basic education

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

**NATIONAL
SENIOR CERTIFICATE**

**GRADE 10**

**MECHANICAL TECHNOLOGY**

**2016**

**MARKS: 200**

**TIME: 3 HOURS**

**This question paper consists of 22 pages and a 2 page formula sheet**

## INSTRUCTIONS AND INFORMATION

1.      Write your NAME on the ANSWER BOOK.

2.      This question paper consists of FOUR sections: SECTIONS A, B, C and D

3.      SECTION A is compulsory

4.      SECTION B – Fitting and Machining

5.      SECTION C – Automotive

6.      SECTION D – Welding and Metalwork

7.      Answer SECTION A (compulsory) and then answer SECTION B or C or D according to your choice of specialisation.

8.      Number the answers correctly according to the numbering system used in this question paper.

9.      Start EACH question on a NEW page.

10.     Show ALL calculations and units. Round off final answers to TWO decimal places.

11.     Candidates may use non-programmable scientific calculators and drawing instruments.

12.     The value of gravitational force should be taken as 10 m.s$^{-2}$.

13.     All dimensions are in millimetres, unless stated otherwise in the question.

14.     Write neatly and legibly.

15.     A formula sheet is attached to the question paper.

16.     Use the criteria below to assist you in managing your time.

| MECHANICAL TECHNOLOGY | | | |
|---|---|---|---|
| SECTION A (GENERIC) | | | |
| QUESTION | CONTENT | MARKS | TIME |
| 1 | Multiple-choice questions (Generic) | 20 | 15 minutes |
| 2 | Safety (Generic) | 10 | 10 minutes |
| 3 | Tools and Equipment(Generic) | 12 | 10 minutes |
| 4 | Materials(Generic) | 12 | 10 minutes |
| 5 | Joining Methods(Generic) | 24 | 20 minutes |
| 6 | Forces(Generic) | 27 | 25 minutes |
| 7 | Maintenance(Generic) | 16 | 15 minutes |
| 8 | Engines (Generic) | 19 | 20 minutes |
| | **TOTAL FOR SECTION A** | **140** | **125 minutes** |

## SECTION A (GENERIC)

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

Various options are provided as possible answers to the following questions. Choose a correct answer and write the letter (A – D) next to the question number (1.1–1.20) in your ANSWER BOOK.

Example:
1.21    A

1.1     Which ONE of the following safety precautions is applicable when using hand tools?

    A     Working at a very slow speed
    B     Working with well lubricated tools
    C     Use tools only for the purpose it were made for
    D     Replace all tools after use                                                                    (1)

1.2     What is the maximum safe distance of the tool rest from the grinding wheel on a bench grinder?

    A     8 mm
    B     10 mm
    C     3 mm
    D     6 mm                                                                                                 (1)

1.3     Which ONE of the following tools is used for marking off?

    A     Combination spanner
    B     Circlip pliers
    C     Allen keys
    D     Scriber                                                                                              (1)

1.4     What is the included angle of the centre punch?

    A     $45^{\circ}$
    B     $60^{\circ}$
    C     $90^{\circ}$
    D     $0^{\circ}$                                                                                              (1)

1.5     A smooth file is preferred to finish off…

    A     soft material
    B     hard material
    C     wood
    D     plastics                                                                                             (1)

1.6     Lead is characterised as a...

     A     hard, grey coloured metal.
     B     soft, bluish-grey coloured metal.
     C     medium-soft, light-grey coloured metal.
     D     very soft, white-grey coloured metal.                                                (1)

1.7     Which ONE of the following is a use of duralumin?

     A     Roof trusses
     B     School desks
     C     Aircraft parts
     D     Garden furniture                                                                      (1)

1.8     Why is tungsten one of the principal alloying elements of tool steels?

     A     It increases the strength and toughness of the steel
     B     It increases the malleability of the steel
     C     It makes the steel lighter
     D     It decreases the life span of the steel                                               (1)

1.9     Which ONE of the following statements describes the application of a split pin?

     A     Metal ring fitted into a groove on a metal bar or in the bore of a boss to hold a component or object in position.
     B     Metal pin passed through a hole and held in place by its bended ends Metal nut with slots in one end that gives it a castle-like appearance.
     C     Metal strip to fit in a space.
     D                                                                                           (1)

1.10    Identify the item shown in FIGURE 1.1.
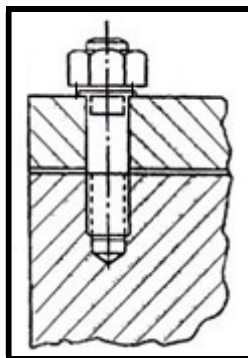


**FIGURE 1.1**

     A     Stud bolt
     B     Hexagonal bolt
     C     Taper bolt
     D     Gib-head bolt                                                                         (1)

1.11    Identify the type of key shown in FIGURE 1.2.
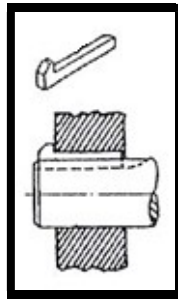


**FIGURE 1.2**

A    Woodruff key
B    Gib-head key
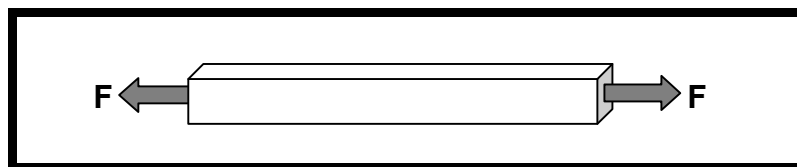C    Taper key
D    Parallel key                                                                                                (1)

1.12    What type of force is indicated in FIGURE 1.3?



**FIGURE1.3**

A    Tensile force
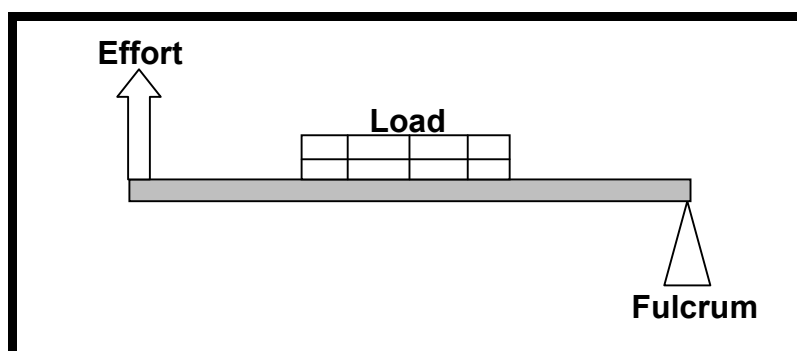B    Compressive force
C    Rolling force
D    Shearing force                                                                                           (1)

