THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2012**

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) Describe five safety precautions that should be taken during the removal and refitting of engine components in an automotive workshop.

Before beginning any engine work, disconnect the vehicle's battery to avoid electrical shocks or accidental short circuits. This is especially important when working near the starter motor or alternator.

Use proper lifting equipment such as an engine hoist or crane when removing or reinstalling the engine. This prevents injuries caused by lifting heavy components manually and reduces the risk of damaging the engine.

Label all removed wires, hoses, and bolts clearly to avoid confusion during reassembly. This also helps prevent incorrect connections which may lead to engine malfunction.

Always wear personal protective equipment including gloves, safety boots, and safety glasses to protect yourself from sharp edges, chemical splashes, or falling parts.

Ensure the work area is well-ventilated and clean. Spilled oil or coolant should be cleaned immediately to prevent slipping and to maintain a safe and organized workspace.

(b) What precautions must be observed when working with each of the following tools?

(i) Torque wrench
Ensure the torque wrench is calibrated correctly before use. Set the correct torque value according to the manufacturer's specifications and avoid using the tool as a breaker bar, which can damage its mechanism.

(ii) Pneumatic wrench
Inspect hoses and connectors before use to ensure there are no air leaks. Hold the wrench firmly during operation and wear ear protection, as pneumatic tools generate high noise levels.

(iii) Screwdriver
Use the correct size and type of screwdriver for the screw head to prevent slipping and damage. Keep the handle dry and clean for a firm grip, and avoid using a screwdriver as a chisel or pry bar.

(c) Sketch and label three types of commonly used vehicle chassis layout.

(i) Front-engine rear-wheel-drive layout: The engine is positioned at the front, and power is transmitted to the rear wheels through a propeller shaft.

(ii) Front-engine front-wheel-drive layout: The engine and transmission are located at the front, and power is transmitted directly to the front wheels.

(iii) Rear-engine rear-wheel-drive layout: The engine is mounted at the rear of the vehicle, transmitting power to the rear wheels directly, commonly seen in sports and compact vehicles.

2. (a) (i) What is the function of a micrometer in an automotive workshop?

A micrometer is used to measure small distances or thicknesses with high precision. In an automotive workshop, it is commonly used for measuring engine components like cylinder bores, crankshaft journals, valve stems, and bearing thickness.

(ii) Mention four types of micrometers and indicate the use of each.

The outside micrometer is used to measure the outside diameter or thickness of components like shafts and rods.

The inside micrometer is designed to measure the internal diameter of bores and cylinders.

The depth micrometer is used to measure the depth of holes, slots, or recesses in engine parts.

The blade micrometer is used to measure narrow grooves or small recesses that cannot be accessed by a standard micrometer.

(iii) State the importance of using a vernier caliper during mechanical measurements.

A vernier caliper is essential for measuring both internal and external dimensions as well as depths. It offers flexibility and precision in measuring engine parts like piston diameters, valve stem length, and gasket thickness. It can measure down to 0.02 mm or 0.001 inch, making it suitable for detailed inspection.

(b) (i) What is meant by backfiring in a petrol engine?

Backfiring refers to the explosion or combustion of the air-fuel mixture outside the combustion chamber, typically occurring in the intake manifold or exhaust system. It produces a loud popping sound and may indicate poor combustion timing or mixture issues.

(ii) Identify four possible causes of backfiring through the intake manifold.

Incorrect ignition timing may cause the spark plug to ignite the air-fuel mixture while the intake valve is still open, resulting in backfire.

A lean air-fuel mixture burns slower, allowing the intake valve to reopen before combustion is complete.

Damaged or improperly seated intake valves may allow combustion gases to escape back into the intake manifold.

Worn or broken timing belts and chains may cause valve timing to be off, leading to early ignition and backfire.

(c) Explain the purpose of steering dampers and briefly describe how each of the following factors affect steering performance.

