basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2011

MARKS: 200

TIME: 3 hours

This question paper consists of 19 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. Round off FINAL answers to TWO decimal places.
6. You may use a non-programmable scientific calculator and drawing instruments.
7. Take the value of gravitational force as 10 m/s^2.
8. Start EACH question on a NEW page.
9. All measurements are in millimetres, unless otherwise stated.
10. Write neatly and legibly.
11. Use the criteria below to assist you in managing your time.

QUESTION	ASSESSMENT STANDARD(S)	CONTENT	MARKS	TIME
1	1 – 9	Multiple-choice questions	20	18 minutes
2	6 and 8	Forces, Systems and Control	50	45 minutes
3	2	Tools and Equipment	20	18 minutes
4	3	Materials	20	18 minutes
5	1, 4 and 5	Safety, Terminology and Joining methods	50	45 minutes
6	7 and 9	Maintenance and Turbines	40	36 minutes
		TOTAL	**200**	**180 minutes**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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 Which of the following safety precautions apply to a valve spring press?

A Use correct attachments to compress the valve spring.
B Be very careful when removing and fitting the two halves (cotters) from the valve stem.
C Be very careful that the jaws of the valve spring compressor do not slip out.
D All the above-mentioned (1)

1.2 Which ONE of the following safety procedures relates to the milling machine?

A Never reach over or near rotating cutter.
B Chips can be removed while the machine is in operation.
C Take measurements while the machine is in operation.
D Know the feed ratios of the table. (1)

1.3 What is the reason for the loss of compression pressure in an internal combustion engine?

A Leaking cylinder head gasket
B Leaking inlet valve
C Leaking exhaust valve
D All the above-mentioned (1)

1.4 Which of the following safety and operating rules apply to a multimeter?

A A voltmeter is connected in parallel with the circuit to be tested.
B An ammeter is connected in series with the circuit to be tested.
C When making any resistance measurements in a circuit always check first that the power to the circuit is switched OFF.
D All the above-mentioned (1)

1.5 Thabo had to soft solder a bronze pipe fitting. What step of the soldering process is shown in FIGURE 1.1?

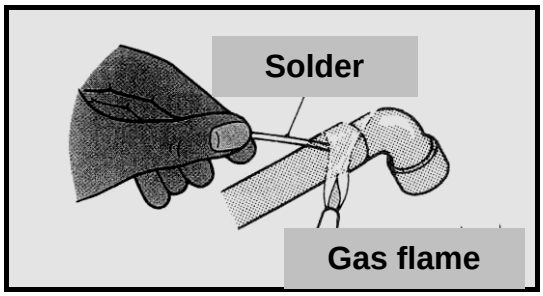

FIGURE 1.1

A Clean the surface to be joined with emery cloth
B Heat the joint and apply solder to the joint
C Allow the joint to cool
D Apply flux to the cleaned surface (1)

1.6 Define a *thermoplastic material*.

A Materials that form a rigid shape under pressure or heat
B Materials that can be stretched but rapidly return to their original shape
C Material that soften under heat and become hard when cooled
D All the above-mentioned (1)

1.7 Identify the type of milling cutter shown in FIGURE 1.2.

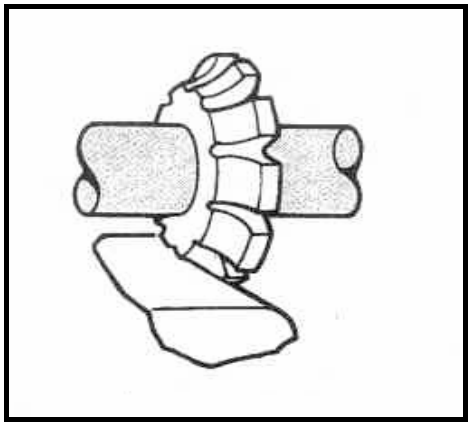

FIGURE 1.2

A Single corner rounding cutter
B Convex cutter
C Equal angle cutter
D Cylindrical cutter (1)

1.8 Which lathe operation is shown in FIGURE 1.3?

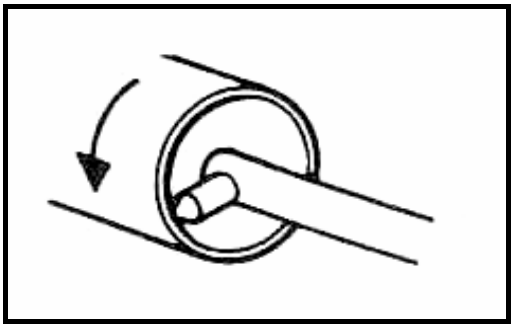

FIGURE 1.3

A Parting
B Parallel turning
C Internal parallel boring
D External thread cutting (1)

1.9 What are the important steps to consider for slab milling (flat surface)?

A The type of cutting process
B What cutter is best for the job
C Types of materials that the work piece is made of
D All the above-mentioned (1)

1.10 What is the reason for visually examining the testing of welds?

A To check for size of the weld
B To train welders
C To test the skill of the welder
D To approve welders and welds to certain standards (1)

