THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2010**

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) Outline five essential safety procedures a technician should follow before and during the removal of a manual gearbox from a vehicle.

First, the technician must disconnect the vehicle's battery, especially the negative terminal. This is essential to prevent accidental short circuits or electric sparks that could result from disconnected sensors or wiring near the gearbox.

Secondly, the vehicle must be securely lifted and supported using jack stands or a hydraulic lift. This ensures stability and prevents the vehicle from falling during the removal of the gearbox, which is a heavy component.

Third, the technician should drain the transmission fluid before starting disassembly. This prevents fluid spillage on the workshop floor, which can create slipping hazards and environmental contamination.

Fourth, all electrical connectors, cables, and sensors connected to the gearbox should be properly labeled and disconnected. This helps in reassembly and prevents damage to electronic components.

Fifth, the technician should use appropriate lifting equipment such as a transmission jack to support the gearbox. Attempting to remove or reinstall it manually can lead to injury or component damage due to its weight and awkward shape.

(b) Explain the workshop-specific safety considerations when operating the following equipment:
(i) Engine analyzer

The technician must ensure the engine analyzer is properly grounded to avoid electrical shock. They should connect it while the engine is off and make sure all sensor leads are correctly attached. Caution must be taken not to stand in front of the fan or belts during the test to avoid injury from rotating parts.

(ii) Hydraulic jack

Before use, the jack should be inspected for fluid leaks and structural integrity. The jack must be placed on a level, solid surface and positioned correctly under the vehicle's jacking point. Never work under a vehicle supported only by a jack; always use jack stands for safety.

(iii) Brake bleeding machine

The technician should wear gloves and eye protection to avoid contact with brake fluid, which is corrosive. The machine should be properly connected to the reservoir, and pressure should be kept within recommended levels to avoid bursting seals. Spilled brake fluid must be cleaned immediately to avoid floor damage or slipping.

(c) Sketch and label three types of vehicle chassis structures, indicating their typical applications.

1. Ladder Frame – Consists of two longitudinal rails joined by cross members. It is strong and commonly used in trucks, buses, and some SUVs.

2. Monocoque Frame – Integrates the chassis and body into a single shell. It is lightweight, enhances fuel economy, and is widely used in passenger cars.

3. Backbone Frame – Has a central strong tubular section that supports the drivetrain. It is mainly used in sports cars and utility vehicles for better rigidity.

2. (a) (i) Define the term "bushing reaming" and state its role during reconditioning of suspension components.

Bushing reaming is a machining process used to precisely resize the inner diameter of a new bushing after it has been pressed into place. In suspension components such as control arms or spring eyes, the reaming process ensures that the bushing bore aligns properly with the mating shaft or bolt and that the surface is smooth enough to reduce friction and wear.

(ii) Identify four precision tools used in timing gear alignment and explain their functions.

1. Dial gauge – Measures the movement of timing gears with high accuracy, especially for checking backlash and gear concentricity.
2. Timing pin – Locks the crankshaft or camshaft at TDC position to ensure correct timing alignment.
3. Vernier caliper – Used to measure gear thickness, keyway width, or spacer dimensions.
4. Feeler gauge – Measures gap between gears and ensures correct lash in timing components.

(iii) What is a torque angle gauge and how is it applied in engine assembly?

A torque angle gauge is used to measure the angle of rotation after a bolt has been torqued to its initial value. It is essential in modern engines where torque-to-yield bolts are used, requiring a specific angle of additional rotation to achieve proper clamping force. It ensures bolts are not over- or under-tightened.

(b) (i) What is "fuel injector pulse width"?

Fuel injector pulse width refers to the amount of time the injector remains open during each injection cycle. It is measured in milliseconds and controlled by the ECU based on load, throttle position, air-fuel ratio, and temperature. A longer pulse width delivers more fuel; a shorter one delivers less.

(ii) State four factors that affect pulse width in a multi-point fuel injection system.

1. Throttle position – Wider throttle opening increases air intake, requiring a longer pulse width.
2. Engine load – Under heavy load, the ECU increases pulse width to enrich the fuel mixture.
3. Engine temperature – A cold engine requires more fuel, increasing pulse width.
4. Oxygen sensor feedback – A lean mixture prompts the ECU to increase pulse width for better combustion.