Steering dampers are used to absorb shock and reduce steering vibrations transmitted from rough road surfaces. They enhance steering stability and comfort, especially in off-road or heavy-duty vehicles.

(i) Steering play
Excessive steering play results in delayed response and imprecise control of the vehicle. It is usually caused by worn steering linkages or loose joints.

(ii) Steering column angle
An improper steering column angle can lead to driver discomfort and mechanical strain on the steering shaft and joints, affecting steering effort and accuracy.

(iii) Wheel balance
Unbalanced wheels cause vibration at certain speeds, which affects the steering wheel and may lead to premature wear of steering components and tires.

3. (a) Define the term "piston displacement" as applied in internal combustion engines.

Piston displacement refers to the total volume swept by all the pistons inside the engine cylinders during a single complete stroke. It is calculated by multiplying the area of the cylinder bore by the stroke length and the number of cylinders.

(b) Differentiate between bore and stroke and explain their importance in engine design.

Bore is the diameter of the engine cylinder, while stroke is the distance the piston travels from top dead center to bottom dead center. A larger bore allows for bigger valves and more airflow, while a longer stroke increases torque. Their ratio influences engine characteristics—over-square engines favor high RPM power, while under-square engines offer better low-end torque.

(c) Explain three advantages of using overhead camshaft (OHC) engines over pushrod engines.

OHC engines have fewer moving parts between the camshaft and the valves, leading to more precise valve timing and better high-speed performance.

OHC engines generally allow for higher RPMs and smoother operation, making them ideal for modern performance-oriented vehicles.

With better valve placement and improved airflow, OHC engines can achieve better fuel efficiency and cleaner combustion compared to pushrod designs.

(d) Describe how to perform a cylinder leakage test and interpret its findings.

To perform a cylinder leakage test, first bring the piston of the cylinder being tested to top dead center on the compression stroke. Apply compressed air through a special tester into the spark plug hole. Listen and observe where the air escapes.

If air escapes through the oil filler cap, piston rings may be worn. Air from the exhaust suggests a leaking exhaust valve. Air heard at the throttle body or intake indicates an intake valve leak. Bubbles in the radiator may suggest a blown head gasket or cracked cylinder head.

4. (a) An inline four-cylinder engine with firing order 1-3-4-2 is operating under four-stroke cycle. Complete the stroke table to show piston activity at a given moment.

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

(b) Describe the compression stroke in a diesel engine and state its importance in the power cycle.

During the compression stroke, the piston moves from bottom dead center to top dead center with both intake and exhaust valves closed. The air drawn during the intake stroke is compressed to a high pressure and temperature. This compression heats the air sufficiently so that when diesel fuel is injected at the end of the stroke, it auto-ignites. This stroke is crucial for initiating combustion without the need for a spark.

(c) State four differences between an air-cooled engine and a water-cooled engine.

Air-cooled engines use fins on the cylinder and head to dissipate heat into the air, while water-cooled engines circulate coolant through jackets surrounding the cylinders.

Air-cooled engines are simpler and lighter due to the absence of radiators and coolant hoses, whereas water-cooled engines are heavier but provide more stable operating temperatures.

Air-cooled engines tend to be noisier due to lack of insulation, while water-cooled engines are quieter and more suitable for passenger vehicles.

Air-cooled engines are more suitable for motorcycles and small equipment, while water-cooled systems are ideal for larger, high-performance, or heavily loaded vehicles.

5. (a) List four differences in operation between petrol and gas (LPG) engines.

Petrol engines use liquid fuel that is vaporized before mixing with air, while LPG engines use gaseous fuel that mixes with air directly, allowing for more complete and cleaner combustion.

LPG engines tend to run at lower combustion temperatures, which reduces engine wear and allows for longer engine life compared to petrol engines that operate at higher temperatures.

Starting a petrol engine in cold weather is easier due to its better vaporization properties, whereas LPG may require preheating or a petrol start before switching over to gas in colder environments.

