THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2001**

Instructions

1. This paper consists of t**en (10)** questions.
2. Answer any **five (5)** questions
3. Each question carries **twenty (20)** marks.
4. Programmable calculators, cellular phones and other unauthorized materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

1. (a) Explain five safety precautions a technician must follow when working on a vehicle engine in a workshop.

A technician should disconnect the battery before beginning any work on the engine. This prevents accidental short circuits or sparks that could lead to fire or injury, especially when working on electrical components or fuel systems.

The technician must always allow the engine to cool down before touching components such as the radiator, exhaust manifold, or cylinder head. Working on a hot engine can result in severe burns.

Proper personal protective equipment (PPE) such as safety gloves, goggles, and overalls must be worn. This protects the technician from oil, coolant, and sharp metal parts that may cause injuries.

The working area should be kept clean and free from oil spills or scattered tools. A clutter-free environment reduces the risk of slipping, tripping, or tool-related accidents.

The vehicle should be properly supported using jack stands and wheel chocks if it is to be lifted. Relying solely on a jack can be dangerous as it may collapse, leading to crushing injuries.

(b) Describe how to safely dispose of used engine oil and coolant.

Used engine oil should be collected in a sealed container and taken to an authorized recycling or disposal facility. It must not be poured into drains, soil, or water bodies, as it is toxic to the environment.

Used coolant should also be drained into a clean, sealable container and labeled clearly. It should be taken to a recycling center or hazardous waste disposal site since it contains chemicals like ethylene glycol that are harmful if released untreated.

When disposing of either fluid, technicians should avoid skin contact by using gloves and prevent spillage by using proper funnels and containers. Spill kits should be available nearby in case of accidental leaks.

(c) Sketch and label the following vehicle body constructions:
(i) Body-on-frame construction
(ii) Unibody construction

For **body-on-frame construction**, sketch a ladder-type frame with a vehicle body mounted on top. Label the frame, body, and mounting points.

For **unibody construction**, sketch a vehicle shell where the body and frame are integrated. Label structural areas like front subframe, rear subframe, and integral body panels. Let me know if you want these diagrams drawn digitally.

2. (a) Differentiate between torque and horsepower in vehicle performance.

Torque is a measure of rotational force produced by the engine. It determines how much pulling or twisting power the engine can deliver at a given moment. Higher torque is especially important for heavy-duty work such as towing or climbing steep hills.

Horsepower, on the other hand, is a measure of how quickly work is done. It is a product of torque and engine speed (RPM). Horsepower reflects the engine's overall capacity to maintain speed and acceleration over time.

While torque gives a vehicle its initial thrust or pulling power, horsepower determines how fast a vehicle can travel. Both are important, but their influence depends on the type of vehicle use.

(b) List and explain four factors that affect engine power output.

The size of the engine, usually measured in displacement (cc), directly affects power. A larger engine allows more air and fuel into the cylinders, resulting in more powerful combustion.

The compression ratio influences power by determining how much the air-fuel mixture is compressed before ignition. Higher compression produces more power but may require higher-octane fuel.

The efficiency of the air intake and exhaust systems affects how smoothly air and gases flow in and out of the engine. Restrictive systems reduce performance, while tuned systems enhance power.

The quality and timing of fuel combustion, controlled by ignition timing and fuel injection systems, affect how much energy is released. Improper timing or poor fuel quality can reduce output significantly.

(c) With the help of a simple diagram, explain how torque is transmitted from the engine to the drive wheels in a rear-wheel-drive vehicle.

[Diagram not shown in text.]

Torque transmission in a rear-wheel-drive vehicle begins at the engine crankshaft. The rotating crankshaft sends torque through the clutch or torque converter into the transmission.

From the transmission, torque travels along the propeller shaft to the differential at the rear axle. The differential splits the torque between the two rear wheels while allowing them to rotate at different speeds.

The final drive gears in the differential increase torque before transmitting it to the rear axle shafts, which rotate the wheels and move the vehicle.

3. (a) State and explain the functions of the following engine components:
(i) Camshaft
(ii) Crankshaft
(iii) Cylinder head
(iv) Gudgeon pin

The camshaft controls the opening and closing of the engine's intake and exhaust valves. It ensures valves operate in correct timing with the pistons, allowing proper air-fuel intake and exhaust discharge.