1.13    What class of lever is indicated in FIGURE 1.4?



**FIGURE1.4**

A    $1^{st}$ class
B    $2^{nd}$ class
C    $3^{rd}$ class
D    $4^{th}$ class                                                                                            (1)

1.14    What do you understand by the term "stress" in materials?

      A     Internal force in a material resisting a shearing load
      B     Internal force in a material resisting a pulling load
      C     Internal force in a material resisting a compressive load
      D     Internal force in a material resisting an external load        (1)

1.15    Which ONE of the following is the main purpose of maintenance on machinery?

      A     To ensure that machinery always operates at an optimal level.
      B     To ensure that minor repairs are separated from major repairs of machinery.
      C     To make sure that the well-being of workers is always taken care of
      D     To provide systematic inspection and resulting failure of workshop equipment.        (1)

1.16    Which ONE of the following is an advantage for the use of cutting fluid on a machine?

      A     Keeps the cutting tool and work piece cool during the cutting process
      B     Increases vibration on the machine parts
      C     Causing the work peace to rust
      D     Decrease the life span of the cutting tool        (1)

1.17    What is understood by the term pour point?

      A     The lowest temperature at which the fluid will flow.
      B     The highest temperature at which the fluid will flow.
      C     The lowest pressure at which the fluid will flow.
      D     The highest pressure at which the fluid will flow.        (1)

1.18    What type of fuel is used in a spark ignition engine?

      A     Diesel
      B     Oil
      C     Gas
      D     Petrol        (1)

1.19    The correct stoke order of a four stroke-spark ignition engine is as follows:

      A     Compression stroke; Power stroke; Inlet stroke; Exhaust stroke
      B     Inlet stroke; Compression stroke; Power stroke; Exhaust stroke
      C     Power stroke; Exhaust stroke; Compression stroke; Inlet stroke
      D     Inlet stroke; Compression stroke; Exhaust stroke; Power stroke        (1)

1.20   The crankshaft of a four stroke engine rotates at 3000 revolutions per minute. At how many revolutions per minute will the camshaft rotate?

A   6 000 rpm
B   4 500 rpm
C   1 500 rpm
D   3 000 rpm

**TOTAL QUESTION 1:    [20]**

## QUESTION 2:  SAFETY (GENERIC)

2.1   Mention THREE personal protective equipment to be worn while operating machinery in the workshop.    (3)

2.2   Name TWO safety precautions to be observed before a drill press can be used.    (2)

2.3   State THREE safety precautions to be adhered to while a milling machine is in operation.    (3)

2.4   Which is the important safety procedure needs to be carried out after finishing the  cutting process on the lathe?    (1)

2.5   State the type of fire extinguisher used to extinguish flammable liquids.    (1)

**TOTAL QUESTION 2:    [10]**

## QUESTION 3:  TOOLS AND EQUIPMENT (GENERIC)

3.1   State TWO file profiles.    (2)

3.2   Describe the advantage of using an open-ended spanner over a ring spanner.    (1)

3.3   Name TWO different types of pliers.    (2)

3.4   Why are Phillips screwdrivers preferred to flat screwdrivers.    (2)

3.5   State THREE uses of the combination set.    (3)

3.6   State ONE use for each of the following punches:

    3.6.1  Prick punch    (1)

    3.6.2  Centre punch    (1)

**TOTAL QUESTION 3:    [12]**

## QUESTION 4:  MATERIALS (GENERIC)

4.1     State the THREE groups of carbon steel.                                              (3)

4.2     Cast iron is divided into white and grey cast iron. What determines the
        hardness of these two types of cast iron?                                            (2)

4.3     State ONE use of each of the following non-ferrous elements:

        4.3.1    Copper                                                                       (1)

        4.3.2    Tin                                                                          (1)

        4.3.3    Aluminium                                                                    (1)

4.4     Name FOUR non-ferrous alloys.                                                         (4)

                                                            **TOTAL QUESTION 4:      [12]**

## QUESTION 5:  JOINING METHODS (GENERIC)

5.1     Name the sequence of the THREE taps used to cut internal screw thread.               (3)

5.2     State THREE reasons for inferior results during hand threading referring to
        accuracy and finishing of the screw thread.                                          (3)

5.3     What is the purpose of the die during hand threading?                                (2)

5.4     A pulley needs to be fitted on a 42 mm diameter shaft. Calculate the
        following dimensions of the parallel key needed for this assembly:

        5.4.1    The width of the parallel key                                               (3)

        5.4.2    The thickness of the parallel key                                           (3)

        5.4.3    The length of the parallel key                                              (3)

5.5     A M16 x 2 – V-thread needs to be tapped in a workpiece. Calculate the
        diameter of the drill needed.                                                        (3)

5.6     Draw neat sketches of the following rivet heads:

        5.6.1    Pan head                                                                     (2)

        5.6.2    Countersunk head                                                             (2)

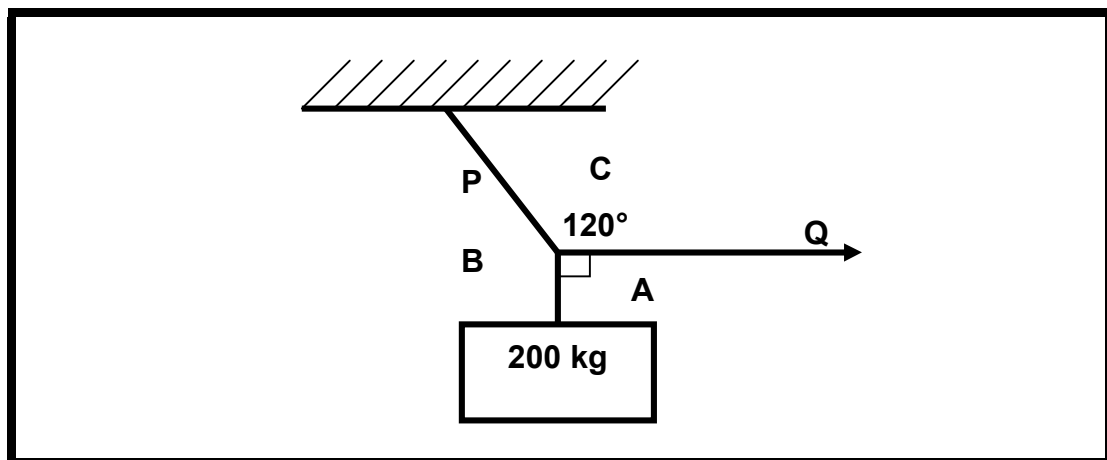                                                            **TOTAL QUESTION 5:      [24]**

