education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 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. 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. Write neatly and legibly.
9. All dimensions in millimeter unless stated otherwise.
10. Start each new question on a new page.
11. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT COVERED	MARKS	TIME
1	Multiple-choice questions	20	15 minutes
2	Forces and systems and control	50	55 minutes
3	Tools and equipment	20	15 minutes
4	Materials	20	15 minutes
5	Safety, terminology (manufacturing processes) and joining methods	50	45 minutes
6	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 What is the main safety precaution when using the gas analyser?

A Work in a confined area
B Work in a well ventilated area
C Work with windows closed
D Work in a well illuminated area (1)

1.2 Which ONE of the following answers is the most appropriate safety measure regarding a milling machine?

A Wear safety goggles and appropriate clothing.
B Do not use your hands to remove chips from the machine.
C Never reach over or near the rotating cutter.
D All the above-mentioned (1)

1.3 Identify the part **X** indicated in FIGURE 1.1.

FIGURE 1.1

A Terminal switch
B Socket switch
C Range selector switch
D Connector switch (1)

1.4 The main reason for performing a hardness test on engineering materials is to determine the …

A elasticity of the material.
B resistance of the material against denting.
C corrosion of the material.
D fluidity of the material. (1)

1.5 Select the carbon content for medium carbon steel from the following:

A 0,89% – 1,012%
B 0,5% – 0,8%
C 0,14% – 0,25%
D 0,35% – 0,55% (1)

1.6 Tungsten is commonly used to manufacture …

A cutting tools.
B connecting rods.
C crankshafts.
D engine blocks. (1)

1.7 Identify the cutting method, shown in FIGURE 1.2 below, that can be used on a milling machine.

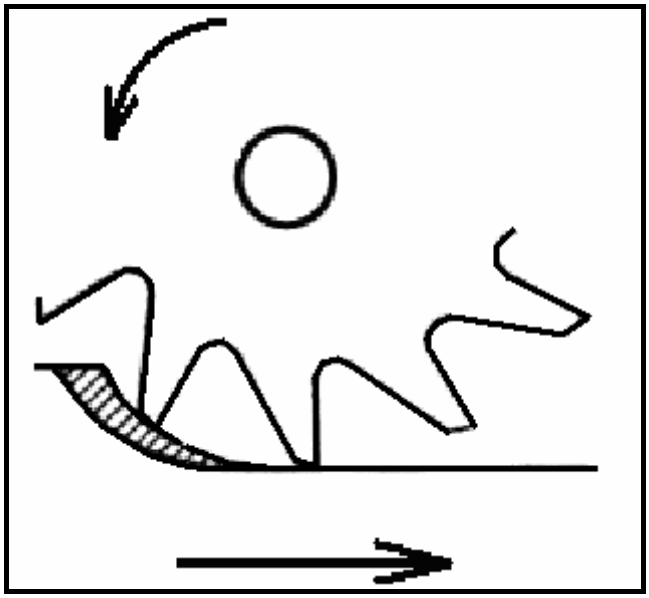


FIGURE 1.2

A Upcut milling
B Side and facecut milling
C Downcut milling
D T-slot cut milling (1)

1.8 Identify the symbol, shown in FIGURE 1.3 below, which relates to a pneumatic system.

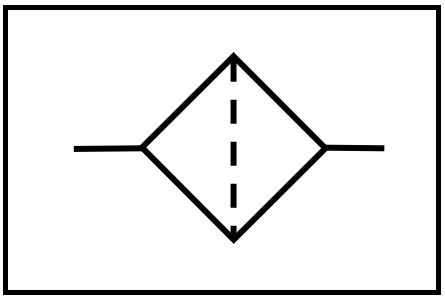


FIGURE 1.3

A Valve
B Filter
C Compressor
D Motor (1)

1.9 Select the definition of the nick-bend test from the following options:

A Breaking the weld open for examination of external defects.
B Breaking the weld open for examination of internal defects.
C Checking of shear fracture of a weld.
D Determining the relative ductility of a metal that is to be formed. (1)

1.10 Which of the following indicates the reason why the ultrasonic sound wave test is used on welding joints?

A External cracks
B External flaws
C Surface flaws
D Sub-surface flaws (1)

1.11 Select the definition of porosity regarding welded joints from the following options:

A Small pinholes occur in the weld metal.
B Occurs as a cavity at the end of the weld.
C Holes which occur in the weld metal due to trapped gases.
D A groove melted into the base metal adjacent to the edge of a weld. (1)

1.12 As shown in FIGURE 1.4, determine what the stress in a hollow pipe with a 50 mm outside diameter and a 30 mm inside diameter will be if a load of 80 N is applied.

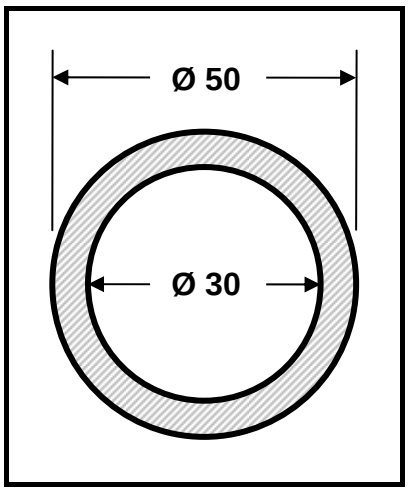


FIGURE 1.4

A 63,70 kPa
B 63,70 MPa
C 63,70 Pa
D 63,70 GPa (1)

