**THE UNITED REPUBLIC OF TANZANIA**

**NATIONAL EXAMINATION COUNCIL OF TANZANIA**

**DIPLOMA IN TECHNICAL EDUCATION EXAMINATION**

**790** **AUTOMOBILE TECHNOLOGY**

**Time: 3 Hour.** **ANSWERS** **Year: 2008**

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**Instructions**

1. This paper consists of **eight (8)** 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 advanced safety precautions that must be taken when removing a vehicle's engine from the chassis using a hydraulic hoist.**

Before removal, disconnect the vehicle battery to prevent accidental short circuits or electrical sparks that could ignite fuel vapors around the engine bay.

Drain all engine fluids including coolant, engine oil, and fuel from the system to avoid spills that could cause slips or fire hazards during hoisting.

Ensure the hoist is rated for the engine's weight and that lifting chains are securely fastened to designated lifting eyes on the engine block to prevent tipping or slipping.

Clear the work area of unnecessary tools, flammable materials, and bystanders to maintain a safe zone around the engine bay and the hoist operation path.

Wear safety gear such as steel-toe boots, gloves, and eye protection to shield against injuries from accidental drops, swinging parts, or tool slippage.

(b) Explain the safety considerations for each of the following workshop situations:

(i) Grinding ferrous metals

Use face shields and goggles to prevent metal shards from entering the eyes. Ensure grinding wheels are not cracked and always use the guard attachment.

(ii) Handling high-pressure fuel lines

Relieve system pressure before loosening any fittings. Use protective gloves and keep open flames or sparks away due to risk of fuel spray and fire.

(iii) Using oxy-acetylene welding equipment

Check hoses and regulators for leaks before use. Keep cylinders upright and properly secured. Always wear flame-resistant clothing and a welding mask.

(c) Sketch and label three types of vehicle body structures, showing their load paths and stress zones.

Sketches should include:

– Body-on-frame structure
– Monocoque (unibody) structure
– Tubular space frame

Each sketch must indicate primary load-bearing paths, crumple zones, and reinforcement areas such as pillars and crossmembers.

**2. (a) (i) What is a broach, and how is it used in reconditioning automotive components?**

A broach is a precision cutting tool with multiple teeth arranged in a sequence to progressively remove material in a single pass. In automotive servicing, broaches are used to resize and finish internal surfaces such as cylinder bores, valve guide holes, and keyways during reconditioning.

(ii) List four types of broaches and their applications in vehicle servicing.

Keyway broach – used for cutting key slots in pulleys or gears for engine timing systems.
Round broach – for enlarging and finishing circular holes in engine blocks.
Spline broach – creates internal splines for shafts in transmission systems.
Surface broach – used to machine flat surfaces like valve body seats or cylinder heads.

(iii) Explain the purpose of a dial bore gauge and how it is zeroed before measurement.

A dial bore gauge is used to accurately measure internal diameters of engine bores, such as cylinders or valve guides. It is zeroed by placing it inside a ring gauge or using a micrometer set to the desired nominal bore size. The dial is adjusted so the needle reads zero, ensuring accurate deviation measurement when inserted into the actual workpiece.

(b) (i) Define the term fuel starvation in automotive systems.

Fuel starvation is a condition where insufficient fuel reaches the engine's combustion chamber, leading to hesitation, misfiring, or engine stalling.

(ii) Identify four likely causes of fuel starvation in a modern fuel-injected engine.

Clogged fuel filter blocking fuel flow to the injectors.
Faulty fuel pump not generating enough pressure.
Leaking or damaged fuel lines allowing air into the system.
Faulty fuel pressure regulator not maintaining required fuel pressure.

(c) Discuss the functions and adjustment methods of the following wheel alignment parameters:
(i) Camber
Camber is the tilt of the wheel inward or outward when viewed from the front. Positive camber means the top of the wheel tilts outward; negative means inward. It's adjusted by altering the suspension upper arm or strut mount settings.

(ii) Toe-out on turns
Toe-out on turns ensures that inner wheels turn at a greater angle than outer wheels during cornering. It is influenced by steering geometry and adjusted through steering arms or tie rods.

(iii) Steering center point

This is the natural return point of the steering system when driving straight. It ensures equal toe on both sides and proper wheel alignment. It's adjusted by centering the steering rack during alignment and checking toe values.

**3. (a) Explain the meaning of a rotary engine and give two of its unique advantages over reciprocating piston engines.**

A rotary engine, such as the Wankel engine, uses a rotating triangular rotor inside an epitrochoidal housing instead of pistons. It completes the four engine strokes in different sections of the housing as the rotor turns.

It has fewer moving parts, making it lighter and more compact than a piston engine. It also delivers smooth and high-revving power, with fewer vibrations due to its rotational motion.

(b) With examples, differentiate between naturally aspirated and turbocharged engines in terms of power output, fuel efficiency, and construction.

Naturally aspirated engines draw air by atmospheric pressure and have simpler intake systems. Example: Toyota 4AGE. Turbocharged engines force more air into the combustion chamber using exhaust-driven turbines, increasing power. Example: Subaru EJ20 Turbo.