The crankshaft converts the linear up-and-down motion of the pistons into rotary motion, which is then transmitted to the drivetrain for vehicle movement.

The cylinder head closes the top of the engine cylinder. It contains combustion chambers, intake and exhaust ports, and valve mechanisms. It seals the combustion process and supports efficient engine breathing.

The gudgeon pin, also called the wrist pin, connects the piston to the connecting rod. It allows pivoting motion between these two parts during the engine's cycles.

(b) List four symptoms of a worn-out piston ring and explain the effects on engine performance.

Excessive blue smoke from the exhaust is a sign of oil leaking past the piston rings and burning in the combustion chamber, reducing engine efficiency.

Loss of compression results in reduced engine power and poor acceleration because the combustion gases escape past the worn rings.

Increased oil consumption occurs as more oil enters the combustion chamber, requiring frequent topping up and raising operating costs.

Engine misfiring or hard starting can happen due to inadequate compression or fouled spark plugs from oil contamination, making the engine unreliable.

(c) Describe the steps involved in replacing a head gasket in an internal combustion engine.

First, disconnect the battery and drain the engine coolant. Remove the intake and exhaust manifolds to access the cylinder head.

Unbolt and carefully lift the cylinder head from the engine block. Clean the surfaces of the head and block thoroughly to remove old gasket material and debris.

Inspect the cylinder head and block for warping or cracks. If necessary, resurface or replace damaged components.

Place a new head gasket onto the block, aligning it properly with bolt holes and water/oil passages. Refit the cylinder head and tighten bolts in the correct sequence and torque specification.

Reassemble the manifolds, reconnect wiring and hoses, refill the cooling system, and check for leaks or overheating once the engine runs.

4. (a) Describe the working principle of a four-stroke compression ignition engine.

In the intake stroke, the piston moves down while the intake valve opens, drawing in air into the cylinder.

During the compression stroke, the piston moves up with both valves closed, compressing the air to a high pressure and temperature.

In the power stroke, fuel is injected into the compressed air. The heat ignites the fuel spontaneously, causing expansion and forcing the piston down, generating power.

In the exhaust stroke, the piston moves up again while the exhaust valve opens, expelling combustion gases from the cylinder to complete the cycle.

(b) A four-cylinder engine has a bore of 80 mm and a stroke of 100 mm. Calculate the engine capacity in cubic centimeters (cc).

Engine capacity = $(\pi/4) \times \text{bore}^2 \times \text{stroke} \times \text{number of cylinders}$
Convert bore and stroke to cm:
Bore = 8 cm, Stroke = 10 cm, Cylinders = 4

Capacity = $(3.14/4) \times 8^2 \times 10 \times 4$
$= 0.785 \times 64 \times 10 \times 4$
$= 0.785 \times 2560$
$= 2009.6$ cc

The engine capacity is approximately **2010 cc**.

(c) Highlight three mechanical differences between a naturally aspirated engine and a turbocharged engine.

A naturally aspirated engine draws air into the cylinder solely by atmospheric pressure and piston movement, while a turbocharged engine uses a turbine-driven compressor to force more air into the cylinders.

Turbocharged engines require additional components such as intercoolers, oil cooling lines, and stronger pistons to handle higher pressure and temperature.

Turbocharged engines often operate at higher compression or boost pressures, providing more power from smaller engine sizes, whereas naturally aspirated engines rely on larger displacement for more output.

5. (a) Explain the operation of a hydraulic braking system using a well-labeled diagram.

[Diagram not included.]

In a hydraulic braking system, when the brake pedal is pressed, force is transmitted through a pushrod to the master cylinder. The master cylinder pressurizes brake fluid and sends it through brake lines to the wheel cylinders or calipers.

At each wheel, the fluid pressure forces the brake pads or shoes against the rotating disc or drum. This friction slows down or stops the vehicle.

When the pedal is released, return springs and fluid backflow retract the pads or shoes, and the system resets for the next braking cycle.

(b) List three causes of spongy brake pedal and explain their remedies.

Air in the brake lines reduces fluid pressure transmission and causes a soft or spongy brake feel. Remedy is to bleed the brake system and remove air bubbles.

Worn brake hoses may expand under pressure instead of transmitting it properly. Replacing the flexible hoses restores normal braking response.

Contaminated or old brake fluid can absorb moisture, compressing under load and reducing efficiency. Flushing the system and refilling with fresh brake fluid solves this issue.

