basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL
SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2015

MARKS: 200

TIME: 3 hours

This question paper consists of 13 pages and a 4-page formula sheet.

INSTRUCTIONS AND INFORMATION

1.   This question paper consists of TEN questions.

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.   Take the value of gravitational force as 10 m/s^2.

9.   All dimensions are in millimetres, unless stated otherwise in the question.

10.   A formula sheet for your use is attached at the back of this question paper.

11.   Write neatly and legibly.

12.   Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME (minutes)
1	Multiple-choice questions	20	15
2	Safety	10	10
3	Tools and Equipment	12	10
4	Materials	13	10
5	Terminology	30	20
6	Joining Methods	25	25
7	Forces	30	30
8	Maintenance	15	15
9	Systems and Control	25	25
10	Turbines	20	20
	TOTAL	200	180

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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 number (1.1–1.20) in the ANSWER BOOK, for example 1.21 D.

1.1   Which ONE of the following safety rules applies to the spot welder?

A   The area must be open to other workers.
B   Make sure that the time and current settings are suitable for the type and thickness of material being welded.
C   Oil the copper contact surfaces.
D   Make sure that the copper tips operate at a high temperature.   (1)

1.2   Which ONE of the following safety measures applies to a torsion tester?

A   Stop the rotating test piece by hand.
B   Be careful of metal particles coming off after the torsion.
C   Use a hammer to remove the test piece from the tester.
D   Use a strong lever to mount the test piece in the tester.   (1)

1.3   Which ONE of the following pieces of equipment is used to test the compression in the cylinders of an internal combustion engine?

A   Torsion tester
B   Pressure tester
C   Tensile tester
D   Brinell tester   (1)

1.4   Identify the engineering equipment shown in FIGURE 1.1.

FIGURE 1.1

A   Milling machine
B   Gas analyser
C   Brinell tester
D   Lathe   (1)

1.5   When carbon steel is heated at a constant rate, its temperature rises to 720 °C where the temperature then remains constant. This point is called the ...

    A   recalescence point.
    B   cooling point.
    C   decalescence point.
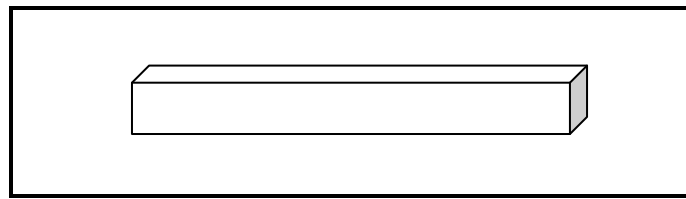   D   lower critical point.   (1)

1.6   Which structure of steel is characterised by an intensely hard and brittle characteristic?

    A   Austenite
    B   Cementite
    C   Pearlite
    D   Ferrite   (1)

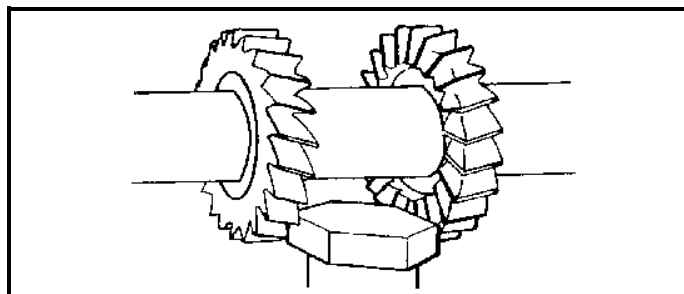1.7   Identify the type of key shown in FIGURE 1.2.

FIGURE 1.2

    A   Parallel key
    B   Gib head key
    C   Pratt and Whitney key
    D   Woodruff key   (1)

1.8   Identify the milling process shown in FIGURE 1.3.

FIGURE 1.3

    A   Gang milling
    B   Slab milling
    C   Slot milling
    D   Straddle milling   (1)

1.9   Which ONE of the following consumable parts is contained in the MIG/MAGS welding gun?

    A   Nozzle
    B   Shielding gas
    C   Electrode wire
    D   Earth cable   (1)

1.10   Which ONE of the following non-destructive tests uses sound waves to detect defects in a welded joint?

    A   X-ray test
    B   Dye/Liquid penetration test
    C   Visual inspection
    D   Ultrasonic test   (1)

