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GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2018

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 to 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 E.

- 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 an employee based on his/her HIV status.
 - D Employers cannot simply dismiss a person who has HIV. (1)
- 1.2 Which ONE of the following items of personal protective equipment (PPE) is applicable when arc welding is performed on a work piece?
- A Hard hat
 - B Welding goggles
 - C Welding helmet
 - D Face shield (1)
- 1.3 Who is responsible for the provision of safety equipment in the workplace?
- A Employer
 - B Employee
 - C Customer
 - D Foreman (1)
- 1.4 Which ONE of the following properties of solid steel will change if the steel is subjected to a heat treatment process?
- A Length
 - B Hardness
 - C Size
 - D Shape (1)
- 1.5 The purpose of normalising steel is to ...
- A harden.
 - B temper.
 - C harden the core.
 - D relieve internal stresses. (1)
- 1.6 If a sound test is applied to high-carbon steel, which ONE of the following sounds will help one to identify the metal?
- A Loud and clear sound
 - B Dull sound
 - C Soft ringing sound
 - D Low ringing sound (1)

[6]

QUESTION 2: SAFETY (GENERIC)

- 2.1 An angle grinder is used to smoothen a welded joint. State TWO safety measures that must be observed before using the angle grinder. (2)
- 2.2 Give TWO reasons why it is important to wear welding goggles during oxy-acetylene gas welding. (2)
- 2.3 Name TWO items of personal protective equipment (PPE) that one will use when working with a hydraulic press. (2)
- 2.4 Name TWO types of workshop layouts. (2)
- 2.5 Name TWO responsibilities of the employer when applying first aid in the workplace. (2)
- [10]**

QUESTION 3: MATERIALS (GENERIC)

- 3.1 Name ONE property of steel that is tested by conducting a bending test on steel. (2)
- 3.2 Give TWO reasons for conducting EACH of the following heat-treatment processes on steel:
- 3.2.1 Annealing (2)
- 3.2.2 Case hardening (2)
- 3.3 Explain why the tempering of steel is done after the hardening process. (2)
- 3.4 State the THREE factors that must be considered during all heat-treatment processes. (3)
- 3.5 Explain the *hardening process* of steel. (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 compound slide set-over method for taper turning on the 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 in FIGURE 4.2 below.

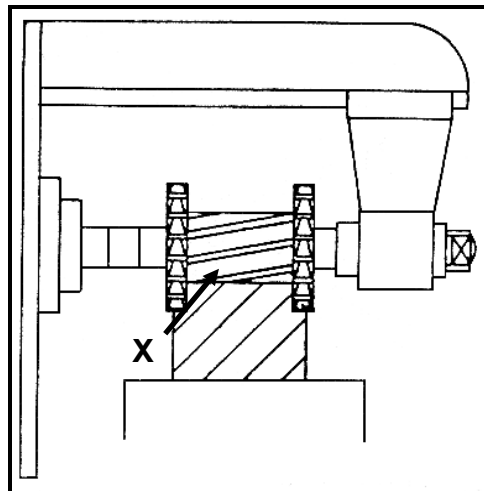


FIGURE 4.2

A Gang milling
B Slab milling
C Slot milling
D Straddle milling

(1)

- 4.3 Which indexing process uses change gears to do indexing?

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?

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 If the addendum of a spur gear is 3 mm, what will be the module?
A 6
B 3
C 1,5
D 9 (1)
- 4.6 Which ONE of the following statements describes the function of a force tester?
A To illustrate the concept of the triangle of forces
B To determine the reactions on either side of a loaded beam
C To illustrate the concept of the friction forces
D To determine the reaction on one side of a loaded beam (1)
- 4.7 What is the measure unit for stress?
A Newton
B Pascal
C No unit
D Newton per metre (1)
- 4.8 Which ONE of the following represents the same value as 1 Pa?
A $1 \text{ Pa} = 1 \text{ N/m}^3$
B $1 \text{ Pa} = 1 \text{ N/m}^2$
C $1 \text{ Pa} = 1 \text{ kg/m}^2$
D $1 \text{ Pa} = 1 \text{ N.m}$ (1)
- 4.9 Which ONE of the following materials is classified as a thermoplastic composite?
A Bakelite
B Fibreglass
C Carbon fibre
D Vesconite (1)
- 4.10 The friction coefficient will ... when lubricant is added between two surfaces.
A increase
B be eliminated
C decrease
D have no effect (1)
- 4.11 Which ONE of the following is an advantage of multiple-start screw threads?
A More locking power
B Produce faster movement
C Produce slower movement
D Use more power due to friction (1)

4.12 Which clearance angle is normally used, unless stated otherwise, to calculate the leading and following tool angles of a square-thread cutting tool?

