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GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2014

MARKS: 200

TIME: 3 hours

This question paper consists of 18 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. You may use a non-programmable/scientific calculator and drawing/mathematical instruments.
8. The value of gravitational force 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 appears at the end of the question paper.
12. Use the criteria below to assist you in managing your time.

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

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are given 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 A.

- 1.1 What safety measure is applicable to the milling machine in terms of the Occupational Health and Safety Act, 1993 (Act 85 of 1993)?
- A Guards could be removed while cutting material.
 - B Do not leave spanners or keys on rotating parts of a machine.
 - C Make sure the dial on the cross slide is set to '0'.
 - D Use the milling machine table as an anvil. (1)
- 1.2 Which ONE of the following safety procedures relates to the cylinder leakage tester?
- A Use water to remove dust around the spark plug area.
 - B Make sure the high tension lead to the spark plugs is connected.
 - C Do not exceed the prescribed pressure in the cylinder.
 - D Exceed the prescribed pressure in the cylinder. (1)
- 1.3 What is the function of a gas analyser?
- A Analyse inlet gases
 - B Analyse oil gases
 - C Analyse fuel gases
 - D Analyse exhaust gases (1)
- 1.4 Which property of material is tested using a Brinell tester?
- A Tensile strength
 - B Elasticity
 - C Hardness
 - D Brittleness (1)
- 1.5 How does high carbon content affect the quality of carbon steel?
- A Makes it tough
 - B Makes only the surface soft
 - C Makes it easy to weld
 - D Makes it malleable (1)

1.6 Which ONE of the following is a property of pearlite?

- A It is ductile
- B It is elastic
- C It is malleable
- D It becomes brittle

(1)

1.7 Identify the type of milling process shown in FIGURE 1.1 below.

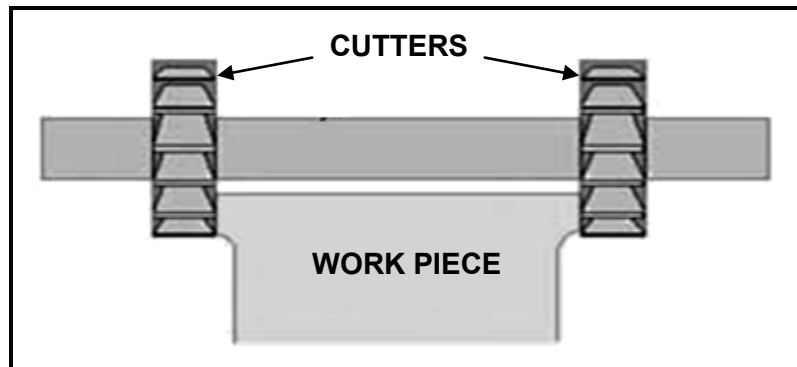


FIGURE 1.1

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

(1)

1.8 Which ONE of the following statements defines the pitch of a screw thread?

- A The distance from one crest point of a screw thread to the next corresponding crest point on the screw thread
- B The distance from any given point on the screw thread to a point on the flank
- C The distance from any given point on the screw thread to the centre line
- D The distance from any given point on the screw thread to a point corresponding in depth

(1)

1.9 What mixture of inert shielding gases is used in the MIGS/MAGS welding process?

- A Argon and acetylene
- B Argon and carbon dioxide
- C Argon and monoxide
- D Argon and helium

(1)

1.10 Which ONE of the following methods to test weld defects uses sound waves?

- A X-ray inspection
- B Free bend test
- C Ultrasonic test
- D Nick break test

(1)

1.11 Calculate Young's modulus of elasticity for a metal with a strain value of 2×10^{-3} caused by stress of 6 MPa:

- A 12 MPa
- B 3 MPa
- C 12 GPa
- D 3 GPa

(1)

1.12 Which ONE of the following statements describes Hooke's law regarding stress in materials?

- A Strain is indirectly proportional to the stress that causes it, provided the limit of elasticity is not exceeded.
- B Strain is directly proportional to the stress that causes it, provided the limit of elasticity is not exceeded.
- C Strain is indirectly proportional to the stress that causes it, provided the limit of elasticity is exceeded.
- D Strain is directly proportional to the stress that causes it, provided the limit of elasticity is exceeded.

(1)

1.13 The beam in FIGURE 1.2 below is in equilibrium. Calculate the distance between the support point and the 9 kN load.

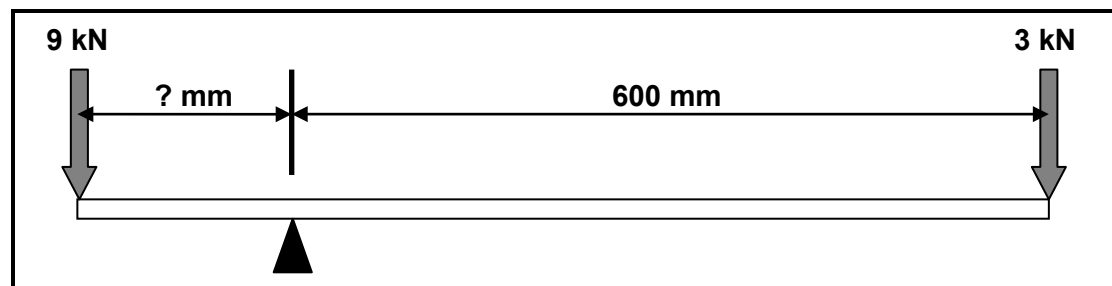


FIGURE 1.2

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

(1)

1.14 SAE 80 oil is used for ...

- A gearbox lubrication.
- B engine lubrication.
- C automatic transmission lubrication.
- D power steering lubrication.

