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Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY**

**FEBRUARY/MARCH 2015**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 14 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  $10 \text{ m/s}^2$ .
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
<b>TOTAL</b>		<b>200</b>	<b>180 minutes</b>

**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 precaution is applicable to the MIGS/MAGS welding process?
- A Always use a striker to light the torch and not a match or lighter.
  - B The welder is completely insulated by means of boots and gloves.
  - C Open the cylinder valves quickly.
  - D Allow for oxygen and acetylene leaks. (1)
- 1.2 Which hardness tester uses a steel ball to determine the hardness of steel?
- A Vickers tester
  - B Rockwell tester
  - C Victor tester
  - D Brinell tester (1)
- 1.3 The gas analyser is used during the fuel mixture setting of a motor-car engine. Which ONE of the following is the CORRECT reason for a high carbon-monoxide reading?
- A Low compression
  - B Worn valves
  - C A clogged air filter
  - D Worn piston rings (1)
- 1.4 The function of the tensile tester:
- A To determine the compressive stress and ultimate pushing stress on a piece of a material
  - B To demonstrate a pulling stress on a supported beam
  - C To demonstrate the deflection of a simply supported beam
  - D To determine yield stress, ultimate pulling stress and percentage of elongation on a piece of material (1)
- 1.5 When carbon steel is heated at a uniform rate, the temperature rises evenly to 700 °C. The temperature then remains constant for a while. This point is known as the ... point.
- A decalescent
  - B melting
  - C lower critical
  - D heating (1)

- 1.6 Steel can be hardened and annealed at a temperature between 885 °C and 925 °C. What percentage carbon content will allow for this hardening and annealing? Use the iron carbon equilibrium diagram in FIGURE 1.1 below.

