education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

MARCH 2009

MEMORANDUM

MARKS: 200

This memorandum consists of 17 pages.

QUESTION 1: MULTIPLE CHOICE QUESTIONS
(Learning Outcome 3: Assessment Standards 1 – 9)

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

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL
(Learning Outcome 3: Assessment Standards 6 and 8)

2.1 STRESS AND STRAIN (Young's modulus)

2.1.1 Calculate the diameter of the pin.

$$\text{Stress}\,(\sigma) = \frac{\text{Force}\,(\text{F})}{\text{Area}\,(\text{A})}$$

$$\text{A} = \frac{100 \text{ x } 10^{3}}{204 \text{ x } 10^{6}} \quad ✓$$

$$= 0{,}49 \text{ x } 10^{-3} \text{ m}^2 \quad ✓$$

$$\text{But Area} = \frac{\pi \text{d}^2}{4} \quad ✓$$

$$\text{d} = \sqrt{\frac{4\text{A}}{\pi}}$$

$$= \sqrt{\frac{4 \text{ x } 0{,}49 \text{ x } 10^{-3}}{\pi}} \quad ✓$$

$$= \sqrt{0{,}624 \text{ x } 10^{-3}} \quad ✓$$

$$= 0{,}025 \text{ m}$$

$$\text{d} = 25 \text{ mm} \quad ✓ \quad (6)$$

2.1.2 Calculate the strain induced in the pin.

$$E = \frac{\sigma}{\varepsilon}$$

$$\varepsilon = \frac{\sigma}{E} \quad ✓$$

$$= \frac{204 \times 10^{6}}{210 \times 10^{9}} \quad ✓$$

$$= 0{,}97 \times 10^{-3} \quad ✓ \quad (3)$$

2.1.3 Calculate the change in length of the pin.

$$\varepsilon = \frac{\Delta L}{OL} \quad ✓$$

$$\Delta L = \varepsilon \times OL$$

$$= \left(0{,}97 \times 10^{-3}\right) \times \left(110\right) \quad ✓$$

$$= 0{,}11 \text{ mm} \quad ✓ \quad (3)$$

2.1.4 Type of stress induced in the pin

Compressive stress ✓ (1)

2.1.5 Effect the load has on the pin

The load will shorten the length of the pin

The new length = (110 – 0,11) mm ✓
✓
= 109,89 mm ✓ (3)

2.1.6 Effect when using brass

The length of the brass pin will be shortened more than the mild steel pin. ✓

Young's modulus of elasticity will be less than mild steel because it is a softer material. ✓ (2)

2.2 BELT DRIVES

2.2.1 Calculate the mass of the belt.

$$Mass\ per\ metre = Area \times Length \times Density$$
$$= (thickness \times width) \times (length) \times (density)$$ ✓
$$= (0,005 \times 0,28) \times (1) \times (1) \times 10^3$$ ✓
$$= 1,40\ kg/m$$ ✓ (3)

2.2.2 Calculate the belt speed.

$$Belt\ speed\ (V) = \frac{\pi(D+t) \times N}{60}$$
$$= \frac{\pi(0,34+0,005) \times 2000}{60}$$ ✓ ✓
$$= 36,14\ m/s$$ ✓ (3)

2.2.3 Calculate the power to drive the belt system.

$$P = \frac{2\pi NT}{60}$$

$$but\ T = F \times r$$

$$= 400\ N \times 0{,}17\ m \quad ✓$$

$$= 68\ Nm \quad ✓$$

$$P = \frac{2 \times \pi \times 2000 \times 68}{60} \quad ✓$$

$$= 14241{,}89\ W$$

$$= 14{,}24\ kW \quad ✓ \quad (4)$$

2.2.4 The thicker belt

✓✓

The thicker belt will result in reducing the speed of the pulley because of its weight. (2)