1.11   Stress can be defined as an internal force in a material resisting a/an …

    A   internal load.
    B   spin load.
    C   moving load.
    D   external load.   (1)

1.12   What will Young's modulus of elasticity be for a metal if the strain value caused by 6 MPa stress is 2×10^{-3}?

    A 3×10^3 Pa
    B 3×10^6 Pa
    C 3×10^3 MPa
    D 3×10^6 MPa   (1)

1.13   What is the unit of a turning moment?

    A $N.m^{-2}$
    B $N.m$
    C $N.m^2$
    D $N.mm$ (1)

1.14   What is the definition of the *flash point* of engine oil?

    A   The lowest temperature at which a liquid will flow
    B   The lowest temperature at which oil gives off vapours which can ignite
    C   The lowest temperature at which oil converts from liquid to solid
    D   The lowest temperature at which oil converts from solid to liquid   (1)

1.15   The definition of the viscosity index of oil is a measure of how much the oil's viscosity changes as the ... changes.

A   temperature
B   pressure
C   flow
D   resistance   (1)

1.16   Which unit is used to measure power transmitted by a belt drive system?

A   Pascal
B   Watt
C   Volt
D   Joule   (1)

1.17   Boyle's law regarding a given mass of gas is defined as follows:

A   The volume is inversely proportional to the pressure, if the temperature remains constant.
B   The volume is directly proportional to the pressure, if the temperature remains constant.
C   The pressure is directly proportional to the volume, if the temperature remains constant.
D   The volume is inversely proportional to the pressure, if the temperature increases.   (1)

1.18   Which ONE of the following is a disadvantage of a flat belt drive system compared to a gear drive system?

A   It needs no lubrication.
B   It can only transmit power over a distance of more than one metre.
C   It changes direction.
D   It can slip on the pulley.   (1)

1.19   How is a supercharger driven?

A   Mechanical systems
B   Exhaust systems
C   Inlet systems
D   Fuel systems   (1)

1.20   A ... is a dynamic compressor in which air or gas is compressed by the mechanical action of an impeller which is spun by using the kinetic energy of moving air.

A   supercharger
B   gas turbine
C   turbocharger
D   steam turbine   (1)
    [20]

QUESTION 2: SAFETY

2.1 Name any THREE pieces of personal safety equipment that you need to wear when working with an angle grinder. (3)

2.2 State THREE safety precautions you should observe before pressing a bearing from a shaft on a hydraulic press. (3)

2.3 When assembling a cylinder head of a vehicle, the valve springs must be tested before installation. State TWO safety precautions you should observe when working with the spring tester. (2)

2.4 State any TWO safety precautions that you must consider when working with a bearing and gear puller. (2)

[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Tools are very important to complete different tasks in the workplace. Explain the function of EACH of the following testers:

    3.1.1 Cylinder leakage tester (2)

    3.1.2 Fuel pressure tester (2)

    3.1.3 Torsion tester (2)

3.2 Give any TWO reasons why it is necessary to perform a cylinder leakage test on an engine. (2)

3.3 The gas analyser in FIGURE 3.1 is used to determine the CO and CO_2 readings of the exhaust gases of an internal combustion engine.
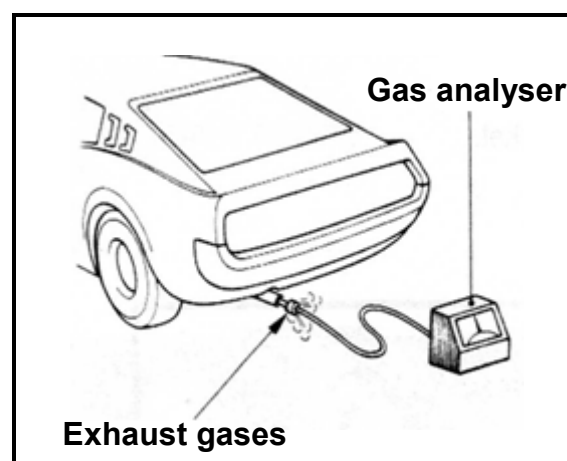
FIGURE 3.1

    Give TWO reasons for a high CO reading. (2)

3.4 Name any TWO tests that can be performed with a multimeter. (2)

[12]

