THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2014**

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) List five engine-related faults that may trigger the check engine light on a modern vehicle dashboard.

A faulty oxygen sensor can cause the check engine light to illuminate, as it affects the air-fuel mixture and leads to increased emissions or poor fuel economy.

A misfiring cylinder due to a worn spark plug or ignition coil failure results in incomplete combustion, triggering the light and potentially damaging the catalytic converter.

A loose or faulty gas cap may cause fuel vapor leaks, reducing fuel system pressure and prompting the check engine light to indicate an evaporative emission fault.

A malfunctioning mass airflow sensor (MAF) provides incorrect airflow data to the ECU, disrupting fuel injection calculations and triggering the warning light.

A clogged or defective catalytic converter can increase exhaust backpressure and reduce engine performance, which the ECU detects and flags with a check engine warning.

(b) Describe the correct procedure for removing a cylinder head from an overhead camshaft engine.

First, disconnect the battery and drain the coolant and engine oil. Remove all necessary components such as the air intake assembly, exhaust manifold, radiator hoses, and wiring harnesses connected to the cylinder head.

Next, remove the timing belt or chain. On overhead camshaft engines, you must carefully align timing marks and remove the camshaft sprockets. Loosen the camshaft bearing caps in sequence and remove the camshaft if required.

Loosen the cylinder head bolts in the correct reverse sequence (as per the service manual) to prevent warping. Once all bolts are loose, lift the cylinder head straight up from the block, using guide studs or a hoist if needed.

Finally, place the head on a clean surface and inspect the head gasket, combustion chambers, and valves for damage or wear.

(c) Explain three advantages of using aluminum alloy in engine block construction.

Aluminum alloys are significantly lighter than cast iron, reducing the overall weight of the vehicle and improving fuel efficiency and handling.

They offer excellent heat dissipation properties, allowing the engine to run cooler and reducing the risk of overheating during high-performance operation.

Aluminum can be easily cast into complex shapes, allowing for better integration of cooling passages and other internal structures, which improves design flexibility and efficiency.

2. (a) (i) What is the function of a manifold absolute pressure (MAP) sensor?

The MAP sensor measures the pressure inside the intake manifold. This data is used by the ECU to calculate air density and determine the correct amount of fuel to inject for efficient combustion.

(ii) Mention four symptoms of a faulty MAP sensor in an engine.

A faulty MAP sensor can cause rough idling due to incorrect air-fuel ratio adjustments.

It may result in poor fuel economy as the ECU delivers too much or too little fuel.

Engine hesitation or stalling can occur during acceleration due to improper sensor readings.

The check engine light may illuminate, and diagnostic trouble codes related to the MAP sensor may be stored in the ECU.

(iii) Why is accurate MAP sensor data critical to engine performance?

Accurate MAP sensor readings ensure the ECU calculates the correct amount of fuel and ignition timing. Incorrect readings lead to poor combustion, reduced power, increased emissions, and potential engine damage.

(b) (i) State the difference between direct and indirect fuel injection in diesel engines.

In direct injection, fuel is sprayed directly into the combustion chamber, while in indirect injection, fuel is injected into a pre-combustion chamber where it partially burns before entering the main cylinder.

(ii) Explain two benefits and two drawbacks of direct injection.

Direct injection offers better fuel efficiency and power due to precise fuel delivery and improved combustion.

It also enables cleaner emissions by optimizing the air-fuel mixture under various engine loads.

However, it can produce more noise during combustion and is more sensitive to poor fuel quality, leading to injector clogging or carbon buildup.

(c) Sketch and describe a simple fuel return system in a diesel engine.

The fuel return system includes a fuel tank, fuel pump, injectors, and return lines. Excess fuel not injected into the combustion chamber is routed from the injectors back to the fuel tank via the return lines. This system helps cool the injectors and maintain consistent pressure by recycling unused fuel.

3. (a) A vehicle fitted with anti-lock braking system (ABS) skids on wet roads. Identify five likely causes.

A faulty ABS wheel speed sensor may provide incorrect readings, causing the ABS to malfunction and fail to prevent wheel lock.

Damaged ABS wiring or connectors can lead to signal loss, preventing the ABS module from controlling brake pressure accurately.

A malfunctioning ABS control module may fail to process sensor inputs or modulate braking, resulting in loss of anti-lock function.

