basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

MAY/JUNE 2025

MARKS: 200

TIME: 3 hours

This question paper consists of 17 pages and a 6-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Start EACH question on a NEW page.
6. Show ALL calculations and units. Round off final answers to TWO decimal places.
7. Candidates may use non-programmable scientific calculators and drawing instruments.
8. The value of gravitational acceleration could be taken as 9,81 m/s^2 or 10 m/s^2.
9. ALL dimensions are in millimetres, unless stated otherwise in the question.
10. Write neatly and legibly.
11. A formula sheet is attached at the end of the question paper.
12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME IN MINUTES
	GENERIC		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	SPECIFIC		
4	Multiple-choice Questions	14	10
5	Terminology (Lathe and Milling Machine)	18	20
6	Terminology (Indexing)	28	25
7	Tools and Equipment	13	10
8	Forces	33	33
9	Maintenance	18	12
10	Joining Methods	18	12
11	Systems and Control (Drive Systems)	28	28
	TOTAL	**200**	**180**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

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 numbers (1.1 to 1.6) in the ANSWER BOOK, e.g. 1.7 E.

1.1 Which ONE of the following is a safety device on the power-driven guillotine?

A Rear light curtain
B Chuck
C Cutting table
D Blade (1)

1.2 Which statement forms part of the general responsibilities of the employee according to the Occupational Health and Safety (OHS) Act, 1993 (Act 85 of 1993)?

A Eliminate hazards in the workplace.
B Make provision for maintenance at the workplace.
C Report any accidents immediately.
D Inform all employees of their scope of work. (1)

1.3 Which recommendation below is important when applying first aid?

A Cover the wound with an adhesive plaster.
B If necessary, cool wounds with cold water.
C Pull out all sharp objects.
D Do not check for any broken limbs. (1)

1.4 Which test determines the ductility of a metal?

A Sound test
B Hardness test
C X-ray test
D Bending test (1)

1.5 The spark test is useful for testing the … content of many metals.

A magnesium
B carbon
C aluminium
D chrome (1)

1.6 The hardening temperatures used as a rule during the hardening process is … above the critical temperature.

A 10 °C–38 °C
B 10 °C–720 °C
C 10 °C–268 °C
D 10 °C–100 °C (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 State THREE safety precautions to adhere to when using a manual guillotine.

(**NOTE:** ALL PPE and environmental factors have been taken care of.) (3)

2.2 State THREE examination procedures when performing first aid. (3)

2.3 Why must one always leave the acetylene cylinder spindle key on the cylinder valve when working? (1)

2.4 State whether EACH of the following is a result of product layout or process layout:

2.4.1 Machines are grouped according to their type of operation (1)

2.4.2 Greater flexibility during manufacturing (1)

2.4.3 Handling of material is limited to a minimum (1)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 State the THREE factors that affect the hardness of steel during the heat-treatment process. (3)

3.2 State if EACH of the following materials is easy or difficult to cut during a machining test:

3.2.1 Cast iron (1)

3.2.2 Cast steel (1)

3.2.3 Mild steel (1)

3.3 Give ONE reason why steel is annealed during the heat-treatment process. (1)

3.4 Complete the following definition for normalising by filling in the missing words. Write only the words next to the question numbers (3.4.1 to 3.4.4) in the ANSWER BOOK.

The process of normalising is when an iron base alloy or steel is heated to approximately 56 °C (3.4.1) ... the critical temperature, (3.4.2) … the metal until it is uniformly heated, followed by (3.4.3) … it down to (3.4.4) … temperature in still air, away from draughts. (4)

3.5 Why must steel be cooled rapidly during the hardening process? (1)

3.6 State TWO manufacturing processes that cause internal stress in steel. (2)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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 numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

4.1 Identify the lathe component **A** shown in FIGURE 4.1 below.

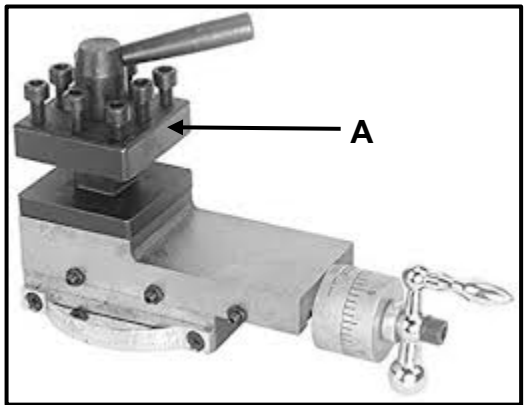


FIGURE 4.1

A Cross slide
B Dial gauge
C Tool post/Tool holder
D Chuck (1)