## QUESTION 6: FORCES (GENERIC)

6.1     Make use of the parallelogram of forces and determine graphically the magnitude and direction of the resultant for the system of forces indicated in FIGURE 6.1. (Use Scale: 1 mm = 5 N)
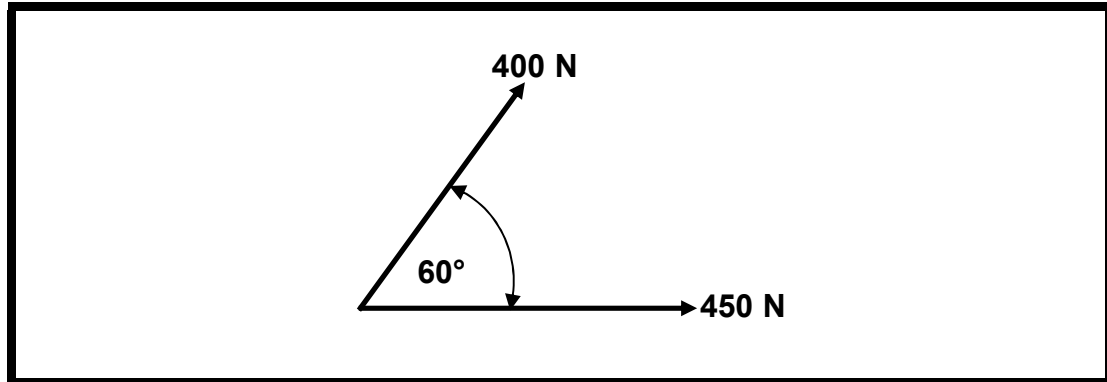


**FIGURE 6.1**                                                                                 (4)

6.2     A system of forces indicated in FIGURE 6.2 is in equilibrium. Make use of Bow's Notation and determine graphically the magnitude and directions of the unknown forces P and Q. (Use Scale: 1 mm = 20 N)



**FIGURE 6.2**                                                                                 (5)

6.3     Define a force.                                                                        (5)

6.4    FIGURE 6.3 shows a single force of 150 N acting in a direction 35° north from west. Calculate the magnitudes and directions of the horizontal and vertical components of this force.
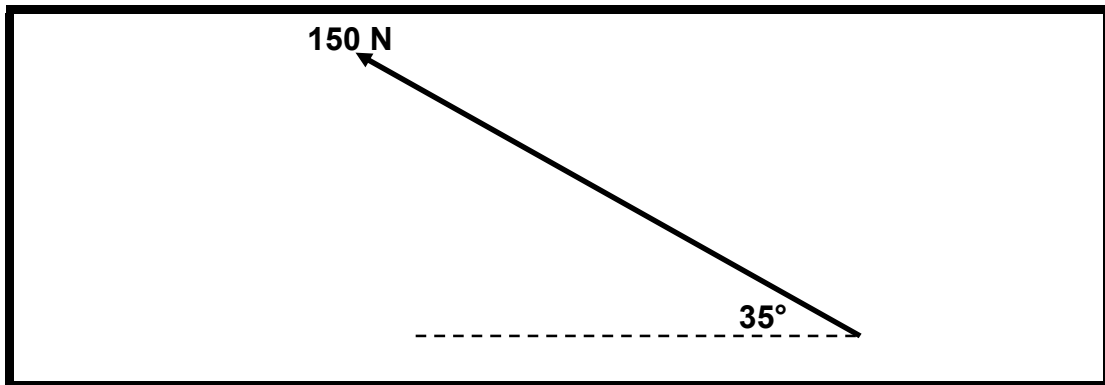


**FIGURE 6.3**                                                        (4)

6.5    A compressive force of 30 kN is exerted onto a round bar with a diameter of 15 mm. Calculate the stress in the material.                         (5)

6.6    FIGURE 6.4 indicates an uniform beam onto which two perpendicular forces are exerted. Calculate the total moment around point "A" caused by the forces.
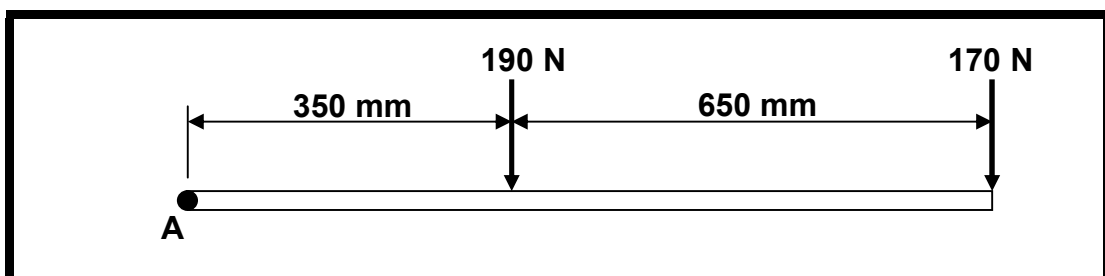


**FIGURE 6.4**                                                        (4)

**TOTAL QUESTION 6:     [27]**

**QUESTION 7:  MAINTENANCE (GENERIC)**

7.1    Name FOUR effects caused by the lack of maintenance on equipment.    (4)

7.2    Briefly explain what do the following types of maintenance entails and give an example of each:

       7.2.1    Preventative ("routine") maintenance                       (2)

       7.2.2    Predictive ("in-service") maintenance                      (2)

7.3    Different lubricants are used to extent machinery reliability and maintenance. Explain the purpose of a lubricant on machine components.    (3)

7.4  Define viscosity with reference to lubricants.     (1)

7.5  Classify the viscosity ("high, medium or low") of each of the following types of lubricants and motivate your answer.

