



Province of the
EASTERN CAPE
EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2024

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

MARKS: 200

TIME: 3 hours

This question paper consists of 23 pages, including a 4-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your NAME 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. You may use a non-programmable scientific calculator and drawing instruments.
8. The value of gravitational force should be taken as 10 m/s^2 .
9. ALL dimensions are in millimeters, unless stated otherwise in the question.
10. A formula sheet is attached to the question paper.
11. Write neatly and legibly.
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	10
	SPECIFIC		
4	Multiple-choice questions	14	10
5	Terminology (Lathe and Milling)	18	20
6	Terminology (Indexing)	28	30
7	Tools and Equipment	13	15
8	Forces	33	40
9	Maintenance	18	20
10	Joining Methods	18	20
11	Systems and Control (Drive systems)	28	30
TOTAL		200	180

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

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, for example 1.7 A.

- 1.1 Which safety law state that all employers must ensure that the workplace is safe, and that the employees are not at risk of becoming infected with HIV at work?
- A The code of good practice on HIV/Aids and employment.
 - B Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993)
 - C Employment Equity Act (EEA), 1998 (Act 55 of 1998)
 - D Basic Conditions of Employment Act (BCEA), 1997 (Act. 75 of 1997) (1)
- 1.2 Checking breathing, heart rate, consciousness, pulse and loss of blood of an injured person, is called ...
- A vital functions.
 - B indicators to diagnosis.
 - C visible signs and symptoms.
 - D environmental observation. (1)
- 1.3 The safe working pressure must never be exceeded.
- At which of the following equipment is the safety precaution mentioned in the above statement applicable?
- A Drill press
 - B Bench grinder
 - C Hydraulic press
 - D Guillotine machine (1)
- 1.4 It is important to stand and work only in dry surroundings. Always keep your hands and clothing dry.
- In which joining equipment is the above statement applicable?
- A Hand riveter
 - B Gas welding
 - C Arc welding
 - D All the above-mentioned (1)

- 1.5 FIGURE 1.5 shows a spark test conducted on a material. Identify the material used during the spark test.

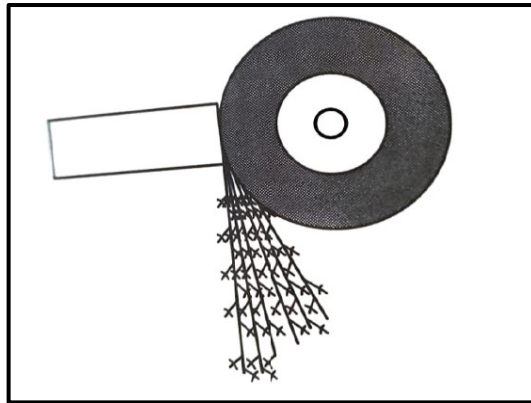


FIGURE 1.5

- A High-carbon steel
- B Low-carbon steel
- C Cast iron
- D None of the above-mentioned

(1)

- 1.6 FIGURE 1.6 below shows one of the heat treatment processes. Which heat-treatment process is represented by FIGURE 1.6?

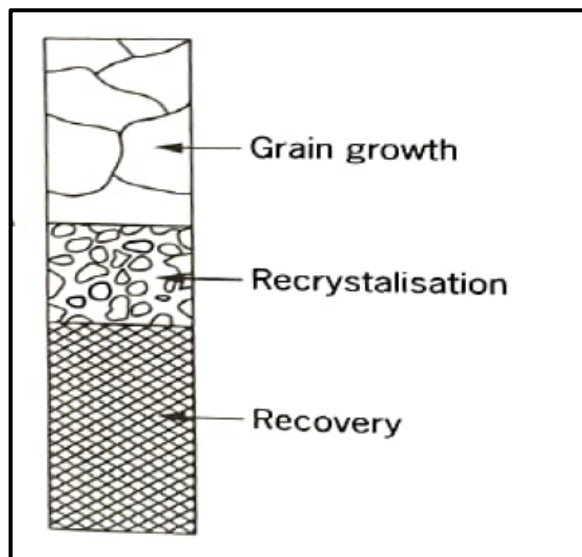


FIGURE 1.6

- A Hardening process
- B Tempering process
- C Normalising process
- D Annealing process