(c) Describe inspection and adjustment methods for the following steering system conditions:
(i) Excessive play in steering wheel

This may be caused by worn tie rod ends, loose steering gear, or worn steering shaft couplings. Inspection involves manually checking each joint for looseness and measuring steering free play at the wheel. Adjustment includes tightening the steering gear or replacing worn linkages.

(ii) Pulling to one side during braking

This may result from uneven brake pressure, worn suspension bushings, or misaligned wheels. The technician should check for seized calipers, unequal tire pressure, or bent suspension arms. Correction includes aligning wheels, servicing brakes, and replacing worn suspension parts.

(iii) Off-center steering wheel

An off-center wheel indicates incorrect alignment or unbalanced steering linkage. The steering linkage length should be checked and reset. After wheel alignment, the steering wheel should be centered and verified by road testing.

3. (a) Define a "stratified charge engine" and explain two ways in which it improves combustion efficiency.

A stratified charge engine introduces a rich fuel-air mixture near the spark plug and a lean mixture in the rest of the combustion chamber. It allows controlled combustion with lower fuel usage, especially at low loads.

First, it improves fuel efficiency by allowing lean burn under low throttle conditions without misfire. Second, it reduces emissions by limiting fuel consumption and maintaining combustion stability even with a lean mixture.

(b) Compare three technical features of overhead valve (OHV) engines and overhead camshaft (OHC) engines.

OHV engines have the camshaft located in the engine block, operating valves via pushrods and rocker arms. OHC engines have the camshaft located in the cylinder head, allowing more direct valve actuation.

OHC engines offer higher RPM performance due to reduced valvetrain inertia, while OHV engines are compact and simpler to manufacture.

Valve timing is more precise in OHC engines, making them more suitable for multi-valve configurations and variable valve timing systems.

(c) Describe a workshop method for checking cylinder head flatness using appropriate tools.

Place a straight edge across the cylinder head surface in multiple directions (lengthwise, across, and diagonally). Use a feeler gauge to check for gaps between the head and the straight edge. If the gap exceeds manufacturer-specified tolerance (usually 0.05 mm), the head must be resurfaced to ensure a proper seal with the head gasket.

(d) Describe how to test each of the following injector faults:

(i) Leaking injector tip

Connect the injector to a pop tester and pressurize it. If fuel drips or sprays before the designated opening pressure, the injector is leaking and must be replaced or serviced.

(ii) Clogged injector

Use an injector cleaning machine or ultrasonic cleaner to remove deposits. Conduct a spray test; if the spray is weak, uneven, or non-existent, the injector is clogged.

(iii) Weak solenoid

Use a multimeter to check the resistance of the injector coil. If it's out of range or shows an open circuit, the solenoid is faulty. You can also check response using an oscilloscope or ECU signal test.

4. (a) A four-cylinder petrol engine has a firing order of 1-4-3-2. Assuming cylinders move in pairs (1–4 and 2–3), fill in the strokes for each cylinder.

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

(b) Explain what occurs during the compression stroke in a petrol engine in terms of piston movement and valve positions.

During the compression stroke, the piston moves upward from bottom dead center (BDC) to top dead center (TDC). Both the intake and exhaust valves remain closed. The upward motion compresses the air-fuel mixture in the cylinder, increasing its pressure and temperature in preparation for ignition by the spark plug.

(c) State four functional disadvantages of using a two-stroke engine in highway vehicles.

Two-stroke engines have poor fuel economy due to overlapping intake and exhaust strokes, causing unburned fuel to escape.

They produce high levels of exhaust emissions because of incomplete combustion and oil mixed in the fuel.

Lubrication relies on mixing oil with fuel, which leads to more engine deposits and faster wear.

Their high noise levels and short lifespan make them unsuitable for long-distance or high-speed driving common in highway conditions.

5. (a) List four key differences in the lubrication systems of diesel and petrol engines.

Diesel engines typically operate under higher pressures and temperatures compared to petrol engines, so they require a higher capacity oil pump and stronger oil circulation system to maintain effective lubrication under stress.

