education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2008

MARKS: 200

TIME: 3 hours

This question paper consists of 21 pages and a 4-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. Write neatly and legibly.
5. A formula sheet is attached to this paper.
6. Show ALL calculations and units. Round answers off to TWO decimal places.
7. Candidates may use non-programmable scientific calculators and drawing instruments.
8. The value of the gravitational force should be taken as 10 m/s^2.
9. Use the criteria below to assist you in managing your time.

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

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 1 – 9)

Various possible options are provided as 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 safety measure is NOT applicable to shearing machines in terms of the Occupational Health and Safety Act?

A Make sure that the blades are tightened properly.
B Make sure that the blades run parallel to one another.
C Cut or punch mild steel only.
D Use the shearing bed as an anvil. (1)

1.2 Which ONE of the following equipment do we use to test the compression of an internal combustion engine?

A Torsion tester
B Brinell tester
C Pressure tester
D Tensile tester (1)

1.3 Identify the engineering equipment shown in FIGURE 1.1.

FIGURE 1.1

A Gas analyser
B Spring tester
C Dial tester
D Multimeter (1)

1.4 Which ONE of the following statements is a safety measure when using arc-welding equipment?

A Use gloves to carry hot metal.
B Open the gas cylinder valves quickly.
C Allow for oxygen and acetylene leaks.
D Keep oil, dirt and foreign matter away from the valves. (1)

1.5 Solder is an alloy of …

A lead and tin.
B copper and zinc.
C copper and tin.
D copper and lead. (1)

1.6 What is the common use of Teflon?

A Forgings
B Fan blades
C Bearings
D Valves (1)

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

FIGURE 1.2

A Slotting cutter
B Side and face cutter
C Nicked helical cutter
D T-slot cutter (1)

1.8 What does the symbol in FIGURE 1.3, relating to a pneumatic system, indicate?

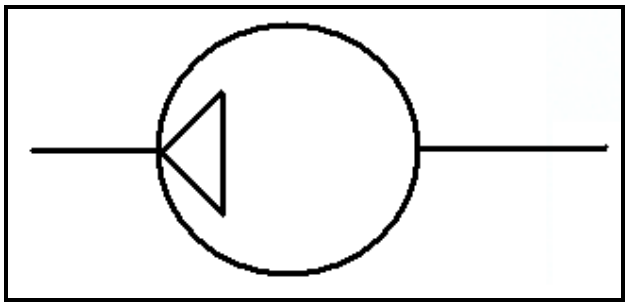


FIGURE 1.3

A Valve
B Filter
C Compressor
D Motor (1)

1.9 What is understood by the term *nick-break test*?

A Breaking the weld open for examination of external defects
B Breaking the weld open for examination of internal defects
C Checking of a shear fracture of a weld
D Checking the high-frequency sound effect of a weld (1)

1.10 Ultrasonic inspection uses high-frequency sound waves to detect different defects as …

A cracks that show up as an echo blip on the screen.
B cracks that show up on the plasma arc.
C cracks that show up as surface defects.
D cracks that show up on the film. (1)

1.11 The definition for the term *undercutting* which may occur during the welding process:

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

1.12 What will the stress in a 12 mm x 20 mm rectangular bar be, as shown in FIGURE 1.4, if a load of 80 N is applied to the bar?

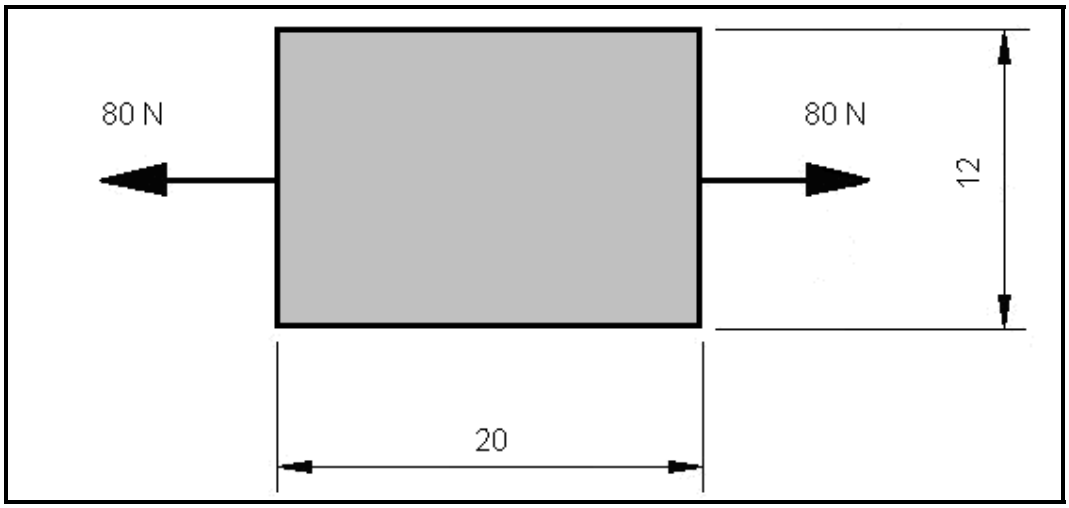


FIGURE 1.4

A 33,30 MPa
B 2,471 MPa
C 347,33kPa
D 333,33 kPa (1)