(1)

1.15 What is understood by the term *viscosity* with reference to liquids?

- A Measure of the resistance to boiling
- B Measure of the resistance to foaming
- C Measure of the resistance to solidification
- D Measure of the resistance to flow

(1)

- 1.16 Which ONE of the following statements describes Boyle's law regarding a given mass of gas?
- A The volume of the gas is indirectly proportional to the pressure on the gas if the temperature remains constant.
 - B The volume of the gas is directly proportional to the pressure on the gas, if the temperature remains constant.
 - C The pressure on the gas is directly proportional to the volume of the gas, if the temperature remains constant.
 - D The volume of the gas is indirectly proportional to the pressure on the gas, if the temperature increases. (1)
- 1.17 An advantage of an air bag system compared to seat belts in a motor vehicle is that air bags ...
- A are much cheaper.
 - B do not have to be activated by passengers.
 - C prevent collisions.
 - D protect the inside of the vehicle. (1)
- 1.18 Traction control in a motor vehicle serves the following purpose:
- A Fuel consumption increases
 - B Prevents clutch slip
 - C Reduces engine wear
 - D Prevents wheel spin and slip (1)
- 1.19 Which method is used to drive a turbocharger?
- A Chain drive
 - B Belt drive
 - C Gas drive
 - D Gear drive (1)
- 1.20 The THREE stages of a gas turbine:
- A Inlet port, cooling, turbine
 - B Compression, combustion, thrust
 - C Compression, inlet port, turbine
 - D Cooling, inlet port, combustion (1)
- [20]**

QUESTION 2: SAFETY

- 2.1 Name THREE safety precautions that should be adhered to when handling gas cylinders. (3)
- 2.2 Why is it important to wear an arc welding helmet/shield during arc welding? (1)
- 2.3 State TWO safety precautions that should be adhered to before you start working on a centre lathe. (2)
- 2.4 When completing a given task on a milling machine, what safety aspects must be considered before leaving the machine? (1)
- 2.5 What is the maximum distance that the tool rest should be set from the grinding wheel of a bench grinder? (1)
- 2.6 A gas analyser is used to analyse the exhaust gases of a motor vehicle. Why is it important to make sure that there are no leakages in the exhaust pipe or inlet manifold? (2)
- [10]**

QUESTION 3: TOOLS AND EQUIPMENT

- 3.1 When a dry compression test is conducted on the first cylinder of a four-stroke spark ignition engine, the results are very low compared to the engine specification. State TWO possible causes of the low compression in the first cylinder. (2)
- 3.2 Most welding companies use MIGS/MAGS welding equipment extensively for their welding.
- 3.2.1 Give TWO reasons for using inert gas during MIGS/MAGS welding. (2)
- 3.2.2 Name TWO advantages of MIGS/MAGS welding. (2)
- 3.3 When assembling a cylinder head, the valve spring must be tested before installation. Give TWO reasons why the valve spring needs to be tested. (2)

- 3.4 FIGURE 3.1 below indicates a multimeter that is used to test different electrical components and electrical circuits. Label parts **A–D**.

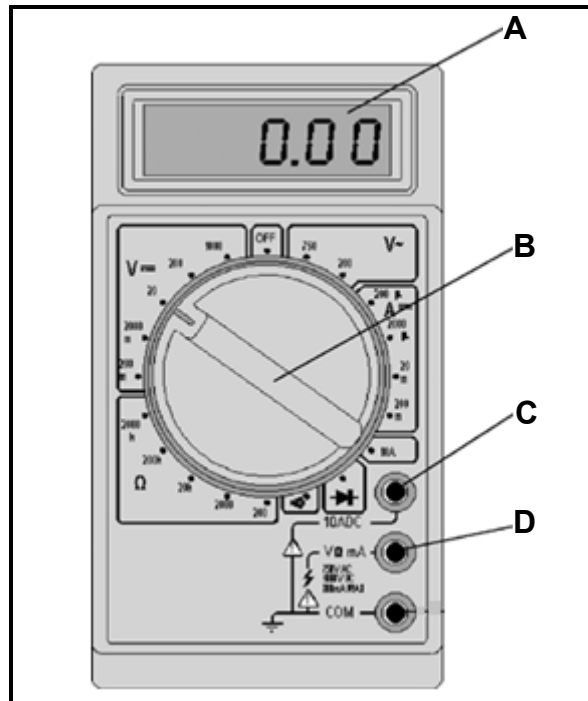
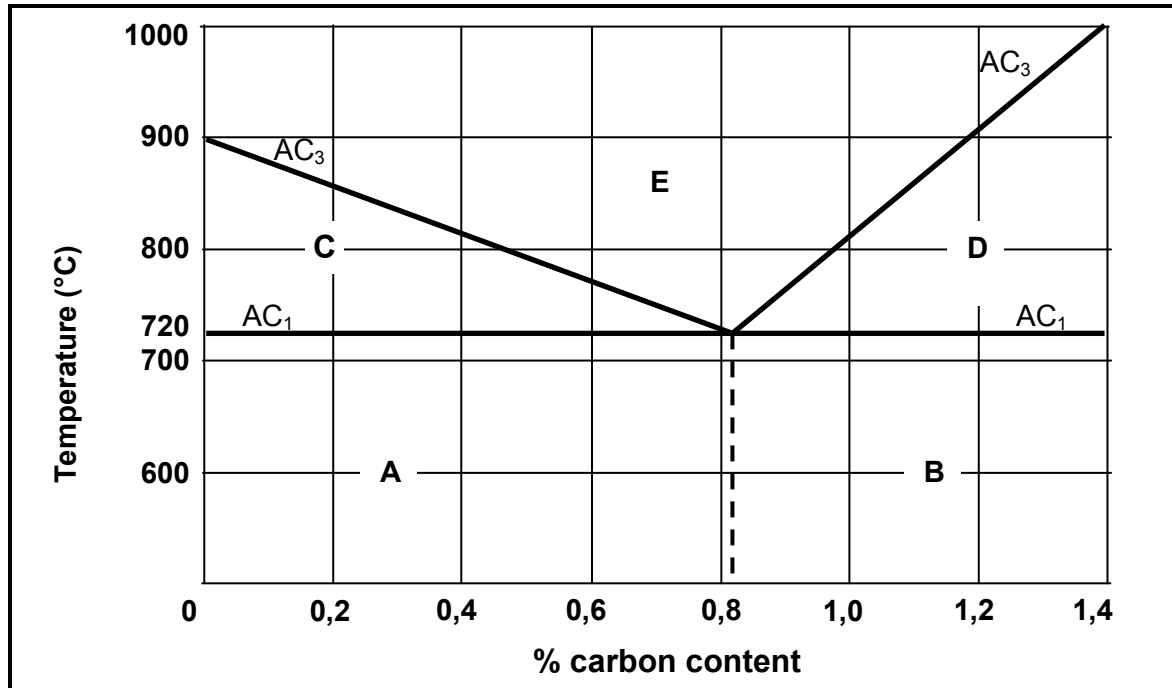


