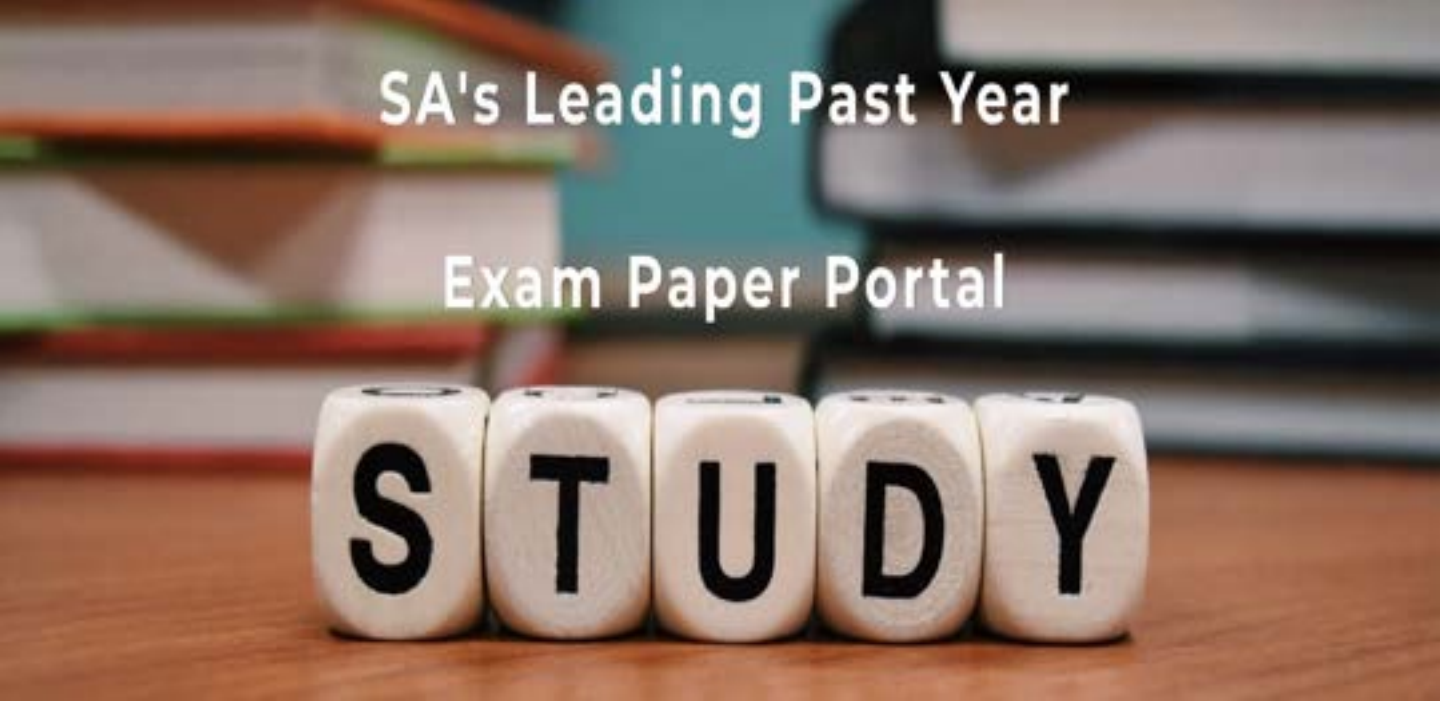

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GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2017

MARKS: 200

TIME: 3 hours

This question paper consists of 15 pages and a 4-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of TEN questions.
2. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.
3. Read ALL the questions carefully.
4. Answer ALL the questions.
5. Number the answers correctly according to the numbering system used in this question paper.
6. Start EACH question on a NEW page.
7. Show ALL calculations and units. Round off ALL answers to TWO decimal places.
8. Candidates may use non-programmable, scientific calculators and drawing instruments.
9. Take the value of gravitational force as 10 m/s^{-2}.
10. All dimensions are in millimetres, unless stated otherwise in the question.
11. A formula sheet for your use is attached to this question paper.
12. Write neatly and legibly.
13. Use the guidelines 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 Before operating the centre lathe, you should …

