basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2024

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 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**

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 your 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?

Do NOT …

A   remove anything that is stuck to the wound.
B   check the pulse of the patient.
C   give attention to the loss of blood or breathing difficulties.
D   check the surroundings for dangerous objects.   (1)

1.2   Where more than … employees are employed at a workplace, the employer must provide an accessible first-aid box.

A   2
B   3
C   4
D   5   (1)

1.3   What causes accidents when working with revolving machinery, such as a bench grinder?

A   Overconfidence
B   Correct wheel size
C   Gap between tool rest and grinding wheel not exceeding 3 mm
D   Correctly rated grinding wheel for the bench grinder   (1)

1.4   Which test does NOT damage a work piece?

A   Spark test
B   Sound test
C   Bending test
D   Machining test   (1)

1.5   Which of the following products is case-hardened?

A   Tin cans
B   Machine guards
C   Hand files
D   Gears and cams   (1)

1.6   Which process is the first step in the production of high-strength steel?

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

QUESTION 2: SAFETY (GENERIC)

2.1   State TWO safety precautions that must be adhered to after the horizontal band saw has been switched on.   (2)

2.2   Name the THREE stages when basic first-aid treatment is given to help an injured person.   (3)

2.3   Why must oil or grease NOT be in contact with the oxygen fittings when handling oxygen cylinders?   (1)

2.4   State TWO disadvantages of the process workshop layout.   (2)

2.5   State TWO advantages of the product workshop layout.   (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1   State if the following materials are easy or hard to file during a filing test:

      3.1.1   Cast iron   (1)

      3.1.2   Cast steel   (1)

      3.1.3   Mild steel   (1)

3.2   Explain what *heat treatment* is.   (3)

3.3   Explain what the effects will be if metal is heated too fast during the heat-treatment process.   (4)

3.4   Name the TWO types of steel best suited for case hardening.   (2)

3.5   Explain the reason for tempering steel during the heat-treatment process.   (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.

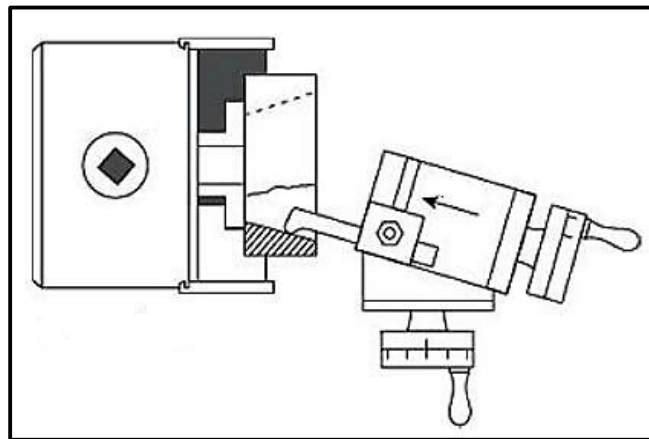4.1   Identify the lathe procedure shown in FIGURE 4.1 below.

FIGURE 4.1

      A   Parallel boring
      B   Internal taper cutting
      C   Internal drilling
      D   Taper measuring   (1)

4.2   Identify the CORRECT statement below regarding a safety precaution of a lathe machine after it has been switched on:

      A   Never lean on the lathe.
      B   Make sure all guards are in place.
      C   Remove all jewellery.
      D   Check that there is no oil or grease on the floor around the machine.   (1)

4.3   Machining on a centre lathe that is unbalanced results in …

      A   a good finish.
      B   clatter on the gear teeth.
      C   less wear of machine parts.
      D   no vibrations.   (1)

4.4   Which of the following are basic codes used during coding of CNC machines?

      A   E-codes
      B   F-codes
      C   G-codes
      D   H-codes   (1)

4.5   How should you take care of a moment tester?

      A   Store the equipment in a moist area.
      B   Leave all mass pieces to avoid mass pieces from being stolen.
      C   Add mass pieces very quickly.
      D   All nuts and bolts should be secured properly.   (1)