FIGURE 3.1

(4)
[12]

QUESTION 4: MATERIALS

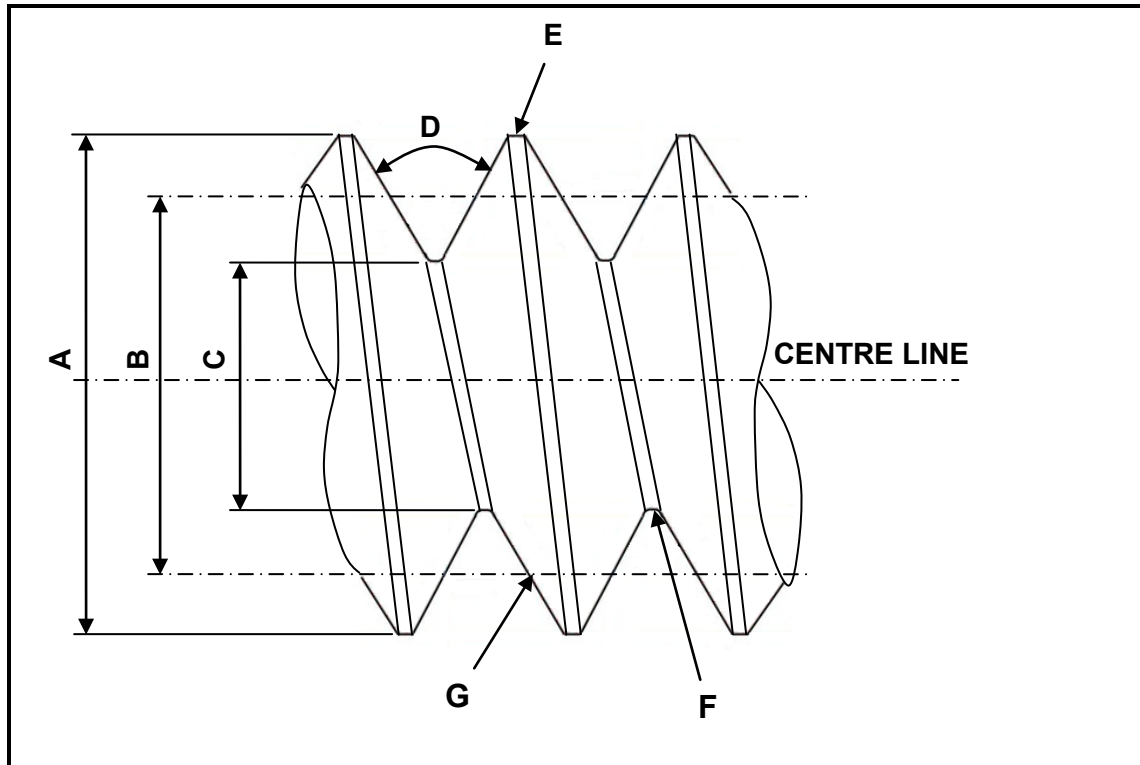
- 4.1 FIGURE 4.1 below shows an iron-carbon equilibrium diagram. Answer the questions that follow.

**FIGURE 4.1**

- 4.1.1 Label parts **A–E**. (5)
- 4.1.2 What does the critical point **AC₁** represent? (2)
- 4.2 Name TWO characteristics of each of the following microscopic structures:
- 4.2.1 Cementite (2)
- 4.2.2 Ferrite (2)
- 4.3 Explain the composition of austenite. (2)
- [13]**

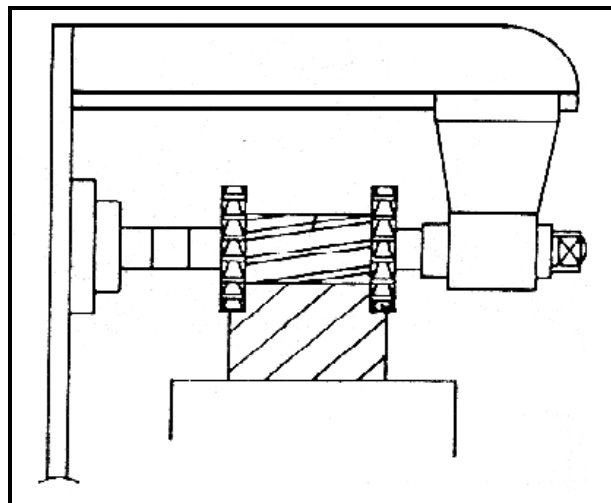
QUESTION 5: TERMINOLOGY

- 5.1 FIGURE 5.1 below shows a diagram of a metric V-screw thread. Label parts **A–G**.