- A 90°
- B 45°
- C 5°
- D 3°

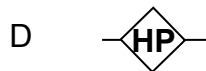
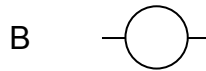
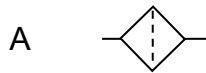
(1)

4.13 Which ONE of the following is an advantage of a gear drive system over a belt drive system?

- A Drive can take place over a longer distance.
- B Less expensive parts are used.
- C No lubrication is needed.
- D Transmission of power without slip is possible.

(1)

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



(1)
[14]

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

- 5.1 State TWO advantages of using the tailstock set-over method to cut an external taper on the centre lathe. (2)
- 5.2 An 85 mm long external taper, with a large diameter of 60 mm and a small diameter of 28 mm, needs to be cut on a centre lathe. Calculate the angle at which the compound slide must be set to cut this taper. (5)
- 5.3 State TWO uses of the centre gauge when cutting screw thread on a centre lathe. (2)
- 5.4 Calculate the length of a parallel key suitable for a 42 mm diameter shaft. (3)
- 5.5 State TWO advantages of up-cut milling. (2)
- 5.6 State TWO disadvantages of down-cut milling. (2)
- 5.7 State TWO methods of centring a milling cutter to the axis of a work piece. (2)
- [18]**

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

- 6.1 A spur gear with 50 teeth has a module of 3. Calculate the chordal tooth thickness of the gear teeth. (4)
- 6.2 Calculate the required simple indexing to cut a gear with 13 teeth. (4)
- 6.3 A gear with 127 teeth must be cut on a universal milling machine, using a 40 : 1 Cincinnati-dividing head.
- Calculate the following:
- 6.3.1 The differential indexing required (Choose 125 teeth.) (3)
- 6.3.2 The change gears required (5)
- 6.3.3 The direction of rotation of the index plate in relation to the index crank handle. (1)

- 6.4 FIGURE 6.4 below shows a dovetail groove. Calculate distance **X** between the rollers in FIGURE 6.4.

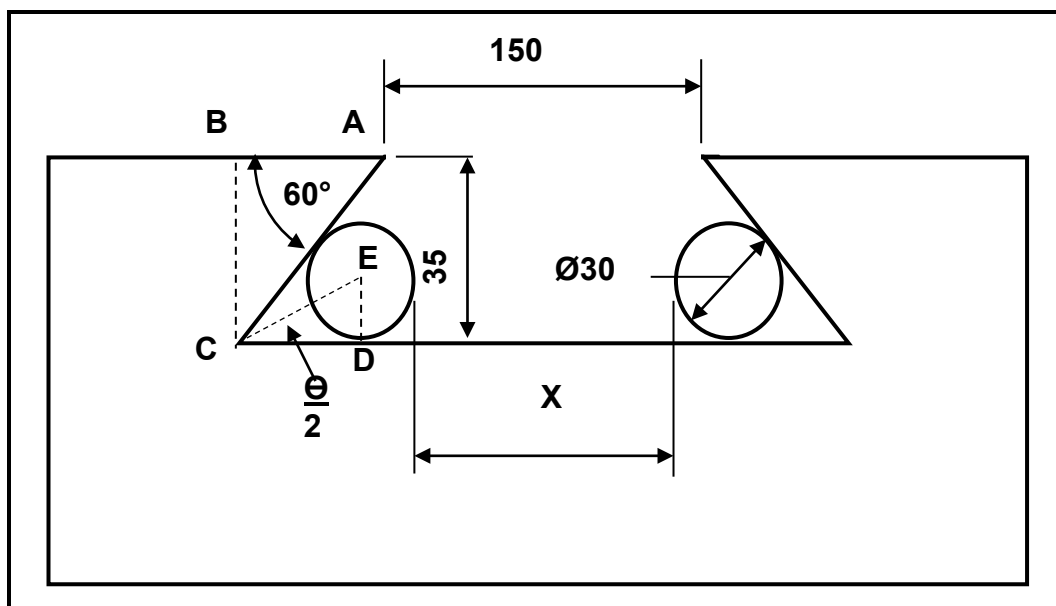


FIGURE 6.4

- 6.5 Give TWO reasons why a work piece must be balanced on a centre lathe when a face plate is used.