1.13 What type of stress is acting on the bolt of the knuckle joint shown in FIGURE 1.5?

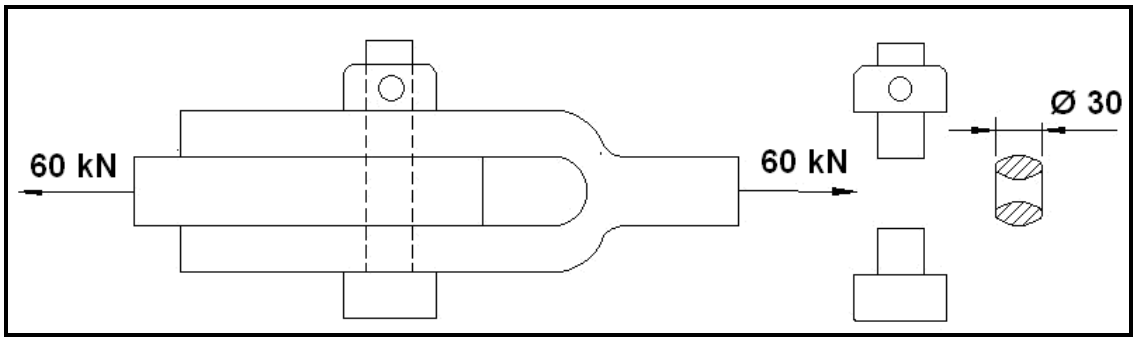


FIGURE 1.5

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

1.14 What does point A denote in the stress/strain diagram shown in FIGURE 1.6?

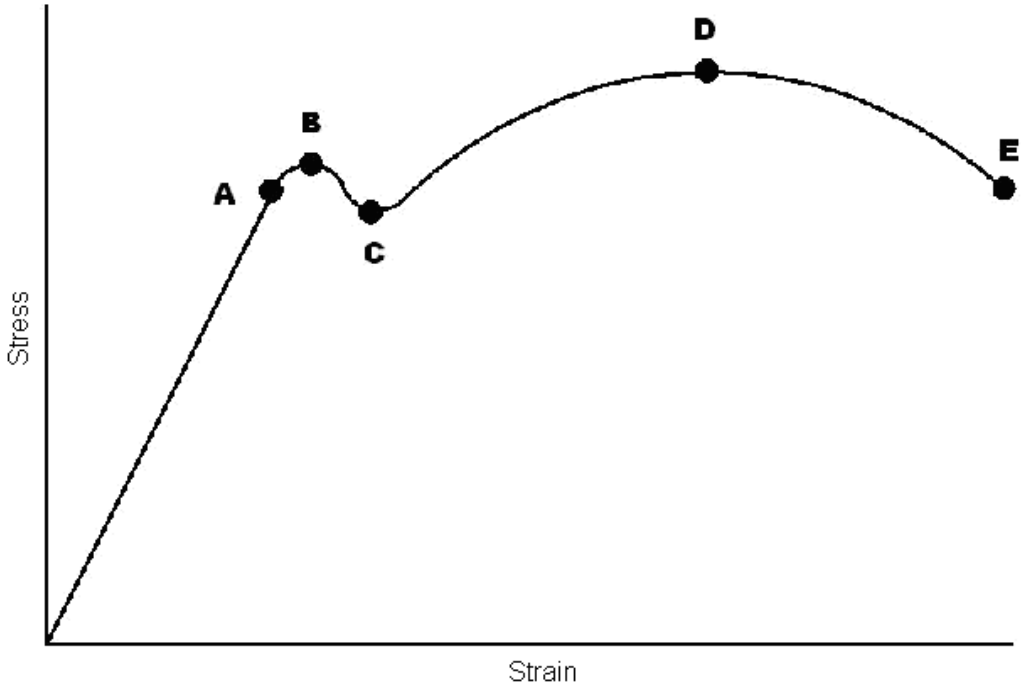


FIGURE 1.6

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

1.15 Which one of the following descriptions does NOT indicate the desired property of a cutting fluid?

A Acts as a lubricant
B Keeps the cutting tool cool
C Gives the cutting tool a longer life span
D Causes the machine to rust (1)

1.16 What is understood by the term *viscosity*?

A Measure of the resistance of a fluid to deform under linear stress
B Measure of the resistance of a fluid to deform under tensile stress
C Measure of the resistance of a fluid to deform under shear stress
D Measure of the resistance of a fluid to deform under compressive stress (1)

1.17 What is the velocity ratio of the pulley system shown in FIGURE 1.7 if pulley A is the driver?

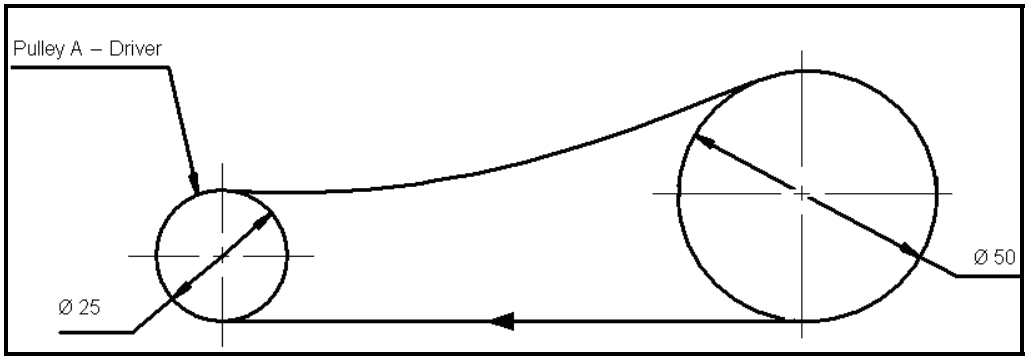


FIGURE 1.7

A 1:1
B 1:2
C 3:1
D 2:1 (1)

1.18 A simple gear train is shown in FIGURE 1.8. Driver gear A has 20 teeth rotating in a clockwise direction. When gear A is rotated 10 times, gear B rotates 5 times. How many teeth does gear B have and in which direction does it rotate?