4.6   Identify the reading shown in FIGURE 4.6 below when a 25–50 mm interchangeable rod is used with the micrometer.
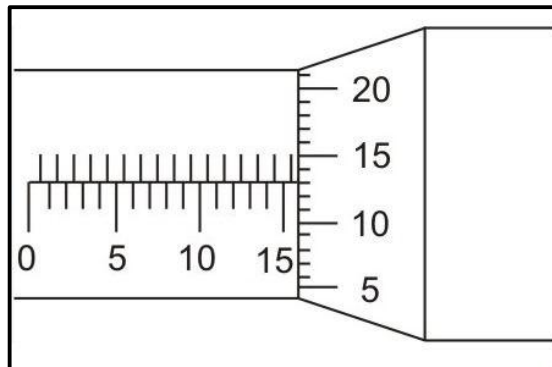

FIGURE 4.6

      A   40,17 mm
      B   40,23 mm
      C   40,13 mm
      D   40,63 mm   (1)

4.7   Which ONE of the following is a factor that governs the value of the safety factor?

      A   The value of the minimum load
      B   The consequences of success
      C   The effect of corrosion and wear
      D   The unreliability of the material   (1)

4.8   What is the unit for strain?

      A   No unit
      B   Pascal
      C   Millimetres
      D   Metres   (1)

4.9   Which type of material is used to make water pipes?

      A   Teflon
      B   PVC
      C   Vesconite
      D   Bakelite   (1)

4.10   Which of the following describes coefficient of friction?

    A   It is the minimum force needed to stop an object moving on a surface, divided by the forces pressing them together.

    B   It is the maximum force needed to stop an object moving on a surface, divided by the forces pressing them together.

    C   It is the minimum force needed to get an object to move on a surface, divided by the forces pressing them together.

    D   It is the maximum force needed to get an object to move on a surface, divided by the forces pressing them together.   (1)

4.11   Which statement below describes metric square screw thread CORRECTLY?

    A   Square thread is a screw thread where the width of the screw thread, the depth of the screw thread and the space between the threads are approximately equal.

    B   Square thread is a screw thread where the total length of the screw thread, the minimum thickness of the screw thread and the space between the threads are approximately equal.

    C   Square thread is a screw thread where only the width of the screw thread and the minor depth of the screw thread are approximately equal.

    D   Square thread is a screw thread where only the total depth of the screw thread and the minimum space between the threads are approximately equal.   (1)

4.12   Where are multiple screw threads mostly used?

    A   Where greater holding strength is needed
    B   Where slow motion is needed to turn the screw
    C   Where parallel motion is needed
    D   Where quick motion is needed   (1)

4.13   Where would you find a radial piston pump?

    A   Hydraulic system
    B   Gear system
    C   Pneumatic system
    D   Pulley system   (1)

4.14   Which ONE of the following is a function of a reservoir in a hydraulic system?

    A   Controls the flow of hydraulic pressure
    B   Prevents any heat dispersion
    C   Promotes air separation from the fluid
    D   Pumps the hydraulic fluid through the system   (1)
    [14]

                      Please turn over

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

5.1   State THREE disadvantages of cutting a taper on a lathe machine using the compound slide method.   (3)

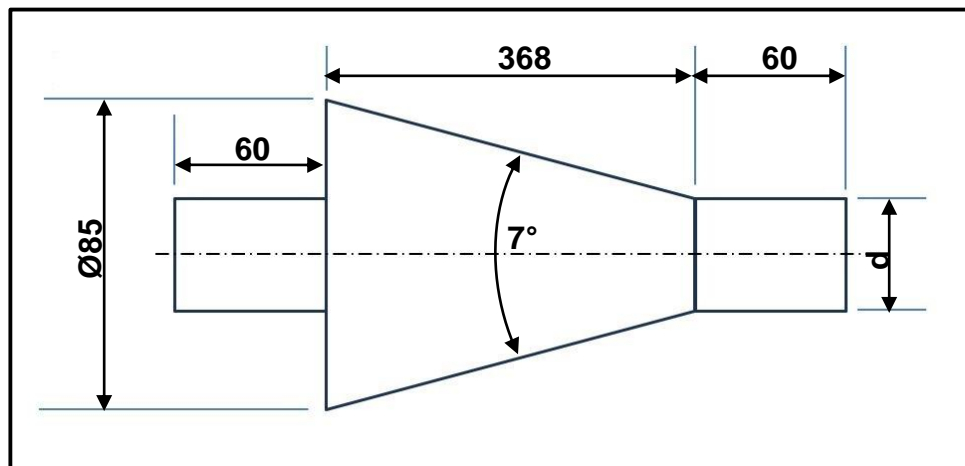5.2   FIGURE 5.2 below shows a taper with an included angle of 7° that should be machined between centres.