1.13 Identify the type of stress acting on the pin of the chain that is shown in FIGURE 1.5.

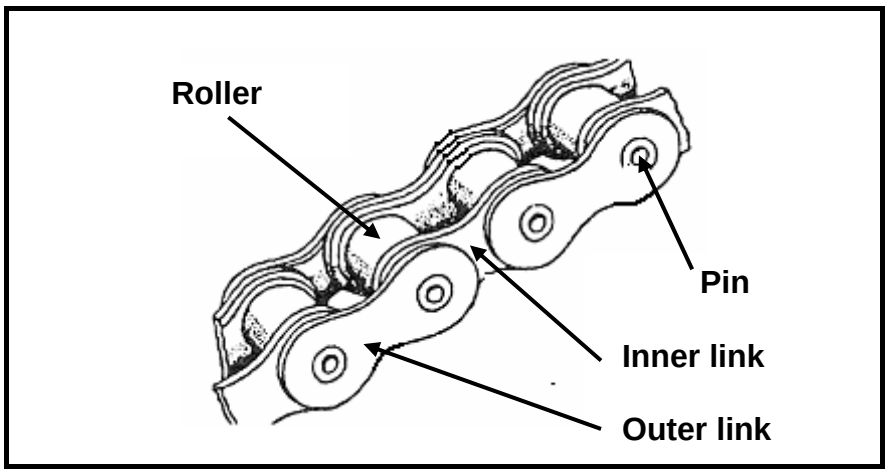


FIGURE 1.5

A Compression stress
B Shear stress
C Tensile stress
D Safe stress (1)

1.14 What does point D in the stress/strain diagram, shown in FIGURE 1.6 below, denote?

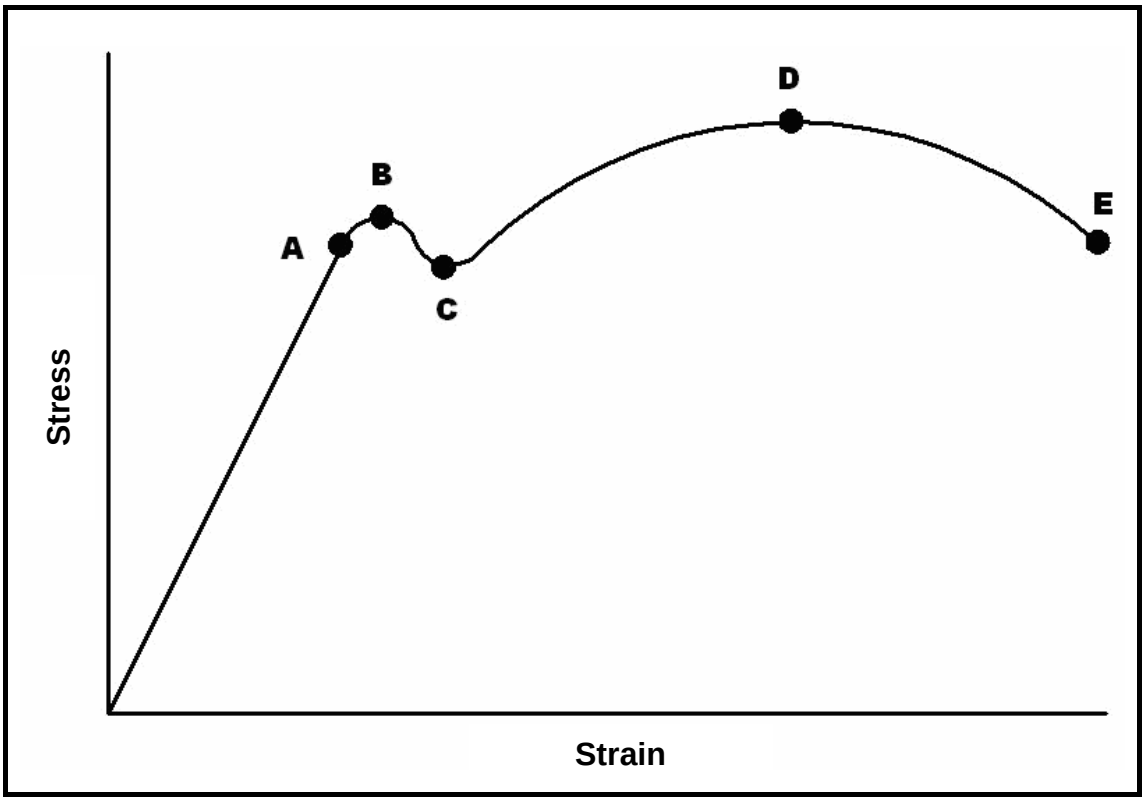


FIGURE 1.6

A Maximum stress
B Limit of proportionality
C Yield point
D Elastic limit (1)

1.15 Which ONE of the following statements is the DESIRED property of a cutting fluid?

A Acts as a lubricant.
B Keep the cutting tool cool.
C Gives the cutting tool a longer life span.
D All the above-mentioned (1)

1.16 The term *pour point*, in terms of lubricating oil, is the …

A resistance of a fluid to deform under linear stress.
B resistance of a fluid to deform under tensile stress.
C lowest temperature at which the fluid can flow.
D resistance of a fluid to deform under shear stress. (1)

