basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

MAY/JUNE 2026

MARKS: 200

TIME: 3 hours

This question paper consists of 21 pages and a 5-page formula sheet.

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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 should 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**

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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 statement below is CORRECT in terms of a recommendation for the application of first aid?

A Remove anything that is stuck to the wound.
B Check the pulse of the patient.
C Pay no attention to loss of blood or breathing difficulties.
D Check the surroundings for safe objects. (1)

1.2 Which ONE of the following Acts states that employers must ensure that the workplace is safe?

A Occupational Health and Safety (OHS) Act, 1993 (Act 85 of 1993)
B Basic Conditions of Employment (BCE) Act, 1997 (Act 75 of 1997)
C Labour Relations (LR) Act, 1995 (Act 66 of 1995)
D Employment Equity (EE) Act, 1998 (Act 55 of 1998) (1)

1.3 Which ONE of the following is the cause of accidents while the surface grinder is being used?

A Overconfidence
B Correct wheel size
C Not forcing grinding
D Correct wheel design for the surface grinder (1)

1.4 Which ONE of the following types of steel will be least affected during the hardening process?

A High-carbon steel
B Medium carbon steel
C Low-carbon steel
D Stainless steel (1)

1.5 Which ONE of the following metals will be cut easily while the machinability test is being conducted?

A Spring steel
B Mild steel
C High-speed steel
D Cast steel (1)

1.6 Which ONE of the following heat treatment processes provides a material with a hard casing and a tough core?

A Tempering
B Cyaniding
C Annealing
D Normalising (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 Name ONE specific safety device that is fitted on EACH of the following machines to avoid injury:

2.1.1 Vertical band saw (1)

2.1.2 Power-driven guillotine (1)

2.1.3 Drill press (1)

2.1.4 Bench grinder (1)

2.2 State TWO safety rules for EACH of the following machines WHILE they are being operated:

NOTE: All PPE and environmental factors have been taken care of.

2.2.1 Horizontal band saw (2)

2.2.2 Arc-welding equipment (2)

2.3 Identify the following workshop layouts with reference to the following advantages:

2.3.1 Control over operations is easier (1)

2.3.2 Greater flexibility in manufacturing (1)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 TABLE 3.1 below shows the different metal tests and results. Complete the table by writing only the question numbers (3.1.1 to 3.1.4) and the answers in the ANSWER BOOK.

TYPE OF TEST	TYPE OF STEEL/IRON	TEST RESULTS
Sound test	3.1.1	Medium metallic sound
Bend test	Cast steel	3.1.2
Filing test	3.1.3	Very hard to file
Machining test	Cast iron	3.1.4

TABLE 3.1 (4)

3.2 FIGURE 3.2 below shows the iron-carbon equilibrium diagram. Label **A**–**D**.

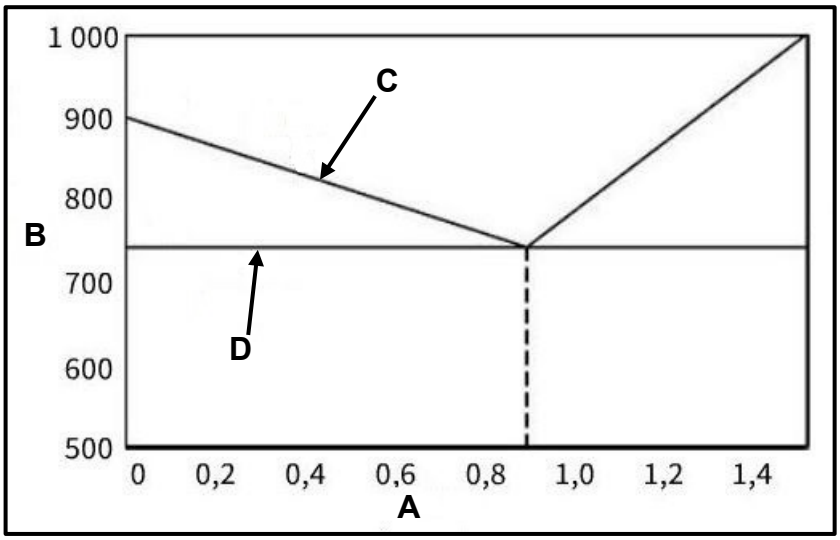


FIGURE 3.2 (4)

3.3 Which type of quenching medium is used in extreme cooling of heat-treated materials? (1)

3.4 Give TWO reasons why the lengths of metals are normally marked or colour coded at the ends. (2)

3.5 FIGURE 3.5 below shows the changes in metal structures during the annealing process. Label **A**–**C**.

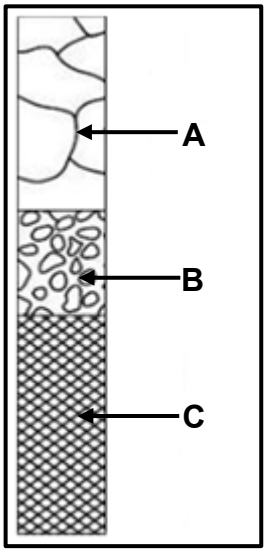


FIGURE 3.5

(3)
[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 shown in FIGURE 4.1 below.



