education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MCHT.1

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2010

MARKS: 200

TIME: 3 hours

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

MORNING SESSION

INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions. 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. Start each question on a NEW page.
5. Show ALL the calculations and units. Round off answers to TWO decimal places.
6. Candidates may use non-programmable scientific calculators and drawing instruments.
7. The value of the gravitational force should be taken as 10 m/s^2.
8. All dimensions are in millimetres, unless stated otherwise.
9. A formula sheet is attached at the end of this question.
10. Use the criteria below to assist you in managing your time.
11. Write neatly and legibly.

QUESTION	ASSESSMENT STANDARDS	CONTENT COVERED	MARKS	TIME
1	1 – 9	Multiple-choice questions	20	15 minutes
2	6 and 8	Forces and 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 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

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 a way to remove a bearing from a shaft using a hook spanner. Which step of the safe work procedure does the figure show?

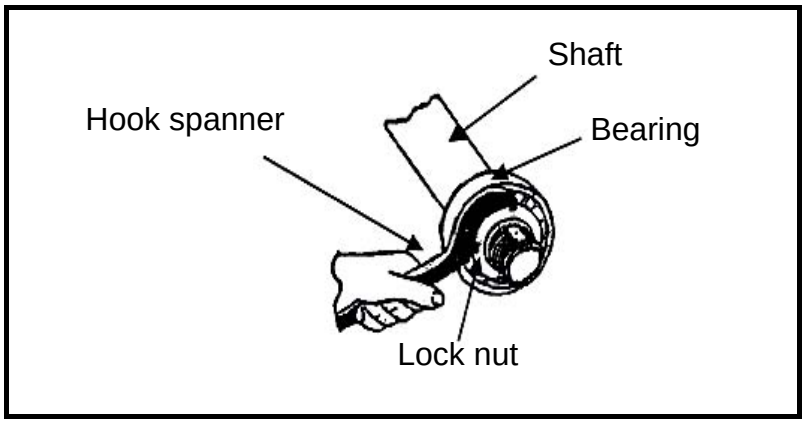


FIGURE 1.1

A Place a dolly between the ram and the shaft assembly.
B Slacken the lock nut two or three turns.
C Press the shaft out using a hydraulic press.
D Support the shaft with your hand. (1)

1.2 Which ONE of the following safety precautions is applicable when working with the gas analyser?

A Ensure that the fuel tank is full before doing the test.
B The test can only be done at room temperature.
C The exhaust gases of a vehicle must always be tested in a well-ventilated area.
D All persons who are not involved with the test should leave the working area. (1)

1.3 Identify the type of equipment shown in FIGURE 1.2.

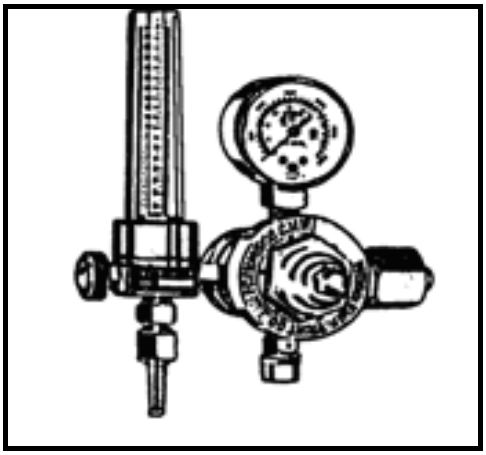


FIGURE 1.2

A Wire feed of MAGS machine
B Gun of MAGS machine
C Regulator and flow meter of MAGS machine
D Power supply of MAGS machine (1)

1.4 A torsion tester determines how the specimen behaves under continuous …

A shear-force loading.
B torque loading.
C pressure loading.
D stress loading. (1)

1.5 Which ONE of the following engineering materials is a synthetic composite?

A Brass
B Stainless steel
C High-carbon steel
D Nylon (1)

1.6 … are products made from polyvinyl chloride (PVC).

A Electrical insulation and wiring harnesses
B Connecting rods
C Bolt cutter
D Bicycle frames (1)

1.7 What will the spindle speed be if you were required to mill a material having a cutting speed of 60 m/min with a cutter of 100 mm in diameter?

A 119,80 r/min
B 911,04 r/min
C 190,99 r/min
D 291,72 r/min (1)

1.8 Identify the types of screw threads shown in FIGURE 1.3 (a), (b) and (c) respectively.

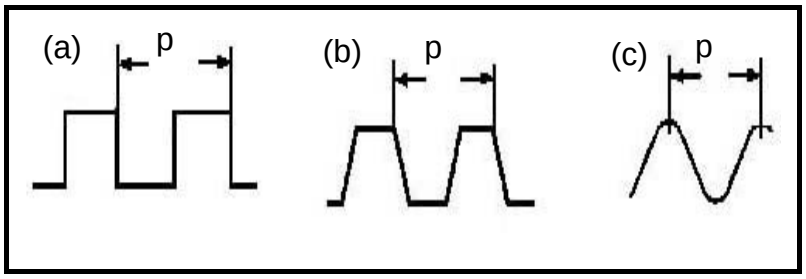


FIGURE 1.3

A Super course; fine; coarse
B Square; acme; I.S.O. metric
C Coarse; fine; super course
D Acme; I.S.O. metric; square (1)

1.9 Identify the type of milling cutter shown in FIGURE 1.4.

FIGURE 1.4

A Slot drill
B End mill
C Side-and-face cutter
D Shell end mill (1)

1.10 What is the MAIN FUNCTION of the inert gas used in MIGS welding?

A Makes cleaning of the weld easy
B Keeps contaminants out and prevents oxidation in the weld
C Reduces heat and stress in the weld
D Reduces grain growth (1)

1.11 … is the main cause of weld craters.