1.11 What is the disadvantage of up-cut milling?

A A coarse feed may be used
B Vibration is less
C Less strain on the cutter and arbor
D The finish of the job is not of a high standard (1)

1.12 What is the unit for torque?

A Newton
B Newton metre
C Metres per second
D Kilogram per metre (1)

1.13 What do you understand by the term Young's modulus of elasticity?

A The measurement of extension or contraction of a bar when an external load is applied
B Stress value required to produce unit strain in a tensile specimen of the particular material
C Strain is directly proportional to the stress it causes, provided the limit of proportionality is not exceeded
D A measurement of the deformation produced by the application of the external forces (1)

1.14 What is the function of the ball bearing shown in FIGURE 1.4 when in use on the clutch assembly of a motor vehicle?

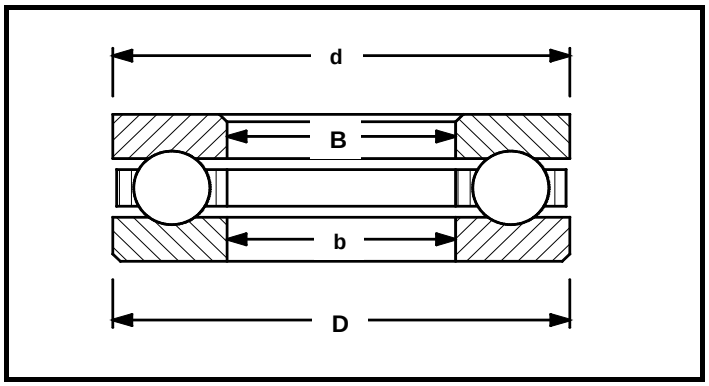

FIGURE 1.4

A For supporting light radial loads
B For the prevention of considerable misalignment between inner and outer rings
C For supporting high-thrust loads on the assembly
D For carrying a combination of radial and axial loads (1)

1.15 What type of stress are the rivets shown in FIGURE 1.5 subjected to?

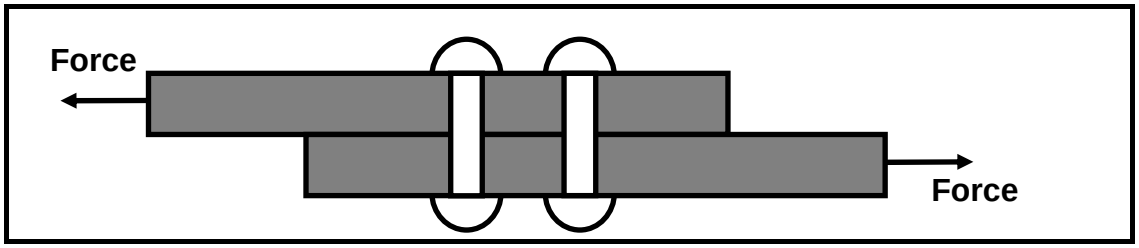

FIGURE 1.5

A Shear stress
B Tensile stress
C Compressive stress
D Pushing stress (1)

1.16 What is the name of the series of pulleys with attached rope or chain, as shown in FIGURE 1.6?

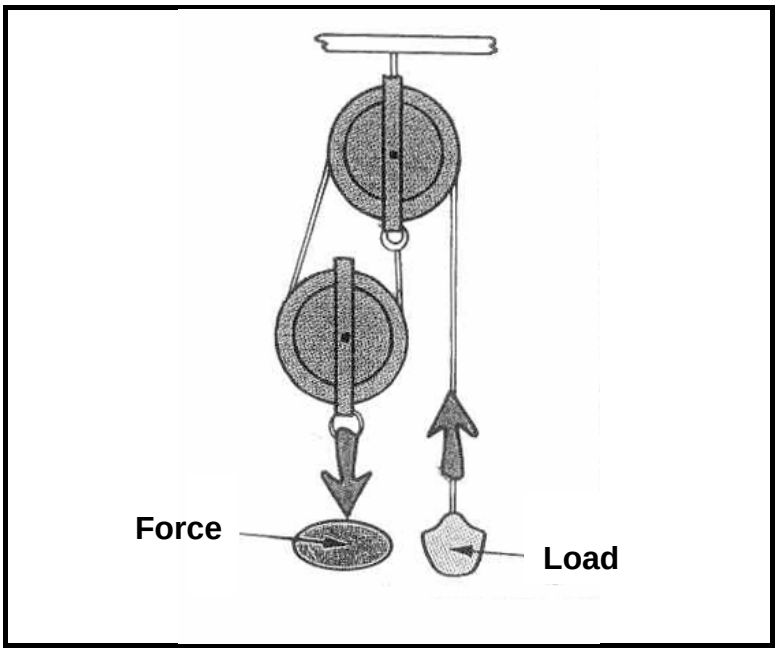

FIGURE 1.6

A Wheel and axle
B Stepped pulley and idler
C Block and tackle
D Open-belt pulley system (1)

