



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY: FITTING AND MACHINING**

**NOVEMBER 2025**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 18 pages and a 5-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 should be taken as  $9,81 \text{ m/s}^2$  or  $10 \text{ m/s}^2$ .
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
	<b>GENERIC</b>		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	<b>SPECIFIC</b>		
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
<b>TOTAL</b>		<b>200</b>	<b>180</b>

### 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 refers to the code of good practice on HIV/Aids and employment?
- A Employers can simply dismiss a person who has HIV/Aids.
  - B It does not elaborate on how everybody has the right to fair labour practices regarding HIV/Aids.
  - C It contains the daily working hours of employees.
  - D It contains common guidelines on how employers, employees and trade unions should respond to HIV/Aids in the workplace. (1)
- 1.2 Who is responsible for the provision of PPE in the workshop?
- A Employee
  - B Cleaning staff
  - C Foreman
  - D Employer (1)
- 1.3 The function of the finger protector in the power-driven guillotine is to prevent the operators from ...
- A reaching below the hold-down guards.
  - B touching revolving parts.
  - C getting their clothes caught in the machine.
  - D bending the work piece. (1)
- 1.4 FIGURE 1.4 below shows a spark test being conducted. Identify the type of material with reference to the spark pattern.

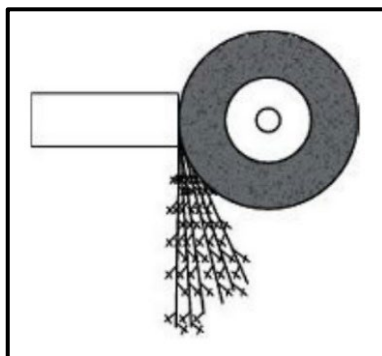


FIGURE 1.4

- A Copper
- B Brass
- C High-carbon steel
- D Aluminium alloy (1)

- 1.5 The hardening temperature depends on the ... of the steel.
- A carbon content
  - B malleability
  - C size
  - D weight
- (1)
- 1.6 What determines the properties of steel during heat treatment?
- A The melting point
  - B Type of grain structure
  - C The water content of the metal
  - D The molten state of the metal
- (1)  
**[6]**

**QUESTION 2: SAFETY (GENERIC)**

- 2.1 State TWO visible signs on an injured person that a first-aider must take note of before treatment. (2)
- 2.2 State TWO safety measures to be considered BEFORE arc welding can be performed. (2)
- 2.3 State TWO safety rules that must be adhered to BEFORE switching on a portable angle grinder.
- (NOTE: All PPE has already been taken care of.) (2)
- 2.4 State TWO safety rules when handling oxy-acetylene gas cylinders. (2)
- 2.5 State ONE disadvantage of the product layout. (1)
- 2.6 State ONE general duty every employee must adhere to in the workplace according to the Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993). (1)  
**[10]**

**QUESTION 3: MATERIALS (GENERIC)**

- 3.1 What will be the effect on the following materials when conducting a bend test?
- 3.1.1 Mild steel (1)
  - 3.1.2 High-carbon steel (1)
- 3.2 What is the purpose of heat treatment of metals? (1)
- 3.3 State THREE quenching media used in the heat treatment of steel. (3)

- 3.4 Which TWO methods are used to conduct a sound test to identify metals? (2)
- 3.5 What is the purpose of case hardening of steel during heat treatment? (2)
- 3.6 Name TWO common methods of case hardening. (2)
- 3.7 Explain the reason for normalising steel during heat treatment. (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 procedure shown in FIGURE 4.1 below.