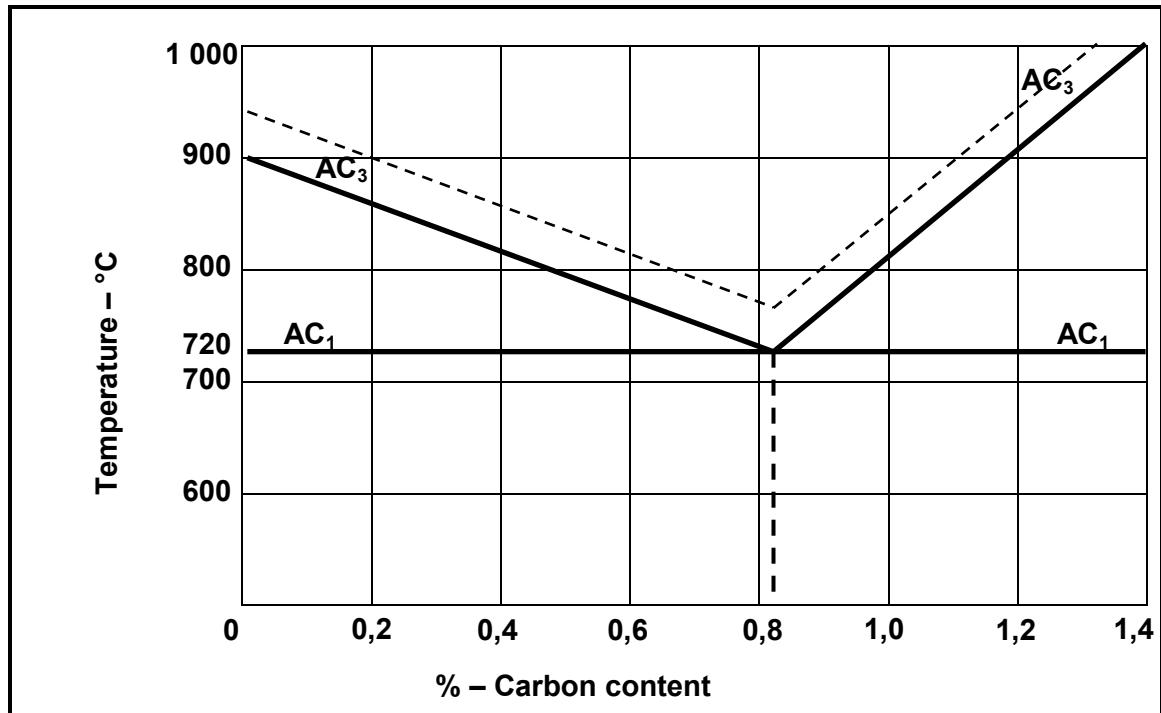


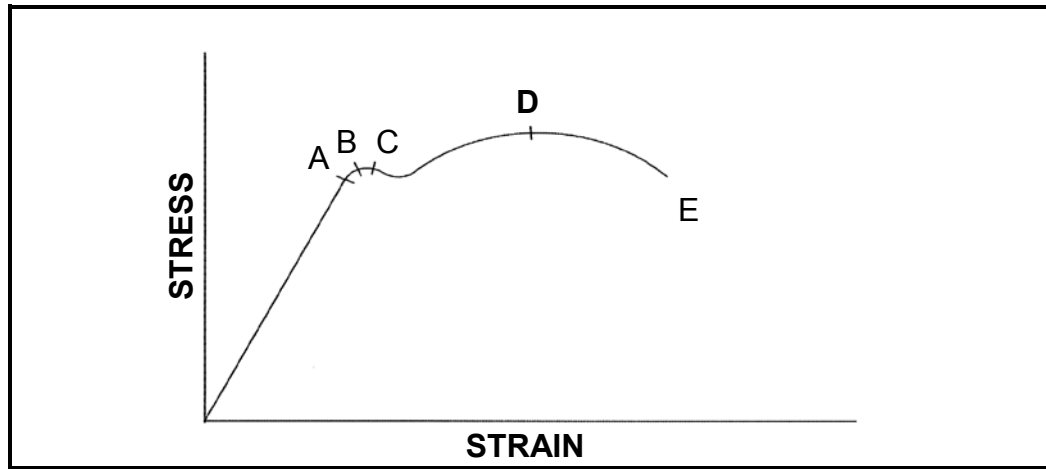
FIGURE 1.1

- A 0,60%  
 B 0,20%  
 C 0,80%  
 D 0,40% (1)
- 1.7 Name the tool that is used to set the cutting tool perpendicular to the axis of the work piece when cutting a screw thread on the lathe:
- A Screw-pitch gauge  
 B Screw-thread ring gauge  
 C Centre gauge  
 D Screw gauge (1)
- 1.8 What is the standard ratio of a taper key?
- A 1 in 50  
 B 1 in 100  
 C 1 in 150  
 D 1 in 75 (1)

- 1.9 What defect appears as a groove in the parent metal, directly along the edges of the weld?
- A Undercutting
  - B Slag inclusion
  - C Porosity
  - D Incomplete penetration
- (1)
- 1.10 Which ONE of the following is an example of a destructive test?
- A X-ray test
  - B Liquid dye penetration test
  - C Ultrasonic test
  - D Bend test
- (1)
- 1.11 Compressive stress can be defined as an internal force in material that provides resistance against a ... load.
- A shearing
  - B tensile
  - C compressive
  - D linear
- (1)
- 1.12 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)
- 1.13 The following statement describes an advantage of a belt-drive system compared to a gear-drive system:
- A Stronger
  - B Needs no lubrication
  - C Changes direction
  - D More durable
- (1)

- 1.14 Calculate the strain when a tensile force causes a stress of 6 MPa in a work piece. The material has an elasticity module of 3 GPa:
- A  $2 \times 10^3$
  - B 500
  - C  $1,8 \times 10^9$
  - D  $2 \times 10^{-3}$
- (1)
- 1.15 What is the composition of cutting fluid?
- A Soluble oil and water
  - B Grease and water
  - C Engine oil and water
  - D Machine oil and water
- (1)
- 1.16 What does the abbreviation ECU stand for in terms of the vehicle management system?
- A Economical control unit
  - B Electronic control unit
  - C Electricity control unit
  - D Engine control unit
- (1)
- 1.17 How is the supercharger driven?
- A Hydraulically driven
  - B Gas driven
  - C Pneumatically driven
  - D Mechanically driven
- (1)
- 1.18 During a gas turbine application the auxiliary power unit is described as ... gas turbine designed for auxiliary power.
- A a large
  - B a medium
  - C a larger
  - D a small
- (1)
- 1.19 Force is a vector unit which is recognised by ...
- A magnitude only.
  - B direction only.
  - C magnitude and direction.
  - D volume and direction.
- (1)

1.20 What does point **D** denote in FIGURE 1.2 below?



**FIGURE 1.2**

- A Limit of proportionality
- B Maximum strain
- C Maximum stress
- D Limit of elasticity

(1)  
[20]