1.17 Identify the type of thread shown in FIGURE 1.7

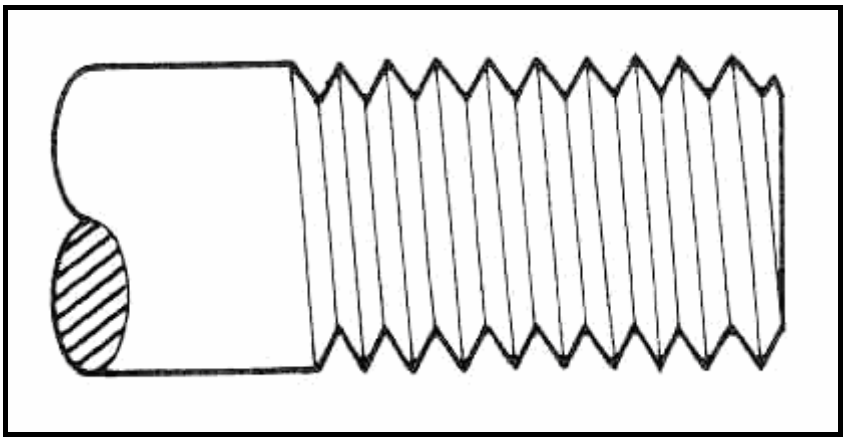

FIGURE 1.7

A Square thread
B Trapezium screw thread
C Acme thread
D V-thread (1)

1.18 Identify the cam by referring to FIGURE 1.8 below.

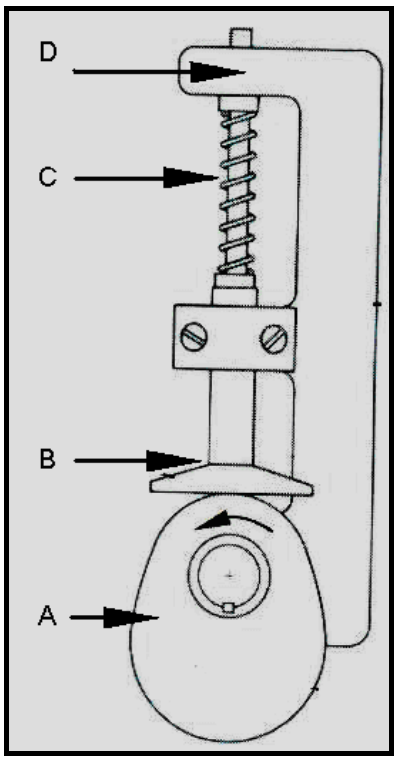

FIGURE 1.8

A A specially shaped piece of metal fixed to an axle
B A device that firmly holds the guide against the profile
C A device designed to move up and down following the profile
D A device that tensions the valve (1)

1.19 How does a turbocharger differ from a supercharger?

A It is driven by gears
B It is driven by pulleys
C It is driven by exhaust gases
D It is driven by inlet gases (1)

1.20 Which THREE stages best describe a gas turbine?

A Compressor, common shaft and turbine
B Inlet ports, combustion and cooling
C Inlet ports, turbine and cooling
D Compression, combustion and thrust (1)

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

2.1 A brass bush, 80 mm long with an inside diameter of 30 mm and an outer diameter of 40 mm, is used in a press to push out bearings. A force of 23 kN is exerted onto the bush.

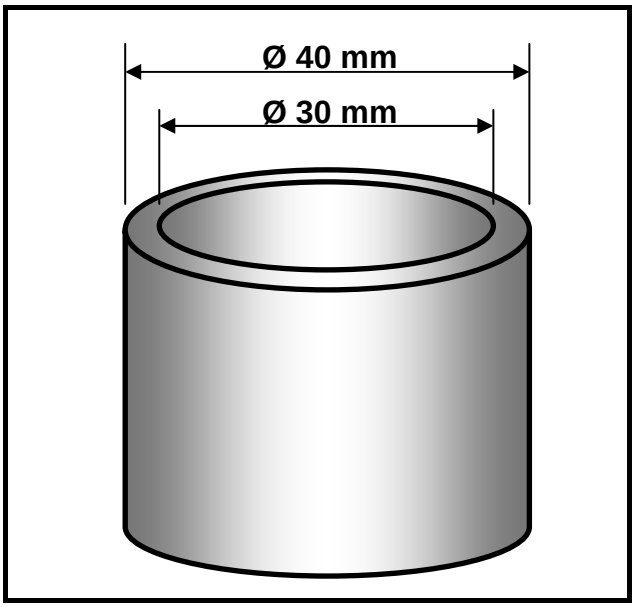

FIGURE 2.1

2.1.1 Name the type of stress that the bush material is subjected to. (1)

2.1.2 Calculate the stress in the material. Indicate the answer in MPa. (5)

2.1.3 Calculate how much the bush will shorten under the given load, if Young's modulus of elasticity for brass is 90×10^3 MPa. (5)

2.2 An artisan was instructed to design a hydraulic press that will be used to push out bearings. The force that should be exerted onto the bearings is 23 kN. The maximum force that can be exerted onto the 38 mm plunger is 200 N.