(1)
[6]

QUESTION 2: SAFETY (GENERIC)

- 2.1 List TWO safety precautions when handling gas cylinders in a workshop. (2)
- 2.2 Describe the employer's responsibility regarding safety in the workplace. (2)
- 2.3 State TWO safety measures to observe before switching on an angle grinder. (2)
- 2.4 Give any TWO reasons why it is important to wear welding goggles during gas welding. (2)
- 2.5 State TWO disadvantages of a process layout of machines. (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Metals are usually marked or colourcoded on the ends. Why is it important to cut from the unmarked end of the metal? (1)

3.2 Tabulate the following heat-treatment processes and identify ONE property of each.

	PROCESS	PROPERTY
3.2.1	Hardening	
3.2.2	Tempering	
3.2.3	Annealing	
3.2.4	Normalising	

(4)

3.3 Explain THREE factors to considered when heat-treatment of steel is done. (3)

3.4 List THREE types of quenching media used to harden steel. (3)

3.5 State the type of test that can be used to obtain the following properties of metals:

3.5.1 Hardness (1)

3.5.2 Carbon content (1)

3.5.3 Ductility (1)

[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, for example 4.15 A.

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

- A Pascal
- B Watt
- C Volt
- D Joule

(1)

4.2 Identify the type of micrometer in FIGURE 4.2 below.



FIGURE 4.2

- A Screw-thread micrometer
- B Inside micrometer
- C Outside micrometer
- D Depth micrometer

(1)

4.3 Which ONE of the following is an advantage of cutting tapers on a lathe, using the compound slide method?

- A Tapers with large angles can be cut.
- B The automatic feed of the machine can be used.
- C Long tapers can be cut.
- D It causes the operator to become fatigued.

(1)

4.4 Name the tool that is used to set the cutting tool perpendicular to the axis of the workpiece when cutting a screw-thread on the lathe.

- A Screw-pitch gauge
- B Screw-thread ring gauge
- C Centre gauge
- D Screw gauge

(1)

4.5 Identify the engineering equipment shown in FIGURE 4.5 below.



FIGURE 4.5

- A Gas analyser
- B Brinnell tester
- C Milling machine
- D Drilling machine

(1)

4.6 What is the unit of a turning moment?

- A N.m^{-2}
- B N.m^2
- C N.m
- D N.mm

(1)

4.7 Identify the type of milling process shown in FIGURE 4.7 below.

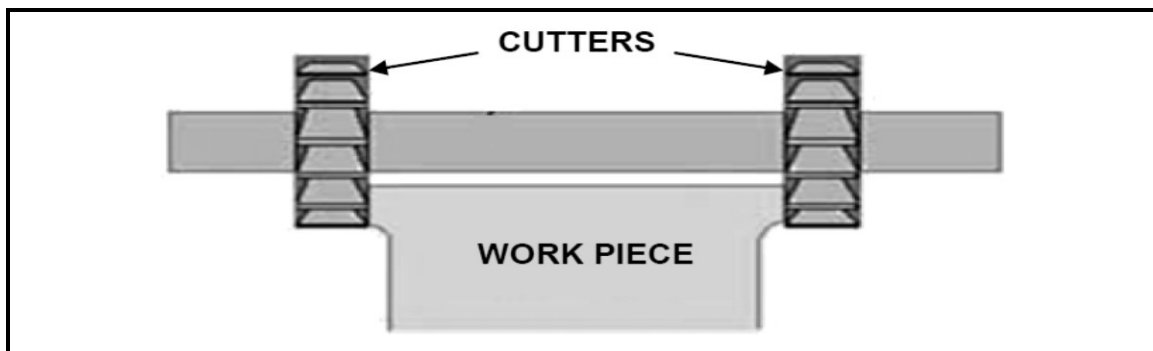


FIGURE 4.7

- A Slab milling
- B Gang milling
- C Side milling
- D Straddle milling

(1)

4.8 Upcut milling is also known as ...

- A gang milling.
- B slot milling.
- C climb milling.
- D conventional milling.

