THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2015**

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 major causes that can lead to low engine oil pressure during vehicle operation.

A worn-out oil pump may fail to circulate oil with adequate pressure throughout the engine. As the pump's internal components wear out, it loses the ability to maintain pressure, especially at idle or high temperatures.

Insufficient engine oil level caused by leakage, burning, or neglect leads to a shortage of oil for circulation. This reduces pressure and increases the risk of engine component wear or failure.

Worn main and rod bearings create excess clearance between bearing surfaces and crankshaft journals, allowing oil to escape more freely and lowering pressure in the lubrication system.

A clogged oil filter restricts the flow of oil to vital engine components, resulting in pressure drops. In some cases, the bypass valve may open, allowing unfiltered oil into the system.

Using oil with incorrect viscosity, especially too thin for the engine's operating conditions, can reduce the oil's ability to maintain a proper pressure film between moving parts.

(b) Describe the step-by-step procedure followed when replacing a timing belt in a four-cylinder overhead camshaft engine.

First, disconnect the battery and remove all necessary components obstructing access to the timing belt, including the engine covers, belts, and accessories like the alternator or power steering pump.

Drain the coolant if the water pump is driven by the timing belt, then remove the crankshaft pulley and timing belt covers.

Rotate the engine by hand until the timing marks on the crankshaft and camshaft pulleys align at top dead center (TDC) for cylinder one.

Loosen the tensioner and remove the old timing belt carefully. Inspect the tensioner, idler pulley, and water pump, and replace them if worn.

Install the new belt, making sure the timing marks remain aligned. Adjust the tensioner and check belt tension by hand rotation of the crankshaft two full revolutions back to TDC.

Reassemble all removed components, refill coolant if necessary, reconnect the battery, and start the engine to check for proper operation and unusual noises.

(c) Identify three types of oil pumps used in internal combustion engines and explain one advantage of each.

Gear-type oil pumps use intermeshing gears to create suction and pressure. They are simple in design, highly durable, and provide consistent flow at various engine speeds.

Rotor (or gerotor) pumps consist of an inner and outer rotor. They are compact and efficient, making them ideal for modern engines with limited space and lower noise levels.

Trochoid pumps use an inner and outer rotor in an oval-shaped housing. Their high-volume capacity and smoother flow characteristics make them suitable for high-performance engines.

2. (a) (i) What is the function of a knock sensor in a modern petrol engine?

The knock sensor detects vibrations caused by abnormal combustion (knock or detonation) inside the engine cylinders. It sends signals to the ECU, which adjusts ignition timing to prevent engine damage and optimize performance.

(ii) Mention four signs that indicate a knock sensor is faulty.

A loss of engine power may occur because the ECU retards timing as a precaution when the knock sensor fails to send valid signals.

The check engine light may illuminate on the dashboard due to stored fault codes related to the knock sensor.

Poor fuel economy can result from incorrect ignition timing caused by the absence of input from the sensor.

Engine knocking or pinging sounds might occur because the ECU is unable to detect and correct the abnormal combustion.

(iii) How does the ECU adjust engine operation based on input from the knock sensor?

When the knock sensor detects detonation, the ECU retards the ignition timing to reduce cylinder pressure and eliminate knocking. Once knocking subsides, the ECU gradually advances the timing to restore optimal performance and efficiency.

(b) (i) Differentiate between open-loop and closed-loop fuel control systems used in electronic fuel injection.

An open-loop system operates based on preset parameters without feedback from oxygen sensors, typically during engine warm-up or high-load conditions. It cannot adjust fuel delivery based on real-time emissions or combustion efficiency.

A closed-loop system continuously monitors feedback from oxygen sensors in the exhaust to adjust the air-fuel mixture in real time. This results in more accurate fuel control, better performance, and lower emissions.

(ii) Explain two reasons why closed-loop systems are preferred over open-loop systems in modern vehicles.

Closed-loop systems reduce emissions significantly by maintaining an optimal stoichiometric air-fuel ratio, helping the vehicle meet modern environmental regulations.

They also improve fuel economy by adjusting fuel delivery based on actual combustion results, making them more efficient in varied driving conditions.

(c) Sketch and explain a cross-flow cylinder head design, stating its advantages in combustion efficiency and engine performance.

A cross-flow cylinder head design has intake and exhaust ports on opposite sides of the combustion chamber. This layout allows fresh air-fuel mixture to enter from one side while exhaust gases exit through the other.

This separation improves airflow, increases volumetric efficiency, and reduces heat transfer between intake and exhaust, leading to better combustion, enhanced power output, and improved fuel economy.

3. (a) List five possible causes of continuous white smoke emission from the exhaust pipe of a petrol engine.

A blown head gasket allows coolant to enter the combustion chamber, resulting in white steam-like smoke from the exhaust.