    7.5.1  Engine oil           (2)

    7.5.2  Grease            (2)

**TOTAL QUESTION 7: [16]**

## QUESTION 8: ENGINES (GENERIC)

8.1  Describe the following terms regarding internal combustion engines:

    8.1.1  Stroke            (1)

    8.1.2  Top dead centre (T.D.C)      (1)

    8.1.3  Cycle            (1)

8.2  FIGURE 8.1 indicates a stroke of a two stroke petrol engine. Answer the questions that follow:
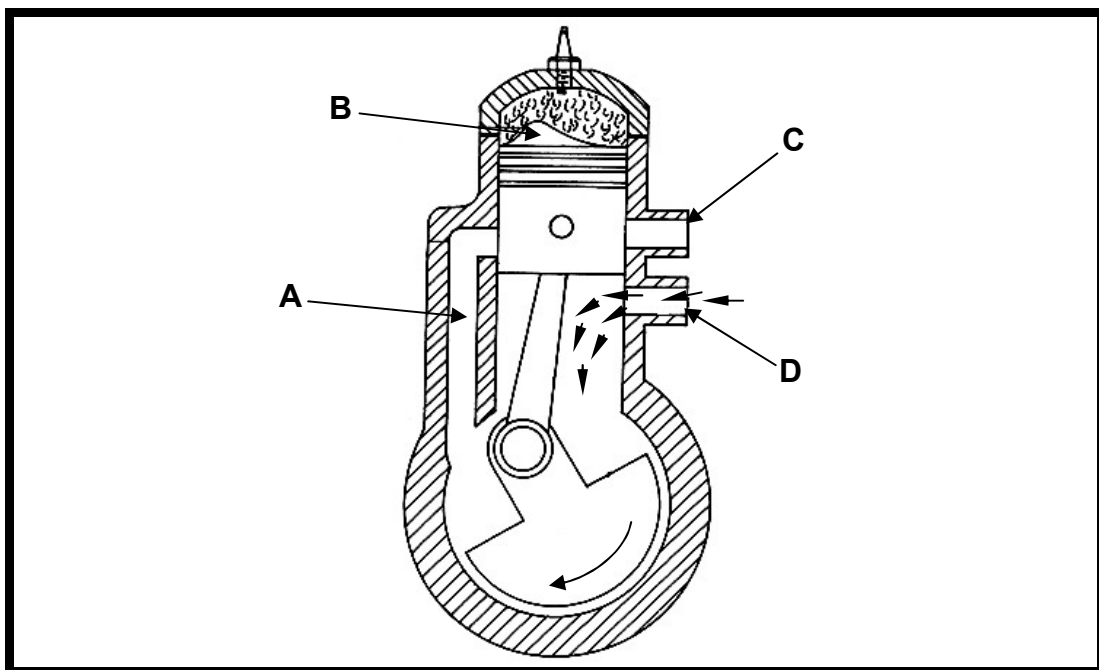


**FIGURE 8.1**

    8.2.1  Label FIGURE 8.1 according to the letters A – D.  (4)

    8.2.2  Identify and explain the operation of the stroke indicated in FIGURE 8.1.           (4)

8.3    FIGURE 8.2 shows a stroke from a four stroke petrol engine. Answer the
       questions that follow:
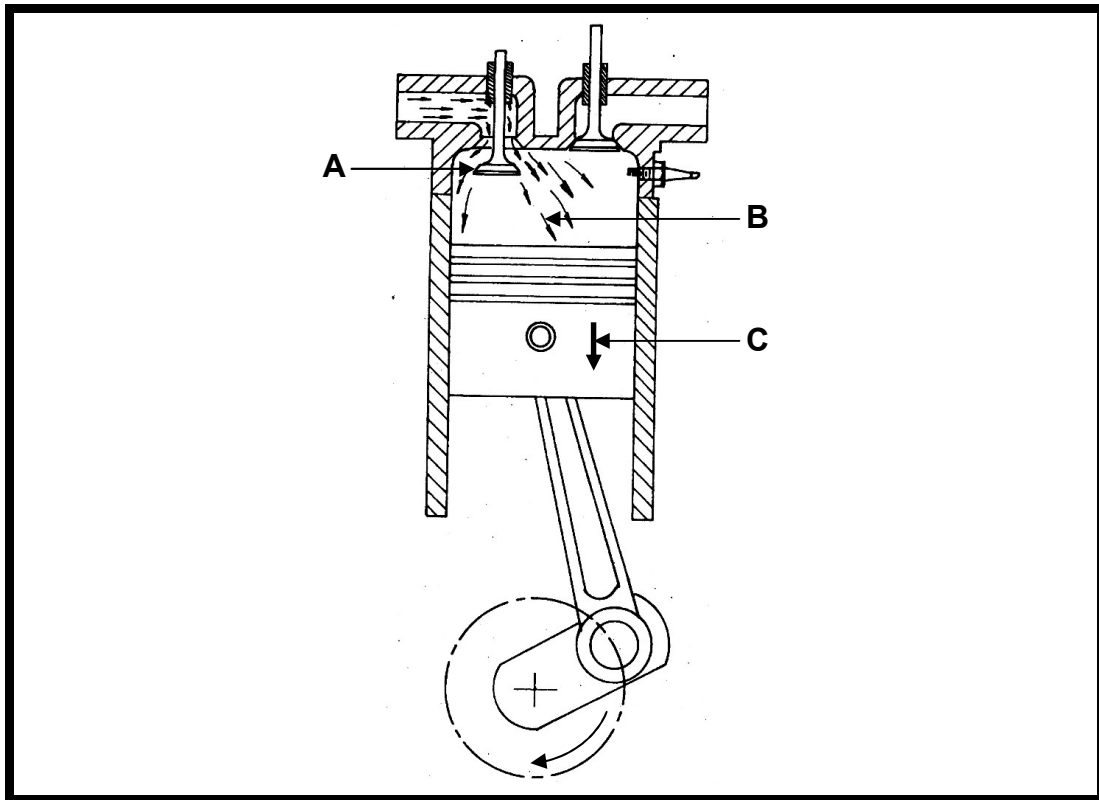