1.17 What will the rotational speed of Pulley A be if Pulley B is rotating at 1 000 r/min as shown in FIGURE 1.7?

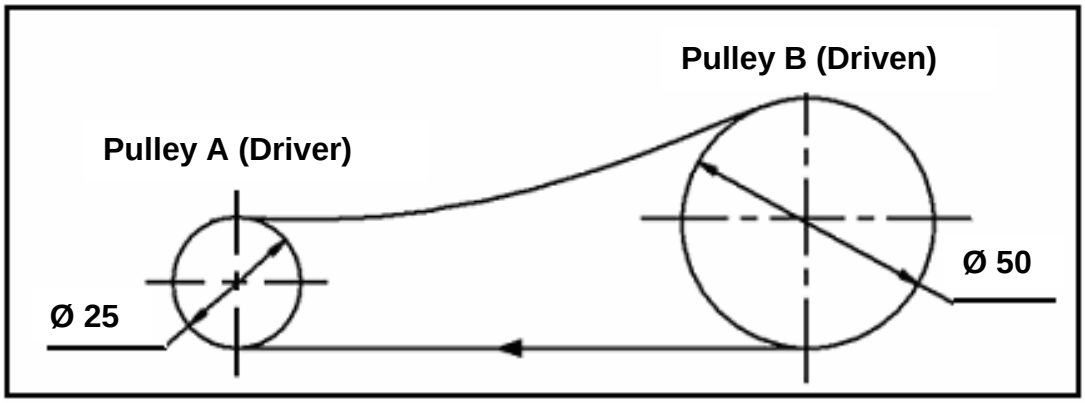


FIGURE 1.7

A 1 000 r/min
B 2 000 r/min
C 2 250 r/min
D 2 500 r/min (1)

1.18 Determine the speed ratio of a racing cycle that uses the chain and sprocket system as shown in FIGURE 1.8.

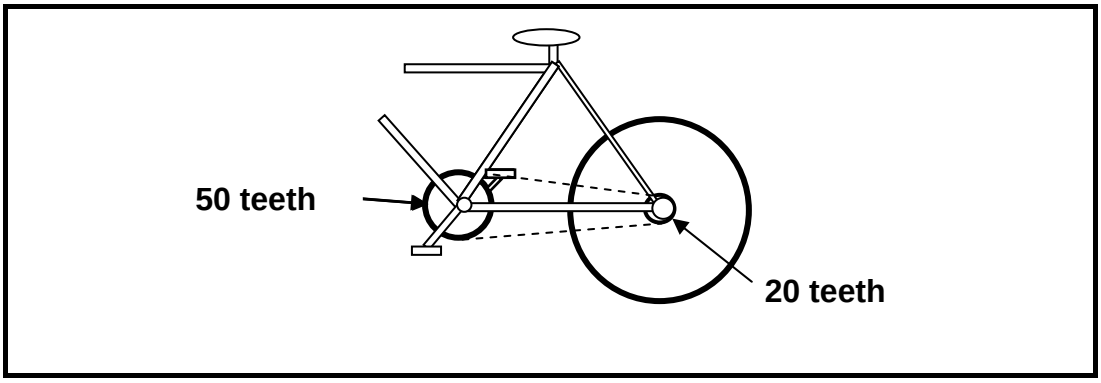


FIGURE 1.8

A 25:25
B 0,4:1
C 2,5:1
D 25:1 (1)

1.19 Choose the advantage of a turbocharger over a supercharger from the following options:

A The turbocharger makes use of diesel to operate.
B The turbocharger makes use of an engine to operate.
C The turbocharger makes use of petrol to operate.
D The turbocharger makes use of exhaust gases (waste) to operate. (1)