A cracked cylinder head or engine block can leak coolant into the cylinders, causing similar symptoms to a head gasket failure.

Coolant leaking into the intake manifold due to a faulty intake gasket or corrosion can produce white smoke during combustion.

Condensation in the exhaust system may generate white vapor, especially during cold starts, although this should disappear after warm-up.

Using transmission fluid in engines with vacuum-assisted transmission modulators can allow fluid to be drawn into the intake, causing white exhaust smoke.

(b) Explain the correct method for performing a battery load test and how to interpret the test results.

First, fully charge the battery and allow it to rest. Measure its open-circuit voltage; it should be about 12.6 volts for a fully charged 12V battery.

Connect a battery load tester and apply a load equal to half the battery's cold cranking amps (CCA) rating for 15 seconds.

Monitor the voltage during the load. If it stays above 9.6 volts at room temperature, the battery is good. If it drops below 9.6 volts, the battery is weak or failing.

(c) What is engine hesitation and what are three common faults that may lead to this problem during acceleration?

Engine hesitation is a delay or stumble in power delivery when the driver accelerates. It feels like a temporary loss of power or jerking motion.

A clogged fuel injector may not deliver adequate fuel during rapid throttle input, causing a lean condition and hesitation.

A faulty throttle position sensor (TPS) can send incorrect signals to the ECU, delaying the fuel response and affecting acceleration.

Ignition system problems such as worn spark plugs or coils can result in misfires during acceleration, contributing to hesitation.

(d) Describe how the electronic throttle control system works and how it differs from the mechanical throttle system.

Electronic throttle control (ETC) replaces the traditional cable between the accelerator pedal and throttle body with electronic sensors and actuators.

When the driver presses the accelerator, the pedal position sensor sends a signal to the ECU. The ECU processes this input and commands an electric motor to adjust the throttle valve accordingly.

Unlike mechanical systems, ETC allows for smoother acceleration, better fuel efficiency, and integration with features like cruise control and traction systems.

4. (a) Identify and explain four engine-related faults that may lead to increased hydrocarbon (HC) emissions from a petrol engine.

A misfiring cylinder caused by faulty spark plugs or ignition coils results in unburned fuel exiting the exhaust, increasing HC emissions.

A rich air-fuel mixture delivers more fuel than necessary, which may not combust completely, contributing to higher hydrocarbons.

A leaking fuel injector allows fuel to enter the cylinder continuously or dribble after shutdown, creating unburned vapor in the exhaust.

Poor compression due to worn piston rings or valves reduces combustion efficiency, leaving unburned hydrocarbons in the exhaust stream.

(b) Describe the procedure for conducting a vacuum test on a petrol engine and explain what high, low, or fluctuating readings indicate about engine condition.

Connect a vacuum gauge to a manifold vacuum source with the engine idling at normal temperature. A healthy engine should read steady vacuum between 17–22 inches of mercury (Hg).

A low steady reading may indicate late ignition timing or leaking valves.

A fluctuating needle may suggest valve problems or a leaking head gasket.

A steady but high reading could point to a restricted exhaust or high idle speed.

(c) Explain the importance of correct firing order in a four-cylinder engine and how wrong firing order affects engine operation.

Correct firing order ensures balanced power delivery, smooth engine operation, and proper exhaust scavenging. It also prevents mechanical stress on the crankshaft and avoids backfiring.

If the firing order is incorrect, cylinders fire at the wrong time, causing misfires, engine vibration, rough idling, and potential engine damage due to improper combustion or exhaust overlap.

5. (a) List four main functions of a cooling fan in an internal combustion engine.

The cooling fan increases airflow through the radiator when the vehicle is stationary or moving slowly, helping to dissipate heat from the coolant effectively.

It assists in maintaining a stable engine operating temperature by ensuring adequate cooling even under heavy engine loads or in hot environments.

The fan helps prevent engine overheating by supplementing natural airflow during low-speed conditions or when idling for extended periods.

It supports the efficiency of the air conditioning system by providing additional airflow across the condenser, enhancing heat transfer.

(b) A V6 engine has a bore of 92 mm and a stroke of 88 mm. Calculate its total displacement in liters.

Convert the bore and stroke into meters:
Bore = 92 mm = 0.092 m
Stroke = 88 mm = 0.088 m
Number of cylinders = 6

Volume per cylinder = $(\pi/4) \times \text{bore}^2 \times \text{stroke}$
$= (3.1416 / 4) \times (0.092)^2 \times 0.088$
= 0.00672 liters (approximately per cylinder)

Total displacement = 0.00672 × 6 = **4.032 liters**

So, the total engine displacement is approximately **4.03 liters**

(c) Mention four negative effects of running an engine at excessively high temperatures for prolonged periods.

Prolonged overheating can cause the cylinder head to warp, leading to head gasket failure, coolant leaks, and loss of compression.

