education

Department:
Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## MECHANICAL TECHNOLOGY

## NOVEMBER 2009

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 20 pages and a 5-page formula sheet.**

## INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. A formula sheet is attached to this paper.
5. Show ALL calculations and units.
6. Round off answers to TWO decimal places.
7. Candidates may use non-programmable scientific calculators and drawing instruments.
8. The value of acceleration of gravity should be taken as 10 $m/s^2$.
9. All dimensions are in millimetres unless stated otherwise in the question.
10. Start EACH question on a NEW page.
11. Use the guidelines below to assist you in managing your time.
12. Write neatly and legibly.

| QUESTION | ASSESSMENT STANDARDS | CONTENT | MARKS | TIME |
|---|---|---|---|---|
| 1 | 1 – 9 | Multiple-choice questions | 20 | 15 minutes |
| 2 | 6 and 8 | Applied Mechanics (Forces, Systems and Control) | 50 | 55 minutes |
| 3 | 2 | Tools and Equipment | 20 | 15 minutes |
| 4 | 3 | Materials | 20 | 15 minutes |
| 5 | 1, 4 and 5 | Safety, Terminology (Manufacturing Process) and Joining Methods | 50 | 45 minutes |
| 6 | 7 and 9 | Maintenance and Turbines | 40 | 35 minutes |
| | | **TOTAL** | **200** | **180 minutes** |

 

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

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.20) in the ANSWER BOOK.

1.1 FIGURE 1.1 shows one of the ways to remove and replace adapter bearings. What safety procedure is shown in FIGURE 1.1?

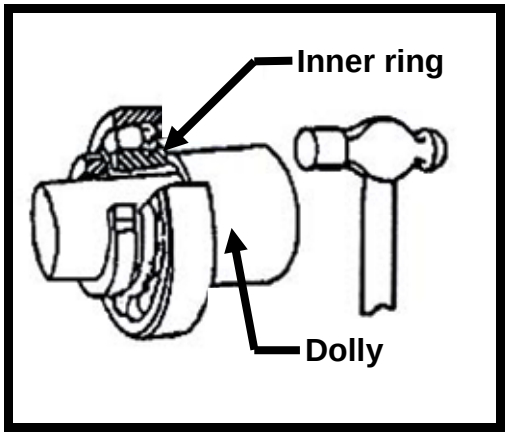


**FIGURE 1.1**

A Remove the adapter sleeve by driving the tapered point of a screw driver or wedge in the split of the sleeve and forcing it open.
B Remove the burrs from a shaft to prevent damage to the sleeve.
C Place the driving dolly against the inner ring of the bearing and tap the dolly with a hammer.
D Slacken the lock nut two or three turns with a spanner. (1)

1.2 Which ONE of the following safety procedures does NOT relate to revolving machinery in terms of the Occupational Health and Safety Act, 1993 (Act 85 of 1993)?

A Belt drives should be in a well-ventilated area.
B Every driving belt, rope or chain must be guarded.
C The underside of every overhead driving belt must be guarded.
D Grinding wheels should be guarded. (1)

1.3 What does the symbol "d" denote in the Brinell hardness test shown in FIGURE 1.2?

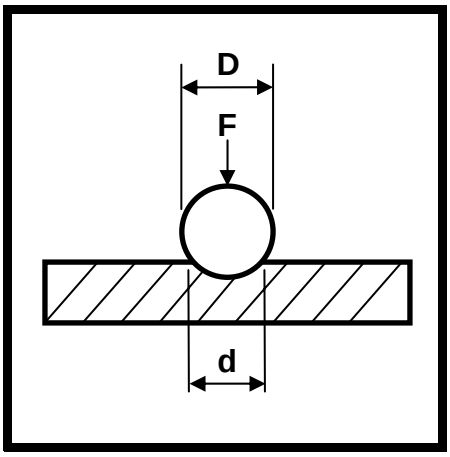


**FIGURE 1.2**

A Ball diameter
B Hardness number
C Test piece
D Indentation diameter (1)

1.4 The reason for using a compression tester on an internal combustion engine is to determine …

A a clogged air filter.
B a leaking exhaust pipe.
C worn piston rings.
D worn crank-shaft bearings. (1)

1.5 Which ONE of the following engineering materials is a ferrous alloy?

A Teflon
B Vanadium steel
C White metal
D Bronze (1)

1.6 … is an example of a product made from high-carbon steel.

A A screw-driver shaft
B A garden fork
C A piston
D A twist drill (1)

1.7 What would the spindle speed be if you were required to mill a material having a cutting speed of 35 m/min with a cutter of 50 mm in diameter?

A 223 r/min
B 233 r/min
C 322 r/min
D 232 r/min (1)

1.8 Identify the type of milling cutter shown in FIGURE 1.3.

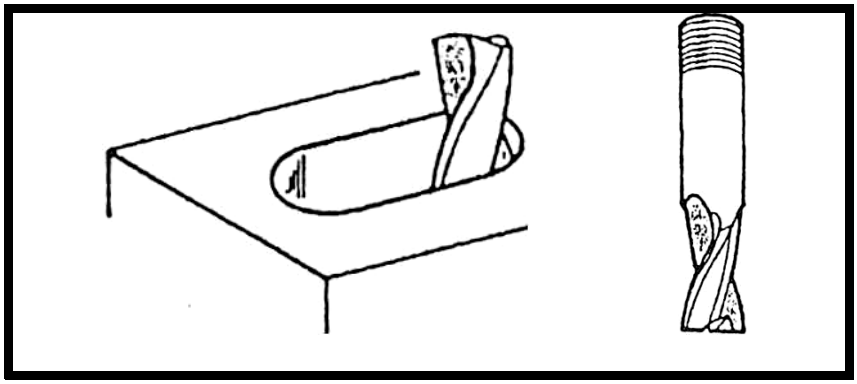

**FIGURE 1.3**

A Plain straight-tooth cutter
B Straight-tooth side-milling cutter
C Slot drill
D Shell end mill (1)