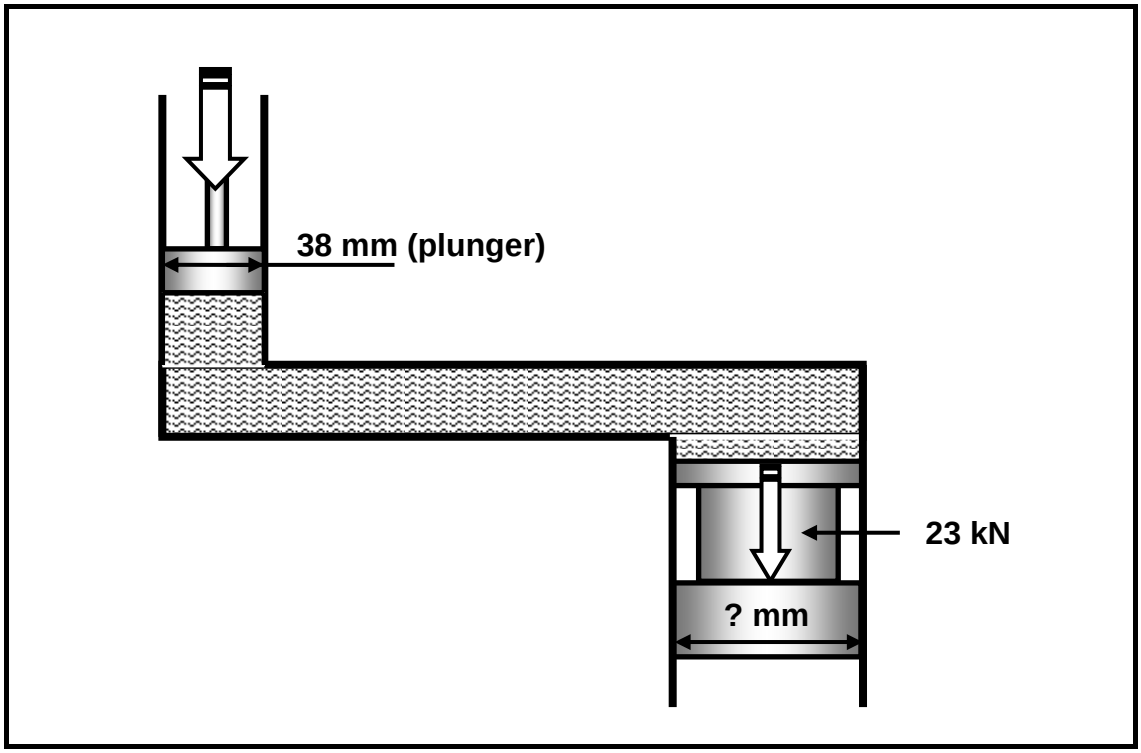

FIGURE 2.2

Help the artisan by calculating the following:

2.2.1 The fluid pressure in the hydraulic system (3)

2.2.2 The diameter of the ram so that the maximum force of 23 kN can be exerted onto the bearings (4)

2.3 Lukas is the engineer who must design a gear drive for a mincing machine. The shaft of the mincing machine must rotate at 90 r/min. The rest of the gear drive is as follows:

On the electrical motor is a driver gear with 30 teeth that meshes in with a driven gear with 80 teeth on a counter shaft. On the counter shaft is a second driver gear with 20 teeth that meshes in with the final driven gear which has 40 teeth.