Worn or uneven brake pads may reduce braking performance, causing some wheels to lock up before the system can react.

Incorrect tire pressure or mismatched tires can cause uneven traction, leading to premature skidding before ABS can respond effectively.

(b) Briefly explain how to diagnose an alternator using a multimeter and observation.

Start by checking battery voltage with the engine off—it should read around 12.6V. Start the engine and measure again. A properly functioning alternator should raise the voltage to between 13.8V and 14.5V.

Observe the dashboard warning light; if it stays on while running, the alternator may not be charging.

Check for unusual noises like whining or grinding from the alternator, which could indicate bearing or pulley problems.

(c) What is meant by engine surging, and what are three potential causes?

Engine surging refers to a condition where engine speed fluctuates repeatedly without driver input, often felt as pulsing or jerking while cruising.

It may be caused by a faulty idle air control valve that improperly regulates airflow during idle and low-speed driving.

Vacuum leaks can introduce unmetered air, disrupting the air-fuel ratio and causing speed instability.

Dirty or malfunctioning fuel injectors may deliver inconsistent fuel quantities, leading to irregular combustion and RPM fluctuations.

(d) Mention three factors that influence the efficiency of an internal combustion engine.

Compression ratio greatly affects thermal efficiency; higher ratios allow more energy to be extracted from combustion.

The air-fuel mixture quality must be ideal (stoichiometric) for complete combustion and minimal energy loss.

Ignition timing must be accurately controlled to ensure peak pressure occurs at the right point in the piston stroke, maximizing power output and fuel efficiency.

4. (a) With reference to vehicle electrical systems, explain the function of the following:

(i) Starter solenoid
The starter solenoid acts as a high-current switch that connects the battery to the starter motor when the ignition key is turned. It also pushes the pinion gear into the flywheel to crank the engine.

(ii) Voltage regulator
The voltage regulator maintains a consistent output voltage from the alternator to the battery and electrical system, preventing overcharging or undercharging.

(iii) Fusible link
A fusible link is a short piece of wire designed to melt and break the circuit under excessive current, protecting sensitive components in the wiring harness.

(b) Describe how to perform a cylinder balance test on a petrol engine and interpret the results.

Start the engine and allow it to idle at a steady speed. Using a diagnostic tool or by manually disabling one injector or spark plug at a time, monitor the engine's RPM drop.

Each cylinder should cause a similar drop in RPM when disabled. If disabling one cylinder results in little or no RPM change, that cylinder may be weak due to a fuel, ignition, or compression issue.

(c) A four-cylinder engine has a firing order 1-3-4-2. Fill in the table below for the strokes assuming cylinder 1 is on the power stroke.

Cylinder	Stroke
1	Power
3	Compression
4	Induction
2	Exhaust

5. (a) Differentiate between lean and rich air-fuel mixtures. How does each affect combustion and emissions?

A lean air-fuel mixture contains more air and less fuel than the stoichiometric ratio (typically 14.7:1 for petrol). While it improves fuel economy and reduces carbon monoxide emissions, it may cause engine knocking, misfiring, or higher NOx emissions due to high combustion temperatures.

A rich air-fuel mixture has more fuel and less air than the ideal ratio. It results in smoother operation and more power, but increases fuel consumption and leads to higher emissions of unburned hydrocarbons and carbon monoxide, potentially damaging the catalytic converter.

(b) A six-cylinder engine has a bore of 86 mm and a stroke of 90 mm. Determine the engine displacement in liters.

First, convert units to meters:
Bore = 86 mm = 0.086 m
Stroke = 90 mm = 0.09 m
Number of cylinders = 6

Volume per cylinder = $(\pi/4) \times \text{bore}^2 \times \text{stroke}$
$= (3.1416 / 4) \times (0.086)^2 \times 0.09$
$= 0.000521\ m^3$ per cylinder

Total displacement = $0.000521 \times 6 = 0.003126\ m^3$
Convert to liters: $0.003126 \times 1000 =$ **3.13 liters**

So, the engine displacement is approximately **3.13 L**

(c) List four possible effects of operating an engine with incorrect valve timing.

Incorrect valve timing can lead to a loss of power because valves open or close at the wrong time, disrupting the intake and exhaust flow.

It can cause engine misfires and rough idling, especially when the intake valves open too early or the exhaust valves close too late.

Poor fuel economy may occur because combustion efficiency is reduced due to improper airflow and fuel burn.

