basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2019

MARKS: 200

TIME: 3 hours

This question paper consists of 14 pages and a 4-page formula sheet.

INSTRUCTION AND INFORMATION

1.   Write your centre and examination number 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 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
	GENERICS		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	SPECIFICS		
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 (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 The workplace is organised by national policies and procedures dealing with HIV/Aids. What is the purpose of this code of practice?

    A   The act on safety states that all employers must make sure that the workplace is safe and that employees are not at risk of becoming ill or injured at work.

    B   The act contains common guidelines on how employers, employees and trade unions should respond to HIV/Aids in the workplace.

    C   Employers may not demote or promote an employee based on his/her HIV/Aids status.

    D   Employers may dismiss a person who is infected with HIV/Aids. (1)

1.2 During which ONE of the following work processes do you have to wear a helmet to prevent harmful ultra violet rays?

    A   Lathe work
    B   Angle grinding
    C   MIG/MAGS welding
    D   Drilling (1)

1.3 Which ONE of the following describes a workshop layout?

    A   Process layout
    B   Drill layout
    C   Inspection layout
    D   Receiving layout (1)

1.4 Which heat treatment process is used to increase the surface hardness of a steel shaft?

    A   Annealing
    B   Tempering
    C   Case hardening
    D   Normalising (1)

1.5 The purpose of hardening steel is to …

    A   increase the resistance against denting.
    B   increase the toughness.
    C   soften it.
    D   improve the welding results. (1)

1.6 Which ONE of the following tests can be classified as a non-destructive test?

    A   Bend
    B   Machinability
    C   X-ray
    D   Nick-break   (1)
    [6]

QUESTION 2: SAFETY (GENERIC)

2.1 State ONE important safety rule that should be adhered to before any machine in the mechanical workshop is switched on. (1)

2.2 Give ONE reason why you need to clamp down a small work piece before any drilling is done. (1)

2.3 State TWO safety rules you should observed before a hydraulic press is used. (2)

2.4 Give TWO reasons why you have to use surgical gloves when treating a co-worker with open wounds. (2)

2.5 State TWO safety precautions that must be taken into consideration for the safe handling of portable electrical equipment. (2)

2.6 State ONE responsibility of an **employer** regarding safety in the work place. (1)

2.7 State ONE responsibility of an **employee** regarding safety in the work place. (1)
    [10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Explain how you will prevent damage to a file when conducting a filing test on a hard metal. (2)

3.2 What is the purpose of the heat treatment of steel? (2)

3.3 Give TWO reasons for tempering hardened steel. (4)

3.4 Describe how the following heat treatment processes are carried out on steel:

    3.4.1   Annealing   (3)

    3.4.2   Hardening   (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 Which ONE of the following is an advantage of the tailstock set-over method for taper turning on the centre lathe?

  A Long tapers can be cut
  B Internal tapers can be cut
  C Tapers with large included angles can be cut
  D Large cuts can be done (1)

4.2 Identify the milling process in FIGURE 4.2 below.
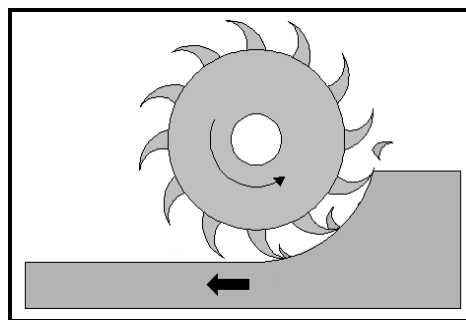
FIGURE 4.2

  A Down-cut milling
  B Gang milling
  C Straddle milling
  D Up-cut milling (1)

4.3 Which indexing process using the universal dividing head will be the easiest method to cut a gear with 30 teeth?

  A Rapid indexing
  B Simple indexing
  C Angular indexing
  D Differential indexing (1)

4.4 What is meant by the term *incremental programming* on a three-axis digital read-out system on a computer numeric control (CNC) machine?