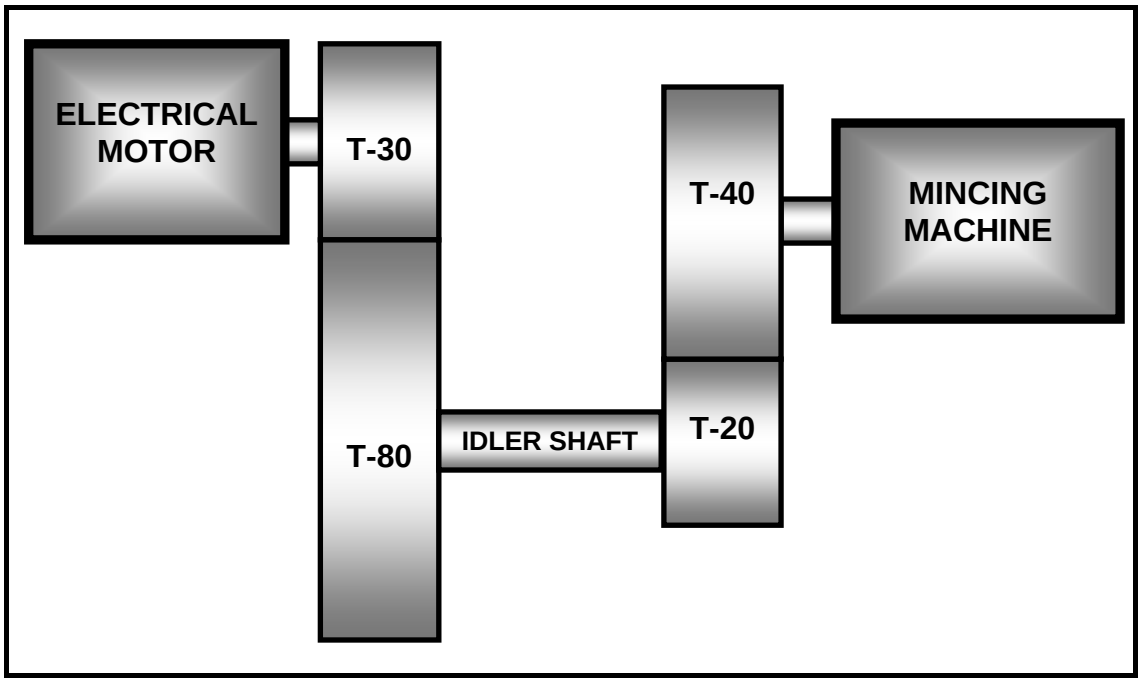

FIGURE 2.3

Calculate:

2.3.1 The rotation frequency of the electrical motor (2)

2.3.2 Name TWO advantages of a gear drive compared to a belt drive (2)

2.4 The power transmitted by a belt from a belt pulley with a diameter of 420 mm, that rotates at 710 r/min, is 8 kW. The ratio between the tensile force in the tight side and the tensile force in the slack side is 2,5. The acceptable tensile force is 4 N per mm belt width.

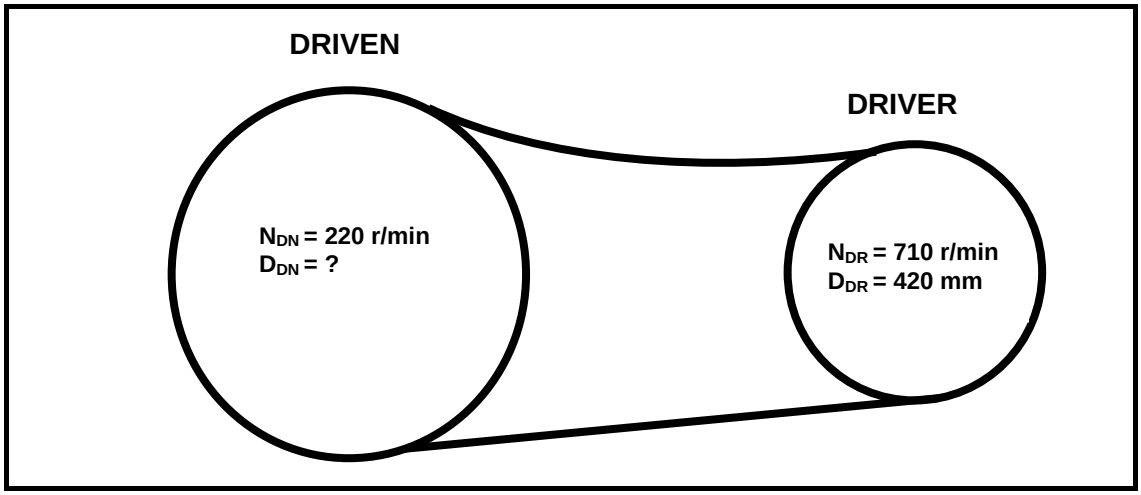

FIGURE 2.4

Calculate:

2.4.1 The diameter of the second pulley if the rotation frequency is 220 r/min (3)

2.4.2 The width of the belt (6)

2.5 A product inspector inspects gears that have been manufactured, but finds that there is some uncertainty regarding the gear specifications. You are requested to calculate the following gear terms of a straight-tooth gear with 60 teeth and a module of 4.

Determine, by means of calculations, the following:

2.5.1 The pitch-circle diameter (2)

2.5.2 The addendum (2)

2.5.3 The clearance (2)

2.5.4 The dedendum (2)

2.5.5 The outside diameter of the gear (2)

2.6 FIGURE 2.5 shows a cutting tool suitable for cutting left-hand square screw thread, in position. Label the angles according to the letters A – D.