A Insufficient weld metal
B A small electrode
C A high current
D An incorrect electrode angle (1)

1.12 Tensile stress is stress that acts ...

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

1.13 What will Young's Modulus be for a 20 mm square bar and with a length of 600 when it lengthens by 0,5 mm under a load of 45 kN?

A 135,05 GPa
B 315,15 GPa
C 515,65 GPa
D 151,51 GPa (1)

1.14 Which ONE of the following is the purpose of lubrication?

A To reduce friction
B To reduce wear
C To prevent corrosion
D All the above-mentioned (1)

1.15 What type of lubrication method is shown in FIGURE 1.5?

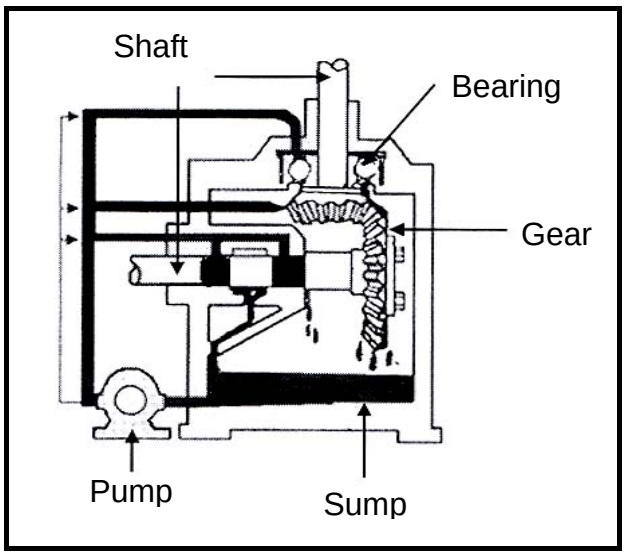


FIGURE 1.5

A Manual lubrication
B Gravity lubrication
C Pressure pump lubrication
D Natural lubrication (1)

1.16 The air compressor shown in FIGURE 1.6 is driven via a pulley system from a motor running at 300 r/min. What is the rotation frequency of the compressor shaft?

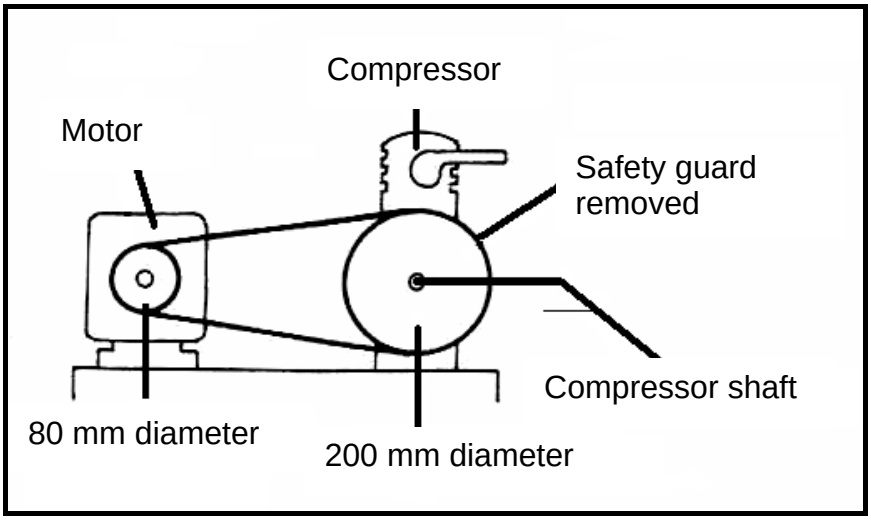


FIGURE 1.6

A 201 r/min
B 120 r/min
C 102 r/min
D 750 r/min (1)

1.17 What force is produced by the piston shown in FIGURE 1.7 if the air pressure is 1,2 N/mm^2? (Hint: 1N/mm^2 = 1 MPa.)

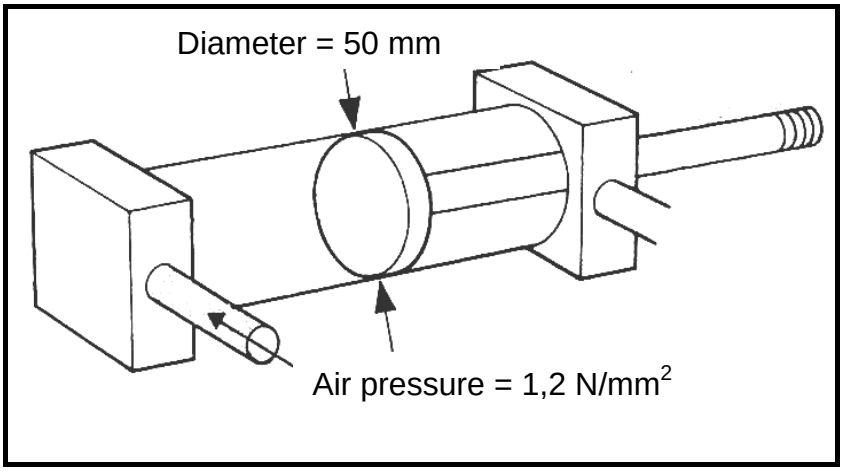


FIGURE 1.7

A 2 738,49 N
B 5 632,87 N
C 3 265,91 N
D 2 356,19 N (1)

