Province of the
EASTERN CAPE
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

MECHANICAL TECHNOLOGY: AUTOMOTIVE

MARKS: 200

TIME: 3 hours

This question paper consists of 18 pages, including a 1-page formula sheet

INSTRUCTIONS AND INFORMATION

1.   Write your NAME 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 instruments.

8.   The value of gravitational force should be taken as 10 m/s^2

9.   All dimensions are in millimeters, unless stated otherwise in the question.

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

11.   Write neatly and legibly.

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

QUESTION	CONTENT	MARKS	TIME in minutes
GENERIC			
1	Multiple-choice questions	6	6
2	Safety	10	10
3	Materials	14	14
SPECIFIC			
4	Multiple choice questions (specific)	14	10
5	Tools and Equipment (Specific)	23	20
6	Engines (Specific)	28	25
7	Forces (specific)	32	25
8	Maintenance (Specific)	23	20
9	Systems and Control (Automatic gearbox)	18	20
10	Systems and control (Axles, Steering Geometry and Electronics)	32	30
	TOTAL	**200**	**180**

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

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question numbers (1.1 to 1.6) in your ANSWER BOOK, for example 1.7 A.

1.1 What is the purpose of the Employment Equity Act (EEA No. 55 of 1998)?

    A   To create an environment of equality in the workplace.
    B   To promote non-discrimination in the workplace.
    C   Employer may not demote or promote an employee because of his/her HIV status.
    D   All of the above   (1)

1.2 Which ONE of the following options does NOT constitute the responsibility of the employer when applying first aid in the workplace?

    A   Provision of first aid equipment.
    B   Keeping record of daily activities in the workplace.
    C   Provision of first aid training.
    D   Provision of first aid service by qualified personnel.   (1)

1.3 Which ONE of the following is an advantage of product workshop layout?

    A   Minimum material handling
    B   Low equipment cost
    C   Greater flexibility
    D   High production time   (1)

1.4 Which ONE of the following is a reason why oil and grease must NOT come in contact with the oxygen fitting?

    A   It will extinguish the flame.
    B   It makes the oxygen fittings slippery.
    C   It will form a flammable mixture.
    D   It accumulates dust.   (1)

1.5 Safety devices of a power driven guillotine are used to prevent accidents during the cutting stroke of the machine. Which ONE of the following is NOT among the guillotine safety devices?

    A   Automatic sweep away
    B   Revolving warning light
    C   Pressure gauge
    D   Rear view mirror   (1)

1.6 Which factor is important in the heat treatment of steel?

    A   Colour
    B   Temperature
    C   Length
    D   Shape   (1)
    [6]

QUESTION 2: SAFETY (GENERIC)

2.1   State THREE personal protective equipment (PPE) that must be worn before an arc welding operation is carried out. (3)

2.2   State THREE safety measures that must be observed before using an arc welding machine. (3)

2.3   Give ONE reason why you must not force a drill bit into a workpiece during drilling operations. (1)

2.4   It is very important to clamp a small workpiece securely before drilling commences. Give ONE reason why it is important to do this. (1)

2.5   State TWO safety precautions that must be observed when handling gas cylinders. (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1   State ONE test required to identify each of the following properties of metals.

      3.1.1   Carbon content   (1)

      3.1.2   Ductility   (1)

3.2   Metals are usually marked or colour coded on the ends in order to know the carbon content or the type of steel they are. Why is it important to cut from the unmarked end of the metal?   (1)

3.3   List the THREE types of case-hardening used in the metallurgical industry.   (3)

3.4   Why is it impossible to use medium or high carbon steel in case-hardening?   (1)

3.5   Briefly explain the heat treatment process of metal.   (3)

3.6   State THREE factors that determine the hardness of steel during the heat treatments of metals.   (3)

3.7   Give ONE property that can be achieved by annealing steel.   (1)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, for example 4.15 E.

4.1   Identify the equipment shown in FIGURE 4.1 below.

FIGURE 4.1

     A   Exhaust gas analyser
     B   Compression tester
     C   Cylinder leakage tester
     D   Diagnostic scanner   (1)

4.2   Which of the following equipment is used to measure the pressure the piston will create when moving from bottom dead centre (BDC) to top dead centre (TDC) in an internal combustion engine?

