THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2009**

Instructions

1. This paper consists of **eight (8)** 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) Describe five safety measures that must be taken when handling electric and hybrid vehicle systems in a service workshop.

Before working on electric or hybrid vehicles, technicians must disconnect the high-voltage battery system using the manufacturer's recommended shutdown procedure. This helps to eliminate the risk of electric shock, which can be fatal due to the high voltages involved.

All personnel must wear high-voltage insulated gloves, boots, and face shields when servicing or inspecting electric circuits. These protective items provide insulation against electric currents that could otherwise travel through the body.

Warning tags and physical barriers must be placed on high-voltage components to prevent accidental contact by other technicians. This isolates the work area and alerts others of potential danger.

Technicians should use insulated tools rated for high-voltage work. Ordinary tools can conduct electricity and lead to short circuits or personal injury.

Clear labeling and color coding of high-voltage cables (usually orange) must be understood and observed. This helps technicians quickly identify live circuits and avoid cutting or disconnecting cables while under voltage.

(b) Explain the workshop precautions for each of the following equipment:
(i) Engine hoist

Before use, the hoist must be inspected for leaks, cracks, or faulty chains. It must be placed on a flat, solid surface to prevent tipping. While lifting an engine, the load should be centered and supported evenly to avoid swinging and loss of control.

(ii) Wheel alignment machine

Ensure the alignment machine is properly calibrated and grounded. The lift must be locked in place before climbing under the vehicle. Loose wires or sensors should be secured to prevent tripping and equipment damage.

(iii) Spark plug tester

The tester should be connected only to properly grounded systems to avoid electrical shock. Testing should be done away from fuel sources, as sparks generated during operation may ignite vapors. Operators must wear eye protection to avoid exposure to arc flashes.

(c) Sketch and label three types of load-bearing vehicle body structures used in light-duty vehicles.

1. Ladder frame: Consists of two long longitudinal members connected by several cross-members. It supports the body above and is used in pickup trucks and SUVs.

2. Monocoque frame: Integrates the body and chassis into a single load-bearing structure. It is lighter, offers better fuel efficiency, and is used in most modern cars.

3. Tubular space frame: Made of interconnected tubular steel. It's light and rigid, often used in sports cars and racing vehicles.

2. (a) (i) Explain the term "honing" and its application during cylinder reconditioning.

Honing is a machining process that uses abrasive stones to finish the surface of a cylinder bore. It creates a crosshatch pattern which aids in oil retention, smooth piston movement, and proper sealing by piston rings. It is commonly applied during engine overhauls to remove minor surface imperfections and restore cylinder roundness.

(ii) List four precision measuring tools used in crankshaft and connecting rod inspection.

1. Micrometer – Measures the outer diameter of crankshaft journals with high precision.
2. Dial indicator – Measures crankshaft runout and axial play.
3. Vernier caliper – Used for measuring rod length and thicknesses.
4. Plastigauge – Measures oil clearance between the crankshaft journal and bearing surface.

(iii) What is the purpose of a straight edge and feeler gauge during cylinder head inspection?

The straight edge is placed across the surface of the cylinder head to check for warpage. The feeler gauge is then inserted under the straight edge to measure any gaps. This method determines if the head is flat enough to reseal or needs machining.

(b) (i) Define the term "air lock" in a fuel delivery system.

Air lock occurs when air becomes trapped in the fuel lines, preventing fuel from reaching the injectors. This condition interrupts fuel flow and can prevent engine starting or cause rough idling.

(ii) Give four consequences of air lock in high-pressure fuel systems.

1. Engine cranking without starting because no fuel reaches the combustion chamber.
2. Intermittent misfiring or stalling due to inconsistent fuel delivery.
3. Reduced engine performance and acceleration as the fuel pressure drops.
4. Increased wear on the fuel pump as it runs dry or cavitates due to the absence of fuel.

(c) Explain the process of inspecting and correcting the following suspension geometry faults:
(i) Uneven camber

Camber is adjusted by altering the upper control arm or using cam bolts. Uneven camber causes uneven tire wear and steering pull. Measurement is done using alignment gauges, and correction is made by repositioning suspension components to restore equal angles.