Turbocharged engines deliver more power and better efficiency from smaller displacement, but require intercoolers, stronger components, and precise fuel management. Naturally aspirated engines are more linear and cheaper to maintain.

(c) Describe a workshop method for determining the compression ratio of a petrol engine.

Measure the swept volume using bore and stroke dimensions. Then determine the clearance volume by filling the combustion chamber with fluid at TDC using a graduated burette.

Compression ratio = (Swept volume + Clearance volume) / Clearance volume

(d) Explain how to inspect and service a diesel injection pump with reference to:

(i) Governor control

Check the governor linkage for wear or free play. Ensure the control mechanism smoothly responds to throttle movement and maintains steady RPM.

(ii) Plunger wear

Remove and visually inspect the plunger for scoring, corrosion, or uneven wear. Use a micrometer to check clearance between the plunger and bore.

(iii) Injection timing

Use a dial indicator or timing tool on the pump to set the correct start of injection. Compare with manufacturer specifications and rotate the pump body slightly to adjust timing.

**4. (a) A four-stroke petrol engine has a firing order of 1-2-4-3. Complete the table below to show the strokes for each cylinder, assuming cylinders move in pairs.**

Assuming 1-4 and 2-3 move together:

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

(b) Describe the function and events during the exhaust stroke in a four-stroke engine.

The exhaust stroke occurs after combustion. The exhaust valve opens, and the piston rises from BDC to TDC, pushing burned gases out of the cylinder through the exhaust port. This clears the combustion chamber for the next intake cycle.

(c) Outline four disadvantages of two-stroke engines that limit their use in modern automotive technology.

They have poor fuel efficiency due to loss of unburned fuel during the scavenging process.

They emit more pollution because of incomplete combustion and oil mixed in fuel.

Their moving parts wear out faster due to continuous operation without separate intake and exhaust strokes.

They produce excessive noise and vibration, making them unsuitable for modern passenger vehicle standards.

**5. (a) Describe four critical differences in the fuel systems of petrol and diesel engines.**

Petrol engines use spark ignition with throttle-controlled air-fuel mixture, while diesel engines use compression ignition with direct fuel injection.

Petrol systems operate at lower fuel pressure (3–5 bar), whereas diesel systems operate at high pressure (up to 2000 bar) using high-pressure pumps and rails.

Petrol injectors are usually located in the intake manifold or directly in the cylinder, while diesel injectors always inject directly into the combustion chamber.

Diesel engines require fuel filters with water separators due to the high precision of injection components, unlike simpler petrol filters.

(b) An engine develops 120 Nm torque at 2000 rpm and transfers power through a 5:1 reduction gearbox with 88% efficiency. Calculate:

(i) The torque at the output shaft

Output torque = 120 × 5 × 0.88 = 528 Nm

(ii) The output shaft speed

Output speed = 2000 / 5 = 400 rpm

(c) Identify four characteristics of an effective engine oil and explain their roles in engine protection.

High viscosity index ensures the oil maintains proper thickness at varying temperatures, providing consistent lubrication.

Detergency helps clean engine internals by suspending carbon deposits and preventing sludge buildup.

Anti-wear additives reduce metal-to-metal contact in high-stress areas like cam lobes and bearings, extending component life.

Thermal stability allows the oil to resist breakdown at high temperatures, maintaining its protective properties under load.

**6. (a) Explain the importance of adjusting differential side bearing preload and the consequences of improper adjustment.**

Adjusting the differential side bearing preload is important to ensure that the differential gears operate smoothly without excessive play. Proper preload maintains correct gear mesh and alignment between the crown wheel and pinion, reducing gear noise, wear, and heat.

If the preload is too low, the bearings can become loose, resulting in vibration, rapid wear, and backlash in the gear system. If the preload is too high, it can cause excessive bearing friction, overheating, and premature failure of the differential components.

(b) (i) What is a pilot bearing in a clutch assembly, and what are its functions?

A pilot bearing (or bushing) is fitted in the center of the crankshaft and supports the input shaft of the gearbox. Its main function is to center and support the transmission shaft while the clutch is disengaged, allowing smooth rotation and alignment during gear shifting.

(ii) Describe how torque is transferred from the engine to the transmission during normal clutch engagement.

When the clutch pedal is released, the pressure plate clamps the clutch disc against the flywheel. This action locks the flywheel, clutch disc, and transmission input shaft together. Engine torque is transferred through the flywheel to the clutch disc, then to the gearbox input shaft and onward to the drivetrain.

(iii) What are the effects of a warped pressure plate?

A warped pressure plate causes uneven clamping on the clutch disc, leading to clutch chatter, vibration, and poor engagement. It may also result in slippage or uneven wear on the friction surface, reducing clutch efficiency and life span.

(iv) State two causes of clutch judder during take-off.

Worn or contaminated clutch disc friction material creates inconsistent contact, causing vibration during take-off.

A misaligned or warped flywheel or pressure plate results in uneven torque transmission, which produces jerking movements when the clutch engages.