(9)

(2)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

- 7.1 Name the TWO hardness testers that are used to determine the hardness of a metal. (2)
- 7.2 State the purpose of a moment tester. (2)
- 7.3 Describe the *tensile test* applied on steel. (3)
- 7.4 What is the reading on the depth micrometer, as shown in FIGURE 7.4 below?

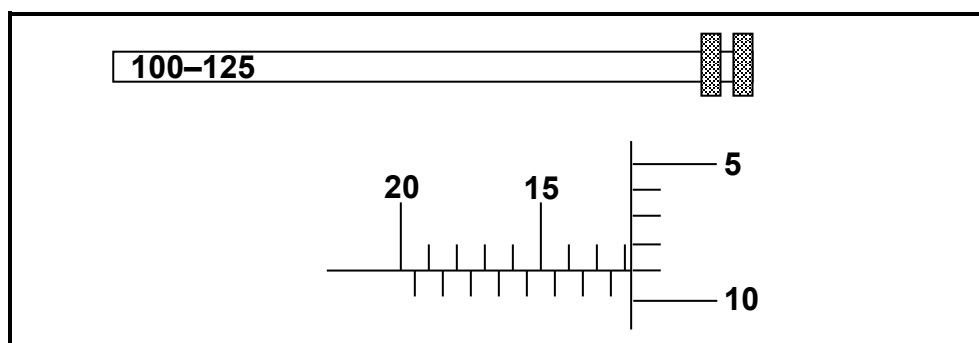


FIGURE 7.4

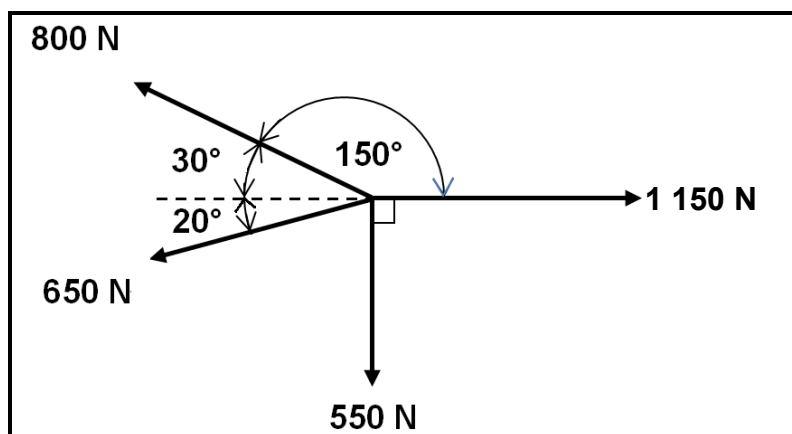
- 7.5 A depth micrometer can accurately measure the depth of a hole. Name another precision measuring tool that can also measure the depth of a hole accurately.

(5)

(1)
[13]

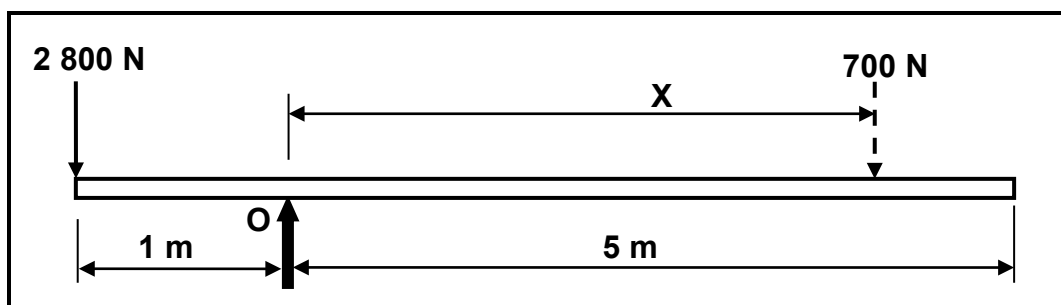
QUESTION 8: FORCES (SPECIFIC)

- 8.1 FIGURE 8.1 below shows a system of forces with four coplanar forces acting on the same point. Calculate the magnitude and direction of the **equilibrant** of this system of forces.

**FIGURE 8.1**

(15)

- 8.2 The diagram in FIGURE 8.2 below shows a beam with two vertical point loads of 2 800 N and 700 N acting on it. The beam is supported at point **O**. Calculate distance **X** from **O** to place the 700 N load to ensure that the beam is in equilibrium.