QUESTION 4: MATERIALS

4.1   Indicate the following by means of a neat iron-carbon equilibrium diagram:

      4.1.1   Austenite structure   (2)

      4.1.2   Ferrite + Austenite structure   (2)

      4.1.3   Ferrite + Pearlite structure   (2)

      4.1.4   Temperature in degrees Celsius   (1)

      4.1.5   Percentages of carbon content   (1)

      4.1.6 AC_3 line   (1)

4.2   Explain how the following structures are formed:

      4.2.1   Pearlite   (2)

      4.2.2   Cementite   (2)
[13]

QUESTION 5: TERMINOLOGY

5.1   A spur gear has a pitch-circle diameter of 108 mm and 36 teeth.

      Calculate the following:

      5.1.1   Module   (2)

      5.1.2   Outside diameter   (3)

      5.1.3   Cutting depth   (2)

      5.1.4   Addendum   (1)

      5.1.5   Dedendum   (2)

      5.1.6   Circular pitch   (2)

      5.1.7   Clearance   (2)

5.2   State TWO advantages of using the compound slide method to cut an external V-thread on the centre lathe.   (2)

5.3   State TWO disadvantages of using the cross-slide method to cut an external metric V-thread on the centre lathe.   (2)

5.4   Calculate the indexing required to cut a 72-tooth gear.   (4)

5.5 State TWO advantages of up-cut milling. (2)

5.6 State TWO disadvantages of down-cut milling. (2)

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

5.7.1 Width/Breadth (2)

5.7.2 Thickness (2)

[30]

QUESTION 6: JOINING METHODS

6.1 What is the purpose of the shielding gas in the MIG/MAGS welding process? (2)

6.2 Explain the relationship between the voltage (V) and the wire feed during the MIG/MAGS welding process. (3)

6.3 Name TWO causes of the following welding defects:

6.3.1 Slag inclusion (2)

6.3.2 Incomplete penetration (2)

6.4 Explain TWO preventative measures for EACH of the following weld defects:

6.4.1 Porosity (2)

6.4.2 Lack of fusion (2)

6.5 Give ONE reason for performing the following destructive tests:

6.5.1 Free-bend test (2)

6.5.2 Nick and break test (2)

6.5.3 Machinability test (2)

6.6 Name FOUR causes of atmospheric contamination during the MIG/MAGS welding process. (4)

6.7 What is the function of the transmitter-receiver unit as used in the ultrasonic test on a welded joint? (2)

[25]

QUESTION 7: FORCES

7.1 In FIGURE 7.1 four forces of 200 N, 300 N, 280 N and 350 N are acting on the same point.
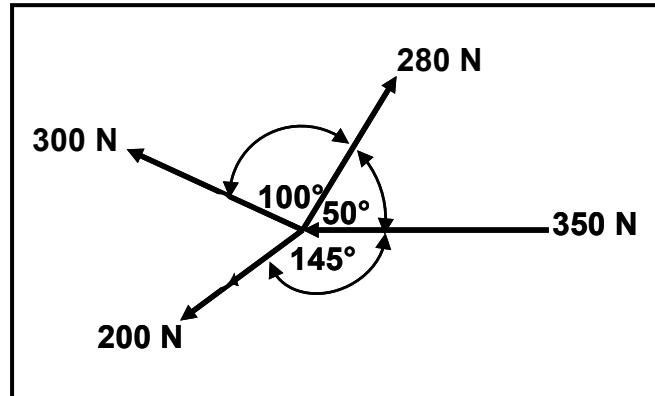
FIGURE 7.1

7.1.1	Calculate the resultant of the horizontal components.	(5)
7.1.2	Calculate the resultant of the vertical components.	(4)
7.1.3	Calculate the magnitude of the equilibrium force.	(3)
7.1.4	Calculate the equilibrium angle with reference to the horizontal plane.	(3)