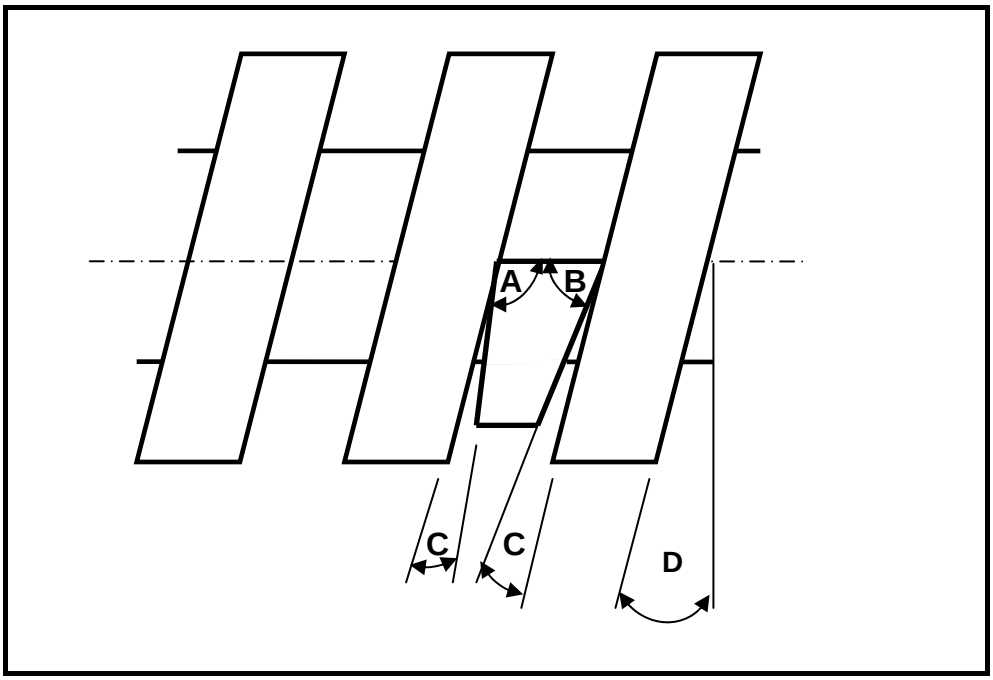

FIGURE 2.5 (4)

2.7 A single-plate friction clutch is used to transmit 245 N.m 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. Calculate the effective diameter of the clutch. (5)

[50]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Princess uses the Brinell hardness tester to test the specimen given to her by the supervisor. FIGURE 3.1 below shows a specimen under test. Label the figure according to the numbers 1 to 4.

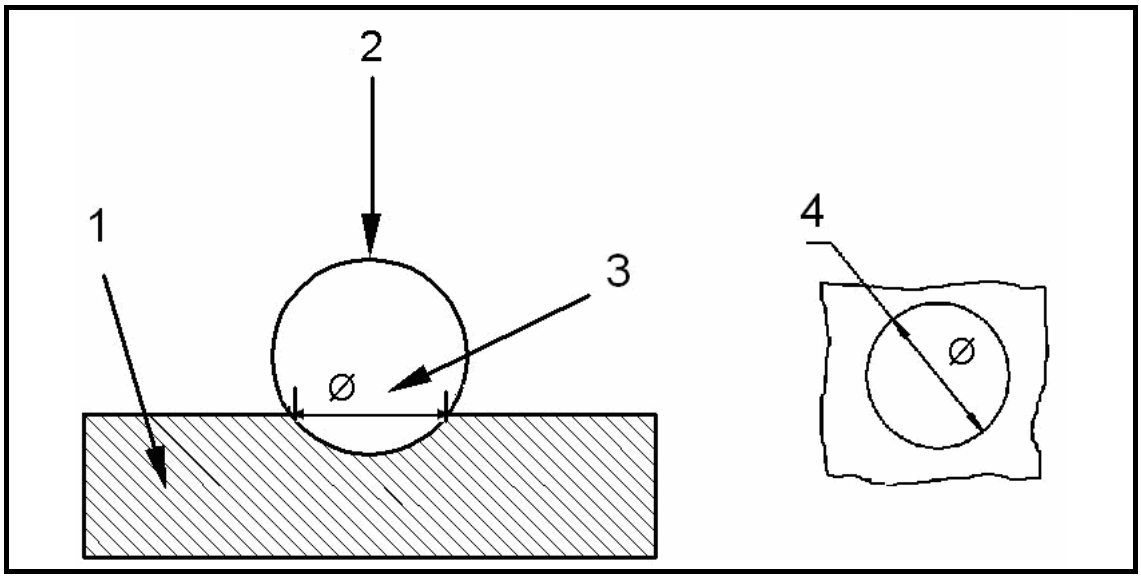

FIGURE 3.1 (4)

3.2 A designer needs material with high tensile strength for his project. Mr Bonga is requested to do a destructive tensile test on the given specimen. What is the purpose of such a tensile test? (4)

3.3 The performance of Gert's car decreased. He performed a wet compression test on the engine. What is the purpose of the wet compression test? (4)

3.4 Carbon monoxide is a health risk to humans and therefore carbon monoxide emissions of motor vehicles must be set according to the manufacturer's specifications.

3.4.1 What equipment shall be used for setting the carbon monoxide levels for the car? (2)

3.4.2 Name any TWO gases that are released during the combustion process. (2)

3.5 Many parts of a motor vehicle's suspension are exposed to torsion. Describe *torsion*. (2)

3.6 An engineer is performing a bending test on a beam he needs for the framework of a truck's trailer. What is the reason for performing this test? (2)

[20]