1.20 What type of supercharger is shown in FIGURE 1.9?

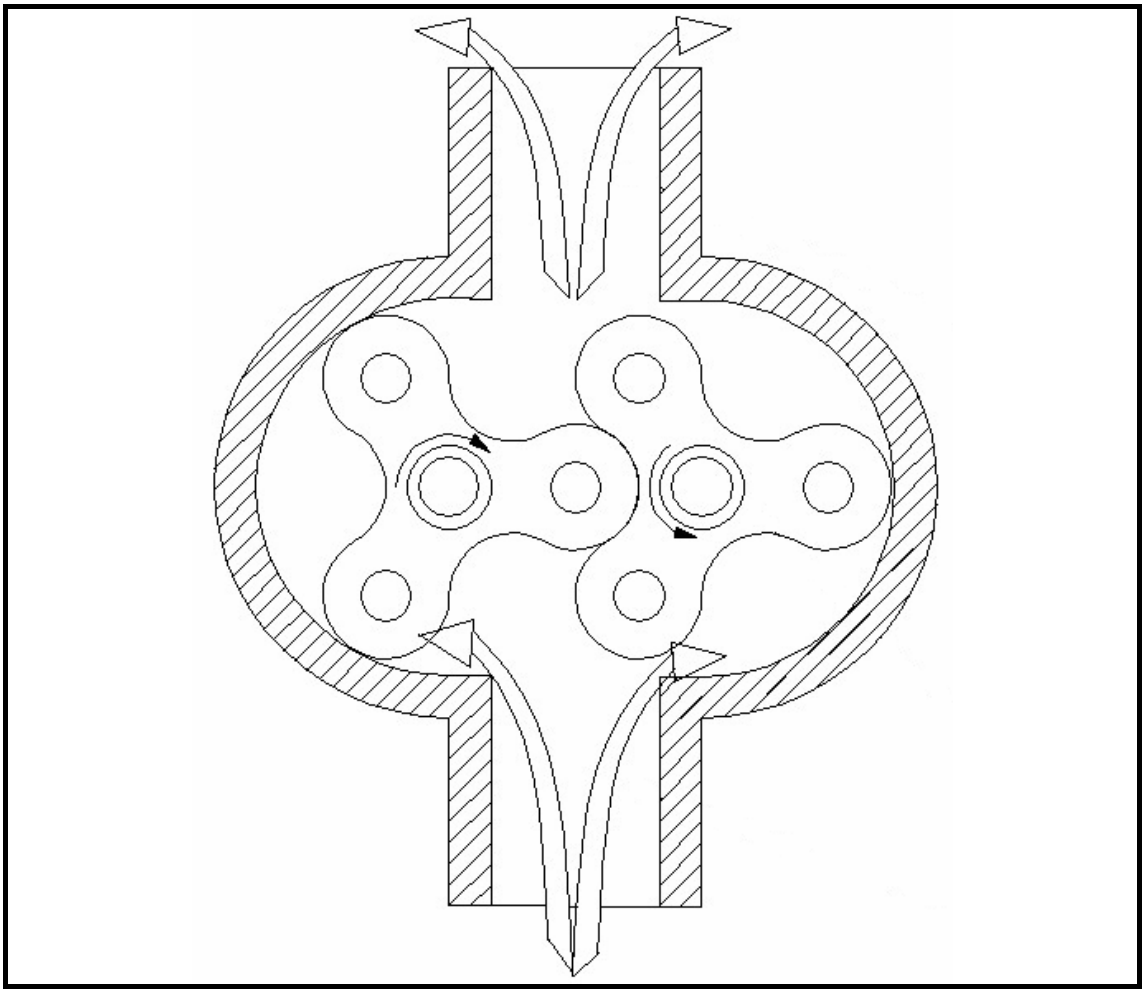


FIGURE 1.9

A Roots supercharger
B Vane supercharger
C Centrifugal supercharger
D Plunger supercharger (1)

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

2.1 Peter was instructed to use a mild steel pin to remove a bush from the yoke using a hydraulic press. The drawing of the pin, shown in FIGURE 2.1, indicates a load of 100 kN that causes a stress of 204 MPa.

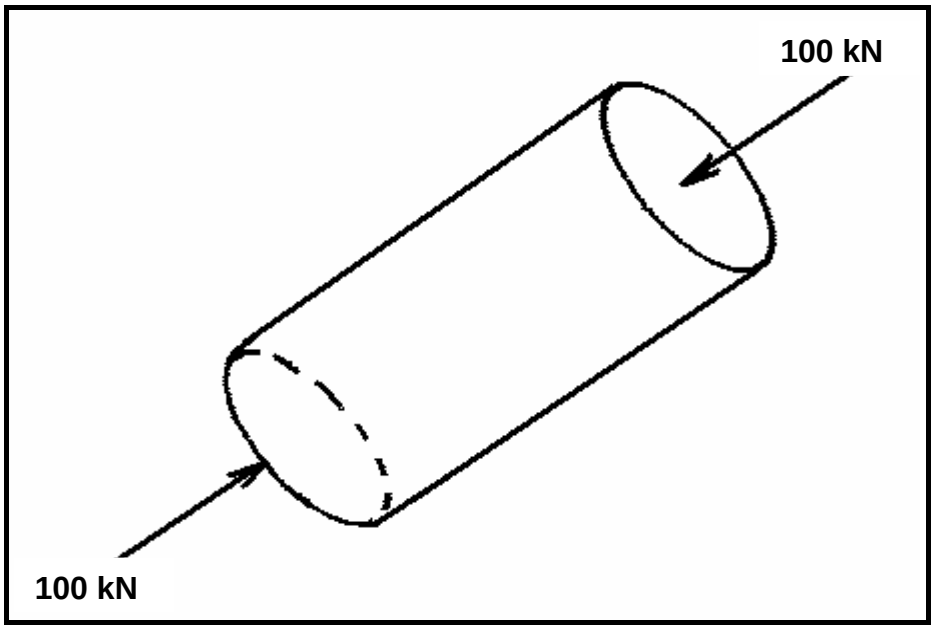


FIGURE 2.1

2.1.1 Calculate the diameter of the pin in millimetres. (6)

2.1.2 Calculate the strain induced in the pin if Young's modulus of elasticity is 210 GPa. (3)

2.1.3 Calculate the change in the length of the pin if the original length is 110 mm. (3)

2.1.4 What type of stress is induced in the pin? (1)

2.1.5 What effect will the above load have on the pin? Calculate the new length if a load of 100 kN is applied on the pin. (3)

2.1.6 If the pin had been made of brass, what effect will this have on the length of the pin with reference to Young's modulus of elasticity compared to the mild steel pin? (HINT: The value of Young's modulus for brass is lower than that of mild steel.) (2)

2.2 A mechanical engineer is requested to design a flat belt drive system to transport coal from the mine to the plant as shown in FIGURE 2.2. The specifications for the flat belt drive are as follows:

Thickness of belt = 5 mm
Width of belt = 280 mm
Diameter of pulley = 340 mm
Speed of pulley = 2 000 r/min
Density of belt material = 1,0 Mg/m^3

