Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2010

MECHANICAL TECHNOLOGY

MEMORANDUM

This memorandum consists of 13 pages.

SECTION A: COMPREHENSION

QUESTION 1: READING FOR MEANING AND UNDERSTANDING

1.1 A √ (1)

1.2 B √ (1)

1.3 A √ (1)

1.4 A √ (1)

1.5 B √ (1)

1.6 A √ (1)

1.7 B √ (1)

1.8 B √ (1)

1.9 B √ (1)

1.10 A √ (1)

1.11 B √ (1)

1.12 A √ (1)

1.13 A √ (1)

1.14 C √ (1)

1.15 B √ (1)

1.16 C √ (1)

1.17 D √ (1)

1.18 C √ (1)

1.19 C √ (1)

1.20 C √ (1)

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

LEARNING OUTCOME 3: ASSESSMENT STANDARDS 6 AND 8

2.1 Clockwise moments = Anti-clockwise moments

$$\sin 60° = \frac{x}{500} \quad \surd$$

$$x = \sin 60° \times 500 \quad \surd$$
$$= 0{,}866 \times 500$$
$$= 433 \text{ m}$$

$$P \times 750 = 50 \times 433 \quad \surd$$
$$P = \frac{21\,650}{75} \quad \surd$$
$$P = 28{,}6 \text{ N} \quad \surd \qquad (6)$$

2.2 2.2.1 MECHANICAL ADVANTAGE $= \frac{\text{Load}}{\text{Effort}}$ √

$$MA = \frac{W}{F}$$
$$4 = \frac{1\,400_N}{F} \surd$$
$$F = \frac{1400_N}{4}$$
$$= 350 \text{ N} \quad \surd \qquad (3)$$

2.2.2 VELOCITY RATIO (VR) $= \frac{2D}{d_1 - d_2}$ √ √

$$= \frac{2(210)}{160 - 140} \quad \surd$$
$$= \frac{420}{20}$$
$$= 21 : 1 \quad \surd \qquad (4)$$

2.2.3 MECHANICAL EFFICIENCY (η) $= \frac{MA}{VR} \times 100\%$ √

$$= \frac{4}{21}$$
$$= 19{,}048\% \quad \surd \qquad (2)$$

2.3 2.3.1 1. Circular pitch = $\pi \times m$ √
$= \pi \times 6$
$= 18{,}85$ mm √ (2)

2.3.2 2. Velocity ratio between gears 4 : 1 √

Large gear pitch circle radius = $\frac{4}{5} \times$ centre distance
$= \frac{4}{5} \times 675$ mm
$= 540$ mm √
Large gear PCD = 540 × 2 mm
= 1 080 mm

Therefore No. of teeth of large gear

$$m = \frac{PCD}{T} \quad \surd$$
$$T = \frac{PCD}{m}$$
$$= \frac{1\ 080}{6}$$
$$= 130 \text{ teeth} \surd$$

Small gear PCR = $\frac{1}{5} \times 675$ mm
= 135 mm
Small gear PCD = 135 × 2 mm √
= 270 mm

Therefore No. of teeth of small gear

$$m = \frac{PCD}{T}$$
$$T = \frac{270}{6}$$
$$= 45 \text{ teeth} \surd$$ (5)

2.3.3 Tooth height = 2,25 × m √
= 2,25 × 6 mm
= 13,5 mm √ (2)

2.3.4 Addendum (a) = 6 mm √ (1)

2.3.5 Dedendum (b) = 1,25 x 6 mm
= 7,5 mm √ (1)

2.3.6 Clearance (c) = 0,25 x 6 mm
= 1,5 √ (1)

2.4 2.4.1 Belt length of an open belt drive

$$\text{Length} = \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4C} + 2C \text{ (refer to formula sheet)}$$

$$= \frac{\pi(600+300)}{2} + \frac{(600-300)^2}{4(850)} + 2(850) \quad \surd$$

$$= \frac{\pi(900)}{2} + \frac{(90\,000)}{3\,400} + 1\,700 \quad \surd$$

$$= 3\,139,47 \text{ mm} \quad \surd \qquad (3)$$

2.4.2 The cross belt system contact angle is bigger and slip would therefore be less √√ (2)

2.5 2.5.1 First calculate area of piston B = $\frac{\pi D^2}{4}$ OR Area of piston A = $\frac{\pi D^2}{4}$ √