(1)

4.9 Which lathe operation is shown in FIGURE 4.9 below?

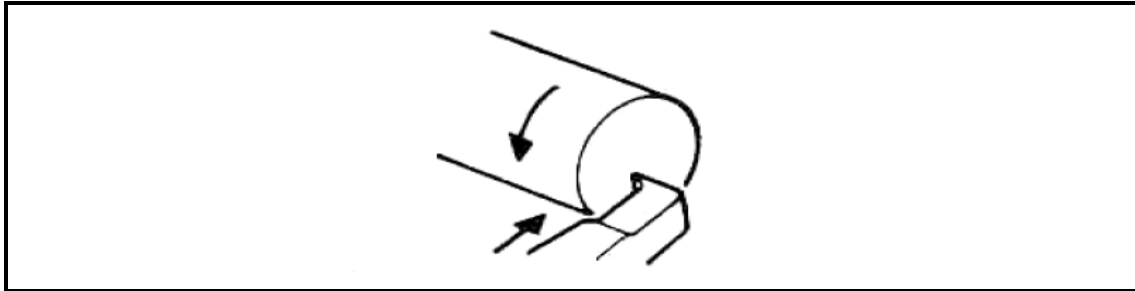


FIGURE 4.9

- A Diameter turning
- B Thread cutting
- C Facing off
- D Boring

(1)

4.10 Which ONE of the following statements describes Pascal's law?

- A The area is inversely proportional to the pressure on it if the temperature remains constant.
- B The pressure exerted on the surface of the liquid in a closed hydraulic system is transmitted equally in all directions.
- C The pressure is proportional to the volume if the temperature remains constant.
- D The volume is inversely proportional to the pressure on it if the temperature increases.

(1)

4.11 The beam in FIGURE 4.11 below is in equilibrium. Calculate the distance between the support point and the 9 kN load.

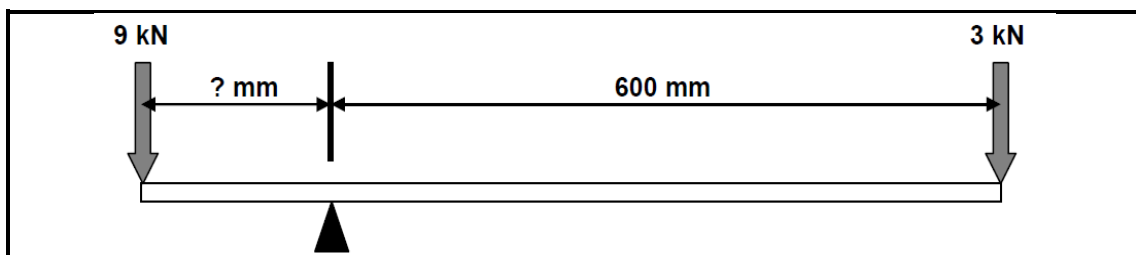


FIGURE 4.11

- A 300 mm
- B 200 mm
- C 150 mm
- D 600 mm

(1)

4.12 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)

4.13 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)

4.14 What is the drill size for a M14 x 1,5 screw thread?

- A 13,5 mm
- B 1,5 mm
- C 21 mm
- D 12,5 mm

(1)

[14]

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHICE) (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.

Calculate the included angle.

(4)

- 5.2 FIGURE 5.2 below shows a drawing of a keyway being cut with a 12 mm wide cutter on a 48 mm diameter shaft. Answer the questions that follow.