4.2 Which ONE of the following safety measures is to be taken into consideration when the lathe is running?

A Do not lean on the machine.
B Remove shavings with your hands.
C Stop work piece by hand.
D Adjust the chuck. (1)

4.3 A CNC milling machine … the data which processes it and calculates the movement.

A deletes
B understands
C moves
D corrupts (1)

4.4 In absolute cutter compensation, … stand alone during the programming of a CNC machine.

A individual points
B deleted diameters
C errors
D tools (1)

4.5 Which type of material is used to make the ball indenter of a Rockwell Hardness tester?

A Hardened brass
B Solid graphite
C Soft copper
D Hardened steel (1)

4.6 Identify the type of tester shown in FIGURE 4.6 below.

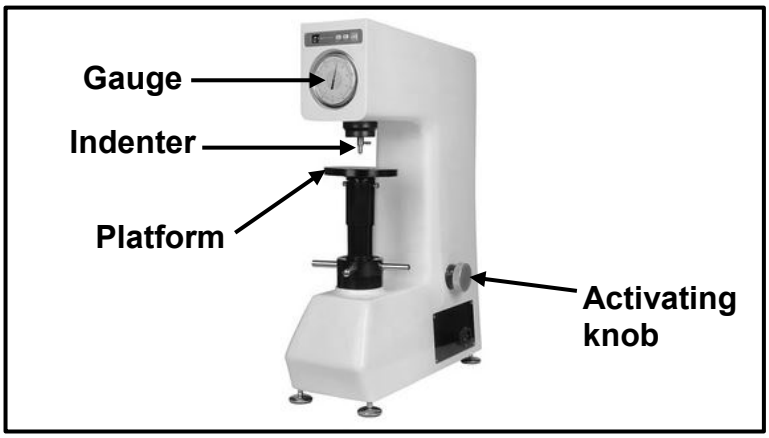


FIGURE 4.6

A Tensile tester
B Moment tester
C Hardness tester
D Force tester (1)

4.7 The equilibrant of a system of forces has the same … as the resultant.

A direction
B coefficient
C magnitude
D effect (1)

4.8 Safe stress is the allowable stress in a material to prevent it from …

A yielding.
B welding.
C being cut.
D being scratched. (1)

4.9 Which ONE of the following materials is non-toxic and best suited for recycling?

A Fibreglass
B Nylon
C Graphite
D Bakelite (1)

4.10 Which ONE of the following types of composites would you use to coat non-stick frying pans?

A PVC
B Nylon
C Teflon
D Graphite (1)

4.11 The crest and root of a V-screw thread are rounded for … movement.

A restricted
B smooth
C tight
D short (1)

4.12 Which ONE of the following is an advantage of multiple-start screw threads?

A Has less holding power
B Provides slower movement
C Provides more load bearing surface
D Needed where more locking power is required (1)

4.13 Which drive system will you use where the parallel shafts are far away from each other?

A Gear drive system
B Belt drive system
C Block and tackle system
D Pneumatic system (1)

4.14 A non-return valve is also called a …valve.

A check
B back
C straight
D two-way (1)
[14]

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 Which lathe component allows the operator to engage the lead screw half-nuts accurately? (1)