2.3 FRICTION

2.3.1 Calculate the torque applied.

$$Torque = \mu WnR$$

$$= 0{,}35 \times 3{,}4 \times 10^3 \times 2 \times 0{,}1 \quad ✓$$

$$= 238\ Nm \quad ✓ \quad (2)$$

2.3.2 Calculate the power transmitted.

$$Power = \frac{2\pi NT}{60}$$

$$= \frac{2 \times \pi \times 3\,200 \times 238}{60} \quad ✓ ✓$$

$$= 79{,}75\ kW \quad ✓ \quad (3)$$

2.4 HYDRAULIC PRESS

2.4.1 Calculate the diameter of Piston A.

$First\ \ calculate\ \ the\ volume\ \ of\ \ cylinder\ \ B.$ ✓

$$V_B = Area_B \times Stroke\ \ length_B$$

$$= \frac{\pi \times D_B^2}{4} \times L_B$$

$$= \frac{\pi \times (0{,}18)^2}{4} \times 0{,}012$$ ✓

$$= 0{,}305 \times 10^{-3} m^3$$ ✓

$$But, V_A = V_B$$

$$\therefore A_A \times L_A = V_B$$ ✓

$$A_A \times 0{,}06 = 0{,}305 \times 10^{-3}$$ ✓

$$A_A = \frac{0{,}305 \times 10^{-3}}{0.06}$$

$$= 5{,}08 \times 10^{-3} m^2$$ ✓

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

$$D_A^2 = \frac{5{,}08 \times 10^{-3} \times 4}{\pi}$$ ✓

$$D_A = \sqrt{6{,}47 \times 10^{-3}}$$ ✓

$$D_A = 0{,}80\ m$$

$$= 80\ mm$$ ✓ (9)

2.4.2 Calculate the pressure exerted on Piston A.

$$Pressure\ \ at\ \ A = \frac{F_A}{A_A}$$

$$P_A = \frac{550}{5{,}08\ \times 10^{-3}}$$ ✓

$$= 108{,}268\ \times 10^3\ Pa$$

$$= 108{,}27\ \ kPa$$ ✓ (2)

2.4.3 Calculate the force exerted on Piston B.

NOTE: Pressure at A is equal to Pressure at B

$$P_B = P_A \quad \checkmark$$

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

$$F_B = 108,268 \times 10^3 \times A_B \quad \checkmark$$

$$= 108,268 \times 10^3 \times 25,45 \times 10^{-3}$$

$$= 2755,42\ N \quad \checkmark$$

$$= 2,76\ kN$$

(4)
[50]

QUESTION 3: TOOLS AND EQUIPMENT
Learning Outcome 3: Assessment Standard 2

3.1 METAL ARC GAS SHIELDED WELDING

1. *Regulator* ✓
2. *Gun cable* ✓
3. *Welding gun / torch* ✓
4. *Earth cable* ✓
5. *Power cable* ✓
6. *Wire feed control* ✓
7. *Gas cylinder* ✓ (7)

3.2 ABBREVIATION MAGS/MIGS

Metal Arc Gas Shielded /Metal Inert Gas Shielded ✓ (1)

3.3 GAS USED IN MAGS/MIGS WELDING

Argon
Carbon dioxide ✓
Helium
Oxygen *(Any 2)* ✓ (2)

3.4 DETERMINE CYLINDER LEAKAGES

- *Listen at the carburetor for a hissing noise* ✓
  - *Valve is leaking* ✓
- *Listen at the exhaust pipe for a hissing noise* ✓
  - *Exhaust valve is leaking* ✓
- *Listen for a hissing noise in the dipstick hole* ✓
  - *Piston ring is worn* ✓
- *Remove the filler cap on the tappet cover and listen for a hissing noise* ✓
  - *Rings are worn* ✓
- *If you see bubbles in the radiator water,* ✓
  - *The cylinder head gasket is blown* *(10)* ✓ (10)

[20]

QUESTION 4: MATERIALS
(Learning Outcome 3: Assessment Standard 3)

4.1 MATERIALS

4.1.1 ***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 alloy.* ✓ ✓ (2)

4.1.2 ***Composites*** *are materials that are made up of two or more different materials put together.* ✓ ✓ (2)

4.2 ENGINEERING MATERIALS

	PROPERTIES	***USES***
4.2.1 White metal	*Any TWO of the following:* • *Low friction* ✓ • *Low melting* ✓ • *Casts well* ✓	*Any TWO of the following:* • *Big-end bearings* ✓ • *Main bearings* ✓ • *Bearings for electrical machines* ✓