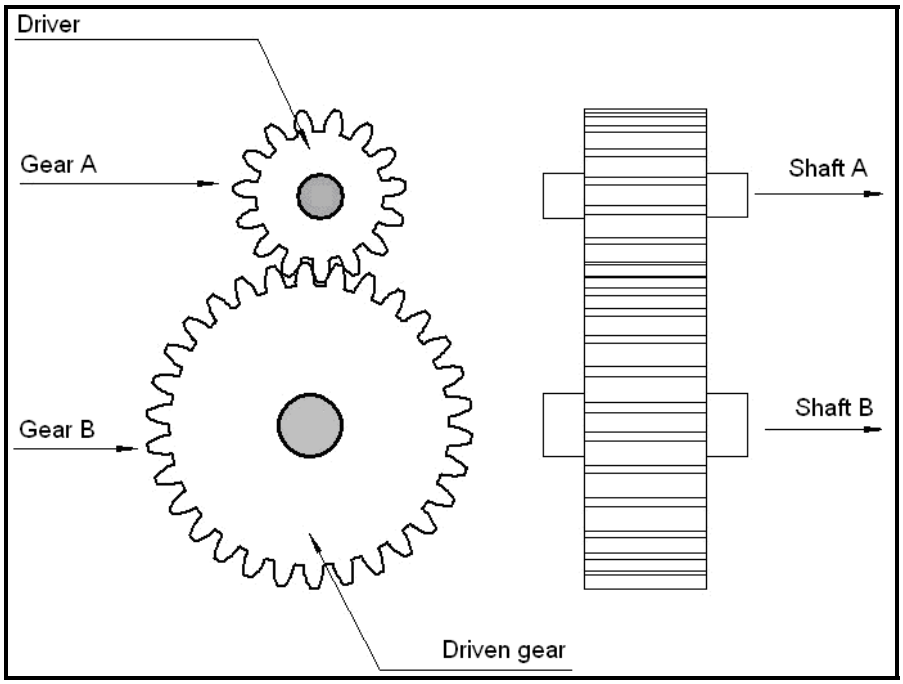


FIGURE 1.8

A 30 teeth rotating in a clockwise direction
B 10 teeth rotating in an anti-clockwise direction
C 40 teeth rotating in a clockwise direction
D 40 teeth rotating in an anti-clockwise direction (1)

1.19 What is the advantage of the turbocharger over the supercharger? The turbocharger ...

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

1.20 What type of a supercharger is shown in FIGURE 1.9?

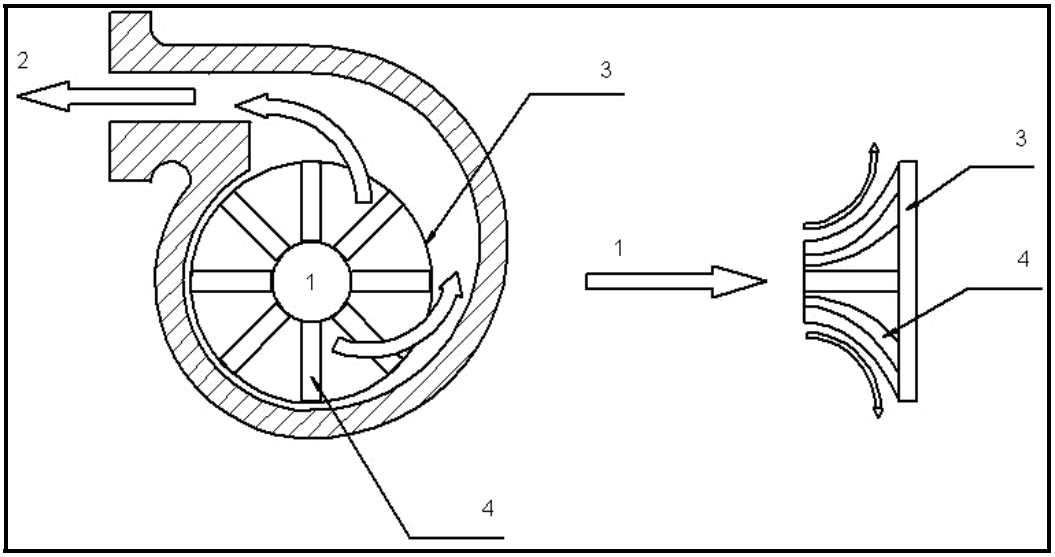


FIGURE 1.9

A Centrifugal supercharger
B Vane supercharger
C Rotor supercharger
D Plunger pump (1)

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 6 AND 8)

2.1 A mechanical engineer is required to design a compound gear train for a tool-making machine as shown in FIGURE 2.1. The input shaft is dissipating 5 kW at 840 r/min. The customer requires the torque to be 200 Nm at 200 r/min.