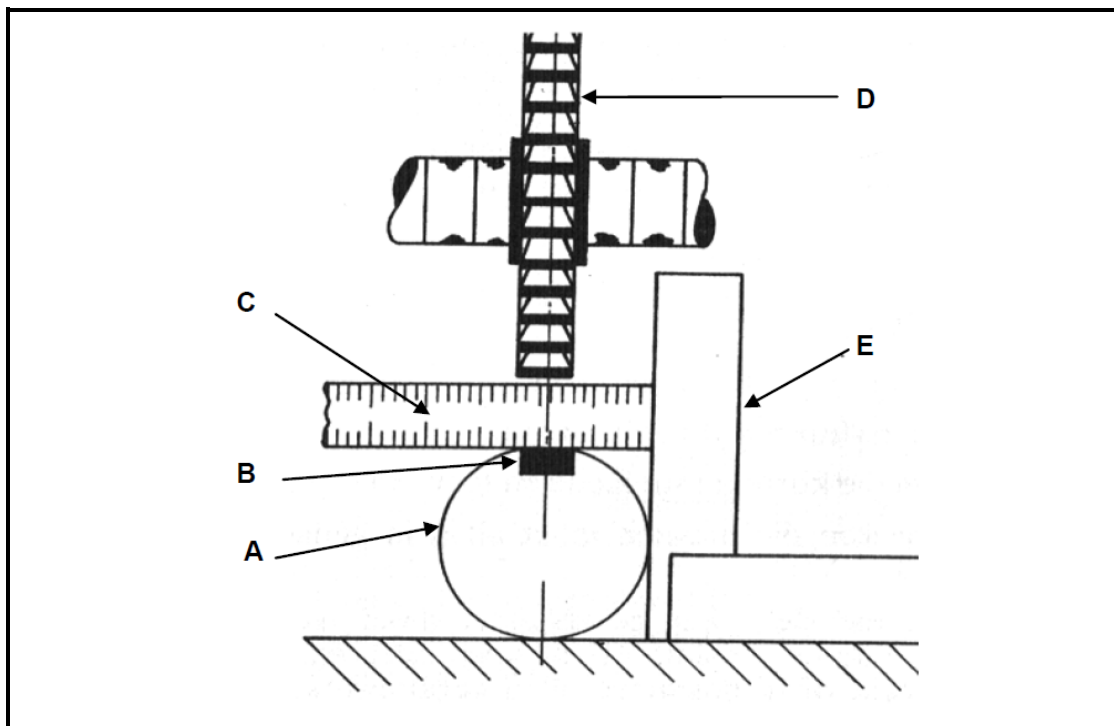


FIGURE 5.2

Determine by means of calculations the:

- 5.2.1 Width of the key (2)

- 5.2.2 Thickness of the key (2)

- 5.2.3 Length of the key (2)

- 5.2.4 Distance between the square and the side of the cutter facing the square (3)

- 5.3 Label parts **A–E**. (5)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 Explain the function of an index plate as used during differential indexing. (2)

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

Calculate the following:

6.2.1 Module (2)

6.2.2 Outside diameter (2)

6.3 A spur gear with 129 teeth must be cut on a milling machine. The dividing head has a ratio of 40 : 1.

By means of calculations, determine:

6.3.1 The indexing that is needed (Choose 120 divisions) (3)

6.3.2 The change gears that are needed (5)

6.3.3 Direction of rotation of the index plate (1)

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

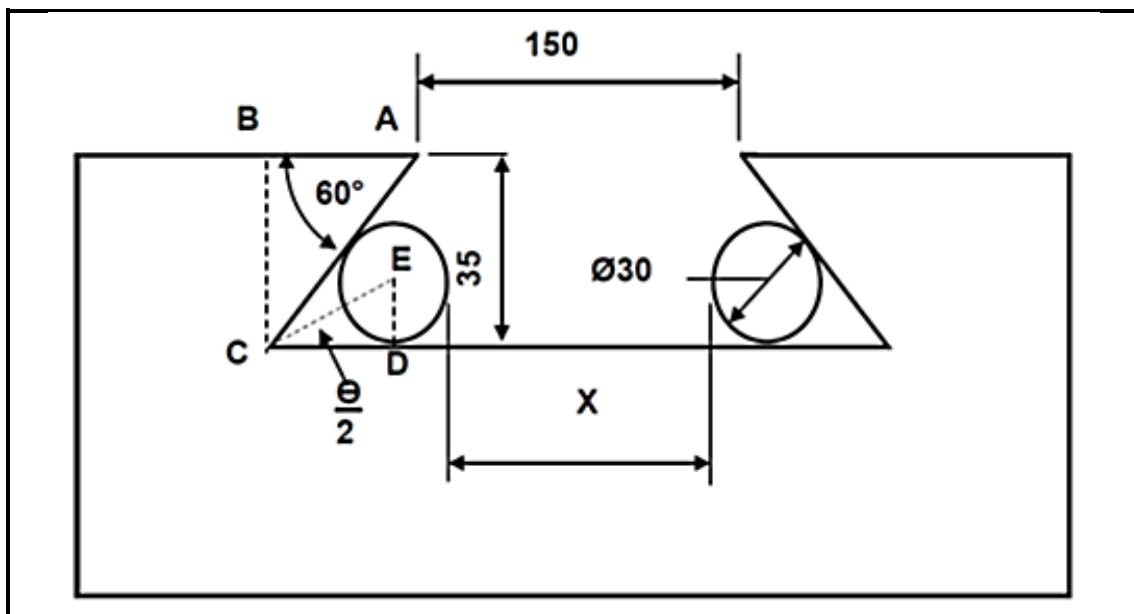


FIGURE 6.4

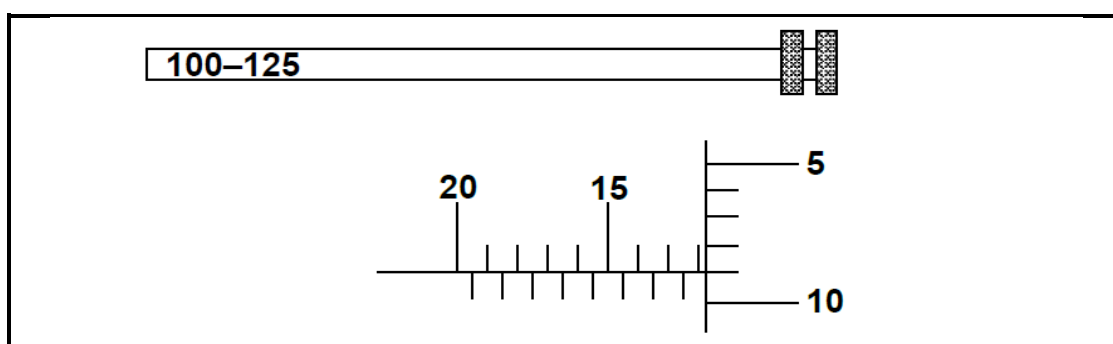
6.5 Name TWO types of balancing methods. (2)

6.6 State TWO advantages of balancing the rotating components of a machine. (2)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

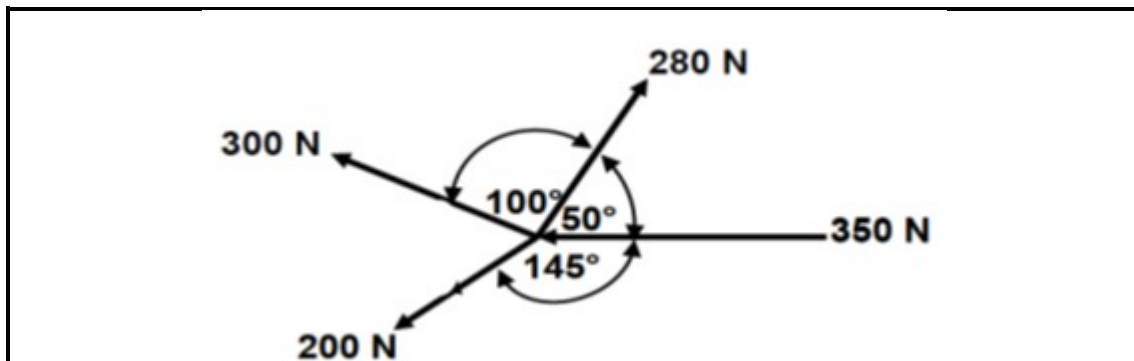
- 7.1 Explain the difference between *Brinell* and *Rockwell hardness testers* that are used to determine the hardness of a steel. (4)
- 7.2 State ONE of the functions of a moment tester. (1)
- 7.3 A vernier calliper is used to do precision measuring of an outside diameter, an inside diameter and the depth of a hole.
Name THREE other precision measuring instruments that can be used for precision measuring these dimensions. (3)
- 7.4 What is the reading on the measuring instrument, as shown in FIGURE 7.4 below?