5.2 Name the tool that is used to check the correct cutting angles when grinding a V-thread cutting tool. (1)

5.3 What type of collar/driving plate is used to machine multi-start screw threads on a lathe? (1)

5.4 FIGURE 5.4 below shows a taper with an included angle which should be machined between two centers.

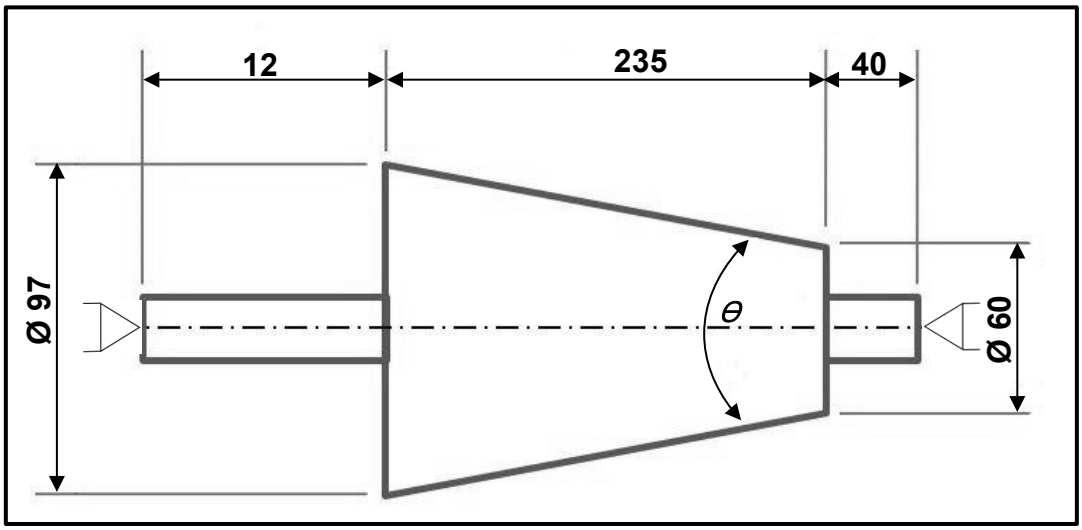


FIGURE 5.4

Calculate the following:

5.4.1 The included angle (θ) of the taper (4)

5.4.2 Set-over of the tailstock (3)

5.5 Calculate the following dimensions for a parallel key suitable for an 87 mm diameter shaft:

5.5.1 Width (2)

5.5.2 Thickness (2)

5.5.3 Length (2)

5.6 Calculate the depth of a M24 x 3 V-screw thread (2)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 A machinist is required to cut a spur gear with a pitch-circle diameter of 384 mm and a module of 4.

Calculate the following:

6.1.1 Number of teeth (3)

6.1.2 Dedendum (2)

6.1.3 Outside diameter (2)

6.1.4 Circular pitch (2)

6.2 FIGURE 6.2 below shows an internal dovetail component.

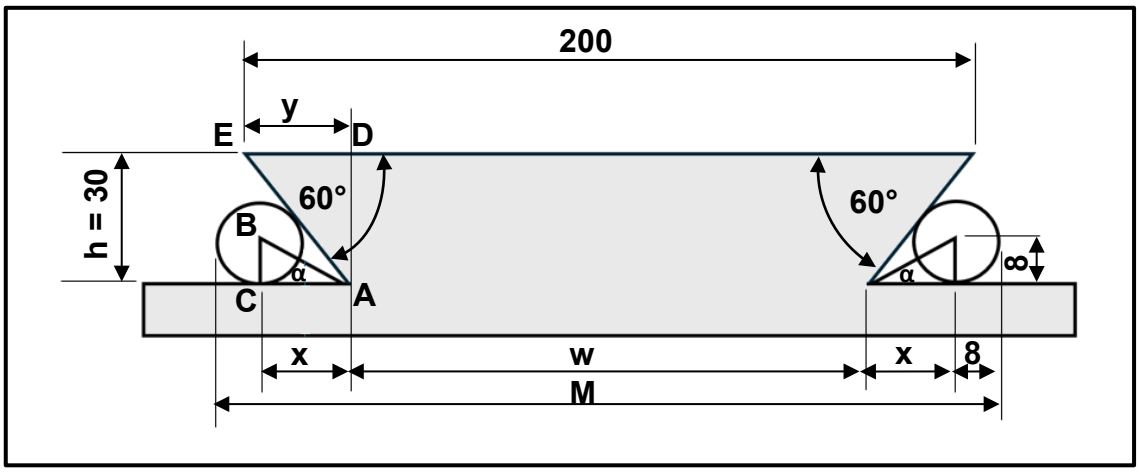


FIGURE 6.2

Calculate the following:

6.2.1 Minimum width (w) of the dovetail (6)

6.2.2 Distance (M) over the precision rollers (6)

6.3 Jack is required to mill a spur gear with 157 teeth. The dividing head has a ratio of 40 **:** 1.

HINT: A = 160 divisions for simple indexing

Calculate the following:

6.3.1 Indexing that is needed (3)

6.3.2 Change gears that are required (4)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 Which property of a metal refers to its ability to resist permanent deformation? (1)

