THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2013**

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 possible causes that may lead to sudden engine shutdown during highway driving in a petrol-powered vehicle.

One common cause is fuel starvation due to a faulty fuel pump, clogged fuel filter, or empty fuel tank. If fuel fails to reach the engine, combustion stops and the engine shuts down.

Ignition system failure, such as a failed ignition coil, crankshaft position sensor, or distributor malfunction, can interrupt the spark, leading to a sudden engine stop.

Overheating can cause engine shutdown to protect internal components. A failed thermostat, low coolant level, or defective radiator fan may trigger high engine temperature and shutdown.

An electrical failure such as a blown fuse, bad ground connection, or failed main relay can cut power to the engine management system, resulting in shutdown.

A faulty ECU or sensor malfunction (e.g., camshaft sensor) may send incorrect data or shut off fuel and spark delivery entirely, causing unexpected engine stoppage.

(b) Describe the procedures that should be followed when performing engine compression testing using a compression gauge.

Begin by warming up the engine to normal operating temperature to ensure proper sealing of piston rings and valves. Then shut off the engine.

Disable the fuel system and ignition system to prevent the engine from starting during cranking. This can be done by disconnecting injectors and ignition coils.

Remove all spark plugs to allow the engine to crank more easily and ensure accurate readings across all cylinders.

Install the compression tester into the first cylinder's spark plug hole and crank the engine for about 5–7 revolutions while observing the pressure reading on the gauge.

Record the reading, release pressure from the gauge, and repeat the procedure for each remaining cylinder. Compare the results to the manufacturer's specifications and check for consistency among cylinders.

(c) Briefly explain three effects of prolonged engine overheating on aluminum engine components.

Prolonged overheating can cause aluminum cylinder heads to warp due to their lower thermal resistance, leading to head gasket failure and loss of compression.

Overheating can weaken or deform pistons, causing scuffing against the cylinder wall, loss of sealing, and reduced engine performance.

Thermal expansion of aluminum can lead to cracking in the engine block or head, especially around valve seats or spark plug threads, resulting in coolant leakage and engine misfire.

2. (a) (i) Describe how a dial test indicator is used to check crankshaft end play.

To check crankshaft end play using a dial indicator, first position the indicator so its tip contacts the end of the crankshaft. Secure the indicator base firmly to the engine block.

Gently pry the crankshaft forward and backward with a lever while observing the indicator. The total movement of the needle represents the end play.

Compare the reading to the manufacturer's specifications. Excessive end play may indicate worn thrust bearings or crankshaft damage.

(ii) Why is excessive crankshaft end play a concern in engine operation?

Excessive end play can lead to crankshaft misalignment, causing bearing wear and oil pressure loss. It may also result in erratic timing, vibrations, and damage to the transmission input shaft or flywheel.

(iii) State two signs that may indicate crankshaft end play in an operating engine.

One sign is a noticeable knocking or clunking noise from the engine when the clutch is engaged or disengaged, indicating crankshaft movement.

Another sign is irregular or erratic engine RPM at idle, especially in vehicles with automatic transmissions, due to inconsistent positioning of internal components.

(b) (i) Explain the function of the catalytic converter in the exhaust system.

The catalytic converter reduces harmful emissions by converting carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx) into less harmful substances like carbon dioxide (CO_2), water vapor, and nitrogen through chemical reactions facilitated by precious metals inside the converter.

(ii) Identify four conditions that can cause premature failure of a catalytic converter.

Misfiring spark plugs can allow unburned fuel to enter the exhaust, overheating and melting the catalyst material.

Use of leaded fuel or fuel additives not meant for catalytic systems can contaminate the catalyst and reduce its effectiveness.

Oil or coolant leaks into the combustion chamber can create deposits on the catalyst surface, blocking its pores and reducing efficiency.

Running the engine with a faulty oxygen sensor can cause incorrect air-fuel mixture, overloading the converter and shortening its life.

