basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

2022

MARKS: 200

TIME: 3 hours

This question paper consists of 16 pages and a 5-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 E.

1.1 Which ONE of the following safety procedures relates to the operation of a hydraulic press?

A The platform on which the work piece rests must be rigid and perpendicular to the press cylinder.
B Make sure all gas valves in the cylinders are properly adjusted.
C Chips can be removed while the machine press is in operation.
D Ensure that the maximum air pressure is not exceeded in the cylinders. (1)

1.2 Which safety measure is applicable to drilling machines?

A Leave the key in the chuck when the machine is not operated.
B Choose a correctly sharpened drill bit for the type of work you need to do.
C There is no need to wear safety goggles.
D Leave the machine running while having lunch. (1)

1.3 Which ONE of the following types of personal protective equipment (PPE) is required when arc welding a work piece?

A Hard hat
B Welding goggles
C Welding helmet
D Cotton gloves (1)

1.4 Which ONE of the following types of steel is the easiest to cut?

A High-speed steel
B Cast iron
C Cast steel
D Mild steel (1)

1.5 Which method can be used to conduct a sound test?

A Dropping the work piece on a concrete floor
B Drilling into the metal
C Using a surface grinder
D Welding the metal (1)

1.6 Nitriding is done during the ... process.

A hardening
B annealing
C case-hardening
D normalising (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 Why should the rated speed of the grinding wheel never exceed the maximum speed of the grinder? (1)

2.2 State TWO safety precautions that should be observed while the vertical band saw is in operation. (2)

2.3 Identify the THREE stages in which first aid is applied. (3)

2.4 Name the TWO main categories into which the causes of accidents can be divided according to the Occupational Health and Safety Act. (2)

2.5 State TWO advantages of the product workshop layout. (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Define *tempering* of steel. (2)

3.2 Give THREE reasons why the annealing process is conducted on steel. (3)

3.3 At what approximate temperature is steel heated during the normalising process? (2)

3.4 Identify the type of steel/iron from the spark patterns shown in FIGURES 3.4.1–3.4.3 below.

3.4.1

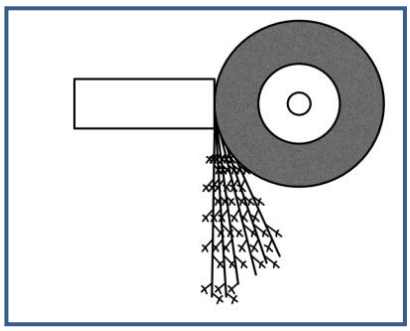

FIGURE 3.4.1 (1)

3.4.2

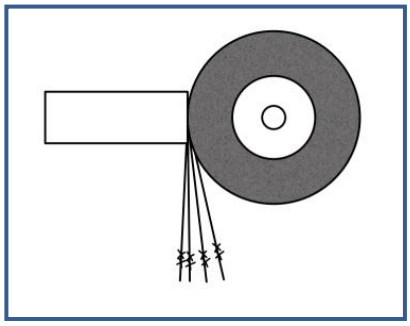

FIGURE 3.4.2 (1)

3.4.3

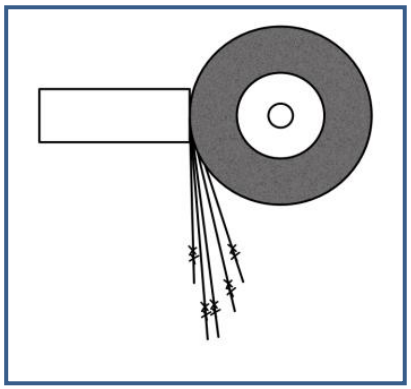

FIGURE 3.4.3 (1)

3.5 FIGURE 3.5 below shows an iron-carbon equilibrium diagram. Label **A** to **D**.

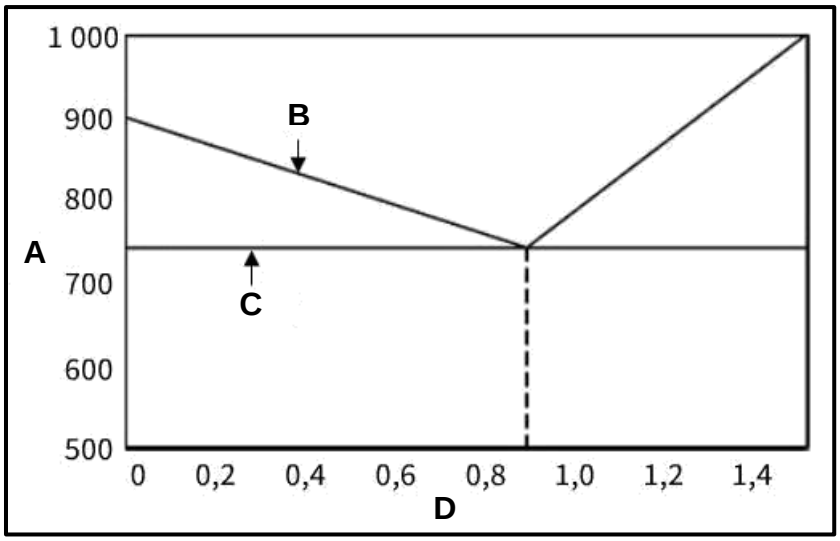

FIGURE 3.5 (4)

[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 Identify the lathe component in FIGURE 4.1 below.

