basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**SENIOR CERTIFICATE/
NATIONAL SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2020

MARKS: 200

TIME: 3 hours

This question paper consists of 13 pages and a 4-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 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 A.

1.1 What is the purpose of the Occupational Health and Safety Act, 1993 (Act 85 of 1993) with regard to HIV/Aids awareness?

    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 infected with HIV at work.

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

    C   Employers may not demote or promote employees based on their HIV status.

    D   Employers cannot simply dismiss a person who has been infected with HIV.   (1)

1.2 Which ONE of the following pieces of personal protective equipment is applicable when using a drill press?

    A   Hard hat
    B   Apron
    C   Surgical gloves
    D   Safety goggles   (1)

1.3 Which statement describes the placing of the machines in a product layout?

    A   The machines are arranged in the sequence in which operations are carried out.

    B   The machines are arranged according to the worker's skills.
    C   The machines are grouped according to their types of operation.
    D   The machines are arranged according to the products.   (1)

1.4 Which heat-treatment process is used to give steel a high resistance against wear?

    A   Annealing
    B   Tempering
    C   Hardening
    D   Normalising   (1)

1.5 The purpose of tempering steel is to …

    A   harden it.
    B   increase the toughness.
    C   soften it.
    D   cool it down.   (1)

1.6 Which test uses an indenter to determine the hardness of steel?

   A   Sound test
   B   Rockwell test
   C   Bending test
   D   Machining test (1)
                                                                    [6]

QUESTION 2: SAFETY (GENERIC)

2.1 What safety rule must be adhered to after work procedures on a machine have been completed? (1)

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

2.3 Give TWO reasons why surgical gloves must be worn when treating a co-worker with open wounds. (2)

2.4 State TWO pieces of personal protective equipment (PPE) which must be worn during arc welding. (2)

2.5 Describe the responsibility of an employer regarding the safety and health of the employees in the workplace. (2)

2.6 Who is responsible for administering first aid to an injured person at the workplace? (1)
                                                                    [10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Explain how you will conduct the following tests to identify various metals:

   3.1.1   Sound test (2)

   3.1.2   File test (2)

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

3.3 What is the purpose of the case hardening of steel? (2)

3.4 Describe the *tempering process* of steel. (3)

3.5 Name the THREE factors which need to be taken into consideration when heat treatment of steel is done. (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 A.

4.1   Which ONE of the following statements is an advantage of the compound slide method over the taper-turning attachment method for taper turning on a centre lathe?

    A   Long tapers can be cut.
    B   Only internal tapers can be cut.
    C   Tapers with large angles can be cut.
    D   Good finishing is obtained.   (1)

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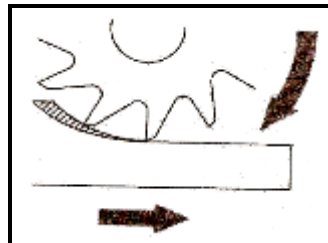
FIGURE 4.2

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

4.3   Which indexing process will be the easiest to cut a hexagon bolt head if the universal dividing head is used?

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

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

    A   Rockwell hardness tester
    B   Brinell hardness tester
    C   Vickers hardness tester
    D   Pascal hardness tester   (1)

4.5 What is meant by the term *absolute programming* on a three-axis digital read-out system?

The point of reference is taken from …

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

4.6 Which equipment is used on the lathe to set the screw thread cutting tool at centre height, square to the axis of the work piece?

A Thread-pitch gauge
B Centre gauge
C Graduated collar
D Screw-cutting dial (1)

4.7 What is the measure unit for strain?

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

4.8 Which ONE of the following terms is described as the load-carrying capacity of a system beyond the expected or actual loads?