(ii) Rear axle misalignment

Rear axle alignment is checked using laser alignment equipment. If misaligned, it can cause the vehicle to dog-track. The axle may be shimmed or the suspension arms adjusted to bring the axle back into square with the frame.

(iii) Ride height imbalance

Ride height is measured from the ground to a fixed point on the chassis. Imbalance can result from worn springs, uneven loads, or damaged suspension parts. Correction involves replacing springs or shocks and ensuring proper load distribution.

3. (a) Define a dual-fuel engine and give two advantages of its use in modern heavy-duty vehicles.

A dual-fuel engine operates using a combination of two fuels, typically diesel and natural gas or biogas. It starts with a small amount of diesel to initiate combustion, followed by gas injection.

One advantage is reduced fuel costs, as gas is often cheaper and more efficient in high-load applications. Another advantage is environmental: dual-fuel systems emit fewer nitrogen oxides and particulates, meeting stricter emission standards.

(b) Compare electronic fuel injection and carburetor systems by giving three points of contrast.

Electronic fuel injection delivers fuel with precise timing and quantity through sensors and actuators controlled by an ECU. Carburetors rely on vacuum created by air flow to draw fuel mechanically.

Fuel injection adjusts instantly for changes in load and temperature, improving fuel efficiency. Carburetors require manual tuning and are less accurate.

Fuel injection provides better throttle response and lower emissions. Carburetors, while simpler, tend to perform poorly under varying operating conditions.

(c) Describe a standard workshop procedure for checking valve clearance in a four-cylinder petrol engine.

First, ensure the engine is cold. Rotate the crankshaft until the piston of the cylinder being checked is at top dead center (TDC) on the compression stroke. Use a feeler gauge to measure the gap between the valve tip and the rocker or cam lobe. Compare the reading to the manufacturer's specifications. If the clearance is incorrect, adjust the valve using the adjustment screw or shim. Repeat the process for each valve.

(d) Explain how to test and diagnose performance of diesel fuel injectors using:

(i) Pop tester

The pop tester is a hand-pump device that pressurizes the injector. It allows observation of the opening pressure and spray pattern. The injector should open at the specified pressure and emit a fine, even mist.

(ii) Spray pattern test

This checks the shape and distribution of the fuel spray. A faulty injector may produce an uneven, dribbling, or offset pattern, indicating clogging or damage.

(iii) Return flow measurement

Return flow is measured using graduated cylinders connected to each injector return line. Excess return indicates internal leakage, which reduces injection pressure and affects performance.

4. (a) A four-cylinder engine operates on the firing order 1-2-3-4. Complete the cycle table showing strokes for each cylinder assuming 1–4 and 2–3 move together.

Stroke	**Cylinder 1**	**Cylinder 2**	**Cylinder 3**	**Cylinder 4**
Power (P)	P	I	C	E
Compression (C)	C	E	P	I
Induction (I)	I	C	E	P
Exhaust (E)	E	P	I	C

(b) Describe the piston movement and valve actions during the power stroke in a diesel engine.

During the power stroke, the piston moves downward from top dead center (TDC) to bottom dead center (BDC). At this point, both the intake and exhaust valves remain closed to allow the combustion pressure to push the piston. The fuel-air mixture, having ignited due to high compression, expands rapidly, producing the force that turns the crankshaft.

(c) Outline four performance disadvantages of using a two-stroke engine in modern automotive applications.

Two-stroke engines have high fuel consumption due to incomplete combustion and fuel loss during scavenging.

They produce more emissions, including unburnt hydrocarbons, making them unsuitable for emission-regulated markets.

Their lubrication system, often using oil mixed with fuel, leads to higher internal wear and environmental pollution.

They have shorter service life and lower durability under continuous use, limiting their application in long-distance or heavy-duty vehicles.

5. (a) Outline four differences in the ignition systems of petrol and diesel engines.

Petrol engines use spark ignition with spark plugs to initiate combustion, while diesel engines rely on compression ignition, where fuel self-ignites due to high pressure and temperature.

Petrol ignition systems require distributors or coil packs, while diesel engines use high-pressure fuel injectors and glow plugs for cold starting.

