THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

790 **AUTOMOBILE TECHNOLOGY**

Time: 3 Hour. **ANSWERS** **Year: 2007**

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) Safety in automotive service workshops involves knowledge of risk anticipation. Explain five detailed safety precautions a technician must follow when dismantling a hydraulic braking system in a vehicle fitted with ABS (Anti-lock Braking System).

A technician must disconnect the vehicle battery before starting work on the ABS braking system to prevent accidental electrical short circuits and to disable the ABS control module during component disassembly.

The brake fluid in the hydraulic system must be properly depressurized before loosening any components. This avoids sudden fluid ejection under pressure which could cause eye injuries or skin irritation.

When lifting the vehicle to access brake components, the technician must use jack stands on a firm surface. Relying on the hydraulic jack alone is unsafe and can lead to vehicle collapse.

Use of appropriate personal protective equipment is crucial. This includes gloves to protect from brake fluid, safety goggles to protect eyes from sprays, and coveralls to avoid skin contact.

All removed parts should be kept in an organized and clean area to prevent contamination. Brake dust, particularly from older vehicles, may contain harmful materials like asbestos and should be handled with care using a brake dust vacuum or damp cloth—not compressed air.

(b) Explain the safety measures to be observed when using each of the following precision tools in the workshop:
(i) Micrometer screw gauge

The user should always ensure the micrometer is clean and calibrated before use. Applying too much force when closing the spindle can damage the measuring surfaces and give false readings.

(ii) Dial indicator

When using a dial indicator, the technician must secure the base firmly to avoid movement during measurement. Misalignment can lead to inaccurate readings and possible damage to the plunger or dial face.

(iii) Torque wrench

The torque wrench must be set only when in use and reset to zero after use to avoid weakening the spring mechanism. Applying force beyond its calibrated range can cause inaccurate torque delivery and tool failure.

(c) With the aid of sketches, show three types of chassis frame constructions and label their structural components.

Three common types of chassis frame constructions are:

- Ladder frame: Resembles a ladder with two long side members connected by several cross members. Common in trucks and commercial vehicles.
- Backbone frame: Consists of a strong tubular backbone usually housing the drivetrain. Used in sports and utility vehicles.
- Monocoque (Unibody): Body and frame are integrated into one structure. Found in most modern passenger cars.

Sketches would show:

1. Longitudinal side members
2. Cross members
3. Suspension mounting points
4. Engine cradle/mount
5. Central tunnel (in backbone) or integrated floor pan (in monocoque)

2. (a) (i) Explain the principle of operation of a taper reamer and its importance in engine overhauling.

A taper reamer operates by gradually enlarging or finishing a tapered hole to a precise dimension. It has a conical shape with cutting edges that remove material as it is rotated into the hole. During engine overhauling, it is used for accurately sizing tapered holes such as valve guides or conical seating surfaces, ensuring proper component fit and alignment.

(ii) Describe four differences between hand reamers and machine reamers in terms of use and structure.

Hand reamers have a square end designed for use with a wrench, allowing manual turning, while machine reamers have a round shank meant to be mounted on machines for powered rotation.

Hand reamers typically have a longer lead-in taper to help guide the tool manually into the hole, whereas machine reamers have a shorter taper suitable for automated feeding.

Machine reamers are usually made to tighter tolerances because they are used in production settings, while hand reamers are more forgiving and can compensate slightly for hand-driven inconsistencies.

Hand reamers are used for small-batch or repair work, where accessibility and control are prioritized, while machine reamers are ideal for repetitive, high-precision production tasks.

(iii) State two advantages of using a telescopic gauge and explain how it is used alongside a micrometer.

A telescopic gauge allows accurate internal diameter measurements of holes and bores that are difficult to reach with standard tools. It also enables quick comparison of internal sizes without direct reading, which is ideal for engine block bores or cylinder liners.

To use it, the gauge is compressed and inserted into the bore. It is then released to expand and lightly touch the walls, locked in position, and carefully removed. The final width is measured across the tips using an external micrometer to determine the internal dimension.

(b) (i) Define the term vapor lock as used in fuel systems.

Vapor lock is a condition in which liquid fuel changes into vapor in the fuel delivery system due to high temperature, preventing the proper flow of fuel to the engine. This causes engine stalling or difficulty in starting, especially in hot weather or under heavy engine load.

(ii) Mention four possible conditions that may result in vapor lock during vehicle operation.

Excessive engine heat radiating to fuel lines can cause fuel to vaporize before reaching the combustion chamber.

Use of low-boiling-point fuel increases the risk of vapor formation, especially in tropical climates.

Routing fuel lines too close to hot engine parts or exhaust components increases the chance of vapor lock.

Low fuel pressure in the system, especially in carbureted engines with mechanical pumps, can allow bubbles to form and disrupt fuel flow.