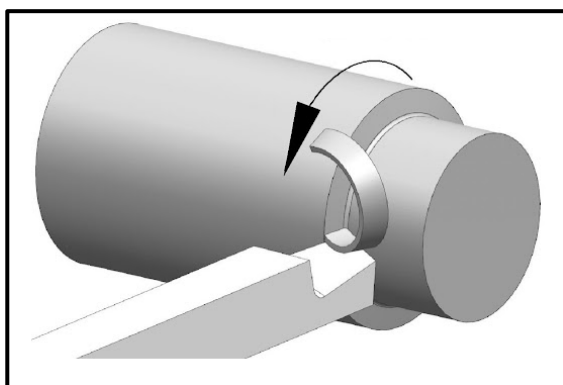


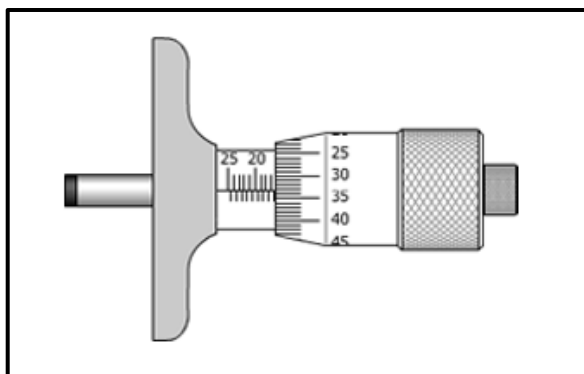
FIGURE 4.1

- A Boring  
B Parallel cutting  
C Knurling  
D Taper cutting (1)
- 4.2 Identify the CORRECT statement regarding a safety precaution of a lathe machine after it has been switched on:
- A Leave the tools on the lathe.  
B Secure the tailstock against the work piece.  
C Adjust the cutting tool in the tool holder.  
D Give attention to cutting-fluid control. (1)
- 4.3 How many axes are displayed on a digital read-out (DRO) system on a milling machine?
- A 2  
B 3  
C 4  
D 5 (1)
- 4.4 Where must a technician feed the information into a CNC milling machine once the instructional programming has been completed?
- A Work sheet  
B Laptop  
C Localised CPU  
D Drawing (1)

4.5 When using a moment tester, how should it be taken care of?

- A All nuts and bolts should be secured properly.
  - B Leave all mass pieces outside.
  - C Add mass pieces very quickly.
  - D Store the equipment in a damp area.
- (1)

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



**FIGURE 4.6**

- A Screw-thread micrometer
  - B Depth micrometer
  - C Vernier calliper
  - D Vernier height gauge
- (1)

4.7 What terminology is used to describe the load-carrying capacity of a system beyond the expected or actual loads?

- A Young's modulus
  - B Limit of proportionality
  - C Safety factor
  - D Break stress
- (1)

4.8 Strain is the ratio between the original length and the change in length, therefore it has no ...

- A unit.
  - B stress.
  - C force.
  - D length.
- (1)

4.9 The coefficient of friction between two materials in relative sliding may depend on ...

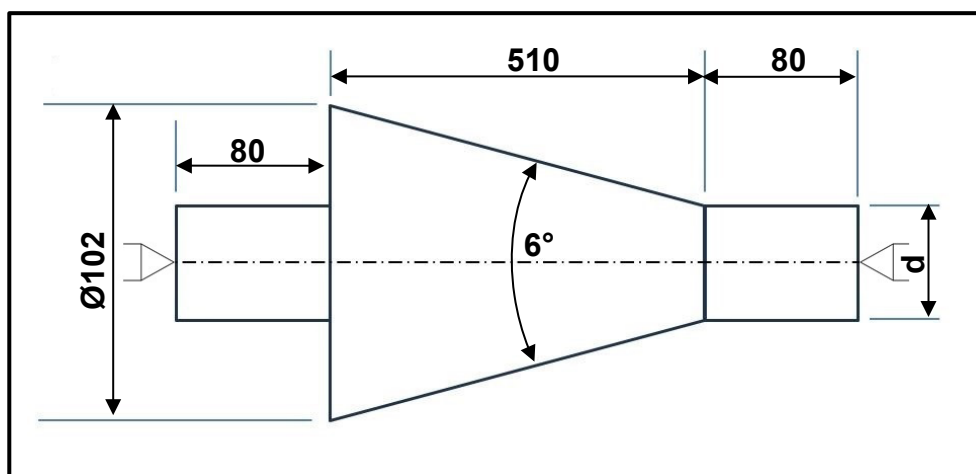
- A air ratio.
  - B the available space.
  - C temperature.
  - D hardness.
- (1)