Timing in petrol engines is controlled electronically or mechanically, while diesel injection timing is managed by the fuel pump or ECU.

Diesel engines operate with higher compression ratios, eliminating the need for external ignition components, unlike petrol systems.

(b) An engine produces 95 Nm torque at 3000 rpm and uses a 4.2:1 reduction gearbox with 88% efficiency. Calculate:
(i) Output torque

Output torque = 95 Nm × 4.2 × 0.88 = 351.12 Nm

(ii) Final drive rotational speed

Output speed = 3000 rpm / 4.2 = 714.29 rpm

(c) List four chemical and physical properties of a good brake fluid and explain the significance of each.

High boiling point prevents vapor lock under high temperatures during repeated braking.

Low compressibility ensures consistent hydraulic pressure and firm pedal feel.

Corrosion resistance protects metal components like calipers and master cylinders from rusting.

Low moisture absorption helps maintain boiling point and performance over time, as absorbed water reduces effectiveness.

6. (a) Explain the importance of correct preload adjustment on tapered roller bearings used in differential assemblies.

Correct preload on tapered roller bearings ensures that there is sufficient clamping force to hold the bearings firmly in place without allowing excessive movement. Proper preload helps maintain gear alignment, reduces play in the differential, and prevents gear chatter or misalignment under load.

If preload is too loose, the bearings will have excessive clearance, leading to vibration, increased noise, accelerated wear, and potential gear damage. If preload is too tight, it increases friction and heat, causing premature bearing failure and potential seizure. Therefore, preload must be set using torque-to-turn or end-play measurements as per manufacturer specifications.

(b) (i) What is the clutch pressure plate and what role does it play in clutch operation?

The clutch pressure plate is a spring-loaded component that forms part of the clutch assembly. Its primary role is to apply force against the clutch disc, pressing it firmly against the flywheel. This enables the transmission of engine torque to the gearbox. When the clutch pedal is pressed, the pressure plate retracts, allowing the clutch disc to disengage and interrupt power flow.

(ii) Describe how clutch pedal movement disengages the drive.

When the driver presses the clutch pedal, the pedal movement is transferred through mechanical linkage or a hydraulic system to the release bearing. The bearing pushes against the diaphragm spring or release fingers of the pressure plate. This action pulls the pressure plate away from the clutch disc, releasing the clamping force and allowing the disc to spin freely, thus disengaging the engine from the transmission.

(iii) What are the signs and causes of clutch slipping?

Signs of clutch slipping include a noticeable increase in engine RPM without a corresponding increase in vehicle speed, especially during acceleration. The vehicle may also have difficulty climbing hills or towing loads. Causes include a worn or oil-contaminated clutch disc, a weak pressure plate, or misadjusted clutch linkage.

(iv) State two effects of a worn clutch disc on vehicle performance.

A worn clutch disc reduces friction between the flywheel and the disc, leading to slipping and power loss during acceleration.

It also causes rough gear engagement, shuddering during take-off, and premature wear of other clutch components such as the pressure plate and flywheel surface.

(c) Mention five desirable properties of materials used in clutch facings.

High friction coefficient to ensure effective torque transmission between the engine and gearbox.

Heat resistance to maintain performance during high-temperature operations, such as stop-and-go traffic or heavy load.

Wear resistance to extend service life under repeated engagement and disengagement cycles.

Vibration damping to reduce clutch shudder and noise during operation.

Oil resistance to maintain performance even in the presence of minor oil contamination.

(d) (i) Where is the thermostat housing typically located in a vehicle engine?

The thermostat housing is commonly located at the engine end of the upper radiator hose, usually mounted on the cylinder head or engine block. It contains the thermostat and serves as a junction between the engine and the cooling system.

(ii) Explain how to verify if a thermostat is opening at its rated temperature.

To test, remove the thermostat and place it in a container of water alongside a thermometer. Gradually heat the water and observe the temperature at which the thermostat begins to open. It should start opening at the temperature stamped on the thermostat (typically between 80°C and 90°C). If it does not open or opens too late, it is defective and should be replaced.

7. (a) State four major functions of a dead front axle in commercial vehicles.

It supports the weight of the front portion of the vehicle, including the engine, cab, and other components.