     A   Compression tester
     B   Cylinder leakage tester
     C   Hydraulic pressure gauge
     D   Exhaust gas analyser   (1)

4.3   The diagram in FIGURE 4.3 below shows the outside structure of a super charger. Identify the type of supercharger.

FIGURE 4.3

     A   Vane-type supercharger
     B   Centrifugal supercharger
     C   Twin-screw supercharger
     D   Roots supercharger   (1)

4.4   The most commonly used firing order of a 6-cylinder V-engine is …

    A   1 3 5 2 4 6.
    B   1 4 2 5 3 6.
    C   1 2 3 4 5 6.
    D   6 5 4 3 2 1.   (1)

4.5   What do you understand by the term *boost* in a turbocharged engine?

    A   Decrease in the intake manifold temperature
    B   Increase in the intake manifold temperature
    C   Decrease in the intake manifold pressure below the atmospheric pressure
    D   Increase in the intake manifold pressure above the atmospheric pressure   (1)

4.6   Which ONE of the following is an important factor that determines the thermal efficiency of an engine?

    A   Size of the exhaust manifold
    B   Catalytic converter
    C   Size of the carburettor venturi
    D   Design of the combustion chamber   (1)

4.7   The indicated power of an engine may be defined as …

    A   a measure to determine the power developed by the burning fuel within the cylinder of an engine.
    B   the power developed by the engine at the output shaft.
    C   the rate at which work is done.
    D   pressure developed in the cylinder of an internal combustion engine.   (1)

4.8   What will the mechanical efficiency of an engine be, if it delivers 56 kW brake power and 70 kW indicated power?

    A   92%
    B   64%
    C   80%
    D   78%   (1)

4.9   Which type of gear train is shown in FIGURE 4.9 below?

FIGURE 4.9

    A   Double epicyclic gear train
    B   Ring gear train
    C   Single epicyclic gear train
    D   Compound gear train   (1)

4.10 What do you understand by the term *torsional vibration* in relation to crankshaft balancing?

    A   Twisting movement
    B   Rotational movement
    C   Reciprocating movement
    D   Linear movement   (1)

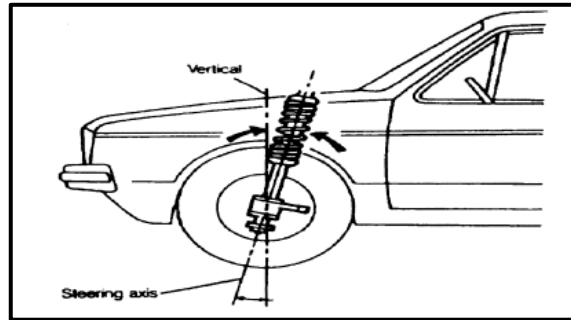4.11 What type of wheel alignment is displayed in FIGURE 4.11 below?

FIGURE 4.11

    A   Negative castor
    B   Positive castor
    C   Positive chamber
    D   Negative chamber   (1)

4.12 Identify the type of engine cylinder configuration shown in FIGURE 4.12 below.

FIGURE 4.12

    A   Crankshaft for a horizontally opposed engine
    B   In-line crankshaft
    C   Crankshaft of a V-engine
    D   W-engine   (1)

4.13   Which of the following methods is applicable in raising the compression ratio of an internal combustion engine?

    A   Increase the bore of the cylinder
    B   Fit piston with suitable higher crown
    C   Machine metals from the cylinder head
    D   All of the above   (1)

4.14   What does the symbol 'X' signify in FIGURE 4.14 below?

FIGURE 4.14

    A   Combustion chamber
    B   Cylinder bore
    C   Stroke length
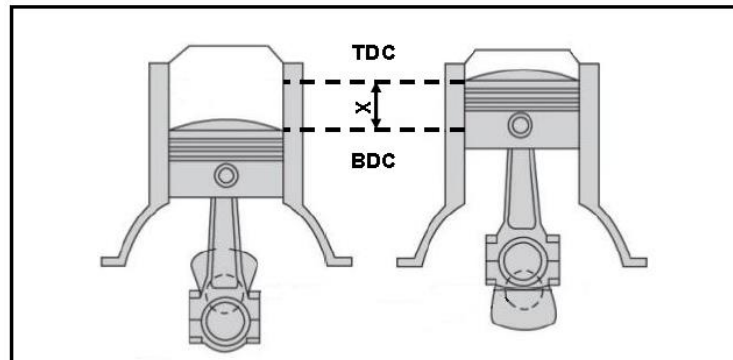   D   Clearance volume   (1)
                                                                                                                              [14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1   FIGURE 5.1 below shows wheel alignment equipment commonly used in tyre fitment centres. Use it to answer the questions that follow.