A Stress
B Break stress
C Safety factor
D Strain (1)

4.9 Which ONE of the following materials can be reheated and deformed?

A Bakelite
B Fibreglass
C Carbon fibre
D Nylon (1)

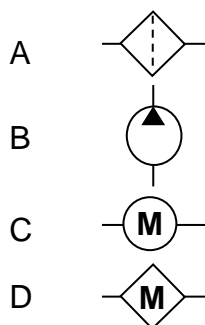4.10 What can be done to increase the frictional force between two horizontal surfaces that make contact?

A Increase the weight of the object.
B Add lubrication between the surfaces.
C Change the cross-sectional surface that makes contact.
D Decrease the perpendicular load on the surface. (1)

4.11   Which ONE of the following screw-thread terms is defined by the words,
         'the axial distance that a nut will move through one revolution'?

         A   Crest
         B   Pitch
         C   Lead
         D   Root   (1)

4.12   Which ONE of the following defines the helix angle of a screw thread?

         A   The angle that the crest diameter makes with a line perpendicular
               (90°) to the axis of the screw thread
         B   The angle that the thread makes with a line perpendicular (90°) to the
               axis of the screw thread
         C   The angle that the centre line makes with a line perpendicular (90°) to
               the axis of the screw thread
         D   The angle that the thread makes with a line perpendicular (90°) to the
               pitch of the screw thread   (1)

4.13   Which ONE of the following statements is an advantage of a chain drive
         over a gear drive?

         A   Lubrication is needed.
         B   Drive can take place over a longer distance.
         C   More power can be transmitted.
         D   Transmission of power without slip is possible.   (1)

4.14   Which ONE of the following hydraulic symbols is used to indicate an
         electrical motor in a hydraulic flow diagram?

         A

         B

         C

         D
                                                                                                (1)
                                                                                               [14]

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

5.1   A taper with a length of 60 mm and a large diameter of 40 mm and a small diameter of 31,6 mm needs to be cut on a lathe using the compound slide method.

      5.1.1   Draw a neat sketch of the taper and label it.   (3)

      5.1.2   Calculate the included angle.   (4)

      5.1.3   At what degree do you need to set the compound slide to cut this taper?   (1)

5.2   Calculate the width and length of a parallel key suitable for a 30 mm diameter shaft.   (4)

5.3   A 15 mm wide keyway must be cut on a work piece with a diameter of 60 mm. The rule and square method is used to centre the cutter. Calculate the distance **X** shown in FIGURE 5.3.
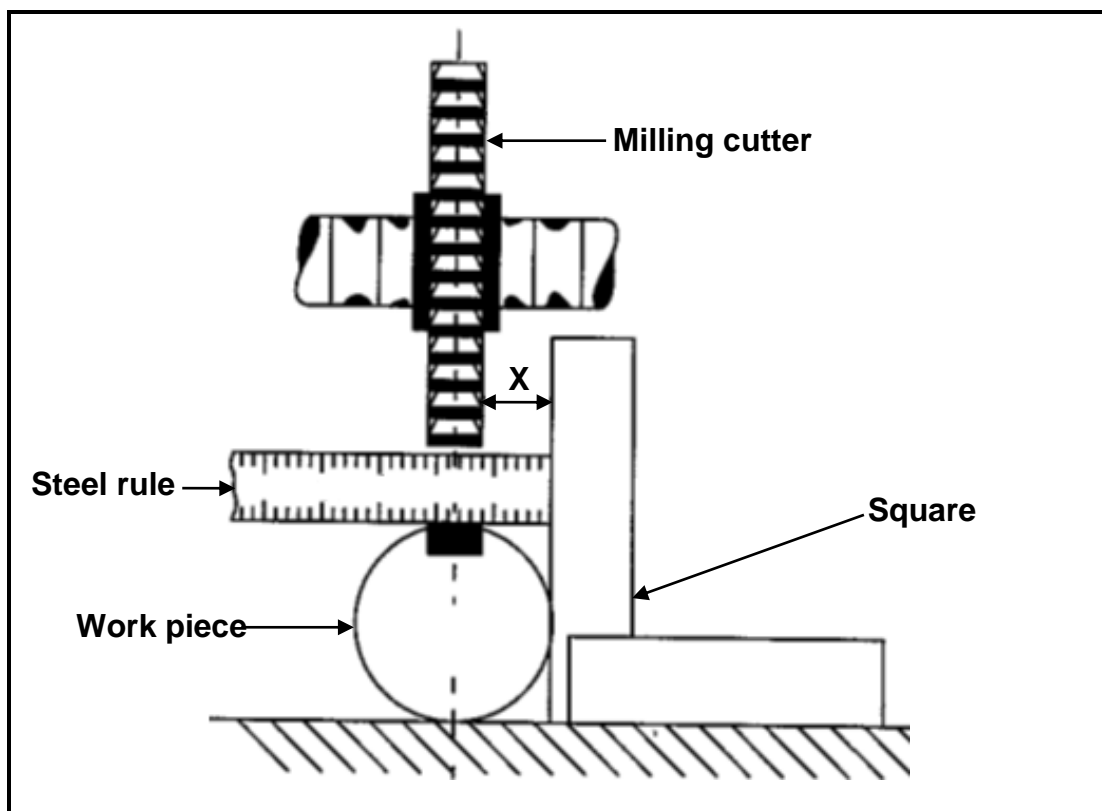
FIGURE 5.3   (3)

