



# basic education

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

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY: FITTING AND MACHINING**

**EXEMPLAR 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 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  $10 \text{ m/s}^2$ .
9. All dimensions are in millimetres, unless stated otherwise in the question.
10. Write neatly and legibly.
11. A formula sheet is attached to the question paper
12. Use the criteria below to assist you with your time management.

QUESTION	CONTENT	MARKS	TIME
	<b>Generic</b>		
1	Multiple-choice questions	6	6 minutes
2	Safety	10	10 minutes
3	Materials	14	14 minutes
	<b>Specific</b>		
4	Multiple-choice questions	14	10 minutes
5	Terminology (Lathe and Milling Machine)	18	20 minutes
6	Terminology (Indexing)	28	25 minutes
7	Tools and Equipment	13	10 minutes
8	Forces	33	33 minutes
9	Maintenance	18	12 minutes
10	Joining Methods	18	12 minutes
11	Systems and Control (Drive Systems)	28	28 minutes
	<b>TOTAL</b>	<b>200</b>	<b>180 minutes</b>

### QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (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) regarding HIV/Aids awareness?
- A The safety laws state 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 It 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 is infected with HIV. (1)
- 1.2 Which ONE of the following types of personal protective equipment is applicable when executing oxy-acetylene welding?
- A Welding helmet
  - B Welding goggles
  - C Hard hat
  - D Welding mask (1)
- 1.3 What is the maximum gap allowed between the tool rest and the grinding wheel of a bench grinder?
- A 4 mm
  - B 3 mm
  - C 5 mm
  - D 4,5 mm (1)
- 1.4 Which heat treatment process is used to decrease the brittleness in hardened steel?
- A Annealing
  - B Tempering
  - C Hardening
  - D Normalising (1)
- 1.5 What is the purpose of annealing steel?
- A To harden it
  - B To temper it
  - C To soften it
  - D To cool it down (1)
- 1.6 Which test is used to determine the ductility of a metal?
- A Sound test
  - B Hardness test
  - C Bending test
  - D Machining test (1)

**[6]**

### QUESTION 2: SAFETY (GENERIC)

- 2.1 What safety rule must be adhered to after the work procedures on any machine have been completed? (1)
- 2.2 Which safety precaution should be adhered to when drilling a small work piece on a drill press? (1)
- 2.3 State TWO safety rules to be observed when using the hydraulic press. (2)
- 2.4 Give TWO reasons for wearing surgical gloves when treating a co-worker with open wounds. (2)
- 2.5 State TWO safety precautions for the handling of gas cylinders. (2)
- 2.6 Name ONE responsibility of an EMPLOYER regarding safety in the workplace. (1)
- 2.7 Name ONE responsibility of an EMPLOYEE regarding safety in 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 Filing test (2)
- 3.1.2 Machining test (2)
- 3.2 When executing a sound test on steel, what sound is made by the following materials?
- 3.2.1 High carbon steel (HCS) (2)
- 3.2.2 Low carbon steel (LCS) (2)
- 3.3 What is the reason for executing the following heat treatment processes on steel?
- 3.3.1 Case hardening (2)
- 3.3.2 Hardening (2)
- 3.3.3 Normalising (2)
- [14]**

**QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)**

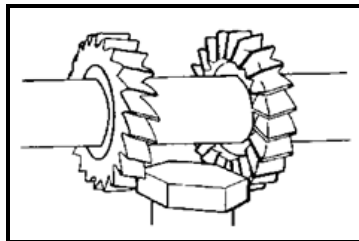
Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 A.

4.1 Which ONE of the following statements is an advantage of the 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 angles can be cut
- D Poor finishing is obtained

(1)

4.2 Identify the milling process shown 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, using the universal dividing head, will be the easiest method to cut a gear with 24 teeth?

- A Rapid indexing
- B Simple indexing
- C Angular indexing
- D Differential indexing

(1)

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

- A Point of reference is taken from the previous point.
- B Point of reference is taken from the zero point.
- C Point of reference is taken from a common point.
- D Point of reference is taken from any point.