7.2 What determines the selection of using a steel ball or a diamond indenter when conducting a hardness test? (1)

7.3 When using the Brinell hardness tester, the material is usually subjected to a load of 3 000 kg. What load is applied to softer material when conducting this test? (1)

7.4 State TWO functions of a tensile tester. (2)

7.5 State FOUR measures for taking care of a force tester. (4)

7.6 What is the main purpose of the ratchet on a screw-thread micrometer? (1)

7.7 What tester can be used to test the reaction on either side of a simply loaded beam? (1)

7.8 What is a screw-thread micrometer specifically designed for? (2)
[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 FIGURE 8.1 below shows a system of forces with THREE pulling forces and ONE pushing force acting on the same point.

HINT: Draw and complete the diagram in FIGURE 8.1. Show ALL the horizontal and vertical components before you do the calculation.

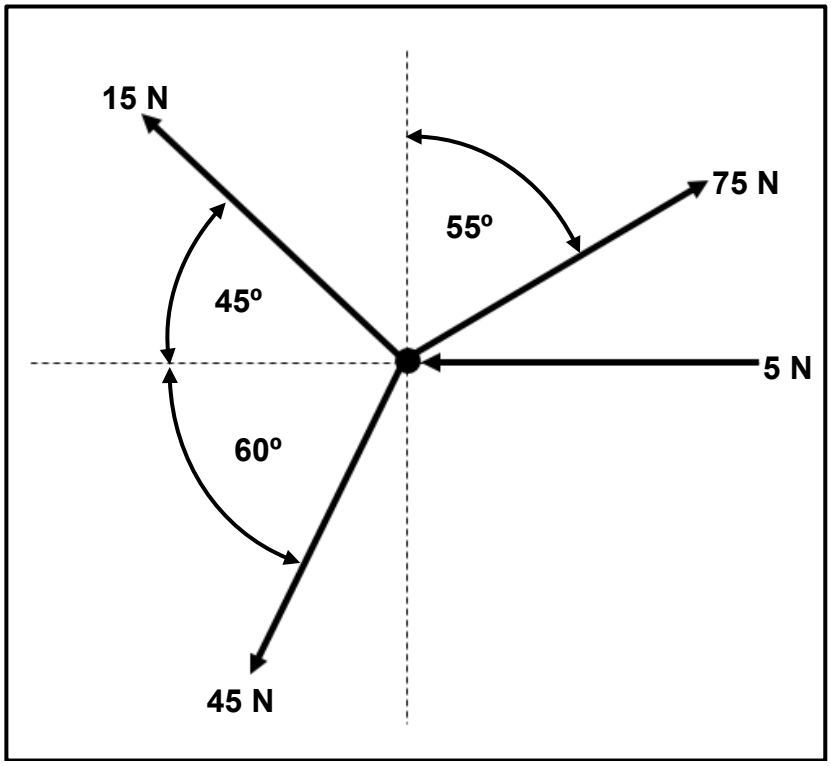


FIGURE 8.1

Calculate the following:

8.1.1 Sum of the horizontal components (5)

8.1.2 Sum of the vertical components (4)

8.1.3 Magnitude of the resultant (2)

8.1.4 Angle and direction of the resultant (3)

8.2 FIGURE 8.2 below shows a uniform beam supported by TWO vertical supports, **A** and **B**. TWO vertical point loads and a uniformly distributed load (UDL) are exerted onto the beam.