FIGURE 5.1

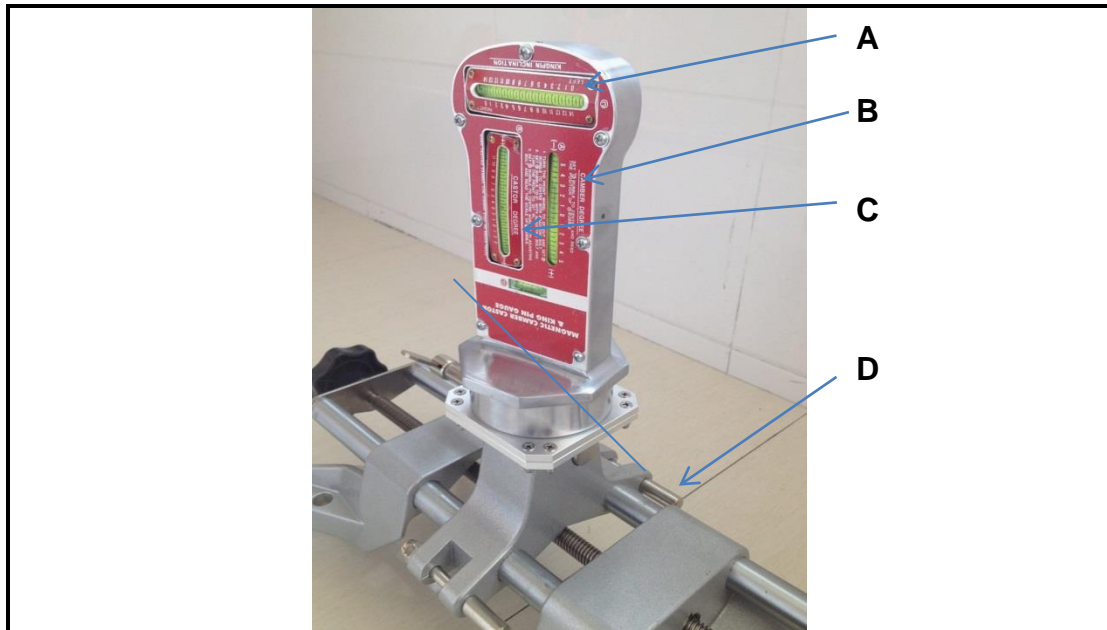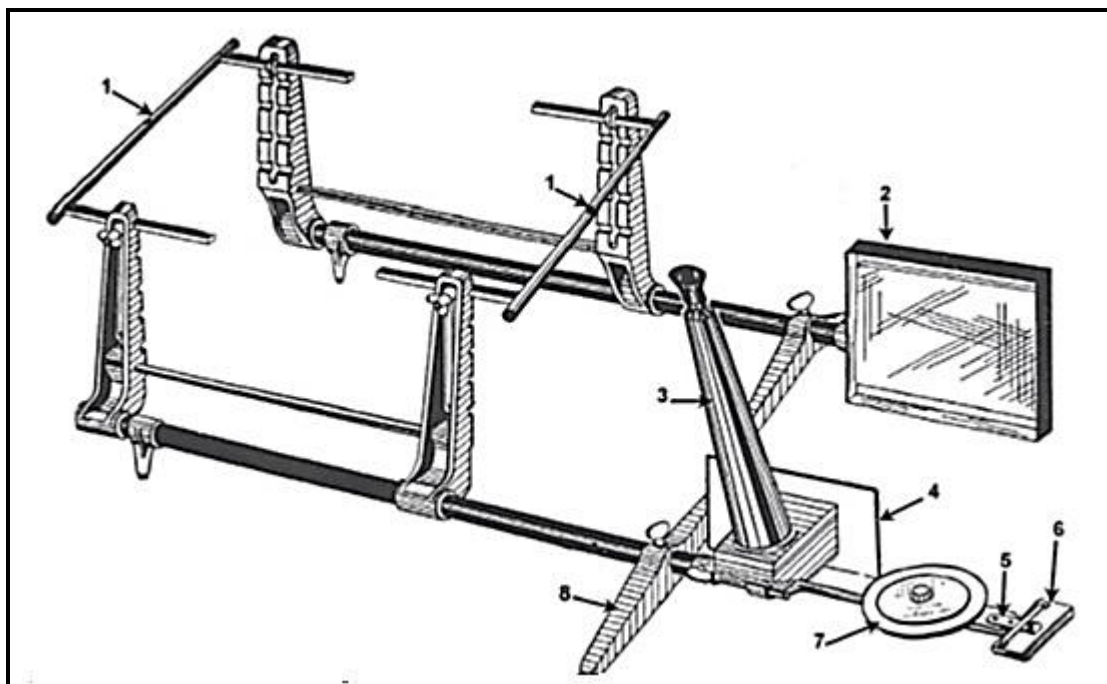5.1.1   Identify the equipment in FIGURE 5.1.   (1)