**FIGURE 5.1**

(7)

- 5.2 Identify the milling process shown in FIGURE 5.2 below.

**FIGURE 5.2**

(2)

- 5.3 FIGURE 5.3 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.

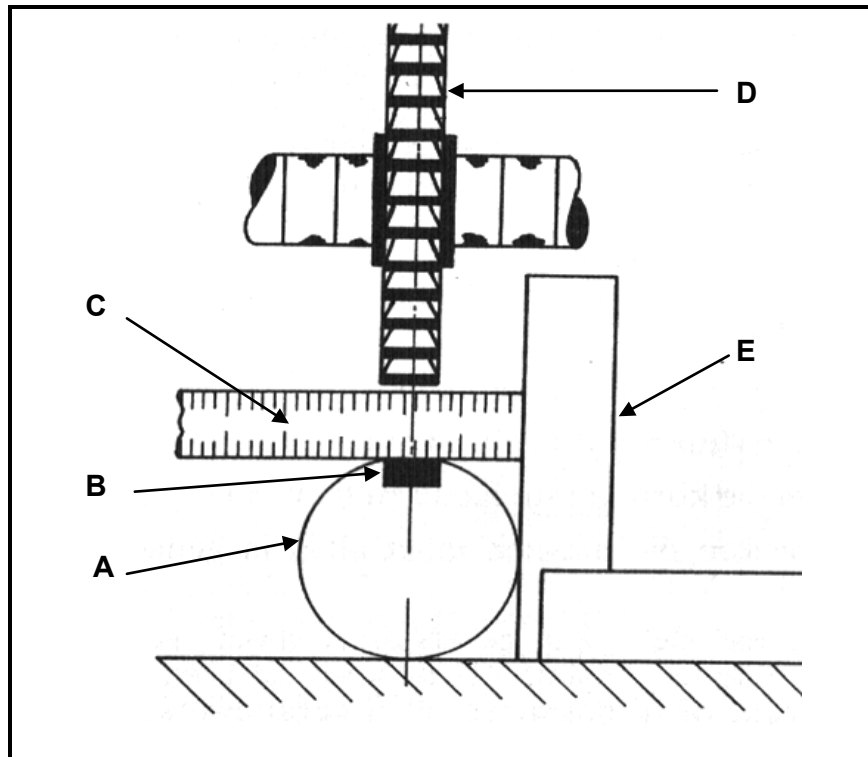
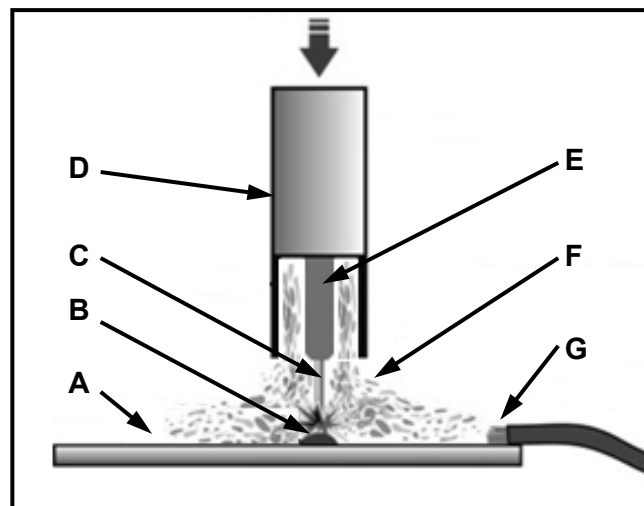


FIGURE 5.3

- 5.3.1 Identify the cutter used to cut the keyway. (1)
- 5.3.2 Label parts **A–E**. (5)
- Determine by means of calculations:
- 5.3.3 The width of the key (2)
- 5.3.4 The thickness of the key (2)
- 5.3.5 The length of the key (2)
- 5.3.6 The distance between the square and the side of the cutter facing the square (3)
- 5.4 Calculate the indexing needed to cut a gear with 14 teeth. (4)
- 5.5 Name TWO methods used to cut screw threads using a centre lathe. (2)
- [30]**

QUESTION 6: JOINING METHODS

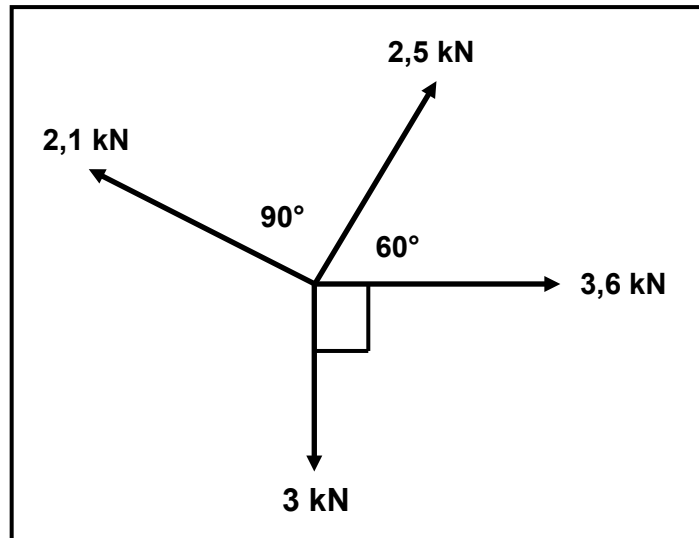
- 6.1 Give THREE reasons for each of the following welding defects:
- 6.1.1 Porosity (3)
- 6.1.2 Slag inclusion (3)
- 6.2 Explain the procedure followed during a nick break test on a welded joint. (5)
- 6.3 Explain how to conduct a dye penetration test on a welded joint to determine whether external defects exist. (5)
- 6.4 Name TWO advantages of non-destructive tests over destructive tests as applicable to testing welded joints. (2)
- 6.5 FIGURE 6.1 below shows the MIGS/MAGS welding process. Label parts **A–G**.