FIGURE 4.1

A Compound slide
B Tailstock
C Lathe steady
D Head stock (1)

4.2 What action would you use to cut an internal taper on a centre lathe?

A Boring
B Drilling
C Milling
D Parallel cutting (1)

4.3 What is the purpose of the sector arms on a dividing head?

A Keeping the index plate in place
B To enable indexing where fractions of turns are required
C It disengages the worm shaft from the worm wheel
D It breaks the round work piece into a number of equal parts (1)

4.4 The principle of an incremental cutter in a CNC milling machine operation is that each point influences the …

A previous point.
B immediate point.
C following point.
D following and the previous points. (1)

4.5 What is the reason for measuring the depth and diameter of the indentation during the Brinell hardness test?

A To check if the metal can dent deep enough
B To observe if the metal can resist indentation
C To determine the tensile strength of the material
D To be able to calculate the hardness number (1)

4.6 Which ONE of the following statements describes the process shown in FIGURE 4.6 below?

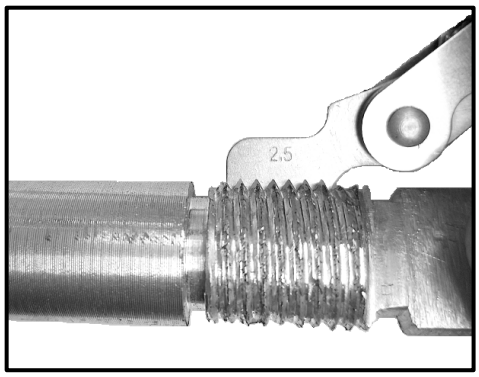


FIGURE 4.6

A Cleaning the root of the screw thread
B Cutting of the screw thread
C Checking the quality of the screw thread
D Checking the pitch of a screw thread (1)

4.7 What does the term *tensile stress* refer to?

A The resistance of a material to shear forces
B The stress experienced by a material when subjected to a compressive force
C The internal force per unit area experienced by a material when subjected to a pulling force
D The ability of a material to resist impact forces (1)

4.8 Which unit is used for the safety factor number?

A No unit
B Pascal
C N/m^2
D Fraction (1)

4.9 What type of material is most effective in the manufacturing of bearings and bushes?

A Teflon
B PVC
C Vesconite
D Bakelite (1)

4.10 Where would you use bakelite?

A Door frames
B Recyclable bottles
C Electrical switches
D Stove plates (1)

4.11 What does the '20' refer to in the term M20 x 1,5, regarding the classification of a certain screw thread?

A Nominal diameter
B Pitch diameter
C Minor diameter
D Root diameter (1)

4.12 Which term in screw thread terminology describes the distance a nut moves within one revolution on a screw thread?

A Pitch
B Lead
C Axis
D Crest (1)