FIGURE 4.1

A Dead centre
B Revolving centre
C Centre drill
D Taper drill bit (1)

4.2 What is the purpose of the screw-cutting dial gauge found on a lathe machine?

A Allows an operator to engage a lead screw half-nut accurately
B To keep the lead screw and half-nut in place
C Assists with counting the number of screw threads that have been cut
D To check if the screw thread has been cut accurately (1)

4.3 How many axes are displayed on a digital read-out (DRO) system on a lathe machine?

A 2
B 3
C 4
D 6 (1)

4.4 Which codes does a CNC (computer numerical controlled) milling machine use for machine tool moving?

A X-codes
B Z-codes
C G-codes
D Y-codes (1)

4.5 What is the size of the carbide ball in a Brinell hardness tester when used for testing material?

A 20 mm
B 15 mm
C 10 mm
D 5 mm (1)

4.6 Identify the type of precision measuring tool in FIGURE 4.6 below.

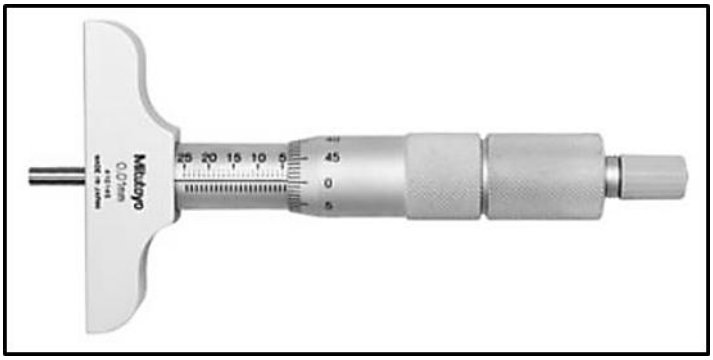

FIGURE 4.6

A Screw-thread micrometer
B Inside micrometer
C Outside micrometer
D Depth micrometer (1)

4.7 What type of stress is caused in a cable of a hoisting crane when lifting a load?

A Form stress
B Tensile stress
C Compressive stress
D Shearing stress (1)

4.8 Which ONE of the following factors determines the value of the safety factor?

A The consequences of failure
B The value of the minimum load
C The length of the material
D The weight of the material (1)

4.9 Which ONE of the following is an example of PVC?

A Non-stick coated frying pan
B Quick-setting glue
C Cling wrap
D Distributor rotor (1)

4.10 Which ONE of the following is an advantage of nylon?

A Corrodes easily
B Has a high coefficient of friction
C Can quickly turn to liquid
D Not affected by fungus (1)

4.11 Identify **A** in FIGURE 4.11 below.

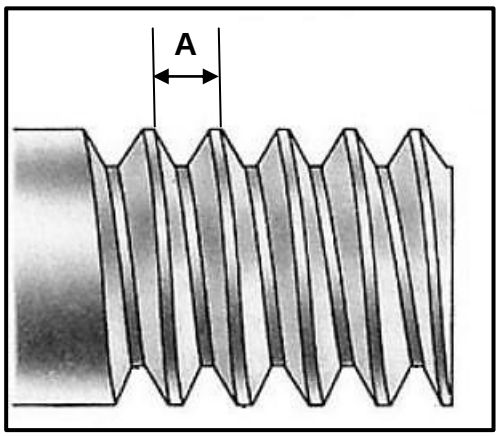

FIGURE 4.11

A Root
B Pitch
C Depth
D Crest (1)

4.12 Which ONE of the following is an advantage of a multiple-start screw thread?

A Turns slower as it fastens
B Frequently used
C Produces faster movement
D Loses more power due to friction (1)

4.13 A block and tackle is also known as a ...

A pulley system.
B gear system.
C hydraulic system.
D mechanical drive system. (1)

4.14 Identify the symbol of the hydraulic component in FIGURE 4.14 below.

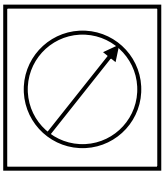

FIGURE 4.14

A Pressure gauge
B Lubricator
C Filter
D Pump (1)

[14]

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

5.1 State TWO disadvantages of cutting a taper on a lathe machine using the compound slide method. (2)

5.2 FIGURE 5.2 below shows a taper with an included angle of 12° which should be machined between two centres. Answer the questions that follow.