(c) Explain five reasons why asbestos-free materials are now preferred for clutch friction linings.

Asbestos-free materials eliminate health risks associated with inhaling asbestos fibers, which can cause lung cancer and asbestosis.

They comply with international environmental and occupational safety regulations that ban the use of asbestos in manufacturing.

Modern non-asbestos materials provide equal or superior friction performance under high temperature and heavy-duty applications.

They reduce pollution and environmental contamination during disposal and recycling processes.

Asbestos-free linings offer better thermal stability and wear resistance, improving the lifespan and reliability of the clutch system.

(d) (i) Where is the water temperature sensor located in a typical engine cooling system?

The water temperature sensor is commonly located near the thermostat housing or on the engine cylinder head, in direct contact with engine coolant to monitor its temperature.

(ii) Explain how the sensor output affects engine management.

The sensor sends voltage signals to the engine control unit (ECU) based on coolant temperature. The ECU uses this data to adjust fuel injection, ignition timing, idle speed, and radiator fan operation. Accurate readings ensure efficient engine performance, emissions control, and protection against overheating.

**7. (a) Explain four functions of a live front axle in a four-wheel-drive vehicle.**

It transmits torque from the transfer case to the front wheels, enabling all-wheel traction in rough or slippery terrain.

It supports the vehicle's front weight and maintains alignment of the steering and suspension components.

It allows front-wheel steering through integration with steering knuckles and linkages, essential for maneuvering.

It absorbs shocks and vibrations from road irregularities, transmitting them through the suspension system to the frame.

(b) (i) Describe the function of a steering damper and its role in improving vehicle handling.

A steering damper is a hydraulic device connected to the steering linkage that reduces oscillations and sudden steering movements. It stabilizes the steering system, especially in off-road or heavy vehicles, reducing kickback and improving control during rough driving conditions.

(ii) Explain three problems that may occur due to a faulty injection nozzle valve.

A leaking nozzle valve causes unburned fuel to enter the combustion chamber, leading to black smoke and poor fuel economy.

Clogged or worn nozzle tips result in poor atomization of fuel, causing rough idling, misfires, and hard starting.

Delayed or uneven injection timing from a malfunctioning nozzle causes knocking, reduced power, and increased emissions.

(c) A technician is estimating overhaul costs for a 4-cylinder inline petrol engine. Use the data below to compute the total cost:

Overhaul kit – 290,000/=
Main bearing set – 38,000/=
Big end bearing set – 30,000/=
Piston ring sets (4 pcs) – 72,000/= each = 4 × 72,000 = 288,000/=
Valves (8 pcs) – 13,500/= each = 8 × 13,500 = 108,000/=
Head gasket – 22,000/=
Oil pump – 85,000/=

**Total cost =**

290,000 + 38,000 + 30,000 + 288,000 + 108,000 + 22,000 + 85,000 = **861,000/=**

**8. (a) Explain how the following faults in a suspension system affect vehicle performance:**

(i) Loose U-bolts

Loose U-bolts can cause axle misalignment and shifting during movement, leading to poor handling, uneven tire wear, and potential driveline damage.

(ii) Cracked leaf spring

A cracked spring reduces load-carrying capacity and causes the vehicle to lean or bottom out on bumps. It can also lead to a complete failure under heavy load.

(iii) Weak shock absorbers

Weak shocks fail to dampen spring movement, causing excessive bouncing, poor road grip, and longer braking distances.

(iv) Damaged stabilizer link

A broken stabilizer link reduces the anti-roll function of the suspension, increasing body roll during cornering and decreasing vehicle stability.

(b) (i) State five common causes of weak ignition spark in a spark ignition engine.

Worn-out spark plugs with excessive gap reduce voltage strength and combustion reliability.

A faulty ignition coil fails to generate adequate high voltage for proper spark.

Damaged or corroded HT leads (plug wires) increase resistance and reduce spark intensity.

Weak battery voltage limits the energy available for ignition components.

A defective ignition control module can misfire or delay spark timing, weakening performance.

(ii) Describe how to test a high-tension coil with a multimeter.

Set the multimeter to the ohm scale. Measure the primary resistance by placing probes on the coil's low-voltage terminals; typical values range from 0.4 to 2 ohms.

Then measure secondary resistance between the high-voltage terminal and one primary terminal; typical values are 6,000 to 15,000 ohms. Any open or short circuit indicates a faulty coil.

(c) Explain the detailed steps involved in performing ignition timing adjustment using a crankshaft timing mark and a distributor.

Warm the engine to normal operating temperature. Connect a timing light to the battery and the number one spark plug wire. Start the engine and point the timing light at the crankshaft pulley and timing cover.

Observe the timing mark on the pulley in relation to the reference pointer. If the mark is not aligned with the specified timing value, loosen the distributor hold-down clamp.

Rotate the distributor slightly while observing the mark. Clockwise rotation generally retards timing; counterclockwise advances it. Once the timing is set to the manufacturer's specification, tighten the clamp.

Recheck the timing and adjust the idle speed if needed. Disconnect the timing light and restore all connections.