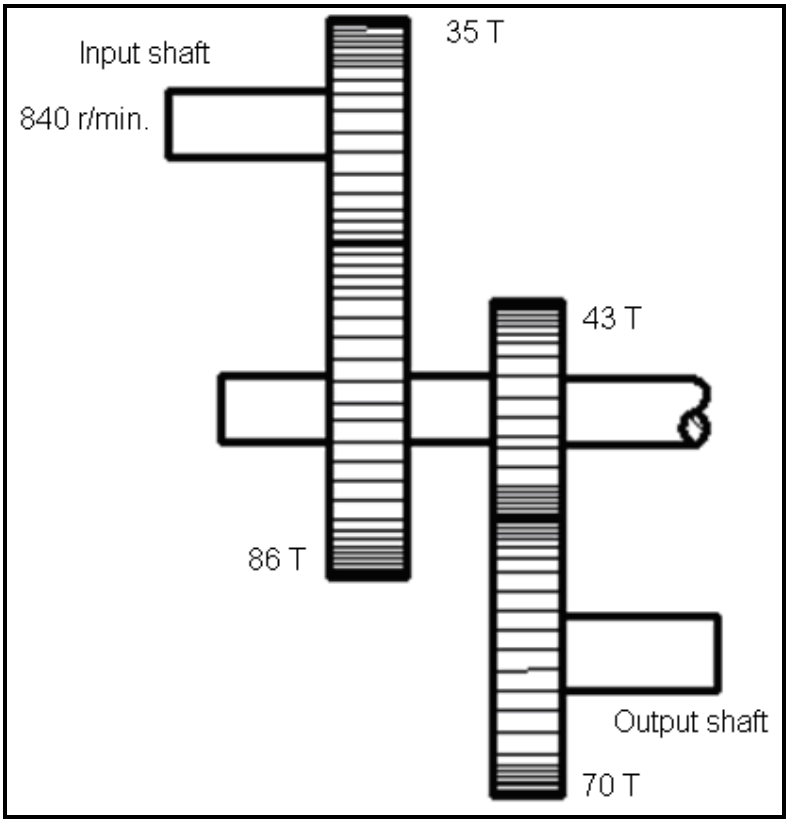


FIGURE 2.1

2.1.1 Calculate the gear ratio. (2)

2.1.2 Calculate the output speed of the output shaft. (2)

2.1.3 Calculate the actual torque of the output shaft. (2)

2.1.4 Is this compound gear train suitable to meet the requirements set by the customer? Explain your answer. (2)

2.2 The Agricultural Science learners in your school are given the task to prepare an area to plant carrots. Sipho uses the wheelbarrow to transport 100 kg of manure from the storeroom to this area. The load is positioned 0,5 m from the centre of the wheelbarrow wheel (fulcrum). The total distance of the centre of the wheel to the end of the handle (effort) is 1,5 m, as illustrated in FIGURE 2.2.

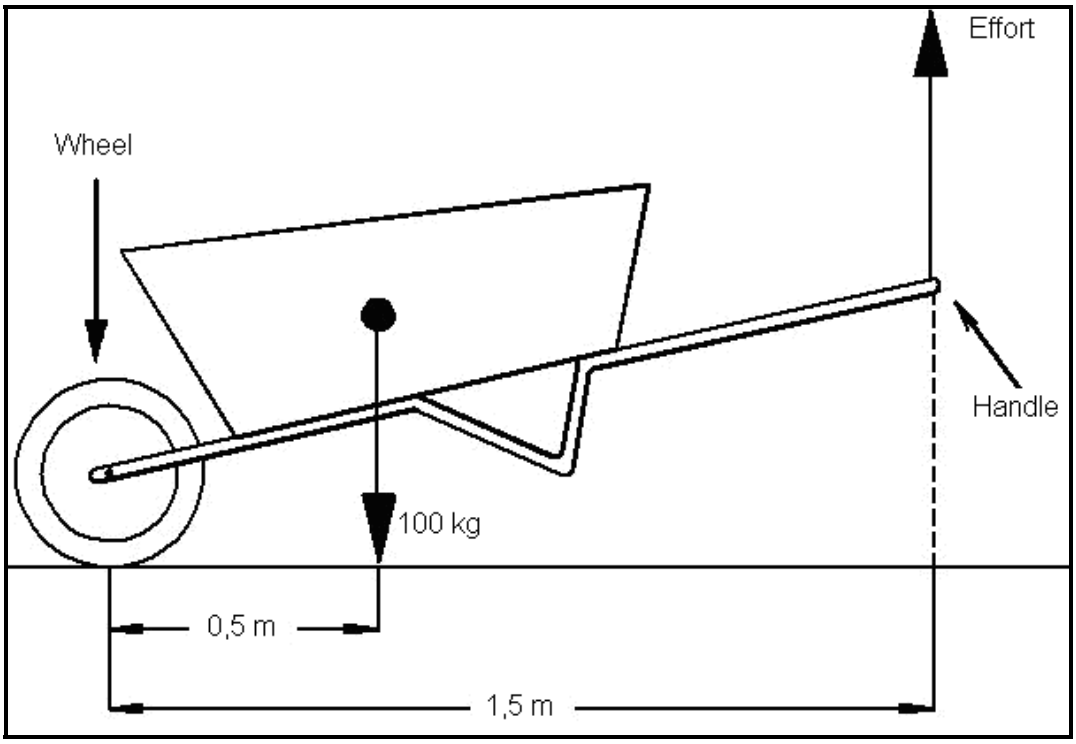


FIGURE 2.2

2.2.1 Calculate the effort to lift the handle of the wheelbarrow. (4)

2.2.2 Calculate the mechanical advantage (MA). (2)

2.2.3 Calculate the work done by the effort if the handle is lifted 200 mm. (2)

2.2.4 Calculate the power required if the work is done in 3 seconds. (2)

2.2.5 What is your opinion regarding the efficiency/advantage of using a wheelbarrow? (3)

2.3 During the planting season a farmer experienced a problem with his plough. The stepped pin holding the blade to the frame was broken. He requires a new pin that can carry a load of 150 kN. You have decided to design a stepped pin made of brass with dimensions as shown in FIGURE 2.3.