Petrol engines are more commonly used and supported by fueling infrastructure, while LPG engines require specialized fuel tanks, mixers, and regulators, limiting their usage in areas without LPG filling stations.

(b) An engine delivers 105 Nm torque at 4000 rpm. Calculate the power output in kilowatts.

Use the formula:
Power (W) = (2 × π × Torque × RPM) / 60

Substitute values:
Power = (2 × 3.1416 × 105 × 4000) / 60
Power = (2 × 3.1416 × 105 × 4000) = 2,638,937
Power = 2,638,937 / 60 ≈ 43,982.3 W
Convert to kilowatts:
Power ≈ 43.98 kW

So, the power output is approximately 43.98 kilowatts.

(c) Outline four essential characteristics of a good coolant in an automotive cooling system.

A good coolant must have a high boiling point and low freezing point to function effectively across a wide temperature range, preventing engine overheating or freezing.

It should provide anti-corrosion protection for engine metals like aluminum, iron, and copper, preserving the cooling system's integrity.

It must have good thermal conductivity to efficiently absorb and transfer heat from the engine to the radiator.

The coolant should be chemically stable and not evaporate or break down under operating conditions to ensure long-term performance.

6. (a) Why is backlash necessary between gears in a final drive system?

Backlash is the small clearance between mating gear teeth that allows for lubrication and thermal expansion during operation. It prevents gears from binding or seizing when they expand due to heat. Without backlash, the gears may wear rapidly or generate noise due to excessive friction and stress.

(b) (i) What is a centrifugal clutch?

A centrifugal clutch is an automatic clutch that engages and disengages based on engine speed. It uses centrifugal force to push clutch shoes outward against a drum as engine speed increases, transmitting torque to the transmission without manual intervention.

(ii) Describe how it engages and disengages during vehicle operation.

At low engine speeds, the clutch shoes remain retracted and do not contact the drum, so no power is transmitted. As the engine speed increases, centrifugal force causes the clutch shoes to expand outward and press against the inner surface of the drum, engaging the drive. When engine speed drops, the shoes retract, and the clutch disengages.

(iii) What are the signs of a worn clutch disc?

Signs of a worn clutch disc include difficulty engaging gears, engine revving without corresponding vehicle acceleration (slipping), shuddering during take-off, burning smell, and a low or soft clutch pedal.

(iv) What causes clutch judder during acceleration?

Clutch judder is often caused by contaminated clutch linings (e.g., oil or grease), warped pressure plates, or damaged engine mounts. Uneven contact between the clutch surfaces leads to vibrations during engagement.

(c) List five essential properties of an ideal brake fluid.

Brake fluid must have a high boiling point to withstand the heat generated during braking without vaporizing, which can cause brake failure.

It should have low compressibility to transmit pedal force effectively to the braking components with minimal loss.

The fluid must be non-corrosive to metals and rubber components in the brake system to ensure long-term reliability.

It should have low viscosity variation with temperature to maintain consistent performance in both hot and cold conditions.

It must have good lubricating properties to reduce wear on moving parts like pistons and seals within the braking system.

(d) (i) Where is the thermostat installed in a vehicle's cooling system?

The thermostat is typically installed between the engine and the upper radiator hose, at the outlet of the cylinder head. It controls coolant flow to the radiator based on engine temperature.

(ii) Explain the function of the thermostat during engine warm-up and normal operation.

During engine warm-up, the thermostat remains closed to prevent coolant from flowing to the radiator. This allows the engine to reach optimal operating temperature quickly. Once the engine reaches the designated temperature (usually around 80–90°C), the thermostat opens, allowing coolant to circulate through the radiator and maintain a stable temperature.

7. (a) State four purposes of using an independent front suspension system.

Independent front suspension improves ride comfort by allowing each front wheel to move independently over bumps without affecting the other wheel.