1.9 Which ONE of the following indexing methods can be used to machine a spur gear with 119 teeth on a milling machine?

A Simple indexing
B Angular indexing
C Differential indexing
D None of the above-mentioned (1)

1.10 Which ONE of the following is a non-destructive welding test?

A Bend test
B Dye penetrating test
C Free-bend test
D Nick-break test (1)

1.11 The main cause of a cracked weld is …

A a damp electrode.
B contamination of the joint.
C a fast cooling rate.
D a faulty electrode. (1)

1.12 Compressive stress is stress that acts ...

A against the lengthening of an object.
B perpendicular to a surface.
C parallel to a surface.
D against the shortening of an object. (1)

1.13 What will the deformation of a bar that is 0,73 m long be when the strain is $0,5 \times 10^{-3}$?

A 0,653 mm
B 0,036 mm
C 0,498 mm
D 0,365 mm (1)

1.14 Which ONE of the following is NOT a function of lubricating oil?

A It must act as a seal.
B It must reduce engine noise.
C It must increase engine speed.
D It must prolong engine life. (1)

1.15 SAE 20W50 oil is used for …

A engine lubrication.
B gearbox lubrication.
C differential lubrication.
D automatic gearbox lubrication. (1)

1.16 The gear ratio of the compound gear shown in FIGURE 1.4 is …

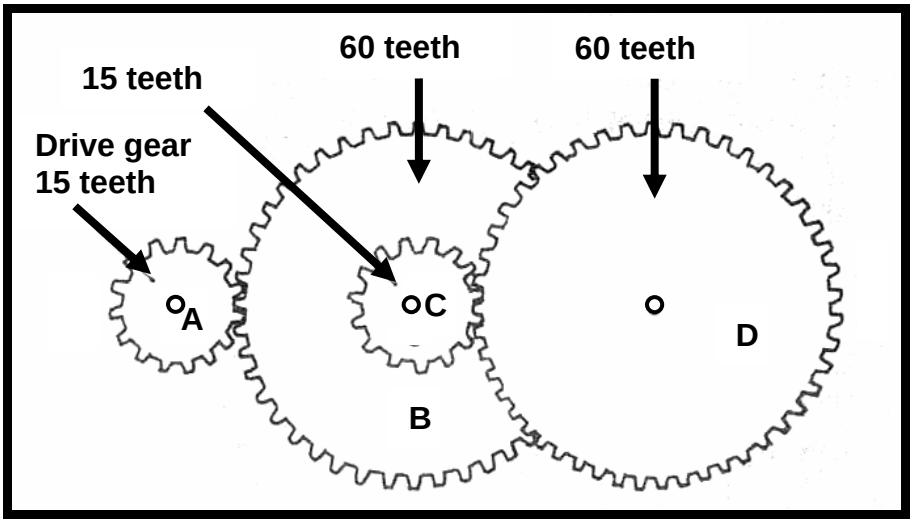


**FIGURE 1.4**

A 1:16
B 1:4
C 16:1
D 4:1 (1)

1.17 What is the magnitude of the force produced by the piston shown in FIGURE 1.5 if the air pressure is 0,3 N/mm$^2$? (Hint: 1 N/mm$^2$ = 1 MPa)

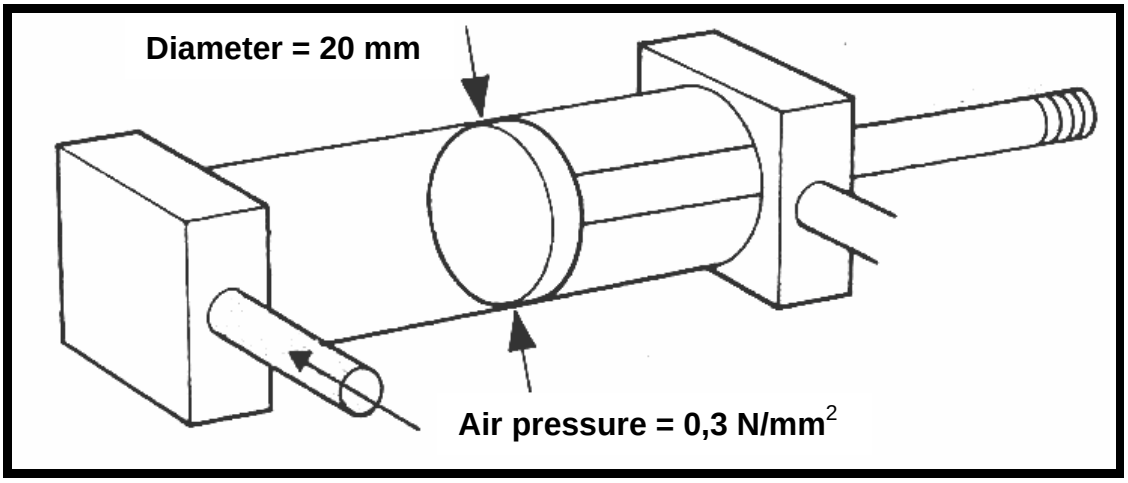


**FIGURE 1.5**

A 9,42 kN
B 942 MN
C 942 N
D 94,2 N (1)

1.18 FIGURE 1.6 shows an industrial sewing machine. The machine uses the crank and slider mechanism to produce reciprocating motion at the needle. At what speed does the crank rotate if the needle moves down 120 times per minute at its slowest operating speed?