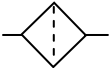
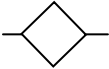


(1)

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

- A Rockwell hardness tester
- B Brinell hardness tester
- C Vickers hardness tester
- D Pascal hardness tester

(1)

- 4.6 Which ONE of the following statements describes the function of the moment 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 parallelogram of forces
  - D To determine the reaction on one side of a simply loaded beam (1)
- 4.7 What is the measure unit for strain?
- A Newton
  - B Pascal
  - C No unit
  - D Newton per metre (1)
- 4.8 What is the measure unit for moments?
- A Newton. metre (N.m)
  - B Pascal (Pa)
  - C No unit
  - D Newton/metre (N/m) (1)
- 4.9 Which ONE of the following materials is classified as a thermo hardened composite?
- A Nylon
  - B Teflon
  - C Carbon fibre
  - D Vesconite (1)
- 4.10 What can be done to reduce the frictional force between two of the same or two different materials?
- A Increase the weight of the object
  - B Add lubrication between the surfaces
  - C Change the cross-sectional area of materials used
  - D Decrease the perpendicular load on the surface (1)
- 4.11 Which ONE of the following screw thread terms is defined as the axial distance from any given point on the screw thread to the corresponding point on the adjacent thread?
- A Lead
  - B Pitch
  - C Crest
  - D Root (1)

- 4.12 Which ONE of the following is the definition of the helix angle of a screw thread?
- A The angle that the crest diameter makes with a line perpendicular ( $90^\circ$ ) to the axis of the thread
  - B The angle that the thread makes with a line perpendicular ( $90^\circ$ ) to the axis of the thread
  - C The angle that the centre line makes with a line perpendicular ( $90^\circ$ ) to the axis of the thread
  - D The angle that the thread makes with a line perpendicular ( $90^\circ$ ) to the pitch of the thread
- (1)
- 4.13 Which ONE of the following statements is an advantage of a belt drive system compared to a gear drive system?
- A Drive can take place over a long distance
  - B Expensive parts are used
  - C More power can be transmitted
  - D Transmission of power without slip is possible
- (1)
- 4.14 Which symbol is used to indicate a filter on a hydraulic flow diagram?
- A 
  - B 
  - C 
  - D 
- (1)  
[14]

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

- 5.1 Calculate the tailstock set-over required to cut a taper with an included angle of  $8^\circ$  on a centre lathe. The length of the taper is 300 mm. (3)
- 5.2 Name the THREE methods that can be used on the centre lathe to cut multiple-start screw threads. (3)
- 5.3 Calculate the following dimensions of a parallel key suitable for a 42 mm diameter shaft:
- 5.3.1 Width (2)
  - 5.3.2 Thickness (2)
- 5.4 State TWO advantages of using the compound slide method instead of the cross slide method to cut an external V-thread on the centre lathe. (2)
- 5.5 State THREE advantages of down-cut milling. (3)
- 5.6 State THREE factors that may be the cause of vibrations on the milling machine. (3)  
[18]

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

6.1 A spur gear has a pitch-circle diameter of 108 mm and a module of 3.

Calculate the following regarding this gear:

6.1.1 Number of teeth (2)

6.1.2 Outside diameter (2)

6.1.3 Cutting depth (2)

6.1.4 Addendum (1)

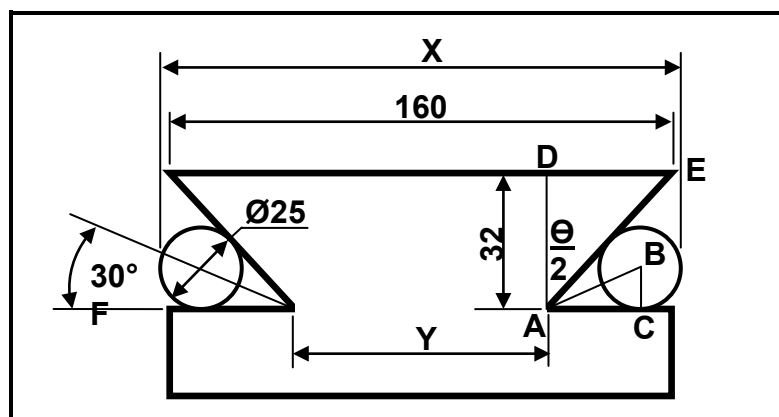
6.1.5 Dedendum (1)

6.1.6 Circular pitch (2)

6.2 Calculate the required angular indexing for an angle of 38°. (4)

6.3 A gear with 119 teeth must be cut on a universal milling machine with the help of a Cincinnati dividing head (40 : 1 ratio). Calculate the differential indexing and change gears needed for this process. (6)