(c) With aid of a labeled outline, describe the air intake system in a turbocharged diesel engine.

The air intake system consists of an air filter, turbocharger, intercooler, intake manifold, and associated piping. Outside air passes through the air filter, enters the turbocharger where it is compressed, and then flows through the intercooler to reduce its temperature before entering the intake manifold. The cooled, compressed air is then delivered to the engine cylinders for combustion, improving power and efficiency.

3. (a) A technician observes poor acceleration and black smoke emission from the exhaust of a diesel vehicle. Identify five possible causes.

A clogged air filter restricts airflow into the engine, resulting in a rich fuel mixture and black smoke.

Faulty or worn fuel injectors may deliver excessive fuel into the cylinders, leading to incomplete combustion and smoke.

A malfunctioning turbocharger can reduce air boost, causing improper air-fuel ratios and poor performance.

A defective fuel pressure regulator may supply excessive fuel pressure, increasing injector flow and causing over-fueling.

ECU sensor issues, such as a faulty mass airflow or intake pressure sensor, can lead to incorrect fuel delivery and inefficient combustion.

(b) Describe how a multimeter can be used to test:

(i) Battery voltage
Set the multimeter to DC voltage, place the red probe on the positive battery terminal and the black probe on the negative terminal. A healthy battery should read around 12.6V when off and 13.5–14.5V when charging.

(ii) Continuity in a circuit
Set the multimeter to continuity mode. Touch the two probes across the section of wire or component being tested. A beep indicates continuity; no beep means an open circuit.

(iii) Alternator charging voltage
Start the engine and measure voltage across the battery terminals. A reading between 13.5V and 14.5V confirms proper charging. Anything below 13V or above 15V indicates alternator or regulator issues.

(c) Discuss three benefits of using electronic fuel injection (EFI) over a carburetor system in modern vehicles.

EFI provides better fuel efficiency and more precise fuel delivery, adjusting the mixture based on real-time engine parameters for optimal performance.

It reduces emissions by ensuring complete combustion, as sensors constantly monitor and adjust the air-fuel ratio.

EFI improves engine start-up, especially in cold conditions, by regulating fuel flow accurately, unlike carburetors that rely on manual choke adjustments.

(d) Highlight three challenges associated with diagnosing faults in electronically controlled engines.

Electronic systems involve numerous interconnected sensors and control modules, making fault tracing complex and requiring diagnostic equipment.

Faults may be intermittent or triggered by software glitches, making them hard to replicate and diagnose without real-time monitoring.

Technicians must have updated training and tools to interpret error codes and manufacturer-specific systems, increasing the learning curve and repair time.

4. (a) State four vehicle systems that are directly affected when the engine's ECU malfunctions and briefly explain how.

The fuel injection system may deliver incorrect fuel amounts, resulting in poor performance, high fuel consumption, or engine stalling.

The ignition system may experience misfires or timing errors, affecting acceleration and potentially damaging engine components.

The emission control system, including EGR and catalytic converter regulation, may malfunction, leading to increased pollution and possible regulatory violations.

The cooling fan system may fail to engage at the right temperature, causing overheating and possible engine damage.

(b) Explain the term "detonation" in internal combustion engines and its effects on engine components.

Detonation is the uncontrolled explosion of the air-fuel mixture in the combustion chamber after the spark plug has already ignited the charge. It causes high-pressure shock waves that can damage the piston crown, cylinder walls, spark plugs, and bearings, eventually leading to engine failure if not addressed.

(c) Complete the following table by filling the stroke activity of each cylinder at a given crank angle for a four-cylinder engine with firing order 1-3-4-2.

Cylinder	Stroke
1	Power
3	Compression
4	Induction
2	Exhaust

5. (a) Compare four differences between dry-sump and wet-sump lubrication systems.