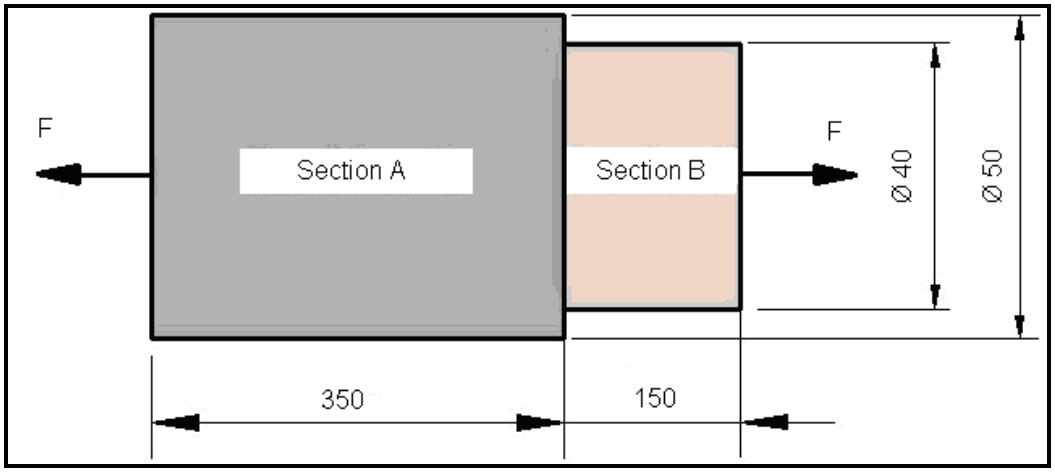


FIGURE 2.3

2.3.1 Calculate the total original length of the stepped pin. (2)

2.3.2 Calculate the stress in Section A and in Section B caused by a 150 kN load. (6)

2.3.3 Calculate the strain induced in Section A and in Section B. Take Young's Modulus of Elasticity for brass as 80 GPa. (2)

2.3.4 Calculate the total final length of the pin after the load was applied to it. (5)

2.3.5 Explain what the influence regarding the strain in the pin would have been if the pin was made of mild steel with Young's Modulus of Elasticity as 204 GPa. (2)

2.4 Ms Siyabonga requires a hydraulic press to be designed for her new engineering workshop. Use the specifications given in FIGURE 2.4 to design the hydraulic press. The force applied on piston A is 600 N. Piston A moves 65 mm downwards. The diameters of pistons A and B are 70 mm and 200 mm respectively.

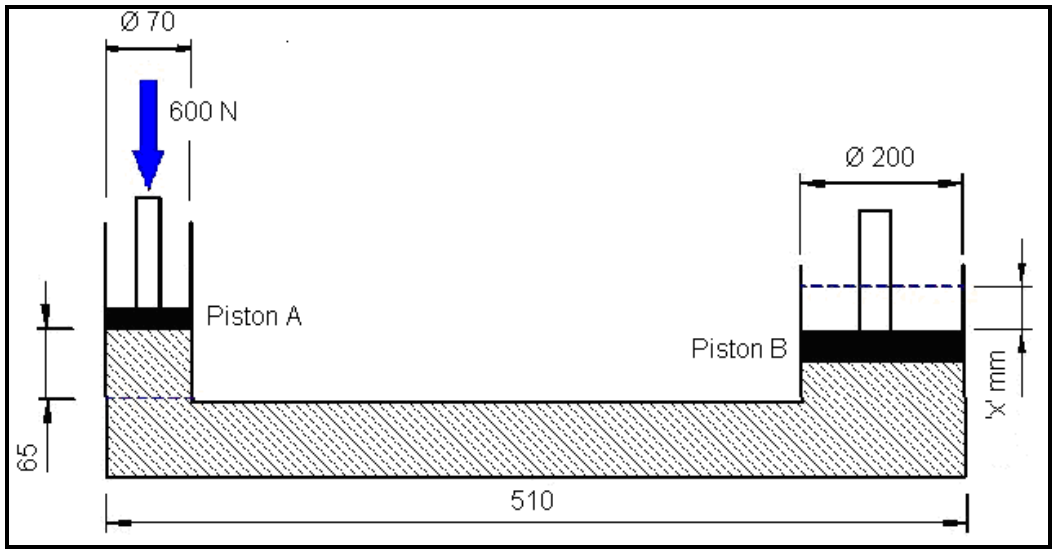


FIGURE 2.4

2.4.1 Calculate the pressure applied to piston A. (3)

2.4.2 Calculate the distance 'x' that piston B moves upwards in millimetres. (4)

2.4.3 If the length (510 mm) of the press is doubled, what effect will it have on the distance 'x'? Substantiate your answer. (3)

2.4.4 Give other examples where this type of layout is used. (2)
[50]

QUESTION 3: TOOLS AND EQUIPMENT

(LEARNING OUTCOME 3: ASSESSMENT STANDARD 2)

3.1 Princess uses the Brinell hardness tester to test the hardness of a specimen given to her by the supervisor. FIGURE 3.1 shows a specimen under test. Label the parts numbered 1 to 4.