5.1.2   Label parts **A–D**.   (4)

5.1.3   What is the purpose of the equipment in FIGURE 5.1?   (3)

5.2   The diagram in FIGURE 5.2 below is a periscopic optical alignment tool. Label parts **1–8**.

FIGURE 5.2   (8)

5.3   What is the function of the equipment displayed in FIGURE 5.2?   (1)

5.4   The equipment shown in FIGURE 5.4 below is a card type compression tester used to carry out compression testing in an internal combustion engine.

In point form, briefly explain the procedure on how the test can be performed.


FIGURE 5.4   (6)
[23]

QUESTION 6: ENGINE (SPECIFIC)

6.1   What is the main function of a crankshaft?   (2)

6.2   The crankshaft of an engine is subject to vibrations during the course of operation in an internal combustion engine.
        What are the TWO main causes of these vibrations?   (2)

6.3   Name the TWO main types of balancing that can be done on a crankshaft.   (2)

6.4   Give THREE functions of balance mass pieces.   (3)

6.5   How does the following engine components constitute the built-in features that improve engine balance?

        6.5.1   Connecting rod and piston   (2)

        6.5.2   Flywheels   (2)

        6.5.3   Vibration dampers   (2)

6.6   The diagram in FIGURE 6.6 below is a friction face type vibration damper mounted to the front of the crankshaft of an internal combustion engine.
        Label the parts **A–F**.
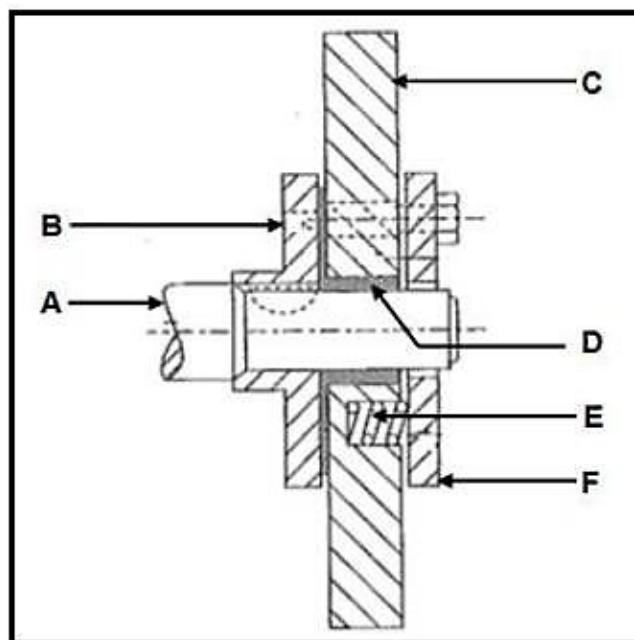
FIGURE 6.6   (6)

6.7   State TWO factors that determine the firing order of an internal combustion engine.   (2)

6.8   In point forms, briefly explain the procedure to determine the firing order of an engine if no specifications are available.   (5)
                                                                              [28]

QUESTION 7: FORCES (SPECIFIC)

7.1   Briefly explain the term *swept volume* of an internal combustion engine.   (2)

7.2   State TWO methods that can be used to increase the compression ratio of an internal combustion engine.   (2)

7.3   A cylinder bore and stroke length of an internal combustion engine is 86 mm and 98 mm respectively. If the compression ratio is 10 : 1.