**FIGURE 7.4**

(5)
[13]

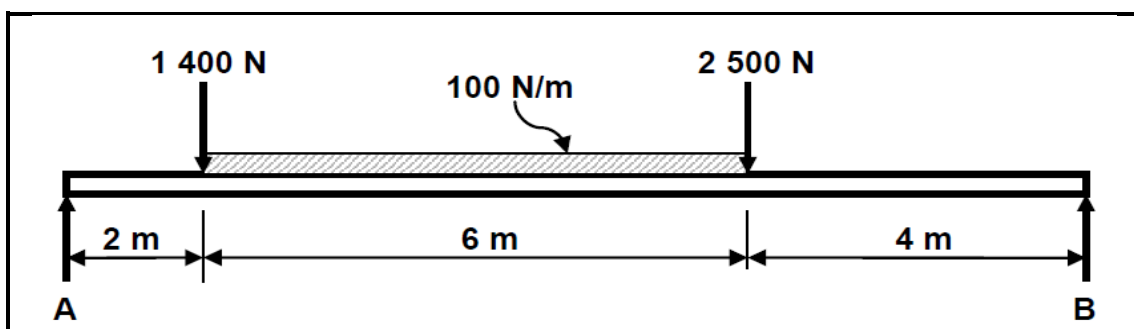
QUESTION 8: FORCES (SPECIFIC)

- 8.1 FIGURE 8.1 shows a system of four forces acting on the same point. Answer the questions that follow.

**FIGURE 8.1**

Calculate the following:

- 8.1.1 Sum of the horizontal components (5)
- 8.1.2 Sum of the vertical components (4)
- 8.1.3 Magnitude of the resultant (2)
- 8.1.4 Angle and the direction of the resultant (3)
- 8.2 FIGURE 8.2 below 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 load of 100 N/m, over a length of 6 metres of the beam.

**FIGURE 8.2**

Calculate the:

- 8.2.1 Uniformly distributed load on the beam (2)
- 8.2.2 Magnitude of the reaction force at **A** (3)
- 8.2.3 Magnitude of the reaction force at **B** (3)

- 8.3 A bar is 600 mm long and is stretched to 605 mm when a force of 50 kN is exerted on the bar. The diameter of the bar is 20 mm.

Calculate the following:

- 8.3.1 Stress in the bar (5)
- 8.3.2 Strain the bar experiences (3)
- 8.3.3 Young's modulus of elasticity (3)
- [33]**

QUESTION 9: MAINTENANCE (SPECIFIC)

- 9.1 State the THREE possible consequences for failure to do maintenance. (3)
- 9.2 Name the THREE factors that influence the coefficient of friction. (3)
- 9.3 Why is it essential to use a cutting fluid on a milling or centre lathe? (1)
- 9.4 State TWO ways to conduct preventative maintenance in each of the following drive systems:
- 9.4.1 V-belt drive (2)
- 9.4.2 Gear drive (2)
- 9.5 Give TWO reasons for using glass fibre to manufacture motor vehicle bodies. (2)
- 9.6 Name the element used to enhance the strength of a glass fibre. (1)
- 9.7 State whether EACH of the following materials is a thermo-hardened or a thermoplastic composite:
- 9.7.1 Nylon (1)
- 9.7.2 Bakelite (1)
- 9.7.3 Carbon fibre (1)
- 9.7.4 Polyvinyl chloride (PVC) (1)