A remove all safety guards.
B know where the ON/OFF switch is.
C remove the compound slide.
D oil the area surrounding the machine. (1)

1.2 Which ONE of the following safety rules applies to MIG/MAGS welding equipment?

A Remove oil from the electrode wire.
B The welding pistol must be well lubricated.
C The electrical leads must be well insulated.
D Make sure that the gas flow is set to maximum. (1)

1.3 What is the function of a gas analyser? A gas analyser analyses …

A inlet gases.
B fuel gases.
C oil gases.
D exhaust gases. (1)

1.4 Which measuring equipment is used to measure the indentation of a Brinell hardness test?

A Vernier calliper
B Microscope
C Ruler
D Micrometer (1)

1.5 What will be the result when steel is heated past the AC_2 line?

A Grain structure will be at its smallest.
B It will become brittle.
C It will start losing magnetism.
D It will become a stronger magnet. (1)

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

A Brittle
B Hard
C Very hard
D Soft (1)

1.7 What is the magnitude of the included angle of the isometric V-screw thread?

A 55°
B 30°
C 29°
D 60° (1)

1.8 Which indexing method can be used to mill seven equal divisions with the help of a 40 **:** 1 dividing head?

A Angular indexing
B Rapid indexing
C Simple indexing
D Helical indexing (1)

1.9 How are welding defects observed when an X-ray test is performed on a welding joint? Defects are …

A visible on the weld.
B visible on film.
C determined by sound.
D visible on an oscilloscope screen. (1)

1.10 What is the purpose of performing an ultrasonic test on a welded joint? To detect …

A internal defects.
B internal and external defects.
C external surface defects.
D all kinds of defects. (1)

1.11 What do you understand by the term *strain in materials*? Strain is the ratio between the …

A change in length and the original length.
B load and the area.
C stress and the length.
D stress and the area. (1)

1.12 What does point D represent in the graph in FIGURE 1.12 below regarding the stress and strain?

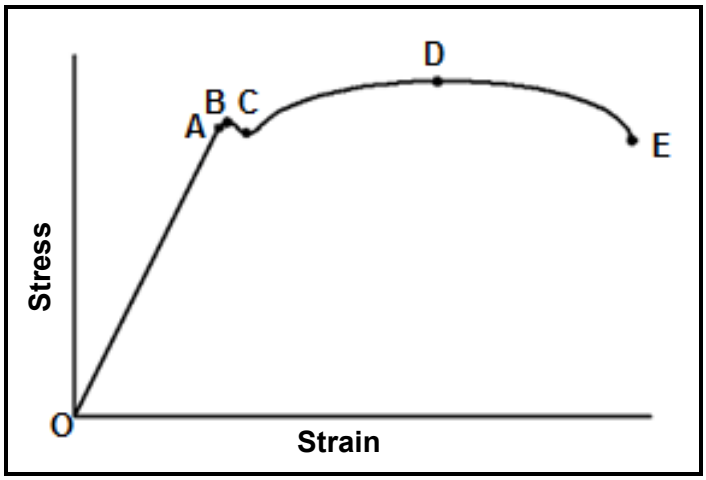

FIGURE 1.12

A The limit of proportionality
B The break stress
C The maximum stress
D The stretch limit (1)

1.13 What is understood by the term *Young's modulus of elasticity*?

A The force value required to produce a unit area in a tensile test specimen
B The ratio between stress and strain in a metal, provided that the limit of elasticity is not exceeded
C A measurement of the extension or contraction of material due to the load experienced
D A ratio of the deformation due to the application of an external force (1)

1.14 What is understood by the term *flashpoint* regarding oil?

A The lowest temperature at which the oil gives off vapours which can expand
B The lowest temperature at which the oil gives off vapours which can ignite
C The highest temperature at which the oil gives off vapours which can expand
D The highest temperature at which the oil gives off vapours which can ignite (1)

1.15 What does the abbreviation *EP* stand for regarding the lubrication of parts?

A External pressure
B Extreme pressure
C Extra pressure
D Excessive pressure (1)

1.16 What can be done to increase the pressure in a gas?

A Increase the volume
B Increase the temperature and the volume
C Decrease the temperature
D Decrease the volume (1)

1.17 What will be the belt speed of a belt drive system if the driven pulley rotates at 500 r/min and has a diameter of 200 mm?