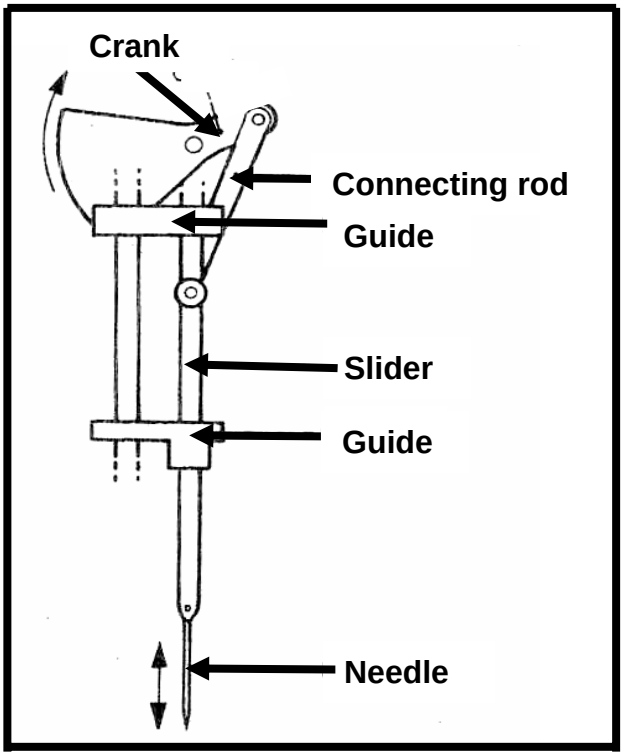


**FIGURE 1.6**

A 240 r/min
B 60 r/min
C 120 r/min
D 180 r/min (1)

1.19 What do you understand by the term *mechanical efficiency* of a supercharger?

A How much a positive displacement blower leaks
B A ratio of boost/power output to boost/power input
C A ratio of the density of the inlet air to the density of the outlet air
D A ratio of the inlet pressure to the outlet pressure (1)

1.20 A supercharger is driven by …

A mechanical drive.
B pneumatic energy.
C steam. (1)
D exhaust gases. **[20]**

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

2.1 A hydraulic press is used to insert machine parts into position during the assembly process. The specifications of the system are diagrammatically presented in FIGURE 2.1.

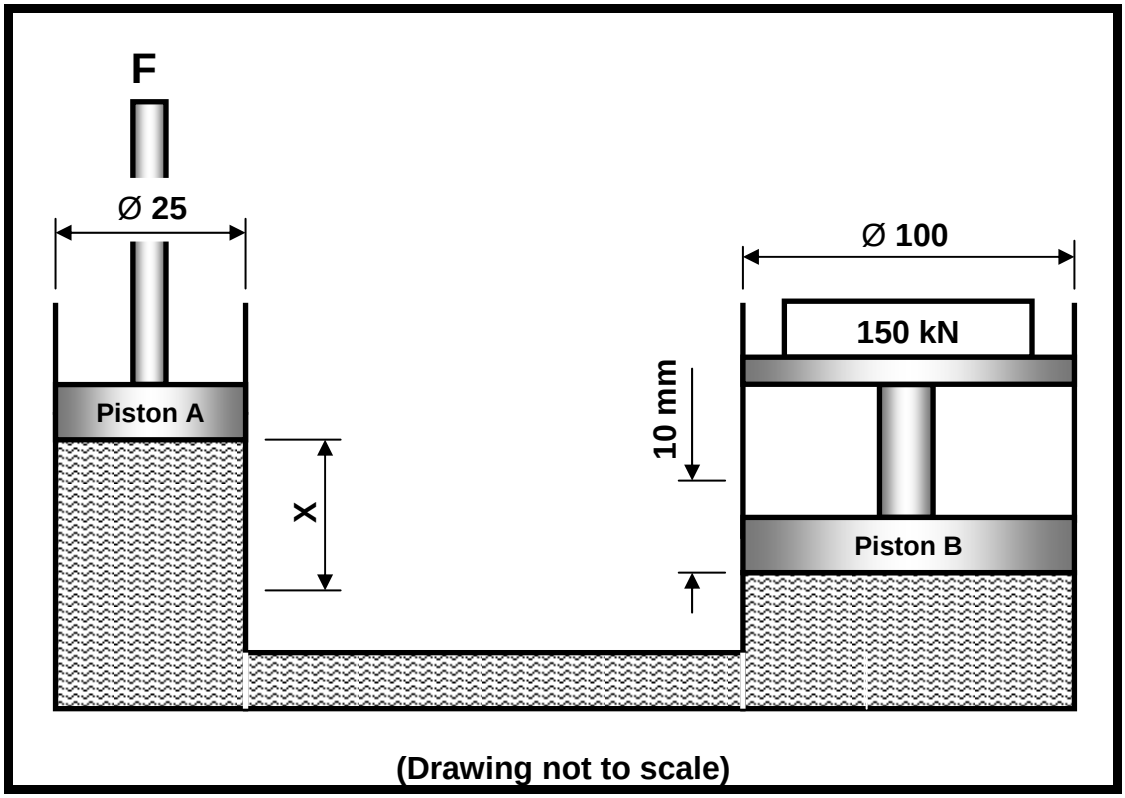


**FIGURE 2.1**

Determine the following by means of calculations:

2.1.1 The fluid pressure in the hydraulic system when in equilibrium. [Answer in megapascal (MPa)] (4)

2.1.2 The force (F) that must be exerted onto piston A to lift the load on piston B (4)

2.1.3 The distance 'X', in millimetres, that piston A should move downwards so that piston B can rise 10 mm (5)

2.2 A load of 30 kN causes a tensile stress of 6 MPa in a brass round bar. The original length of the bar is 250 mm and Young's modulus for brass is 90 GPa.

