THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2011**

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) Briefly explain five general workshop safety rules that every automotive technician must observe during repair and maintenance of vehicle transmission systems.

Every technician must ensure the vehicle is securely supported on jack stands or a lift before working underneath it. Relying on hydraulic jacks alone can be dangerous because they may fail, leading to serious injury.

It is essential to wear proper personal protective equipment (PPE) such as overalls, gloves, safety boots, and eye protection. Transmission components can have sharp edges and contain fluids that may be harmful to the skin or eyes.

Technicians should disconnect the vehicle battery before starting any work on the transmission. This prevents the accidental engagement of electrical systems, such as the starter motor, which can cause injury.

All tools and equipment must be inspected before use to ensure they are in good working condition. Damaged tools can slip or break during use, increasing the risk of injury.

The work area should be kept clean and free of oil spills, loose tools, and parts. A clean workshop environment prevents slips, falls, and confusion, especially when handling transmission parts.

(b) Explain the safety precautions to be followed when working with the following:

(i) Hydraulic jack
Before using a hydraulic jack, ensure that it is placed on a flat, stable surface and that the jack's weight capacity is not exceeded. Always use axle stands to support the vehicle after lifting; never rely solely on the jack for support.

(ii) Bench grinder
When using a bench grinder, always wear safety goggles to protect the eyes from flying particles. Ensure that the grinder guards are in place, and never use excessive force that might cause the wheel to shatter. Stand slightly to the side of the grinding wheel to avoid direct contact in case of breakage.

(iii) Oxy-acetylene welding set
Ensure that hoses are free from leaks and properly connected before starting the welding process. Always wear flame-resistant clothing, gloves, and a welding mask. Work in a well-ventilated area to avoid gas buildup, and never light the torch near flammable materials.

(c) Sketch and label the following frame designs commonly used in vehicles:

(i) Ladder frame
This frame consists of two long parallel steel members (side rails) joined together by several cross members. It resembles a ladder in shape and is commonly used in trucks and older vehicles due to its strength.

(ii) Backbone frame
This frame has a strong central backbone tube that runs along the length of the vehicle. Suspension and drivetrain components are mounted on this central spine. It is commonly used in sports and off-road vehicles.

(iii) Tubular frame
The tubular frame is constructed from numerous interconnected tubes forming a rigid structure. It is light and offers good strength, often used in racing cars and specialized vehicles.

2. (a) (i) What is the purpose of using torque wrenches in automotive repairs?

A torque wrench is used to apply a specific amount of torque to a fastener, such as a bolt or nut. This ensures that the component is tightened correctly according to the manufacturer's specifications, avoiding both under-tightening and over-tightening, which could lead to failure of parts.

(ii) List four common types of torque wrenches and briefly state their unique feature.

The beam-type torque wrench has a simple design with a pointer and scale, making it affordable and reliable for visual torque readings.

The click-type torque wrench produces an audible click and slight release of tension once the preset torque is reached, alerting the user to stop tightening.

The digital torque wrench displays torque readings on an electronic screen and may have memory functions for recording multiple values.

The dial-indicator torque wrench uses a needle and dial to show torque readings in real-time, offering more accuracy for critical applications.

(iii) What is the function of a dial gauge in a vehicle workshop?

A dial gauge is used to measure small linear distances or displacements with high accuracy. In automotive workshops, it is commonly used for checking component runout, end play, or alignment, such as on crankshafts, camshafts, and brake discs.

(b) (i) Define the term "fuel knock" in internal combustion engines.

Fuel knock, also known as engine knocking or detonation, is the uncontrolled and premature ignition of the air-fuel mixture in the combustion chamber. It produces a metallic pinging noise and can cause engine damage if not corrected.

(ii) Outline four causes of fuel knock in petrol engines.

Using low-octane fuel that is not suitable for high-compression engines can result in knocking since the fuel ignites too easily under pressure.

Incorrect ignition timing, especially when advanced too much, causes the air-fuel mixture to ignite before the piston reaches the top dead center.

Carbon deposits in the combustion chamber can increase compression ratio and hot spots, which can lead to premature ignition of the mixture.

Overheating of the engine increases the temperature in the combustion chamber, encouraging uncontrolled ignition of the fuel mixture.