In a dry-sump system, oil is stored in an external reservoir, while in a wet-sump system, oil is stored in a sump (oil pan) located beneath the engine. This design difference allows dry-sump systems to offer better ground clearance and engine placement flexibility.

Dry-sump systems use multiple oil pumps one to scavenge oil from the engine and another to supply it—whereas wet-sump systems use a single pump to circulate oil throughout the engine.

A dry-sump system provides consistent oil pressure even under high acceleration, braking, or cornering, making it suitable for performance and racing vehicles. Wet-sump systems may suffer oil starvation under such conditions due to oil sloshing.

Dry-sump systems are more complex, heavier, and expensive to maintain, while wet-sump systems are simpler, cheaper, and commonly used in regular road vehicles.

(b) A 4-cylinder engine with a bore of 90 mm and a stroke of 100 mm operates at 3500 rpm with a volumetric efficiency of 85%. Calculate the volume of air inducted per minute in cubic meters.

First, calculate the displacement volume per cylinder:

Bore = 90 mm = 0.09 m
Stroke = 100 mm = 0.1 m
Number of cylinders = 4

Volume per cylinder = $(\pi/4) \times \text{bore}^2 \times \text{stroke}$
$= (3.1416/4) \times (0.09)^2 \times 0.1$
$= 0.000636\ m^3$

Total engine displacement = $0.000636 \times 4 = 0.002544\ m^3$

Since it's a four-stroke engine, each cylinder intakes once every two revolutions:

Intake events per minute = (RPM / 2) × number of cylinders = (3500 / 2) × 4 = 7000 intake strokes

Total air per minute (ideal) = 7000 × 0.000636 = 4.452 m^3

Considering volumetric efficiency (85%):

Actual air inducted = 4.452 × 0.85 = **3.784 m^3 per minute**

(c) Outline four essential conditions for achieving complete combustion in internal combustion engines.

An ideal air-fuel mixture is required, generally around 14.7:1 for petrol engines. Deviations from this ratio can lead to incomplete combustion and excess emissions.

Adequate air supply must be maintained through clean air filters and unobstructed intake systems to ensure sufficient oxygen is available.

Proper ignition timing ensures that the spark occurs at the right moment to burn the mixture efficiently. Too early or too late ignition can result in partial combustion.

Effective compression is needed to raise the temperature of the air-fuel mixture to levels that promote complete combustion. Low compression can reduce flame propagation.

6. (a) Explain the importance of performing wheel alignment and how it affects the following:

(i) Tyre wear
Incorrect alignment causes uneven contact between the tire and road surface. This leads to premature wear on one side of the tire and reduces tire lifespan.

(ii) Steering response
Poor alignment affects how the vehicle responds to steering input, making it feel loose, sluggish, or pull to one side, reducing handling performance and control.

(iii) Fuel economy
When wheels are misaligned, rolling resistance increases, forcing the engine to work harder to move the vehicle. This results in higher fuel consumption.

(b) Describe the operational difference between mechanical drum brakes and hydraulic disc brakes.

Mechanical drum brakes use cables and levers to push brake shoes outward against the inner surface of a rotating drum. Their operation relies on mechanical linkages, and they are often found on rear wheels of older or economy vehicles.

Hydraulic disc brakes use brake fluid pressure to push caliper pistons against pads, which clamp onto a rotating disc. They provide better heat dissipation, more consistent braking force, and quicker response, especially under repeated use.

(c) What are the effects of each of the following faults in a braking system?

(i) Air in brake lines
Air is compressible, unlike brake fluid. Presence of air reduces braking efficiency, causing a spongy pedal and poor brake response.

(ii) Worn brake pads
Worn pads reduce braking force and can lead to metal-to-metal contact with the disc, causing noise, vibration, and damage to brake rotors.

(iii) Damaged master cylinder
A faulty master cylinder may fail to generate adequate hydraulic pressure, leading to brake failure, fluid leakage, or a sinking brake pedal.

