safe to use √
- Clamp work piece firmly/securely √
- Choose the correct cutting tool and holding device for the job √
- Make sure that all guards are in place before you operate the machine √
- Remove the chuck key from the chuck before starting the machine √
- Make sure the area around the lathe is free from oil, grease and any scrap metal. √

(Any 4 x 1) (4)

5.3 **OIL AND GREASE** are highly flammable under high pressure in the presence of oxygen. √√ (2)

5.4 **METHODS OF INDEXING**:

- Direct indexing/Rapid indexing √
- Simple indexing √
- Angular indexing √
- Differential indexing √

(4)

5.5 FEED IN MILLIMETRE PER MINUTE:

$$D = \frac{100}{1000}$$
$$= 0,1\,m \quad \surd$$
$$v = \pi DN$$
$$N = \frac{v}{\pi D} \quad \surd$$
$$= \frac{40}{\pi \times 0,1} \quad \surd$$
$$= 127,32\,r/min \quad \surd$$
$$feed = f_1 \times T \times N$$
$$= 0,09 \times 24 \times 127,32 \quad \surd$$
$$= 275,01\ mm/min \quad \surd \quad (6)$$

5.6 GEARS

5.6.1 Calculate the module of the small gear:

$$m = \frac{PCD}{T}$$
$$= \frac{48,75}{39} \quad \surd$$
$$= 1,25\,mm \quad \surd \quad (2)$$

5.6.2 Calculate the outside diameter of the big gear:

$$Outside\ diameter = m(T+2)$$
$$= 1,25(63+2) \quad \textbf{or}$$
$$= 81,25\,mm$$

$$OD = PCD + 2m$$
$$= m \times T + 2m \quad \surd$$
$$= 1.25 \times 63 + 2.5 \quad \surd \quad (2)$$
$$= 78.75 + 2.5$$
$$= 81.25mm$$

5.6.3 Calculate the PCD of the big gear:

$$PCD = m \times T$$
$$= 1,25 \times 63 \quad \surd$$
$$= 78,75\,mm \quad \surd \quad (2)$$

5.6.4 **Calculate the dedendum of the big gear**:

$$Dedendum = 1{,}157 \times m$$
$$= 1{,}157 \times 1{,}25 \quad \surd$$
$$= 1{,}446\ mm \quad \surd$$
$$= 1{,}45\ mm \quad (2)$$

OR

$$OR$$
$$Dedendum = 1{,}25 \times m$$
$$= 1{,}25 \times 1{,}25 \quad \surd$$
$$= 1{,}56\ mm \quad \surd \quad (2)$$

5.6.5 **The centre distance Y**

$$Distance\ Y = \frac{PCD\ big\ gear + PCD\ small\ gear}{2} \quad \surd$$
$$= \frac{78{,}75 + 48{,}75}{2} \quad \surd$$
$$= 63{,}75\ mm \quad \surd \quad (3)$$

5.7 **WELDING DEFECTS**

5.7.1 **Cracks:**

Causes:

- Atmospheric pollution √
- Wrong welding technique √
- Dirty or wet electrodes / corroded MIG wire √
- Wrong electrode √
- Stressed weld √
- Faulty weld joint preparation √
- Cooling rate too fast √
- Craters present √

(Any 2 x 1) (2)

Corrective measures:

- Use low hydrogen electrode. √
- Increase the temperature of the parts to be welded. √
- Fill craters with welding material. √
- Use the correct welding current settings. √

(Any 1 x 1) (1)

5.7.2 **Slag inclusion:**

Causes:
- Rapid chilling √
- Repeating a weld without removing the previous slag √
- Weld temperature is too low √
- High viscosity of the molten metal √
- Included angle is too small √

(Any 2 x 1) (2)

Corrective measures:
- Remove slag from the previous weld run. √
- Increase the preparation angle. √

(Any 1 x 1) (1)

5.8 **NON-DESTRUCTIVE TESTS**:

- Liquid dye penetrant √
- Ultrasonic √
- X-ray √
- Sound test √
- Hardness test √
- Visual inspection √

(Any 3 x 1) (3)

5.9 **INDEXING**

5.9.1 **Calculate the required indexing**:

$$Indexing = \frac{40}{n}$$
$$= \frac{40}{60} \quad \surd$$
$$= \frac{2}{3}$$
$$= \frac{2}{3} \times \frac{8}{8} \quad \surd$$
$$= \frac{16}{24}$$

No full turns, and 16 holes on the 24 hole circle √√ (4)