5.4   Use a neat, labelled sketch to explain straddle milling.   (3)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 A spur gear has 51 teeth and a module of 3.

Calculate the following:

6.1.1 The outside diameter of the gear (2)

6.1.2 The cutting depth of the gear (2)

6.1.3 The required simple indexing to cut this gear (3)

6.2 A gear with 83 teeth has to be milled on a dividing head with a ratio of 40 **:** 1.

Calculate the following regarding this indexing process:

6.2.1 The differential indexing (Choose 80 divisions) (4)

6.2.2 The change-gears needed for this process (5)

6.2.3 The rotation of the index plate relative to the rotation of the index crank handle (1)

6.3 FIGURE 6.3 below indicates a dovetail part. Calculate distance **X** across the rollers, as shown in FIGURE 6.3.
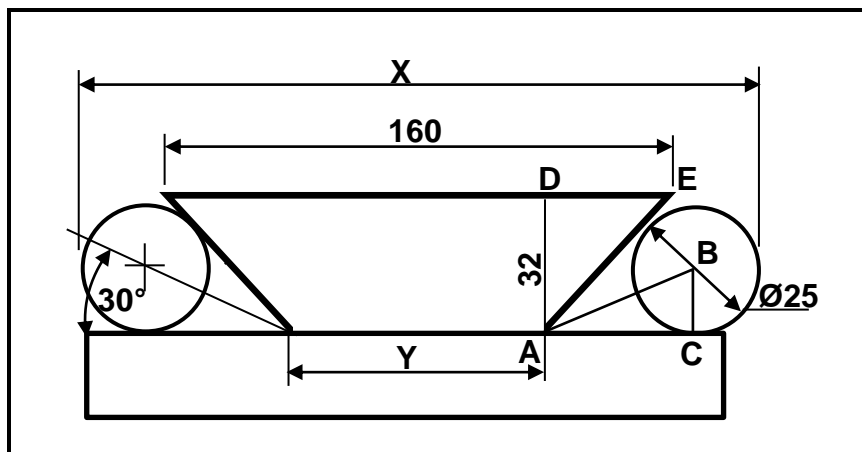
FIGURE 6.3 (9)

6.4 Give TWO reasons for balancing a work piece on a lathe. (2)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 Distinguish between the *Brinell* and *Rockwell hardness testers* that are used to determine the hardness of a metal. Use neat, labelled drawings to indicate the differences. (4)

7.2 Describe the function of a *tensile tester*. (2)

7.3 A vernier calliper is used to do precision measuring of an outside diameter, an inside diameter and the depth of a hole. Name THREE other precision measuring instruments that can be used for precision measuring these dimensions. (3)