(iv) Uneven brake fluid levels
Uneven or low brake fluid can cause one brake circuit to fail or underperform, resulting in uneven braking and increased stopping distance.

7. (a) List four components mounted on a propeller shaft and explain the function of each.

Universal joints (U-joints) allow for flexible movement of the shaft as the vehicle suspension moves, preventing binding during rotation.

A slip yoke allows for length changes in the shaft during suspension movement, ensuring smooth torque transfer without stressing components.

A center bearing supports a two-piece propeller shaft, maintaining alignment and reducing vibrations in longer shaft assemblies.

The flange or yoke connects the propeller shaft to the gearbox output or differential input, enabling torque transmission.

(b) Describe the operation of a constant velocity joint and give two advantages over universal joints.

A CV joint transmits torque at a constant speed regardless of the angle between shafts. It uses bearings and a ball cage to maintain uniform motion and smooth operation.

Advantages over U-joints include smoother power delivery at sharp angles and reduced vibration, especially in front-wheel-drive vehicles where large angle changes occur.

(c) An automotive technician is tasked with replacing rear axle bearings. Outline the step-by-step procedure to perform this service, mentioning at least five steps.

Lift the vehicle and safely support it on jack stands. Remove the wheels and brake assemblies to expose the axle shaft.

Remove the differential cover and slide out the C-clips or retaining bolts to release the axle shaft.

Pull the axle shaft outward to access the bearing and use a slide hammer or bearing puller to remove the old bearing from the axle housing.

Clean the bearing seat and press in the new bearing using a bearing installer tool or appropriate socket and hammer.

Reinstall the axle shaft, secure it with clips or bolts, replace the differential cover, refill gear oil, and reassemble the brakes and wheels.

(d) Explain how torque is transferred from the engine to the drive wheels in a front-wheel-drive vehicle.

The engine's output torque is transferred to the gearbox, where it is reduced or multiplied depending on gear selection.

From the gearbox, torque flows to the differential, which splits the power and allows the two front wheels to rotate at different speeds during turning.

The differential connects to drive shafts equipped with constant velocity joints, which transmit torque to the front wheel hubs while allowing suspension and steering movement.

At the wheel hubs, the rotational force turns the wheels and propels the vehicle forward.

8. (a) List four functions of engine mountings in a motor vehicle.

They support the weight of the engine and hold it securely in position within the engine bay.

They absorb and isolate engine vibrations from the chassis to improve comfort and reduce noise.

They allow limited engine movement during acceleration and deceleration, preventing stress on other components like exhaust or hoses.

They help maintain proper engine alignment with the transmission and drivetrain for efficient power transfer.

(b) Describe the procedure of adjusting valve clearance in a four-stroke engine.

Warm up the engine to normal operating temperature, then shut it down and allow slight cooling for safe handling.

Remove the valve cover to access the rocker arms and valves. Rotate the crankshaft to bring cylinder number one to top dead center (TDC) on the compression stroke.

Use a feeler gauge to measure the gap between the rocker arm and valve stem. Compare the reading to the manufacturer's specification.

If adjustment is needed, loosen the locknut and turn the adjustment screw until the correct clearance is obtained, then retighten the locknut.

Repeat the procedure for the remaining valves, recheck all clearances, and reinstall the valve cover after completion.

(c) Identify five common faults found in suspension systems and explain their impact on vehicle handling and safety.

Worn shock absorbers lead to poor damping of road impacts, causing bouncing, reduced traction, and longer braking distances.

Broken or sagging springs affect ride height and cause uneven tire wear, reducing stability during cornering and braking.

Loose or damaged suspension bushings result in excessive play in control arms, leading to poor alignment and handling.

Bent control arms or struts misalign the wheels, increasing tire wear and reducing steering accuracy and comfort.

Leaking struts or shocks reduce suspension effectiveness, leading to nose diving during braking and body roll during turns, increasing rollover risk.