- 4.10 What is used to create a carbon fibre reinforced plastic?
- A Acid
  - B Graphite grease
  - C Oil
  - D Epoxy resin
- (1)
- 4.11 What is the included angle for metric V-screw thread?
- A 55°
  - B 60°
  - C 65°
  - D 70°
- (1)
- 4.12 The helix angle is the angle that the thread makes with a line ... the axis of the screw thread.
- A below
  - B above
  - C parallel to
  - D perpendicular to
- (1)
- 4.13 Which component would you find inside a filter?
- A Strainer
  - B Blades
  - C Stones
  - D Glass
- (1)
- 4.14 Pneumatics is the field of operation where ... is used to do work.
- A steam
  - B oil
  - C compressed air
  - D water
- (1)
- [14]**



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

- 5.1 State TWO disadvantages of cutting a taper on a lathe using the tailstock set-over method. (2)
- 5.2 FIGURE 5.2 below shows a taper with an included angle of  $6^\circ$  which should be machined between centres. (2)



**FIGURE 5.2**

Calculate the following:

- 5.2.1 The small diameter (d) of the taper (4)
- 5.2.2 The set-over of the tailstock required to cut the taper (3)
- 5.3 Calculate the following dimensions for a parallel key suitable for a 210 mm diameter shaft that must be used in a machine:
- 5.3.1 Width (2)
- 5.3.2 Thickness (2)
- 5.3.3 Length (2)
- 5.4 State TWO results of an unbalanced work piece on a lathe. (2)
- 5.5 State ONE disadvantage of up-cut milling. (1)

**[18]**

### QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

- 6.1 A spur gear with a pitch-circle diameter of 240 mm and a module of 3 must be cut.

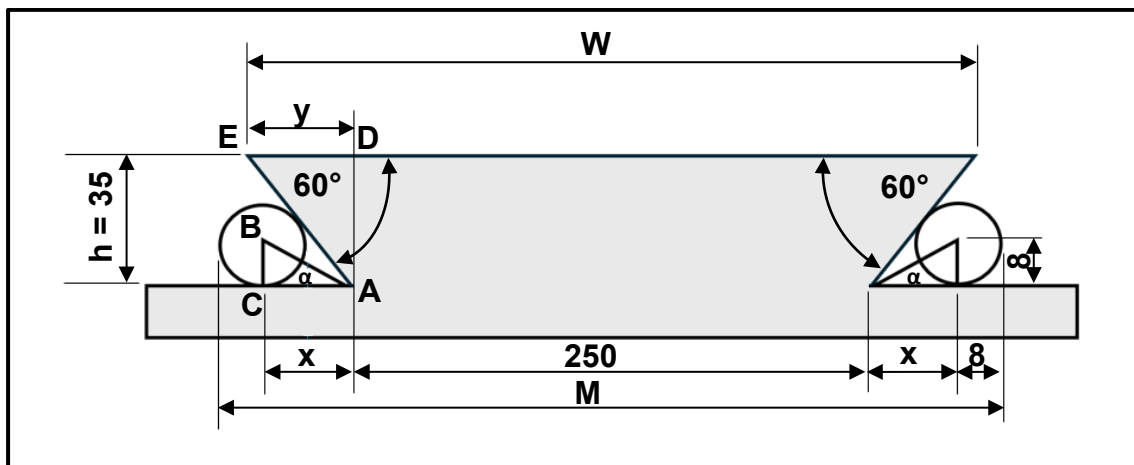
Calculate the following:

- ### 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 97 teeth needs to be manufactured for a client. The dividing head used has a ratio of 40 : 1.

**HINT:** Use  $A = 100$  divisions for the simple indexing.

Calculate the following:

- 6.3.1 Indexing that is needed (3)

- 6.3.2 Change gears that are required (5)

- 6.4 What type of code is used during CNC milling operations? (1)

### QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 State ONE principle to measure the hardness of materials. (1)

7.2 FIGURE 7.2 below shows an indentation during a Brinell hardness test. Label **A–D**.

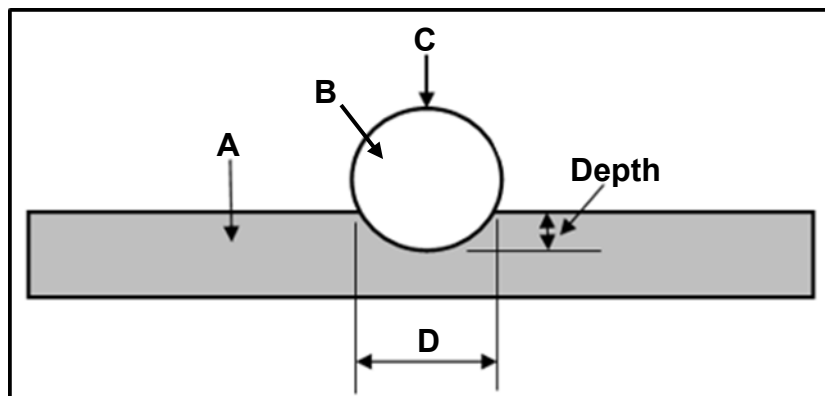


FIGURE 7.2

(4)

7.3 Calculate the depth of a V-screw thread with a pitch of 2,5 mm. (2)

7.4 FIGURE 7.4 below shows a screw thread micrometer. Label **A–D**.

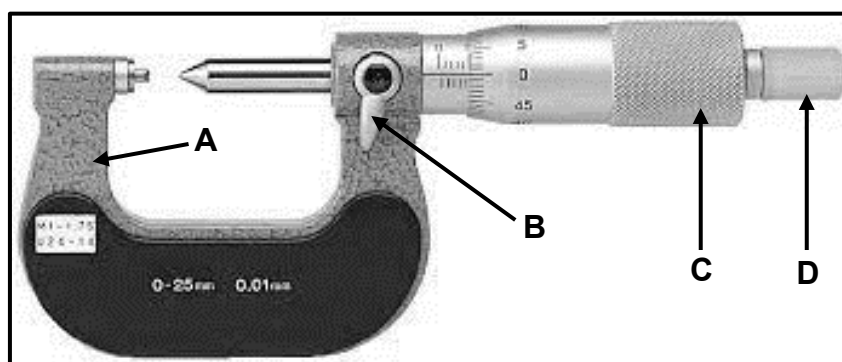


FIGURE 7.4

(4)

7.5 Determine the reading of the depth micrometer shown in FIGURE 7.5 below.

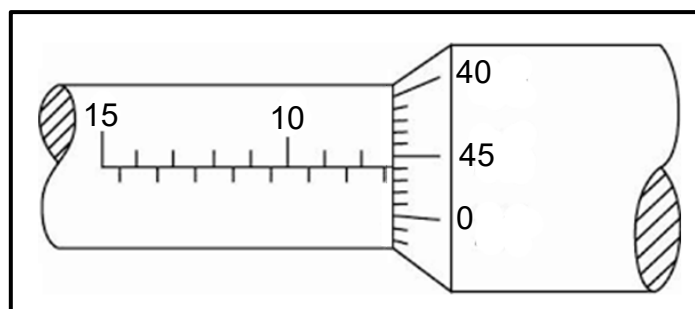


FIGURE 7.5

(2)  
[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. Show ALL the horizontal and vertical components before you do the calculations.

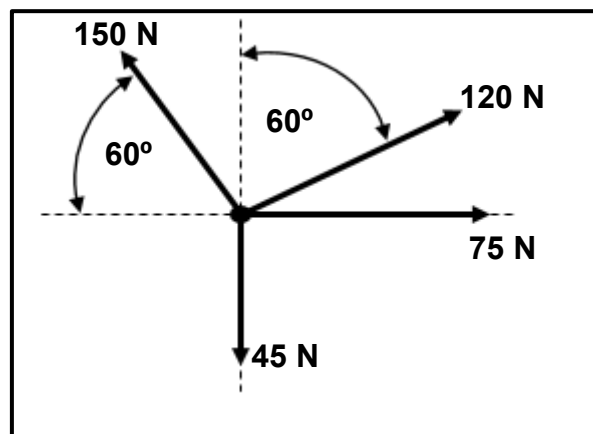


FIGURE 8.1

Calculate the following:

- |       |   |     |
|-------|---|-----|
| 8.1.1 | Sum of the horizontal components and the sum of the vertical components | (8) |
| 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.