1.18 Define the type of linkage (an assembly of levers designed to transmit motion and force) shown in Figure 1.8?

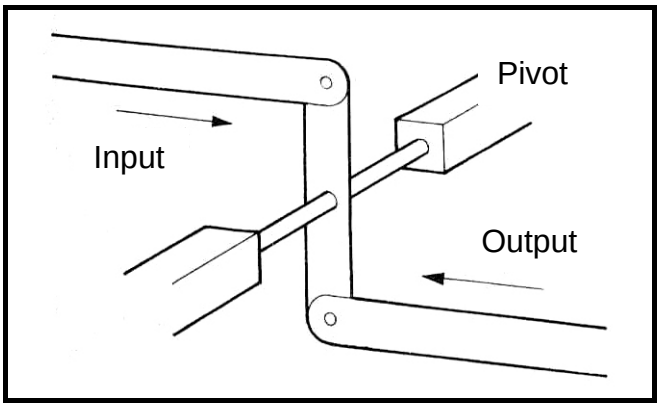


FIGURE 1.8

A Input and output forces are equal; direction of motion the same
B Output force greater than input force; direction of motion reversed
C Input and output forces are equal; direction of motion reversed
D Output force smaller than input force; direction of motion the same (1)

1.19 What do you understand by the term *pressure ratio* of a turbocharger?

A How much the turbocharger leaks
B Inlet pressure compared to outlet pressure
C A power output to power input ratio
D Rate of inlet air compared to outlet air is reduced (1)

1.20 Which ONE of the following classifications of turbines is used for internal combustion engine applications?

A Turbocharger
B Roots blower
C Centrifugal blower
D All the above-mentioned (1)

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

2.1 A production inspector has to inspect spur gears that have been manufactured. The gear specifications known are 60 teeth and a module of 4.

Determine the following through calculations:

2.1.1 The pitch-circle diameter of the gear (3)

2.1.2 The addendum (2)

2.1.3 The clearance (3)

2.1.4 The dedendum (3)

2.1.5 The outside diameter of the gear (3)

2.2 FIGURE 2.1 shows a cutting tool in position suitable for cutting a right-hand square screw thread. Label the angles according to letters A to D.

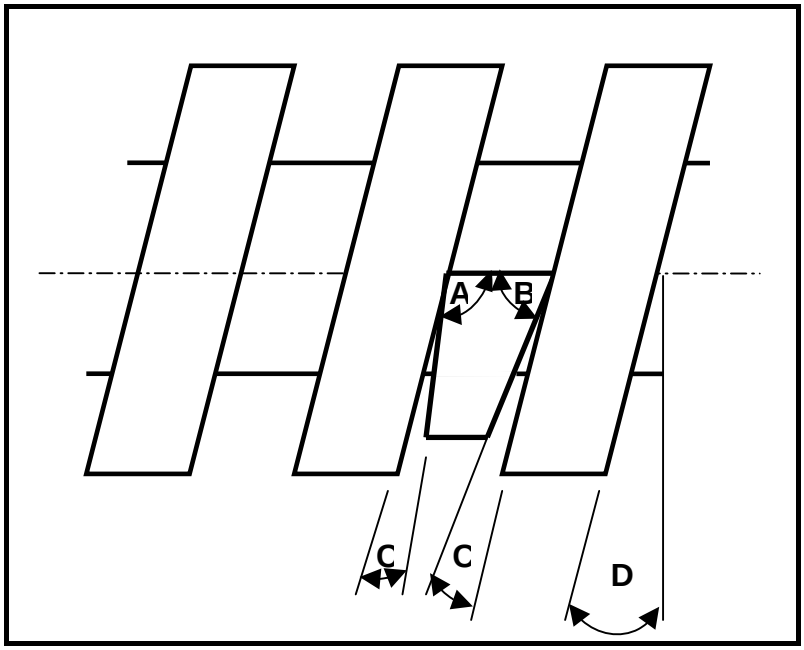


FIGURE 2.1 (4)

2.3 A single-plate friction clutch is used to transmit torque of 245 Nm in an engine/generator combination. The clutch plate has friction material on both sides. The friction coefficient is 0,35. The total force exerted onto the pressure plate is 2,5 kN. Calculate the effective diameter of the clutch. (5)

2.4 FIGURE 2.2 shows a simple lever at work.

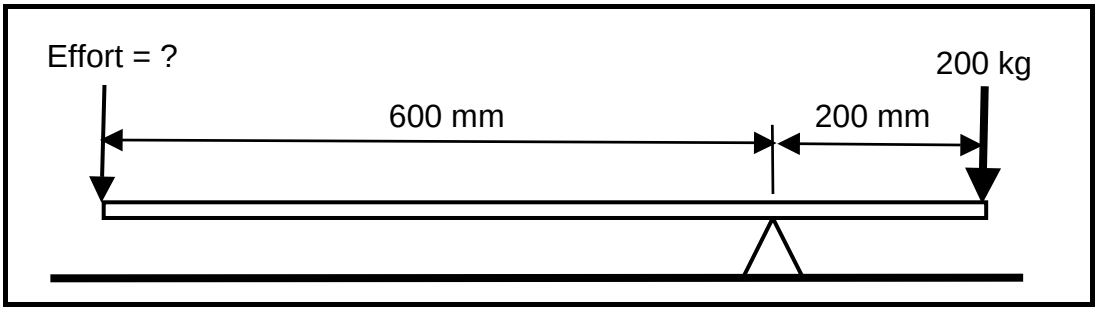


FIGURE 2.2

Calculate the following:

2.4.1 The value or magnitude of the effort (4)

2.4.2 The mechanical advantage (3)

2.5 FIGURE 2.3 shows two 12 mm rivets under shear stress.

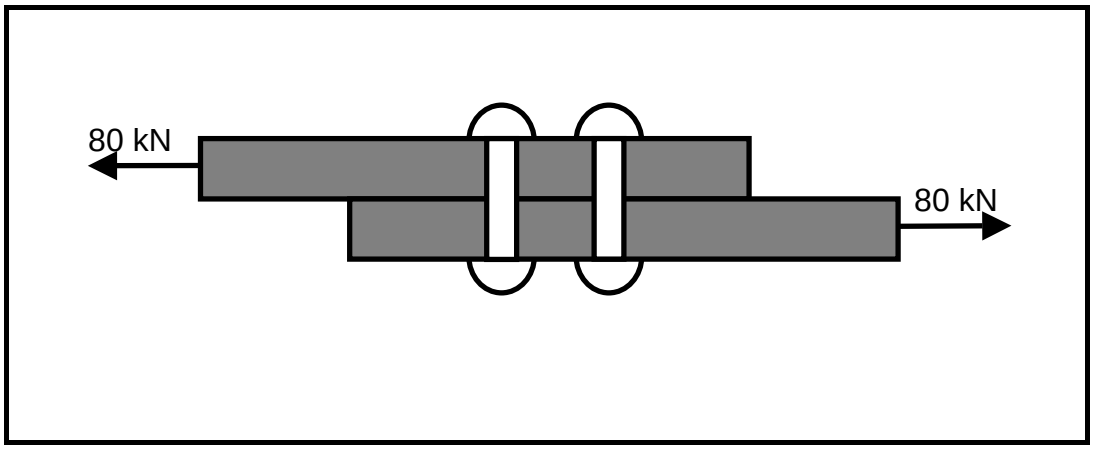


FIGURE 2.3

Calculate the following:

2.5.1 The total resistant area (5)

2.5.2 The stress induced in ONE of the rivets (Give the answer in mega-magnitude.) (5)

2.6 A machine must be driven at a speed of 10 r/s from a pulley with a diameter of 600 mm, which rotates at a speed of 7,2 r/s. The tensile force in the tight side of the belt is 300 N. The ratio between the tensile force in the tight side and the tensile force in the slack side is 2,5 : 1. (Belt thickness can be omitted.)

Calculate the following:

2.6.1 The diameter of the pulley that must be fitted to the machine (4)

2.6.2 The power that can be transmitted (6)

[50]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 A digital multimeter, shown in FIGURE 3.1, is an instrument that is used often by an auto-electrician to test an electrical circuit.

List FOUR operating rules when using a multimeter.

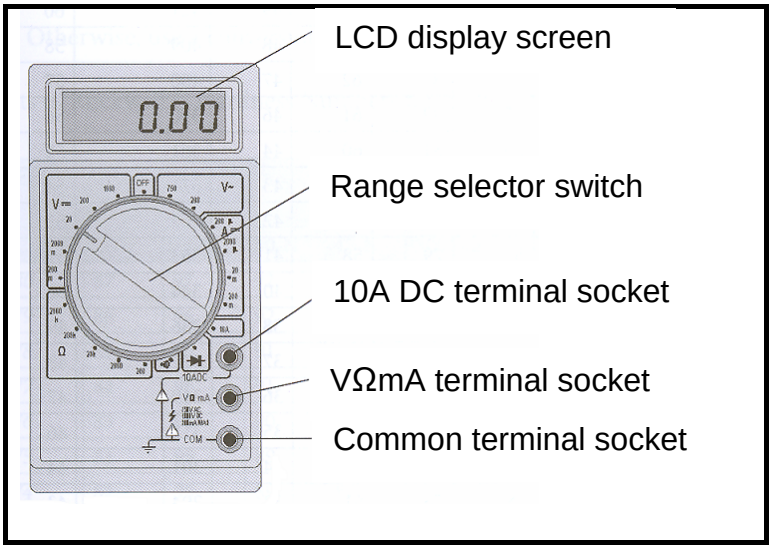


FIGURE 3.1 (4)

3.2 What does the abbreviation *MIGS/MAGS* stand for? (2)

3.3 When assembling the cylinder head of an internal combustion engine, certain tests have to be carried out using a spring tester, as shown in FIGURE 3.2. Explain how a test is carried out using a valve spring.

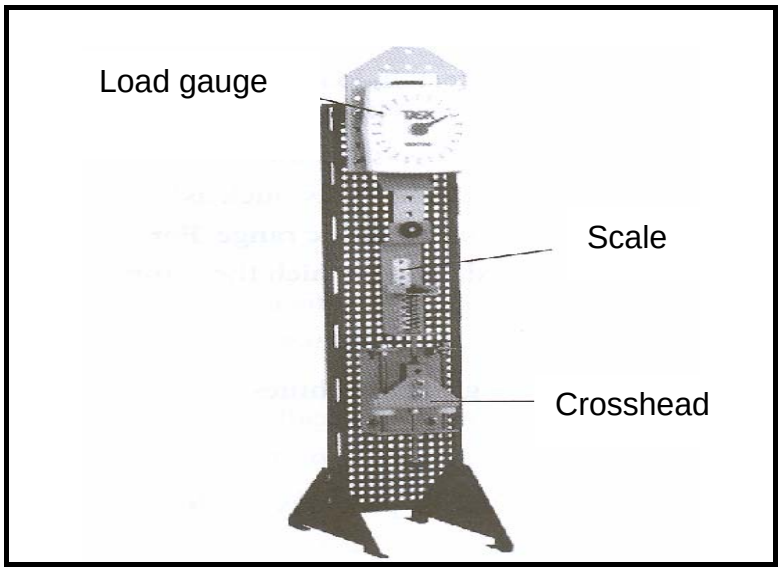


FIGURE 3.2 (4)

3.4 A number of tests can be done on a vehicle engine using a cylinder leakage tester. Name THREE such tests, indicate the possible faults and state how these could be identified.