4.13 Which pulley system shown in FIGURE 4.13 below will provide you with the most mechanical advantage?

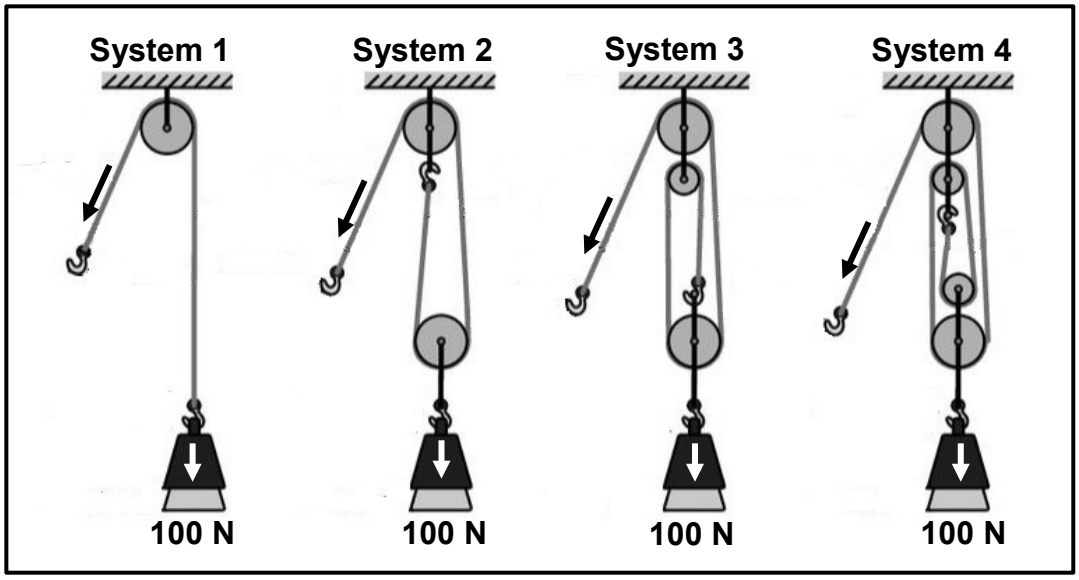


FIGURE 4.13

A System 1
B System 2
C System 3
D System 4 (1)

4.14 Identify the hydraulic symbol shown in FIGURE 4.14 below.

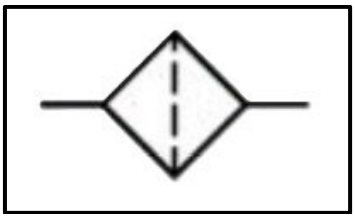


FIGURE 4.14

A Hydraulic motor
B Hydraulic reservoir
C Hydraulic filter
D Hydraulic flow control valve (1)

[14]

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

5.1 FIGURE 5.1 below shows a screw-cutting dial found on a centre lathe to assist with the accurate engagement of the lead screw half nuts. Label **A**–**C**.

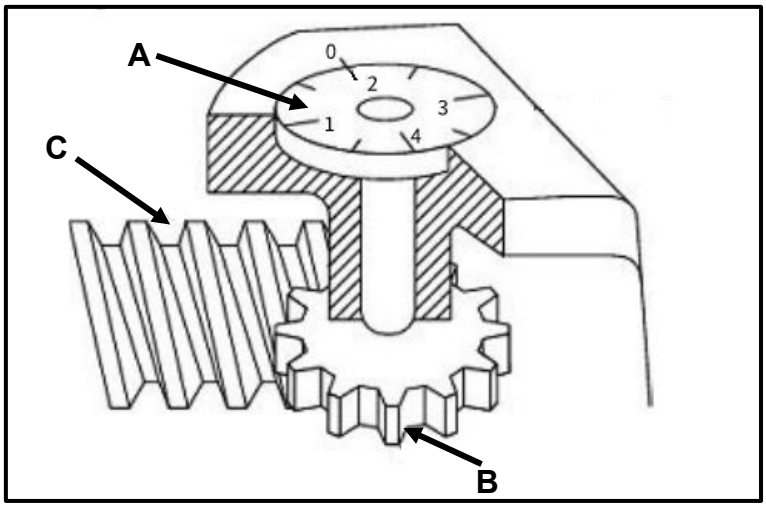


FIGURE 5.1 (3)

5.2 FIGURE 5.2 below shows a taper with an included angle of 4° that should be machined between centres.

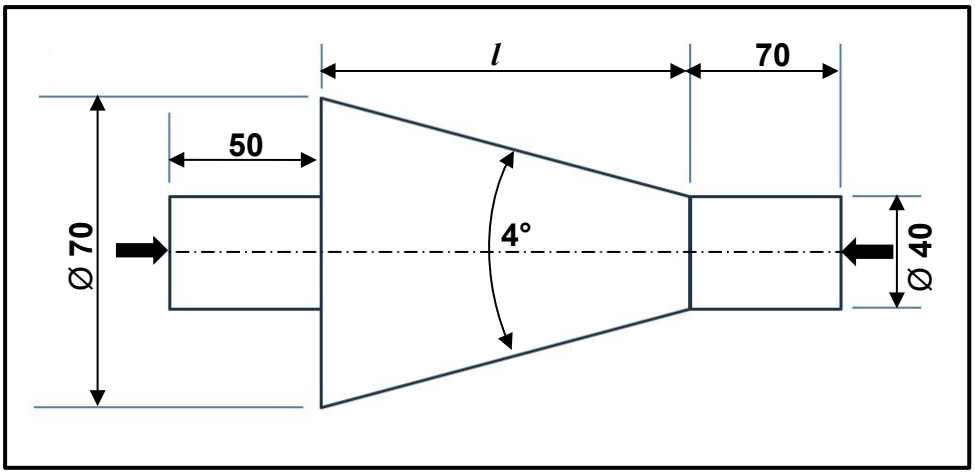


FIGURE 5.2

Calculate the following:

5.2.1 The length (*l*) of the taper (4)

5.2.2 The set-over of the tailstock required to cut this taper (3)

5.3 Calculate the following dimensions for a parallel key suitable for a 80 mm diameter shaft:

5.3.1 Width (2)

5.3.2 Thickness (2)

5.3.3 Length (2)

5.4 State TWO disadvantages of up-cut milling. (2)
[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 Willy needs to cut a spur gear with a pitch-circle diameter of 285 mm and a module of 3.