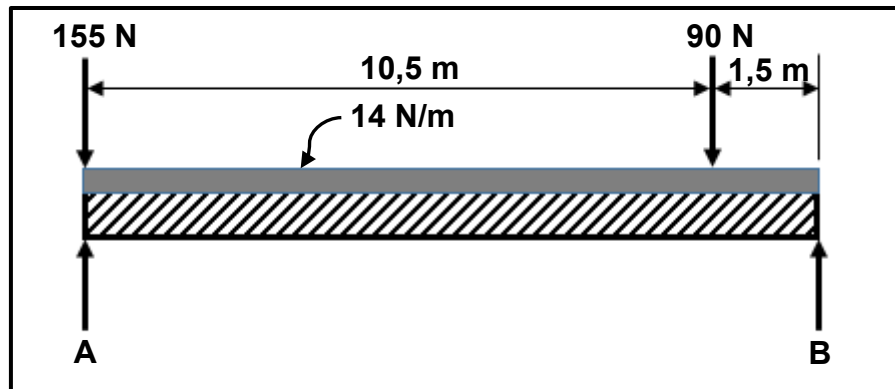


FIGURE 8.2

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 FIGURE 8.3 below shows a stress-strain diagram. Label **A–C**.

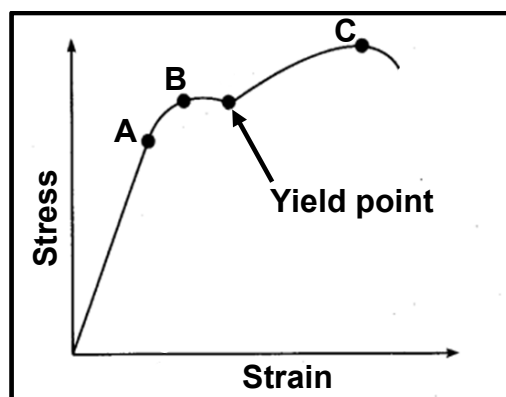


FIGURE 8.3

(3)

- 8.4 A tensile stress of 28,56 MPa is generated in a 45 mm round brass bar. The original length of the bar is 350 mm and Young's modulus for brass is 90 GPa.

Calculate the following:

- 8.4.1 The load that is applied on the brass bar in Newton (5)

- 8.4.2 The change in length in millimetres if the strain caused by the load is 0,0003 (3)

[33]

### QUESTION 9: MAINTENANCE (SPECIFIC)

- 9.1 Complete the following definition for thermoplastics by filling in the missing words. Write only the words next to the question numbers (9.1.1 to 9.1.4) in the ANSWER BOOK.

Thermoplastics can be (9.1.1) ... and therefore (9.1.2) ... in various ways. This type of plastic can be (9.1.3) ... because it softens when (9.1.4) ... and hardens on cooling.

(4)

- 9.2 Give the reason for conducting adjustments and parts replacement during preventative maintenance.

(1)

- 9.3 Name THREE types of thermo-hardened composites.

(3)

- 9.4 Name FOUR types of thermoplastic composites.

(4)

- 9.5 State THREE preventative maintenance measures on chain drives.

(3)

- 9.6 What type of composite material is used to manufacture the following products?

9.6.1 Bushes

(1)

9.6.2 Frying pan coatings

(1)

9.6.3 Distributor rotors

(1)

**[18]**

### QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 State what the following terms represent in a M24 x 2,75 screw thread:

10.1.1 M (1)

10.1.2 24 (1)

10.1.3 2,75 (1)

10.2 A two-start square screw thread needs to be cut on a lathe. The lead of the thread is 36 mm and the crest diameter is 70 mm. The clearance angle must be  $3^\circ$ .