(c) Explain why correct steering geometry is important. Then briefly describe how each of the following angles affects steering:

Correct steering geometry ensures stability, smooth handling, reduced tire wear, and overall safety of the vehicle during operation. Misaligned steering angles can lead to difficult control, pulling to one side, and premature tire damage.

(i) Kingpin inclination
This angle helps return the steering wheel to the straight-ahead position after turning and improves straight-line stability. It reduces the effort required to steer the vehicle.

(ii) Setback
Setback is the difference in the position of one front wheel compared to the other. It can be due to collision damage. Excessive setback can cause pulling to one side during driving.

(iii) Included angle
This is the sum of kingpin inclination and camber angle. It helps technicians diagnose suspension or steering component issues, particularly when there is no direct measurement of kingpin inclination.

3. (a) Define the term “combustion chamber” as applied in automotive engines.

A combustion chamber is the space within the engine cylinder where the air-fuel mixture is compressed and ignited. It is designed to promote efficient mixing, compression, and combustion of the fuel to generate power.

(b) Differentiate the terms compression ratio and clearance volume.

Compression ratio is the ratio between the total cylinder volume when the piston is at bottom dead center and the clearance volume when the piston is at top dead center. It indicates how much the air-fuel mixture is compressed before ignition.

Clearance volume is the small volume remaining in the combustion chamber when the piston is at top dead center. It is a part of the combustion chamber and determines the engine's compression ratio.

(c) Describe three major engine block materials and give one advantage of each.

Cast iron is commonly used for engine blocks due to its durability and excellent wear resistance. It also dampens vibrations well.

Aluminum alloy is lighter than cast iron and provides better heat dissipation, which helps in maintaining cooler engine temperatures.

Compacted graphite iron (CGI) offers a balance between strength and weight. It is stronger than aluminum but lighter than traditional cast iron, making it suitable for high-performance engines.

(d) Explain the procedures of testing a battery for:

(i) State of charge
The state of charge can be tested using a hydrometer, which measures the specific gravity of the electrolyte in each cell. Higher specific gravity indicates a fully charged battery.

(ii) Internal resistance
A battery tester or multimeter with internal resistance testing capability is used. The device applies a load and measures voltage drop to determine resistance, which should be low in a healthy battery.

(iii) Electrolyte level
Remove the battery caps and visually inspect the level of electrolyte in each cell. The fluid should cover the top of the battery plates. If low, distilled water should be added.

4. (a) A six-cylinder inline engine has the firing order 1-5-3-6-2-4. Complete the table to show the stroke sequence if the engine is operating under four-stroke cycle.

Cylinder No	**Stroke**
1	Power (P)
5	Compression (C)
3	Induction (I)
6	Exhaust (E)
2	Power (P)

4	Compression (C)

(b) Explain the exhaust stroke in a four-stroke diesel engine.

During the exhaust stroke, the piston moves from bottom dead center (BDC) to top dead center (TDC). The exhaust valve opens while the intake valve remains closed. The upward motion of the piston pushes the burnt gases from the combustion process out through the exhaust valve and into the exhaust manifold, making room for fresh air in the next cycle.

(c) Identify four key differences between spark ignition and compression ignition engines.

Spark ignition engines use a spark plug to ignite the air-fuel mixture, whereas compression ignition engines rely on the heat generated by compression to ignite the fuel.

Spark ignition engines typically use petrol as fuel, which is more volatile, while compression ignition engines use diesel, which has higher energy content per unit volume.

In spark ignition engines, the fuel and air are mixed before entering the cylinder, but in compression ignition engines, air alone is compressed and fuel is injected directly into the cylinder.

Compression ignition engines generally have higher compression ratios and are more fuel-efficient, but they tend to be heavier and noisier compared to spark ignition engines.

5. (a) Highlight four major distinctions between a naturally aspirated engine and a turbocharged engine.

A naturally aspirated engine relies solely on atmospheric pressure to draw air into the cylinders during the intake stroke. It does not use any external device to increase air pressure or density, making it mechanically simpler and generally more reliable.

In contrast, a turbocharged engine uses a turbine driven by exhaust gases to compress the intake air, increasing the amount of air and fuel mixture entering the combustion chamber. This results in greater power output from a smaller engine size.