(c) Explain the effects of incorrect wheel alignment and describe how the following are inspected and corrected:
(i) Set-back
(ii) Thrust angle
(iii) Steering axis inclination (SAI)

Incorrect wheel alignment leads to uneven tire wear, pulling to one side, poor handling, and reduced fuel efficiency. It can also cause stress on suspension components and steering instability.

(i) Set-back refers to one front wheel being positioned behind the other when viewed from above. It is usually measured using alignment gauges and corrected by adjusting the control arm or strut length, if possible.

(ii) Thrust angle is the angle between the rear axle centerline and the vehicle's centerline. It should ideally be zero. If not, the vehicle may drift. Correction involves adjusting rear axle alignment or suspension links.

(iii) Steering axis inclination (SAI) is the angle between the steering axis and vertical when viewed from the front. It is not adjustable but must be checked to identify bent suspension parts or incorrect installation. It helps return the steering wheel to center and improves straight-line stability.

3. (a) Define the term "multi-fuel engine" and explain two advantages of its use in modern vehicles.

A multi-fuel engine is designed to operate efficiently using more than one type of fuel, such as petrol, diesel, ethanol, or compressed natural gas (CNG), either alternately or in blends. These engines have adaptable fuel and ignition systems.

One advantage is fuel flexibility, allowing operators to choose the most economical or available fuel, which is valuable in remote or fuel-scarce regions.

Another advantage is reduced emissions and better environmental compliance, as some fuel blends like ethanol reduce carbon output and particulate matter.

(b) Differentiate between air-cooled and liquid-cooled engines by giving three specific technical differences and two applications of each.

Air-cooled engines use fins and airflow to dissipate heat, while liquid-cooled engines circulate coolant through jackets and radiators.

Air-cooled engines are simpler and lighter, with no radiator or water pump, whereas liquid-cooled engines have more components but allow better temperature control.

Air-cooled engines tend to run hotter and may be noisier, while liquid-cooled ones operate more quietly and evenly.

Air-cooled engines are commonly used in motorcycles and small aircraft. Liquid-cooled engines are standard in most cars and heavy-duty trucks.

(c) Outline the step-by-step procedure for determining the swept volume and clearance volume of an engine cylinder in the workshop.

To find the swept volume, measure the bore diameter and stroke length. Use the formula:
Swept volume = $(\pi/4) \times \text{bore}^2 \times \text{stroke}$

For clearance volume, bring the piston to top dead center (TDC), fill the combustion chamber with a measured liquid using a burette, and record the volume needed to fill it completely.

Repeat for bottom dead center (BDC), subtract the clearance volume from total volume to confirm swept volume. This procedure helps calculate compression ratio.

(d) Describe the procedures involved in servicing and calibrating a common rail diesel injector with reference to:
(i) Nozzle opening pressure
(ii) Fuel return flow
(iii) Injector response time

(i) Nozzle opening pressure is checked by mounting the injector on a test bench and gradually increasing pressure until fuel begins to spray. It must match manufacturer specifications.

(ii) Fuel return flow is measured to determine leakage. Excess fuel returned to the tank may indicate worn components. The injector is tested under pressure and the return line volume is recorded.

(iii) Injector response time is tested using computerized diagnostic tools. It measures how quickly the injector opens and closes under electronic command. Slow response may signal clogging or electrical issues.

4. (a) An inline four-cylinder engine has a firing order of 1-3-4-2. Complete the table below to show the strokes for each cylinder, assuming pistons move in pairs.

Assuming 1–4 and 2–3 are paired:

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) Explain the operation of the compression stroke in a four-stroke compression ignition engine.

During the compression stroke, the intake and exhaust valves remain closed. The piston moves upward from bottom dead center (BDC) to top dead center (TDC), compressing the air inside the cylinder. The air pressure and temperature increase significantly. Near the end of the stroke, fuel is injected into the hot compressed air, leading to spontaneous combustion without a spark.

(c) Analyze four key operational and structural differences between two-stroke engines and four-stroke engines, and discuss their implications on efficiency and emissions.

Two-stroke engines complete a power cycle in one crankshaft revolution, while four-stroke engines require two revolutions.

Two-stroke engines have ports instead of valves, making them simpler and lighter, while four-stroke engines use a complex valve train.

Lubrication in two-stroke engines is typically through oil mixed with fuel, which increases emissions, whereas four-stroke engines have separate oil lubrication systems.

Two-stroke engines deliver more power per stroke but are less fuel-efficient and pollute more. Four-stroke engines are more efficient, cleaner, and durable, making them suitable for cars and trucks.

5. (a) Explain four major performance and design-based differences between petrol and diesel engines used in commercial vehicles.