QUESTION 4: MATERIALS

4.1 FIGURE 4.1 shows tin snips. Answer the questions that follow.

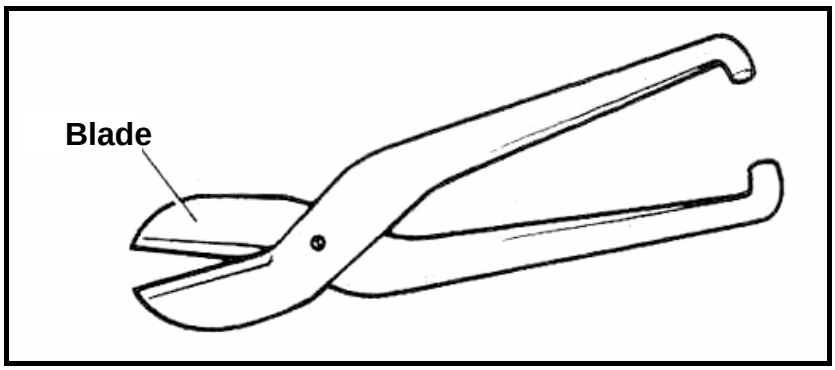

FIGURE 4.1

4.1.1 Name the material used for the manufacturing of the blades. (1)

4.1.2 Name TWO properties of the material mentioned in QUESTION 4.1.1. (2)

4.1.3 Why may an artisan treat the blades of tin snips with oil? (1)

4.2 Define a *ferrous alloy* and give TWO examples. (3)

4.3 FIGURE 4.2 shows a hammer head. Answer the questions that follow.

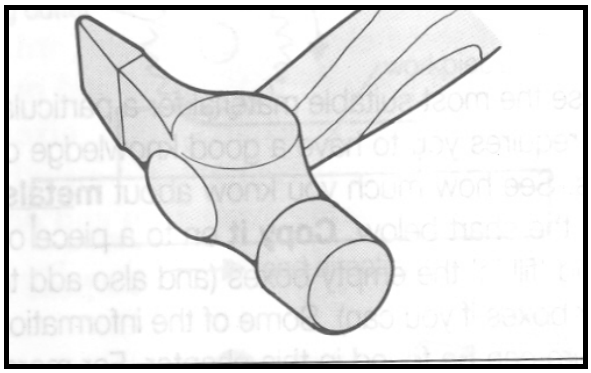

FIGURE 4.2

4.3.1 What material is used for the manufacturing of the hammer head? (1)

4.3.2 Which TWO properties make it particularly suitable for this product? (2)

4.4 Define *tensile strength* as a property of materials. (2)

4.5 Which of the materials, A or B, shown in FIGURE 4.3 has the lower tensile strength and why? (The same force is applied to both materials.)

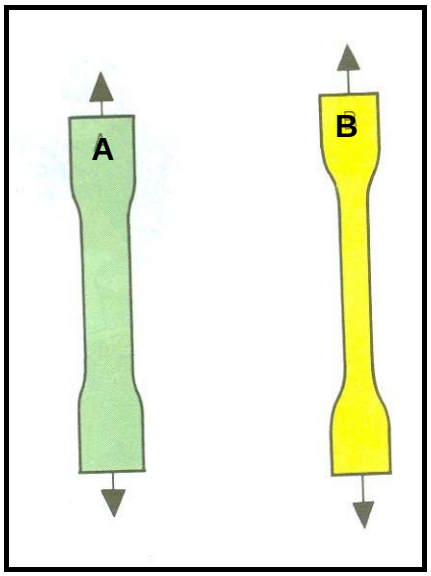

FIGURE 4.3 (2)

4.6 The casing and contact pins of the plug shown in FIGURE 4.4 is made of nylon and bronze respectively. Answer questions that follow.

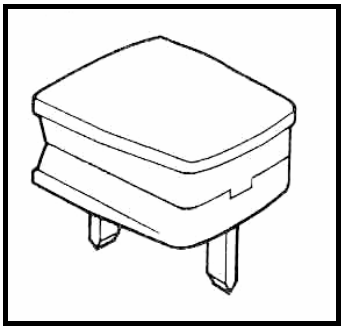

FIGURE 4.4

4.6.1 Why is nylon used to manufacture the casing of the above product? Give TWO reasons. (2)

4.6.2 Which TWO properties of bronze make this material particularly suitable for manufacturing the contact pins of the plug? (2)

4.7 Name TWO properties of carbon fibre. (2)
[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

5.1 Name FOUR safety precautions to be observed when using a torsion tester. (4)

5.2 Name FOUR safety rules to be observed when using the MIG welder. (4)

5.3 Name FOUR advantages when using a helical cutter. (4)

5.4 What is the main function of a dividing head? (2)

5.5 Nick is a machinist and is required to mill 163 teeth on a spur gear. The dividing head ratio is 40 : 1. (HINT: Use N = 160 divisions for the simple indexing.)

5.5.1 Calculate the indexing that is required. (5)

5.5.2 Calculate the change gears that are required. (5)

5.5.3 Determine the direction of rotation of the index plate in relation to the index crank. (2)

5.6 Calculate the feed in millimetre per minute of a 200 mm diameter cutter with 20 teeth, operating at a cutting speed of 200 metres per minute and a feed of 0,1 mm per tooth. (6)