(4)

4.2.2 Vanadium	*Any TWO of the following:* • *Wear resistant* ✓ • *Fatigue resistant* ✓ • *Makes steel stronger* ✓	*Any TWO of the following:* • *Crankshafts* ✓ • *Connecting rods* ✓ • *Gears* ✓ • *Vehicle axles* ✓ • *Steering components* ✓

(4)

4.2.3 Nylon	*Any TWO of the following:* • *Needs no lubrication* ✓ • *Can withstand a lot of shock* ✓ • *No maintenance* ✓ • *Light in weight* ✓ • *Easy to machine* ✓	*Any TWO of the following:* • *Fan blades* ✓ • *Bearings* ✓ • *Gears* ✓ • *Trolley wheels* ✓ • *Bolts and nuts* ✓

(4)

4.3 BRASS

- *It is resistant against corrosion.* ✓
- *It is ductile and malleable.* ✓
- *Can be polished to give a good shine.* ✓
- *It is softer than mild steel and easy to machine.* ✓

(4)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS
(Learning Outcome 3: Assessment Standards 1, 4 and 5)

5.1 LATHE MACHINE – SAFETY

- *Clamp work piece solidly.* ✓
- *Use the correct size tool and work-holding device for the job.* ✓
- *Get an assistant when working with heavy chucks, attachments and work piece.* ✓
- *Make sure that all guards are in place before you operate the machine.* ✓
- *Stop the machine before making measurements or adjustments.* ✓
- *Do not attempt to remove chips with your hand. Use a brush or short stick.* ✓
- *Remove neck tie, wrist watch and jewelry.* ✓
- *Always remove the key from the chuck.* ✓
- *Wear apron and safety goggles when working on a lathe.* ✓
- *Tools must not be placed on the lathe ways.* *(any 5 x 1 = 5)* ✓ (5)

5.2 METAL ARC GAS SHIELDED SAFETY OR METAL INERT GAS WELDING SAFETY

- *The work area must be well ventilated because of toxic gases.* ✓
- *The work area must be well illuminated.* ✓
- *Wear flameproof gauntlet, gloves, flameproof apron or leather, asbestos or other non-flammable materials, because of hot sparks.* ✓
- *Do not use gloves to carry hot metal, use a pair of pliers.* ✓
- *Use fire-resistant leggings and safety boots to protect legs and feet.* ✓
- *When performing overhead welding, the operator must use the face shield and helmet.* *(any 4 x 1 = 4)* ✓ (4)

5.3 MILLING CUTTERS

5.3.1 *Plain helical cutter* ✓ (1)
5.3.2 *Side and face cutter* ✓ (1)
5.3.3 *Slotting cutter* ✓ (1)
5.3.4 *Dove tail cutter* ✓ (1)
5.3.5 *Slot drill* ✓ (1)

5.4 INDEXING

INDEX PLATE 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*

STANDARD CHANGE GEARS										
24 x 2	*28*	*32*	*40*	*44*	*48*	*56*	*64*	*72*	*86*	*100*

5.4.1 Indexing:

Use A = 86 and n=87

$Indexing = \frac{40}{A} = \frac{40}{87} \Rightarrow$ *no calculation possible* ✓

choose $A = 86$

$$Indexing = \frac{40}{A} \quad \checkmark$$
$$= \frac{40}{86}$$
$$= \frac{20}{43} \quad \checkmark$$

i.e. no full turns and 20 holes in a 43 hole circle plate (3)

5.4.2 Change gears:

$$\frac{Dr}{Dv}(Gear\ ratio) = (A/N - n)\,x\,\frac{40}{A/N} \quad \checkmark$$
$$= (86 - 87)\,x\,\frac{40}{86} \quad \checkmark$$
$$= -1\,x\,\frac{40}{86} \quad \checkmark$$ ✓
$$\frac{Dr}{Dv} = -\frac{40}{86} \quad \checkmark$$ ✓

(6)

5.4.3 Meaning of positive (+) and negative (-) signs

If the sign is positive (+) when determining change gears, the rotation of the index plate will be in the same direction of rotation of the crank handle. ✓ ✓