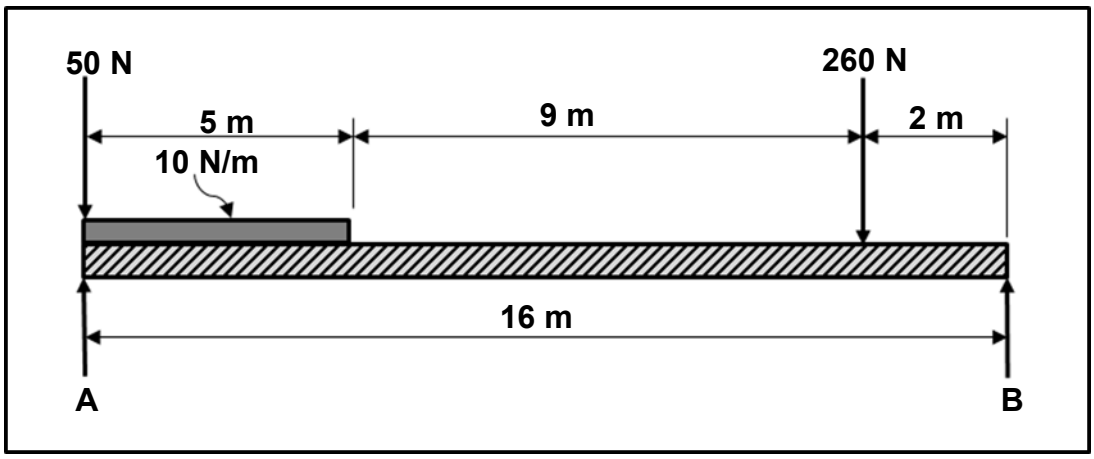


FIGURE 8.2

Calculate the following:

8.2.1 The point load representing the UDL (1)

8.2.2 The reactions in supports **A** and **B** (9)

8.3 A tensile stress of 56,5 MPa is measured in a 20 mm x 20 mm aluminium square bar with a cross-sectional area of 4 x 10^{-4} m^2. The original length of the bar is 270 mm and Young's modulus for brass is 90 GPa.

Calculate the following:

8.3.1 The force exerted on the bar (3)

8.3.2 The strain in the material (3)

8.3.3 The change in length in millimetres (3)
[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 State THREE factors that affect the coefficient of friction between two surfaces. (3)

9.2 Identify EACH of the following as either planned or condition-based maintenance in QUESTIONS 9.2.1 to 9.2.3 below.

9.2.1 Regular services (1)

9.2.2 Cluttering gears (1)

9.2.3 Broken machine shaft (1)

9.3 What is used to correct the slack in a chain of a chain drive? (1)

9.4 Which material, Vesconite or fibreglass, is more suitable for making gears? (1)

9.5 FIGURE 9.5 below shows different types of belt drives. Identify the different types of belts **A**–**C**.

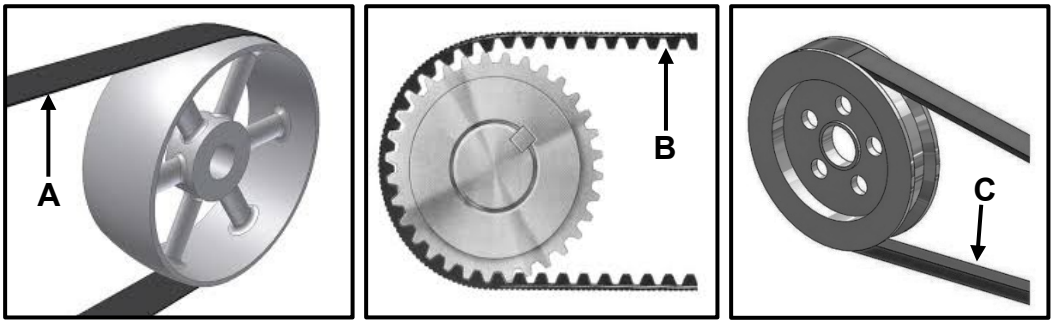


FIGURE 9.5 (3)

9.6 State FOUR preventative maintenance measures that can be conducted on chain drives. (4)

9.7 Identify EACH of the following composites as thermoplastic or thermo-hardened/setting composites:

9.7.1 Polyvinyl chloride (1)

9.7.2 Carbon fibre (1)

9.7.3 Vesconite (1)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 Define the following screw thread terminology:

10.1.1 Lead (3)

10.1.2 Helix angle (3)

10.2 A two-start square thread must be manufactured. The lead of the thread is 38 mm and the crest diameter is 80 mm. The clearance angle on the cutting tool must be 3°.

Calculate the following:

10.2.1 Pitch (3)

10.2.2 Pitch diameter (2)

10.2.3 Helix angle of the screw thread (3)

10.2.4 Leading tool angle (2)

10.2.5 Following tool angle (2)
[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 FIGURE 11.1 below shows a hydraulic system.