Calculate the following:

6.1.1 Circular pitch (2)

6.1.2 Number of teeth (3)

6.1.3 Dedendum (2)

6.2 FIGURE 6.2 below shows an internal dovetail component.

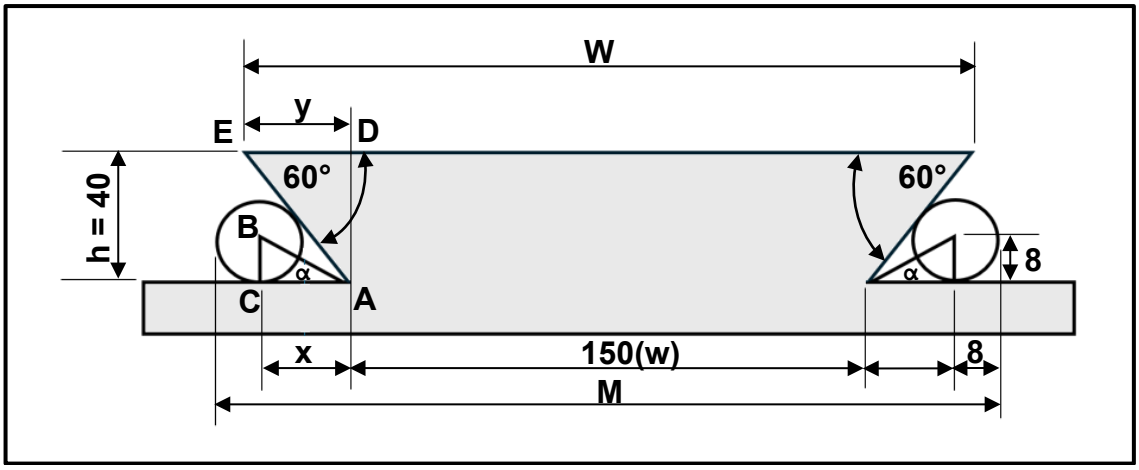


FIGURE 6.2

Calculate the following:

6.2.1 Maximum width distance (W) of the dovetail (6)

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

6.3 A spur gear with 71 teeth needs to be manufactured. The dividing head used has a ratio of 40 **:** 1.

HINT: Use A = 70 divisions for the simple indexing.

Calculate the following:

6.3.1 The indexing that is needed (4)

6.3.2 The change gears that are required (5)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 FIGURE 7.1 below shows a screw thread micrometer. Answer the questions that follow.

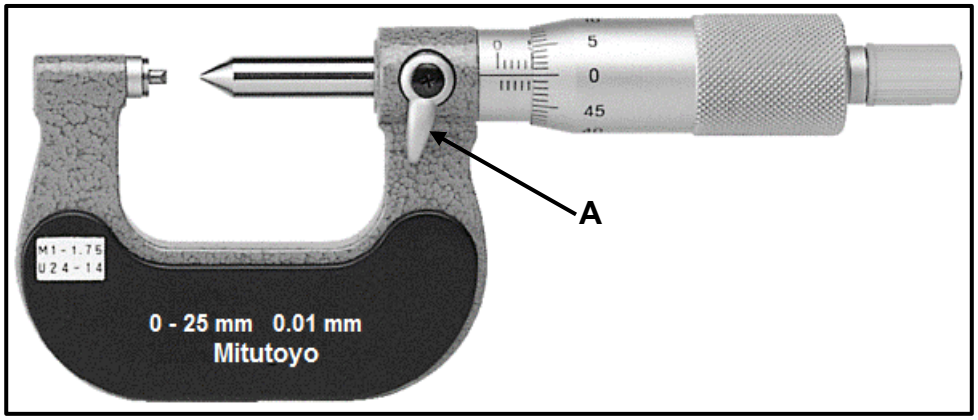


FIGURE 7.1

7.1.1 What is the maximum size that this micrometer can measure? (1)

7.1.2 What is the function of **A**? (1)

7.2 Determine the reading of the outside micrometer shown in FIGURE 7.2 below.

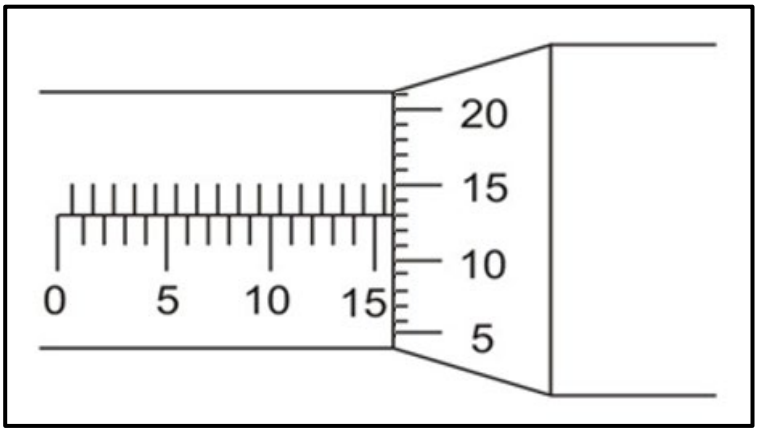


FIGURE 7.2 (2)