7.4 State THREE properties of a metal which can be determined by using a tensile tester to conduct a tensile test on a metal. (3)

7.5 Which measuring instrument is used to measure the root diameter of a screw thread? (1)

[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 FIGURE 8.1 below indicates a system of forces with three coplanar forces acting on the same point. Use calculations and determine the magnitude and direction of the resultant force of this system of forces. (Draw and complete the diagram in the ANSWER BOOK. Show ALL the horizontal and vertical components.)
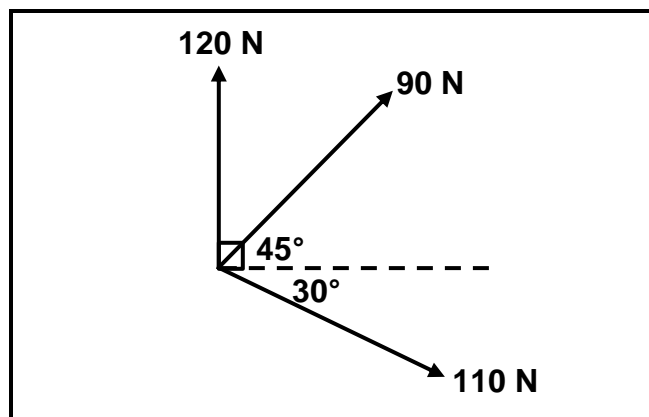
FIGURE 8.1 (13)

8.2 The diagram in FIGURE 8.2 below shows a beam with two vertical point loads of 3 000 N and 500 N acting on it. The beam is supported at point **O**. Calculate distance **X** from **O** to place the 500 N load to ensure that the beam is in equilibrium.
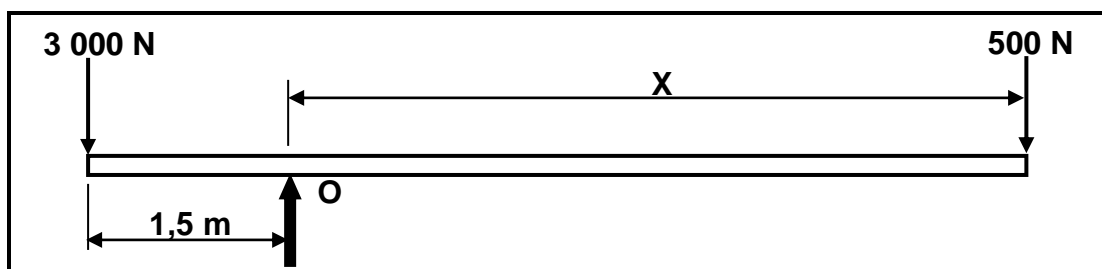
FIGURE 8.2 (4)

8.3   A compressive force of 50 kN is exerted on a rectangular mild steel bar. The length of the bar is 80 mm and the side lengths are 30 mm and 16 mm respectively. Answer the questions that follow.

    8.3.1   Name the type of stress induced in the material. (1)

    8.3.2   Calculate the stress in the material in megamagnitude. (6)

    8.3.3   Calculate the change in length caused by the force if Young's modulus for this material is 90 GPa. (6)

    8.3.4   Calculate the safe working stress if the break stress is 600 MPa and a safety factor of 4 is used. (3)

[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1   Name THREE aspects that need to be checked during the preventative maintenance of a belt drive system. (3)

9.2   State THREE results of a lack of preventative maintenance on a gear drive system. (3)

9.3   Name TWO procedures to reduce wear on a chain drive system. (2)

9.4   Describe the procedure to replace the belt on a belt drive system. (5)

9.5   State TWO properties of bakelite. (2)

9.6   State THREE main properties that make vesconite an outstanding bearing material. (3)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1   A three-start square screw thread with a 6 mm pitch needs to be cut on a lathe. The crest diameter of the thread is 58 mm and the clearance angle 3°.