**FIGURE 8.2**

8.3.1    Identify the stroke indicated in FIGURE 8.2.                                    (1)

8.3.2    Label FIGURE 8.2 according to the letters A – C.                                (3)

8.3.3    Explain the operation of the stroke indicated in  FIGURE 8.2.                   (4)

**TOTAL QUESTION 8:      [19]**

**TOTAL SECTION A:      [140]**

**SECTION B: FITTING AND MACHINING (SPECIFIC)**

**Use the criteria below to assist you in managing your time.**

| FITTING AND MACHINING | | | |
|---|---|---|---|
| SECTION B (SPECIFIC) | | | |
| QUESTION | CONTENT | MARKS | TIME |
| 9 | Terminology (Specific) | 33 | 30 minutes |
| 10 | Systems and Control (Specific) | 27 | 25 minutes |
| TOTAL FOR SECTION B | | 60 | 55 minutes |
| TOTAL FOR SECTION A + B | | 200 | 180 minutes |

**QUESTION 9: TERMINOLOGY (SPECIFIC)**

9.1     A vernier calliper is shown in FIGURE 9.1. Answer the questions which follow:
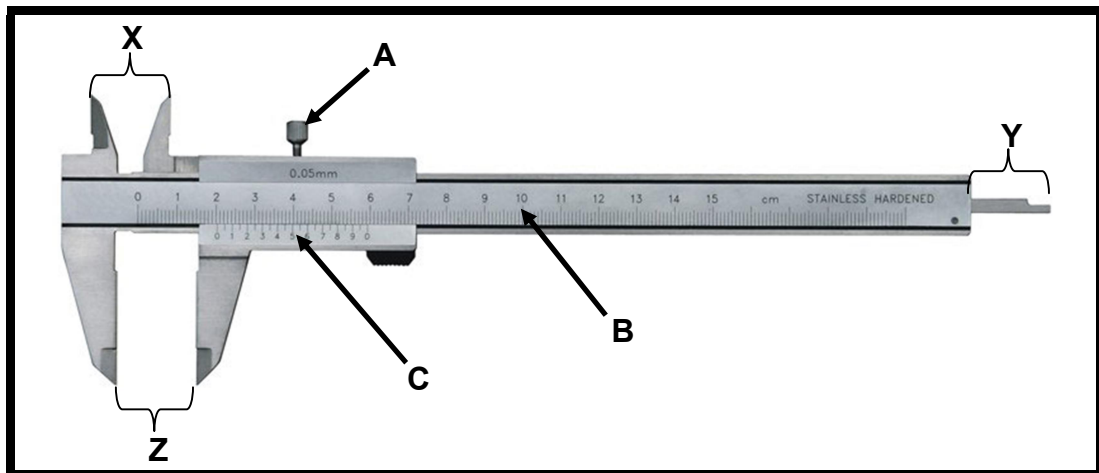


**FIGURE 9.1**

9.1.1   Label the components of the vernier calliper according to the letters A – C.                                                                              (3)

9.1.2   Which measurements are indicated by the letters X,Y and Z.        (3)

9.1.3   Draw a neat diagrammatic representation of the reading on the calliper for 107,42 mm (Accuracy of the calliper is 0,02 mm).    (5)

9.2     FIGURE 9.2 indicates a reading on the outside micrometer. What is the value of the reading?
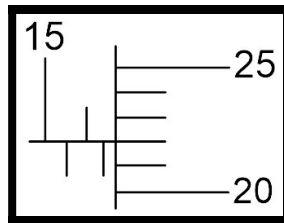


**FIGURE 9.2**                                                    (4)

9.3     List TWO types of centre lathe beds.                                    (2)

9.4     What is the purpose of the four-jaw chuck on the centre lathe?          (2)

9.5     Describe the function of the following centre lathe components:

        9.5.1   Lead screw                                                      (2)

        9.5.2   Tail stock                                                      (2)

9.6     FIGURE 9.3 indicates the angles on a centre lathe cutting tool. Label the angles according to the letters A – D.
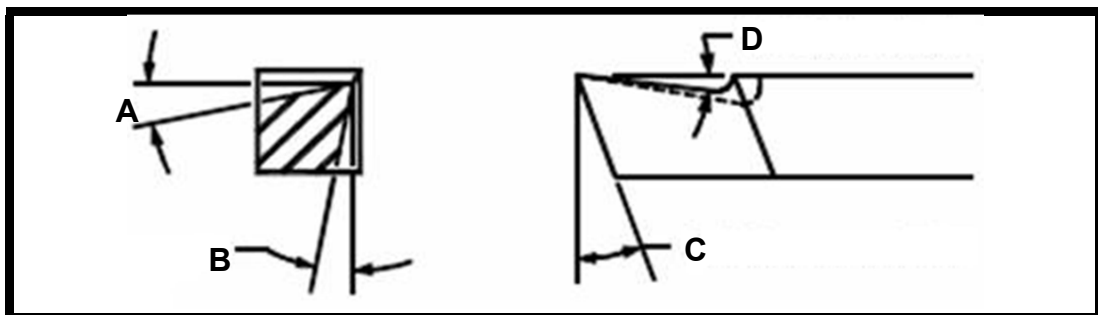


**FIGURE 9.1**                                                    (4)

9.7     State TWO reasons for using coolant when machining is done on the centre lathe.                                                               (2)

9.8     State TWO advantages of the compound slide method for taper cutting on the centre lathe.                                                        (2)

9.9     State TWO disadvantages of the compound slide method for taper cutting on the centre lathe.                                                     (2)

**TOTAL QUESTION 9:     [33]**

## QUESTION 10:  SYSTEM AND CONTROL (SPECIFIC)

10.1    Draw neat labelled sketches of the following screw threads to indicate the profile, pitch and included angle of each.