Determine the following by means of calculations:

2.2.1 The diameter of the brass bar (6)

2.2.2 The strain caused by the load (3)

2.2.3 The change in length caused by the load (3)

2.3 Study FIGURE 2.2. Lucas is the engineer who has to design a belt drive system for a water pump. The main shaft of the pump rotates at 3 000 r/min while the rotation frequency of the 100 mm pulley on the electrical motor is 1 440 r/min. Calculate the diameter of the pulley on the pump.

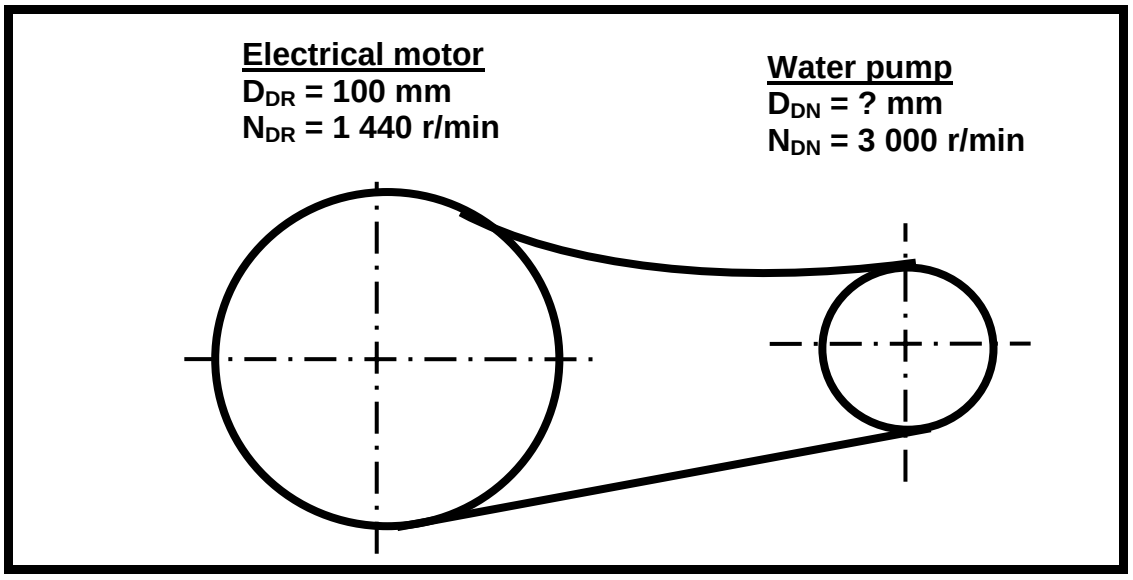


**FIGURE 2.2** (3)

2.4 A differential wheel and axle lifting machine is used to lift a generator with a mass of 80 kg. The diameter of the wheel is 300 mm and that of the axles is 150 mm and 120 mm. An effort of 56 N is needed to lift the generator.

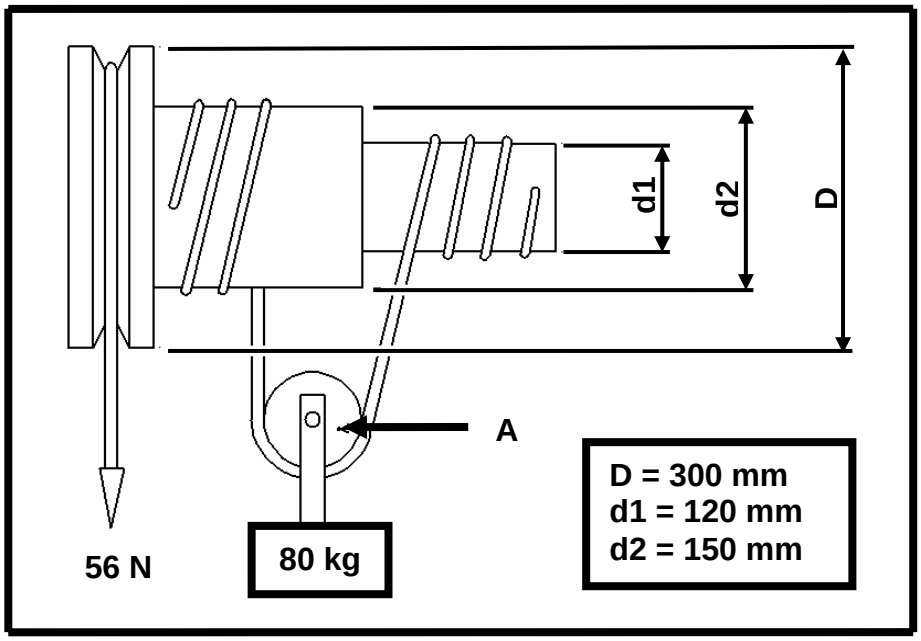


**FIGURE 2.3**

Determine by means of calculations:

2.4.1 The mechanical advantage of the appliance (4)

2.4.2 The velocity ratio (4)

2.5 FIGURE 2.4 shows a double-start right-hand square thread of a mechanical house jack that is to be manufactured by an artisan. The square thread has an outside diameter of 50 mm and a pitch of 12 mm. Help the artisan to obtain the necessary information regarding the screw thread and cutting tools that are needed to cut a new thread. (Clearance angles are 3°.)

