THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

093 MOTOR VEHICLE MECHANICS

Time: 3 Hours **ANSWERS** **Year: 2013**

Instructions

1. This paper consists of section A, B and C.

2. Answer all questions in section A and B and three questions from section C.

1. (i) Which of the following is the arrangement of an opposed cylinder engine?
A One crankshaft and one camshaft
B Two camshaft and one crankshaft
C Two crankshaft and two camshaft
D Four camshaft and two crankshaft
E Two crankshaft and one camshaft

Answer: A – Opposed (flat) cylinder engines have horizontally opposite cylinders connected to a single crankshaft and one camshaft.

(ii) The device for smoothing out the power of engine is called
A Clutch
B Differential
C Gear box
D Torque converter
E Flywheel

Answer: E – A flywheel stores rotational energy, maintaining engine momentum and smoothing power delivery between combustion strokes.

(iii) Some examples of non-positive locking device in motor vehicles are
A Split pin, castellated nut and spring washer
B Nylon locknut, tab washer and flat washer
C Flat washer, spring washer and nylon locknut
D Bolt, nut and split pin
E Nut, spring washer, split pin

Answer: C – Non-positive locking devices depend on friction to resist loosening (e.g., spring washer, flat washer, nylon locknut).

(iv) What is the name of the openings in the cylinder block through which coolant pass through?
A Water jackets
B Water channels
C Water path
D Water ways
E Water circuit

Answer: A – Water jackets are cavities in the engine block around cylinders where coolant flows to absorb heat.

(v) Petrol engines are sometimes known as

A Gas ignition engines
B Spark ignition engines
C Coil ignition engines
D Light ignition engines
E Carburettor ignition engines

Answer: B – Petrol engines use spark plugs for ignition and are thus known as spark ignition engines.

(vi) The function of the 'dip stick' in lubrication system of the engine is to measure
A Amount of pressure in the system
B Quality of the lubricating oil
C Fluidity of the lubricating oil
D Quantity of the oil in the sump
E Viscosity of the lubricating oil in the sump

Answer: D – Dip stick is a rod used to check the level (quantity) of lubricating oil in the engine sump.

(vii) The main purpose of a damper in suspension system is to
A Support the oscillation of the springs
B Cut off the prolonged oscillation of springs
C Extend the springs oscillation
D Extend the life of the springs
E Control the sideways rolling of the vehicle

Answer: B – Dampers or shock absorbers limit excessive spring oscillations to maintain ride stability and comfort.

(viii) What is the name of instrument which controls the working temperature of an engine?
A Controller unit
B Thermometer
C Temperature limiter
D Relief valve
E Thermostat

Answer: E – A thermostat regulates the flow of coolant in response to engine temperature, helping maintain optimal operating temperature.

(ix) The level of petrol in a carburettor is controlled by a
A Venturi
B Choke
C Float
D Control chamber
E Compensating jet

Answer: C – The float in a carburettor maintains constant fuel level by opening/closing the needle valve as needed.

(x) If a leaf spring is fixed to the frame of a chassis without swinging shackle, the spring will
A Break
B Be weakened
C Oscillate for a long time
D Cause the damper to fail
E Become loose

Answer: A – Without a shackle to accommodate length changes during flexing, the leaf spring is stressed and eventually breaks.

2. (a) Briefly state why it is strictly prohibited to indulge in horseplay when working in the workshop?
Horseplay in the workshop can lead to accidents, injuries, and damage to tools or machinery, posing a safety hazard to workers.

(b) State why it is advised to wear safety boot with stout design when working in the workshop?
Safety boots protect feet from sharp objects, heavy falling tools, oil spills, and electrical hazards commonly found in workshops.

3. (a) State how files are classified.
Files are classified by their shape (flat, round, half-round, triangular), cut (single cut, double cut), and coarseness (bastard, second cut, smooth).

(b) Why a file should always be fitted with handle?
A handle provides grip and protects the user's hand from injury caused by the sharp tang of the file.