  The point of reference is taken from …

  A the previous point.
 B the zero point.
  C a common point.
  D any point. (1)

4.5   Which hardness tester uses a steel ball to determine the hardness of steel?

        A   Rockwell
        B   Brinell
        C   Vickers
        D   Pascal   (1)

4.6   Which ONE of the following statements describes the function of the moment
        tester?

        A   Illustrates the concept of the triangle of forces
        B   Determines the reactions on either side of a loaded beam
        C   Illustrates the concept of the parallelogram of forces
        D   Determines the reaction on one side of a simply loaded beam   (1)

4.7   What is the measure unit for Young's modulus of elasticity?

        A   Newton
        B   Pascal
        C   No unit
        D   Newton per metre   (1)

4.8   Turning moment is defined by …

        A   force x distance.
        B   force x pressure.
        C   pressure x area.
        D   pressure x distance.   (1)

4.9   Which ONE of the following materials is classified as a thermosetting (thermo-
        hardened) composite?

        A   Nylon
        B   Teflon
        C   Fibre glass/Glass fibre
        D   Vesconite   (1)

4.10   What can be done to reduce the friction force between two different
        materials?

        A   Increasing the weight of the object
        B   Adding lubrication between the surfaces
        C   Change the cross-sectional area of the materials used
        D   Decreasing the speed between the two objects   (1)

4.11   What is the included angle of a metric V-screw thread?

A   45°
B   29°
C   55°
D   60°   (1)

4.12   Which statement defines the helix angle of a screw thread? The angle that …
of the thread.

A   crest diameter makes with a line perpendicular (90°) to the axis
B   thread makes with a line perpendicular (90°) to the axis
C   centre line makes with a line perpendicular (90°) to the axis
D   thread makes with a line perpendicular (90°) to the flank   (1)

4.13   Which ONE of the following statements is an advantage of a belt drive system
when compared to a gear drive system?

A   Drive can take place over a long distance.
B   Less expensive lubrication is used.
C   More power can be transmitted.
D   Power transmission without slip is possible.   (1)

4.14   Which law describes the operation of hydraulics?

A   Boyle's law
B   Pascal's law
C   Ohm's law
D   Bernoulli's principle   (1)
                                                                                               [14]

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

5.1   FIGURE 5.1 below shows the set-up of a taper with an included angle of 8°, to be machined between centres.
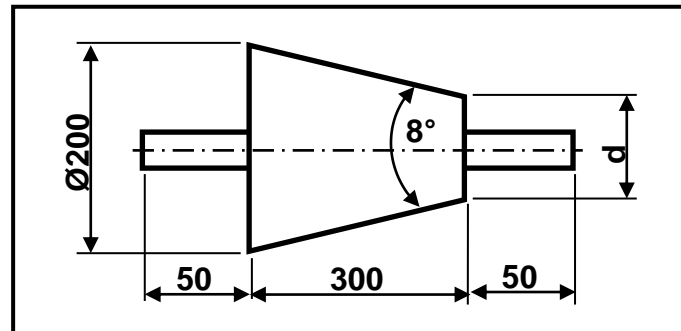
FIGURE 5.1

  5.1.1   Calculate the small diameter **(d)** of the taper.   (5)

  5.1.2   Calculate the tailstock set-over required for cutting the taper in FIGURE 5.1.   (3)

5.2   Calculate the following dimensions of a parallel key suitable for a 42 mm diameter shaft:

  5.2.1   Width   (2)

  5.2.2   Thickness   (2)

5.3   State TWO advantages of down-cut milling.   (2)

5.4   Use a neatly labelled sketch to show straddle milling.   (4)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1   A spur gear has a pitch-circle diameter of 126 mm with 42 teeth.

        Calculate the following:

  6.1.1   Module   (2)

  6.1.2   Working depth   (2)

  6.1.3   Cutting depth   (2)

6.2   Calculate the required angular indexing for an angle of 34°.   (4)

6.3   A gear with 121 teeth must be cut on a universal milling machine with the help of a Cincinnati dividing head (40 **:** 1 ratio).