Other hole circles can also be allowed

5.9.2 **Calculate the required change gears**:

$$\frac{Dr}{Dv} = (A - n) \times \frac{40}{A}$$

$$= (60 - 63) \times \frac{40}{60} \qquad OR \quad = \frac{-120}{60}$$

$$= -\frac{3 \times 2}{3} \qquad = \frac{-2}{1} \qquad \surd$$

$$= \frac{-2}{1} \times \frac{24}{24} \qquad = \frac{-2}{1} \times \frac{24}{24} \qquad \surd$$

$$= \frac{-48}{24} \qquad = \frac{-48}{24}$$

Drive gears has 48 teeth and Driven gear has 24 √√ (4)

5.9.3 **Direction of rotation of the index plate in relation to the index crank:**

The index plate rotates in the opposite direction of the crank. (- sign) √√ (2)

Anti clockwise or left

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QUESTION 6: MAINTENANCE AND TURBINES

6.1 CUTTING FLUIDS:

- Carry away the heat generated by machining process. √
- Acts as a lubricant. √
- Prevents the chips/swarf from sticking and fusing to the cutter teeth. √
- Improve quality of the finish of machine surface. √
- To keep the cutting tool cool. √
- To obtain a higher cutting speed. √
- It gives the cutting tool a longer lifespan. √
- Does not rust the machine. √
- Helps to wash away the chips/swarf of the metal being removed from the work piece, thus keeping the cutting edge of the cutting tool clean. √

(Any 4 x 1) (4)

6.2 VEHICLE SERVICE

6.2.1 Functions of an oil:

- It lubricates √
- Provide cooling and control temperature √
- It acts as a seal √
- Reduce engine noise √
- Prolong engine life √
- It absorbs shocks and vibrations √
- Cleans the inside of the engine √

(Any 3 x 1) (3)

6.2.2 Draining and filling oil for differential unit:

- Run the vehicle so that the rear axle oil is warm, so that it drains easily. √
- Keep a drain tray that can hold all the oil at hand. √
- Clean area around the drain and filler plug. √
- Remove filler plug this will allow the oil to flow easily and fast. √
- Remove the drain plug using a correct spanner and allow oil to drain into the tray. √
- Allow all the oil to drain out. √
- Wash the drain and filler plug. √
- Fit new washers to both the drain and filler plugs. √
- Replace the drain plug. √
- Fill oil using oil from a plastic dispenser. √
- Fill the oil until the oil just trickles out of the filler hole.
- Do not overfill the rear axle because this can cause the side shaft seals to fail √
- Replace filler plug and wipe off surplus oil √ (13)

6.3 BLOWER

6.3.1 Centrifugal blower √ (1)

6.3.2 **Components**

1. Air inlet √
2. Air outlet √
3. Impeller √
4. Fins √ (4)

6.3.3 **Operation**:

- This blower can be driven mechanically by means of a belt drive from the crank shaft or by means of exhaust gases moving through to the exhaust manifold √
- The shaped fins on the impeller move the air around to the outer edge of the impeller into the housing. √
- In doing so, the moving fins leave a low pressure behind it. √
- Air, under atmospheric pressure, rushes in to fill the low pressure at the centre of the impeller. √
- The impeller rotates so fast that a continuous movement of air is present which now builds up a pressure as it is thrown at the rim of the edge. √ (5)

6.4 SUPER CHARGER

6.4.1 **Advantages of a supercharger:**

- More power is obtained compared to an engine with a similar capacity without a supercharger √
- Supercharged engines are more economical per given kilowatt output. √
- Less fuel is used compared to engine mass. √
- Power loss is eliminated above sea level. √

(Any 3 x 1) (3)

6.4.2 **Disadvantages of a supercharger**:

- A small amount of power is lost in order to drive the supercharger because it uses the engine power to drive it √
- Higher fuel consumption if the power generated is not fully used, as in the case of passenger vehicles √
- Due to the compression of the air this results in an increase in air temperature causing a decrease in the density of the inlet charge. √
- The lifespan of the engine is decreased because of higher cylinder pressure, which increases the load on the engine components. √

(Any 3 x 1) (3)

6.5 **FUNCTION OF STEAM TURBINE**:

- Steam turbines are operated by using steam that generates kinetic energy √
- This generates rotational motion which is mechanical energy. √ (2)

6.6 **TURBINE USES**:

- To power generators which generate large amounts of electricity. √
- To power ship propulsion. √ (2)

[40]

TOTAL: 200