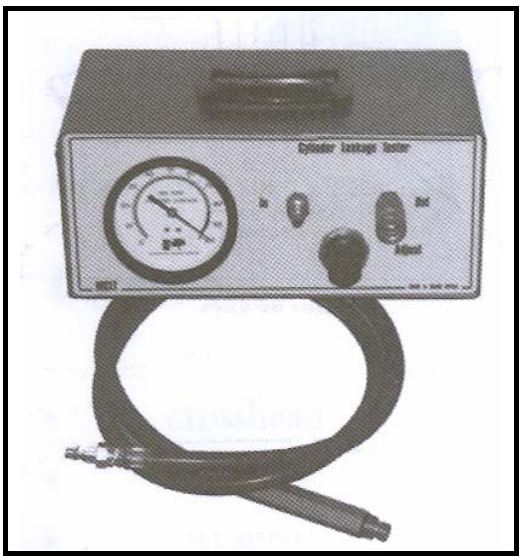


FIGURE 3.3 (6)

3.5 Describe in point form the procedure of operating the Brinell hardness tester. (4)
[20]

QUESTION 4: MATERIALS

4.1 The frame of a baby carriage/pram was fabricated from stainless steel tubing, as shown in FIGURE 4.1.

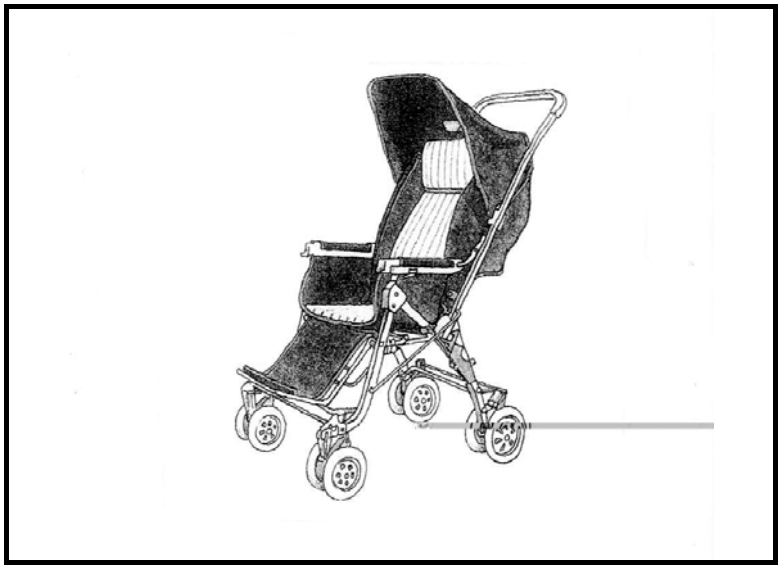


FIGURE 4.1

4.1.1 Which TWO properties make stainless steel particularly suitable for this product? (2)

4.1.2 Give TWO reasons why tubing was used rather than a solid bar. (2)

4.1.3 Name TWO disadvantages of using mild steel for this product. (2)

4.2 The wheel rims on some motor cars are fabricated from mild steel pressings. Others are cast in aluminium alloys as shown in FIGURE 4.2. Steel has a density of 7,8 g/cm^3 and aluminium alloys of around 2,7 g/cm^3.

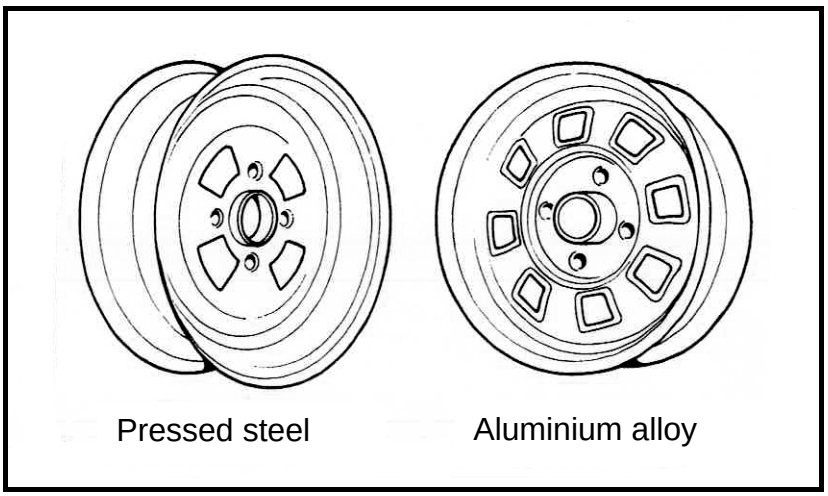


FIGURE 4.2

Why are the wheel rims on most small cars made from mild steel pressings? (2)

4.3 The key, as shown in FIGURE 4.3, is manufactured from specific materials so that it is suitable for **heavy-duty** use.