(c) Describe how to perform a brake bleeding procedure on a vehicle.

Start by filling the master cylinder with clean brake fluid. Attach a transparent tube to the bleed valve of the wheel farthest from the master cylinder.

Have a helper press the brake pedal and hold it down. Open the bleed valve to allow fluid and air to escape, then close it before the pedal is released.

Repeat the process until only clear, bubble-free fluid comes out. Repeat the procedure for each wheel in proper sequence.

Keep checking and topping up the master cylinder to prevent air from entering again.

6. (a) Describe the construction and function of a diaphragm-type clutch.

A diaphragm-type clutch uses a single diaphragm spring instead of coil springs to apply pressure on the clutch disc. The diaphragm spring is conical and acts as both the pressure element and release mechanism.

When the clutch pedal is released, the diaphragm spring pushes the pressure plate against the clutch disc, pressing it against the flywheel and transmitting power.

When the pedal is pressed, the release bearing pushes against the diaphragm spring center, causing it to lift the pressure plate and disengage the clutch.

(b) Explain the importance of clutch free play and describe how it is adjusted.

Clutch free play is the slight movement allowed in the clutch pedal before the release bearing contacts the diaphragm spring. It prevents continuous pressure on the bearing and avoids premature wear.

Too little free play leads to clutch slipping and overheated components. Too much free play results in incomplete clutch disengagement, causing gear shift difficulty.

To adjust free play, locate the clutch cable or hydraulic rod and turn the adjustment nut to either increase or decrease the gap. Test by pressing the pedal and checking for proper engagement.

(c) List four signs of a faulty clutch and explain the possible causes for each.

Slipping clutch occurs when engine speed increases without vehicle acceleration. This may be caused by worn clutch linings or a weak pressure plate.

Hard gear shifting suggests incomplete clutch disengagement, often due to clutch cable issues or air in hydraulic lines.

Vibration or chattering during clutch engagement indicates misalignment, warped clutch disc, or contaminated friction surfaces.

Burning smell from the clutch area is due to excessive friction, usually from riding the clutch or a dragging pressure plate.

7. (a) Differentiate between positive and negative camber and explain their effects on vehicle handling.

Positive camber means the top of the wheel is tilted outward, away from the vehicle. It improves stability in straight-line motion but reduces cornering grip.

Negative camber means the top of the wheel tilts inward toward the vehicle. It enhances cornering performance by increasing tire contact during turns, but excessive negative camber leads to uneven tire wear.

(b) Describe three common types of wheel alignment angles.

Camber is the tilt of the wheels from vertical. It affects tire contact and wear. Proper camber ensures stable handling and even tire wear.

Caster is the angle of the steering axis viewed from the side. Positive caster improves directional stability and steering returnability.

Toe is the difference in distance between the front and rear of the tires. Toe-in helps maintain straight-line stability, while toe-out improves turn-in response.

(c) A front-wheel-drive car shows uneven tire wear on the inner edge. What could be the cause and how is it corrected?

The most likely cause is excessive negative camber, which tilts the top of the wheels too far inward. This causes the inner edge to bear most of the load and wear faster.

To correct this, wheel alignment must be adjusted using alignment tools. The camber angle should be set to the manufacturer's specification. Worn suspension components like ball joints or bushings may also need inspection and replacement.

8. (a) Define the term "voltage drop" and explain its significance in vehicle electrical circuits.

Voltage drop refers to the reduction in electrical potential as current flows through a circuit due to resistance in wires, connectors, or components. It is measured as the difference in voltage between two points in the same circuit.

In vehicle electrical systems, excessive voltage drop can lead to poor performance of electrical devices such as lights dimming, starter motors cranking slowly, or control modules malfunctioning. Identifying and correcting voltage drops ensures reliable operation and prevents component damage.

(b) Describe how to test an alternator using a digital multimeter.

First, start the engine and set the multimeter to DC voltage. Connect the red probe to the positive terminal of the battery and the black probe to the negative terminal.

With the engine running at idle, the voltage should read between 13.8V and 14.5V. If it reads below 13V, the alternator may not be charging properly.

Next, turn on electrical loads such as headlights and fan. Observe if the voltage remains stable or slightly drops. A significant drop may indicate a weak alternator or belt slippage.