FIGURE 5.2

5.2.1   Calculate the small diameter (d) of the taper.   (4)

5.2.2   Calculate 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 105 mm diameter shaft that must be used in a gearbox:

5.3.1   Width   (2)

5.3.2   Thickness   (2)

5.3.3   Length   (2)

5.4   State TWO safety measures when working with a milling machine.   (2)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1   A spur gear with a pitch-circle diameter of 186 mm and a module of 3 must be cut for an engineering firm.

Calculate the following:

6.1.1   Circular pitch   (2)

6.1.2   Number of teeth   (3)
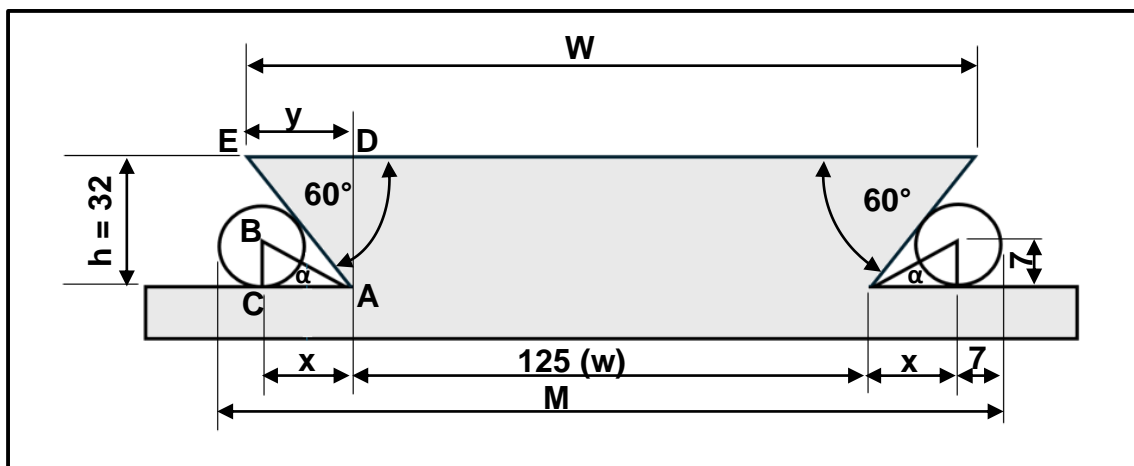
6.1.3   Dedendum   (2)

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 101 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   (4)

6.3.2   Change gears that are required   (5)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1   A Brinell hardness tester is prepared to conduct a hardness test on a specimen. Answer the questions that follow.