A 52,4 $m.s^{-1}$
B 5,24 $m.s^{-1}$
C 10 000 $m.s^{-1}$
D 1 000 $m.s^{-1}$ (1)

1.18 Determine the thickness of a parallel key if the diameter of the shaft is 72 mm:

A 21 mm
B 12 mm
C 18 mm
D 108 mm (1)

1.19 A supercharger is driven by …

A steam.
B a belt drive.
C exhaust gases.
D inlet gases (1)

1.20 Identify the type of turbine in FIGURE 1.20 below regarding the principle of operation.

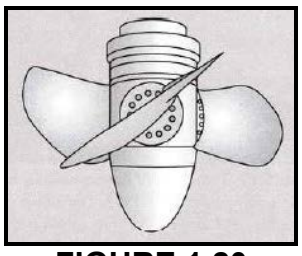

FIGURE 1.20

A Reaction turbine
B Extracting turbine
C Impulse turbine
D Induction turbine (1)

[20]

QUESTION 2: SAFETY

2.1 All personal and environmental safety rules are applicable when a surface grinder is used. State THREE safety rules which are only applicable while the surface grinder is in operation. (3)

2.2 Give TWO reasons why the pressure gauge of a hydraulic press must be tested regularly. (2)

2.3 State THREE important safety precautions that should be observed before MIG/MAGS welding is done. (3)

2.4 State TWO safety rules that must be taken into consideration for the safe handling of coil spring compressors. (2)
[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Explain how a voltmeter and an ammeter are connected to a circuit. (2)

3.2 State FOUR uses of a multimeter. (4)

3.3 A dry compression test on an internal combustion engine indicated a very low reading at cylinder 1. A wet compression test indicated a higher reading at cylinder 1. What conclusion can be made regarding these readings? (2)

3.4 Describe the purpose of the following tests:

3.4.1 Beam-bending test (2)

3.4.2 Cylinder leakage test (2)
[12]

QUESTION 4: MATERIALS

4.1 Name TWO properties of EACH of the following structures of steel:

4.1.1 Cementite (2)

4.1.2 Ferrite (2)

4.2 FIGURE 4.2 below is a diagram that shows the heating process of carbon steel. Answer the questions that follow.

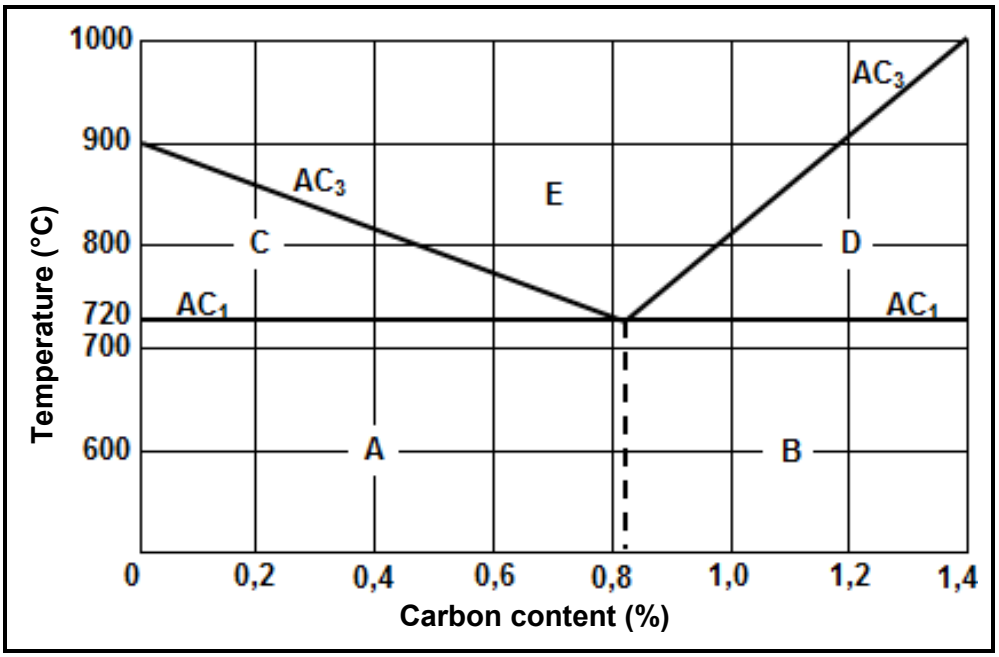

FIGURE 4.2

4.2.1 Identify the diagram shown in FIGURE 4.2. (2)

4.2.2 Label **A**–**E**. (5)

4.2.3 What is the lower critical temperature for steel with a carbon content of 0,83%? (2)

[13]