Also, test for AC ripple by switching the multimeter to AC mode. Excessive AC voltage (above 0.5V) indicates a faulty diode in the alternator.

(c) List four causes of battery overcharging and explain the consequences if not corrected.

A faulty voltage regulator may fail to limit charging voltage, allowing the alternator to continuously overcharge the battery, leading to battery overheating and water loss.

Incorrect alternator installation or using a higher-output alternator without matching regulation can result in overcharging.

Wiring faults, such as poor grounding or short circuits, can affect voltage regulation, causing higher-than-normal charging voltage.

A malfunctioning battery temperature sensor in modern vehicles may give false signals to the ECU, resulting in prolonged charging time.

If not corrected, overcharging shortens battery life, causes acid leakage, and may damage onboard electronic systems due to excess voltage.

9. (a) Outline the procedure for diagnosing a no-start condition in a petrol engine vehicle.

Start by checking the battery voltage with a multimeter. It should be around 12.6V. A low reading means the battery needs charging or replacement.

Inspect the battery terminals and cables for corrosion or loose connections, as these can prevent sufficient current flow to the starter.

Turn the ignition key and listen for a clicking or cranking sound. A single click with no crank may indicate a faulty starter solenoid or relay.

Check if fuel is reaching the engine by turning the key to ON and listening for the fuel pump priming. No sound could mean pump or fuse failure.

Inspect the ignition system by testing for spark using a spark tester or by removing a spark plug. No spark indicates issues with ignition coil, crank sensor, or ECU.

Lastly, use a diagnostic scanner to check for trouble codes that may point to issues with sensors or the fuel injection system.

(b) What is an OBD-II system? Explain its function in modern automotive diagnostics.

OBD-II (On-Board Diagnostics II) is a standardized system found in vehicles manufactured after 1996 that monitors engine performance, emissions, and various vehicle systems.

It uses sensors and control units to detect malfunctions in real time. When a problem is detected, it stores a diagnostic trouble code (DTC) and may trigger the check engine light.

The system allows technicians to access the stored data using a scan tool, enabling faster and more accurate diagnostics and repairs.

OBD-II also supports emissions compliance by identifying faults that may increase pollutant output, helping maintain environmental standards.

(c) Mention three common diagnostic trouble codes (DTCs) and what they indicate.

P0300 indicates random or multiple cylinder misfires, which can be caused by ignition issues, fuel problems, or vacuum leaks.

P0171 means the engine is running lean on bank 1, often due to a vacuum leak, faulty MAF sensor, or low fuel pressure.

P0420 signals a catalyst system efficiency below threshold, which suggests a failing catalytic converter or oxygen sensor.

10. (a) Describe the working of an electronically controlled fuel injection (EFI) system.

In an EFI system, fuel is delivered to the engine through injectors controlled by the Engine Control Unit (ECU). The ECU receives data from various sensors such as throttle position, engine temperature, and oxygen levels.

Based on this data, the ECU calculates the precise amount of fuel needed and the exact timing to inject it into each cylinder. The injectors then spray the fuel into the intake manifold or directly into the combustion chamber.

This system provides more accurate fuel metering than carburetors, leading to better fuel efficiency, lower emissions, and smoother engine performance.

(b) Explain the role of the Mass Air Flow (MAF) sensor and Throttle Position Sensor (TPS) in engine control.

The MAF sensor measures the amount of air entering the engine. This information is sent to the ECU, which adjusts fuel injection to maintain the ideal air-fuel ratio.

The TPS detects the position of the throttle valve and informs the ECU of how much the driver is demanding acceleration. The ECU uses this data to adjust ignition timing, fuel injection, and idle speed.

Both sensors play a critical role in ensuring optimal engine performance, fuel economy, and emissions control.

(c) A vehicle shows poor fuel economy and loss of power. List five possible causes and explain each.

A dirty or clogged air filter restricts airflow to the engine, causing incomplete combustion and increased fuel consumption.

Faulty oxygen sensors can send incorrect data to the ECU, resulting in rich fuel mixtures and poor fuel efficiency.

Worn spark plugs produce weak sparks, causing misfires and unburned fuel, reducing both power and economy.

Low tire pressure increases rolling resistance, making the engine work harder and use more fuel.

Dragging brakes caused by stuck calipers or worn components create extra load on the engine, leading to loss of power and poor mileage.