6.4 FIGURE 6.4 below shows a dovetail part. Calculate distance **X** across the rollers, as shown in FIGURE 6.4.



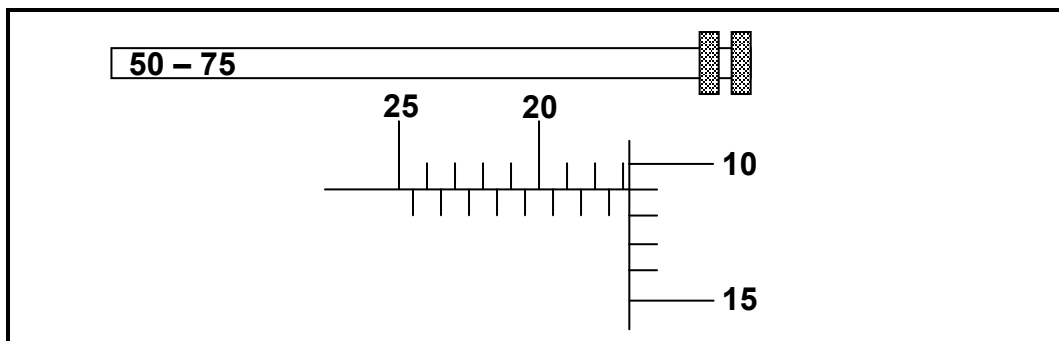
**FIGURE 6.4**

(8)  
**[28]**



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

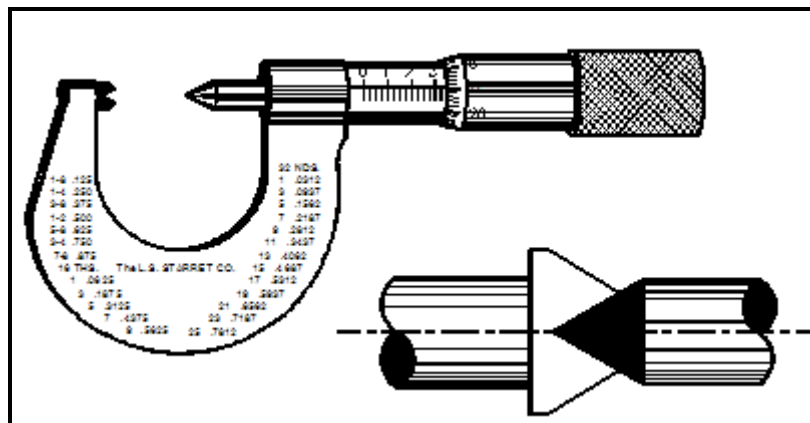
- 7.1 Use TWO neatly labelled sketches to indicate the difference between the *Brinell* and the *Rockwell hardness testers*. (4)
- 7.2 Describe the purpose of the *force tester*. (2)
- 7.3 State TWO properties of materials that can be determined by performing a tensile test using a tensile tester. (2)
- 7.4 What is the reading on the depth micrometer shown in FIGURE 7.4 below? (3)



**FIGURE 7.4**

(3)

- 7.5 Identify the instrument shown in FIGURE 7.5 below. (2)



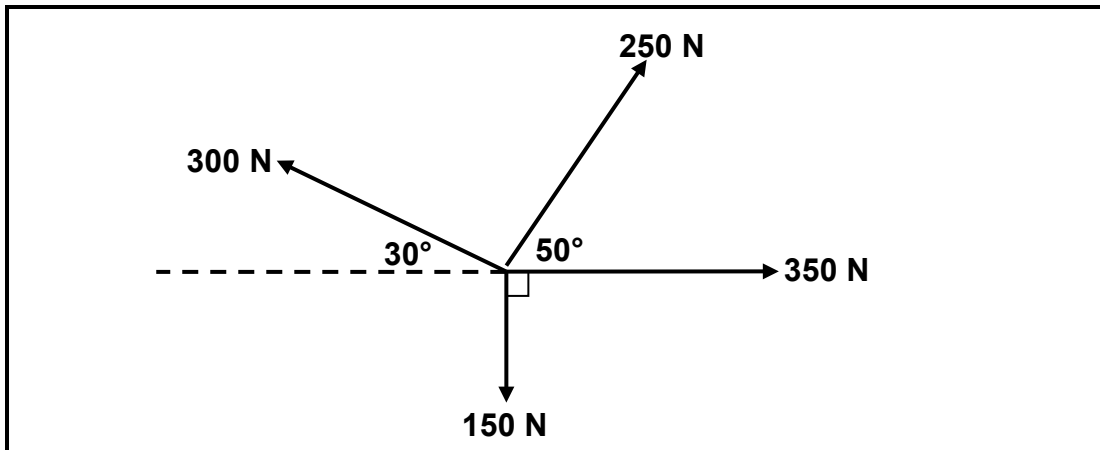
**FIGURE 7.5**

(2)  
[13]

**QUESTION 8: FORCES (SPECIFIC)**

8.1 FIGURE 8.1 below shows a system of forces with four co-planar forces acting on a point. Use calculations and determine the magnitude and direction of the resultant force for this system of forces.