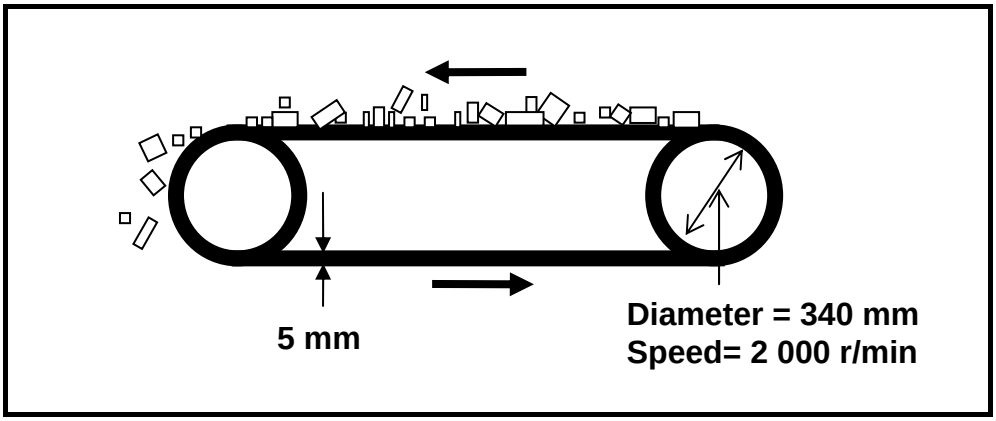


FIGURE 2.2

2.2.1 Calculate the mass of the belt in kilogram per metre (kg/m). (3)

2.2.2 Calculate the belt speed taking the thickness into consideration. (3)

2.2.3 Calculate the required power to drive the belt system if the effective tensile force is 400 N. Ignore the mass of the belt and its friction. (4)

2.2.4 What impact will the thickness have on the speed of the pulley? Give reasons for your answer. (2)

2.3 Mrs Ntuli has an irrigation system that uses a single-plate friction clutch to transmit power from an engine to a pump with an effective diameter of 0,2 m, as shown in FIGURE 2.3. The clutch plate has friction material on both sides with a friction coefficient of 0,35. The total applied force on the pressure plate is 3,4 kN.

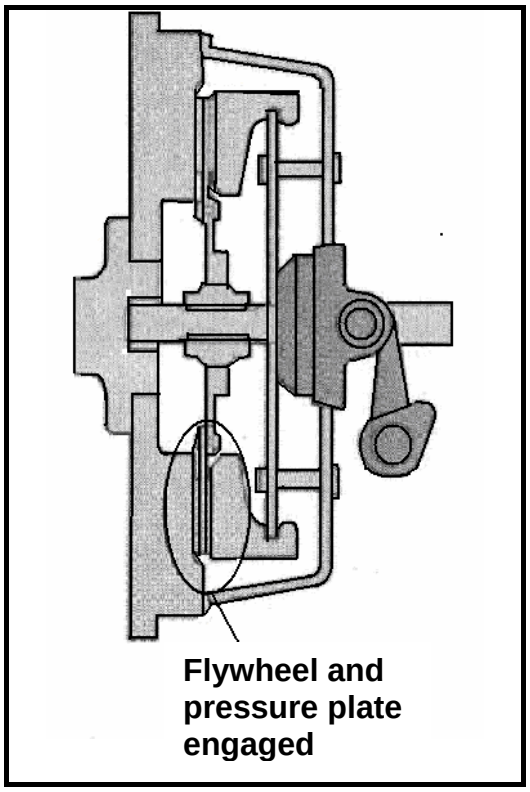


FIGURE 2.3

2.3.1 Calculate the maximum torque applied. (2)

2.3.2 Calculate power transmitted at 3 200 r/min in kW. (3)

2.4 Ms Brij requires a hydraulic press to be purchased for her new engineering workshop. The force applied on Piston A is 550 N. Piston A moves 60 mm downwards. The diameter of Piston B is 180 mm and moves up by 12 mm.