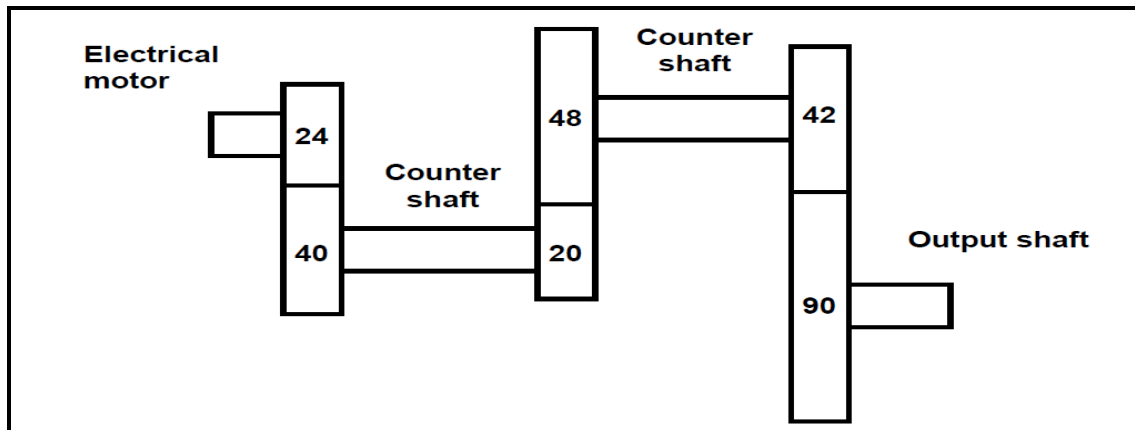
[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

- 10.1 What is the most common screw thread used in South Africa? (1)
- 10.2 State the included angle of the following screw threads:
- 10.2.1 V-screw thread (1)
- 10.2.2 Square screw thread (1)
- 10.3 The measurement of a screw thread is given as M24 x 2,5. What does 2,5 means? (1)
- 10.4 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:
- 10.4.1 Lead of the thread (2)
- 10.4.2 Pitch diameter (2)
- 10.4.3 Helix angle of the screw thread (4)
- 10.4.4 Leading tool angle (2)
- 10.4.5 Following tool angle (2)
- 10.5 Why would a multi-start thread be preferred mostly to a single start thread? (2)
- [18]**

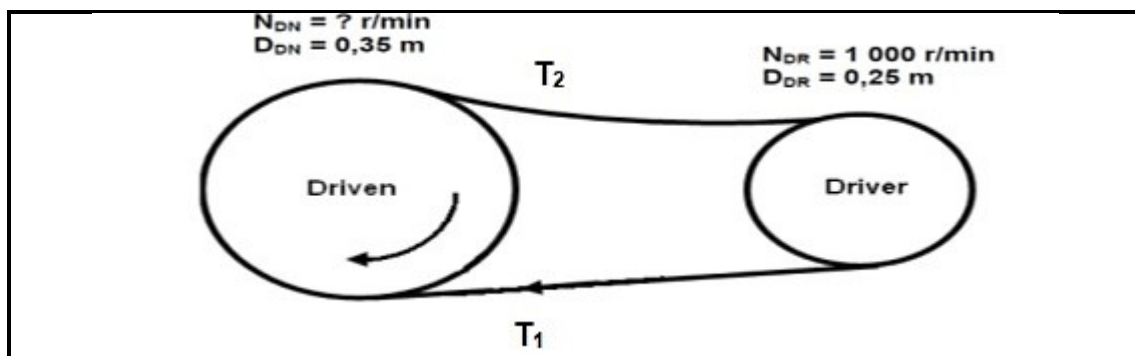
QUESTION 11: SYSTEMS AND CONTROLS (SPECIFIC)

- 11.1 Name the TWO factors that would determine the use of gear drives in the industry. (2)
- 11.2 FIGURE 11.2 shows a gear drive system. A driver gear on the shaft of an electric motor has 24 teeth and meshes with a gear on a counter shaft with 40 teeth. On this counter shaft is another driver gear with 20 teeth that meshes with a gear with 48 teeth on a second counter shaft. The second counter shaft has a driver gear with 42 teeth which drives a gear with 90 teeth on the output shaft.