7.3 FIGURE 7.3 below shows a tester. Answer the questions that follow.

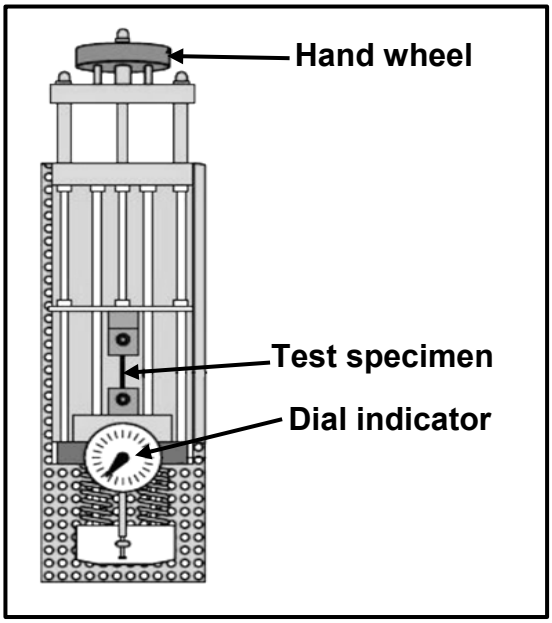


FIGURE 7.3

7.3.1 Identify the type of tester. (1)

7.3.2 State TWO results that can be determined with this type of tester. (2)

7.4 The Brinell hardness test is one of the tests that determines the hardness of steel. The following is a description of how to conduct the test. Complete the sentences by using the words provided in the list below. Write only the word next to the question numbers (7.4.1 to 7.4.6) in the ANSWER BOOK. Each word may be used only ONCE.

calculation; clean; diameter; indenter; load; material; raised; steel

The desired (7.4.1) … is selected on the dial by adjusting the air regulator.

The specimen is placed on the anvil. Ensure that the specimen is (7.4.2) … and free from burrs.

The specimen is (7.4.3) … to be in contact with the Brinell ball by turning the hand wheel.

The load is then applied by pulling out the plunger control. Maintain the load for 30 seconds for non-ferrous metals and 15 seconds for (7.4.4) … Release the load.

Remove the specimen from the tester and measure the (7.4.5) … of the indentation.

Determine the Brinell hardness number by (7.4.6) … or by using the table. (6)
[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 FIGURE 8.1 below shows a system of forces with FOUR pulling forces acting onto the same point.

HINT: Draw and complete the diagram in FIGURE 8.1 below. Show ALL the horizontal and vertical components before the calculations are done.

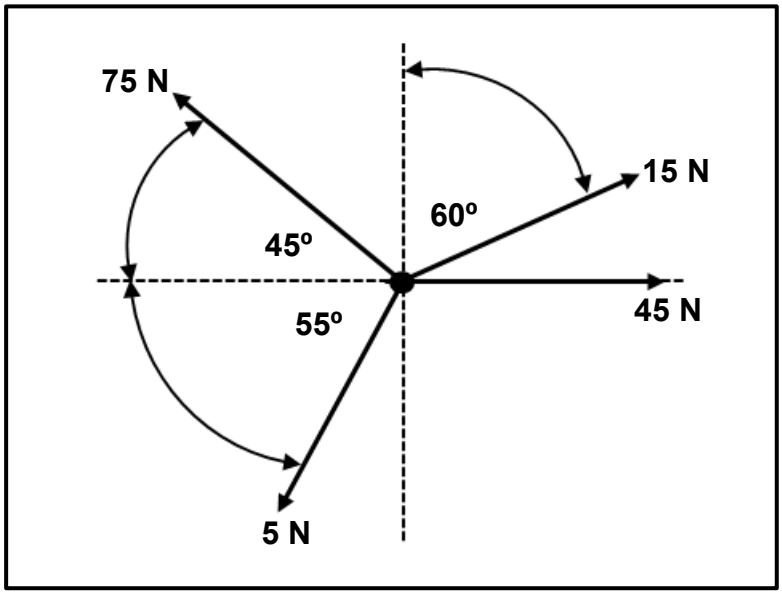


FIGURE 8.1

Calculate the following:

8.1.1 The sum of the horizontal components and the sum of the vertical components (9)

8.1.2 Magnitude of the resultant (2)

8.1.3 Angle and direction of the resultant (3)

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

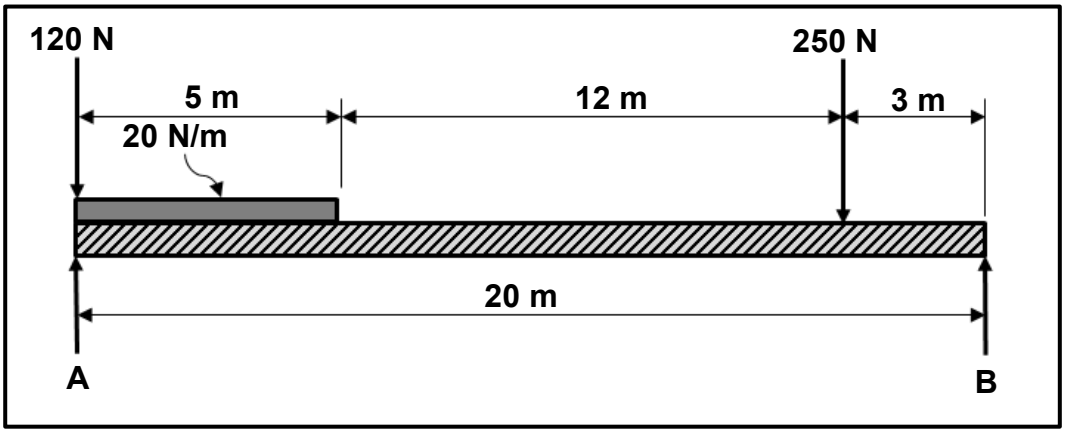


FIGURE 8.2

Calculate the following:

8.2.1 The point load representing the UDL (2)

8.2.2 The reactions in supports **A** and **B** (7)

8.3 A tensile force of 50 kN is applied to an aluminium shaft. The diameter of the shaft is 40 mm and the original length is 68 mm.

Calculate the following:

8.3.1 The stress in the material in MPa if the cross-sectional area of the shaft is $1,26 \times 10^{-3}$ m^2 (3)

8.3.2 The strain if the final length of the shaft is 68,975 mm (3)

8.3.3 Young's modulus of elasticity for the material in GPa (3)

8.4 FIGURE 8.4 below shows a stress-strain diagram. What does **A** represent?

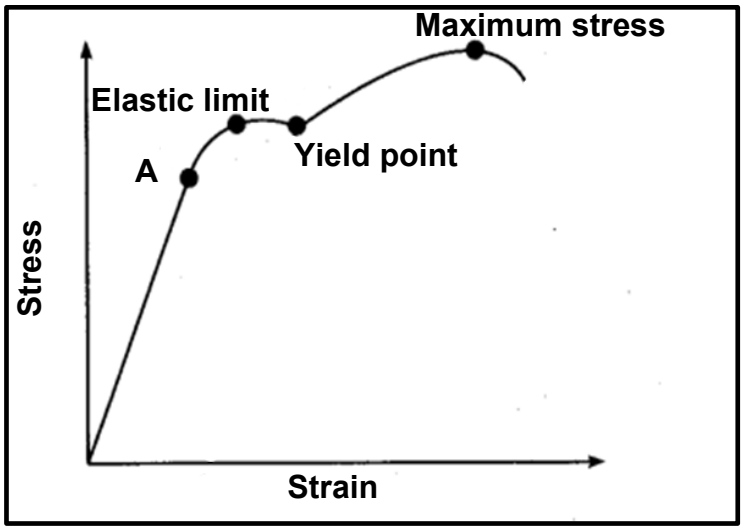


FIGURE 8.4

(1)

[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 State THREE important consequences of a failure to conduct proper preventative maintenance. (3)

9.2 State TWO types of preventative maintenance procedures. (2)

9.3 State ONE corrective maintenance measure of the following:

9.3.1 The tension of the belt is not correct (1)

9.3.2 Excessive noise and wear to the gears (1)

9.3.3 Elongation of the chain is more than 2% (1)

9.3.4 There is extreme wear to the sprocket teeth (1)

9.4 State TWO uses of EACH of the following materials in the mechanical workshop:

9.4.1 Vesconite (2)

9.4.2 Carbon fibre (2)

9.4.3 Fibre glass (2)

9.5 Classify the following materials as either thermoplastic composites or thermo-hardened (thermosetting) composites:

9.5.1 Nylon (1)

9.5.2 Fibre glass (1)

9.5.3 Bakelite (1)
[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 State THREE examples of where multiple start screw threads are generally used. (3)

10.2 State THREE advantages of multiple-start screw threads. (3)

10.3 A single-start square thread needs to be manufactured. The lead of the square thread is 30 mm and the crest diameter is 92 mm. The clearance angle must be 3°.