**FIGURE 6.1**

(7)
[25]

QUESTION 7: FORCES

- 7.1 Four forces of 3 kN, 2,1 kN, 2,5 kN and 3,6 kN respectively have the same acting point as shown in FIGURE 7.1.

**FIGURE 7.1**

Determine by means of calculations:

(**HINT:** Redraw the force diagram above to show the horizontal and vertical component of each force.)

- 7.1.1 The sum of the horizontal components (6)
- 7.1.2 The sum of the vertical components (6)
- 7.2 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.

Determine by means of calculations:

- 7.2.1 The stress in the material (4)
- 7.2.2 The strain if the final length of the bar is 3,005 m (3)

7.3 What do points **A–E** represent in FIGURE 7.2 below?

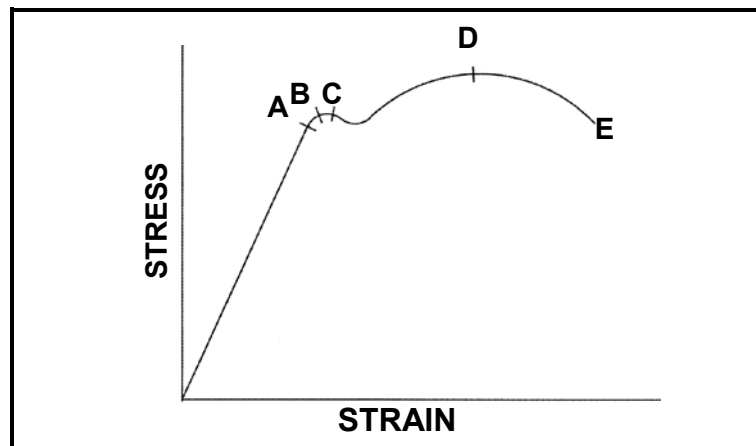


FIGURE 7.2

(5)

7.4 FIGURE 7.3 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.

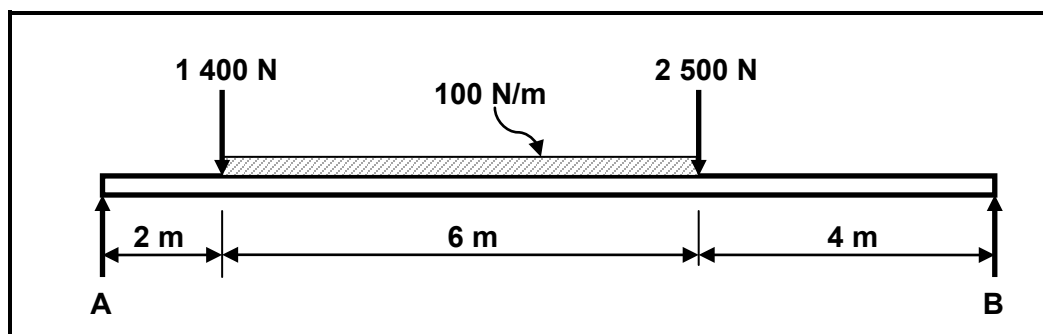


FIGURE 7.3

Determine, by means of calculations and using the turning points method, the magnitudes of the reactions in supports **A** and **B**.

(6)
[30]

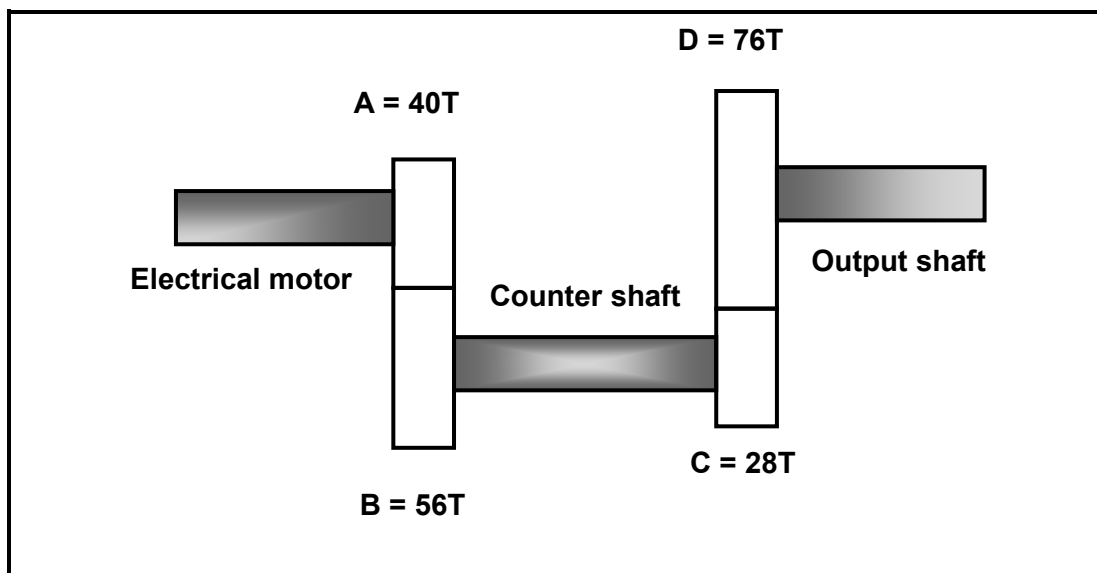
QUESTION 8: MAINTENANCE

- 8.1 Where do we use EP oil (extreme pressure oil)? (1)
- 8.2 What do the following abbreviations stand for with reference to oil?
- 8.2.1 SAE (1)
- 8.2.2 ATF (1)
- 8.3 State TWO properties of grease. (2)
- 8.4 State TWO ways to maintain a V-belt drive. (2)