Calculate the :

7.3.1   Swept volume of that cylinder in cm^3 (3)

7.3.2   Clearance volume of that cylinder   (3)

7.3.3   New bore diameter if the compression ratio is increased to 10,8 : 1, while the clearance volume remains unchanged.   (6)

7.4   Define the term *torque.*   (2)

7.5   The following data was recorded during the course of carrying out a brake test on a four-stroke four-cylinder petrol engine:

Brake arm length   650 mm
Mass registered on the scale   30 kg
Engine speed of rotation   3 600 r/min
Mean effective pressure   1 400 kPa
Cylinder bore   84 mm
Stroke length   92 mm

Calculate the following:

7.5.1   Indicated power   (6)

7.5.2   Torque   (3)

7.5.3   Brake power   (3)

7.5.4   Mechanical efficiency of the engine   (2)

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)

8.1   State FOUR different types of gas coming out of a vehicle exhaust system that
       are analysed.   (4)

8.2   After a cylinder leakage test has been conducted on a spark ignition engine,
       the results indicated high percentage leakage in the cylinders. THREE
       possible faults were detected.

       State the faults and corrective measures in each of the following cases shown
       below:

       8.2.1   Hissing sound from the inlet manifold   (2)

       8.2.2   Hissing sound from the exhaust manifold   (2)

       8.2.3   Bubbles in the radiator water   (2)

8.3   Give THREE possible causes of low oil pressure reading when conducting oil
       pressure tests on an internal combustion engine.   (3)

8.4   Name THREE manufacturer specifications that are needed when doing an oil
       pressure test.   (3)

8.5   Why is it important to conduct pressure tests on an engine cooling system?   (1)

8.6   List TWO possible components in a cooling system where coolant could leak
       during pressure testing.   (2)

8.7   State TWO functions of a radiator cap.   (2)

8.8   State TWO components of an engine cooling system that may have failed
       resulting in an engine overheating.   (2)
                                                                                      [23]

QUESTION 9: SYSTEM AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)

9.1   State THREE major advantages of using an automatic gearbox.   (3)

9.2   What is the main function of a torque converter?   (2)

9.3   In point form, state the principles of operations of lockup torque converters when the lockup clutch is applied.   (5)

9.4   State TWO advantages of using torque converter in an automatic transmission system.   (2)

9.5   What do you understand by *transmission control unit* (TCU) in an automatic transmission system?   (3)

9.6   What is responsible for the heating of transmission fluid in automatic transmission?   (1)

9.7   State TWO methods of cooling the oil in automatic transmission.   (2)

[18]

**QUESTION 10:   SYSTEM AND CONTROL (AXLES, STEERING GEOMETRY
                  AND ELETRONICS) (SPECIFIC)**

10.1   What do you understand by the term *camber*?   (2)

10.2   State THREE disadvantages of using camber in a motor vehicle suspension
        system.   (3)

10.3   The diagrams in the FIGURE 10.3 below show two possible alignment methods
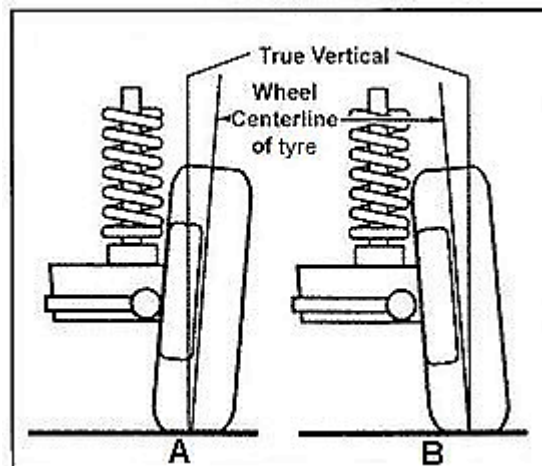   of vehicle wheels with the road.
        Identify diagrams **A** and **B.**

FIGURE 10.3   (2)

10.4   Give TWO advantages of each of the diagrams (**A** and **B**) in FIGURE 10.3
        above, when applied in a vehicle suspension system.   (4)