**FIGURE 8.2**

(4)

- 8.3 A mild steel bush, 80 mm long, with an inner diameter of 30 mm and an outside diameter of 40 mm, is used in a hydraulic press to press out bearings from a hub. A force of 50 kN is exerted on the bush.

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

8.3.2 Calculate the stress in the material. Give your answer in megamagnitude. (5)

8.3.3 Calculate the change in length caused by the force if Young's modulus $E = 90 \text{ GPa}$. (5)

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

[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

- 9.1 State THREE results of a lack of preventative maintenance on mechanical systems. (3)
- 9.2 State TWO causes of the malfunctioning of chain drive systems. (2)
- 9.3 State TWO procedures to reduce wear on a belt drive system. (2)
- 9.4 Explain the procedure to replace the belt on a flat belt drive system. (5)
- 9.5 State ONE property of EACH of the following materials:
- 9.5.1 Polyvinyl chloride (PVC) (1)
- 9.5.2 Carbon fibre (1)
- 9.6 State the main difference between *thermoplastic composites* and *thermo-hardened (thermosetting) composites*. (2)
- 9.7 Give TWO examples of thermo-hardened composites. (2)
- [18]**

QUESTION 10: JOINING METHODS (SPECIFIC)

- 10.1 A two-start square thread with a 5 mm pitch must be cut on a lathe. The crest diameter of the thread is 82 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 measurement of a screw thread is given as M24 x 2,5. What does the following mean:
- 10.2.1 M (1)
- 10.2.2 24 (1)
- 10.2.3 2,5 (1)

- 10.3 FIGURE 10.3 below shows a left-hand square screw thread cutting tool. Label angles **A–D**.

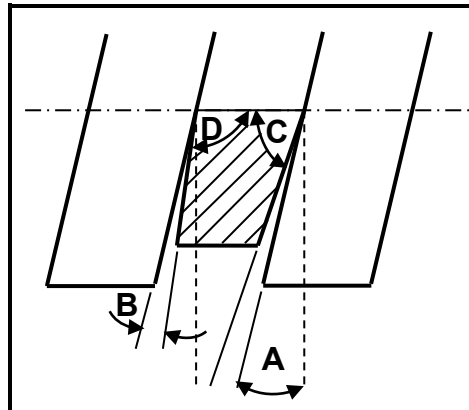


FIGURE 10.3

(4)
[18]

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

- 11.1 State TWO advantages of a belt drive system compared to a chain drive system. (2)
- 11.2 Study FIGURE 11.2 below. An artisan was instructed to design a hydraulic system that will be used to press out bearings. The force that should be exerted on the bearing is 18 kN. The maximum force exerted on the 32 mm plunger is 120 N.

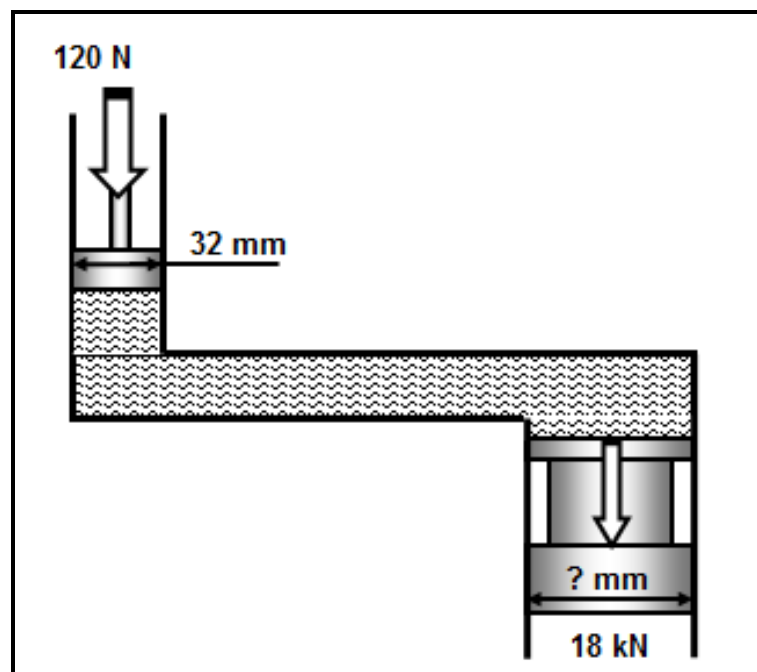
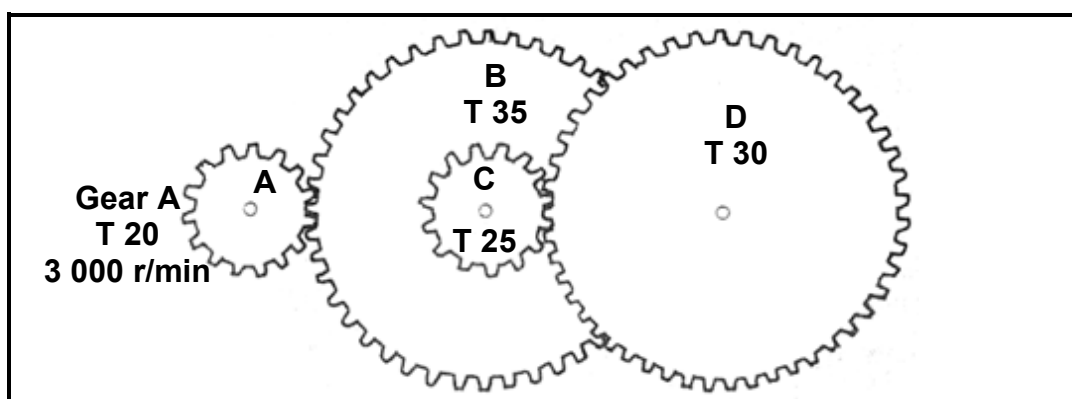