(Copy and complete the diagram in the ANSWER BOOK. Show ALL the horizontal and vertical components before doing the calculations.)

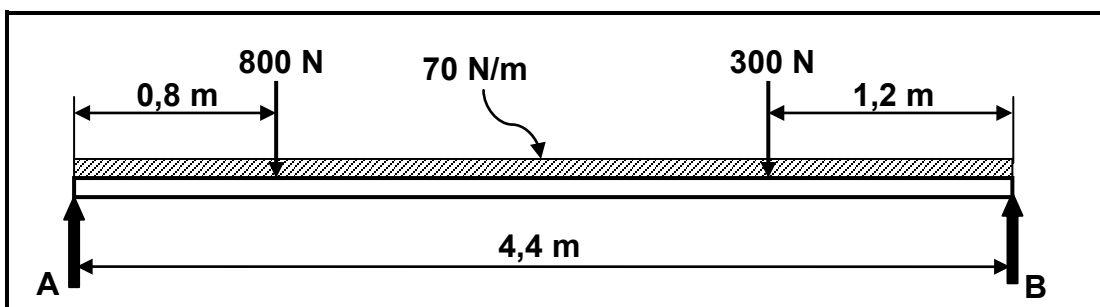


**FIGURE 8.1**

(14)

8.2 The diagram in FIGURE 8.2 below shows a beam supported by two vertical supports, **A** and **B**. Two vertical point loads of 800 N and 300 N as well as a uniformly distributed load of 70 N/m over the total length of the beam are exerted onto the beam. Calculate the magnitude of the reactions in support **A** and support **B**.

(Copy and complete the diagram in the ANSWER BOOK. Indicate the point load replacing the distributed load.)



**FIGURE 8.2**

(7)

8.3 A 25 mm square mild steel bar is subjected to a compressive force of 80 kN.

Calculate the following:

8.3.1 The stress in the material (5)

8.3.2 The strain if Young's modulus of elasticity for steel is 200 GPa (4)

8.3.3 The safe working stress if the break stress is 11 MPa and a safety factor of 3 has been used (3)

**[33]**

**QUESTION 9: MAINTENANCE (SPECIFIC)**

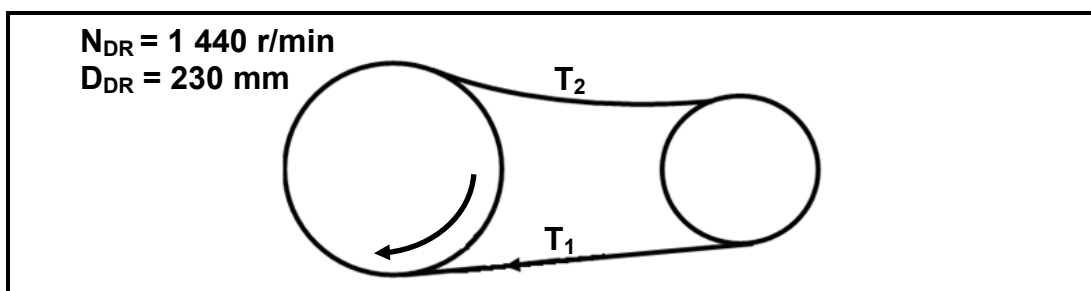
- 9.1 State THREE results of a lack of preventative maintenance of mechanical drive systems. (3)
- 9.2 Give TWO reasons for the malfunctioning of chain drives. (2)
- 9.3 State TWO procedures that can be followed to reduce the wear on a belt drive system. (2)
- 9.4 Briefly explain the procedure to replace a belt on a 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 Classify the following materials as either thermoplastic composites or thermo hardened (thermosetting) composites:
- 9.6.1 Teflon (1)
- 9.6.2 Vesconite (1)
- 9.6.3 Bakelite (1)
- 9.7 Does rubber or thermo composites have a lower coefficient of friction? (1)
- [18]**

**QUESTION 10: JOINING METHODS (SPECIFIC)**

- 10.1 A 7 mm pitch, three-start square thread is to be cut on a lathe. If the crest diameter of the thread is 90 mm and the clearance angle is  $3^\circ$ , calculate the following:
- 10.1.1 The lead of the thread (2)
- 10.1.2 The helix angle of the thread (6)
- 10.1.3 The leading tool angle (2)
- 10.1.4 The following tool angle (2)
- 10.2 An M16 x 2 V-screw thread needs to be tapped in a work piece. Calculate the required drill size. (2)
- 10.3 Draw a neat sketch of a metric V-screw thread. Indicate the following on the sketch:
- 10.3.1 Root diameter (1)
- 10.3.2 Crest diameter (1)
- 10.3.3 Effective diameter (1)
- 10.3.4 Screw-thread pitch (1)
- [18]**