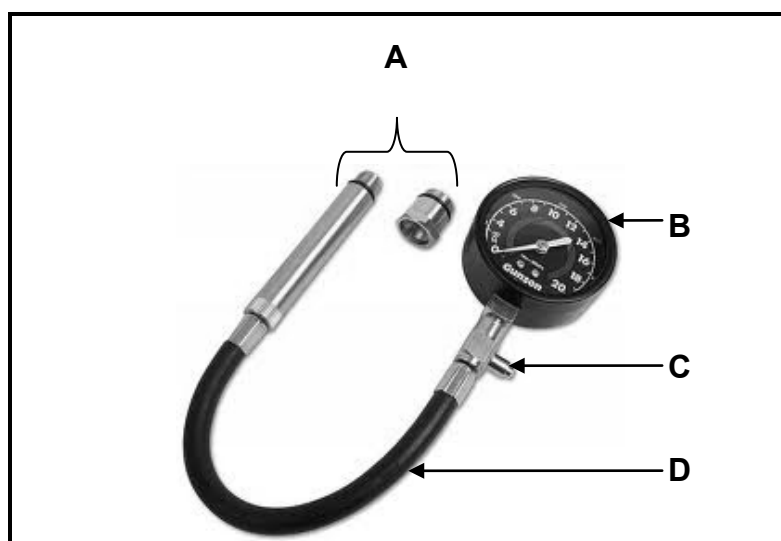


**QUESTION 2: SAFETY**

- 2.1 All personal and environmental safety rules have already been taken care of when a surface grinder is used. State **THREE** safety rules which are only applicable while the surface grinder is being used. (3)
- 2.2 Give **TWO** reasons why the pressure gauge of a hydraulic press must be tested regularly. (2)
- 2.3 Why is it important to keep the copper tips of the spot welder constantly cool during use? (1)
- 2.4 Describe the position of the following regarding the cylinder leakage test:
- 2.4.1 Stroke (1)
  - 2.4.2 Piston (1)
  - 2.4.3 Valves (1)
- 2.5 At what angle to the bearing should a bearing puller be used? (1)
- [10]**

**QUESTION 3: TOOLS AND EQUIPMENT**

- 3.1 Explain how a voltmeter and an ammeter are connected to a circuit. (2)
- 3.2 Describe the purpose of the following tests:
- 3.2.1 Beam-bending test (2)
  - 3.2.2 Cylinder-leakage test (2)
- 3.3 When Johnny conducted a dry compression test, the test indicated that the first cylinder had a very low reading. After conducting a wet test, the reading was higher. To what conclusion can Johnny come about the test? (2)
- 3.4 FIGURE 3.1 below shows a compression tester that is used to check the compression of a cylinder. Label parts **A–D**.

**FIGURE 3.1**

(4)  
**[12]**

**QUESTION 4: MATERIALS**

4.1 Name TWO characteristics of each of the following microscopic structures of steel:

4.1.1 Ferrite (2)

4.1.2 Pearlite (2)

4.2 Determine the microscopic structure that best describes the compound of iron and carbon (iron carbide) by analysing steel and cast iron. (2)

4.3 The table below indicates the carbon content, typical uses, heat treatment and properties of steel. Write your answers for QUESTIONS 4.3.1, 4.3.2 and 4.3.3 in the ANSWER BOOK.

CARBON CONTENT	TYPICAL USES	HEAT TREATMENT	PROPERTIES
Low 0,1–0,25%	<b>4.3.1</b>	Annealing	Strong; durable
Medium 0,25–0,55%	Crankshafts; pliers; screwdrivers	<b>4.3.2</b>	Tough; hard surface
High 0,55–1,00%	Cutting tools; springs; hammers	Hardening	<b>4.3.3</b>

(3)