**FIGURE 11.2**

Calculate the following:

- 11.2.1 The rotation frequency of the output shaft if the electric motor rotates at 1 440 r/min (4)
- 11.2.2 The velocity ratio between the input and output shaft (2)
- 11.3 FIGURE 11.3 shows a belt-drive system. A pulley with a diameter of 0,25 m drives a driven pulley with a diameter of 0,35 m. The driver pulley rotates at 1 000 r/min. $T_1 = 200$ N and $T_2 = 90$ N.

**FIGURE 11.3**

Calculate the following:

- 11.3.1 The rotation frequency of the driven pulley in revolutions per minute (3)
- 11.3.2 The belt speed of the system in metres per second (3)
- 11.3.3 The power transmitted (3)

- 11.4 A hydraulic system is being used to lift a machine part into position. The specifications of the system are diagrammatically presented in FIGURE 11.3 below.

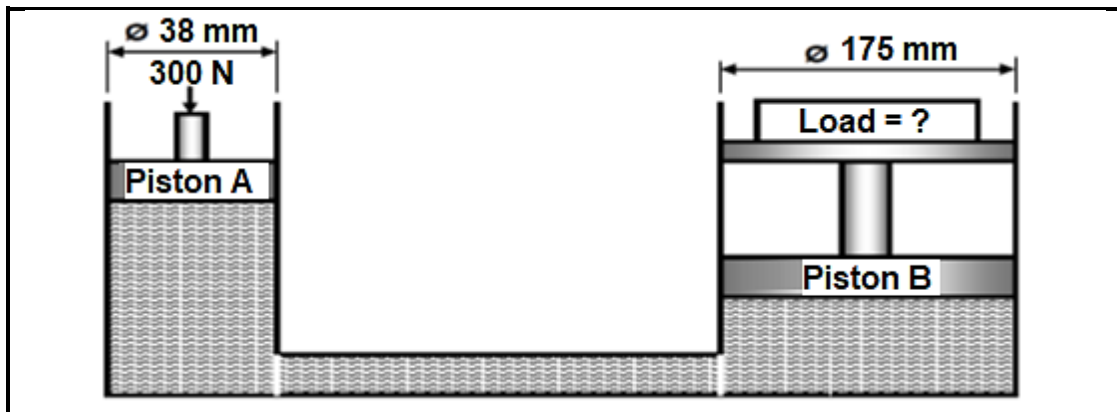


FIGURE 11.4

Calculate the following:

- 11.4.1 The fluid pressure in the hydraulic system when in equilibrium (5)
- 11.4.2 The load that can be lifted by piston **B** when a force of 300 N is applied to piston **A** (6)

[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

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

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

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

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

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

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

3. HYDRAULICS

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

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

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

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

$$N_1 T_1 = N_2 T_2$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6. SCREW THREADS

Helix angle: $\tan \theta = \frac{\text{Lead}}{\text{pitch circumference}}$

Pitch diameter = Outside diameter $1/2$ pitch

Pitch circumference = $\pi \times$ pitch diameter

Lead = pitch \times number of starts

Height of screw thread = $0.866 \times p$ where p = pitch of the screw thread

Depth of screw thread = $.612 \times p$ where p = pitch of the screw thread

Number of turns = Length \times Lead

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

Leading 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

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

Angular Indexing = $\frac{n}{9^\circ}$

Change gears: $\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$ or $\frac{Dr}{Dn} = \frac{(A - n)}{A} \times \frac{40}{1}$
 (where A = chosen divisions) (where n = given divisions)