Diesel engines often use oil coolers to reduce oil temperature due to the intense heat generated, while petrol engines may not require this feature under normal conditions.

The oil in diesel engines accumulates more soot and combustion residues because of the higher compression and fuel characteristics, requiring oil with superior detergent and dispersant additives compared to petrol engine oils.

Oil change intervals are generally shorter for diesel engines due to higher contamination rates and the heavy-duty nature of their operation, whereas petrol engines typically maintain cleaner oil for longer durations.

(b) A 4-cylinder engine produces 100 Nm of torque at 3600 rpm. It drives a gearbox with a reduction ratio of 3.5:1 and efficiency of 89%. Calculate:
(i) Output torque at the gearbox

Output torque = Engine torque × Gear ratio × Efficiency

Output torque = 100 Nm × 3.5 × 0.89 = 311.5 Nm

(ii) Rotational speed at the output shaft

Output speed = Engine speed / Gear ratio

Output speed = 3600 rpm / 3.5 = 1028.57 rpm

(c) Explain four physical and chemical properties that make a good transmission fluid.

A good transmission fluid must have a high viscosity index, meaning it maintains stable thickness across a wide range of temperatures, ensuring consistent performance in both cold starts and high-heat conditions.

It should have strong oxidation stability to resist chemical breakdown when exposed to air and heat. This prolongs the fluid's life and prevents sludge or varnish formation inside the transmission.

It must offer excellent anti-foaming characteristics to prevent bubbles forming within the fluid, which can cause erratic shifting and damage to transmission components due to loss of hydraulic pressure.

Corrosion resistance is vital to protect internal metal components like gears, bearings, and clutches from rust or pitting, especially in moist environments.

6. (a) Explain the effects of incorrect backlash adjustment in the differential assembly of a rear-wheel-drive vehicle.

If backlash is set too small, the gear teeth may bind under load, generating excessive heat, noise, and rapid wear. It can cause pitting or chipping of the gear teeth due to metal-to-metal contact.

If backlash is too large, there is excessive clearance between the gear teeth, resulting in a clunking noise during acceleration or deceleration. It also causes inaccurate power transmission and uneven wear, eventually damaging the crown and pinion gear surfaces.

(b) (i) What is the function of the clutch diaphragm spring?

The diaphragm spring provides the clamping force needed to press the pressure plate against the clutch disc and flywheel. When the clutch pedal is pressed, the diaphragm spring deflects, pulling the pressure plate away from the clutch disc, which allows disengagement of the drive.

(ii) Explain how clutch drag occurs and its effect on shifting.

Clutch drag happens when the clutch disc does not fully release from the flywheel even when the pedal is pressed. This causes continued contact and rotation of the transmission input shaft, making gear shifting difficult or resulting in grinding noise during gear engagement.

(iii) List two causes of hard clutch pedal feel.

A worn or dry clutch cable or linkage causes stiffness due to increased friction.
A failed or seized clutch release bearing or pressure plate spring increases resistance in the system, making the pedal harder to press.

(iv) State two effects of a damaged clutch release bearing.

It produces noise (grinding or whirring) when the clutch pedal is depressed.
A faulty release bearing may cause incomplete disengagement of the clutch, resulting in clutch drag and difficulty shifting gears.

(c) Mention five factors to consider when selecting friction material for heavy-duty clutch systems.

The material must have a high coefficient of friction to ensure strong torque transmission without slippage under load.

It should resist high operating temperatures without degrading, especially in commercial vehicles that undergo frequent starts and stops.

It must offer good wear resistance to extend the service life of the clutch under harsh operating conditions.

The material should dampen vibration to reduce clutch chatter and ensure smooth engagement.

It should also be compatible with environmental regulations, meaning asbestos-free and safe for both workers and the environment.

(d) (i) Where is the coolant temperature sending unit located in an engine?

The coolant temperature sending unit is usually located near the thermostat housing or screwed into the engine block or cylinder head, where it can accurately measure the temperature of the coolant as it exits the engine.

(ii) How does the coolant temperature affect ECU-controlled fuel injection?