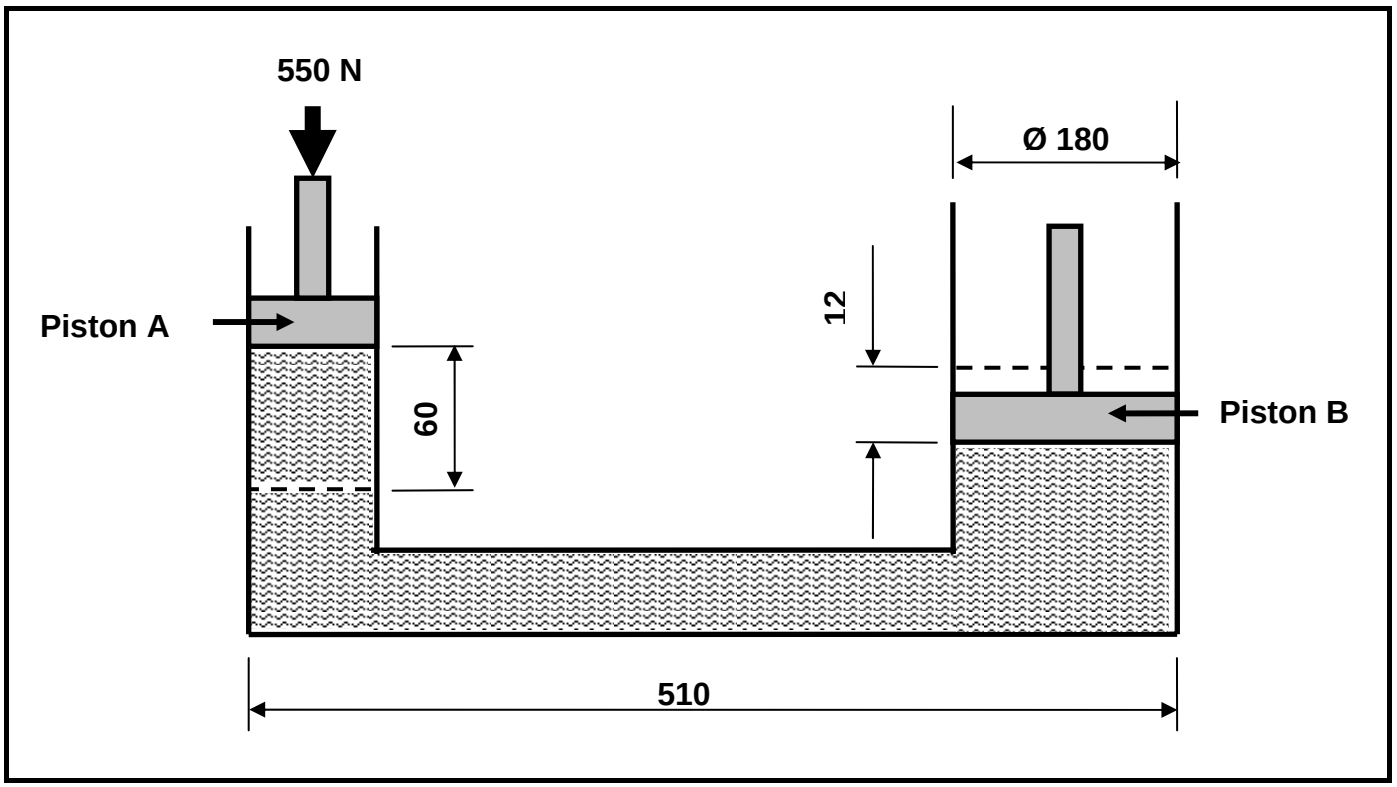


FIGURE 2.4

Use the specifications shown in FIGURE 2.4 and calculate the following:

2.4.1 The diameter of piston A. HINT: $V_A = V_B$ (9)

2.4.2 The pressure exerted on piston A (2)

2.4.3 The force exerted on piston B (4)
[50]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Kobus uses the MAGS/MIGS welding machine to weld a stainless steel pot as shown in FIGURE 3.1. Label (from 1 to 7) the figure.

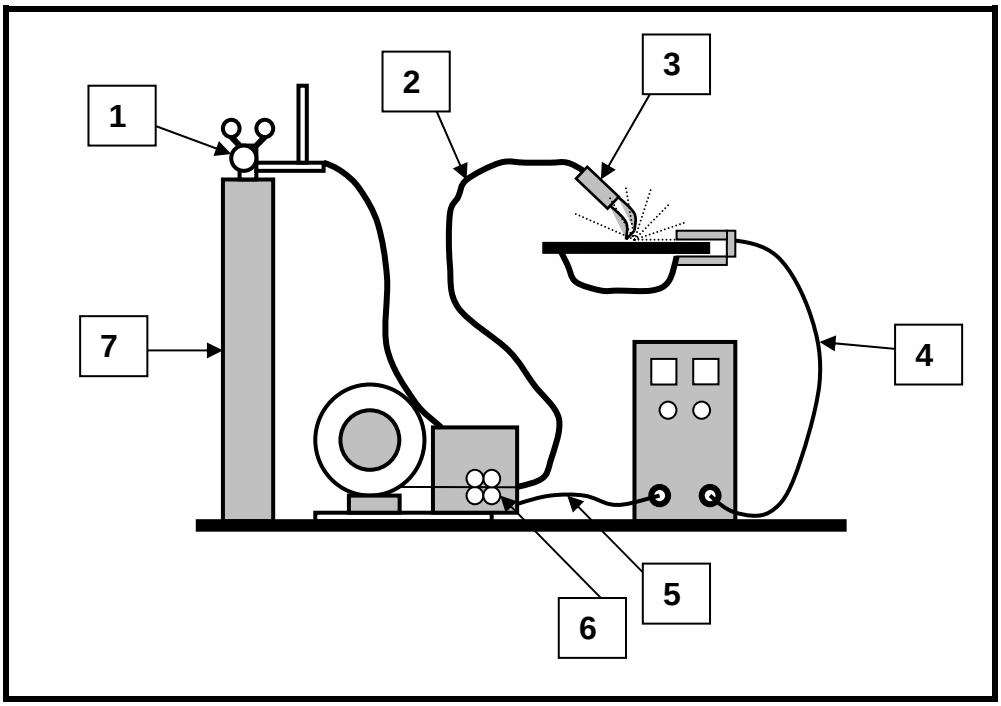


FIGURE 3.1 (7)

3.2 What does the abbreviation *MAGS/MIGS* stand for in terms of welding equipment? (1)

3.3 Name TWO gases that can be used in MAGS/MIGS welding. (2)

3.4 Bongani drives a car to school and back covering a distance of 21 km per day. He has discovered that the speed of his car has reduced drastically. You are instructed to carry out a dry compression test on his car to check if the compression is within specifications. Compare the different causes of pressure drop during a compression test in relation to how leakages can be traced. (10)

[20]

QUESTION 4: MATERIALS

4.1 Define the following terms as applicable to engineering materials:

4.1.1 Non-ferrous alloys (2)

4.1.2 Composites (2)

4.2 You are a designer and are required to use various engineering materials in your projects. In tabulated form compare TWO properties and TWO uses of the following engineering materials:

4.2.1 White metal (4)

4.2.2 Vanadium (4)

4.2.3 Nylon (4)

4.3 Some door hinges are made of mild steel while others are fabricated from brass. Mild steel has a lower density than brass and it is cheaper. Why would you rather choose brass than mild steel if you were to build a house? (4)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