Naturally aspirated engines respond more smoothly at lower RPMs since there is no turbo lag, whereas turbocharged engines may experience a slight delay in throttle response while the turbo spools up.

Turbocharged engines tend to be more fuel-efficient when tuned correctly, as they extract more energy from the same displacement compared to naturally aspirated engines, especially at higher loads or altitudes.

(b) An engine delivers a power output of 75 kW at 3000 rpm. Calculate the torque developed at the crankshaft.

We use the formula:

Power (W) = (2 × π × Torque × RPM) / 60

Rearranging for Torque:

Torque = (Power × 60) / (2 × π × RPM)

Convert 75 kW to watts: 75 kW = 75000 W

Torque = (75000 × 60) / (2 × 3.1416 × 3000)
Torque = 4500000 / 18849.6
Torque ≈ 238.8 Nm

So, the torque developed at the crankshaft is approximately 238.8 Newton-meters.

(c) What are four desirable characteristics of a good engine lubricant?

A good engine lubricant must have high viscosity stability to maintain proper film thickness across a wide range of temperatures, ensuring consistent lubrication and reducing wear.

It should possess excellent thermal and oxidative stability to resist breakdown at high operating temperatures, prolonging its effective service life.

It must provide effective protection against corrosion and rust, especially when moisture or combustion byproducts come into contact with engine internals.

It should have good detergency and dispersant properties to clean and suspend contaminants, preventing sludge formation and keeping engine parts clean.

6. (a) Explain the need for backlash adjustment in a differential gear system.

Backlash adjustment in a differential is necessary to ensure there is a small clearance between the mating gear teeth, particularly between the crown wheel and the pinion. This clearance prevents excessive friction, noise, and heat buildup during operation. If the backlash is too tight, the gears may bind or wear prematurely. If it is too loose, it may lead to knocking sounds, vibration, and increased gear wear.

(b) (i) What is a diaphragm spring clutch?

A diaphragm spring clutch uses a single diaphragm-shaped spring to engage or disengage the clutch mechanism. This spring replaces the multiple coil springs found in conventional clutches and provides smoother and more consistent pressure on the clutch plate.

(ii) Describe how torque is transmitted when the clutch is engaged.

When the clutch pedal is released, the diaphragm spring pushes the pressure plate against the clutch disc, which is sandwiched between the flywheel and the pressure plate. Friction between these surfaces allows torque from the rotating flywheel to be transmitted through the clutch disc and into the input shaft of the gearbox.

(iii) What happens if the clutch pedal is held partially depressed during operation?

If the clutch pedal is held partially depressed, the clutch does not fully engage or disengage, leading to clutch slip. This causes rapid wear of the friction linings, overheating, and loss of power transmission. It can also damage the flywheel and pressure plate surfaces.

(iv) What is clutch drag and how is it caused?

Clutch drag occurs when the clutch fails to completely disengage, even when the pedal is fully pressed. It causes gear grinding and difficulty in shifting gears. It is commonly caused by warped clutch plates, insufficient release bearing travel, or improper clutch adjustment.

(c) List and explain five properties required of a clutch lining material.

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

It should be resistant to heat and able to withstand high temperatures generated during engagement and disengagement without losing strength or structure.

It must be wear-resistant to provide long service life under repeated usage.

It should have enough flexibility to conform to the surface of the flywheel and pressure plate for smooth operation.

The material should also be oil-resistant to maintain performance if exposed to minor oil contamination from the engine or gearbox.

(d) (i) Where is the radiator pressure cap located in a motor vehicle cooling system?

The radiator pressure cap is located at the top of the radiator or on the coolant reservoir, depending on the design of the cooling system. It seals the cooling system and maintains pressure to increase the boiling point of the coolant.

(ii) Describe how the radiator pressure cap contributes to engine cooling.

The radiator cap maintains pressure within the cooling system, which allows the coolant to operate at a higher temperature without boiling. This improves engine cooling efficiency. It also contains a pressure valve that opens to release excess pressure to the overflow tank, and a vacuum valve that allows coolant to return to the radiator as it cools, ensuring a closed-loop system.

7. (a) Describe four functions of the rear axle in an automobile.