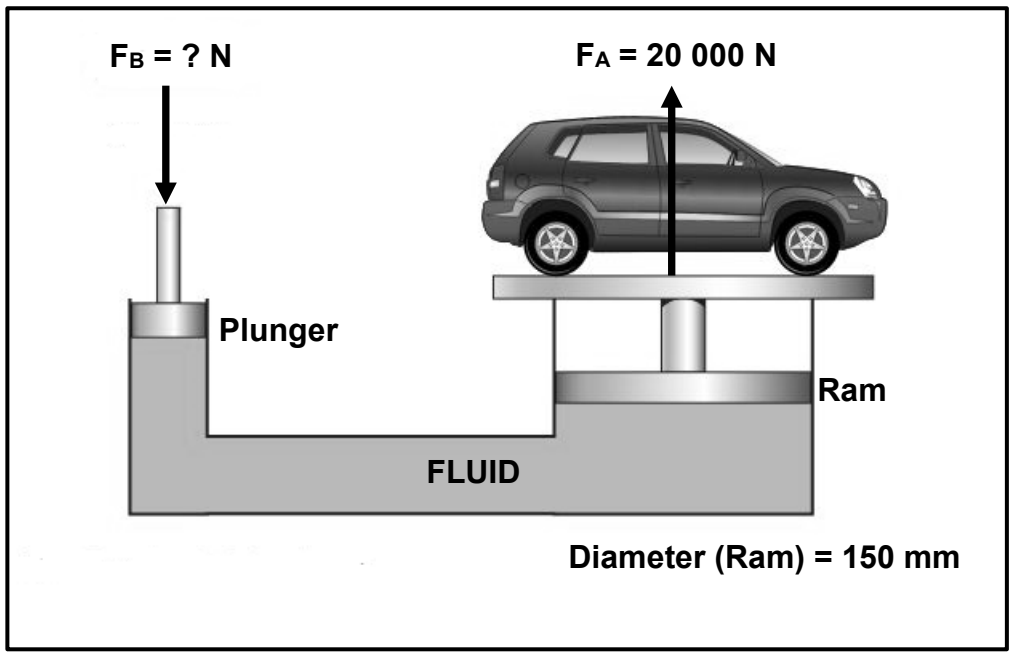


FIGURE 11.1

Calculate the following:

11.1.1 The pressure in the system in MPa (5)

11.1.2 The force exerted on the plunger if the area of the plunger is 0,005 m^2 (4)

11.2 State THREE applications of a hydraulic system in a mechanical workshop. (3)

11.3 The belt drive system of a compressor is shown in FIGURE 11.3 below. The tensile force on the tight side is 1 900 N and on the slack side it is 450 N.

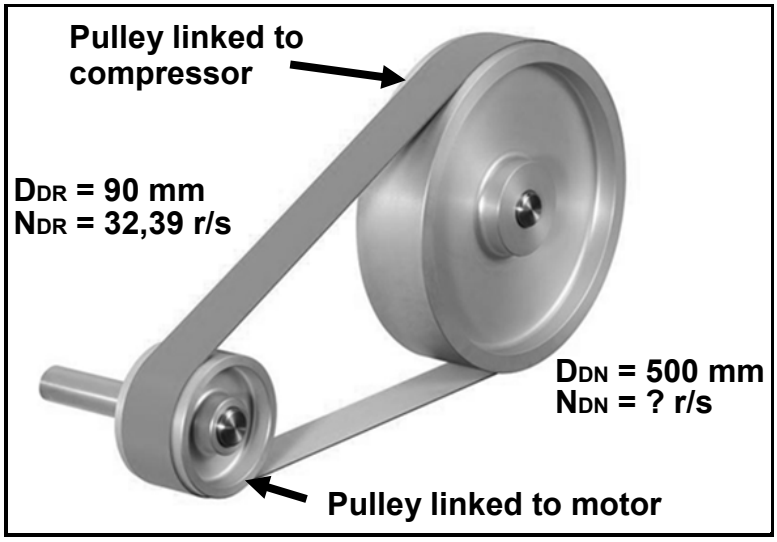


FIGURE 11.3

Calculate the following:

11.3.1 The rotational frequency of the driven pulley in r/s (3)

11.3.2 The power transmitted by the belt in watts (4)

11.4 State TWO disadvantages of a block and tackle pulley system. (2)

11.5 FIGURE 11.5 below shows a gear drive system on the shaft of an electric motor.

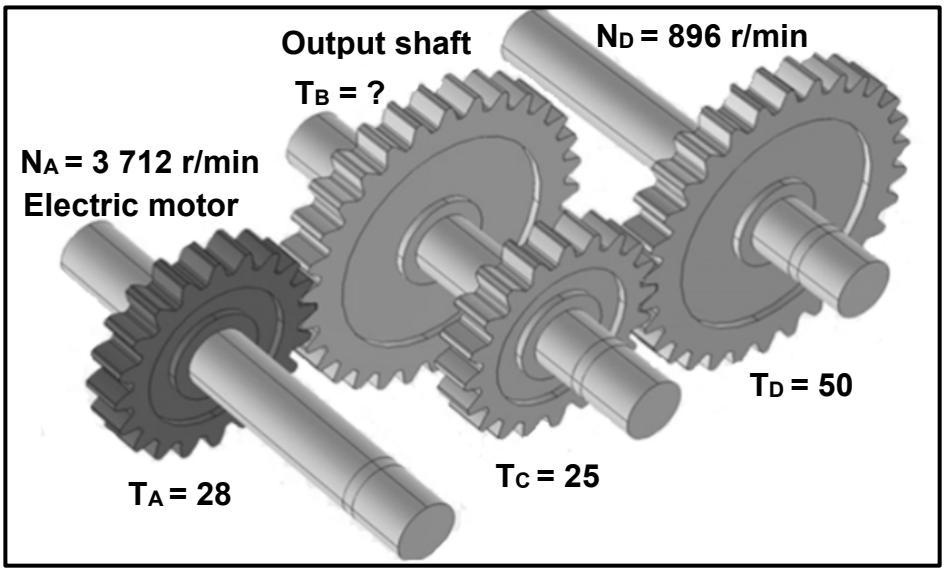


FIGURE 11.5

Calculate the following:

11.5.1 The amount of teeth on T_B (4)

11.5.2 The power transmitted in watts if the torque on the output shaft is 6 780 Nm (3)
[28]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: FITTING AND MACHINING

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 × Length × Density* *(A = thickness × width)*

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

1.5 *Belt length (flat) = [(D + d) × 1,57] + (2 × centre distance)*

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

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

1.8 *Power (P)* $= \frac{(T_1 - T_2)\pi D N}{60}$

Where:

T_1 = *force in the tight side*
T_2 = *force in the slack side*
$T_1 - T_2$ = *effective tensile force* (T_e)

1.9 *Ratio between tight side and slack side* $= \frac{T_1}{T_2}$

1.10 *Width* $= \frac{T_1}{\text{Permissible tensile force}}$

1.11 $N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$

1.12 *Torque = Force × Radius*

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

2. STRESS AND STRAIN

2.1 $A_{shaft} = \frac{\pi d^2}{4}$

2.2 $A_{pipe} = \frac{\pi\left(D^2 - d^2\right)}{4}$

2.3 $Safety\ factor = \frac{Maximum\ stress/Break\ stress}{Safe\ working\ stress}$

2.4 $Stress = \frac{Force}{Area}$ *OR* $\sigma = \frac{F}{A}$

2.5 $Strain = \frac{Change\ in\ length}{Original\ length}$ *OR* $\varepsilon = \frac{\Delta L}{oL}$

2.6 $Young's\ modulus = \frac{Stress}{Strain}$ *OR* $E = \frac{\sigma}{\varepsilon}$

3. HYDRAULICS

3.1 $Pressure = \frac{Force}{Area}$ *OR* $P = \frac{F}{A}$

3.2 *Volume = Area × Stroke length (l or s)*

3.3 *Work done = Force × Distance*

3.4 $P_A = P_B$

3.5 $\frac{F_A}{A_A} = \frac{F_B}{A_B}$

4. GEAR DRIVES

4.1 $Power\ (P) = \frac{2\pi NT}{60}$

4.2 $Gear\ Ratio = \frac{Product\ of\ teeth\ on\ driven\ gear}{Product\ of\ teeth\ on\ driver\ gear}$ *OR* $Speed\ ratio = \frac{N_{input}}{N_{output}}$

4.3 $\frac{N_{input}}{N_{output}} = \frac{Product\ of\ teeth\ on\ driven\ gear}{Product\ of\ teeth\ on\ driver\ gear}$

4.4 $N_A \times T_A = N_B \times T_B$

4.5 $Torque = Force \times Radius$

4.6 $Torque\ transmitted = Gear\ ratio \times Input\ torque$

4.7 $Module = \frac{Pitch\text{-}circle\ diameter}{Number\ of\ teeth}$ OR $m = \frac{PCD}{T}$