5.1 Jan has to turn a stepped shaft using a centre lathe. He needs to adhere to certain safety measures. State FIVE safety measures that Jan has to adhere to when using the centre lathe. (5)

5.2 You are given a task by your supervisor to use the MAGS/MIGS welding machine to weld mild steel sheets. List FOUR precautions you would take when welding using the MAGS/MIGS welding machine. (4)

5.3 Sipho has to use various milling cutters to make a gearbox casing. Help him to identify the various cutters shown below:

5.3.1

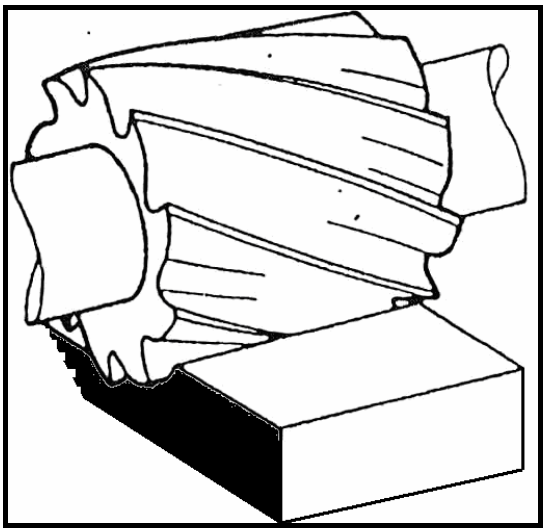


FIGURE 5.1 (1)

5.3.2

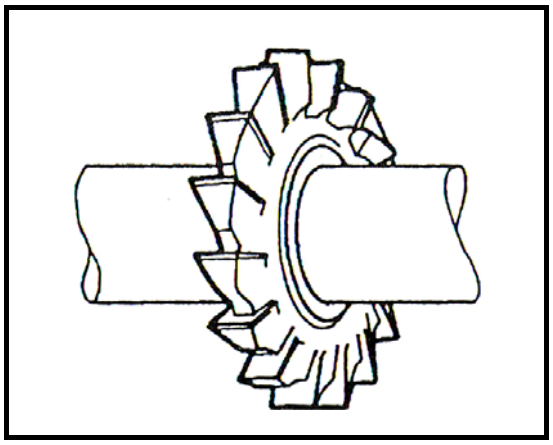


FIGURE 5.2 (1)

5.3.3

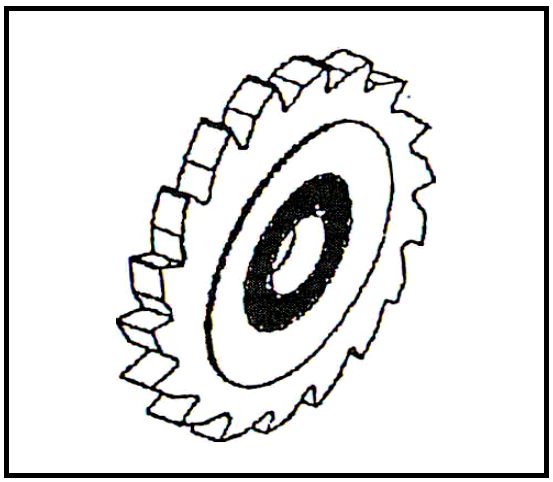


FIGURE 5.3 (1)

5.3.4

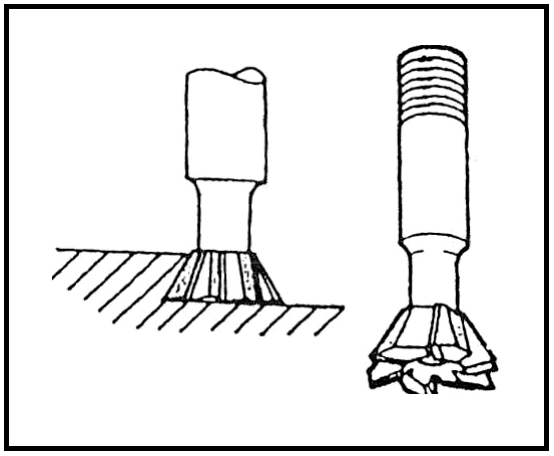


FIGURE 5.4 (1)

5.3.5

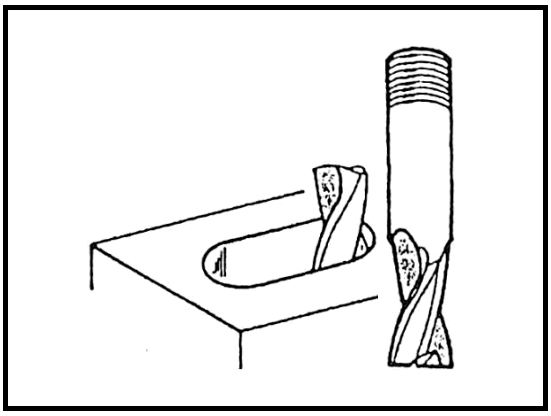


FIGURE 5.5 (1)

5.4 Shaamez is a car rental owner and he is having a problem with the gearbox of one of his cars. When the mechanics strip the gearbox it is found that one of the gears is broken. You are instructed to manufacture the gear for him. The gear has 87 teeth.