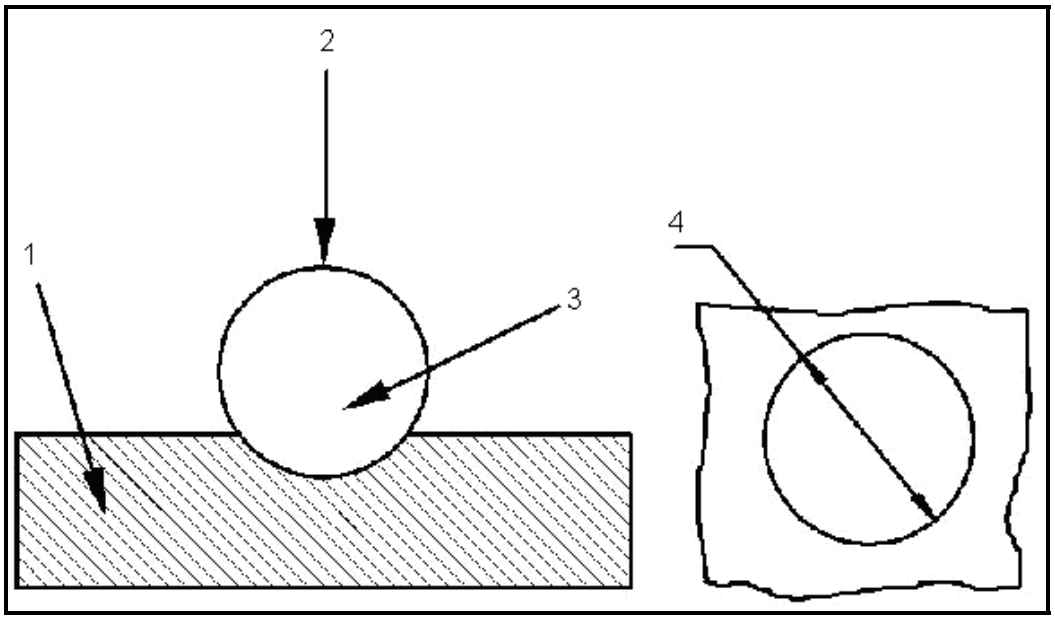


FIGURE 3.1 (4)

3.2 Ms Bonga has a fifteen-seater minibus, which she uses daily to transport learners to school and back. Recently she found that the power of the vehicle had decreased.

Compare the different causes of pressure drop during a compression test in relation to how these leakages could be traced. Tabulate your answers. (10)

3.3 Compare the differences between the *pressure tester* and the *cylinder leakage tester*. (6)
[20]

QUESTION 4: MATERIALS

(LEARNING OUTCOME 3: ASSESSMENT STANDARD 3)

4.1 Non-ferrous alloys are used broadly in industry today for manufacturing various components due to their composition and properties.

Define a *non-ferrous alloy*. (2)

4.2 You are a designer and it is required of you to use various alloys in your projects.

Compare the compositions, properties and uses of the following non-ferrous alloys by completing the table.

	Non-ferrous alloy	Composition	Properties	Uses
4.2.1	Aluminium bronze			
4.2.2	Duralumin			
4.2.3	Carbon fibre			

(3)
(3)
(3)

4.3 Industries make use of nylon as a substitute for steel and non-ferrous alloy materials because of its properties.

State THREE of these properties (3)

4.4 Polyvinyl chloride (PVC) is used mainly in the building industry.

State THREE properties of PVC as a material. (3)

4.5 Teflon can be used in various ways as a replacement for steel.

Give THREE examples where Teflon is used as a material. (3)

[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 1, 4 AND 5)

5.1 Willy has to fit a bearing on a shaft using a hydraulic press. State THREE safety measures that Willy has to observe when using the machine. (3)

5.2 You are given a task by your supervisor to arc weld a burglar gate.

State THREE precautions that a welder needs to take into account when using the arc-welding machine. (3)

5.3 You are working for an equipment manufacturing company. A structural manufacturing customer reported that a pin of his overhead crane has sheared. As a machinist you are required to mill a nut for the pin. Which FOUR safety measures are required when using the milling machine? (4)

5.4 Lindiwe was given a welded joint for testing, using ultrasonic waves. FIGURE 5.1 shows an ultrasonic wave test.

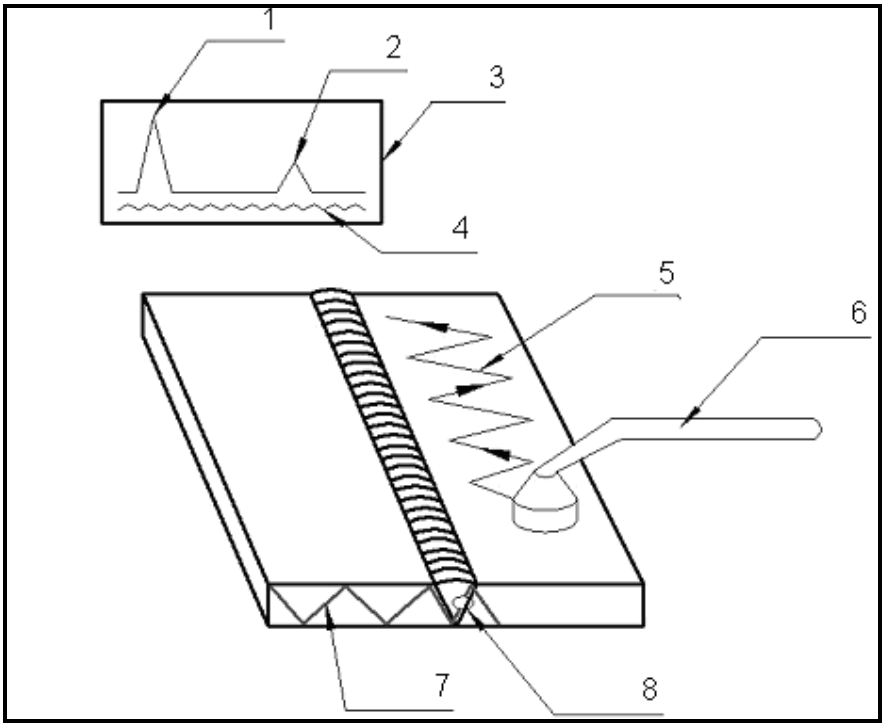


FIGURE 5.1

Label the components numbered 1 to 8. (8)

5.5 Mpilo is a welding instructor. He illustrates to the learners the different types of welding defects found in welding joints and how they appear in a radiograph (x-ray testing). FIGURES 5.2 to 5.5 show the weld defects that occurred during the welding process.