    Calculate the following:

    10.1.1   The lead of the thread (2)

    10.1.2   The helix angle of the thread (5)

    10.1.3   The leading tool angle (2)

    10.1.4   The following tool angle (2)

10.2   The measurements of a screw thread is given as M20 x 2,5. Calculate the required drill size to tap the internal screw thread. (3)

10.3   Explain what is meant by the *pitch of a screw thread*. (4)

[18]

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

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

11.2   A flat belt pulley with a diameter of 0,24 m is fitted to the shaft of an electric motor that drives a water pump. The motor rotates at 1 100 r/min. A pulley with a diameter of 0,36 m is fitted to the pump. The tensile force, T_1, in the tight side of the belt is 200 N and the force, T_2, in the slack side is 90 N.
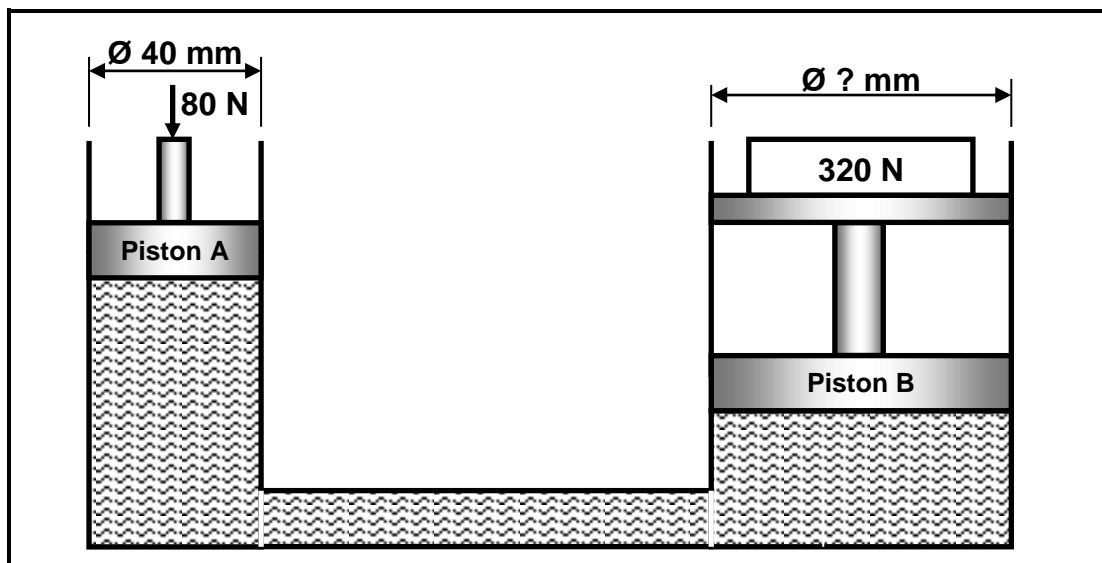
Determine, with the help of calculations:

11.2.1   The rotation frequency of the driven pulley in r/s   (4)

11.2.2   The power transmitted in kW   (4)

11.2.3   The belt speed of the system in $m.s^{-1}$ (3)

11.3   The hydraulic system in FIGURE 11.3 below is used to press machine parts into position. The force that should be exerted onto the ram is 320 N. The maximum force that may be exerted onto the 40 mm plunger is 80 N.

FIGURE 11.3

Determine, with the help of calculations:

11.3.1   The fluid pressure in the hydraulic system   (4)

11.3.2   The diameter of piston B in millimetres (mm)   (7)

11.4   FIGURE 11.4 below shows a gear drive system. Driver gear **A** on the shaft of an electrical motor, which rotates at 1 440 r/min, has 20 teeth and meshes with gear **B**, with 36 teeth, on a countershaft. There is another driver gear **C**, with 18 teeth, on the countershaft that meshes with a gear **D**, with 46 teeth, on a second countershaft. The second countershaft has a driver gear **E**, with 42 teeth, which drives gear **F**, with 80 teeth, on the output shaft.