4.4 Define the terms below with reference to the iron-carbon equilibrium diagram:

4.4.1 Lower critical point ( $AC_1$ ) (2)

4.4.2 Critical temperature (2)

**[13]**

**QUESTION 5: TERMINOLOGY**

5.1 Explain step by step how a metric V-screw thread with a pitch of 1,5 mm is cut on the centre lathe. (11)

5.2 Calculate the cutting depth of a metric V-screw thread with a pitch of 2,5 mm using the compound slide method. (3)

5.3 Calculate the simple indexing needed to cut a gear with 82 teeth. (3)

5.4 The length of a parallel key is 102 mm. Calculate:

5.4.1 The diameter of the shaft (3)

5.4.2 The width of the key (3)

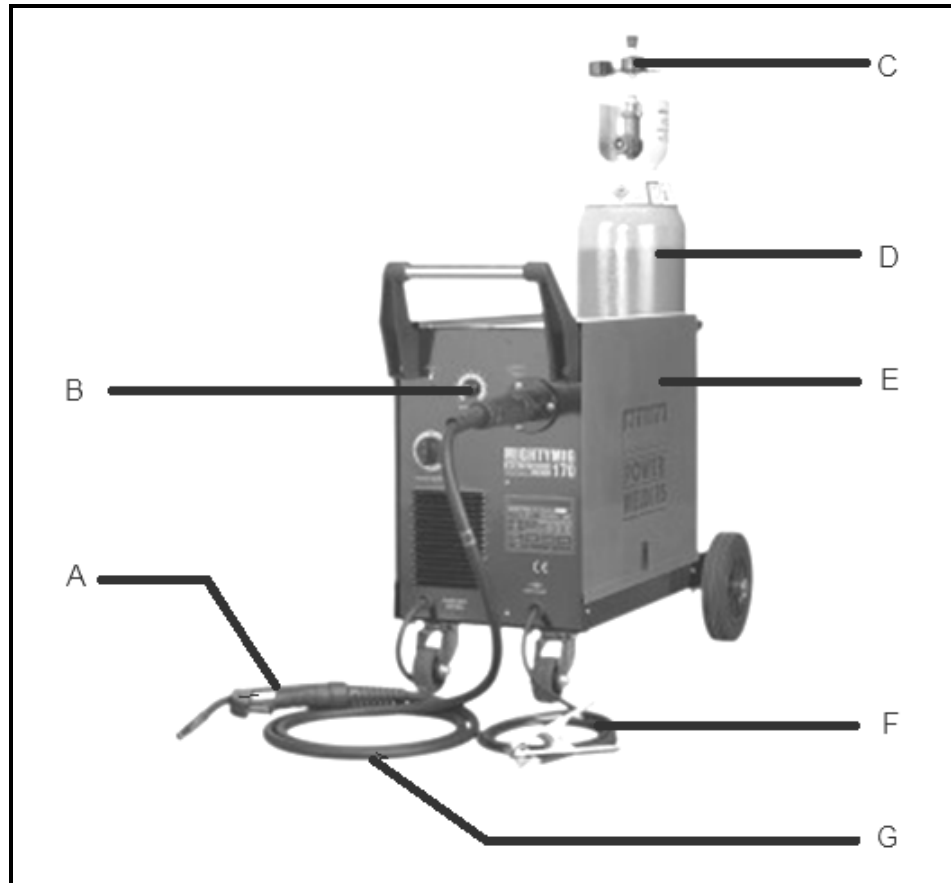
5.4.3 The thickness of the key (3)

5.5 Show, by means of neat labelled sketches, the difference between *upcut milling* and *downcut milling*. (4)

**[30]**

**QUESTION 6: JOINING METHODS**

6.1 FIGURE 6.1 shows a welding machine with different attachments.



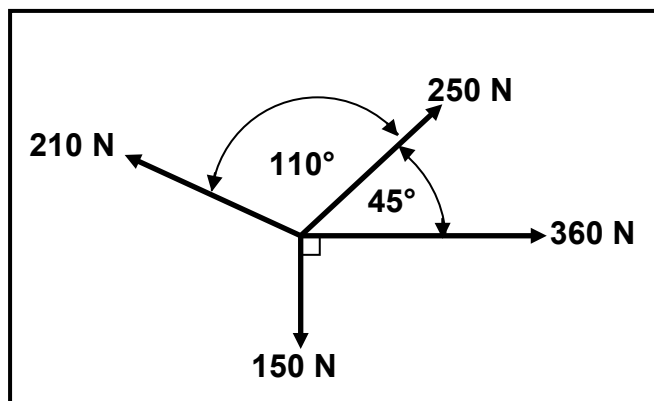
**FIGURE 6.1**

- 6.1.1 Identify the welding machine in FIGURE 6.1. (1)
- 6.1.2 Label parts **A–G** in FIGURE 6.1. (7)
- 6.2 Explain the operating principle of the X-ray testing equipment as applicable to a welded joint. (6)
- 6.3 State THREE advantages of metal-arc shielded welding (MIGS/MAGS). (3)
- 6.4 What is the purpose of a bend test? (2)
- 6.5 State TWO causes of the following welding defects:
- 6.5.1 Incomplete penetration (2)
- 6.5.2 Welding craters (2)
- 6.6 Which TWO aspects regarding welding techniques should be kept in mind during arc welding? (2)

**[25]**

**QUESTION 7: FORCES**

- 7.1 Four forces of 150 N, 210 N, 250 N and 360 N respectively, as shown in FIGURE 7.1 below, act on the same point. Calculate the magnitude and direction of the equilibrant for this system of forces.