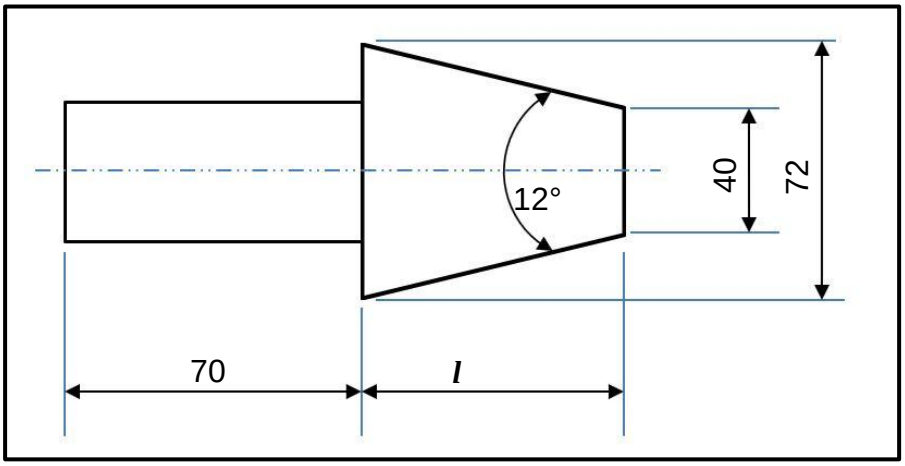

FIGURE 5.2

5.2.1 Calculate the length of the taper. (5)

5.2.2 Calculate the set-over of the tailstock required to cut the taper in FIGURE 5.2 above. (3)

5.3 Calculate the following dimensions for a parallel key suitable for a 102 mm diameter driveshaft:

5.3.1 Width (2)

5.3.2 Thickness (2)

5.3.3 Length (2)

5.4 State TWO disadvantages of gang milling. (2)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 A spur gear, with a pitch-circle diameter of 168 mm and 42 teeth, is needed for a gearbox. Calculate the following:

6.1.1 Module (2)

6.1.2 Circular pitch (2)

6.1.3 Outside diameter (2)

6.2 FIGURE 6.2 below shows an external dovetail that must be manufactured for a compound slide of a lathe machine.

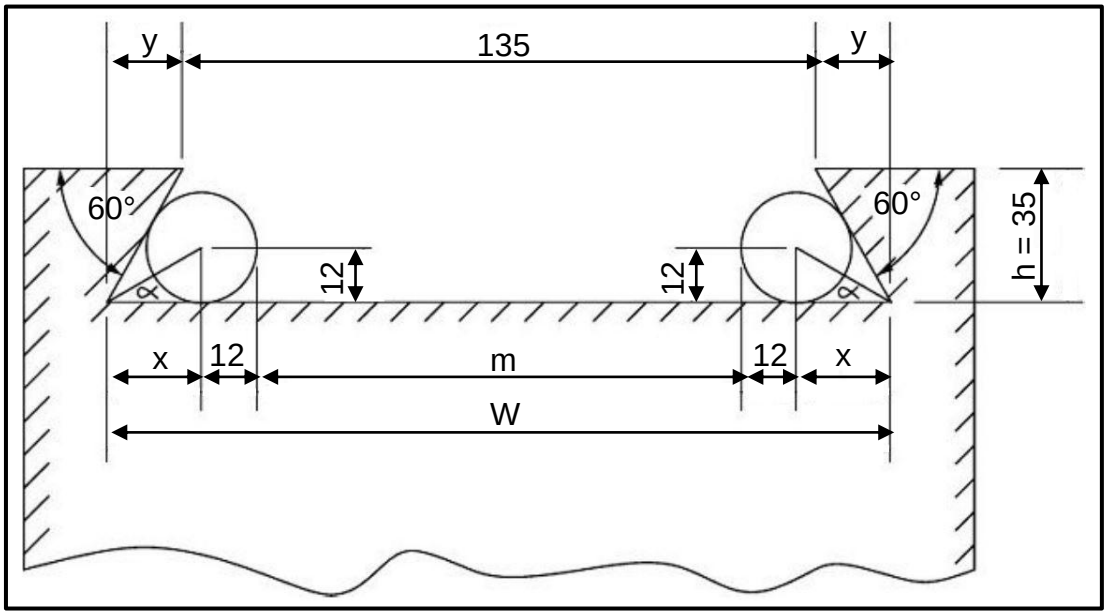

FIGURE 6.2

Calculate the following:

6.2.1 Maximum width (W) of the dovetail (6)

6.2.2 Distance (m) between the precision rollers (6)

6.3 A spur gear with 113 teeth has to be manufactured for a gearbox. The dividing head used has a ratio of 40 **:** 1.

HINT: A = 110 divisions for the simple indexing

6.3.1 Calculate the indexing that is needed. (4)

6.3.2 Calculate the change gears that are required. (4)

6.4 State TWO results of an unbalanced work piece mounted on a centre lathe. (2)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 State THREE different test results that can be obtained from a tensile tester. (3)