Identify, interpret (at least ONE cause in each case) and evaluate (suggest ONE correction method in each case) of the weld defects shown in the figures. Tabulate your answers.

5.5.1

FIGURE 5.2 (3)

5.5.2

FIGURE 5.3 (3)

5.5.3

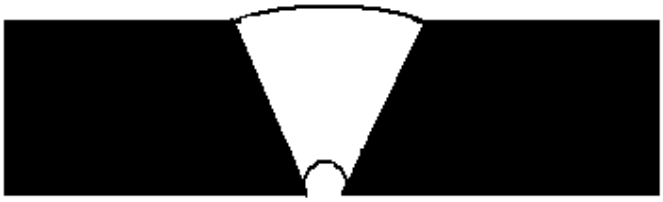


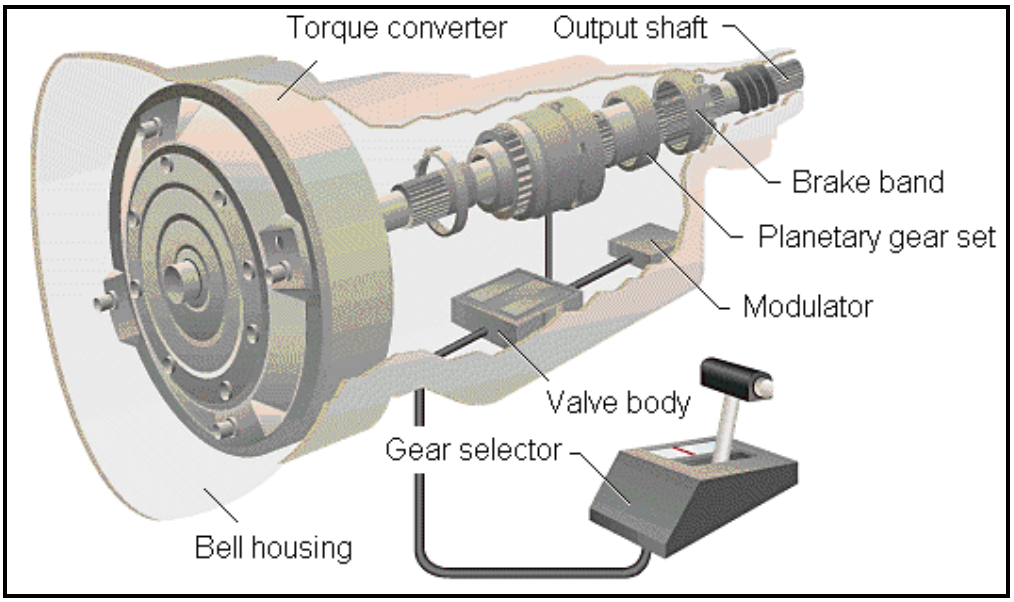
FIGURE 5.4 (3)

5.5.4

FIGURE 5.5 (3)

5.6 Jacko needs to set up the milling machine. The diameter of the cutter is 100 mm with 18 teeth operating at a cutting speed of 40 metres per minute and a feed of 0,06 mm per tooth. Calculate the feed in millimetres per minute. (5)

5.7 **Gear cutting**



Manuel is a taxi owner and he has a problem with the taxi's gearbox. When the mechanics stripped the gearbox they found that one of the gears was broken. You are required to manufacture a replacement gear. The gear has 103 teeth.

5.7.1 Calculate the simple indexing. (Hint: Use 100 divisions for the simple indexing.) (3)

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

5.7.3 What is the meaning of the '+' or '-' signs for the change gears? (6)
[50]

QUESTION 6: MAINTENANCE AND TURBINES

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 7 AND 9)

6.1 Lubrication is very important in the lifespan of an engine. It is used to obtain maximum life and endurance of a machine.

List FOUR needs that lubricating oil must fulfil. (4)

6.2 Explain what you understand by the term *pour point* of oil. (2)

6.3 You are instructed to machine a work piece using the milling machine. One of the requirements is that you use a cutting fluid to ensure that the sharpness of the cutting tool is maintained.

Give FOUR other reasons for using a cutting fluid. (4)

6.4 Mr Venter owns a fleet of city shuttles. It is required to change the clutch regularly. He also requests that during clutch replacements, the gearbox oil should be drained and replaced with the new oil.

Describe the procedure for draining old gearbox oil and filling the gearbox with new oil. (10)

6.5 To increase a vehicle's engine performance output, a blower can be fitted to the engine. Refer to FIGURE 6.1 that shows the type of blower that can be used.

Answer the questions that follow.