$$= \frac{\pi \times 0,75^2 m^2}{4} \qquad = \frac{\pi \times 0,15}{4}$$

$$= 0,442 \text{ m}^2 \qquad = 0,177 \quad \surd$$

Pressure applied on piston B = $\frac{F}{A}$ √

$$= \frac{450 \text{ Pa}}{0,442}$$

$$= 1018,1 \text{ Pa} \quad \surd$$

NOTE: Pressure at piston B is equal to pressure at piston A

Therefore $P_A = \frac{F_A}{A_A}$ √

$$F_A = P_A \times A_A$$

$$= 1018,1 \times 0,0177 \text{ N} \quad \surd$$

$$= 18,02 \text{ N} \qquad (4)$$

2.5.2 $\text{VOLUME}_B = A_B \times L_B$ √

$$= 0,442 \times 0,012 \text{ m}^3 \quad \surd$$

$$= 0,0053 \text{ m}^3 \quad \surd \qquad (2)$$

2.5.3 $\text{VOLUME}_A = \text{Volume}_B$ √

$$0,0053 = A_A \times L_A$$

$$L = \frac{0,0053 \text{m}}{0,0177} = 0,299 \text{ m} = 299 \text{ mm} \quad \surd \quad \surd \qquad (3)$$

2.6 2.6.1 Clockwise moments = Anti-clockwise moments √

$F_B \times S = F_D \times S$

$55 \times 1,3 = F \times 0,7$ N √√√

$F_D = \frac{55 \times 1,3}{0,8}$ N √

= 89,375 N √ (6)

2.6.2 Yes: Downward forces = 89,375 N √

Upward forces = $F_A + F_B$ √

= 55 + 34, 375 N

= 89,374 N √ (3)

[50]

QUESTION 3: TOOLS AND EQUIPMENT

LEARNING OUTCOME 3: ASSESSMENT STANDARD 3

3.1 Pillar drilling machine (drawing)

3.2 Parts:

1. Electric motor √
2. Table √
3. Vertical slide √
4. Coolant pump √
5. Gearbox √
6. Drill speed lever √
7. Feed hand wheel √
8. Spindle √
9. Drill bit √
10. Table adjustment handle √ (10 x 1) (10)

3.3
1. The pillar drilling machine is a larger version of the pedestal drill.
2. The electric motor is more powerful and the speed is varied by a gearbox.
3. The pillar drilling machine can take up to 50 mm drill bit whilst the pedestal drill can only use up to 13 mm.
4. The pillar drill can rotate on its own axis and the pedestal drill cannot. (Any 2 x 1) (2)

3.4 <u>Safety precautions using a pedestal drill:</u>

- Wear goggles to prevent eye injuries
- When working with long hair use a hair net or cap to prevent scalp injuries.
- It is extremely dangerous to stop the drill by hand once the drill has been switched off
- Care to be taken to prevent drilling holes onto the table. Support the work on top of parallels
- It is very important to remove the drill key or the chuck key before starting the drilling machine.
- Use correct sharpened drill bit for the kind of drilling and the material to be drilled.
- Before changing work pieces or any measuring can be done, the drilling machine must be stopped.
- Do not stop work piece by hand if it slips from the clamp. It can cause serious injuries.
- Do not force the drill bit when drilling. This will result in the drill bit breaking and may cause injuries.
- Use the correct speed required for that work and material.
- When removing the metal chips from the drill, use a brush and not your fingers.
- Do not wear loose clothing as this can be caught in the drill.
- Unplug the drill before removing or fitting the drill bit.
- Never use a drilling machine when standing in water.

- Make sure that the plug is well fitted.
  Always check the condition of the electrical wiring for breakage to prevent electrical short circuits and electrical shock. (Any 6 x 1) (6)

[20]

QUESTION 4: MATERIALS

LEARNING OUTCOME 3: ASSESSMENT STANDARD 3

4.1 Basic heat treatment processes

- Hardening √
- Annealing √
- Tempering √
- Normalising √
- Case hardening √ (5 x 1) (5)

4.2 Factors on heat treatment:

- The work piece size √
- The carbon content √
- Cooling rate √
- Temperature range √ (4 x 1) (4)

4.3 4.3.1 E √

4.3.2 D √

4.3.3 C √

4.3.4 B √

4.3.5 A √ (5 x 1) (5)

4.4 Properties of low carbon steel

- Very ductile
- When heated becomes malleable (2)