7.2 FIGURE 7.2 below shows a diagram of a Brinell hardness tester. Label **A**–**C**.

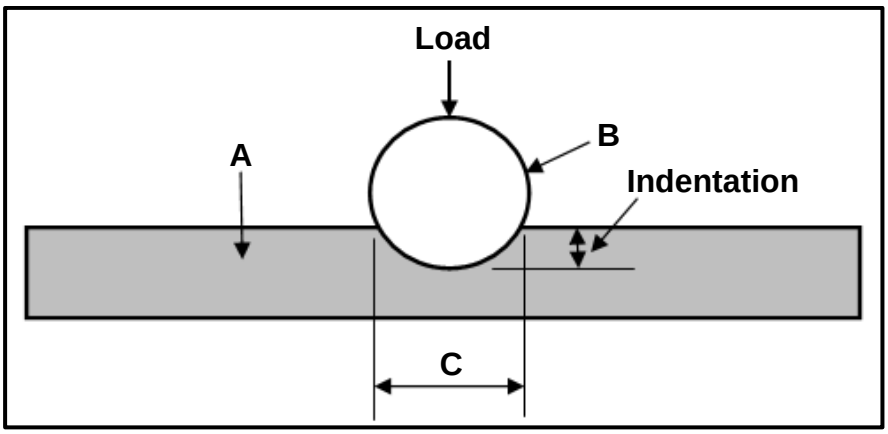

FIGURE 7.2 (3)

7.3 Calculate the cutting depth of a screw thread with a pitch of 1,75 mm. (2)

7.4 Determine the depth micrometer reading shown in FIGURE 7.4 below.

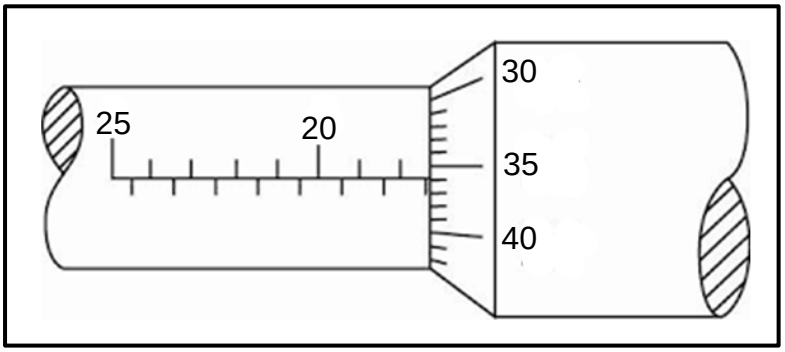

FIGURE 7.4 (2)

7.5 Describe the function of a moment tester. (3)

[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 FIGURE 8.1 below shows a system of four forces acting on the same point. Calculate the magnitude and direction of the resultant for this system of forces.

HINT: Draw and complete the diagram in FIGURE 8.1. Show ALL the horizontal and vertical components before doing the calculations.

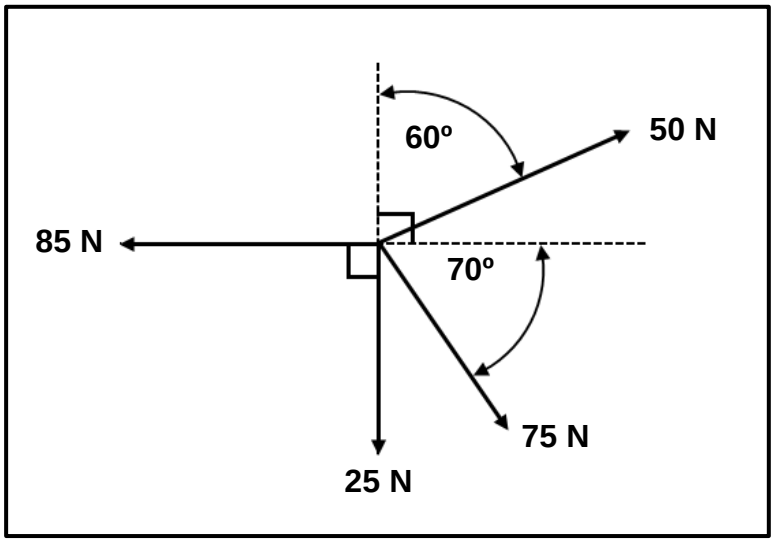

FIGURE 8.1 (15)

8.2 FIGURE 8.2 below shows a beam supported by two vertical supports, **A** and **B**. Two vertical point loads, as well as a uniformly distributed load of 6 kN/m, are exerted onto the beam.