7.2 An unknown force causes 3,5 MPa stress in a 25 mm round bar. Calculate the magnitude of the force. (4)

7.3 Study the stress-strain graph in FIGURE 7.2. Label points A–E as indicated on the graph.
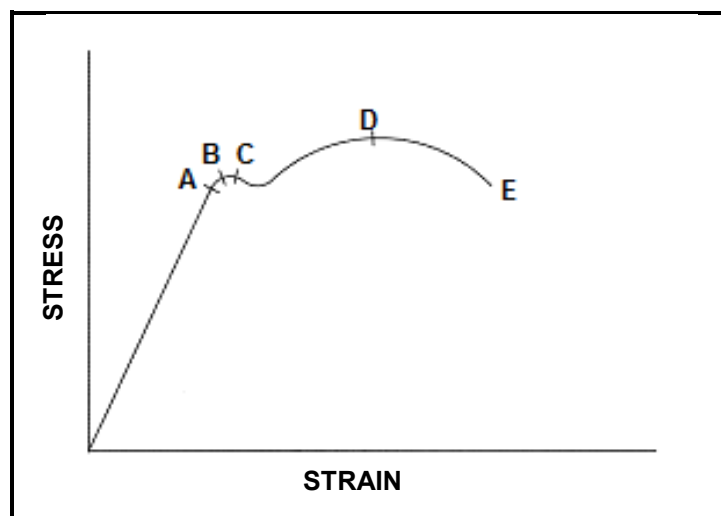
FIGURE 7.2 (5)

7.4 FIGURE 7.3 shows a uniform beam that is supported by two vertical supports, A and B. Two vertical point loads are exerted onto the beam, as well as a uniformly distributed force of 60 N/m, over the distance between the two vertical point loads.
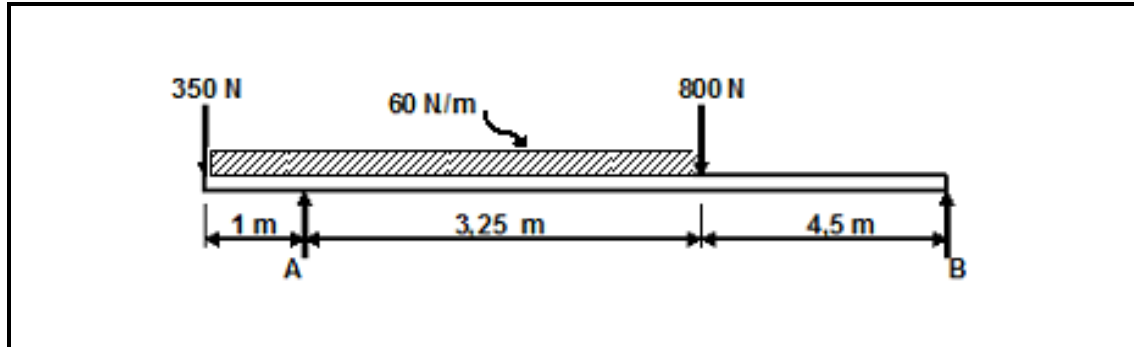

FIGURE 7.3

Determine, by means of calculations, the magnitudes of the reactions in support A and support B. (6)

[30]