If the sign is negative (-) when determining change gears, the rotation of the index plate will be in the opposite direction of rotation of the crank handle. ✓ ✓ (4)

5.5 Calculate the feed on a milling machine.

$$D = \frac{80}{1000}$$
$$= 0{,}08\ m \quad \checkmark \qquad \checkmark$$

$$V = \pi DN$$

$$N = \frac{V}{\pi D} \qquad \checkmark$$
$$= \frac{25}{\pi\ x\ 0{,}08} \qquad \checkmark$$
$$= 99{,}47\ \ r/\text{min} \qquad \checkmark$$

$$f = f_1\ x\ T\ x\ N \qquad \checkmark$$
$$= 0{,}04\ x\ 16\ x\ 99{,}47$$
$$= 63{,}66\ \ mm/\text{min}$$
$$= 64\ mm/\text{min} \qquad \checkmark \quad (6)$$

5.6 LIQUID DYE PENETRANT

- *Clean the surface to be tested.* ✓
- *A liquid dye penetrant is sprayed onto the clean surface.* ✓
- *Allow a short time for the dye to penetrate the weld joint.* ✓
- *Use a cloth to remove excess dye on the weld.* ✓
- *Wash the surface and allow to dry thoroughly.* ✓
- *Use a developer and spray on the surface which brings out the colour in the dye penetrant that has penetrated into the cracks or pinholes.* ✓ (6)

5.7 DESTRUCTIVE TESTS ON A WELDED JOINT

- *To check whether proper welding procedures were followed during the welding process.* ✓
- *To check for visual weld defects.* ✓ (2)

5.8 WELDING DEFECTS (any 3 x 3 = 9)

WELD DEFECT	*CAUSES*	*CORRECTION METHOD*
Poor appearance ✓	*Any ONE of the following:* • *Current too high or too low* ✓ • *Incorrect use of electrode* ✓ • *Faulty electrode* ✓	*Any ONE of the following* • *Adjust current to required amperage* ✓ • *Check the procedure of welding* ✓ • *Change the electrode or use dry electrode* ✓
Weld crater ✓	*Any ONE of the following:* • *Current too high* ✓ • *Improper welding technique* ✓ • *Electrode too small* ✓	*Any ONE of the following:* • *Use lower current* ✓ • *Use proper welding technique* ✓ • *Use correct electrode* ✓
Slag inclusion ✓	*Any ONE of the following:* • *Included angle too narrow* ✓ • *Rapid chilling* ✓ • *Weld temperature too low* ✓ • *High viscosity of molten metal* ✓	*Any ONE of the following:* • *Preheat metal* ✓ • *Remove slag from previous run weld* ✓ • *Increase the included angle* ✓
Porous weld ✓	*Any ONE of the following:* • *Speed too fast* ✓ • *Current too low* ✓ • *Insufficient pudding time* ✓ • *Faulty electrode* ✓ • *High sulphur or other impurities in metal* ✓ • *Impaired base metal* ✓ • *Short arc with exception of low hydrogen and stainless* ✓	*Any ONE of the following:* • *Use correct current* ✓ • *Hold a longe arc* ✓ • *Use low hydrogen electrodes* ✓ • *Check for impurities in base metal* ✓ • *Allow for sufficient puddling time for gases to escape* ✓ • *Weave the weld* ✓ • *Use correct electrode for the job* ✓

WELD DEFECT	*CAUSES*	*CORRECTION METHOD*
Incomplete penetration ✓	*Any ONE of the following:* • *Speed too fast* ✓ • *Joint design faulty* ✓ • *Electrodes too large* ✓ • *Current too low* ✓	*Any ONE of the following:* • *Use correct current to obtain desired penetration* ✓ • *A weld slowly* ✓ • *Calculate the electrode penetration properly* ✓ • *Select correct electrode according to welding groove* ✓ • *Leave enough free space at the bottom of the weld* ✓
Undercutting ✓	*Any ONE of the following:* • *Faulty electrode manipulation* ✓ • *Current too high* ✓ • *Arc length too long* ✓ • *Speed of weld too fast* ✓	*Any ONE of the following:* • *Use a uniform weave in butt welding* ✓ • *Do not use a too large electrode* ✓ • *Avoid excessive weaving* ✓ • *Current to be moderate and weld slowly* ✓ • *Hold the electrode at a safe distance from the vertical plane when making a horizontal fillet weld* ✓