Calculate the following:

10.3.1 Pitch diameter (4)

10.3.2 Helix angle of the screw thread (4)

10.3.3 Leading tool angle (2)

10.3.4 Following tool angle (2)
[18]

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

11.1 FIGURE 11.1 below shows a hydraulic system.

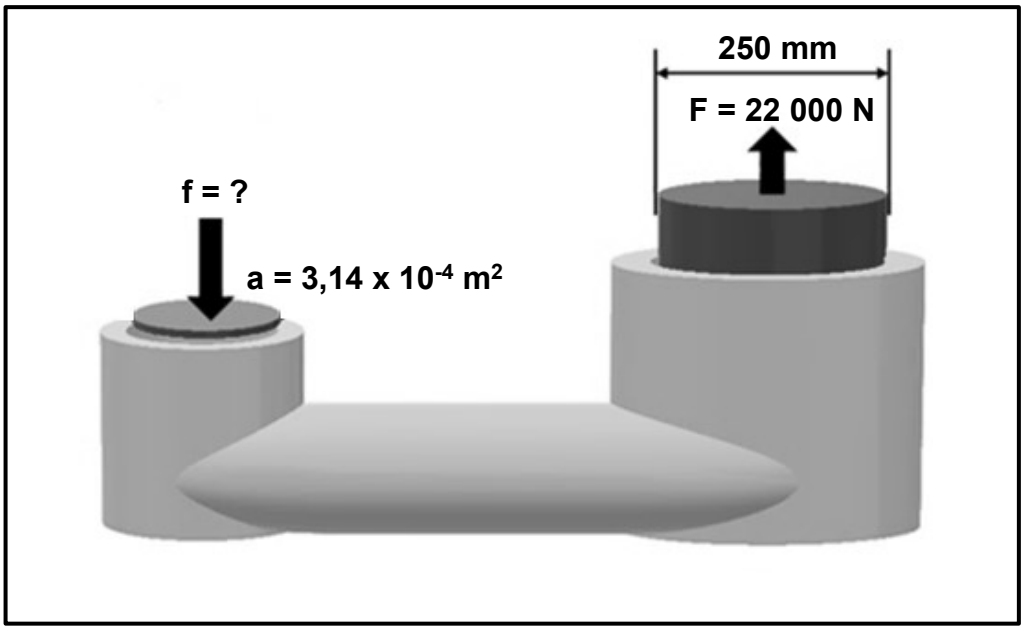


FIGURE 11.1

Calculate the following:

11.1.1 The fluid pressure in the hydraulic system in MPa (5)

11.1.2 The force (**f**) applied to the plunger (3)

11.2 State TWO advantages of belt drives when compared to gear drives. (2)

11.3 State THREE functions of a reservoir in a hydraulic system. (3)

11.4 State TWO applications for pneumatic systems. (2)

11.5 FIGURE 11.5 below shows a belt drive system.

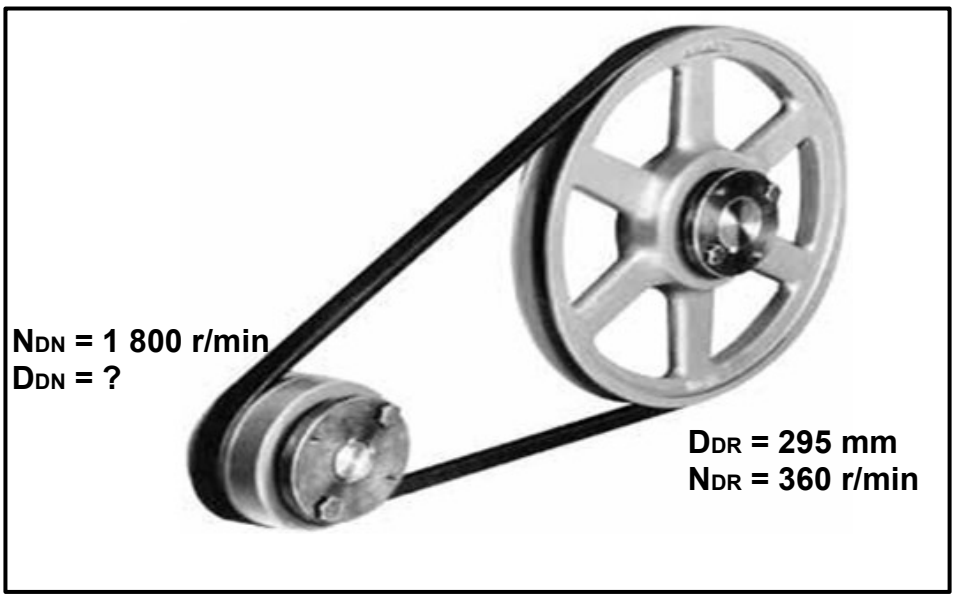


FIGURE 11.5

Calculate the following:

11.5.1 The diameter of the driven pulley (3)

11.5.2 The speed ratio (3)

11.6 FIGURE 11.6 below shows a gear drive system.

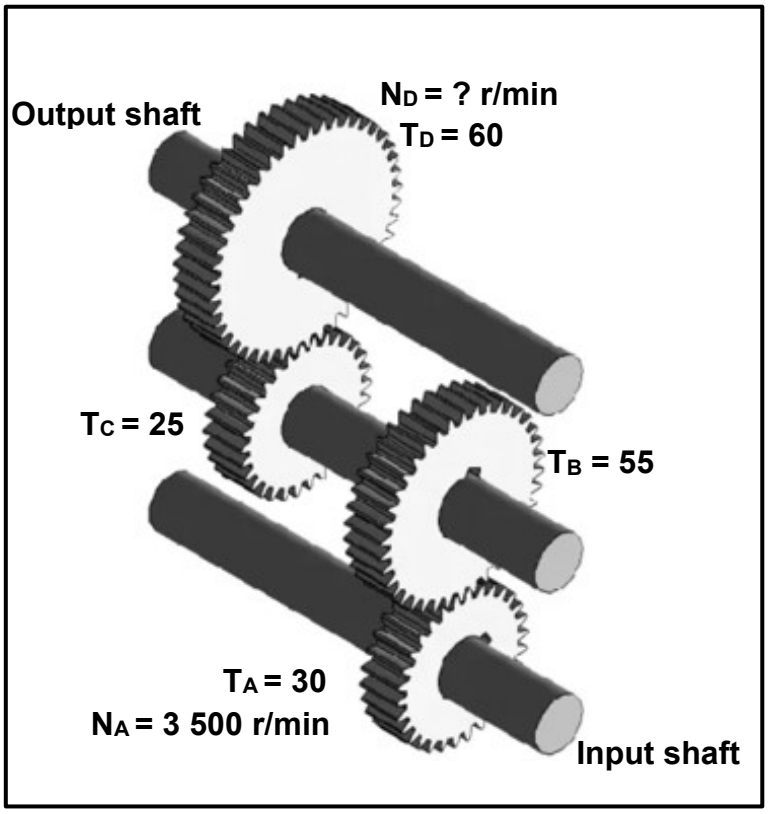


FIGURE 11.6

Calculate the following:

11.6.1 Rotation frequency of the output shaft in r/min if the input shaft rotates at a speed of 3 500 r/min (4)

11.6.2 The gear ratio (3)
[28]

TOTAL: 200

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FORMULA SHEET FOR MECHANICAL TECHNOLOGY: FITTING AND MACHINING

1. BELT DRIVES

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

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

1.3 *Belt mass = Area × Length × Density (A = thickness × width)*

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

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

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

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

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

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

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

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

1.12 *Torque = Force × Radius*

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

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 $Volume = Area \times Stroke\ length \quad (l\ or\ s)$

3.3 $Work\ done = Force \times Distance$

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 × Radius*

4.6 *Torque transmitted = Gear ratio × 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 × m* ***OR*** *Dedendum (b) = 1,25 × m*

4.12 *Cutting depth (h) = 2,157 × m* ***OR*** *Cutting depth (h) = 2,25 × m*

4.13 *Clearance (c) = 0,157 × m* ***OR*** *Clearance (c) = 0,25 × m*

4.14 *Circular pitch (CP) = m × π*

4.15 *Working depth (WD) = 2 × m* ***OR*** *Working depth (WD) = 2 × a*

5. KEYWAYS

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

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

5.3 *Length (L) = 1,5 × 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 × 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 $Tail\ stock\ set\text{-}over = \frac{L(D - d)}{2 \times l}$ *(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)*

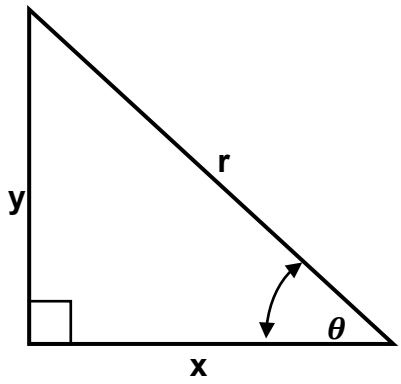
9.6 *Helix angle:* $Tan\ \theta = \frac{Lead}{\pi \times D_m}$

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

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