It enhances vehicle handling and stability, especially during cornering, by maintaining better tire contact with the road surface.

It reduces the weight of the suspension system, improving fuel economy and overall vehicle efficiency.

It offers more flexibility in steering geometry design, allowing for precise alignment and better control of camber, caster, and toe angles.

(b) (i) Explain the working principle of a worm and roller steering box.

In the worm and roller system, the steering wheel rotates a worm gear that meshes with a roller attached to a sector shaft. As the worm gear turns, the roller follows its spiral groove, causing the sector shaft to rotate and move the pitman arm, which in turn moves the steering linkage. The design reduces friction and wear, making it suitable for vehicles requiring strong and smooth steering control.

(ii) Mention three roles of the oil filter in an internal combustion engine.

The oil filter removes contaminants like dirt, carbon particles, and metal shavings from the engine oil, ensuring clean oil circulation.

It helps maintain consistent oil pressure by allowing unrestricted oil flow while trapping harmful particles.

It extends engine life by protecting critical components such as bearings, camshafts, and crankshafts from premature wear due to dirty oil.

(c) Calculate the total cost of engine servicing with the following spare parts:

Gasket set – Tsh. 145,000
Connecting rod bush – Tsh. 9,000 × 4 = Tsh. 36,000
Valve springs – Tsh. 5,000 × 8 = Tsh. 40,000
Timing chain – Tsh. 48,000
Cylinder head bolts – Tsh. 6,500 × 10 = Tsh. 65,000
Fan belt – Tsh. 24,000

Total cost = 145,000 + 36,000 + 40,000 + 48,000 + 65,000 + 24,000 = Tsh. 358,000

The total cost of engine servicing with the listed parts is Tsh. 358,000.

8. (a) State the effect of the following conditions on shock absorber performance:

(i) Oil leakage
Oil leakage reduces the damping ability of the shock absorber, leading to poor handling, increased bouncing, and reduced ride comfort.

(ii) Bent piston rod
A bent piston rod causes irregular movement of the shock absorber, which can lead to jamming or uneven suspension response.

(iii) Broken mounting bush
A broken mounting bush causes metal-to-metal contact, leading to noise, vibration, and reduced shock absorber effectiveness.

(iv) Air entrapment
Entrapped air in the hydraulic system results in foaming and loss of damping force, making the shock absorber ineffective over rough surfaces.

(b) (i) Identify five reasons that may cause engine misfiring.

Worn spark plugs or damaged ignition coils can fail to ignite the air-fuel mixture properly, causing misfires.

A clogged fuel injector may prevent the correct amount of fuel from reaching the combustion chamber.

Vacuum leaks in the intake manifold can disrupt the air-fuel mixture, leading to incomplete combustion.

Faulty sensors like the crankshaft or camshaft position sensors can affect timing and cause misfiring.

Low compression in one or more cylinders due to worn piston rings or valves may result in weak combustion and misfire.

(ii) Describe the method of testing spark plugs for proper function.

Remove the spark plug from the cylinder and inspect the electrode for carbon deposits, wear, or oil fouling. Clean if necessary. Reconnect the plug to the ignition cable, ground the threaded part of the plug to the engine block, and crank the engine. Observe the spark at the gap. A strong, blue spark indicates good condition, while a weak or no spark suggests the plug is faulty or the ignition system is malfunctioning.

(c) Explain the ignition timing adjustment process using a distributor and timing marks.

Start the engine and allow it to reach operating temperature. Locate the timing marks on the crankshaft pulley and timing cover. Use a timing light connected to the number one spark plug wire to illuminate the marks.

Loosen the distributor hold-down bolt and slowly rotate the distributor to advance or retard the ignition timing until the marks align with the manufacturer's specified timing value.

Once correct alignment is achieved, tighten the distributor bolt, recheck the timing, and ensure stable engine operation. Shut off the engine and remove the timing light.