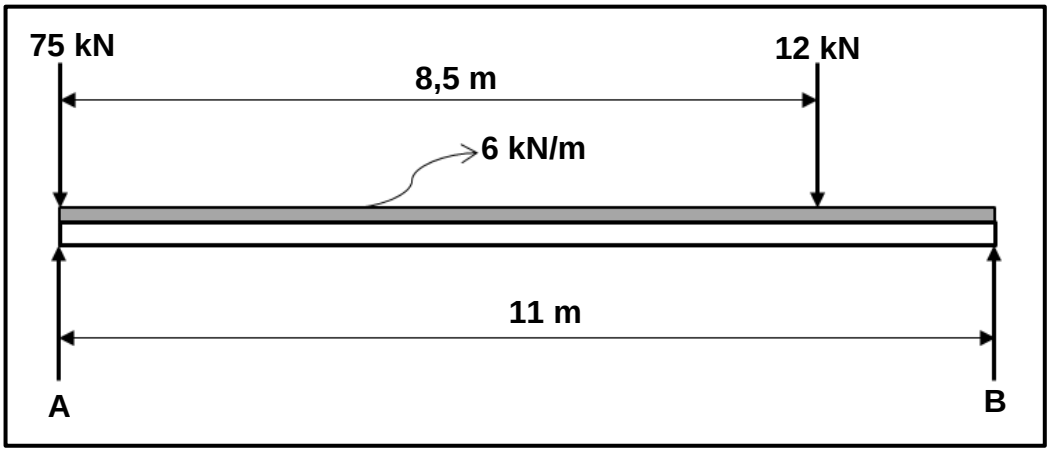

FIGURE 8.2

Calculate the following:

8.2.1 The point load representing the uniformly distributed load (1)

8.2.2 The magnitude of the reaction force at **A** (3)

8.2.3 The magnitude of the reaction force at **B** (3)

8.3 A tensile force of 50 kN is exerted onto a round bar with a diameter of 50 mm and an original length of 3 m. Calculate the following:

8.3.1 Resistance area (2)

8.3.2 Stress in the material in MPa (3)

8.3.3 Strain if the final length of the bar is 3,005 m (2)

8.4 FIGURE 8.4 below shows a stress-strain diagram. Label **A**–**D**.

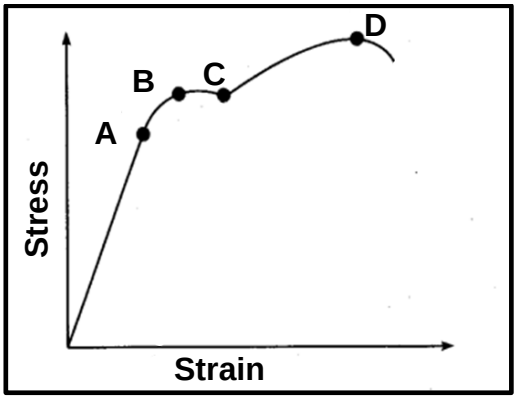

FIGURE 8.4 (4)

[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 What is the main purpose of maintenance? (1)

9.2 Briefly explain how basic preventative maintenance should be performed on the following systems:

9.2.1 Chain drive systems (2)

9.2.2 Belt drive systems (2)

9.3 State TWO properties of EACH of the following nylon products:

9.3.1 Polyethylene (PET) (2)

9.3.2 Polypropylene (PP) (2)

9.3.3 Polystyrene (PS) (2)

9.4 State THREE factors that influence the coefficient of friction. (3)

9.5 Explain why thermo-hardened composites cannot be re-heated to be softened, shaped and moulded. (1)

9.6 State THREE different types of belts used in belt drive systems. (3)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 A triple-start square threaded bar needs to be manufactured. The lead of the square thread is 36 mm and the crest diameter is 70 mm. The clearance angle must be 3°.

Calculate the following:

10.1.1 Pitch (3)

10.1.2 Pitch diameter (2)

10.1.3 Helix angle of the thread (3)

10.1.4 Leading angle (2)

10.1.5 Following angle (2)

10.2 FIGURE 10.2 below shows a cutting tool to cut screw thread. Answer the questions that follow.

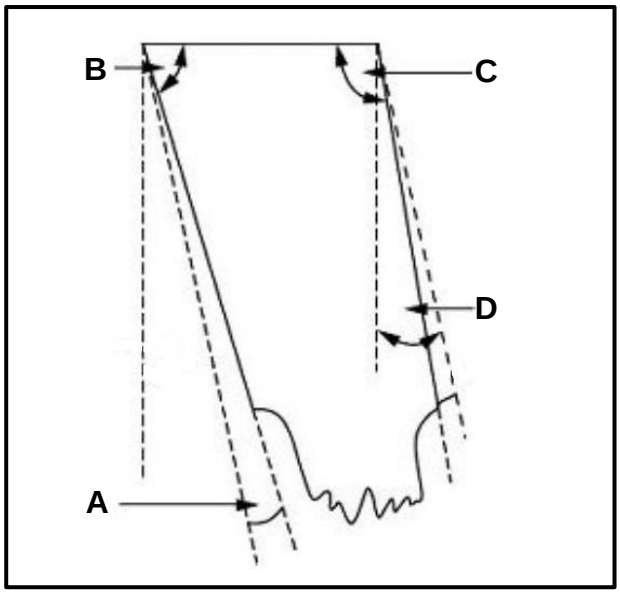

FIGURE 10.2

10.2.1 Identify the type of screw thread. (1)

10.2.2 Label **A**–**D**. (4)

10.3 State the included angle for a metric V-screw thread. (1)

[18]