   7.1.1   Where on the hardness tester is the specimen placed to conduct the test? (1)

   7.1.2   State TWO methods to determine the Brinell Hardness Number (BHN). (2)

7.2   FIGURE 7.2 below shows a V-screw thread micrometer. Label **A–D**.
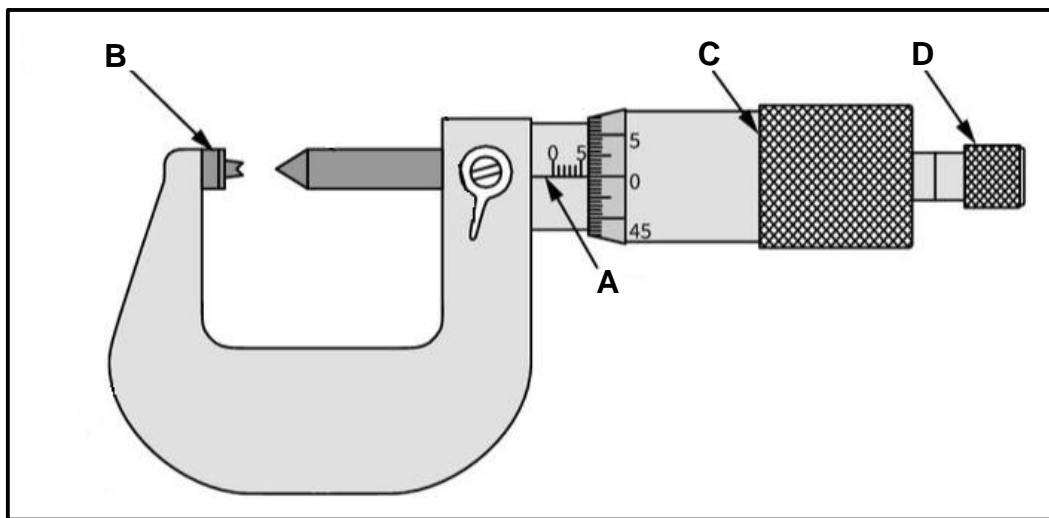

FIGURE 7.2 (4)

7.3   What is the function of a screw-thread micrometer? (2)

7.4   Calculate the height of a M24 x 2,5 screw thread. (2)

7.5   Explain how the reading of a depth micrometer differs from the reading of a screw-thread micrometer. (1)

7.6   Why are interchangeable rods used with depth micrometers? (1)

[13]

QUESTION 8: FORCES (SPECIFIC)

8.1   FIGURE 8.1 below shows a system of 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.
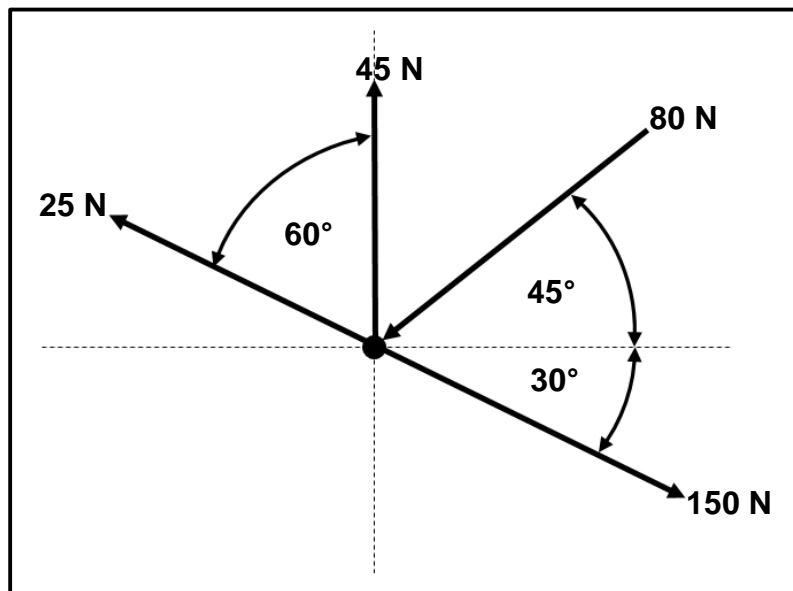
FIGURE 8.1

Calculate the following:

8.1.1   Sum of the horizontal components   (4)

8.1.2   Sum of the vertical components   (5)

8.1.3   Magnitude of the resultant   (2)

8.1.4   Angle and direction of the equilibrant   (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.
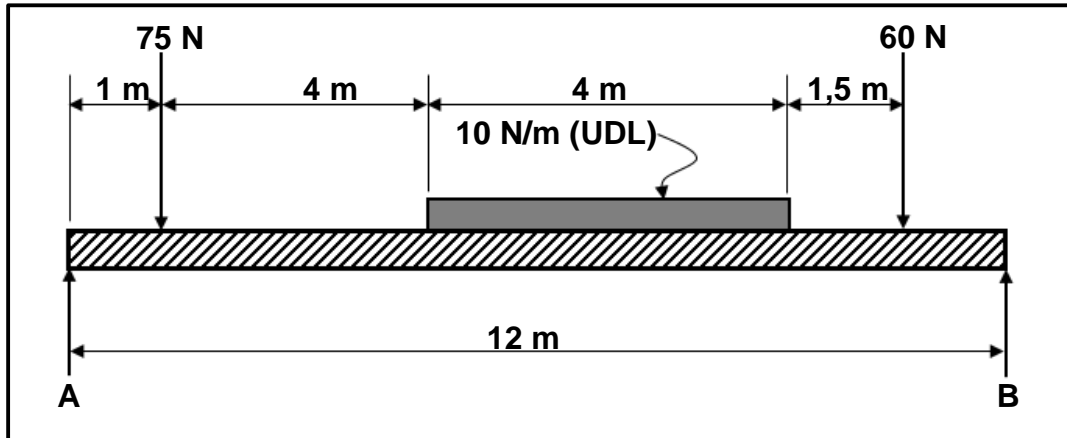
FIGURE 8.2