5.4.1 Calculate the indexing. (HINT: Use 86 divisions.) (3)

5.4.2 Calculate the change gears for the dividing head. (6)

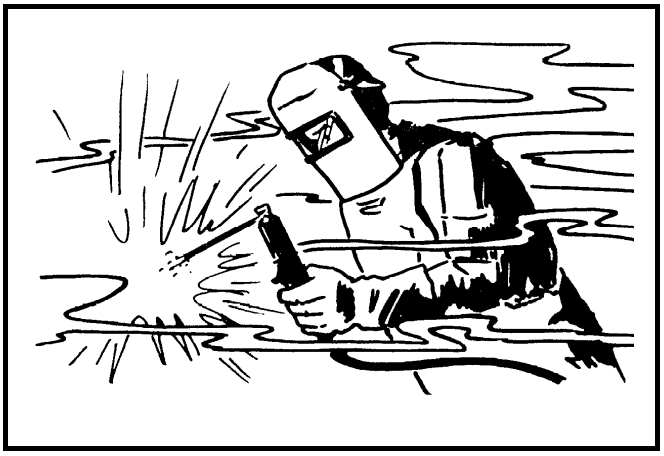
5.4.3 What is the meaning of the positive (+) sign or the negative (-) sign for the change gears? (4)

5.5 Nick needs to set up the milling machine. The diameter of the cutter is 80 mm with 16 teeth operating at a cutting speed of 25 metres per minute and a feed of 0,04 mm per tooth. Calculate the feed in millimetres per minute. (6)

5.6 Bruce, a quality controller, received a welded joint for examination/inspection. He makes use of a liquid dye penetrant test to determine whether the weld has any defects. Explain the procedure to be followed. (6)

5.7 Give TWO reasons why destructive tests are carried out on welded joints. (2)

5.8 WELDING:



Mpilo is a welding instructor. He illustrates to his learners the types of defects found in weldments. Specify THREE possible weld defects that can occur in welded joints and state ONE cause of and ONE remedy for each defect. (9)

[50]

QUESTION 6: MAINTENANCE AND TURBINES

6.1 Describe in detail the effectiveness of cutting fluid as compared to oil when turning a work piece on a centre lathe. (4)

6.2 Explain what is understood by the term *corrosion and rust resistance* of oil. (2)

6.3 Describe what will happen if the engine oil in a vehicle is not changed regularly. (3)

6.4 Mrs Khoza owns a fleet of city shuttles. At regular intervals she requires the differential oil to be replaced. Explain how you would drain and replace the differential oil. (11)

6.5 A friend of yours has decided to increase his car's engine output by fitting a blower. FIGURE 6.1 shows the type of blower that he would like to use.

Answer the questions that follow.

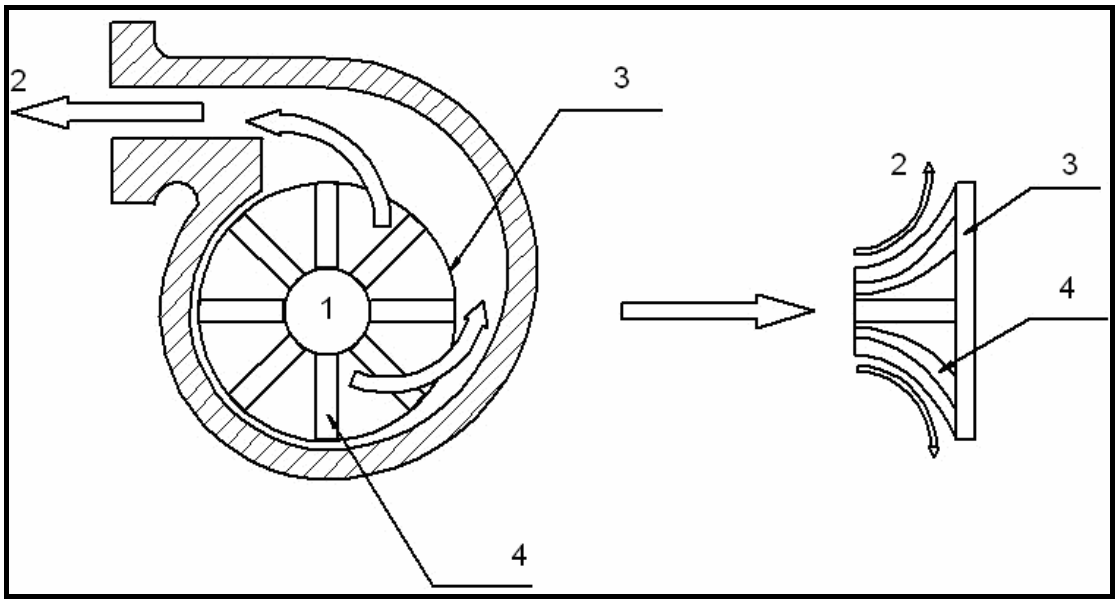


FIGURE 6.1

6.5.1 Identify the type of blower illustrated in FIGURE 6.1. (1)

6.5.2 Name the labels numbered 1 to 4. (4)

6.5.3 State THREE advantages of the use of the above blower. (3)

6.6 State TWO purposes of a supercharger. (2)

6.7 Name TWO examples of where a supercharger is used. (2)

6.8 Turbochargers are used in heavy vehicles to increase the engine power output. Explain the principle of operation of the turbocharger. (8)
[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 $Belt\ mass = Area \times length \times density$ $(A = thickness \times width)$

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 $Pitch\ diameter = Outside\ diamter - ½pitch$

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

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

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

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 of cutter per minute*

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

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

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