Calculate the following:

6.3.1   The differential indexing required (choose 120 teeth)   (5)

6.3.2   The change gears required   (5)

6.4   FIGURE 6.4 below shows a dovetail groove. Calculate distance **Z** between the rollers in the figure. Ø10 mm rollers are used for the measuring.
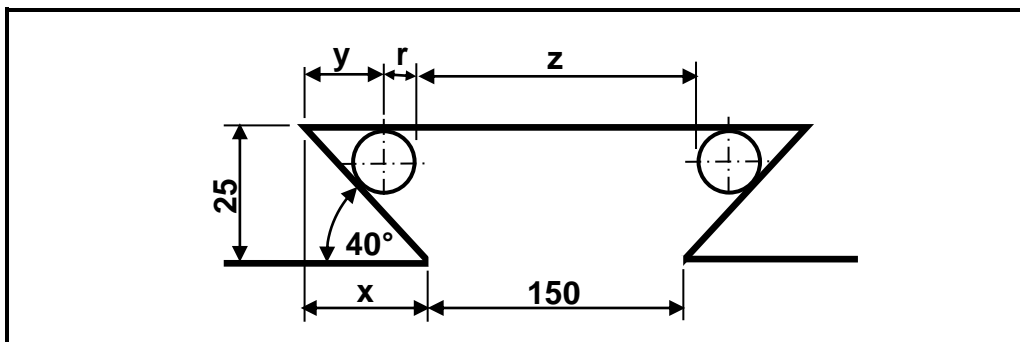

FIGURE 6.4   (8)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1   Draw TWO neatly labelled sketches to indicate the difference between the indentation of the Brinell hardness tester and the Rockwell hardness tester.   (4)

7.2   State TWO properties of materials that can be determined by preforming a tensile test with the tensile tester.   (2)

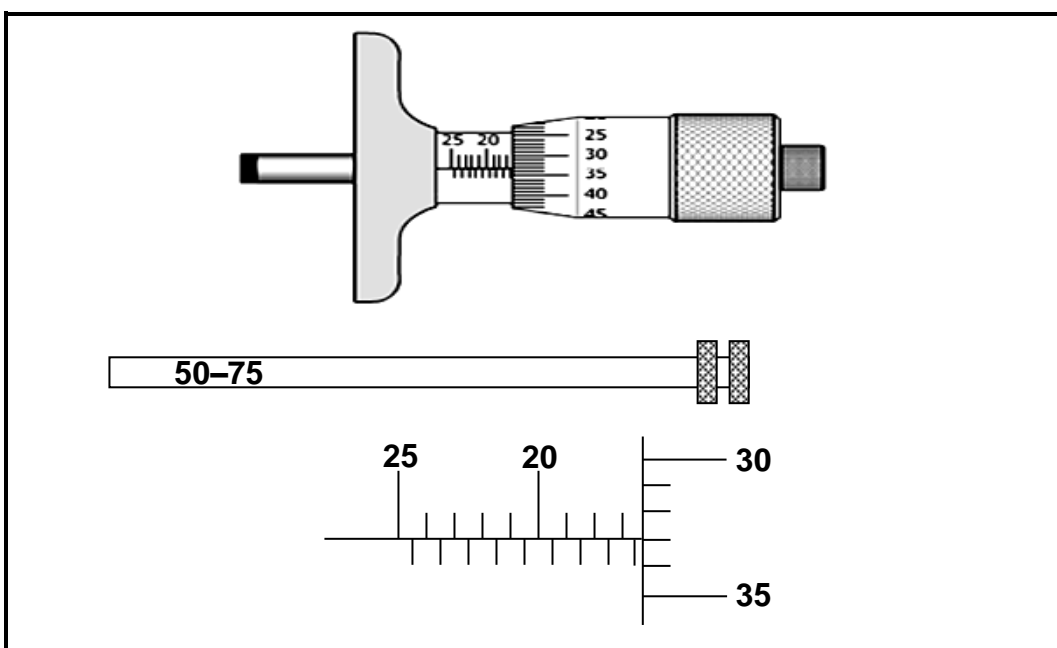7.3   What is the reading on the depth micrometer shown in FIGURE 7.3 below?