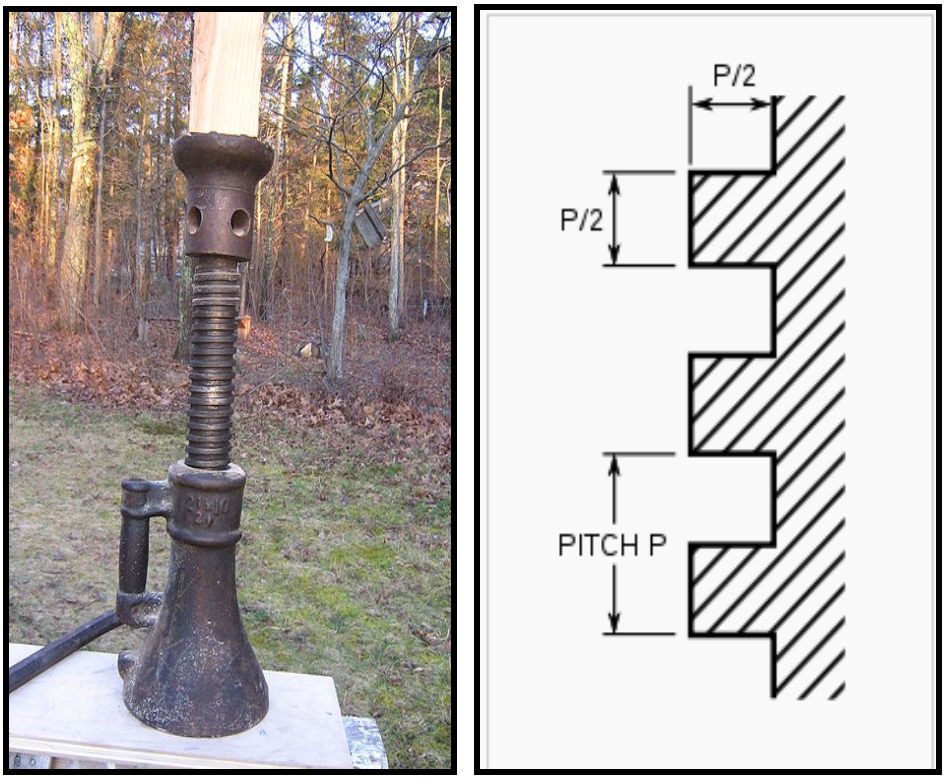


**FIGURE 2.4**

Determine by means of calculation:

2.5.1 The helix angle of the screw thread (6)

2.5.2 The leading angle of the cutting tool (2)

2.5.3 The trailing angle of the cutting tool (2)

2.6 A single-plate friction clutch with an effective diameter of 0,28 m is used to transmit torque in an engine/generator-combination. The clutch plate has a friction material on both sides. The friction coefficient is 0,35. The total applied force on the pressure plate is 2,5 kN. Determine the torque that can be transmitted by this clutch. (4)

**[50]**

## QUESTION 3: TOOLS AND EQUIPMENT
## (Learning Outcome 3: Assessment Standard 2)

3.1 Define the term *torsion*. (2)

3.2 Refer to the graph in FIGURE 3.1 and answer the questions that follow.

3.2.1 Define Hook's law. (3)

3.2.2 Name the part of the graph applicable to Hook's law. (1)

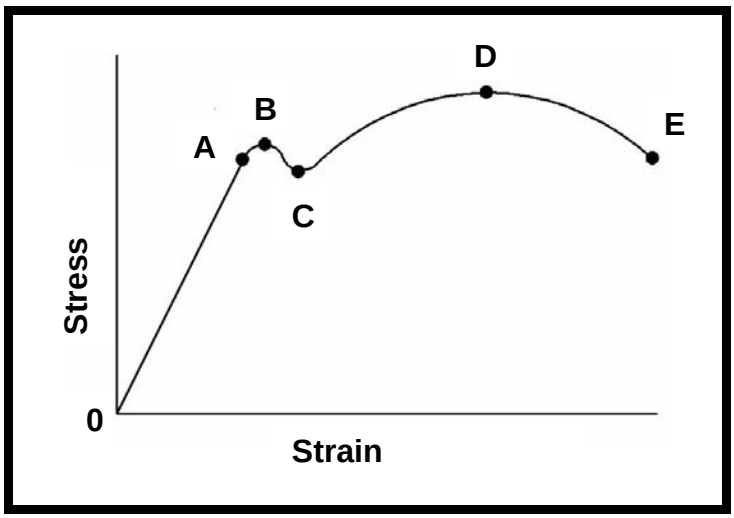


**FIGURE 3.1**

3.3 What is the purpose of a tensile test on steel? (2)

3.4 Fill in the missing words numbered from 3.4.1 to 3.4.4 regarding the function of a tensile tester:

The tensile test is a 3.4.1 ... test which subjects a 3.4.2 ... to an increasing 3.4.3 ... load while measuring the corresponding 3.4.4 ... of the material. (4)