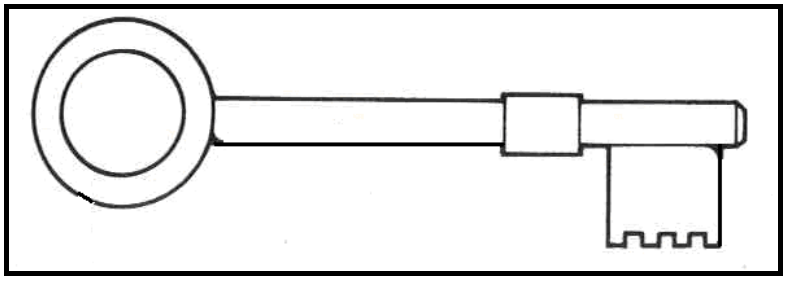


FIGURE 4.3

4.3.1 Which TWO materials would be most suitable for this product? (2)

4.3.2 Give TWO reasons to motivate your answer. (2)

4.4 The high-tensile bolt cutter shown in FIGURE 4.4 was assembled from several components.

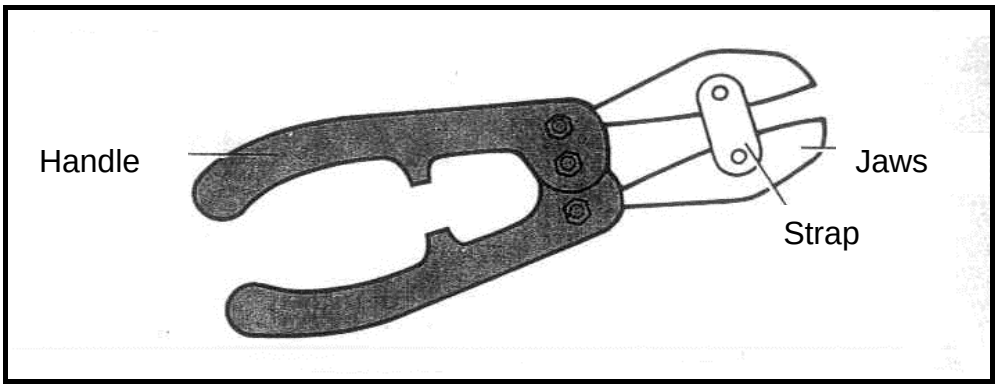


FIGURE 4.4

Which TWO components would be made from high-carbon steel? Give ONE reason for each. (4)

4.5 Solid nylon is widely used for engineering purposes. FIGURE 4.5 shows gear wheels made from solid nylon.

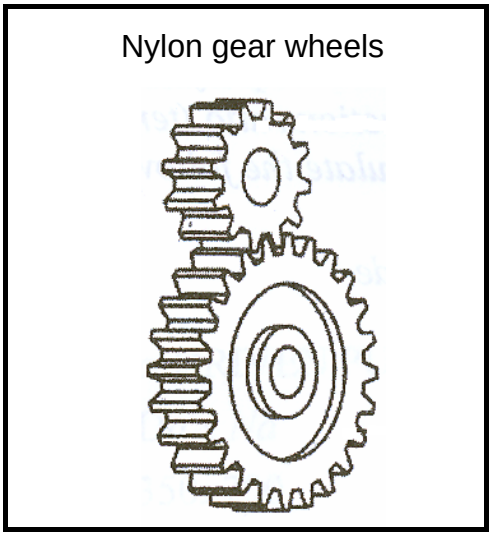


FIGURE 4.5

4.5.1 Name TWO properties which make nylon particularly suitable for the manufacturing of gears. (2)

4.5.2 Nylon is best known in the form of a fibre and is widely used in the manufacture of clothes. What property is desired from nylon fibre to manufacture carpets? (2)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

5.1 List the advantages of the MAGS/MIGS welding method. (5)

5.2 Name TWO advantages of each of the following milling methods:

5.2.1 Up-cut milling

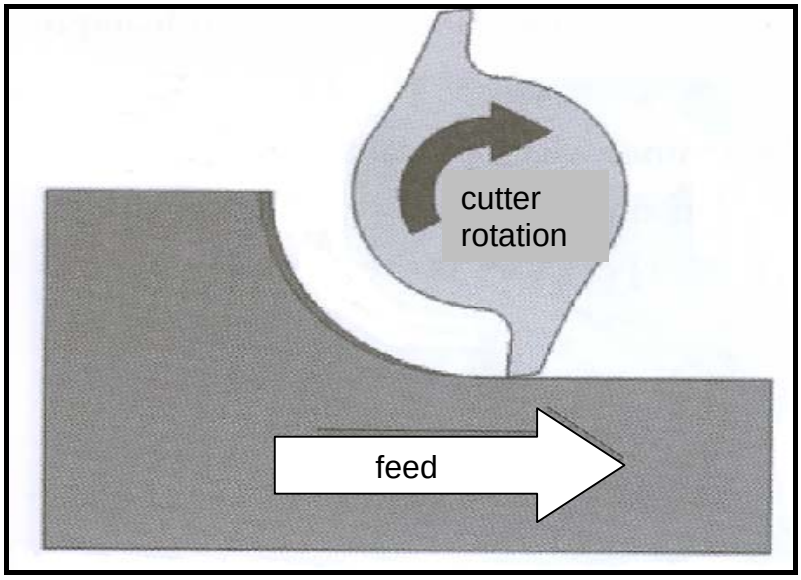


FIGURE 5.1 (2)