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

11.1 FIGURE 11.1 below shows a hydraulic lift. The lift needs to raise a maximum load of 4 500 kg at the ram with a diameter of 120 mm. The diameter of the plunger is 32 mm. Answer the questions that follow.

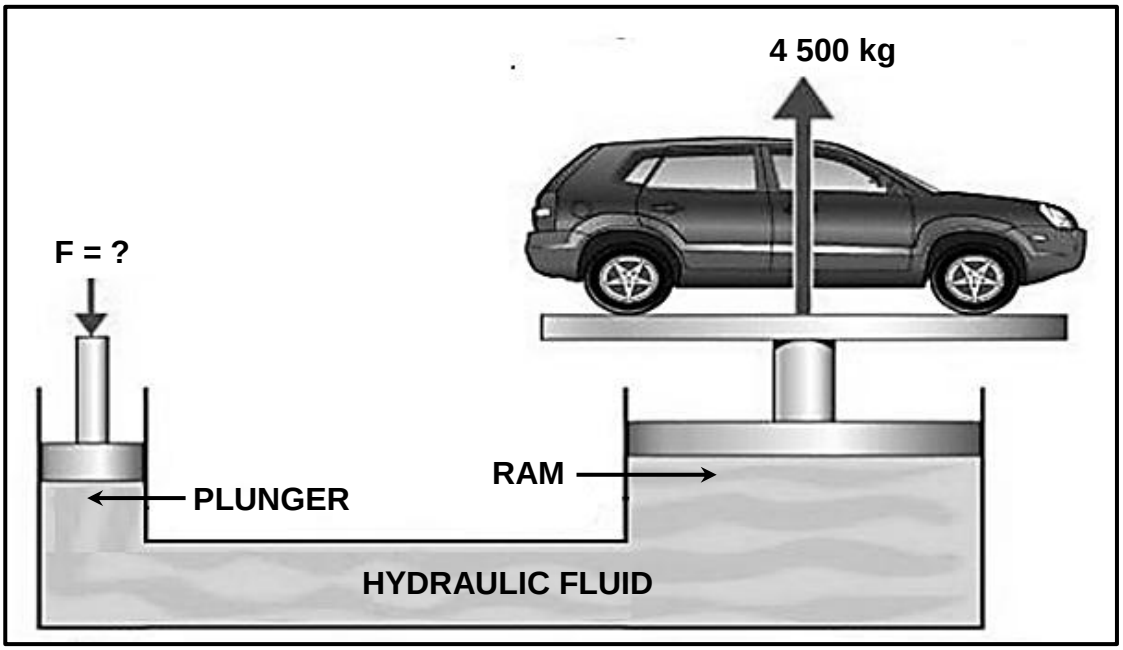

FIGURE 11.1

Calculate the following:

11.1.1 The fluid pressure in the hydraulic system in MPa (4)

11.1.2 The force to be applied on the plunger (5)

11.2 State ONE function of a hydraulic non-return valve. (1)

11.3 Give TWO reasons why a spring-loaded double-action control valve is used in a water line. (2)

11.4 Name the TWO different types of pressure gauges. (2)

11.5 A pulley with a diameter of 375 mm is mounted on a shaft of a concrete mixer. The concrete mixer is driven by a pulley, with a diameter of 85 mm, on a motor which rotates at a speed of 1 320 r/min. The tensile force of the belt in the tight side is 275 N and the slack side is 120 N.

HINT: The belt thickness may be ignored.

Calculate the following:

11.5.1 The rotational frequency in r/s of the pulley on the concrete mixer (4)

11.5.2 The power that can be transmitted in watt (3)

11.6 FIGURE 11.6 below shows a gear drive system. Driver gear **A** meshes with driven gear **B** with 20 teeth on a countershaft. On the countershaft is another driver gear, **C**, with 45 teeth that meshes with gear **D** with 25 teeth on a second countershaft. On the second countershaft is another driver gear, **E**, with 50 teeth that meshes with a final gear **F**. The rotational frequency of the input shaft is 320 r/min and the rotational frequency of the output shaft is 720 r/min. Answer the questions that follow.