3.5 Study FIGURE 3.2. Describe the principle of operation of the metal arc gas shielded equipment.

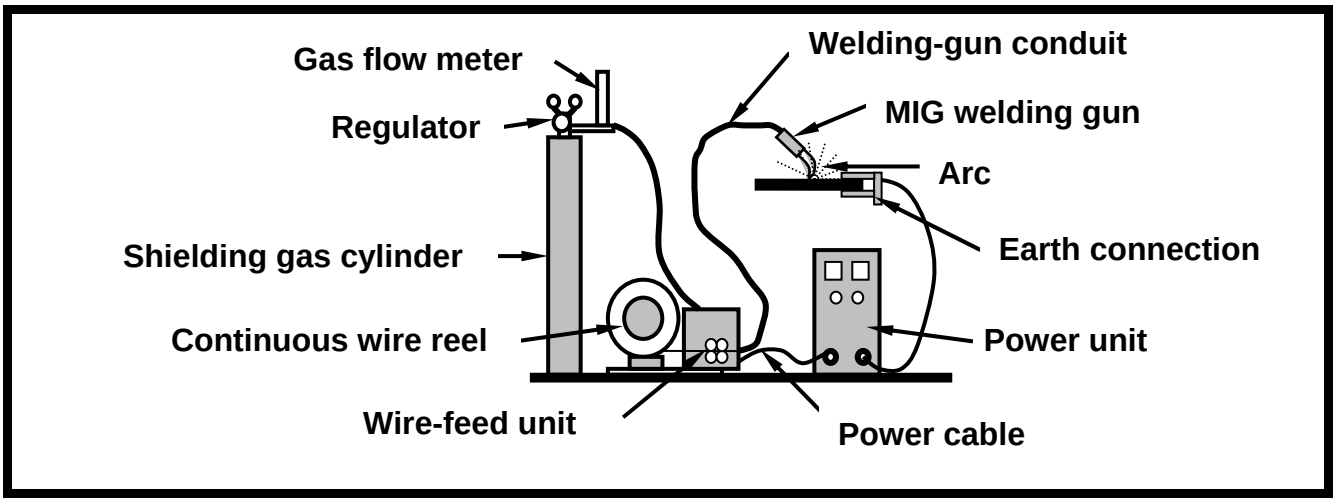


**FIGURE 3.2** (8)

**[20]**

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

4.1 Johannes uses stainless steel in the manufacturing of a BBQ-grid ('braai-grid'). Give THREE reasons why you agree with him, by referring to the properties of stainless steel. (3)

4.2 Name the THREE main elements that make up stainless steel. (3)

4.3 The components of a water tap are made of brass. Answer the questions that follow.

4.3.1 List the elements that brass contains. (2)

4.3.2 Give ONE reason why brass is used in the manufacturing of the tap components. (1)

4.4 Name the elements of soft solder. (2)

4.5 What are the TWO advantages of silver solder compared to soft solder? (2)

4.6 Plastic materials are divided into two categories.

Name the TWO categories and state the most common characteristic of each. (4)

4.7 The abbreviation PVC is commonly used when dealing with plastics. What does the abbreviation *PVC* stand for? (1)

4.8 Name TWO properties of nylon. (2)

**[20]**

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

5.1 Name FIVE important safety rules which must be generally applied during the use of arc welding, gas welding and metal arc gas shielded welding (MAGS) or metal inert gas shielded welding (MIGS) processes. (5)

5.2 Sipho cuts a 25 mm diameter solid mild-steel shaft on a centre lathe. The working environment and personal safety have already been taken care of. Name THREE more safety precautions that Sipho needs to adhere to after the centre lathe has been switched on. (3)

5.3 Give the reason why oil and grease may never be used on the argon or $CO_2$ regulator. (2)

5.4 Name the methods of indexing used on a universal dividing head for the following outcomes:

5.4.1 To mill a hexagon bolt or nut quickly on a milling machine (1)

5.4.2 Two surfaces that form an angle of 35° with each other (1)

5.4.3 To index 26 divisions on the dividing head (1)

5.4.4 To cut a gear with 117 teeth (1)

5.5 A gear with 119 teeth must be machined on a milling machine.

Determine by means of calculation:

5.5.1 The indexing required (Make use of the Cincinnati index plates and use A = 120.) (5)

5.5.2 The change gears needed to cut the gear (Use the given change gear tables.) (5)

5.6 Mr Jacobs needs to cut a spur gear comprising 40 teeth and a module of 2,5 using the milling machine.

Calculate:

5.6.1 The addendum (2)

5.6.2 The dedendum (3)

5.6.3 The cutting depth (3)

5.6.4 The circular pitch (3)

5.6.5 The clearance (3)

5.6.6 The pitch-circle diameter (PCD) (4)

5.7 Enid welds a mild steel plate using an arc welding machine. Excessive spatter is created while she is welding.

5.7.1 Assist Enid by identifying THREE causes of weld spatter. (3)

5.7.2 Tell Enid about THREE ways in which she could prevent this from occurring again. (3)

5.8 Mr Smit is busy manufacturing machine parts where he must do different milling processes. Help him to identify the milling cutters shown in FIGURE 5.1 and FIGURE 5.2. Write down the figure number and then the answer.