10.5   What is the purpose of kingpin inclination in the alignment of car front wheels?   (2)

10.6   The diagram in FIGURE 10.6 below shows the kingpin inclination on the
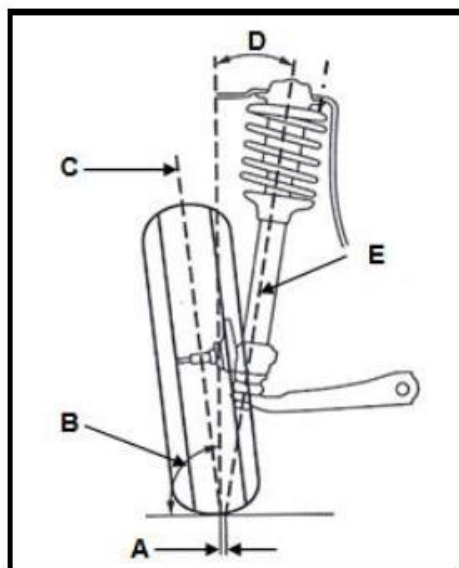   suspension of a motor vehicle.
        Label parts **A–E.**

FIGURE 10.6   (5)

10.7   State FIVE factors that must be taken into account before attempting a wheel alignment adjustment.   (5)

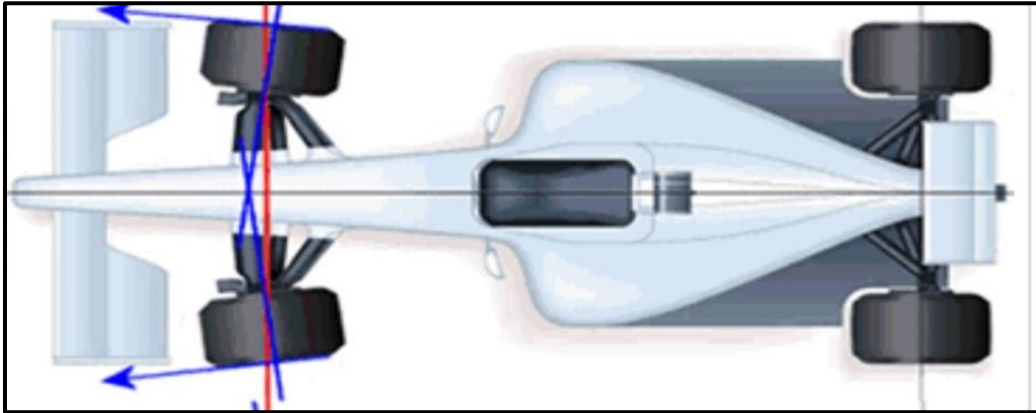10.8   Identify the type of car wheel alignment shown in FIGURE 10.8 below.

FIGURE 10.8
(1)

10.9   What is the purpose of the car alignment shown in FIGURE 10.8 above?   (2)

10.10   What do you understand by the following terms in wheel balancing?

    10.10.1   Static balance   (2)

    10.10.2   Dynamic balance   (2)

10.11   State TWO pre-checks that must be done before a wheel can be balanced.   (2)

[32]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY (AUTOMOTIVE)

Force = m x a   where m = mass
                                               a = acceleration

Work = force x distance (F x d)

$$\text{Power} = \frac{\text{force x distance}}{\text{time}}$$

Torque = force x radius

Indicated power = P x L x A x N x n
where   P = mean effective pressure
               L = length of stroke
               A = area of piston crown
               N = number of power strokes per second
               n = number of cyclinders

Brake power = 2π N x T
where   N = revolutions per second
          T = torque

Brake power (Prony brake) = F x 2 x π x R x N
where   F = force
                         R = length of brake arm
                         N = revolutions per second

$$\text{Mechanical efficiency} = \frac{\text{brake power}}{\text{indicated power}} \text{ x } 100$$

$$\text{Compression ration} = \frac{\text{swept volume + clearance volume}}{\text{clearance volume}}$$

where swept volume = $\frac{\pi \text{ x D}^2}{4}$ x L   clearance volume = $\frac{\pi \text{ x D}^2}{4}$ x I

where L = length of stroke   where D = diameter of bore
       D = diameter of bore   I = clearance

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