**FIGURE 7.1**

(15)

- 7.2 A square steel bar with 100 mm x 100 mm sides is subjected to a compressive force of 80 kN. Determine, by means of calculations, the stress in the material.

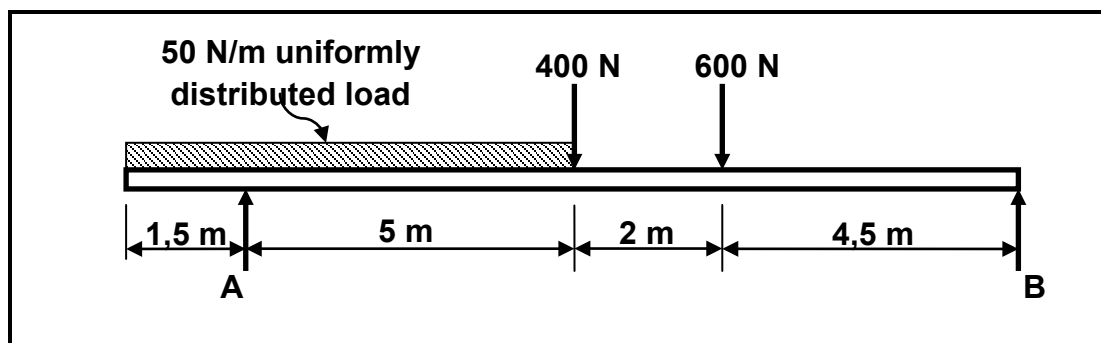
(5)

- 7.3 Define *Hooke's law*.

(3)

- 7.4 FIGURE 7.2 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 50 N/m, over the total left half of the beam.

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

**FIGURE 7.2**

(7)

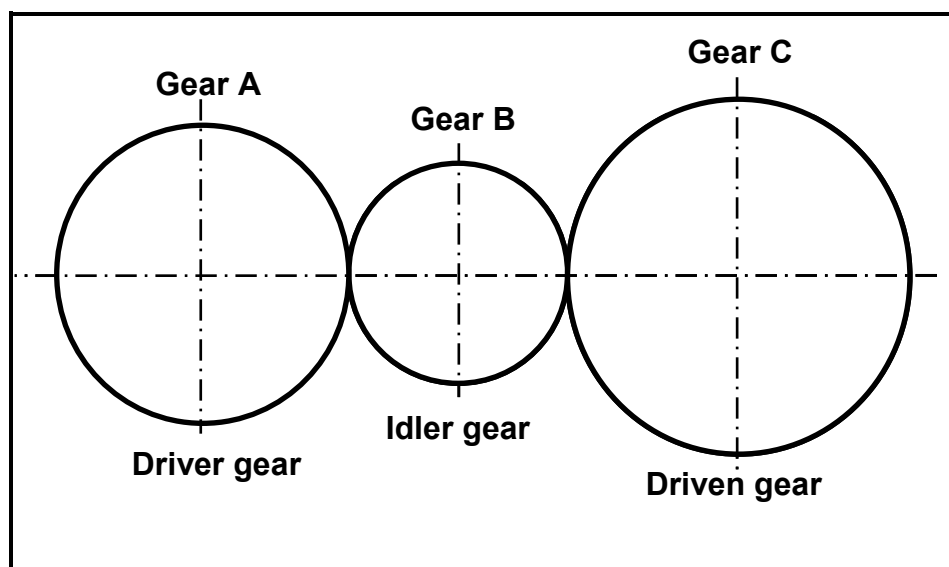
**[30]**

**QUESTION 8: MAINTENANCE**

- 8.1 State TWO advantages of a cutting fluid. (2)
- 8.2 Define *preventive maintenance*. (1)
- 8.3 Car manufacturers recommend that the timing chain of a car engine be replaced every 90 000 km. Answer the questions that follow.
- 8.3.1 Give TWO reasons why a chain drive is preferred to a belt drive. (2)
- 8.3.2 Give TWO reasons why a stretched chain has to be replaced. (2)
- 8.3.3 Explain in point form how you would remove and replace the timing chain of an engine. (6)
- 8.4 Why is it desirable for engine oil to have a high flash point? (2)
- [15]**