    10.1.1   Metric V-screw thread (fine)                                      (3)

    10.1.2   Square screw thread                                               (3)

    10.1.3   Acme screw thread                                                 (3)

10.2    State ONE use for each of the following screw threads:

    10.2.1   Metric V-thread (fine)                                            (1)

    10.2.2   Square thread                                                     (1)

10.3    A gear system used to drive a centrifugal pump consists of the following gears. A driver gear with 60 teeth rotating at 120 rpm and a driven gear rotating at 70 rpm. Calculate the number of teeth on the driven gear.   (4)

10.4    A flat belt pulley with a diameter of 460 mm rotates at 180 revolutions per minute. Calculate the belt speed of this system in meter per second.   (4)

10.5    State TWO advantages of V-belts                                       (2)

10.6    State TWO disadvantages of flat belts                                 (2)

10.7    State TWO advantages of gear drives                                   (2)

10.8    State TWO disadvantages of chain drives                               (2)

TOTAL QUESTION 10:   **[27]**

TOTAL SECTION B:   **[60]**

TOTAL SECTION A + B:   **[200]**

## SECTION C: AUTOMOTIVE (SPECIFIC)

**Use the criteria below to assist you in managing your time.**

| AUTOMOTIVE | | | |
|---|---|---|---|
| SECTION C (SPECIFIC) | | | |
| QUESTION | CONTENT | MARKS | TIME |
| 11 | Terminology (Specific) | 20 | 20 minutes |
| 12 | Maintenance (Specific) | 10 | 10 minutes |
| 13 | Systems and Control (Specific) | 17 | 15 minutes |
| 14 | Engines (Specific) | 13 | 10 minutes |
| TOTAL FOR SECTION C | | 60 | 55 minutes |
| TOTAL FOR SECTION A + C | | 200 | 180 minutes |

### QUESTION 11:  TERMINOLOGY (SPECIFIC)

11.1    The clutch is a unit which engages and disengages the gearbox from the engine. Name TWO types of friction clutches normally used in the drive train of a motor vehicle.     (2)

11.2    Name TWO important adjustments that can be made on the hydraulically-operated clutch unit to ensure proper engagement.     (2)

11.3    Name the TWO types of pressure plates that are used.     (2)

11.4    Why must there be a clearance between the pressure plate and the release bearing (thrust bearing)?     (1)

11.5    FIGURE 11.1 shows a single plate clutch assembly. Label the parts according to the letters A – C.
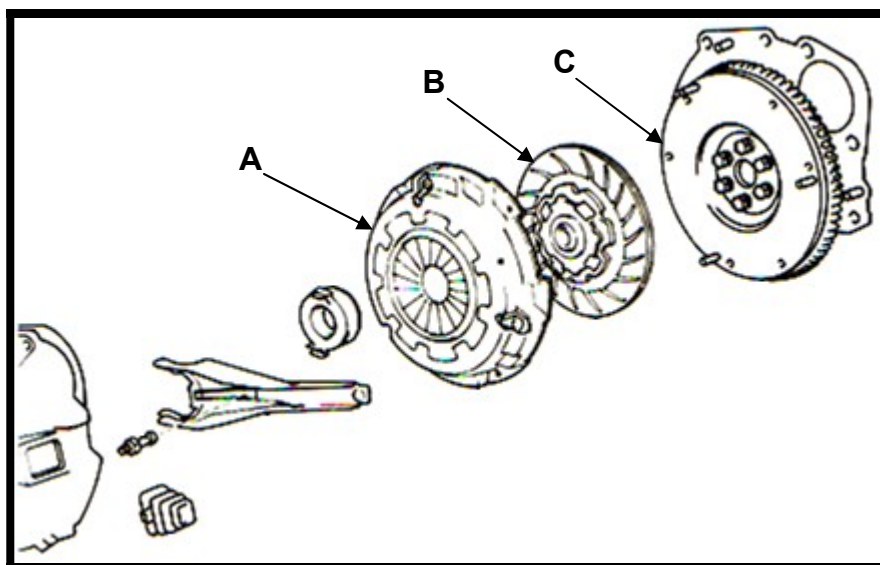


**FIGURE 11.1**     (3)

11.6     Give ONE possible cause for each of the following clutch faults:

         11.6.1   Clutch slip                                                    (1)

         11.6.2   Clutch shudder                                                 (1)

11.7     Describe the function of the following joints:

         11.7.1   Slip joint                                                     (1)

         11.7.2   Universal joint                                                (1)

11.8     Name TWO types of gears used in a motor vehicle's gearbox.             (2)

11.9     Explain the function of the following components in a constant mesh
         gearbox:

         11.9.1   The synchroniser unit                                         (2)

         11.9.2   Selector mechanism                                            (2)

                                                 **TOTAL QUESTION 11:**     **[20]**

## QUESTION 12:  MAINTENANCE (SPECIFIC)

12.1     What is the most important difference between a pressure feed system and
         a full pressure feed system referring to the lubrication in an engine?       (2)

12.2     What do you understand regarding the crankcase ventilation system?     (1)

12.3     State ONE cause of excessive oil consumption in the engine.            (1)

12.4     If there is enough water in the cooling system, why may the engine still
         overheat.                                                              (1)

12.5     What is the origin of harmful gases in the crankcase ventilation system.   (1)

12.6     Describe the main difference between the direct air cooling system and the
         indirect air cooling system for engines.                              (2)