- 8.5 Give THREE reasons for clutch slip. (3)
- 8.6 The owner of a light motor vehicle has a problem with the clutch slipping. Name the components of the clutch assembly that should be replaced to solve the problem. (3)
- 8.7 State the effect if the viscosity of oil used in a four-stroke engine is too low. (2)
- [15]**

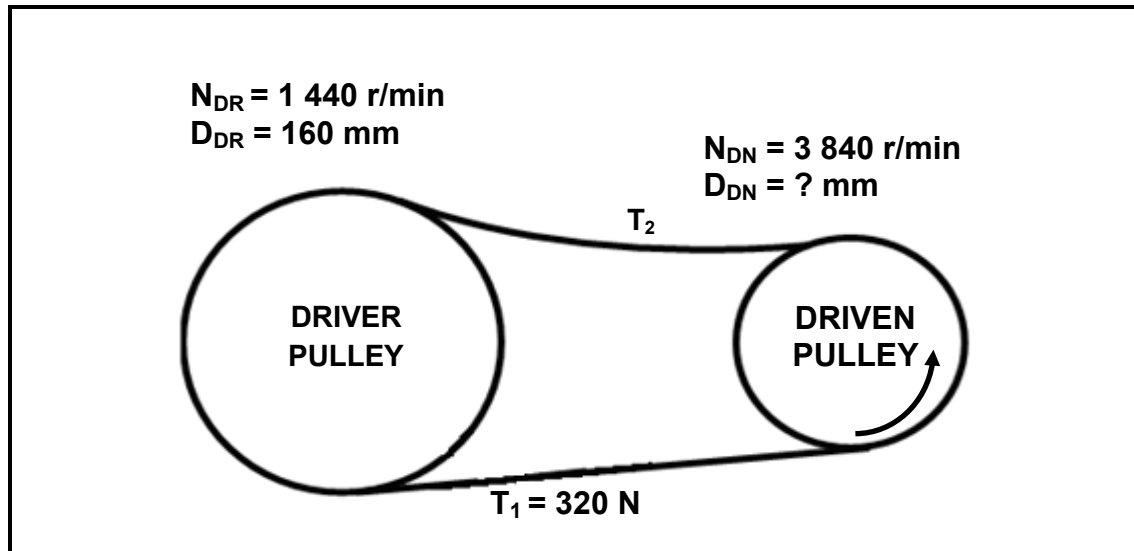
QUESTION 9: SYSTEMS AND CONTROL

- 9.1 FIGURE 9.1 shows a gear drive system on the shaft of an electric motor. Driver gear A has 40 teeth and meshes with a gear B (56 teeth) on a counter shaft. On this counter shaft is another driver gear, C (28 teeth), that meshes with a gear D (76 teeth) on the output shaft.

**FIGURE 9.1**

- Determine, by means of calculations, the rotation frequency of the electric motor if the output shaft needs to rotate at 800 r/min. (5)

- 9.2 A water pump must be driven at 3 840 r/min from a pulley with a diameter of 160 mm, which rotates at a speed of 1 440 r/min. The tensile force in the tight side of the belt is 320 N. The ratio between the tensile force in the tight side to the tensile force in the slack side is 2,5 : 1.

**FIGURE 9.2**

Determine by means of calculations:

- 9.2.1 The diameter of the pulley needed on the water pump (3)
- 9.2.2 The power transmitted (4)

- 9.3 A hydraulic system is used to lift goods when loading it into trucks. The specifications of the system are given in FIGURE 9.3 below.

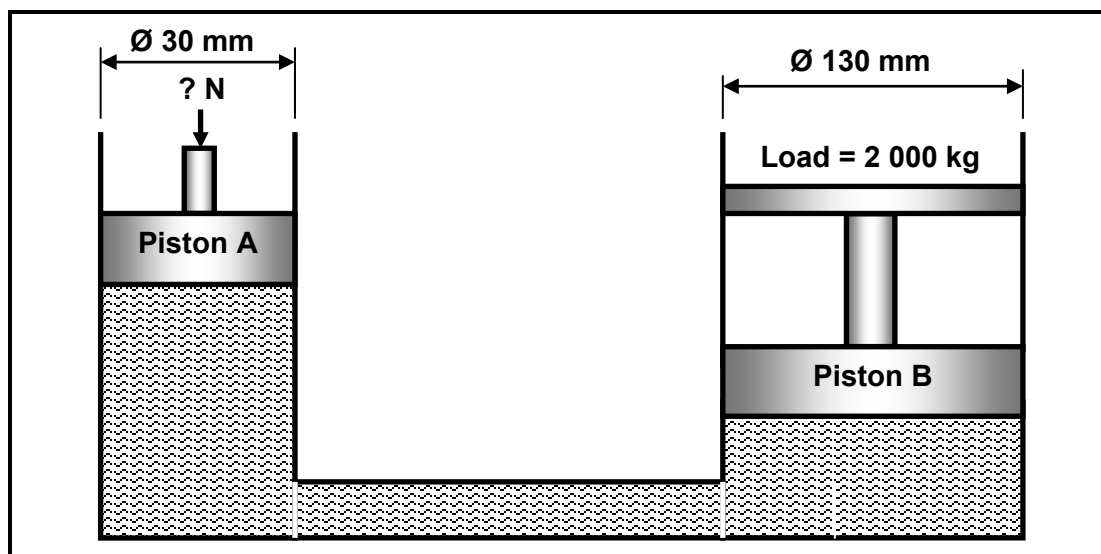


FIGURE 9.3

Determine the following by means of calculations:

- 9.3.1 The fluid pressure in the hydraulic system when the system is in equilibrium (3)
- 9.3.2 The force that needs to be exerted onto piston **A** (4)
- 9.4 Describe the functioning of the engine management system of a motor vehicle. (4)
- 9.5 An anti-lock brake system (ABS) operates effectively under certain circumstances. Name these circumstances when braking. (2)
- [25]**

QUESTION 10: TURBINES

- 10.1 What is the function of a steam turbine? (2)
- 10.2 Explain the following supercharger terms:
- 10.2.1 Boost (2)
- 10.2.2 Density ratio (2)

- 10.3 FIGURE 10.1 below shows a water turbine driving a generator. Answer the questions that follow.

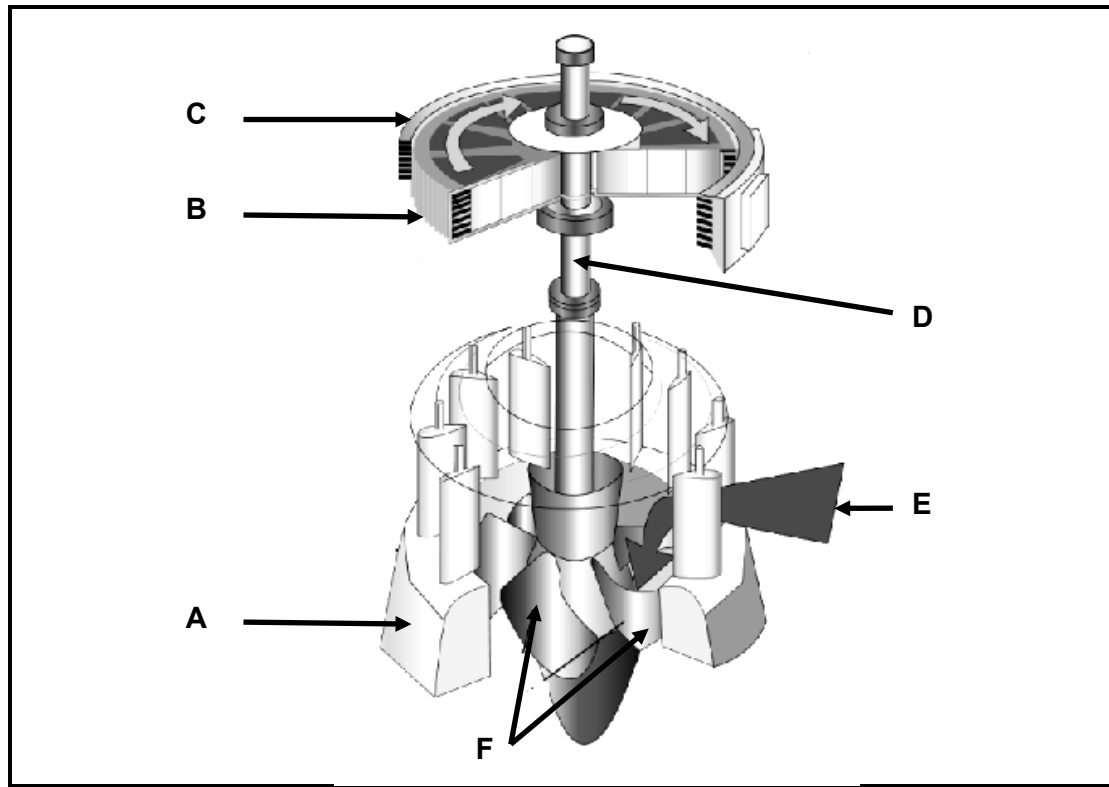


FIGURE 10.1

- 10.3.1 Identify the type of turbine shown in FIGURE 10.1. (1)
- 10.3.2 Label parts **A–F**. (6)
- 10.3.3 State **THREE** advantages of the turbine in FIGURE 10.1 above (3)
- 10.4 What is the purpose of the waste gate used in a turbocharger? (2)
- 10.5 Why is a turbocharged engine fitted with an oil cooler? (2)
- [20]**
- TOTAL: 200**

FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 12**1. BELT DRIVES**

$$1.1 \quad \text{Belt speed} = \frac{\pi D N}{60}$$

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

$$1.3 \quad \text{Belt mass} = \text{area} \times \text{length} \times \text{density} \quad (A = \text{thickness} \times \text{width})$$

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

$$1.5 \quad N_1 D_1 = N_2 D_2$$

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

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

$$1.8 \quad \text{Power (P)} = \frac{2 \pi N T}{60}$$

$$1.9 \quad \text{Ratio of tight side to slack side} = \frac{T_1}{T_2}$$

$$1.10 \quad \text{Power (P)} = \frac{(T_1 - T_2) \pi D N}{60} \quad \text{where } T_1 = \text{force in the tight side}$$