The engine oil may degrade rapidly at high temperatures, reducing its lubrication ability and accelerating wear of internal engine components.

Pistons may expand beyond their design tolerance and seize within the cylinder, causing scoring or total engine seizure.

Excessive heat can damage seals, hoses, and plastic components, leading to fluid leaks, electrical issues, and engine bay deterioration.

6. (a) Describe the construction and working principle of a MacPherson strut suspension system.

The MacPherson strut combines a shock absorber and coil spring into a single unit mounted between the wheel hub and the vehicle body.

The bottom of the strut connects to the steering knuckle or wheel hub assembly, while the top mounts to the strut tower on the vehicle chassis.

As the wheel moves over bumps, the spring compresses, and the shock absorber dampens the motion. This system reduces body roll and maintains tire contact with the road.

It's widely used in front suspensions due to its simplicity, space-saving design, and reduced weight.

(b) Explain the difference between positive and negative camber and their specific effects on vehicle handling and tyre wear.

Positive camber is when the top of the wheel tilts outward, away from the vehicle. It improves straight-line stability but reduces cornering grip and may cause outer-edge tire wear.

Negative camber is when the top of the wheel tilts inward. It enhances grip during cornering by keeping the tire contact patch flat, but excessive negative camber may lead to inner-edge tire wear.

(c) State three possible causes of uneven tyre wear and explain the consequences of each.

Improper wheel alignment causes tires to wear more on one edge. For example, excessive toe-in or toe-out leads to feathered or scuffed tread surfaces.

Worn suspension components, such as control arm bushings or ball joints, can cause tires to move irregularly, resulting in patchy or diagonal wear patterns.

Incorrect tire pressure leads to uneven wear underinflated tires wear more on the edges, while overinflated tires wear more in the center.

7. (a) Mention four advantages of using a transaxle in front-wheel-drive vehicles.

A transaxle integrates the transmission, differential, and drive axle into a single compact unit, saving space and reducing weight, which is ideal for front-wheel-drive configurations.

It improves fuel economy due to its lighter design and fewer components compared to separate transmission and differential units.

By placing the weight of the drivetrain over the drive wheels, transaxles enhance traction, especially during acceleration and in slippery conditions.

They simplify vehicle assembly and maintenance by reducing the number of separate drivetrain parts and connections.

(b) Explain the working principle of a synchronizer unit in a manual transmission system.

A synchronizer allows the gear and the shaft to match speeds before engagement, enabling smooth shifting without gear grinding.

When the driver selects a gear, the selector hub pushes the synchronizer sleeve toward the desired gear. Friction surfaces inside the synchronizer cone bring the gear up to shaft speed.

Once synchronized, the sleeve locks the gear to the shaft via dog teeth, completing the shift without harsh engagement.

(c) An engine produces 180 Nm of torque at 4000 rpm. If the gearbox has a gear ratio of 3.5:1 and an efficiency of 90%, calculate the torque and output speed at the driveshaft.

Output speed = Engine speed ÷ Gear ratio
= 4000 ÷ 3.5 = **1142.86 rpm**

Output torque = Engine torque × Gear ratio × Efficiency
= 180 × 3.5 × 0.9 = **567 Nm**

So, the output speed at the driveshaft is approximately **1143 rpm**, and the torque is **567 Nm**

8. (a) List four symptoms that may indicate a restricted exhaust system in a vehicle.

Loss of engine power, especially at higher RPMs, may suggest backpressure buildup due to restriction.

Engine may overheat more quickly because exhaust gases are not expelled efficiently.

Reduced fuel economy can result from the engine working harder to push exhaust gases through a restricted system.

Unusual noises like hissing or whistling may be heard from the exhaust due to partial blockages or collapsed internal components.

(b) Describe the procedure of performing an exhaust backpressure test and explain how to interpret the results.

Remove the upstream oxygen sensor and install a pressure gauge in its place.

Start the engine and observe the pressure reading at idle. A reading below 1.5 psi is normal. If the reading exceeds 3 psi, there's likely a restriction.

Raise the RPM to 2500 and monitor the pressure. A rapidly rising pressure indicates blockage in the catalytic converter or muffler.

(c) Identify four sources of abnormal engine noise and explain how each can be diagnosed effectively.

A knocking sound from the lower engine area may indicate worn crankshaft bearings, which can be confirmed through an oil pressure test or by removing the oil pan for inspection.

Tapping or ticking noises may be caused by worn valve lifters or loose rocker arms, often diagnosed by checking valve clearance or using a stethoscope on the valve cover.

Squealing sounds may originate from a worn or loose serpentine belt and can be verified by inspecting belt tension and condition.

Pinging or detonation noises during acceleration suggest abnormal combustion, which may be confirmed using a scan tool to check timing advance and knock sensor activity.