QUESTION 8: MAINTENANCE

8.1 Why is it important to use oil with a higher viscosity in a manual transmission? (2)

8.2 What is the reason for using SAE20W50 viscosity oil or other multigrade oil in an internal combustion engine? (2)

8.3 Define the term *pour point* of a lubricant. (1)

8.4 State THREE ways in which cutting fluid should be maintained. (3)

8.5 Explain the importance of maintaining a belt drive system. (2)

8.6 Explain the reason for skimming the flywheel before installing a new clutch plate. (3)

8.7 Give TWO reasons for using grease on bearings. (2)

[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1   The gear system in FIGURE 9.1 is used to control a mechanical gate. The driver gear has 46 teeth and rotates at 500 r/min. The idler gear that is used to change the direction of rotation rotates at 1 000 r/min. The driven gear has 60 teeth.
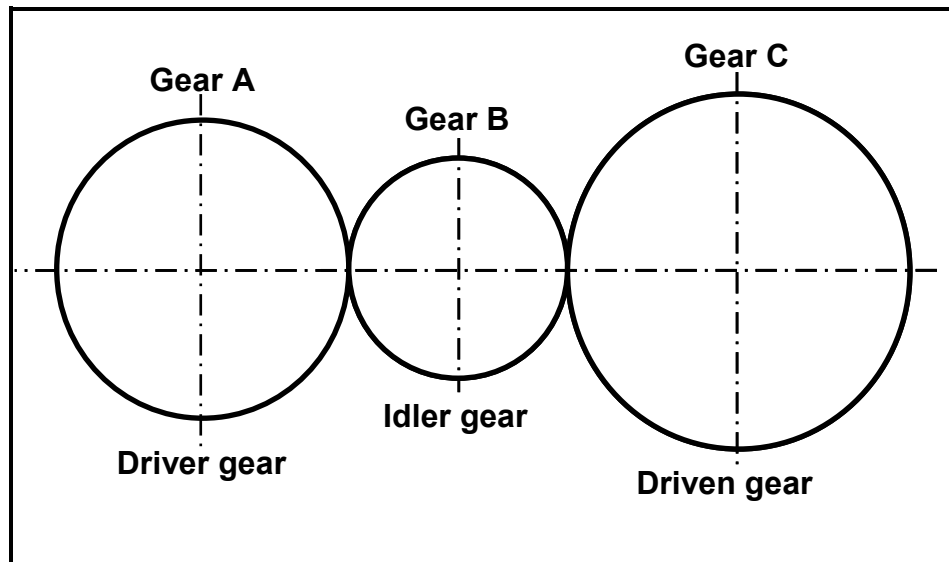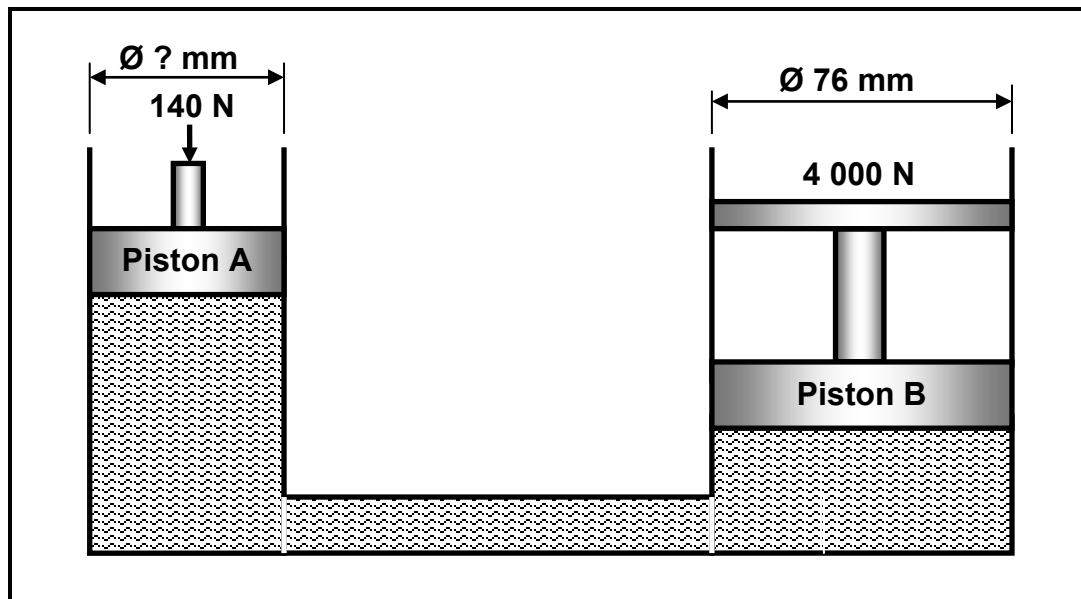

FIGURE 9.1

Determine by means of calculations:

9.1.1   The number of teeth on the idler gear   (3)

9.1.2   The rotation frequency of the driven gear in revolutions per minute   (3)

9.2   A machine must be driven at a speed of 12 r/s from a pulley with a diameter of 600 mm which rotates at a speed of 7,2 r/s. The tensile force in the tight side of the belt is 300 N. The ratio between the tensile force in the tight side and the tensile force in the slack side is 2,5 **:** 1.

Determine by means of calculations:

9.2.1   The diameter of the pulley that must be fitted to the machine   (3)

9.2.2   The power that can be transmitted   (3)

9.3 A hydraulic system is used in a hydraulic press. The specifications of the system are presented diagrammatically in FIGURE 9.2.