12.7     What is the function of the thermostat in a cooling system of an engine?   (1)

12.8     What do you understand by oil dilution?                                (1)

                                                 **TOTAL QUESTION 12:**     **[10]**

## QUESTION 13:  SYSTEM AND CONTROL (SPECIFIC)

13.1     State ONE function of the carburettor of a spark ignition engine.      (1)

13.2     What is the function of a choke on a spark ignition engine?            (2)

13.3    State TWO types of air filtering systems used on internal combustion engines.    (2)

13.4    Why is brake fluid used in a hydraulic braking system. State TWO reasons.    (2)

13.5    Explain the operation of the hydraulic brake wheel cylinder.    (4)

13.6    Define Ohm's law.    (1)

13.7    What is electric current?    (1)

13.8    What is measured by the following units?

13.8.1    Volts    (1)

13.8.2    Amps    (1)

13.8.3    Ohms    (1)

13.9    What is the function of the battery in the spark ignition system of a vehicle's engine.    (1)

**TOTAL QUESTION 13:    [17]**
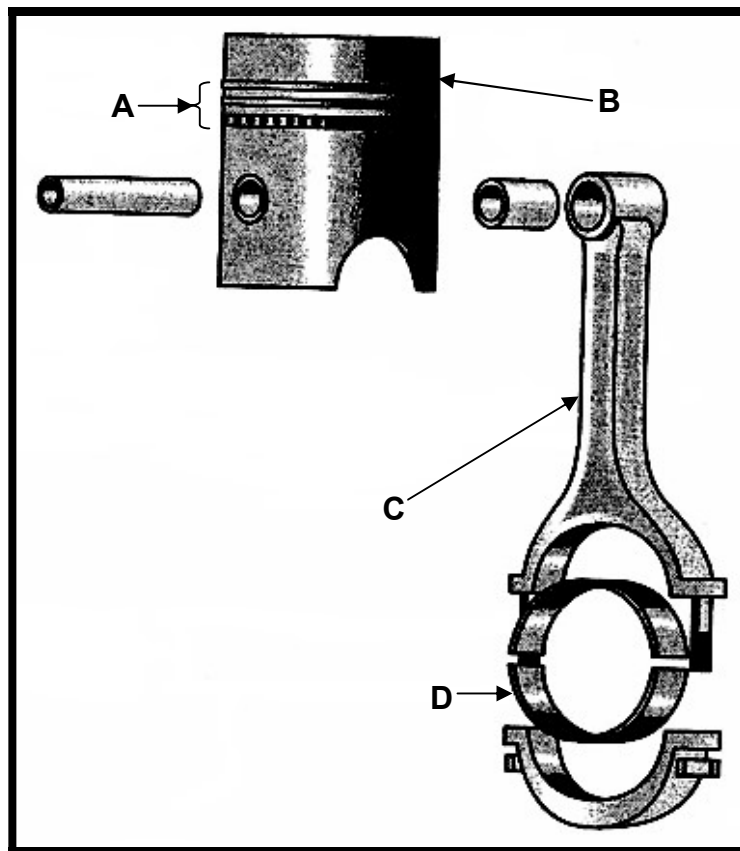
## QUESTION 14:  ENGINE (SPECIFIC)

14.1    Identify the engine component shown in FIGURE 14.1    (1)
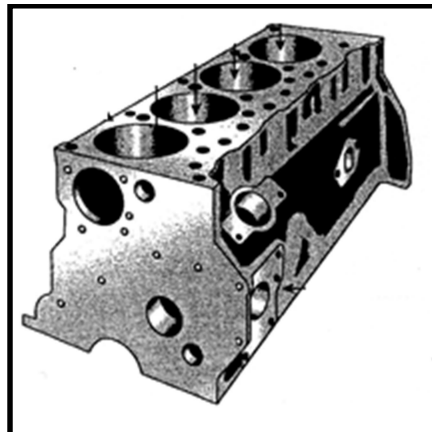


**FIGURE 14.1**

14.2    Describe the function of the crankshaft in relation to the connecting rod and piston.    (2)

14.3     FIGURE 14.2 shows a piston assembly. Label the parts according to the letters A – D.



**FIGURE 14.2**                                                        (4)

14.4     State ONE advantage for each of the following engine positioning layouts:

14.4.1   Engine in front with front wheel drive                        (1)

14.4.2   Engine in front with rear wheel drive                         (1)

14.4.3   Engine at the back with rear wheel drive                      (1)

14.5     State ONE disadvantage for each of the following engine positioning layouts:

14.5.1   Engine in front with front wheel drive                        (1)

14.5.2   Engine in front with rear wheel drive                         (1)

14.5.3   Engine at the back with rear wheel drive                      (1)

**TOTAL QUESTION 14:**     **[13]**

**TOTAL SECTION C:**     **[60]**

**TOTAL SECTION A + C :**     **[200]**

## SECTION D: WELDING AND METALWORK (SPECIFIC)

**Use the criteria below to assist you in managing your time.**

| WELDING AND METALWORK | | | |
|---|---|---|---|
| SECTION D (SPECIFIC) | | | |
| QUESTION | CONTENT | MARKS | TIME |
| 15 | Welding terms (Specific) | 10 | 10 minutes |
| 16 | Arc welding (Specific) | 10 | 10 minutes |
| 17 | Gas welding (Specific) | 10 | 10 minutes |
| 18 | Welding symbols and Joints (Specific) | 15 | 10 minutes |
| 19 | Developments (Specific) | 15 | 15 minutes |
| TOTAL FOR SECTION D | | 60 | 55 minutes |
| TOTAL FOR SECTION A + D | | 200 | 180 minutes |

## QUESTION 15: WELDING TERMINOLOGY (SPECIFIC)

15.1 Draw a neat labeled sketch of a welded joint and show the root, root gap and the included angle. (4)

15.2 Name TWO materials that are used for template making. (2)

15.3 FIGURE 15.1 shows a triangle ABC. Calculate the value of R by applying the theorem of Pythagoras.
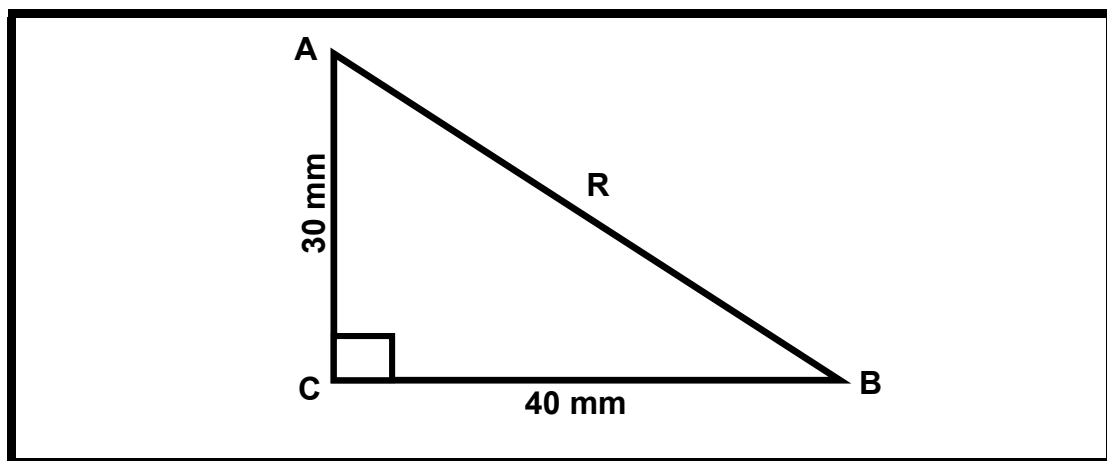