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

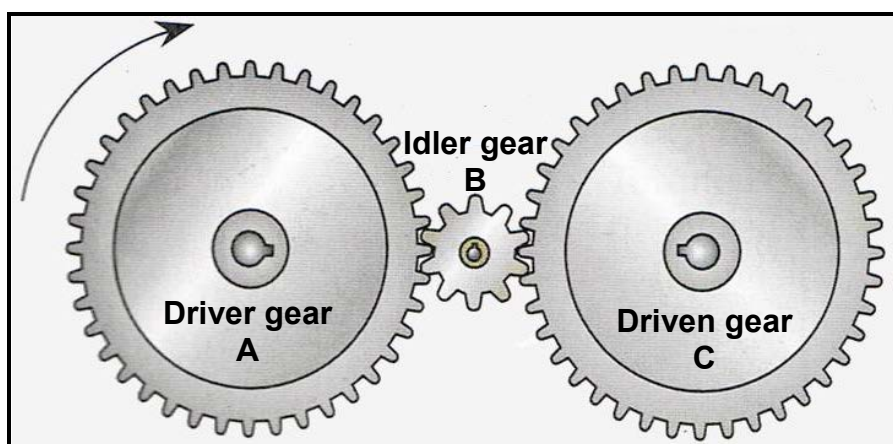
- 11.1 State THREE advantages of a *belt drive system*. (3)
- 11.2 The diameter of a piston is 120 mm and the pressure in the cylinder is 1,2 MPa. Calculate the force during the effective stroke. (7)
- 11.3 Draw the symbols for the following hydraulic components used in a hydraulic flow diagram:
- 11.3.1 Electrical motor (2)
- 11.3.2 Pressure gauge (2)
- 11.4 FIGURE 11.4 below shows a belt drive system with a 230 mm driver pulley rotating at 1 440 r/min. The effective tensile force in the system is 165 N.



**FIGURE 11.4**

Determine by means of calculations:

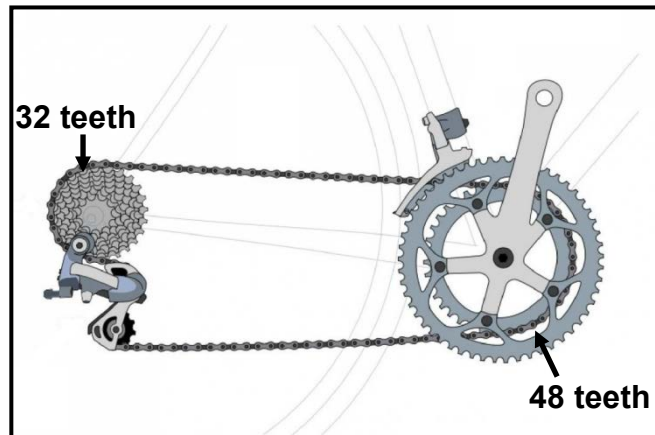
- 11.4.1 The belt speed in  $\text{m}\cdot\text{s}^{-1}$  (3)
- 11.4.2 The power transmitted in kW (3)
- 11.5 FIGURE 11.5 below indicates a gear system in a gearbox. Gear **A** with 102 teeth rotates clockwise at 120 r/min.



**FIGURE 11.5**

- 11.5.1 Determine the direction of rotation of driven gear **C** if driver gear **A** rotates clockwise, as indicated in FIGURE 11.5. (1)
- 11.5.2 Calculate the number of teeth on gear **C** if it needs to rotate at 80 r/min. (4)

- 11.6 The chain drive system of a bicycle is shown in FIGURE 11.6 below. Calculate the gear ratio of the system.



**FIGURE 11.6**

(3)  
[28]

**TOTAL: 200**

**FORMULA SHEET FOR MECHANICAL TECHNOLOGY  
(FITTING AND MACHINING)**

**1. BELT DRIVES**

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

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

$$N_1 D_1 = N_2 D_2$$

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

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

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

$T_2 = \text{force in slack side}$   
 $T_1 - T_2 = \text{effective force } (T_e)$

**2. STRESS AND STRAIN**

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

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

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

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

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

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

### 3. HYDRAULICS

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

Volume = Cross-sectional area × stroke length

### 4. KEYS AND KEYWAYS

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

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

Length of key = 1,5 × Diameter of shaft

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

### 5. GEAR DRIVES

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

$$N_1 T_1 = N_2 T_2$$

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

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

Torque = force × radius

Torque transmitted = gear ratio × input torque

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

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

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

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

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

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

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

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

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

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



## 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)