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

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

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

2. FRICTION CLUTCHES

$$2.1 \quad \text{Torque (T)} = \mu W n R$$

where $\mu = \text{coefficient of friction}$

$W = \text{total force}$

$n = \text{number of friction surfaces}$

$R = \text{effective radius}$

$$2.2 \quad \text{Power (P)} = \frac{2 \pi N T}{60}$$

3. STRESS AND STRAIN

$$3.1 \quad \text{Stress} = \frac{\text{force}}{\text{area}} \quad \text{or} \quad \left(\sigma = \frac{F}{A} \right)$$

$$3.2 \quad \text{Strain} (\varepsilon) = \frac{\text{change in length} (\Delta L)}{\text{original length} (L)}$$

$$3.3 \quad \text{Young's modulus} (E) = \frac{\text{stress}}{\text{strain}} \quad \text{or} \quad \left(\frac{\sigma}{\varepsilon} \right)$$

$$3.4 \quad \text{Area}_{\text{round bar}} = \frac{\pi D^2}{4} \quad \text{and} \quad \text{Area}_{\text{round tube}} = \frac{\pi(D^2 - d^2)}{4}$$

$$\text{Area}_{\text{square bar}} = L^2 \quad \text{and} \quad \text{Area}_{\text{square tube}} = L^2 - l^2$$

4. HYDRAULICS

$$4.1 \quad \text{Pressure} (P) = \frac{\text{force} (F)}{\text{area} (A)}$$

$$4.2 \quad \text{Volume} = \text{cross-sectional area} \times \text{stroke length} (l \text{ or } s)$$

$$4.3 \quad \text{Work done} = \text{force} \times \text{distance}$$

$$4.4 \quad \text{Area} = \frac{\pi D^2}{4}$$

$$4.5 \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

5. GEAR DRIVES

$$5.1 \quad \text{Power} (P) = \frac{2\pi NT}{60}$$

$$5.2 \quad \text{Gear ratio} = \frac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driving gears}}$$

$$5.3 \quad \frac{N_{\text{input}}}{N_{\text{output}}} = \frac{\text{product of the number of teeth on driven gears}}{\text{product of the number of teeth on driving gears}}$$

$$5.4 \quad \text{Torque} = \text{force} \times \text{radius}$$

$$5.5 \quad \text{Torque transmitted} = \text{gear ratio} \times \text{input torque}$$

$$5.6 \quad \text{Module } (m) = \frac{\text{pitch-circle diameter } (PCD)}{\text{number of teeth } (T)}$$

$$5.7 \quad N_1 T_1 = N_2 T_2$$

$$5.8 \quad \text{Pitch-circle diameter } (PCD) = \frac{\text{circular pitch } (CP) \times \text{number of teeth } (T)}{\pi}$$

$$5.9 \quad \text{Outside diameter } (OD) = PCD + 2 \text{ module}$$

$$5.10 \quad \text{Addendum } (a) = \text{module } (m)$$

$$5.11 \quad \text{Dedendum } (b) = 1,157 m \quad \text{or} \quad \text{Dedendum } (b) = 1,25 m$$

$$5.12 \quad \text{Cutting depth } (h) = 2,157 m \quad \text{or} \quad \text{Cutting depth } (h) = 2,25 m$$

$$5.13 \quad \text{Clearance } (c) = 0,157 m \quad \text{or} \quad \text{Clearance } (c) = 0,25 m$$

$$5.14 \quad \text{Circular pitch } (CP) = m \times \pi$$

6. PULLEY DRIVES

$$6.1 \quad N_1 D_1 = N_2 D_2$$

$$6.2 \quad \text{Power } (P) = \frac{2 \pi NT}{60}$$

$$6.3 \quad \text{Velocity Ratio} = \frac{\text{diameter of driven pulley}}{\text{diameter of driver pulley}}$$

7. KEYWAYS

$$7.1 \quad \text{Width of key} = \frac{\text{diameter of shaft}}{4}$$

$$7.2 \quad \text{Thickness of key} = \frac{\text{diameter of shaft}}{6}$$

$$7.3 \quad \text{Length of the key} = 1,5 \times \text{diameter of shaft}$$

$$7.4 \quad \text{Taper of key} = 1 : 100$$

8. LEVERS

$$8.1 \quad \text{Mechanical advantage (MA)} = \frac{\text{load (W)}}{\text{effort (F)}}$$

$$8.2 \quad \text{Input movement (IM)} = \text{effort} \times \text{distance moved by effort}$$

$$8.3 \quad \text{Output movement (OM)} = \text{load} \times \text{distance moved by load}$$

$$8.4 \quad \text{Velocity ratio (VR)} = \frac{\text{input movement}}{\text{output movement}}$$

9. SCREW THREADS

$$9.1 \quad \text{Pitch diameter} = \text{outside diameter} - \frac{1}{2} \text{ pitch}$$

$$9.2 \quad \text{Pitch circumference} = \pi \times \text{pitch diameter}$$

$$9.3 \quad \text{Lead} = \text{pitch} \times \text{number of starts}$$

$$9.4 \quad \text{Height of screw thread} = 0,866 \times \text{pitch (P)}$$

$$9.5 \quad \text{Depth of screw thread} = 0,613 \times \text{pitch (P)}$$

$$9.6 \quad \text{Number of turns} = \frac{\text{height}}{\text{lead}}$$

10. INDEXING**CINCINNATI DIVIDING HEAD TABLE FOR HOLE CIRCLES IN PLATE**

<i>Hole circles</i>											
<i>Side 1</i>	24	25	28	30	34	37	38	39	41	42	43
<i>Side 2</i>	46	47	49	51	53	54	57	58	59	62	66

$$10.1 \quad \text{Indexing} = \frac{40}{n}$$