**FIGURE 15.1** (4)

**TOTAL QUESTION 15: [10]**

## QUESTION 16: ARC WELDING (SPECIFIC)

16.1 Explain the arc welding process. (3)

16.2    State the function of each of the following welding accessories:

     16.2.1    Electrode holder                                                    (1)

     16.2.2    Earth clamp                                                        (1)

     16.2.3    Transformer                                                        (1)

16.3    Briefly describe the principle for the operation of the following welding machines:

     16.3.1    Direct Current ("DC")                                              (2)

     16.3.2    Alternating Current ("AC")                                         (2)

                                 **TOTAL QUESTION 16:      [10]**

## QUESTION 17: GAS WELDING (SPECIFIC)

17.1    Name the TWO different torches used with the oxy-acetylene system.      (2)

17.2    State the purpose of the following gas welding components:

     17.2.1    Regulators                                                         (1)

     17.2.2    Flashback arrestors                                                (1)

     17.2.3    Torch                                                              (1)

17.3    What is the colour code for the following gas cylinders?

     17.3.1    Acetylene                                                          (1)

     17.3.2    Oxygen                                                             (1)

17.4    Briefly explain the application for each of the following oxy-acetylene flames:

     17.4.1    Oxidising flame                                                    (1)

     17.4.2    Carburising flame                                                  (1)

     17.4.3    Neutral flame                                                      (1)

                                 **TOTAL QUESTION 17:      [10]**

## QUESTION 18: WELDING SYMBOLS AND JOINTS (SPECIFIC)

18.1    Draw a neat labelled sketch to indicate the four elements of a welding symbol.                                                                   (4)

18.2    Draw neat sketches of the following welding symbols:

    18.2.1    Double U butt joint                                                    (1)

    18.2.2    J-butt joint                                                              (1)

    18.2.3    V-butt joint                                                             (1)

18.3    Draw neat sketches of the following welded joints:

    18.3.1    Lap joint                                                                 (2)

    18.3.2    Butt joint                                                                (2)

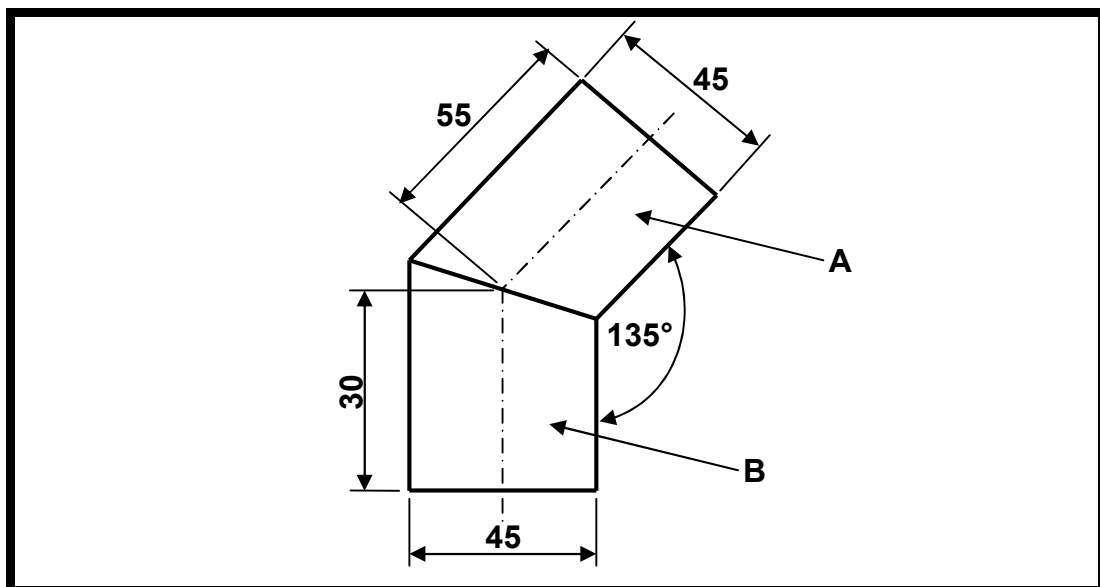    18.3.3    Edge joint                                                               (2)

    18.3.4    Fillet joint                                                               (2)

**TOTAL QUESTION 18:    [15]**

## QUESTION 19: DEVELOPMENTS (SPECIFIC)

19.1    FIGURE 19.1 shows a pipe elbow with one joint. Develop the pattern of pipe A **OR** B. Use full scale (Scale1:1). Start at the right hand side (shortest side).



**FIGURE 19.1**                                                            (15)

**TOTAL QUESTION 19:    [15]**

**TOTAL SECTION D:    [60]**

**TOTAL SECTION A + D :    [200]**

## FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 10

### 1.    BELT DRIVES

1.1       $N_1D_1 = N_2D_2$          where $N$ = rotational frequency
                                      $D$ = diameter of pulley

1.2       Beltspeed $= \dfrac{\pi DN}{60}$

1.3       Speedratio $= \dfrac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

1.4       Power $(P) = \dfrac{2\pi D}{60}$

### 2.    STRESS AND STRAIN

2.1       Stress $= \dfrac{\text{Force}}{\text{Area}}$   or   $(\sigma = \dfrac{F}{A})$

2.2       $A_{shaft} = \dfrac{\pi d^2}{4}$

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

2.4       $A_{square\,bar} = \text{side x side}$

### 3.    KEYS

3.1       Width of key $= \dfrac{\text{Diameter of shaft}}{4}$

3.2       Thickness of key $= \dfrac{\text{Diameter of shaft}}{6}$

3.3       Length of key = 1, 5 x Diameter of shaft

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

## 4. GEAR DRIVES

4.1 $N_1T_1 = N_2T_2$ where $N$ = rotational frequency
$T$ = number of teeth on the gear

4.2 Power $(P) = \dfrac{2\pi\pi N}{60}$

4.3 $\text{Gear ratio} = \dfrac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$

4.4 $\dfrac{N_{input}}{N_{output}} = \dfrac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$