Calculate the following:

8.2.1   The point load representing the UDL   (2)

8.2.2   The reactions in supports **A** and **B**   (8)

8.3   A pulling force of 110 kN is applied to a solid mild-steel shaft. The resistance area of the shaft is 7,07 x 10^{-4} m^2. After the force has been applied to the shaft, the original length extends by 0,0001 m.

Calculate the following:

8.3.1   The stress in the material in MPa   (2)

8.3.2   The diameter of the shaft in mm   (4)

8.3.3   The original length of the shaft in millimetres if the strain is 1,64 x 10^{-5} (3)

[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1   Name THREE different types of mechanical drives.   (3)

9.2   Why is it necessary to conduct maintenance on operating systems or machines?   (2)

9.3   State THREE preventative maintenance procedures to ensure that gear drives work properly.   (3)

9.4   State the TWO subgroups that preventative maintenance is divided into.   (2)

9.5   Why are polyester resins used with glass fibre?   (1)

9.6   State THREE consequences due to a lack of preventative maintenance.   (3)

9.7   Explain the difference between *thermo-hardened* and *thermoplastic* composites.   (4)
[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1   A four-start square thread needs to be manufactured. The lead of the square thread is 40 mm and the crest diameter is 105 mm. The clearance angle must be 4°.

           Calculate the following:

           10.1.1   Pitch diameter   (4)

           10.1.2   Helix angle of the thread   (4)

           10.1.3   Leading angle   (2)

           10.1.4   Following angle   (2)

10.2   FIGURE 10.2 below shows a square thread. Label **A**–**D**.
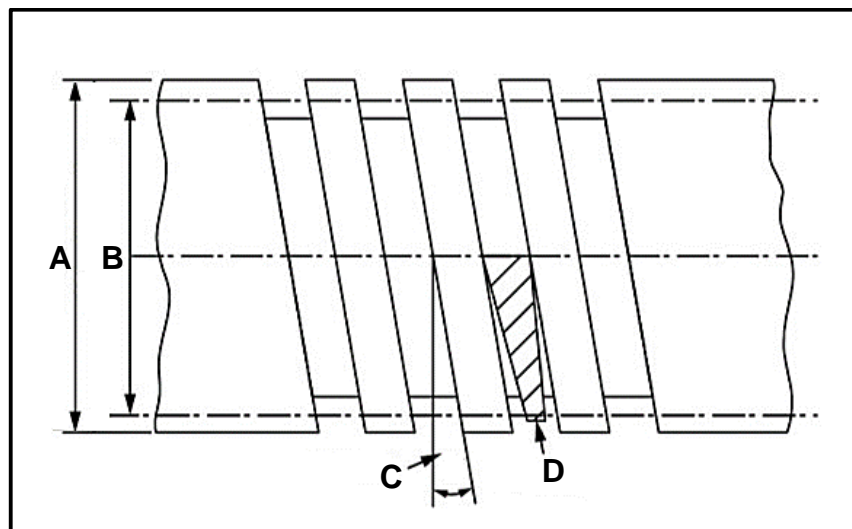
FIGURE 10.2   (4)

10.3   State TWO uses of square threads in the workshop environment.   (2)

                                                                            [18]