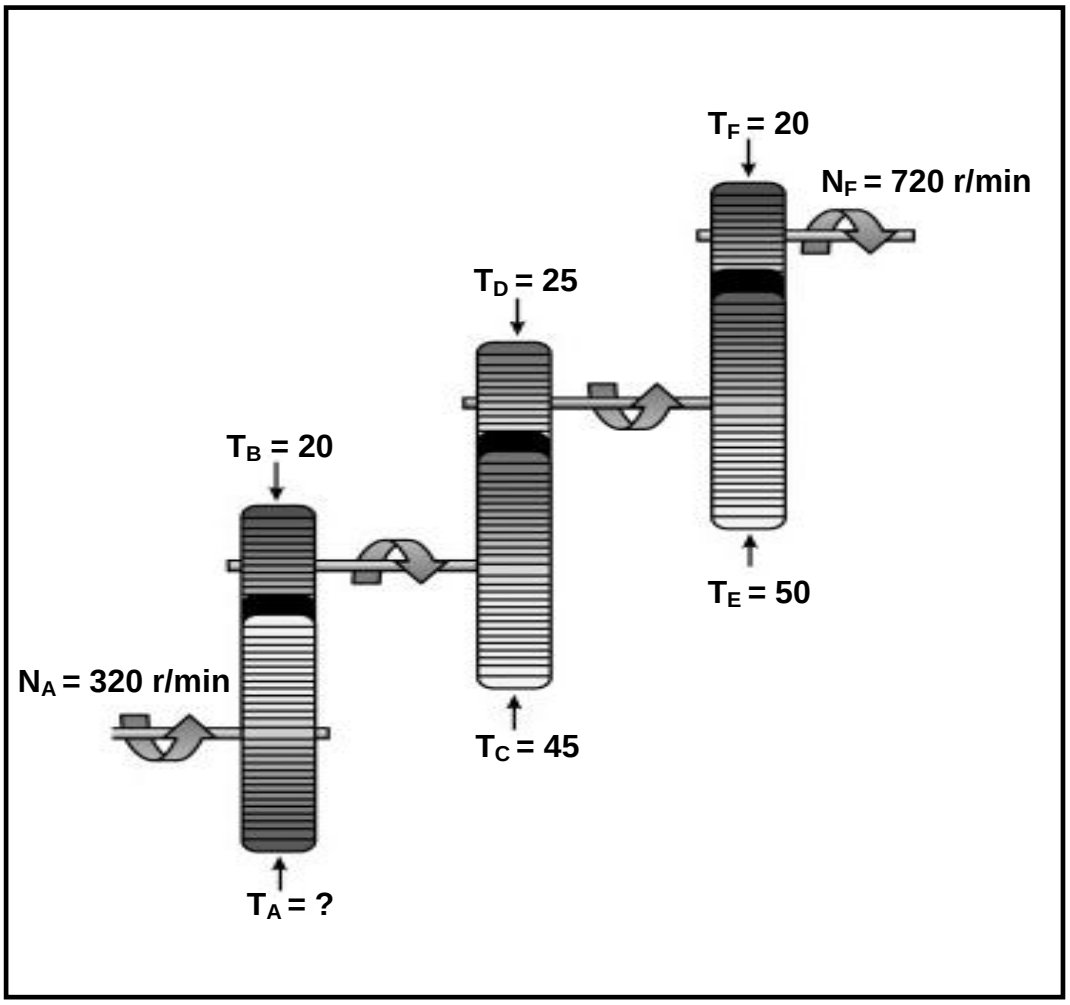

FIGURE 11.6

Calculate the following:

11.6.1 The number of teeth on the driver gear T_A (4)

11.6.2 The gear ratio of the system (3)
[28]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: FITTING AND MACHINING

1. BELT DRIVES

1.1 $\text{Belt speed} = \frac{\pi DN}{60}$

1.2 $\text{Belt speed} = \frac{\pi(D + t) \times N}{60}$ (t = belt thickness)

1.3 $\text{Belt mass} = \text{Area} \times \text{Length} \times \text{Density}$ (A = thickness × width)

1.4 $\text{Speed ratio} = \frac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

1.5 $\text{Belt length (flat)} = [(D + d) \times 1{,}57] + (2 \times \text{centre distance})$

1.6 $\text{Open belt length} = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$

1.7 $\text{Crossed belt length} = \frac{\pi(D + d)}{2} + \frac{(D + d)^2}{4c} + 2c$

1.8 $\text{Power } (P) = \frac{(T_1 - T_2)\pi DN}{60}$

Where:

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

1.9 $\text{Ratio between tight side and slack side} = \frac{T_1}{T_2}$

1.10 $\text{Power } (P) = \frac{2\pi NT}{60}$

1.11 $\text{Width} = \frac{T_1}{\text{Permissable tensile force}}$

1.12 $N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$

2. STRESS AND STRAIN

2.1 $A_{shaft} = \frac{\pi d^2}{4}$

2.2 $A_{pipe} = \frac{\pi(D^2 - d^2)}{4}$

2.3 $\text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$

2.4 $\text{Stress} = \frac{\text{Force}}{\text{Area}}$ OR $\sigma = \frac{F}{A}$

2.5 $\text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$ OR $\varepsilon = \frac{\Delta L}{L}$

2.6 $\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$ OR $E = \frac{\sigma}{\varepsilon}$

3. HYDRAULICS

3.1 $\text{Pressure} = \frac{\text{Force}}{\text{Area}}$ OR $P = \frac{F}{A}$

3.2 $\text{Volume} = \text{Area} \times \text{Stroke length} \quad (l \text{ or } s)$

3.3 $\text{Work done} = \text{Force} \times \text{Distance}$

3.4 $P_A = P_B$

3.5 $\frac{F_A}{A_A} = \frac{F_B}{A_B}$

4. GEAR DRIVES

4.1 $\text{Power } (P) = \frac{2\pi NT}{60}$

4.2 $\text{Gear ratio} = \frac{\text{Product of teeth on driven gear}}{\text{Product of teeth on driver gear}}$ OR $\text{Speed ratio} = \frac{N_{input}}{N_{output}}$

4.3 $\frac{N_{input}}{N_{output}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driver gears}}$

4.4 $N_A \times T_A = N_B \times T_B$

4.5 Torque = Force × Radius

4.6 Torque transmitted = Gear ratio × Input torque

4.7 $\text{Module} = \frac{\text{Pitch circle diameter}}{\text{Number of teeth}}$ OR $m = \frac{PCD}{T}$

4.8 $\text{Pitch circle diameter} = \frac{\text{Circlular pitch} \times \text{Number of teeth}}{\pi}$ OR $PCD = \frac{CP \times T}{\pi}$

4.9 $\text{Outside diameter } (OD) = PCD + 2(m)$

4.10 Addendum = Module OR $a = m$

4.11 $\text{Dedendum } (b) = 1{,}157(m)$ OR $\text{Dedendum } (b) = 1{,}25(m)$

4.12 $\text{Cutting depth } (h) = 2{,}157\,(m)$ OR $\text{Cutting depth } (h) = 2{,}25\,(m)$

4.13 $\text{Clearance } (c) = 0{,}157\ (m)$ OR $\text{Clearance } (c) = 0{,}25\ (m)$

4.14 $\text{Circular pitch } (CP) = m \times \pi$

4.15 $\text{Working depth } (WD) = 2 \times m$

5. PULLEYS

5.1 $N_{DR} \times D_{DR} = N_{DN} \times D_{DN}$

5.2 $\text{Power (P)} = \frac{2\pi NT}{60}$

5.3 $\text{Velocity ratio} = \frac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

6. KEYWAYS

6.1 $\text{Width of key} = \frac{\text{Diameter of shaft}}{4}$

6.2 $\text{Thickness of key} = \frac{\text{Diameter of shaft}}{6}$

6.3 $\text{Length of key} = 1{,}5 \times \text{Diameter of shaft}$

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

7. 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
Change gears											
Gears	24 x 2	28	32	40	44	48	56	64	72	86	100

7.1 $\text{Indexing} = \frac{40}{n}$ (n = number of divisions)

7.2 $\frac{Dr}{Dn} = \frac{A - n}{A} \times \frac{40}{1}$ OR $\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$

Where:

A = chosen number of divisions

n = real number of divisions

8. DOVETAILS

Where:

R = Radius of precision roller
y = Distance from top edge of dovetail in relation to bottom corner of dovetail
x = Distance from middle of precision roller to bottom corner of dovetail
θ = Dovetail included angle (normally 60°)
h = Height of dovetail
w = Minimum width distance of dovetail
W = Maximum width distance of dovetail
m = Distance between rollers
M = Distance over rollers

9. TAPERS

9.1 $\tan\frac{\theta}{2} = \frac{D - d}{2 \times l}$ (l = Taper length)

9.2 Tailstock set–over $= \frac{L(D-d)}{2l}$ (L = Distance between centres)

10. SCREW THREADS

10.1 Mean diameter = Outside diameter $-(\frac{1}{2} \times \text{Pitch})$ OR $D_m = OD - \frac{P}{2}$

10.2 Effective diameter (D_{eff}) = Pitch diameter (D_p) = Mean diameter (D_m)

10.3 Lead = Pitch × Number of starts

10.4 Height of screw thread = 0,866 × Pitch (P)

10.5 Depth of screwthread = 0,613 × Pitch (P)

10.6 Helix angle : $\text{Tan}\theta = \frac{\text{Lead}}{\pi \times D_m}$

10.7 Leading angle = 90° – (Helix angle + Clearance angle)

10.8 Following angle = 90° + (Helix angle – Clearance angle)