FIGURE 7.3   (5)

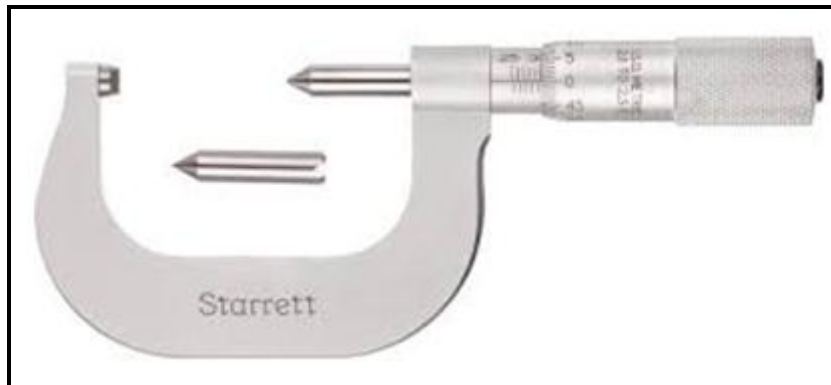7.4   Identify the instrument in FIGURE 7.4 below.

FIGURE 7.4   (2)
[13]

QUESTION 8: FORCES (SPECIFIC)

8.1   FIGURE 8.1 below shows a system of forces with four coplanar forces acting onto the same point. Use calculations and determine the magnitude and direction of the equilibrant of this system of forces.

   HINT: Draw and complete the diagram in FIGURE 8.1 in your ANSWER BOOK. Show ALL the horizontal and vertical components before you do the calculations.
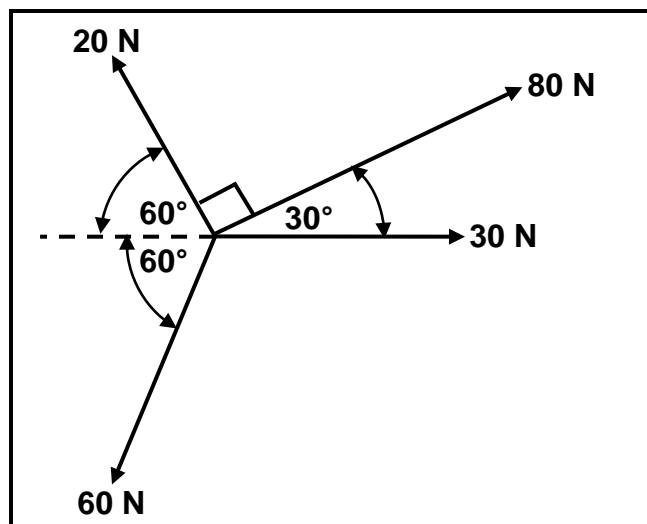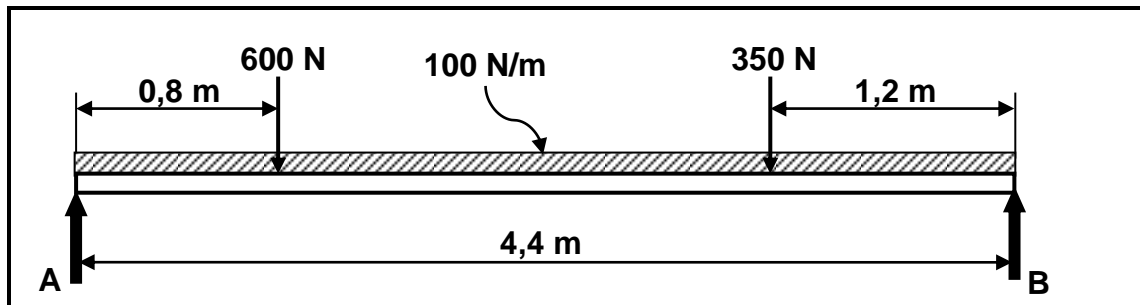

FIGURE 8.1   (14)

8.2   The diagram in FIGURE 8.2 below shows a beam supported by two vertical supports, **A** and **B**. Calculate the magnitude of the reactions in supports **A** and **B**.