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

11.1   FIGURE 11.1 below shows a hydraulic press.
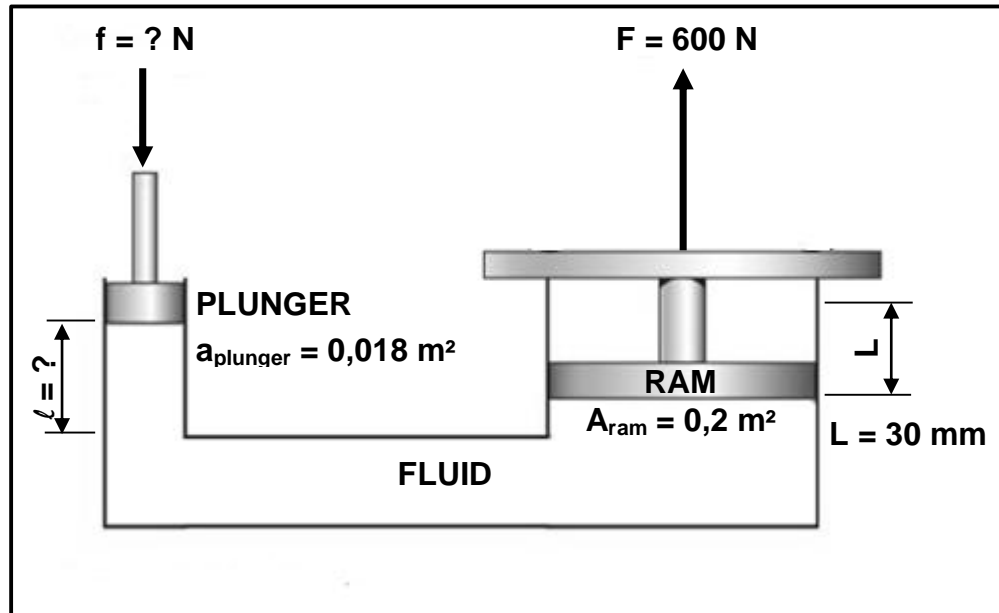
FIGURE 11.1

Calculate the following:

11.1.1   Fluid pressure in the hydraulic system in Pa   (2)

11.1.2   Force applied on the plunger   (3)

11.1.3   The displacement (ℓ) of the plunger in mm   (3)

11.2   Which component is used to determine the hydraulic pressure?   (1)

11.3   State the purpose of a hydraulic filter.   (1)

11.4   FIGURE 11.4 below shows a hydraulic valve. Answer the questions that follow.
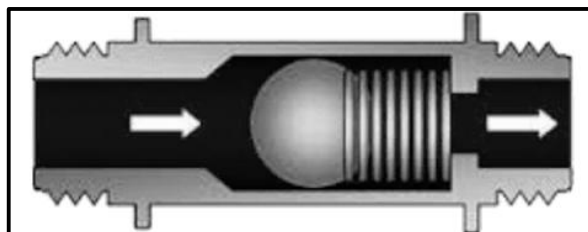
FIGURE 11.4

11.4.1   Identify the valve.   (1)

11.4.2   State TWO functions of the valve.   (2)

11.5   The belt drive system of a compressor is shown in FIGURE 11.5 below.

N_{DN} = 1 100 r/min
D_{DN} = 600 mm

Pulley linked to compressor

D_{DR} = 220 mm
N_{DR} = ? r/min

Pulley linked to motor
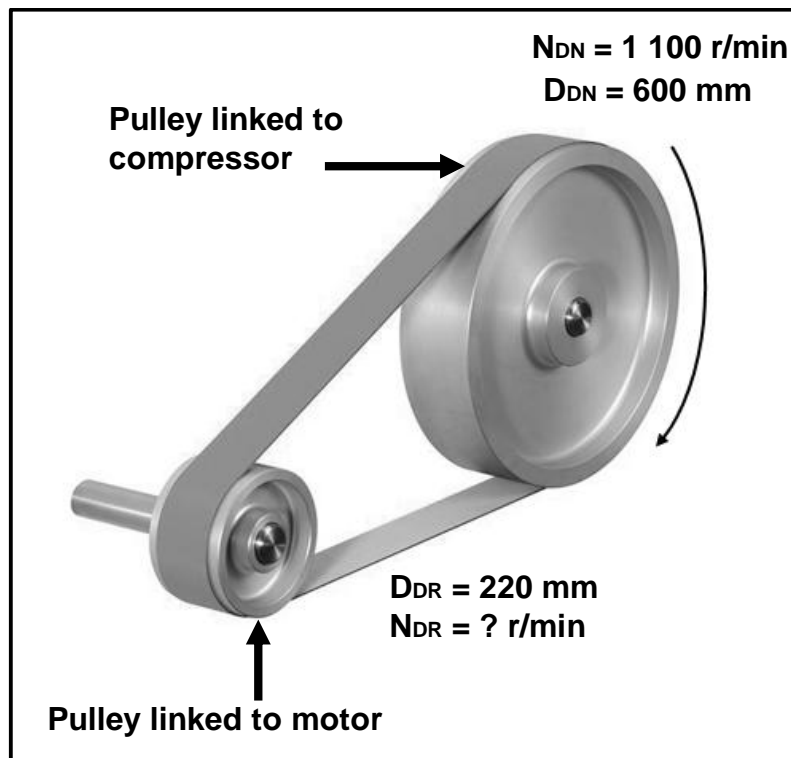
FIGURE 11.5

Calculate the following:

11.5.1   The rotational frequency of the drive pulley in r/s   (4)

11.5.2   The torque on the driven pulley if the power transmitted is 236,65 kW   (3)

11.6   FIGURE 11.6 below shows a gear drive system connected to an electric motor.

N_A = 980 r/min
T_A = 45

T_C = 20

N_D = ? r/min
T_D = 42

Output shaft

Electric motor

T_B = 24
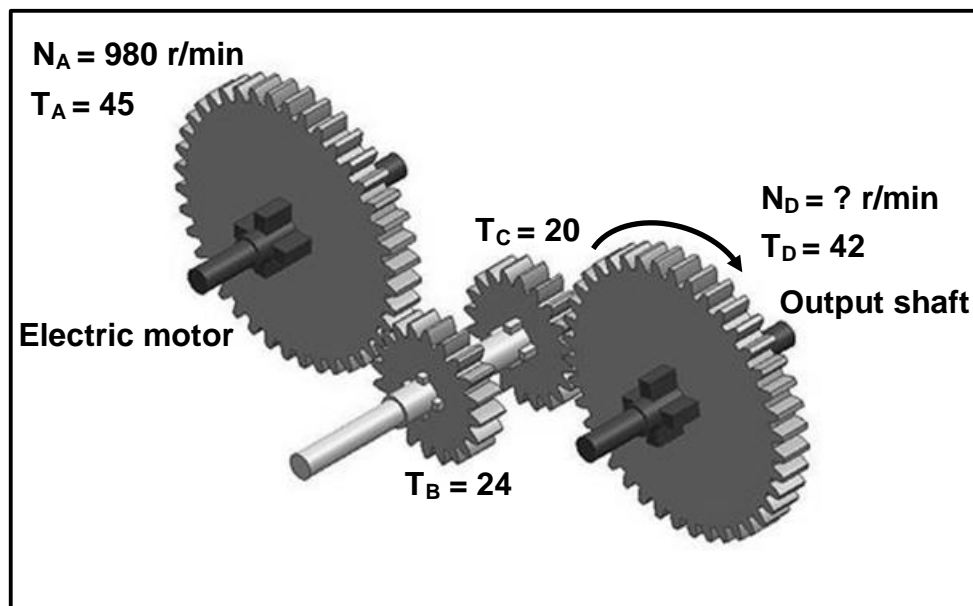
FIGURE 11.6

Calculate the following:

11.6.1   Rotation frequency of the output shaft in r/s if the electric motor rotates at 980 r/min   (4)

11.6.2   Gear ratio   (3)

11.6.3   The direction in which the shaft of the electric motor will rotate if the output shaft rotates clockwise   (1)

[28]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY:
FITTING AND MACHINING

1.   BELT DRIVES

1.1   *Belt speed* = $\dfrac{\pi DN}{60}$

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

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

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

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

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

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

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

     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* = $\dfrac{T_1}{T_2}$

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

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

1.12   *Torque = Force × Radius*

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

2. STRESS AND STRAIN

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

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

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

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

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

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

3. HYDRAULICS

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

3.2 $Volume = Area \times Stroke\ length$ $(l\ or\ s)$

3.3 $Work\ done = Force \times Distance$

3.4 $P_A = P_B$

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

4. GEAR DRIVES

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

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

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

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

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

OR

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

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) =* $\dfrac{D}{4}$

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

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 =* $\dfrac{40}{n}$ *(n = number of divisions)*

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

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

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

9.   SCREW THREADS

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

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 θ =* $\dfrac{Lead}{\pi \times D_m}$

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 $Sin\ \theta = \dfrac{y}{r}$

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

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

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