5.7 FIGURE 5.1 shows the functioning components of a dividing head. Label the components numbered 1 – 5.

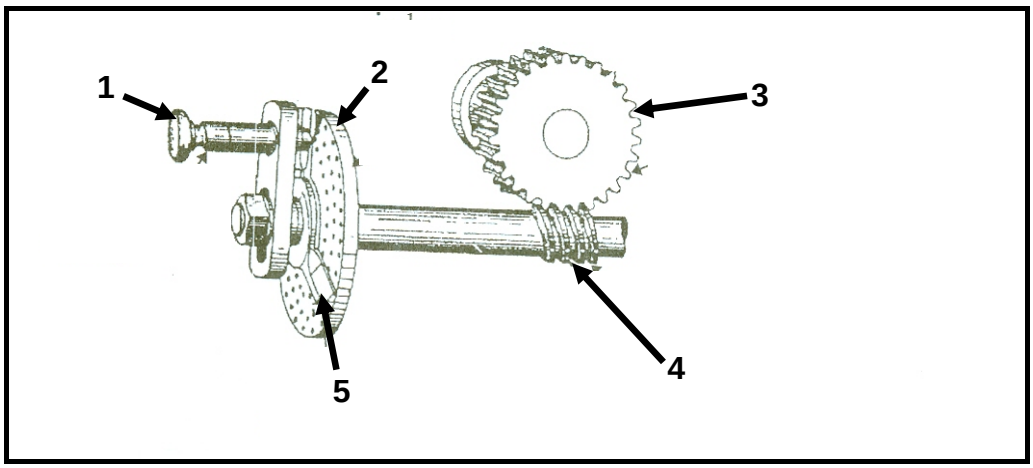

FIGURE 5.1 (5)

5.8 Briefly explain the procedures to be followed when performing the dye/liquid penetrate test. (7)

5.9 Name THREE causes and THREE prevention methods for incomplete penetration in welded joints. (6)

[50]

QUESTION 6: MAINTENANCE AND TURBINES

6.1 Mr Manzi owns a fleet of taxis. He does not keep proper service records of his vehicles. This has resulted in one of his vehicles not being serviced for some time, causing the timing chain to become noisy. Answer the questions that follow.

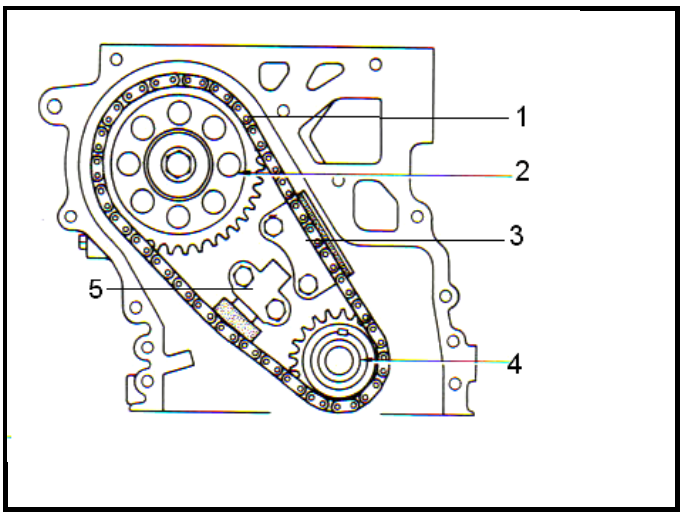

FIGURE 6.1

6.1.1 Label parts 1 – 5 in the above drawing. (5)

6.1.2 Name FOUR properties of lubricating oil. (4)

6.1.3 Give THREE reasons for changing the oil of a motor vehicle. (3)

6.2 Engine manufacturers and lubricant suppliers use abbreviations to classify oils. Write out the following abbreviations:

6.2.1 SE (1)

6.2.2 CE (1)

6.2.3 SAE 20W50 (2)

6.2.4 ATF (1)

6.3 Siyabonga, a Mechanical Technology learner, uses the lathe in order to do his Practical Assessment Task. He uses cutting fluid while working on the lathe. Name FOUR uses of cutting fluid. (4)

6.4 Name THREE properties of grease. (3)

6.5 Superchargers are mainly used in cars to improve their performance. Answer the questions that follow.

6.5.1 Name TWO purposes of the supercharger. (2)

6.5.2 Give THREE examples of where a supercharger is used. (3)

6.5.3 Name THREE advantages of using a supercharger. (3)

6.6 Turbochargers are also used in cars to improve their performance. Name ONE advantage of the turbocharger compared to the supercharger. (2)

6.7 Name THREE advantages of a steam turbine. (3)

6.8 Name THREE advantages of a gas turbine. (3)
[40]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 12

1. BELT DRIVES

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

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

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

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

1.5 $N_1D_1 = N_2D_2$

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 $Power\ = \frac{(T_1 - T_2)\,\pi\,D\,N}{60}$ *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 $$Module\ (m) = \frac{Pitch\text{-}circle\ diameter\ (PCD)}{Number\ of\ teeth\ (T)}$$

7.7 $$N_1T_1 = N_2T_2$$

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 $Pitch\ diameter = Outside\ diameter - \frac{1}{2}pitch$

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

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

8.4 $Helix\ angle:\ \tan \varnothing = \frac{Lead}{Pitch\ circumference}$

8.5 $Leading\ tool\ angle = 90° - (helix\ angle + clearance\ angle)$

8.6 $Following/Trailing\ angle = 90° + (helix\ angle - clearance\ angle)$

8.7 $Number\ of\ turns = \frac{height}{lead}$

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

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

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*

****