QUESTION 5: TERMINOLOGY

5.1 Neatly sketch and label an isometric V-screw thread to indicate the following screw thread terminology on:

5.1.1 Crest, major or outside diameter (1)

5.1.2 Included screw-thread angle (1)

5.1.3 Screw-thread pitch (1)

5.1.4 Screw-thread crest (1)

5.1.5 Screw-thread flanks (1)

5.2 Identify the milling processes indicated in FIGURES 5.2.1 and 5.2.2 below.

5.2.1

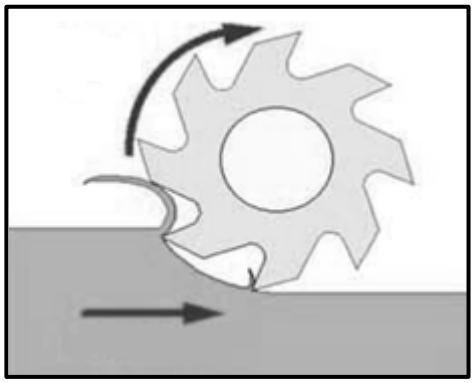

FIGURE 5.2.1 (1)

5.2.2

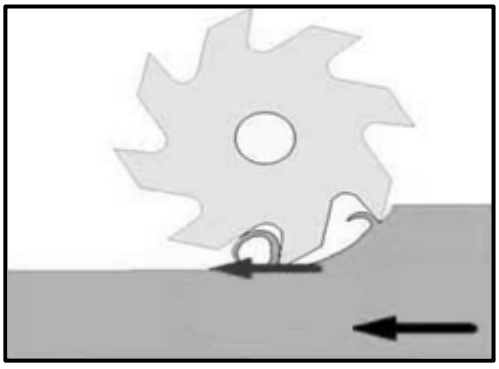

FIGURE 5.2.2 (1)

5.3 A gear with 22 teeth has to be machined on a milling machine. Calculate the required indexing. (6)

5.4 Answer the questions below with reference to the drawing of the dividing head in FIGURE 5.4 below.

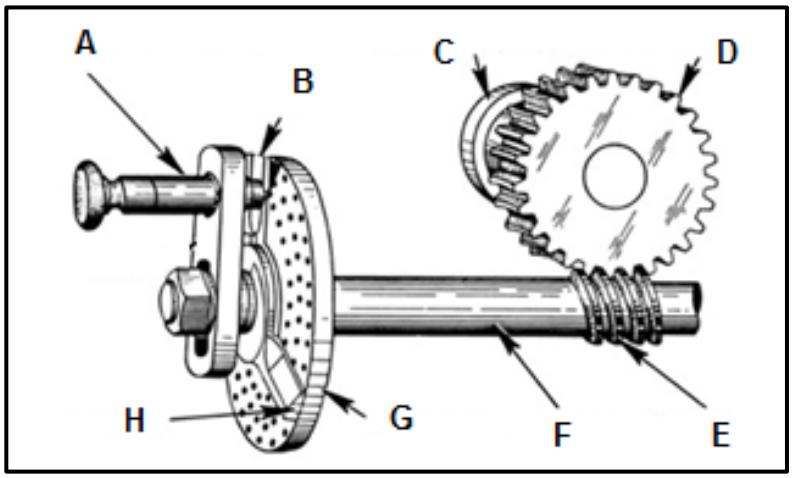

FIGURE 5.4

5.4.1 What is the function of sector arms **B** and **H**? (2)

5.4.2 What is the function of index plate **G**? (2)

5.4.3 What is the function of index pin **A**? (2)

5.4.4 What is the ratio between worm gear **E** and gear **D**? (2)

5.5 A gear with 94 teeth and a module of 3 has to be machined on a milling machine.

Calculate the:

5.5.1 Pitch-circle diameter (PCD) (3)

5.5.2 Outside diameter (2)

5.5.3 Dedendum (2)

5.5.4 Cutting depth (2)
[30]

QUESTION 6: JOINING METHODS

6.1 State TWO causes of undercutting in an arc-welded joint. (2)

6.2 How would you prevent slag inclusion in an arc-welded joint? (2)

6.3 Describe how the liquid dye penetration test is done on a welded joint. (4)

6.4 Name THREE advantages of the use of MIG/MAGS welding rather than arc welding. (3)

6.5 State TWO functions of the gas flow meter. (2)

6.6 Label the parts **A**–**E** in the illustration of the MIG/MAGS-welding process in FIGURE 6.6 below.

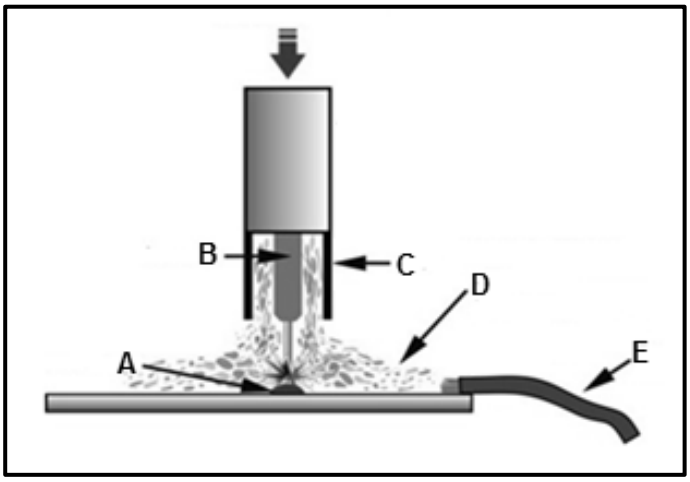

FIGURE 6.6 (5)

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

6.8 Why must the earth cable be properly connected to the parent metal? (2)

6.9 Name THREE types of gases used for MIG/MAGS welding. (3)
[25]

QUESTION 7: FORCES

7.1 Four forces of 100 N, 200 N, 300 N and 400 N respectively are acting on the same point, as shown in FIGURE 7.1 below. Determine, by means of calculations, the magnitude and direction of the resultant force for the system of forces in FIGURE 7.1.

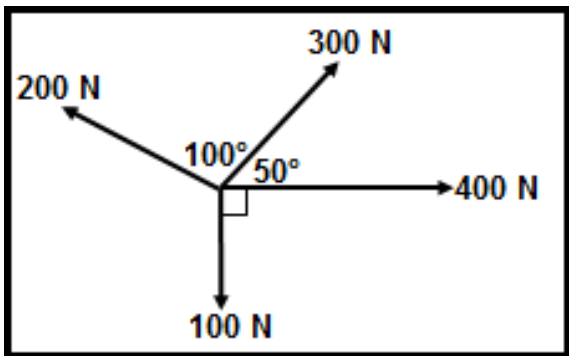

FIGURE 7.1 (13)

7.2 A load of 40 kN is exerted onto a solid brass bar with a diameter of 56 mm. The original length of the bar is 0,85 m. Young's modulus for brass is 90 GPa.

Calculate the:

7.2.1 Stress in the bar (5)

7.2.2 Strain (3)

7.2.3 Change in length (3)

7.3 FIGURE 7.3 below shows a uniform beam that is supported by two vertical supports, **A** and **B**. A uniformly distributed force of 80 N/m is exerted over the whole length of the beam. Determine, by means of calculations, the magnitudes of the reactions in supports **A** and **B**.