Diesel engines have higher compression ratios (typically 14:1 to 22:1) compared to petrol engines (8:1 to 12:1), resulting in better fuel efficiency and torque output.

Diesel engines use compression ignition, meaning no spark plugs are required, while petrol engines rely on spark ignition systems.

Petrol engines run smoother and quieter due to lower pressure and lighter construction, while diesel engines are noisier and heavier but more robust.

Diesel engines are preferred in commercial vehicles for their superior torque, durability, and lower fuel consumption under load, whereas petrol engines are more suited for light-duty and performance applications.

(b) A diesel engine produces a brake power of 50 kW at 1800 rev/min. The torque is transmitted through a gearbox with a ratio of 4.5:1 and final drive efficiency of 85%. Calculate:
(i) Torque at the wheels
(ii) Rotational speed of the wheels

First, calculate torque at the engine:
Power = $(2 \times \pi \times N \times T) / 60$
Rearranged: $T = (\text{Power} \times 60) / (2 \times \pi \times N)$
$T = (50 \times 1000 \times 60) / (2 \times 3.1416 \times 1800) = 265$ Nm (engine torque)

Output torque = $265 \times 4.5 \times 0.85 = 1012.88$ Nm

Rotational speed at wheels = $1800 / 4.5 = 400$ rev/min

(c) Mention four essential characteristics of a good anti-freeze coolant and explain how each helps maintain engine performance.

It must have a low freezing point to prevent coolant from solidifying in cold climates and damaging the engine.

It should have a high boiling point to prevent overheating under high engine loads or hot weather.

It must provide corrosion resistance to protect engine metal parts like the radiator, water pump, and cylinder block from rust.

It should have compatibility with rubber hoses and gaskets to avoid deterioration and coolant leakage.

6. (a) Explain the reasons for adjusting backlash and gear contact pattern between the crown wheel and pinion in a final drive unit.

Backlash is the slight clearance between the mating teeth of the crown wheel and pinion. Adjusting backlash is necessary to prevent noise, wear, and overheating caused by excessively tight or loose engagement. If the backlash is too small, the teeth may bind and overheat; if too large, it can lead to gear rattle and uneven load distribution.

Adjusting the gear contact pattern ensures that the load is distributed evenly across the gear tooth surfaces. Proper contact minimizes wear, prevents localized pressure points, and increases the life span of the gears. This adjustment is made by shifting the pinion depth or moving the crown wheel laterally using shims or adjuster screws.

(b) (i) Define the term “clutch drag” and explain how it affects vehicle performance.

Clutch drag occurs when the clutch disc fails to disengage fully from the flywheel and pressure plate when the clutch pedal is pressed. This results in continued partial transmission of power to the gearbox, making it difficult to shift gears. Clutch drag can lead to gear grinding, poor idling, and potential damage to the gearbox synchronizers.

(ii) Describe the process through which the clutch disengages torque from the engine to the transmission.

When the clutch pedal is pressed, it actuates the clutch release mechanism (either mechanical or hydraulic). This action moves the release bearing against the diaphragm spring or release levers of the pressure plate. The pressure plate then lifts away from the clutch disc, releasing it from the flywheel. This interruption stops torque transmission, allowing smooth gear changes.

(iii) State two causes and effects of a worn release bearing.

A worn release bearing may be caused by constant clutch riding or lack of lubrication. Its effects include a grinding noise when pressing the clutch pedal and increased pedal effort. It may also cause incomplete disengagement of the clutch, leading to clutch drag or gearbox damage.

(iv) Explain what happens when the clutch plate has oil contamination.

Oil contamination on the clutch plate usually comes from a leaking rear main seal or gearbox input shaft seal. It leads to clutch slippage because the oil reduces friction between the disc and flywheel. This causes poor acceleration, overheating of the clutch, and glazing or burning of friction material, requiring replacement.

(c) List and explain five desirable properties of friction materials used in clutch plates.

High coefficient of friction: This ensures effective torque transmission without slippage between the clutch disc and the flywheel.

Heat resistance: Friction materials must withstand high temperatures generated during clutch engagement without degrading or glazing.

Wear resistance: The material should endure prolonged use without rapid wear, which extends the service life of the clutch.

Mechanical strength: It should maintain structural integrity under pressure and rotational force to prevent deformation or breakup.

Oil resistance: It should resist damage or performance loss when exposed to oil contamination from engine or gearbox leaks.

(d) (i) Where is the thermostat located in a typical inline water-cooled engine?

The thermostat is typically located in the thermostat housing at the engine end of the upper radiator hose, where it controls the flow of coolant from the engine to the radiator. It is usually positioned on top of the cylinder head or near the engine block.

(ii) Describe a step-by-step procedure for testing a thermostat using hot water and a thermometer.