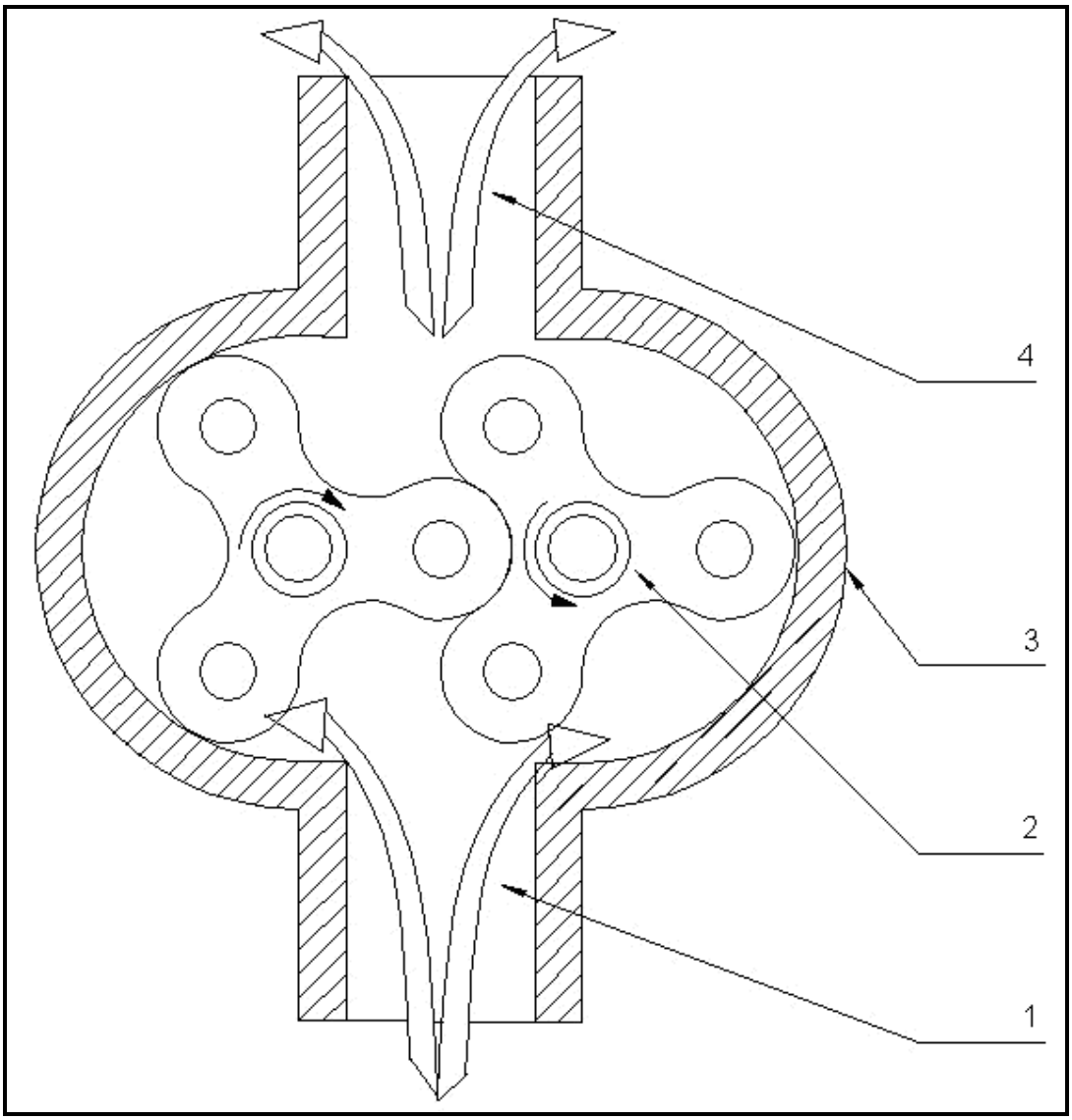


FIGURE 6.1

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

6.5.2 Label the parts numbered 1 to 4. (4)

6.5.3 Explain the operation of the above blower. (5)

6.6 Most of the modern cars make use of superchargers.

Answer the following questions:

6.6.1 State TWO advantages of a supercharger. (2)

6.6.2 State TWO disadvantages of a supercharger. (2)

6.7 Turbochargers are used in heavy vehicles to increase the engine power output. Explain the principle of operation of the turbocharger. (6)
[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 = length x width)*

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

1.5 $Belt\ length\ (flat) = [(D + d) \times 1{,}57] + (2 \times centre\ distance)$

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

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

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

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

4. HYDRAULICS

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

4.2 *Volume = Cross-sectional area x stroke length (l or s)*

4.3 *Work done = force x distance*

5. WHEEL AND AXLE

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

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

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

6. LEVERS

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

6.2 *Input movement (IM) = Effort x distance moved by effort*

6.3 *Output movement (OM) = Load x 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 $Gear\ ratio = \frac{Number\ of\ teeth\ on\ driven\ gear}{Number\ of\ teeth\ on\ driving\ gear}$

7.3 *Torque = Force x Radius*

7.4 *Torque transmitted = gear ratio x input torque*

7.5 $Module\ (m) = \frac{Pitch\text{-}circle\ diameter\ (PCD)}{Number\ of\ teeth\ (T)}$

7.6 $Pitch\text{-}circle\ diameter\ (\ PCD\ ) = \dfrac{circular\ pitch\ (\ CP\ )\ x\ number\ of\ teeth\ (\ T\ )}{\pi}$

7.7 $Outside\ diameter\ (\ OD\ ) = PCD + 2\ module$

7.8 $Addendum\ (\ a\ ) = module\ (\ m\ )$

7.9 $Dedendum\ (\ b\ ) = 1{,}157\ m$

7.10 $Cutting\ depth\ (\ h\ ) = 2{,}157\ m$

7.11 $Clearance\ (\ c\ ) = 0{,}157\ m$

7.12 $Circular\ pitch\ (\ CP\ ) = m\ x\ \pi$

8. SCREW THREADS

8.1 $Pitch\ diameter\ =\ Outside\ diameter\ -\ ½pitch$

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

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

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

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

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

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 $Indexing\ formula = \frac{40}{n}$ *(where n = number of divisions)*

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

or

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

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