Calculate the following:

10.2.1 Pitch diameter (5)

10.2.2 Helix angle of the screw thread (3)

10.2.3 Leading tool angle (2)

10.2.4 Following tool angle (2)

10.3 Label parts **A–C** of the V-screw thread shown in FIGURE 10.3 below.

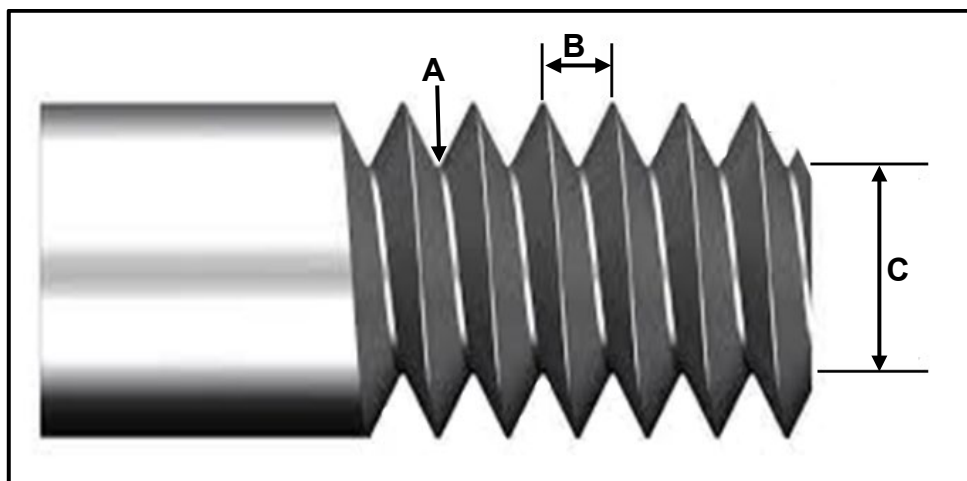
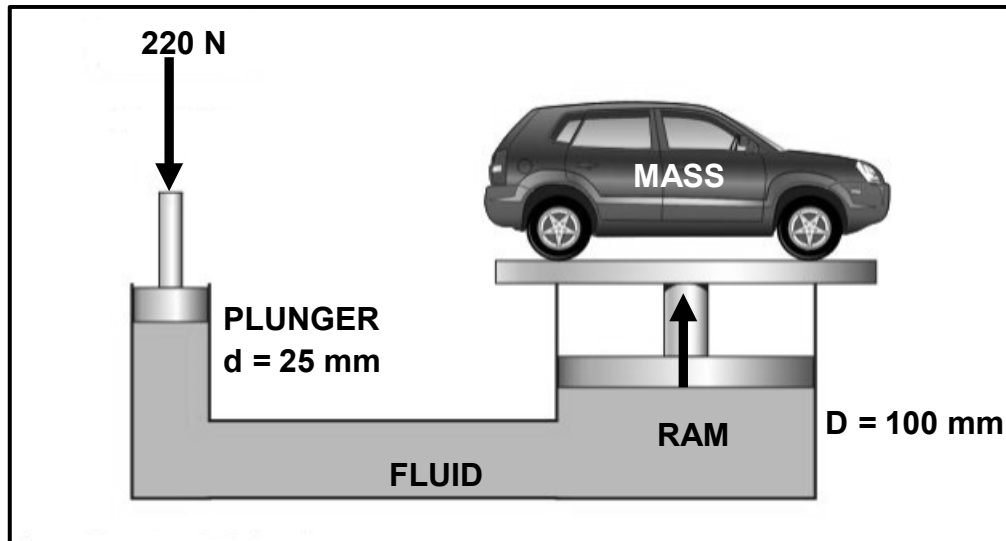


FIGURE 10.3

(3)  
[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 area of the ram (2)
- 11.1.2 The mass in **kg** which can be raised by the hydraulic lift (ram) if the pressure in the system is 6,36 MPa (5)
- 11.2 Name TWO components other than the ram, plunger and hydraulic fluid (oil) utilised in a hydraulic system. (2)
- 11.3 Name ONE basic design of a pump used in hydraulic systems. (1)



- 11.4 The belt drive system on a compressor is shown in FIGURE 11.4 below. The tensile force in the tight side of the belt is 450 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 may be ignored.)