Draw and complete the diagram in FIGURE 8.2 in your ANSWER BOOK. Indicate the point load replacing the distributed load.

FIGURE 8.2   (8)

8.3   A mild-steel bush, 100 mm long, with an inner diameter of 25 mm and an outside diameter of 40 mm, is used in a hydraulic press to press out bearings. A force of 600 N is exerted on the bush.

8.3.1   State the type of stress in the bush material.   (1)

8.3.2   Calculate the stress in the bush material.   (4)

8.3.3   Calculate how much the bush will shorten under the given load. Take Young's modules of elasticity as 90 GPa. Give your answer in mm.   (6)

**[33]**

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1   State THREE types of maintenance procedures used on mechanical systems.   (3)

9.2   State TWO causes of the malfunctioning of belt drive systems.   (2)

9.3   Briefly explain the procedure to replace the chain on a chain drive system.   (5)

9.4   State TWO procedures to reduce the wear on a gear drive system.   (2)

9.5   State ONE use of EACH of the following materials:

        9.5.1   Nylon   (1)

        9.5.2   Glass fibre/Glass fibre   (1)

9.6   Classify the following material as *thermoplastic composites* or *thermo-hardened (thermo-setting) composites*:

        9.6.1   Teflon   (1)

        9.6.2   Bakelite   (1)

9.7   Name any TWO factors that influence the coefficient of friction between two surfaces.   (2)
        [18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1   Draw a neat sketch of a metric V-screw thread and indicate the THREE diameters of the screw thread.   (4)

10.2   Explain what is meant by the *lead of a screw thread.*   (3)

10.3   A three-start square thread with a 4 mm pitch must be cut on a lathe. The crest diameter of the thread is 68 mm and the clearance angle is 3°.

        Calculate the following:

        10.3.1   The lead of the thread   (2)

        10.3.2   The mean circumference of the thread   (3)

        10.3.3   The helix angle of the thread   (2)

        10.3.4   The leading tool angle   (2)

        10.3.5   The following tool angle   (2)
        [18]

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

11.1   State TWO advantages of a gear drive system compared to a belt drive system.   (2)

11.2   A hydraulic system is used to remove parts from a machine. The specifications of the system are indicated in FIGURE 11.2 below.
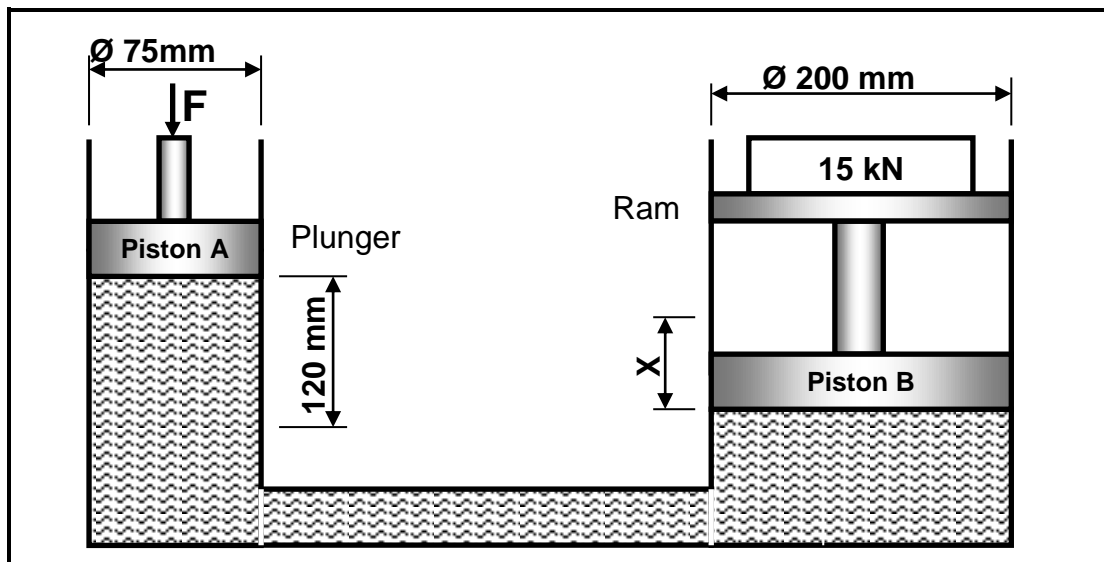
FIGURE 11.2