Properties of medium carbon steel

- Not as ductile as low carbon steel
- In cold state it is difficult to work with
- Stronger than low carbon steel
- With heat treatment it will become tougher and harder (Any 2 x 1) (2)

Properties of high carbon steel

- Has a higher tensile strength
- Resistance to wear
- Much harder than both medium and low carbon steel
- Can be machined
- Can be welded
- Ductility is low (Any 2 x 1) (2)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

LEARNING OUTCOME 3: ASSESSMENT STANDARDS 1, 4 AND 5

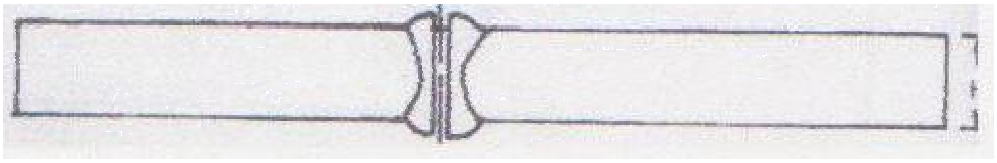
5.1 Arc welding is a fusion of two pieces of metal brought to the correct temperature by the heat obtained from an electric arc. √√ (2)

5.2

NAME	CAUSES	REMEDY
1.Poor appearance	• Current too high or too low • Incorrect use of electrode • Electrode faulty	• Adjust current to required amperage. • Check procedure of welding • Change the electrode or use dry electrode
2.Undercutting	• Faulty electrode manipulation • Current too high • Arc length too long • Speed of weld too fast	• 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
3.Excessive spatter	• Arc blow • Faulty electrode • Arc length too long • Current too high	• Adjust current to needs • Lighten arc blow • Choose a suitable electrode • Adjust to proper arc length
4.Brittle weld	• Wrong electrode • Incorrect heat treatment • Metal hardened by air	• Pre-heat at 150°C to 250°C if welding on medium carbon steel or certain alloy steels. • Make multiple layer welds • Anneal after welding • Use stainless or low carbon electrodes for increased weld ductility.

(Any 2 each) (16)

5.3



(2)

5.4 5.4.1 Root gap: The opening between the parts to be joined at the root of the joint. √√ (2)

5.4.2 Weld Symbol: An ideograph used to indicate the type of weld to be used √√ (2)

5.4.3 Peening: The method of relieving the stresses that result after shrinkage has taken place, by working the joint with hammer blows.√√ (2)

5.5 Safety measures when working with gear drives:

- Construct fences and **guards** around gear drives to protect workers from injury. √
- Always **isolate** the gear drive electrically before starting work on the drive unit. √
- Never lubricate machinery while it is in motion. √
- When working near gear drives make sure that no loose clothing comes into contact with rotating components. √ (Any 2 x 1) (2)

5.6 5.6.1 Shaft alignment: Shaft must be parallel to each other. Shaft which are out of parallel contribute to early sprocket wear on one side. Sprockets should be aligned by holding a steel straight edge across the outer faces of both sprockets. (4)

5.6.2 Sprocket alignment
Inaccurate alignment of the sprocket wheels contributes to wear of the link plates, sprocket teeth and sprocket bearing. (4)

5.6.3 Correct mounting of the chain
Mount the chain on both sprockets by allowing both ends to meet on the further-most edge of the largest sprocket. Next, fit the connecting link along with the slide bar and retainer. Retainer clip should fit with the closed end to force the normal direction of chain travel. Ensure that the retainer clip fits snugly over both pins. (4)

5.7 Factors determining correct meshing of gear teeth

- Pitch circle diameter can be determined directly from the centre distance between meshing gears and the number of teeth.
- Circular pitch is the length of the arc of the pitch circle between corresponding points from one gear tooth to the next.
- Module is the ratio of the pitch diameter to the number of teeth. (2 x 3) (6)

5.8 Advantages of gear drives over belt and chain drives

- They can be used where space is limited as they are more **compact**.
- Gear drives are **positive drives**.
- **Lubrication is easy**. The oil bath type is used more often.
- They **transmit power directly**, by intermeshing gears without additional components.
- They require very **little maintenance**.
- They transmit **large amounts of power**. (Any 2 x 1) (2)