**QUESTION 9: SYSTEMS AND CONTROL**

- 9.1 FIGURE 9.1 below shows a gear system used to control a hoisting machine. The driver gear has 50 teeth and rotates at 660 r/min. The idler gear that is used to change the direction, 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 second (3)

- 9.2 The drive pulley of a belt-drive system rotates at 1 640 r/min. The drive pulley has a diameter of 175 mm and the driven pulley a diameter of 80 mm. The belt thickness is 12 mm.

Take the belt thickness into consideration and determine, by means of calculations:

- 9.2.1 The rotation frequency of the driven pulley in revolutions per second (3)

- 9.2.2 The belt speed of the system (3)

- 9.3 A hydraulic system is used to compress scrap metal for recycling. The specifications of the system are presented diagrammatically in FIGURE 9.2.

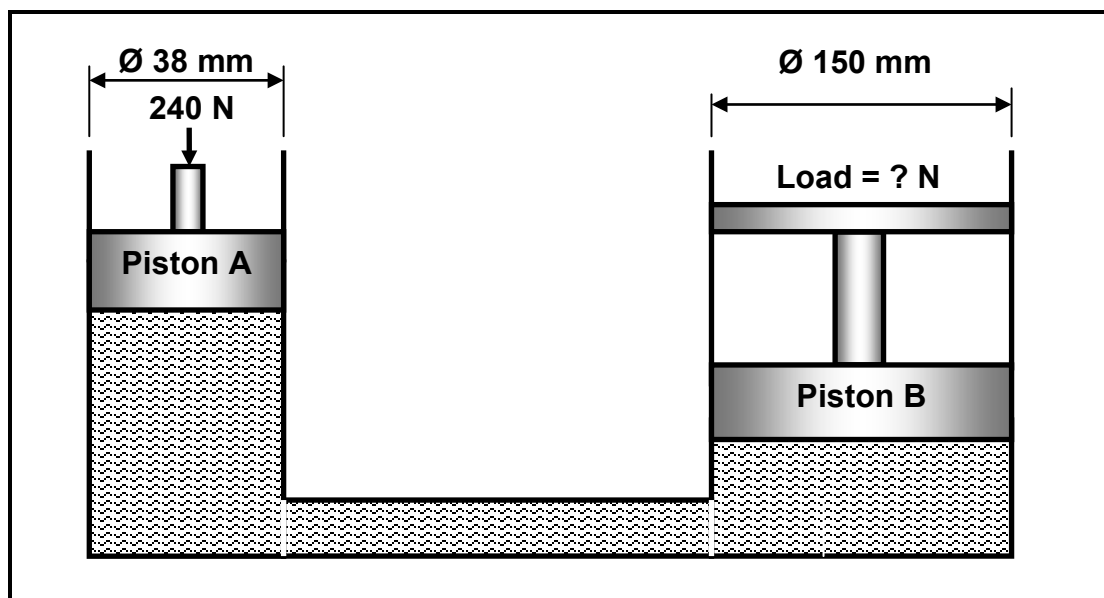


FIGURE 9.2

Determine, by means of calculations:

- 9.3.1 The fluid pressure in the hydraulic system while in equilibrium (3)

- 9.3.2 The force exerted by piston B (4)

- 9.4 Describe the purpose of the vehicle-engine management system. (4)

- 9.5 Describe the purpose of the anti-lock brake system (ABS). (2)

[25]

**QUESTION 10: TURBINES**

- 10.1 State TWO positive impacts a water turbine will have on the environment and society. (2)
- 10.2 Define the following terms regarding a water turbine:
- 10.2.1 Specific speed (2)
- 10.2.2 Free load speed/Runaway speed (2)
- 10.3 State the function of a steam turbine. (2)
- 10.4 Name THREE types of steam turbines. (3)
- 10.5 What is the advantage of using gas turbines on naval vessels? (2)
- 10.6 Define *turbo boost*. (2)
- 10.7 Explain in point form the operation of a twin-screw supercharger. (5)
- [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**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## 6. PULLEY DRIVES

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

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

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

## 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**

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

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