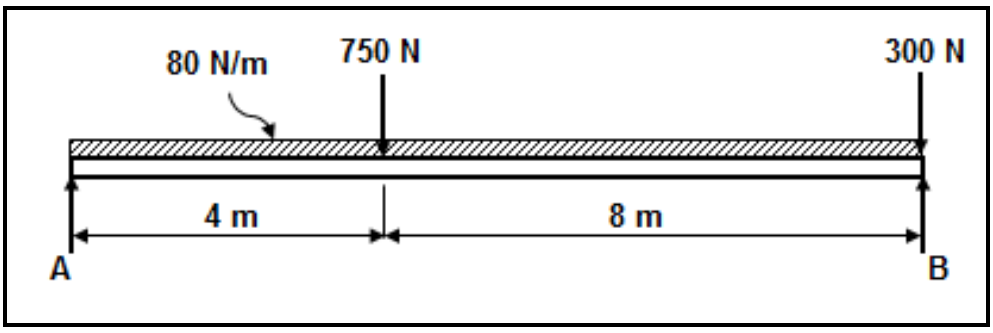

FIGURE 7.3 (6)

[30]

QUESTION 8: MAINTENANCE

8.1 Explain the term *pour point* with regard to oils. (2)

8.2 State THREE advantages of the use of cutting fluid on a centre lathe. (3)

8.3 What does the abbreviation *ATF* stand for with regard to motor oils? (2)

8.4 Name the THREE main parts of a clutch assembly. (3)

8.5 State THREE results of a stretched chain on a chain drive system. (3)

8.6 State TWO causes of belt slip on a belt drive system. (2)
[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1 FIGURE 9.1 below shows a gear drive system. Driver gear **A** on the shaft of an electric motor has 30 teeth and mesh with gear **B** with 40 teeth on a counter shaft. On the counter shaft is another driver gear, **C**, with 20 teeth that mesh with gear **D** with 60 teeth on a second counter shaft. The second counter shaft has driver gear **E** with 50 teeth, which drive gear **F** with 70 teeth on the output shaft.

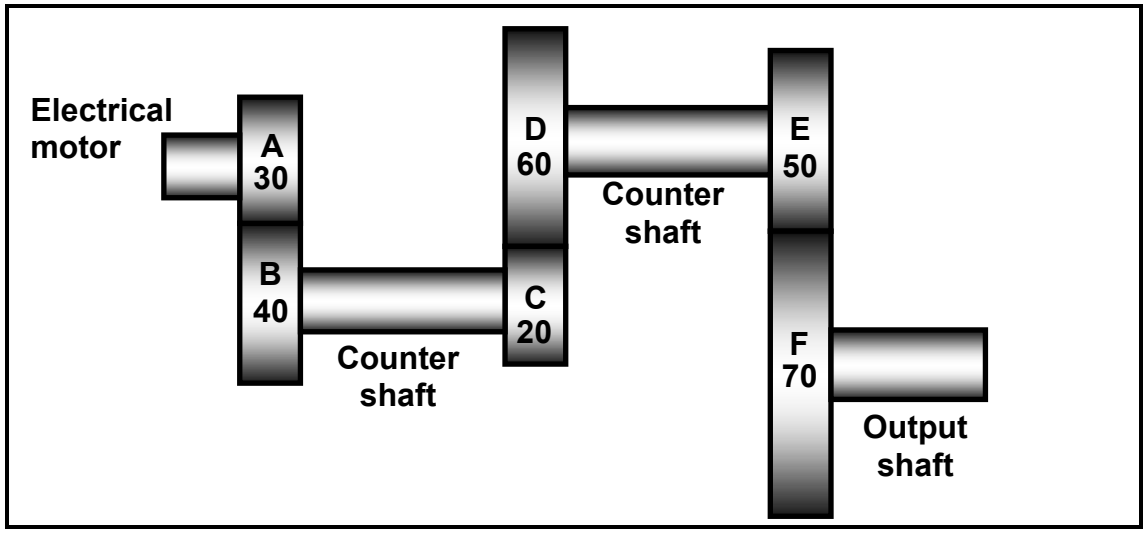

FIGURE 9.1

Calculate the:

9.1.1 Rotation frequency of the output shaft if the electric motor rotates at 2 300 r/min (3)

9.1.2 Velocity ratio between the input and output shaft (2)

9.2 FIGURE 9.2 below shows a belt drive system with a 260 mm driver pulley. The belt speed of the system is 32 $m.s^{-1}$. The tensile force in the slack side is 140 N and the ratio between the force in the tight side and the force in the slack side is 2,5.