5.9 Disadvantages in comparison with belt and chain drives

- Gears are **expensive** to manufacture and require specialist expertise.
- Gears cannot be repaired.
- Where a continuous supply of lubricant cannot be guaranteed, lubrication is a problem.
- Their compact nature restricts **versatility**. (Any 2 x 1) (2)

QUESTION 6: MAINTENANCE AND TURBINES

LEARNING OUTCOME 3: ASSESSMENT STANDARDS 7 AND 9

6.1 The main components in the lubrication system and functions.

- **Oil pump** draws the oil from the sump and delivers it under pressure to the engine lubrication system. √ √ √
- **Relief valve** limits the maximum pressure of the oil supplied by the pump to the system. √ √ √
- **Sump** serves as a reservoir for the oil. √ √ √
- **Oil galleries** are channels or drillings through which the oil passes to the different lubrication points in the engine. √ √ √
- **Oil pressure indicator** shows whether the oil pressure is being kept within the manufactures' limits. √ √ √
- **Oil filter** filters the oil removing impurities to keep it clean. √ √ √

(6 x 3) (18)

6.2 6.2.1 Advantages of air cooling

- An air-cooled engine is generally lighter than an equivalent water-cooled engine. √
- It warms up to its normal running temperature very quickly. √
- The engine can operate at a higher temperature than a water-cooled engine. √
- The system is free from coolant leakage problems and requires no maintenance. √
- There is no risk of damage due to freezing of the coolant in cold water. √ (5)

Disadvantages of air cooling

- A fan and suitable cowls are necessary to provide and direct the air flow. The fan can be noisy and absorbs a large amount of engine power. The cowl makes it difficult to get at various parts of the engine when servicing is required. √
- The engine is more liable to overheating under difficult conditions than a water-cooled engine. √
- Mechanical engine noises tend to be amplified by the fins. √
- The cylinders usually have to be made separately to ensure proper formation of the fins this makes the engine more costly to manufacture. √
- Cylinders must be spaced well apart to allow sufficient depth of fins.√
- It is more difficult to arrange a satisfactory car-heating system. √ (Any 5) (5)

6.2.2 Advantage of water cooling

- Temperatures throughout the engine are more uniform, thus keeping distortion to a minimum. √
- Cylinders can be placed closer together making the engine more compact. √
- Although a fan is usually fitted to force air through the radiator, it is much smaller than the type required for an air-cooled engine. It therefore absorbs less power and is quieter in operation. √
- There is no cowl to obstruct access to the engine. √
- The water jacket absorbs some of the mechanical noise making the running engine quieter. √
- The engine is better able to operate under difficult conditions without overheating. √

(Any 5) (5)

Disadvantage of water cooling

- Weight – not only of the radiator and connections but also of the water; the whole engine installation is likely to be heavier than an equivalent air cooled engine. √
- Because the water has to be heated, it takes longer to warm up after starting from cold. √
- If water is used, the maximum temperature is limited to about 85 – 90°C to avoid the risk of boiling away the water. However, modern cooling systems are pressurised and this permits higher temperatures and better efficiency. √
- If the engine is left standing in very cold weather, precautions must be taken to prevent the water freezing in the cylinder jackets and cracking them. √
- There is a constant risk of coolant leakage developing. √
- A certain amount of maintenance is necessary, for example, checking water level, anti-frost precautions, cleaning out deposits, etc. √

(Any 5) (5)

6.3 Important factors determining the choice of oil

- That the oil meet the quality requirements. √
- That the oil has the right thickness or **viscosity.** √ (2)

6.4 6.4.1
- Kinetic energy is the steam which is converted to mechanical energy to cause rotation.
- Steam at very high temperature and pressure is directed to the turbine.
- Nozzles are used to direct pressure into blades.
- Blades are attached to turbine and shaft causing it to rotate.
- This is mechanical energy created by the impulse and the reaction effort of the steam jet. (5)

6.4.2
- When the engine runs, the rotor rotates.
- Air is trapped between the rotor and aluminium casing.
- Air is carried around outside of the rotor and is pushed into a decreasing volume.
- This raises the pressure of the air with the rotational speed of the rotors.
- Air is forced into the inlet manifold and then fed into the cylinders. (5)

6.4.3
- Supercharger fills the cylinder with an increased pressure that is higher than atmospheric pressure.
- Compression pressure in cylinder is increased.
- Volumetric efficiency of the engine is increased. (6)

[40]

TOTAL: 200