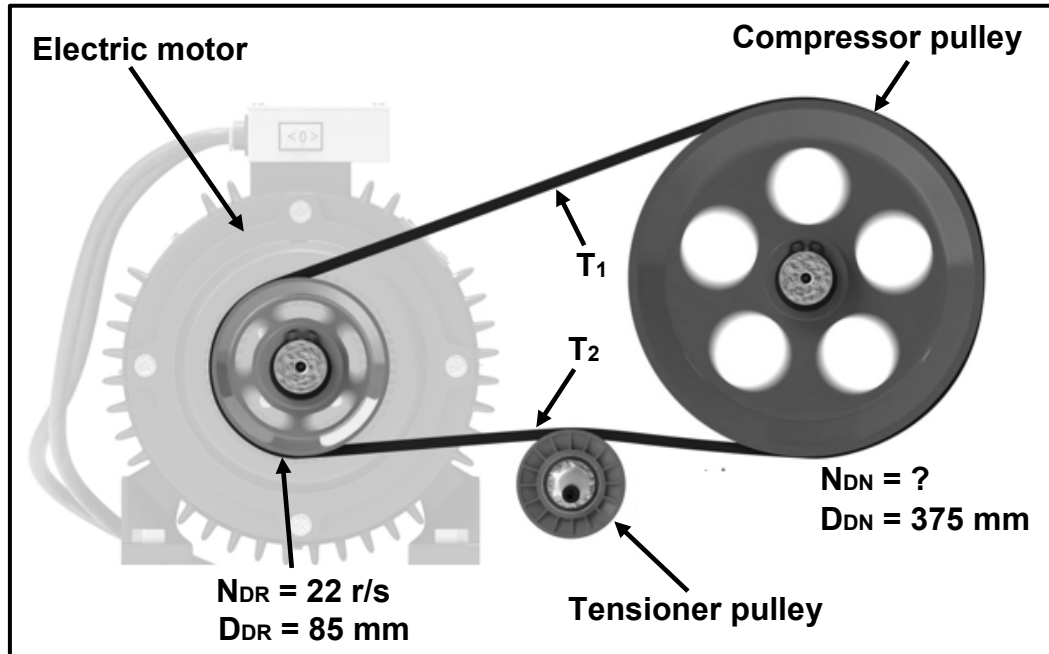


FIGURE 11.4

Calculate the following:

- 11.4.1 The rotational frequency of the driven pulley on the compressor in r/s (3)
- 11.4.2 The power transmitted in kW (5)

11.5 FIGURE 11.5 below shows a gear drive system in a gearbox.

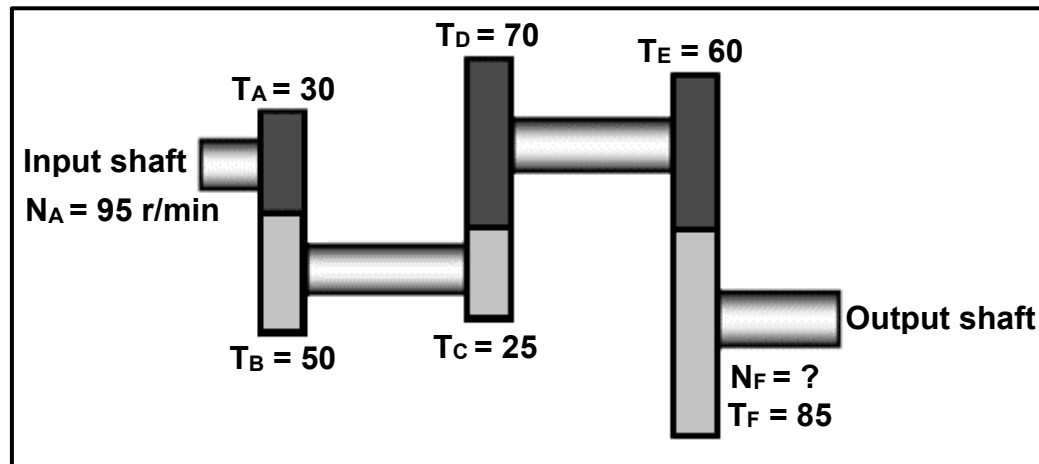


FIGURE 11.5

Calculate the following:

11.5.1 The rotation frequency of the output shaft in r/min (4)

11.5.2 The speed ratio (3)

11.6 William applies a force of 750 N to a lever. The torque created by this force is 712,5 Nm. Calculate the length of the lever. (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  $Belt\ mass = Area \times Length \times Density$  ( $A$  = thickness  $\times$  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  $Open-belt\ length = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$