(any 3 x 3 = 9) (9)

[50]

QUESTION 6: MAINTENANCE AND TURBINES
(Learning Outcome 3: Assessment Standards 7 and 9)

6.1 EFFECTIVENESS OF A CUTTING FLUID AS COMPARED TO OIL

- *It prevents the shavings or metal chips from sticking and fusing to the cutting tool* ✓
- *It will carry away the heat generated by the turning process* ✓
- *It flushes away shavings/metal chips* ✓
- *It improves the quality of the finish of the turned surface* ✓ (4)

6.2 CORROSION AND RUST RESISTANCE OF OIL

- *It is the ability of oil to displace water from the metal allowing the oil to coat the surfaces.* ✓
- *It also has the alkaline reaction to neutralise combustion acid thus preventing corrosion.* ✓ (2)

6.3 REASONS FOR OIL CHANGE

- *Formation of gum, acids and lacquer may be left by the combustion of the fuel.* ✓
- *Oil looses its viscosity after a while due to excessive heat transfer which results in reduction of lubricating efficiency.* ✓
- *Metal particles deposit in the oil due to metal and metal contact.* ✓ (3)

6.4 DRAINING AND FILLING DIFFERENTIAL OIL PROCEDURE

- *Run the vehicle first so that the rear axle oil is warm, so that it drains easily.* ✓
- *Place a drain tray that can hold all the oil removed.* ✓
- *Clean the area around the drain and filler plug.* ✓
- *Remove the filler plug this will allow oil to flow easily and fast.* ✓
- *Remove the drain plug/plate and allow oil to drain into the tray.* ✓
- *Wash drain and filler plugs.* ✓
- *Fit new washers to both the drain and filler plugs.* ✓
- *Replace the drain plug.* ✓
- *Fill the oil until it just trickles out of the filler hole.* ✓
- *Replace filler plug.* ✓
- *Wipe off surplus oil.* ✓ (11)

6.5 BLOWER

6.5.1 Type of blower

Centrifugal blower ✓ (1)

6.5.2 Labels

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

6.5.3 Advantages of the supercharger

- *Increases the output power of the engine.* ✓
- *A smaller engine fitted with a centrifugal blower delivers the same power as a larger engine.* ✓
- *It eliminates lack of oxygen above sea level.* ✓
- *Increases the volumetric efficiency of the engine.* ✓
- *With the aid of the intercooler both the power and the torque output of the engine are increased. (any 3 x 1)* ✓ (3)

6.6 PURPOSES OF A SUPERCHARGER.

Any TWO of the following:

- *The supercharger fills the cylinder with an increased pressure that is higher than atmospheric pressure* ✓
- *The compression pressure in the cylinder is increased.* ✓
- *The volumetric efficiency of the engine is increased. (any 2 x 1 = 2)* ✓ (2)

6.7 USES OF A SUPERCHARGER

Any TWO of the following:

- *Used in high performance cars.* ✓
- *Aircraft engines to overcome loss of power owing to height above sea level.* ✓
- *Heavy vehicles and earth moving equipment. (any 2 x 1 = 2)* ✓ (2)

6.8 OPERATION OF THE TURBOCHARGER

- *The energy at which the exhaust gases that rushes out the exhaust are wasted* ✓
- *This hot expanding gases from the engine is routed in the direction of the turbine wheel through a scroll like housing,* ✓
- *In this manner the turbine wheel is enabled to spin at very high speeds.* ✓
- *The gases are then channeled out of the housing and wheel assembly into the normal exhaust system.* ✓
- *As the turbine wheel spins, it turns a common shaft, which in turn spins the other fan called the impeller.* ✓
- *The impeller and its scroll housing acts as a compressor drawing air or air and fuel mixture in through the inlet compressing and delivering it through the output port.* ✓
- *The induction passage then transfers the air/fuel mixture into the cylinders under pressure.* ✓
- *This boost pressure delivered to the cylinders increases the volumetric efficiency of the engine, as well as the engine performance.* ✓ (8

[40]

TOTAL: 200