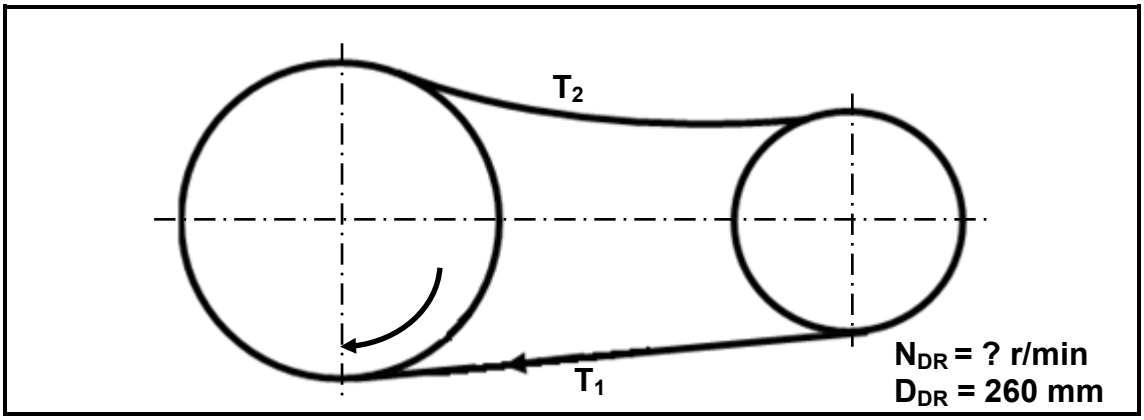

FIGURE 9.2

Calculate the:

9.2.1 Rotation frequency of the driven pulley in r/min (revolutions per minute) (3)

9.2.2 Tensile force in the tight side of the belt used in this system (2)

9.2.3 Power transmitted (3)

9.3 A hydraulic system is used to lift a machine. The specifications of the system are presented diagrammatically in FIGURE 9.3 below.

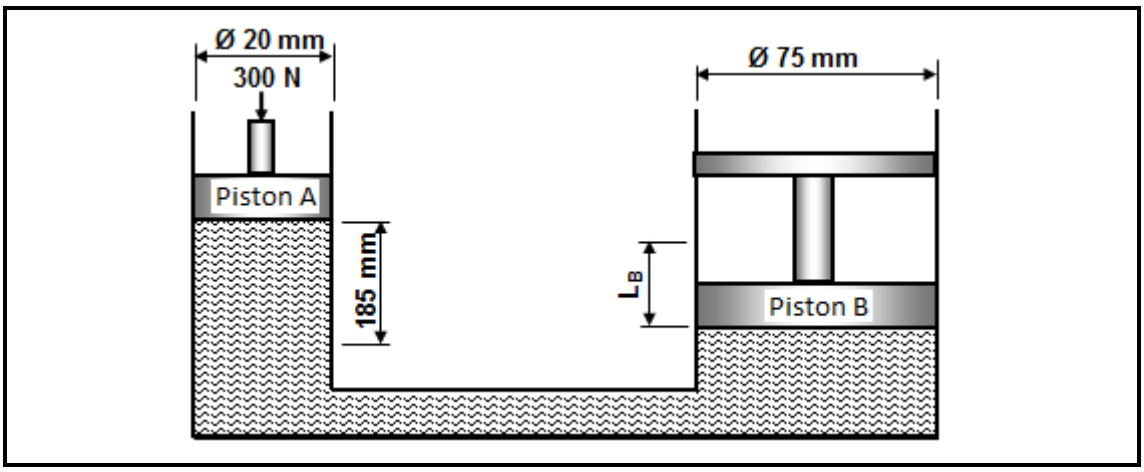

FIGURE 9.3

Calculate the:

9.3.1 Fluid pressure in the hydraulic system when in equilibrium (4)

9.3.2 Distance L_B that Piston B will move with one stroke of Piston A (4)

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

9.5 Why is a safety belt in a motor vehicle regarded as an active safety feature? (2)
[25]

QUESTION 10: TURBINES

10.1 Name ONE type of impulse water turbine. (1)

10.2 Define the *run-away speed* of a water turbine. (2)

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

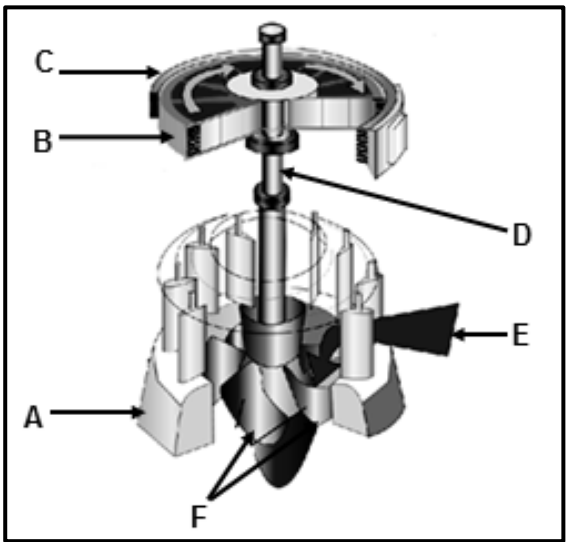

FIGURE 10.3

10.3.1 Identify the type of turbine shown in FIGURE 10.3. (1)

10.3.2 Label parts **A**–**F**. (6)

10.3.3 State THREE advantages of the turbine shown in FIGURE 10.3. (3)

10.4 State the main function of turbochargers and superchargers used on internal combustion engines. (2)

10.5 Name the type of compressor used in a turbocharger. (1)

10.6 How is a turbocharger driven? (1)

10.7 State ONE advantage of a turbocharger. (1)

10.8 State TWO advantages of a steam turbine. (2)
[20]

TOTAL: 200

FORMULA SHEET

1. BELT DRIVES

1.1 $N_{dr} \times D_{dr} = N_{dn} \times D_{dn}$

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

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

1.4 Belt mass = area × length × density (A = thickness × width)

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

1.6 Belt length (flat belt) = [(D + d) × 1,57] + 2 × centre distance

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

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

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

1.10 Power (P) $= \frac{(T_1 - T_2)\,\pi\, D\, N}{60}$ 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)

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

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

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

2. STRESS AND STRAIN

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

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

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

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

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

2.6 Area of a square bar = $A = L^2$ or $A = L \times B$

3. HYDRAULICS

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

3.2 Volume = (cross-sectional area) × stroke length

3.3 Work done = force × distance

4. KEYS AND KEYWAYS

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

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

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

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

5. LEVERS

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

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

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 $$N_{dr} \times D_{dr} = N_{dn} \times D_{dn}$$

6.2 $$\text{Power (P)} = \frac{2\pi N T}{60}$$

6.3 $$\text{Gear ratio} = \frac{\text{product of the number of teeth on the driven gears}}{\text{product of the number of teeth on the driver gears}}$$

6.4 $$\frac{N_{input}}{N_{output}} = \frac{\text{product of the number of teeth on the driven gears}}{\text{product of the number of teeth on the driver gears}}$$

6.5 Torque = force × radius

6.6 Torque transmitted = gear ratio × input torque

6.7 $$\text{Module (m)} = \frac{\text{pitch-circle diameter (PCD)}}{\text{number of teeth (T)}}$$

6.8 $$N_1 T_1 = N_2 T_2$$

6.9 $$\text{Pitch-circle diameter (PCD)} = \frac{\text{circular pitch (CP)} \times \text{number of teeth (T)}}{\pi}$$

6.10 $$\text{Pitch-circle diameter (PCD)} = m \times T$$

6.11 $$\text{Outside diameter (OD)} = m(T + 2)$$

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

6.13 Addendum = module (m)

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

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

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

6.17 Circular pitch (CP) = m × π

6.18 Centre distance between gear A and B $= \frac{(PCD)_A}{2} + \frac{(PCD)_B}{2}$

7. SCREW THREADS

7.1 Pitch diameter = outside diameter – ½pitch

7.2 Pitch circumference = π × 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

Cincinnati Index Plate											
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 $\text{Indexing} = \frac{40}{n}$ (where n = number of divisions)