Calculate the following:

11.2.1   The fluid pressure in the hydraulic system in kPa   (5)

11.2.2   Distance **X**, in **millimetres**, that piston **B** will move with ONE stroke of piston **A**   (6)

11.3   State TWO advantages of pneumatics when compared with hydraulics.   (2)

11.4   An electric motor with a 250 mm diameter driver pulley rotates at 24 r/s. The motor drives a pulley with a diameter of 350 mm with the help of a flat belt. The tensile force in the tight side of the belt is 300 N and in the slack side 120 N.

11.4.1   Draw a neat labelled sketch of the system showing the driver and driven pulley.   (2)

11.4.2   Calculate the belt speed in m/s.   (3)

11.4.3   Calculate the power transmitted in kW.   (4)

11.5   FIGURE 11.5 below shows a compound gear train. A driver gear on the axle of the electric motor has 30 teeth that mesh with a gear on the counter shaft with 80 teeth. On the counter shaft is another driver gear with 40 teeth that mesh with a gear with 60 teeth. The rotation frequency is 120 r/min.

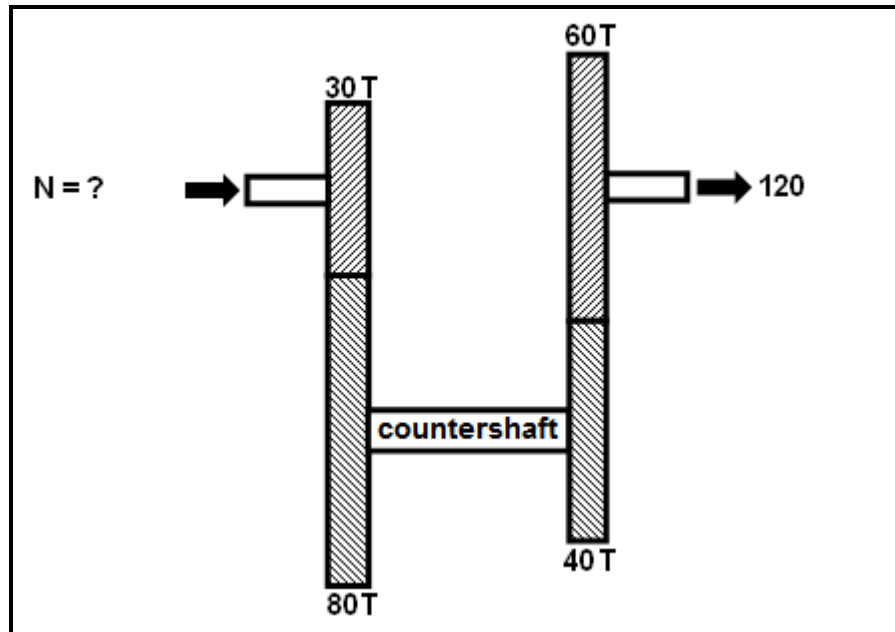Calculate the rotation frequency of the electric motor.

FIGURE 11.5   (4)

[28]

TOTAL: **200**

FORMULA SHEET FOR MECHANICAL TECHNOLOGY
(FITTING AND MACHINING)

1.   BELT DRIVES

$$\text{Belt speed} = \frac{\pi \, D \, N}{60} \qquad \text{or} \qquad v = \frac{\pi \, D \, N}{60}$$

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

$$N_1 D_1 = N_2 D_2$$

$$\text{Ratio of tight side to slack side} = \frac{T_1}{T_2}$$

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

where T_1 = force in the tight side

T_2 = force in slack side

$T_1 - T_2$ = effective tensile force (T_e)

2.   STRESS AND STRAIN

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

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

$$\text{Young's modulus} \, (E) = \frac{\text{stress}}{\text{strain}} \quad \text{or} \quad (E = \frac{\sigma}{\varepsilon})$$