First, remove the thermostat from the engine. Then place it in a container of water along with a thermometer. Slowly heat the water while observing the temperature. The thermostat should begin to open at its rated temperature, usually between 80°C and 90°C. Measure the full opening temperature as well. If it does not open or opens late, it should be replaced.

7. (a) Explain four mechanical functions performed by the front axle assembly in a rigid frame vehicle.

The front axle supports the weight of the front portion of the vehicle, including engine load in front-mounted configurations.

It allows the steering of the front wheels by housing the steering knuckles and associated linkages.

It absorbs shocks and road vibrations through the suspension and transmits them to the frame, enhancing ride comfort and stability.

It maintains proper alignment and position of the front wheels through its structure and attachment to suspension components.

(b) (i) Describe the rack and pinion steering mechanism with the help of a labeled diagram.

In the rack and pinion system, the rotary motion of the steering wheel is transmitted through the steering shaft to a small pinion gear. This pinion meshes with a linear rack gear that moves left or right when the pinion rotates. The rack is connected to the tie rods which push or pull the wheels, steering them. It is compact, simple, and offers direct control.
(*Let me know if you want the labeled diagram drawn.*)

(ii) Explain three functional roles of the delivery valve in a diesel injection pump.

It helps in rapid pressure drop in the fuel line after injection, preventing nozzle dribble and ensuring sharp fuel cut-off.

It prevents fuel from flowing back from the injector line into the pump, maintaining correct fuel delivery timing.

It improves the efficiency of the injection system by ensuring the injector needle closes cleanly and promptly after each injection cycle.

(c) The following are spare parts and costs for overhauling a 6-cylinder diesel engine:

Engine overhaul kit – 370,000/=
Main bearing (3 sets) – 35,000/= per set = 3 × 35,000 = 105,000/=
Piston rings (6 sets) – 78,000/= per set = 6 × 78,000 = 468,000/=
Valve guides (12 pcs) – 8,000/= each = 12 × 8,000 = 96,000/=
Camshaft bearings (4 pcs) – 18,000/= each = 4 × 18,000 = 72,000/=
Connecting rod bearings (6 sets) – 29,000/= per set = 6 × 29,000 = 174,000/=
Cylinder sleeves (6 pcs) – 59,500/= each = 6 × 59,500 = 357,000/=

Total cost:
370,000 + 105,000 + 468,000 + 96,000 + 72,000 + 174,000 + 357,000 = **1,642,000/=**

8. (a) Describe the mechanical effect on vehicle handling and performance when each of the following faults occur in a leaf spring suspension:

(i) Fatigued spring leaves

Fatigued leaves cause the suspension to sag and reduce load-carrying capacity, leading to poor ride height and increased bottoming on rough roads.

(ii) Worn-out eye bushings

Worn bushings result in excessive play between the spring eye and shackle or mounting bolt. This causes unstable handling, clunking noises, and uneven tire wear.

(iii) Misaligned centre bolt

A misaligned bolt causes the axle to shift, leading to poor wheel tracking, erratic braking, and increased tire wear due to misalignment.

(iv) Deformed shackle plate

A deformed shackle restricts spring movement and alters the suspension geometry. This reduces ride comfort, increases noise, and can cause pulling to one side.

(b) (i) Explain five possible causes of engine knocking under load conditions.

Low-octane fuel causes premature ignition of the air-fuel mixture, leading to knocking due to uncontrolled combustion.

Excessive carbon deposits in the combustion chamber increase compression ratio and hot spots, promoting pre-ignition.

Incorrect ignition timing, especially too much advance, can result in knocking as the mixture ignites too early.

Overheating of the engine increases the tendency for knock by raising the temperature inside the cylinder.

Lean air-fuel mixture burns slower and increases combustion temperature, which can cause knocking under load.

(ii) Explain a standard method used to test a condenser using an analogue multimeter.

Set the analogue multimeter to the ohms (Ω) scale. Connect the probes to the condenser terminals. Initially, the needle should swing to low resistance, then gradually return to infinite resistance as the condenser charges. If the needle doesn't move or stays at zero, the condenser is shorted. If it moves and doesn't return, it may be leaking or open.

(c) Describe the complete ignition timing procedure for a petrol engine vehicle using a timing light and manufacturer's specifications.

First, warm up the engine to its normal operating temperature and ensure idle speed is as specified. Next, locate the timing marks on the crankshaft pulley and timing cover. Connect the timing light to the battery and No. 1 spark plug wire. Start the engine and aim the light at the timing marks. Observe the mark's position relative to the reference pointer.

If the mark is not aligned with the specified advance, loosen the distributor hold-down bolt and rotate the distributor slightly. Turn it clockwise to retard timing or counterclockwise to advance. Once the mark aligns with the specified timing, retighten the bolt. Recheck the idle speed and verify final timing with specifications.