It provides a mounting point for the front wheels, allowing them to steer through the use of kingpins and steering knuckles.

It helps absorb and transmit road shocks from the wheels to the suspension system, improving ride comfort and control.

It maintains wheel alignment and ensures proper track width for vehicle stability and control during movement.

(b) (i) Describe the operation of a recirculating ball steering gear.

In a recirculating ball steering system, the steering wheel is connected to a worm gear that rotates when the driver turns the wheel. Ball bearings between the worm gear and a ball nut reduce friction and allow smooth motion. As the worm gear turns, it moves the ball nut linearly, which in turn moves the pitman arm, converting rotary motion into linear motion to steer the wheels.

(ii) List three symptoms of a worn steering gear mechanism.

Excessive free play in the steering wheel, making the vehicle difficult to control.

Steering wheel vibration or noise when turning, indicating internal wear or damaged bearings.

Uneven or delayed steering response due to worn gear teeth or loose internal components.

(c) Using the following prices, calculate the total engine overhaul cost for a 6-cylinder inline diesel engine:
Engine kit – 310,000/=
Piston ring sets (6 pcs) – 70,000/= each = 6 × 70,000 = 420,000/=
Main bearing sets (3 sets) – 33,000/= each = 3 × 33,000 = 99,000/=
Big end bearing sets (6 pcs) – 27,000/= each = 6 × 27,000 = 162,000/=
Valve seats (12 pcs) – 7,500/= each = 12 × 7,500 = 90,000/=
Oil filter – 15,000/=
Head gasket – 24,000/=

Total cost =
310,000 + 420,000 + 99,000 + 162,000 + 90,000 + 15,000 + 24,000 = **1,120,000/=**

8. (a) Explain how the following faults affect the suspension system and vehicle handling:

(i) Loose shock absorber mounting
This causes the shock absorber to move excessively, reducing its ability to dampen vibrations. The vehicle may bounce excessively after hitting bumps, leading to poor handling and braking instability.

(ii) Broken spring leaf
A broken spring cannot support vehicle weight evenly, resulting in sagging, wheel misalignment, and increased stress on other suspension components. It also reduces ride comfort and increases the risk of tire damage.

(iii) Bent suspension arm
This distorts suspension geometry and affects wheel alignment, causing uneven tire wear and pulling to one side. It also compromises stability during cornering and braking.

(iv) Cracked stabilizer bush
Cracked or worn bushes reduce the effectiveness of the stabilizer bar, increasing body roll during turns. This leads to reduced cornering control and driver confidence.

(b) (i) Give five possible causes of misfiring in a petrol engine.

Worn or fouled spark plugs that fail to ignite the fuel-air mixture properly.

Faulty ignition coil or distributor causing irregular or weak spark delivery.

Clogged fuel injectors that limit or distort fuel spray, leading to lean combustion.

Vacuum leaks that disrupt the air-fuel mixture ratio, causing unstable combustion.

Sensor faults (e.g., crankshaft or oxygen sensors) that cause incorrect ECU commands, affecting ignition and fuel timing.

(ii) How can a digital multimeter be used to test a crankshaft position sensor?

Set the multimeter to the appropriate resistance (ohms) range. Disconnect the sensor connector and measure resistance across the sensor terminals. Compare the reading to manufacturer specifications. To test output, switch the multimeter to AC voltage and crank the engine. A functioning sensor should produce a small voltage (typically 0.5–1.5V AC). No output indicates a faulty sensor.

(c) Describe how to perform ignition timing adjustment on an overhead camshaft engine fitted with a distributor.

Warm up the engine to normal operating temperature. Connect a timing light to the battery and number one spark plug wire. Locate the timing marks on the crankshaft pulley and the engine timing cover.

Start the engine and aim the timing light at the timing marks. The light will flash in sync with the ignition, allowing you to observe the mark's position.

If the timing is not within specification, loosen the distributor hold-down clamp and rotate the distributor slightly clockwise to retard timing, counterclockwise to advance it.

Recheck the mark with the timing light. Once the mark aligns with the specified degree of advance, tighten the distributor clamp. Finally, verify idle speed and reconnect any vacuum lines or electronic controls if previously disconnected.