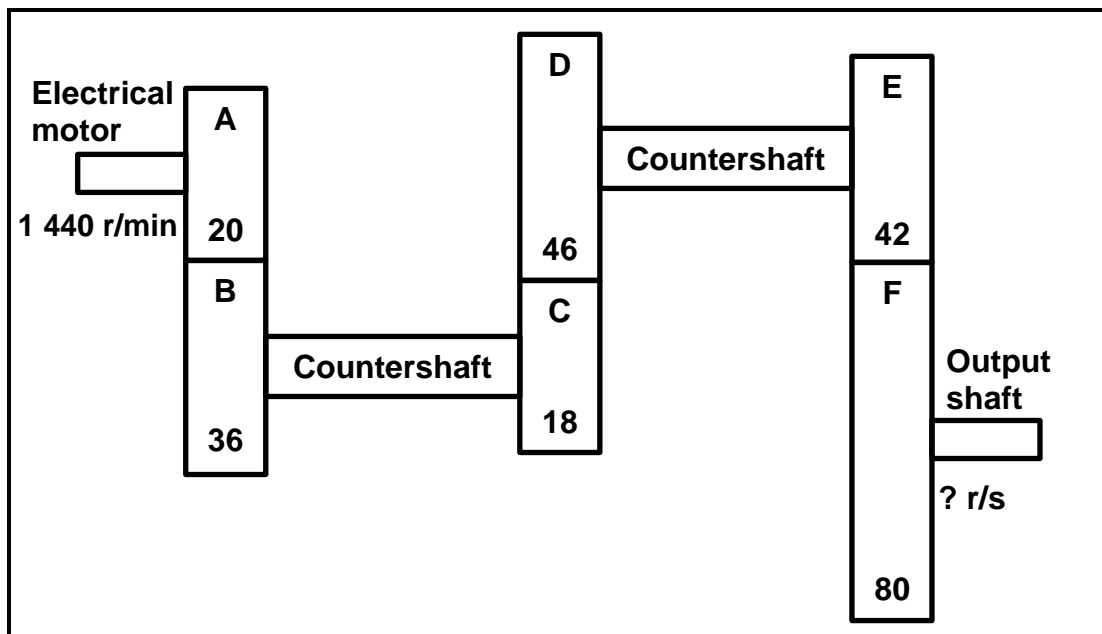Calculate the rotational frequency of the output shaft in revolutions per second.

FIGURE 11.4   (4)

[28]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY
(FITTING AND MACHINING)

1. BELT DRIVES

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

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

$$N_1 D_1 = N_2 D_2$$

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

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

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

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

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

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

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

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

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

3. HYDRAULICS

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

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

4. KEYS AND KEYWAYS

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

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

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

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

5. GEAR DRIVES

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

$$N_1 T_1 = N_2 T_2$$

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

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

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

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

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

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

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**

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

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

(Compound slide angle) $\tan\dfrac{\theta}{2} = \dfrac{D - d}{2l}$

         where :
            $D = $ large diameter
            $d = $ small diameter
            $l = $ length of taper
            $\theta = $ included angle

7. SCREW THREADS

$$\text{Pitch diameter} = \text{outside diameter} - \tfrac{1}{2}\text{pitch}$$

$$\text{Pitch circumference} = \pi \times \text{pitch diameter}$$

$$\text{Lead} = \text{pitch} \times \text{number of starts}$$

$$\text{Height of screw thread} = 0{,}866 \times p \qquad \text{where } p = \text{pitch of the screw thread}$$

$$\text{Depth of screw thread} = 0{,}613 \times p \qquad \text{where } p = \text{pitch of the screw thread}$$

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

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

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

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

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

$$\text{Simple indexing} = \frac{40}{n} \quad (\text{where } n = \text{number of divisions})$$

$$\text{Angular indexing} = \frac{n}{9°} \quad (\text{where } n = \text{given angle})$$

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

$$(\text{where } A = \text{chosen divisions}) \qquad\qquad (\text{where } n = \text{real divisions})$$