When the coolant temperature is low, the ECU enriches the air-fuel mixture for cold start and idling. As the engine warms up, the ECU gradually leans out the mixture to improve efficiency. If the coolant temperature reading is incorrect, the ECU may inject too much or too little fuel, leading to poor engine performance or increased emissions.

7. (a) State four functions of a non-driven front axle in a two-wheel-drive vehicle.

It supports the weight of the front part of the vehicle, including the engine in front-wheel-heavy designs.

It provides steering capability by allowing the front wheels to pivot through the steering knuckle and kingpin.

It absorbs and transfers road shocks to the suspension system, contributing to ride comfort and control.

It helps maintain proper wheel alignment and contributes to overall vehicle stability and handling.

(b) (i) Describe the basic function of a power steering pump.

The power steering pump generates hydraulic pressure by circulating power steering fluid through the steering system. This pressure assists the driver in turning the wheels with less physical effort, especially at low speeds or when the vehicle is stationary.

(ii) Give three symptoms of a failing power steering pump.

A whining or groaning noise when turning the steering wheel, especially at low speeds.
Stiff or heavy steering feel, requiring more effort to turn the wheel.
Fluid leaks around the pump or a low fluid level in the reservoir, leading to reduced system performance.

(c) Calculate the estimated cost of overhauling a 4-cylinder petrol engine using the data below:
Engine gasket kit – 195,000/=

Main bearings – 45,000/=
Big end bearings – 32,000/=
Piston rings (4 pcs) – 68,000/= each = 4 × 68,000 = 272,000/=
Intake valves (4 pcs) – 12,500/= each = 4 × 12,500 = 50,000/=
Exhaust valves (4 pcs) – 14,000/= each = 4 × 14,000 = 56,000/=
Oil seal set – 22,000/=

Total Cost =
195,000 + 45,000 + 32,000 + 272,000 + 50,000 + 56,000 + 22,000 = **672,000/=**

8. (a) Describe the suspension and handling effects of each of the following defects:

(i) Loose upper control arm
This leads to unstable wheel alignment and unpredictable handling, especially when cornering. It can cause the wheel to shift position, leading to excessive tire wear and poor directional control.

(ii) Damaged ball joint
A worn or broken ball joint creates steering play and clunking noises. It affects suspension articulation and may result in the wheel detaching if failure occurs completely.

(iii) Weak coil spring
It causes the vehicle to sag on one side, reducing ground clearance and shock absorber effectiveness. This leads to a rough ride and increased stress on other suspension components.

(iv) Broken stabilizer link
This reduces the ability of the stabilizer bar to limit body roll, especially during cornering. It compromises vehicle stability and increases body sway during lane changes or sharp turns.

(b) (i) Mention five causes of engine backfiring.

Incorrect ignition timing causes premature or delayed spark, resulting in combustion in the exhaust or intake.

A lean air-fuel mixture may not ignite fully in the combustion chamber and may ignite in the exhaust system.

Damaged or leaking exhaust valves allow unburnt gases to enter the exhaust and combust later.

A faulty ignition coil or plug wire may cause spark delivery at the wrong time, leading to backfire.

Injector issues or intake leaks can disrupt fuel metering and lead to unburnt fuel entering the exhaust.

(ii) Explain how to test ignition coil resistance using a multimeter.

Set the multimeter to the ohms (Ω) scale. Measure the resistance between the primary terminals (positive and negative): it should be between 0.4 to 2 ohms. Then measure between the high-tension terminal and one of the primary terminals (secondary resistance), typically 6,000 to 15,000 ohms. Readings outside the manufacturer's specifications indicate a faulty coil.

(c) Describe the procedure for aligning ignition timing on a distributor-less ignition system using a scan tool.

Connect the scan tool to the vehicle's OBD-II port. Start the engine and allow it to reach operating temperature. Navigate the scan tool to the live data stream and locate the ignition timing data. Compare the timing value with the manufacturer's specification.

If adjustment is needed and permitted by the ECU, access the adjustment setting through the scan tool menu and modify the timing. If the ECU controls timing automatically, investigate related sensors like the crankshaft position sensor. Save any adjustments and verify by test driving the vehicle and confirming proper timing stability.