The rear axle supports the weight of the rear part of the vehicle, including the chassis, body, passengers, and cargo, and transfers it to the wheels.

It transmits torque from the differential to the drive wheels, enabling motion of the vehicle in rear-wheel-drive configurations.

It serves as a mounting point for suspension components, shock absorbers, and sometimes the braking system, helping maintain stability and ride comfort.

In vehicles with live axles, the rear axle also maintains alignment of the wheels and controls their movement relative to the body of the vehicle.

(b) (i) Explain how a recirculating ball steering mechanism works.

In a recirculating ball steering system, the steering wheel rotates a worm gear inside a block with ball bearings. These ball bearings circulate between the worm gear and the block to reduce friction. As the worm gear turns, it moves the block, which is connected to the pitman arm. This motion is then transmitted to the steering linkage, turning the wheels. The design reduces friction and wear, making it suitable for heavy-duty vehicles.

(ii) What are three main functions of the pressure relief valve in the lubrication system?

It limits the maximum oil pressure in the system by opening when pressure exceeds a preset level, protecting engine components from damage.

It ensures proper circulation of oil by allowing excess oil to bypass the filter or return to the sump, especially during cold starts when oil is thick.

It maintains consistent oil pressure across the lubrication system, ensuring that all moving parts receive adequate lubrication regardless of engine speed.

(c) Compute the total cost of replacing the following parts in a 4-cylinder 3RZ-FE engine:

Engine gasket kit – Tsh. 175,000
Crankshaft bearing – Tsh. 27,000
Piston assembly – Tsh. 42,000 × 4 = Tsh. 168,000
Valve guide – Tsh. 7,500 × 8 = Tsh. 60,000
Timing belt – Tsh. 33,000
Oil pump – Tsh. 88,000

Total cost = 175,000 + 27,000 + 168,000 + 60,000 + 33,000 + 88,000 = Tsh. 551,000

So, the total cost of replacing the listed parts is Tsh. 551,000.

8. (a) Explain the effect of the following defects in coil spring suspension system:

(i) Cracked coil
A cracked coil reduces the strength and elasticity of the spring, leading to uneven ride height and poor handling. It may eventually break, causing suspension failure.

(ii) Sagging spring
A sagging spring lowers the vehicle on one side, which affects wheel alignment, causes uneven tire wear, and leads to instability, especially when turning or braking.

(iii) Corroded mounting point
Corrosion weakens the structural integrity of the spring mounts, which can result in the spring detaching from the chassis. This poses a serious safety hazard.

(iv) Broken rubber insulator
Rubber insulators cushion the spring and reduce noise and vibration. When broken, they lead to metal-to-metal contact, producing noise and discomfort during driving.

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

A malfunctioning thermostat that remains closed prevents coolant from circulating through the radiator, causing the engine to overheat.

A blocked or leaking radiator restricts coolant flow, reducing its ability to absorb and dissipate heat.

Low coolant level in the reservoir or radiator reduces the cooling system's capacity, leading to rapid overheating.

A faulty water pump fails to circulate coolant through the engine and radiator effectively.

A broken or slipping fan belt results in the cooling fan not operating properly, reducing airflow over the radiator.

(ii) Describe how a water pump is tested for faults.

To test a water pump, inspect for leaks around the housing or weep hole while the engine is running. Any visible leakage suggests a damaged seal.

Check for bearing noise by rotating the pulley by hand. Roughness or wobbling indicates worn bearings.

Observe coolant flow by removing the radiator cap (when cool) and revving the engine. If there is no coolant movement, the impeller may be broken or the pump is not functioning.

(c) Outline the steps to set ignition timing using a timing light in a petrol engine.

First, warm up the engine to its normal operating temperature and ensure idle speed is stable. Turn off any electronic advance systems if applicable.

Connect the timing light's power leads to the battery and the inductive pickup to the number one spark plug wire.

Start the engine and point the timing light at the timing marks on the crankshaft pulley and timing tab.

Observe the strobe flash and note the alignment of the timing marks. If adjustment is needed, loosen the distributor hold-down bolt and rotate the distributor slowly until the marks align at the specified degrees before top dead center (BTDC).

Once set correctly, tighten the distributor, recheck the timing, and then disconnect the timing light.