4.8 $Pitch\text{-}circle\ diameter = \frac{Circular\ pitch \times Number\ of\ teeth}{\pi}$

OR

$PCD = \frac{CP \times T}{\pi}$

4.9 $Outside\ diameter\ (OD) = PCD + 2(m)$

4.10 $Addendum = Module$ OR $a = m$

4.11 $Dedendum\ (b) = 1{,}157 \times m$ OR $Dedendum\ (b) = 1{,}25 \times m$

4.12 $Cutting\ depth\ (h) = 2{,}157 \times m$ OR $Cutting\ depth\ (h) = 2{,}25 \times m$

4.13 $Clearance\ (c) = 0{,}157 \times m$ OR $Clearance\ (c) = 0{,}25 \times m$

4.14 $Circular\ pitch\ (CP) = m \times \pi$

4.15 $Working\ depth\ (WD) = 2 \times m$ OR $Working\ depth\ (WD) = 2 \times a$

5. KEYWAYS

5.1 *Width (W)* = $\frac{D}{4}$

5.2 *Thickness (T)* = $\frac{D}{6}$

5.3 *Length (L)* = $1{,}5 \times D$

Where:

D = *Diameter of shaft*

5.4 *Standard taper for taper key: 1 in 100 or 1 : 100*

6. CINCINNATI DIVIDING HEAD TABLE FOR 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*
Change gears											
Gears	*24 x 2*	*28*	*32*	*40*	*44*	*48*	*56*	*64*	*72*	*86*	*100*

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

6.2 $\frac{Dr}{Dn} = \frac{A-n}{A} \times \frac{40}{1}$ *OR* $\frac{Dr}{Dn} = (A-n) \times \frac{40}{A}$

Where:

A = *chosen number of divisions*
n = *real number of divisions*

7. DOVETAILS

Where:

R = *Radius of precision roller*
y = *Distance from top edge of dovetail in relation to bottom corner of dovetail*
x = *Distance from middle of precision roller to bottom corner of dovetail*
θ = *Dovetail included angle (normally 60°)*
h = *Height of dovetail*
w = *Minimum width of dovetail*
W = *Maximum width of dovetail*
m = *Distance between rollers*
M = *Distance over rollers*

8. TAPERS

8.1 $\tan\frac{\theta}{2} = \frac{D - d}{2 \times l}$ *(l = Taper length)*

8.2 *Tail stock set - over* $= \frac{L(D - d)}{2 \times l}$ *(L = Distance between centres)*

9. SCREW THREADS

9.1 *Mean diameter = Outside diameter – (½ × Pitch)* *OR* $D_m = OD - \frac{P}{2}$

9.2 *Effective diameter* (D_{eff}) *= Pitch diameter* (D_p) *= Mean diameter* (D_m)

9.3 *Lead = Pitch × Number of starts*

9.4 *Height of screw thread = 0,866 × Pitch (P)*

9.5 *Depth of screw thread = 0,613 × Pitch (P)*

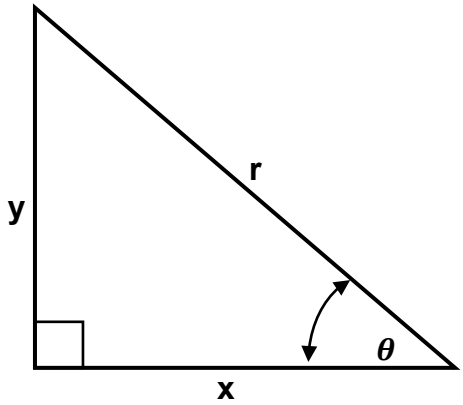
9.6 *Helix angle: Tan* $\theta = \frac{Lead}{\pi \times D_m}$

9.7 *Leading angle = 90° – (Helix angle + Clearance angle)*

9.8 *Following angle = 90° + (Helix angle – Clearance angle)*

9.9 $D_P = D_N - (0{,}866 \times P)$

10. PYTHAGORAS' THEOREM AND TRIGONOMETRY



10.1 $Sin\ \theta = \frac{y}{r}$

10.2 $Cos\ \theta = \frac{x}{r}$

10.3 $Tan\ \theta = \frac{y}{x}$

10.4 $r^2 = x^2 + y^2$