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

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

1.12  $Torque = Force \times Radius$

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

## 2. STRESS AND STRAIN

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

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

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

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

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

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

## 3. HYDRAULICS

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

$$3.2 \quad \text{Volume} = \text{Area} \times \text{Stroke length} \quad (l \text{ or } s)$$

$$3.3 \quad \text{Work done} = \text{Force} \times \text{Distance}$$

$$3.4 \quad P_A = P_B$$

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

## 4. GEAR DRIVES

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

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

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

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

$$4.5 \quad \text{Torque} = \text{Force} \times \text{Radius}$$

$$4.6 \quad \text{Torque transmitted} = \text{Gear ratio} \times \text{Input torque}$$

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

$$4.8 \quad \text{Pitch - circle diameter} = \frac{\text{Circular pitch} \times \text{Number of teeth}}{\pi} \quad \text{OR} \quad PCD = \frac{CP \times T}{\pi}$$

$$4.9 \quad \text{Outside diameter (OD)} = PCD + 2(m)$$

$$4.10 \quad \text{Addendum} = \text{Module} \quad \text{OR} \quad a = m$$

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

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

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

$$4.14 \quad \text{Circular pitch (CP)} = m \times \pi$$

$$4.15 \quad \text{Working depth (WD)} = 2 \times m \quad \text{OR} \quad \text{Working depth (WD)} = 2 \times a$$

## 5. KEYWAYS

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

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

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

Where:

$D$  = Diameter of shaft

$$5.4 \quad \text{Standard taper for taper key: } 1 \text{ in } 100 \text{ or } 1 : 100$$

## 6. CINCINNATI DIVIDING HEAD TABLE FOR MILLING MACHINE

<i>Hole circles</i>											
<i>Side 1</i>	24	25	28	30	34	37	38	39	41	42	43
<i>Side 2</i>	46	47	49	51	53	54	57	58	59	62	66
<i>Change gears</i>											
<i>Gears</i>	$24 \times 2$	28	32	40	44	48	56	64	72	86	100

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

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

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  
 $\theta$  = Dovetail included angle (normally  $60^\circ$ )  
 $h$  = Height of dovetail  
 $w$  = Minimum width of dovetail  
 $W$  = Maximum width of dovetail  
 $m$  = Distance between rollers  
 $M$  = Distance over rollers

## 8. TAPERS

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

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

## 9. SCREW THREADS

$$9.1 \quad \text{Mean diameter} = \text{Outside diameter} - (\frac{1}{2} \times \text{Pitch}) \quad \text{OR} \quad D_m = OD - \frac{P}{2}$$

$$9.2 \quad \text{Effective diameter } (D_{\text{eff}}) = \text{Pitch diameter } (D_p) = \text{Mean diameter } (D_m)$$

$$9.3 \quad \text{Lead} = \text{Pitch} \times \text{Number of starts}$$

$$9.4 \quad \text{Height of screw thread} = 0,866 \times \text{Pitch } (P)$$

$$9.5 \quad \text{Depth of screw thread} = 0,613 \times \text{Pitch } (P)$$

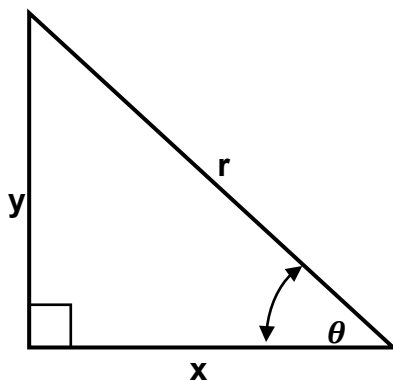
$$9.6 \quad \text{Helix angle: } \tan \theta = \frac{\text{Lead}}{\pi \times D_m}$$

$$9.7 \quad \text{Leading angle} = 90^\circ - (\text{Helix angle} + \text{Clearance angle})$$

$$9.8 \quad \text{Following angle} = 90^\circ + (\text{Helix angle} - \text{Clearance angle})$$

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

## 10. PYTHAGORAS' THEOREM AND TRIGONOMETRY



$$10.1 \quad \sin \theta = \frac{y}{r}$$

$$10.2 \quad \cos \theta = \frac{x}{r}$$

$$10.3 \quad \tan \theta = \frac{y}{x}$$

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