In severe cases, valve-to-piston contact can happen in interference engines, causing serious mechanical damage to valves and pistons.

6. (a) Explain the construction and working of a torsion bar suspension system.

A torsion bar is a long, straight steel bar fixed at one end to the vehicle frame and connected at the other to a control arm. When the wheel encounters a bump, the control arm moves upward, twisting the torsion bar.

As the bar twists, it resists the motion by generating a restoring torque, absorbing road shocks and returning the suspension to its original position. It functions like a spring and can be adjusted by changing the preload on the bar.

(b) Describe the difference between toe-in and toe-out, and state the effect of incorrect adjustment on tyre wear.

Toe-in means the front edges of the wheels point slightly toward each other, while toe-out means the front edges point slightly away from each other when viewed from above.

Incorrect toe settings cause uneven tire wear. Too much toe-in wears the outer edges of the tires, and excessive toe-out wears the inner edges. Both conditions can reduce vehicle stability and increase rolling resistance.

(c) Give three effects of a faulty steering damper on vehicle performance.

A faulty steering damper allows uncontrolled movement of the steering system, resulting in steering wheel vibration or “shimmy” over rough terrain.

It can reduce directional stability, making it harder to keep the vehicle traveling in a straight line at high speeds.

Steering may feel loose or overly sensitive, increasing driver fatigue and reducing vehicle control, especially in off-road or commercial vehicles.

7. (a) Identify four advantages of using a double universal joint in a propeller shaft system.

It allows torque transmission at larger operating angles without causing vibration, making it suitable for longer or misaligned driveshafts.

It maintains a constant angular velocity between the input and output shafts when configured properly with equal angles.

It reduces wear and stress on connected components by minimizing angular acceleration fluctuations.

It enhances smoothness and efficiency of power transfer in vehicles with complex driveline layouts or raised suspensions.

(b) Explain the working principle of a limited-slip differential (LSD).

A limited-slip differential allows for power distribution to both drive wheels while limiting the difference in speed between them.

When one wheel begins to slip, friction plates or helical gears within the LSD resist excessive speed difference, transferring more torque to the wheel with better traction. This improves stability and traction on slippery or uneven surfaces compared to a standard open differential.

(c) An engine produces a torque of 210 Nm at 2500 rpm. If the transmission has an efficiency of 85% and a gear ratio of 4:1, calculate the torque and speed at the propeller shaft.

Output speed = Engine speed / Gear ratio
= 2500 / 4 = 625 rpm

Output torque = Engine torque × Gear ratio × Efficiency
= 210 × 4 × 0.85 = 714 Nm

So, the propeller shaft will rotate at **625 rpm** with **714 Nm** of torque.

8. (a) Give four symptoms of a faulty thermostat in a cooling system.

An engine that takes unusually long to reach operating temperature may indicate a thermostat stuck open, allowing continuous coolant flow.

Overheating shortly after engine start may suggest a thermostat stuck closed, preventing coolant from circulating through the radiator.

Poor fuel economy may occur if the engine runs below optimal temperature due to an open thermostat, causing the ECU to enrich the mixture.

Erratic temperature gauge readings, such as fluctuating needle or sudden spikes, can signal thermostat malfunction or blockage.

(b) Describe the step-by-step procedure of pressure testing a radiator for leaks.

Ensure the engine is cool, then remove the radiator cap.

Attach a radiator pressure tester to the filler neck and pump the tester to pressurize the system to the rated pressure (usually marked on the cap).

Observe the gauge for several minutes. A steady drop in pressure indicates a leak in the system.

Inspect hoses, radiator core, water pump, and heater core for visible signs of coolant leakage.

Release the pressure carefully after testing, remove the tester, and reinstall the radiator cap.

(c) Identify four common faults in the exhaust system and explain their effects on engine performance and emissions.

A cracked exhaust manifold can cause exhaust leaks, leading to reduced engine efficiency, increased noise, and potential sensor errors due to unmeasured air entry.

A clogged catalytic converter increases exhaust backpressure, reducing engine power and efficiency, and may trigger the check engine light.

Leaking exhaust gaskets or joints can allow harmful gases to escape before they are treated, increasing pollution and posing a health hazard.

A damaged muffler may cause excessive noise and vibration, and in some cases, disrupt backpressure balance, affecting engine performance.