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

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

$$\text{Safety factor} = \frac{\text{break stress}}{\text{safe working stress}}$$

3. **HYDRAULICS**

$$\text{Pressure}\,(P) = \frac{\text{force}\,(F)}{\text{area}\,(A)}$$

$$\text{Volume} = \text{area} \times \text{stroke length}$$

4. **KEYS AND KEYWAYS**

$$\text{Width of key} = \frac{\text{diameter of shaft}}{4}$$

$$\text{Thickness of key} = \frac{\text{diameter of shaft}}{6}$$

$$\text{Length of key} = 1{,}5 \times \text{diameter of shaft}$$

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

5. **GEAR DRIVES**

$$Power\,(P) = \frac{2\pi N T}{60}$$

$$N_1 T_1 = N_2 T_2$$

$$\text{Gear ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$\frac{N_{input}}{N_{output}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$\text{Torque} = \text{force} \times \text{radius}$$

$$\text{Torque transmitted} = \text{gear ratio} \times \text{input torque}$$

$$\text{Module}\,(m) = \frac{\text{pitch-circle diameter}\,(PCD)}{\text{number of teeth}\,(T)}$$

$$\text{Pitch-circle diameter}\,(PCD) = \text{module}\,(m) \times \text{number of teeth}\,(T)$$

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

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

Addendum $(a) = $ module (m)

Dedendum $(b) = 1,157\,m$ or   Dedendum $(b) = 1,25\,m$

Cutting depth $(h) = 2,157\,m$ or   Cutting depth $(h) = 2,25\,m$

Clearance $(c) = 0,157\,m$ or   Clearance $(c) = 0,25\,m$

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

$\text{Add}_c = m + \dfrac{Tm}{2}\left(1 - \cos\dfrac{90°}{T}\right)$ (chordal addendum)

$t_c = Tm \sin\dfrac{90°}{T}$ or $t_c = PCD\sin\dfrac{90°}{T}$ (chordal tooth thickness)
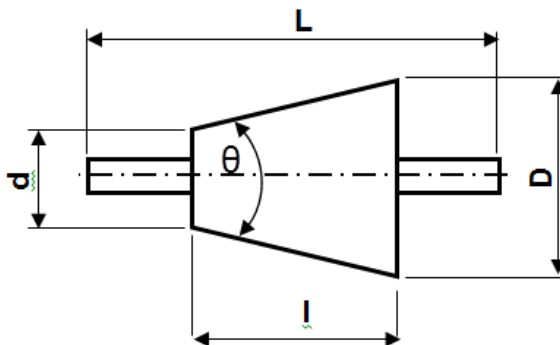
6.   TAPER TURNING

Tailstock set-over $= \dfrac{L(D - d)}{2l}$

where $L = $ Distance between centres
        $l = $ Taper length
        $D = $ Large diameter
        $d = $ Small diameter

7.   SCREW THREADS

Pitch diameter = outside diameter − ½ pitch

Pitch circumference = π × pitch diameter

Lead = pitch × number of starts

Height of screw thread = $0,866 \times p$ where p = pitch of the screw thread

Depth of screw thread = $0,613 \times p$ where p = pitch of the screw thread

Number of turns = $\dfrac{\text{length}}{\text{lead}}$

Helix angle $\tan \theta = \dfrac{\text{lead}}{\text{pitch circumference}}$

Leading tool angle = $90° - \left(\text{helix + clearance angle}\right)$

Following tool angle = $90° + \left(\text{helix − clearance angle}\right)$

8.   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

Change gears										
24 x 2	28	32	40	44	48	56	64	72	86	100

Simple indexing $= \dfrac{40}{n}$ (where n = number of divisions)

Angular indexing $= \dfrac{n}{9°}$ (where n = given angle)

Change gears: $\dfrac{Dr}{Dn} = (A - n) \times \dfrac{40}{A}$ or $\dfrac{Dr}{Dn} = \dfrac{(A - n)}{A} \times \dfrac{40}{1}$

(where A = chosen divisions)   (where n = real divisions)