5.2.2 Down-cut milling

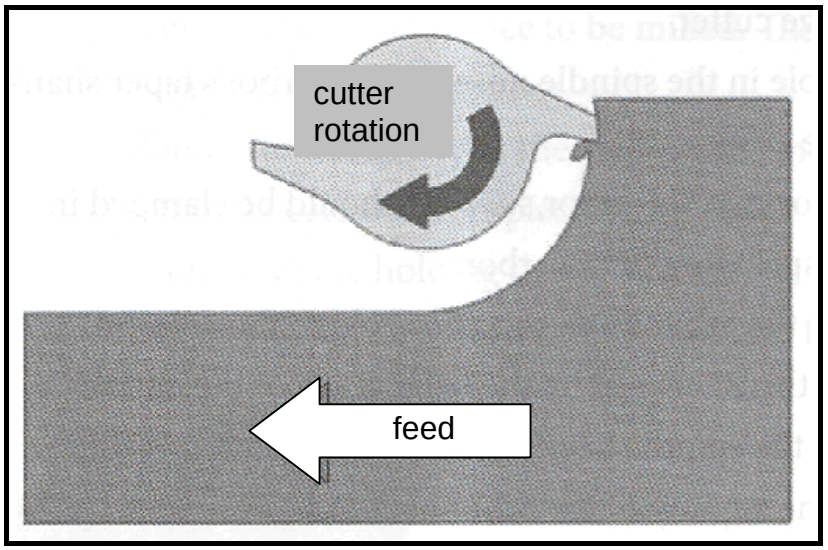


FIGURE 5.2 (2)

5.3 Milling cutters can be divided into two groups: according to design or method of sharpening. Name these TWO groups and also give TWO examples of each. (6)

5.4 Name THREE characteristics of a good milling cutter. (3)

5.5 Name THREE causes and THREE preventative measures of incomplete penetration during the arc welding process.

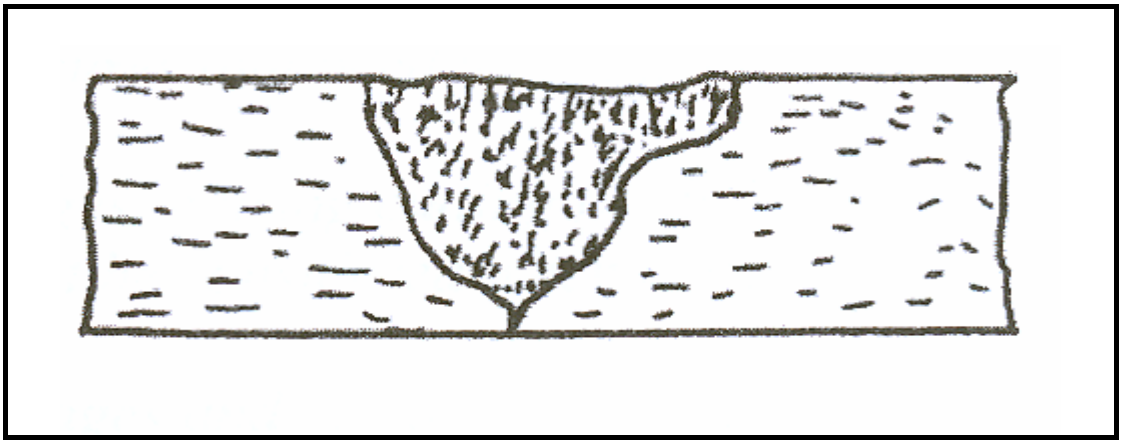


FIGURE 5.3 (6)

5.6 Tabulate THREE destructive and THREE non-destructive tests as applied to welded joints. (6)

5.7 Calculate the feed in millimetres per minute of a 100 mm diameter cutter with 16 teeth, operating at a cutting speed of 30 metres per minute and a feed of 0,06 mm per tooth. (6)

5.8 George is a machinist and is required to mill 50 teeth on a spur gear. The dividing head ratio is 40:1. (Hint: Use 48 divisions for the simple indexing.)

5.8.1 Calculate the indexing that is required. (4)

5.8.2 Calculate the change gears that are required. (4)

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

5.9 State FOUR safety precautions to be observed when using a beam bending tester. (4)

[50]

QUESTION 6: MAINTENANCE AND TURBINES

6.1 Modern lubricating oils must fulfil certain requirements to prolong the lifespan of an engine. Define the following properties of oils:

6.1.1 Fluidity (2)

6.1.2 Pour point (2)

6.1.3 Foam resistance (2)

6.2 In order for an engine to perform at its best, regular servicing is required. State THREE reasons for oil change. (3)

6.3 Bearings are necessary in power transmission systems. Answer the questions related to bearings below.

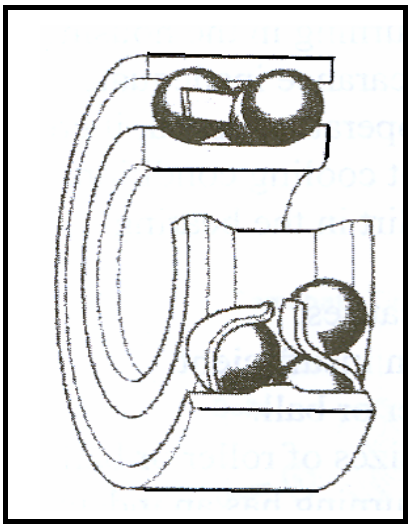


FIGURE 6.1

6.3.1 Give THREE reasons for using bearings. (3)

6.3.2 State THREE causes for bearings overheating. (3)

6.3.3 Name THREE advantages of anti-friction (roller-) bearings. (3)

6.3.4 Name TWO disadvantages of anti-friction (roller-) bearings. (2)

6.4 Big companies like ESKOM use boilers to generate steam to operate steam turbines. Answer the questions related to steam turbines below.