FIGURE 9.2

Determine by means of calculations:

9.3.1 The fluid pressure in the hydraulic system when in equilibrium (4)

9.3.2 The diameter of piston A (5)

9.4 What is the purpose of traction control in the driving system of a motor vehicle? (2)

9.5 Why are air bags in a motor vehicle seen as a passive safety feature? (2)

[25]

QUESTION 10: TURBINES

10.1 Name TWO types of reaction turbines. (2)

10.2 Explain the operation of the water impulse turbine. (6)

10.3 Why is it important to control the speed of a steam turbine? (2)

10.4 State THREE advantages of a gas turbine. (3)

10.5 Name TWO uses of auxiliary power units. (2)

10.6 State TWO functions of a supercharger when used on a motor vehicle engine. (2)

10.7 What effect does a high altitude have on the performance of a motor vehicle engine? (2)

10.8 State ONE advantage of a turbocharger when compared to a supercharger. (1)

[20]

TOTAL: 200

FORMULA SHEET

1.   BELT DRIVES

1.1   Belt speed $= \dfrac{\pi DN}{60}$ where N is in r/min

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 $= \dfrac{\text{diameter of driven pulley}}{\text{diameter of driver pulley}}$

1.5 $N_1 D_1 = N_2 D_2$

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

1.9   Power (P) $= \dfrac{(T_1 - T_2)\,\pi\,D\,N}{60}$ where N is in r/min

T_1 = force in the tight side
T_2 = force in the slack side
$T_1 - T_2$ = effective force (T_e)

1.10   Power (P) $= (T_1 - T_2) \times V$ where V = belt speed in m/s

1.11   Power (P) $= \dfrac{2\,\pi\,N\,T}{60}$ where N is in r/min

1.12   Width $= \dfrac{T_1}{\text{permissible tensile force}}$

2. STRESS AND STRAIN

2.1 $\text{Stress} = \dfrac{\text{force}}{\text{area}}$ or $(\sigma = \dfrac{F}{A})$

2.2 $\text{Strain}\,(\varepsilon) = \dfrac{\text{change in length }(\Delta L)}{\text{original length }(L)}$

2.3 $\text{Young's modulus}\,(E) = \dfrac{\text{stress}}{\text{strain}}$ or $(\dfrac{\sigma}{\varepsilon})$

2.4 Area of a round bar $\quad A = \dfrac{\pi d^2}{4}$

2.5 Area of a pipe $\quad A = \dfrac{\pi\left(D^2 - d^2\right)}{4}$

3. HYDRAULICS

3.1 $\text{Pressure}\,(P) = \dfrac{\text{force }(F)}{\text{area }(A)}$

3.2 Volume = cross-sectional area × stroke length

3.3 Work done = force × distance

4. KEYS

4.1 $\text{Width of key} = \dfrac{\text{diameter of shaft}}{4}$

4.2 $\text{Thickness of key} = \dfrac{\text{diameter of shaft}}{6}$

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

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

5. LEVERS

5.1 $\text{Mechanical advantage}\,(MA) = \dfrac{\text{load }(W)}{\text{effort }(F)}$

5.2 $\text{Velocity ratio} = \dfrac{\text{input movement}}{\text{output movement}}$

5.3 Input movement (IM) = effort × distance moved by effort

5.4 Output movement (OM) = load × distance moved by load

6.   GEAR DRIVES

6.1   Power $(P) = \dfrac{2\pi N T}{60}$

6.2   Gear ratio $= \dfrac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driver gears}}$

6.3 $\dfrac{N_{input}}{N_{output}} = \dfrac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driver gears}}$

6.4   Torque = force × radius

6.5   Torque transmitted = gear ratio × input torque

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

6.7 $N_1 T_1 = N_2 T_2$

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

6.9   Outside diameter (OD) = pitch-circle diameter (PCD) + 2 module

6.10   Addendum = module (m)

6.11   Dedendum = 1,157 m   or   Dedendum = 1,25 m

6.12   Cutting depth = 2,157 m   or   Cutting depth = 2,25 m

6.13   Clearance = 0,157 m   or   Clearance = 0,25 m

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

7.   SCREW THREADS

7.1   Pitch diameter = outside diameter − ½ pitch

7.2   Pitch circumference = $\pi \times$ pitch diameter

7.3   Lead = pitch × number of starts

7.4   Height of screw thread = 0,866 × pitch

7.5   Depth of screw thread = 0,613 × pitch

8. INDEXING

8.1 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

8.2 Indexing $= \dfrac{40}{n}$ (where n = number of divisions)