FIGURE 11.2

Calculating the following:

- 11.2.1 The fluid pressure in the hydraulic system (4)
- 11.2.2 The diameter of the ram so that the maximum force of 18 kN can be exerted on the bearing. (6)

- 11.3 Draw the symbol for a one-way spring-loaded valve used in a hydraulic flow diagram. (1)
- 11.4 The driven pulley of a belt drive system must rotate at a speed of 80 r/min. The driven pulley has a diameter of 240 mm and the driver pulley a diameter of 75 mm. Calculate the rotation frequency of the driver pulley in r/min. (4)
- 11.5 Study FIGURE 11.5 below. The gear box of a motor vehicle is in second gear. The input shaft rotates at 3 000 r/min. The input shaft is equipped with driver gear **A** with 20 teeth, which mesh with gear **B** with 35 teeth. The second acceleration gear **C** on the countershaft has 25 teeth and meshes with the final driven gear **D** with 30 teeth.

**FIGURE 11.5**

Calculate:

- 11.5.1 The rotation frequency of the output shaft in revolutions per second (6)
- 11.5.2 The gear ratio (3)
- 11.6 A force of 250 N moves an object over a distance of 15 m. Calculate the work done by this force. (2)

[28]**TOTAL: 200**

FORMULA SHEET FOR MECHANICAL TECHNOLOGY (FITTING AND MACHINING)

1. BELT DRIVES

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

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

$$N_1 D_1 = N_2 D_2$$

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

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

$$\text{Power} = \frac{(T_1 - T_2) \pi D N}{60} \quad \text{where } T_1 = \text{force in the tight side}$$

$$T_2 = \text{force in slack side}$$

$$T_1 - T_2 = \text{effective force (T}_e\text{)}$$

2. STRESS AND STRAIN

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

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

$$\text{Young's modulus (E)} = \frac{\text{stress}}{\text{strain}} \quad \text{or} \quad \left(\frac{\sigma}{\epsilon} \right)$$

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

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

$$\text{Safety factor} = \frac{\text{Break stress}}{\text{Safe working stress}}$$

3. HYDRAULICS

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}} \quad \text{or} \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\text{Volume} = \text{Cross-sectional area} \times \text{stroke length}$$

4. KEYS AND KEYWAYS

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

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

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

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

5. GEAR DRIVES

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

$$N_1 T_1 = N_2 T_2$$

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

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

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

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

$$\text{Module (m)} = \frac{\text{Pitch-circle diameter (PCD)}}{\text{Number of teeth (T)}}$$

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

$$\text{Outside diameter (OD)} = \text{PCD} + 2 \text{ module}$$

$$\text{Addendum (a)} = \text{module (m)}$$

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

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

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

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

$$\text{Add}_c = m + \frac{Tm}{2} \left(1 - \cos \frac{90^\circ}{T} \right)$$

$$t_c = Tm \sin \frac{90^\circ}{T} \quad \text{or} \quad t_c = \text{PCD} \sin \frac{90^\circ}{T}$$

$$\text{Cordal tooth thickness} = t_c$$

6. SCREW THREADS

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

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

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

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

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

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

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

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

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

7. 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 |

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

$$\text{Angular indexing} = \frac{n}{9^\circ}$$

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

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