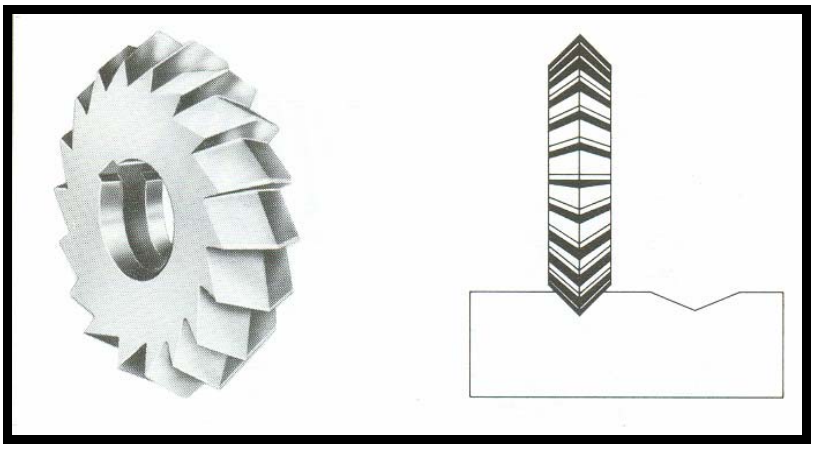

**FIGURE 5.1** (1)

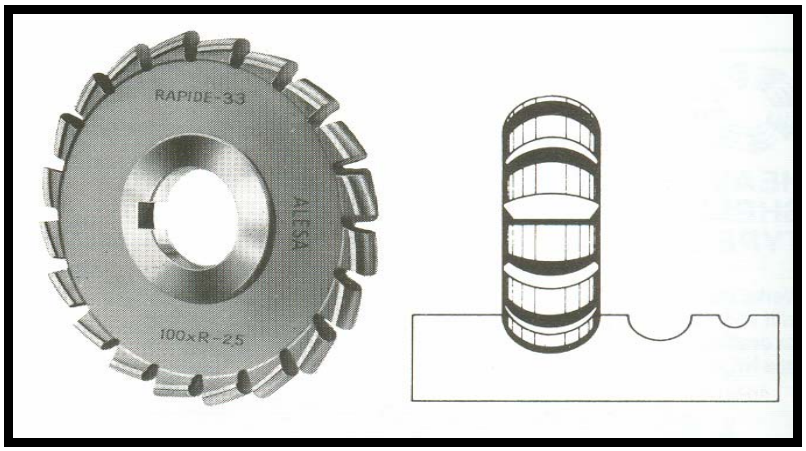


**FIGURE 5.2**

(1)
**[50]**

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

6.1 Mr Jacobs uses the centre lathe to cut a thread on a shaft. When he engages the gears for cutting the thread, he hears a grinding noise. On inspection he discovers that the bearing is damaged.

State FOUR possible causes of bearing failure of the gear system. (4)

6.2 Siyabonga uses the centre lathe to do his practical project. In order to do the job properly he needs to use a cutting fluid. Name FOUR advantages of using a cutting fluid while turning on the lathe. (4)

6.3 Lubricating manufacturers must use additives in their oils to meet certain requirements. Define the following properties of lubricating oil:

6.3.1 Viscosity (2)

6.3.2 Pour point (2)

6.4 The driving efficiency of a belt drive is influenced by factors such as belt slip. Give FOUR reasons why belts slip on machines. (4)

6.5 What do the following letters and numbers denote in SAE 20W50 multi-grade lubricating oil?

6.5.1 SAE (1)

6.5.2 20 (1)

6.5.3 W (1)

6.5.4 50 (1)

6.6 A V-belt is used to drive a water pump and alternator of a motor vehicle. Answer the questions that follow with reference to the above statement.

6.6.1 Name THREE advantages when using a V-belt. (3)

6.6.2 Name THREE disadvantages when using a V-belt. (3)

 

6.7 Mr Willy uses a blower, shown in FIGURE 6.1, to increase the output power of his car's engine. Study the diagram and answer the questions that follow.

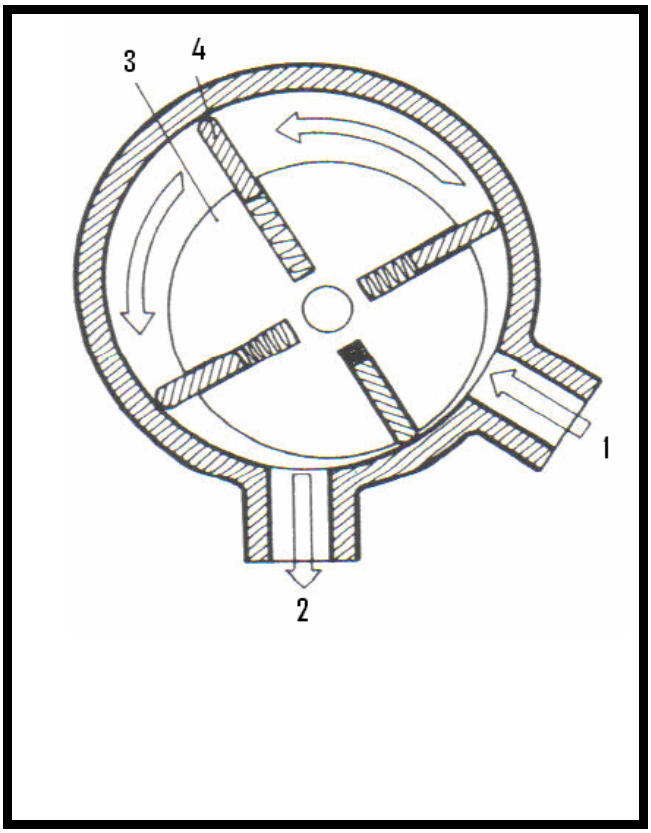


**FIGURE 6.1**

6.7.1 Identify the type of blower shown in FIGURE 6.1. (2)

6.7.2 Label numbers 1 to 4 in FIGURE 6.1. (4)

6.8 Name FOUR advantages of a steam turbine. (4)

6.9 Name FOUR advantages of a gas turbine. (4)
**[40]**

**TOTAL: 200**

# FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 12

## 1. BELT DRIVES

1.1 $$Belt\ speed = \frac{\pi DN}{60}$$

1.2 $$Belt\ speed = \frac{\pi(D + t) \times N}{60} \quad (t = belt\ thickness)$$

1.3 $$Belt\ mass = Area \times length \times density \quad (A = thickness \times width)$$

1.4 $$Speed\ ratio = \frac{Diameter\ of\ driven\ pulley}{Diameter\ of\ driver\ pulley}$$

1.5 $$N_1 D_1 = N_2 D_2$$

1.6 $$Open\text{-}belt\ length = \frac{\pi(D + d)}{2} + \frac{(D - d)^2}{4c} + 2c$$

1.7 $$Crossed\text{-}belt\ length = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$$