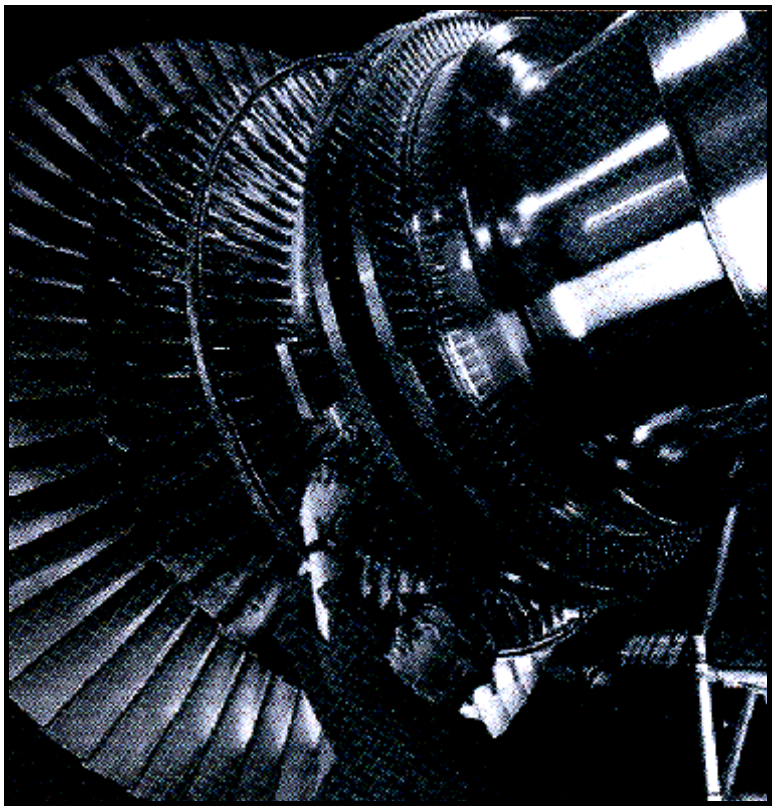


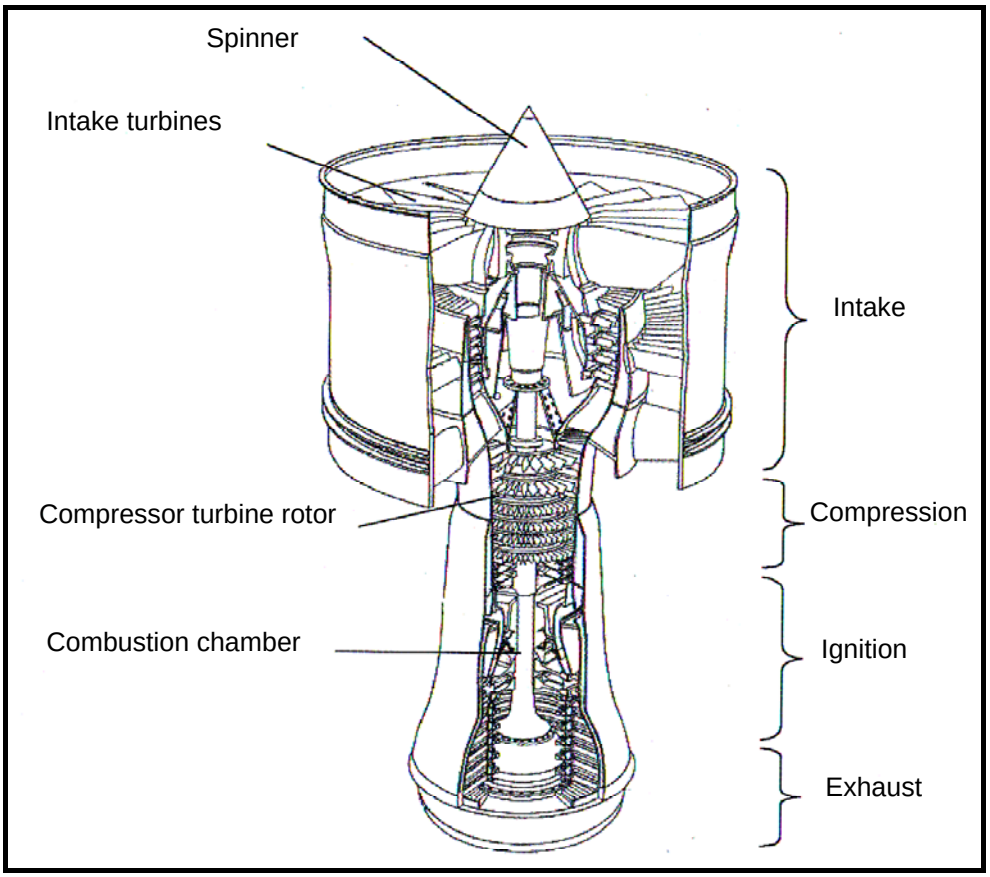
FIGURE 6.2

6.4.1 Explain the basic operation of a steam turbine. (5)

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

6.4.3 Name TWO disadvantages of a steam turbine. (2)

6.5 Most modern jet engines use gas turbines to generate power. Answer the questions related to gas turbines below.



6.5.1 Explain the operation of the gas turbine. (6)

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

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 – ½pitch*

8.2 *Pitch circumference = π × pitch diameter*

8.3 *Lead = pitch × number of starts*

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

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

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

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

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 per minute of cutter*

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

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

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