1.8 $$Power\ (P) = \frac{2\pi NT}{60}$$

1.9 $$Ratio\ of\ tight\ side\ to\ slack\ side = \frac{T_1}{T_2}$$

1.10 $$Power = \frac{(T_1 - T_2)\,\pi\, D\, N}{60} \qquad where\ T_1 = force\ in\ the\ tight\ side$$

1.11 $$Width = \frac{T_1}{permissible\ tensile\ force}$$

## 2. FRICTION CLUTCHES

2.1 $$Torque\ (T) = \mu WnR$$

$\mu = coefficient\ of\ friction$
$W = total\ force$
$n = number\ of\ friction\ surfaces$
$R = effective\ radius$

2.2 $$Power\ (P) = \frac{2\pi NT}{60}$$

## 3. STRESS AND STRAIN

3.1 $$Stress = \frac{Force}{Area} \quad or \quad (\sigma = \frac{F}{A})$$

3.2 $$Strain\ (\varepsilon) = \frac{change\ in\ length\ (\Delta L)}{original\ length\ (L)}$$

3.3 $$Young's\ modulus\ (E) = \frac{stress}{strain} \quad or \quad (\frac{\sigma}{\varepsilon})$$

3.4 $$A_{shaft} = \frac{\pi d^2}{4}$$

3.5 $$A_{pipe} = \frac{\pi(D^2 - d^2)}{4}$$

## 4. HYDRAULICS

4.1 $$Pressure\ (P) = \frac{Force\ (F)}{Area\ (A)}$$

4.2 $$Volume = Cross\text{-}sectional\ area \times stroke\ length\ (l\ or\ s)$$

4.3 $$Work\ done = force \times distance$$

## 5. WHEEL AND AXLE

5.1 $$Velocity\ ratio\ (VR) = \frac{effort\ distance}{load\ distance} = \frac{2D}{d_2 - d_1}$$

5.2 $$Mechanical\ advantage\ (MA) = \frac{Load\ (W)}{Effort\ (F)}$$

5.3 $$Mechanical\ efficiency\ (\eta_{mech}) = \frac{MA}{VR} \times 100\%$$

## 6. LEVERS

6.1 $$Mechanical\ advantage\ (MA) = \frac{Load\ (W)}{Effort\ (F)}$$

6.2 $$Input\ movement\ (IM) = Effort \times distance\ moved\ by\ effort$$

6.3 $$Output\ movement\ (OM) = Load \times distance\ moved\ by\ load$$

6.4 $$Velocity\ ratio\ (VR) = \frac{Input\ movement}{Output\ movement}$$

 

## 7. GEAR DRIVES

7.1 $$Power\ (P) = \frac{2\pi NT}{60}$$

7.2 $$Gear\ ratio = \frac{Product\ of\ the\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ the\ number\ of\ teeth\ on\ driving\ gears}$$

7.3 $$\frac{N_{input}}{N_{output}} = \frac{Product\ of\ the\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ the\ number\ of\ teeth\ on\ driving\ gears}$$

7.4 $$Torque = force \times radius$$

7.5 $$Torque\ transmitted = gear\ ratio \times input\ torque$$

7.6 $$N_1T_1 = N_2T_2$$

7.7 $$Module\ (m) = \frac{Pitch\text{-}circle\ diameter\ (PCD)}{Number\ of\ teeth\ (T)}$$

7.8 $$Pitch\text{-}circle\ diameter\ (PCD) = \frac{circular\ pitch\ (CP) \times number\ of\ teeth\ (T)}{\pi}$$

7.9 $$Outside\ diameter\ (OD) = PCD + 2\ module$$

7.10 $$Addendum\ (a) = module\ (m)$$

7.11 $$Dedendum\ (b) = 1{,}157\ m \quad or \quad Dedendum\ (b) = 1{,}25\ m$$

7.12 $$Cutting\ depth\ (h) = 2{,}157\ m \quad or \quad Cutting\ depth\ (h) = 2{,}25\ m$$

7.13 $$Clearance\ (c) = 0{,}157\ m \quad or \quad Clearance\ (c) = 0{,}25\ m$$

7.14 $$Circular\ pitch\ (CP) = m \times \pi$$

 

## 8. SCREW THREADS

*8.1* *Pitch diameter = Outside diamter – ½pitch*

*8.2* *Pitch circumference* $= \pi \times$ *pitch diameter*

*8.3* *Lead = pitch* $\times$ *number of starts*

*8.4* Helix angle: $\tan\theta = \dfrac{\text{Lead}}{\text{Pitch circumference}}$

*8.5* *Leading tool angle = 90° – (helix angle + clearance angle)*

*8.6* *Following/Trailing angle* = 90° + *(helix angle – clearance angle)*

*8.7* $Number\ of\ turns = \dfrac{height}{lead}$

## 9. CINCINNATI DIVIDING HEAD TABLE FOR THE MILLING MACHINE

| ***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* |

*9.1* $Simple\ indexing = \dfrac{40}{n}$ *( where n = number of divisions )*

*9.2* $Change\ gears: \dfrac{Dr}{Dv} = (A - n) \times \dfrac{40}{A}$ *or* $\dfrac{Dr}{Dv} = \dfrac{(A-n)}{A} \times \dfrac{40}{1}$

*or*

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

## 10. CALCULATIONS OF FEED

*10.1* $Feed\ (f) = f_1 \times T \times N$

*Where:* $f$ = *feed in millimetres per minute*

$f_1$ = *feed per tooth in millimetres*

$T$ = *number of teeth on cutter*

$N$ = *number of revolutions of cutter per minute*

*10.2* $Cutting\ speed\ (V) = \pi \times D \times N$

*Where:* $D$ = *diameter of the cutter in metres*