4. Mention six advantages of C.I engine with regard to S.I engine.
– Higher fuel efficiency
– Better torque output
– Longer engine life
– Less maintenance
– Ability to use cheaper diesel fuel
– Higher compression ratio

5. (a)(i) Name two parts of the drive line.
– Propeller shaft
– Differential

(ii) What is the purpose of the drive line?

To transmit engine torque from the gearbox to the driving wheels.

(iii) State two purposes of the final drive in a motor vehicle.
– To reduce speed and increase torque
– To allow differential action during turns

6. (a) List three causes of a motor vehicle backfiring.
– Incorrect ignition timing
– Lean air-fuel mixture
– Faulty spark plug

(b) Enumerate three possible causes of engine which turns over at normal speed but does not start.
– No spark at spark plug
– Lack of fuel supply
– Low compression

7. Define the following as encountered in motor vehicle mechanics.
(a) Oil galleries – Internal passageways that direct lubricating oil to various engine components.
(b) Oil additives – Chemical compounds added to oil to enhance lubrication, prevent wear, and control deposits.
(c) Oil sump – The reservoir at the bottom of the engine where lubricating oil collects and is stored.

8. (a) Mention the qualities which the brake shoes must meet.
– High friction coefficient
– Resistance to heat
– Long wear life
– Minimal noise or fade

(b) Distinguish between master cylinder and wheel cylinder as employed in a motor vehicle braking system.
Master cylinder generates hydraulic pressure from brake pedal force; wheel cylinders apply this pressure to push brake shoes or pads at the wheels.

9. Briefly explain how the combustion occurs in petrol and diesel engine.
In petrol engines, air-fuel mixture is ignited by a spark plug after compression.
In diesel engines, air is compressed to high pressure and temperature, and fuel is injected which self-ignites due to heat.

10. (a) What preventative measure must be considered before jacking a motor vehicle?
Ensure the vehicle is on a level surface, engage handbrake, chock wheels, and place jack under proper support point.

(b) What will be the outcome if the fault thermostat
(i) Remain open – Engine stays below operating temperature, increasing fuel consumption and emissions.

(ii) Remain closed – Engine overheats, leading to potential damage.

11. (a) What are the two major parts of the chassis frame?
– Side members
– Cross members

(b) Briefly state how propeller shaft is supported?
Propeller shaft is supported by bearings (such as center bearings or hanger bearings) and universal joints to allow flexibility and rotation.

12. (a) Identify five causes and their remedial of the excessive brake pedal travel of a car.

Excessive brake pedal travel occurs when the brake pedal moves too far before the brakes engage, indicating potential issues in the braking system. Here are five causes and their remedies, explained in separate paragraphs.

Air in the brake lines can cause excessive pedal travel because air is compressible, reducing the effectiveness of brake fluid pressure transfer to the brake components. This often happens after maintenance or due to a leak. The remedy is to bleed the brake lines, which involves opening the bleeder valves at each wheel and flushing the system with fresh brake fluid until no air bubbles remain, ensuring proper hydraulic pressure.

Low brake fluid level in the master cylinder can lead to insufficient hydraulic pressure, causing the pedal to travel further before braking occurs. This may result from leaks or normal fluid consumption over time. To fix this, check the brake fluid reservoir, top it up with the manufacturer-recommended brake fluid (such as DOT 3 or DOT 4), and inspect the system for leaks in the brake lines, master cylinder, or wheel cylinders that might be causing fluid loss.

Worn brake pads or shoes can increase pedal travel because, over time, the friction material wears down, requiring the brake components to travel a greater distance to contact the rotor or drum. The solution is to inspect the brake pads or shoes for wear, replacing them if they are below the minimum thickness specified by the manufacturer, and ensuring the rotors or drums are in good condition by resurfacing or replacing them if necessary.

A faulty or worn master cylinder can cause excessive pedal travel if its seals are worn or if there are internal leaks, preventing it from generating sufficient hydraulic pressure. To address this, test the master cylinder for leaks or pressure loss, and if it's faulty, replace it with a new one, then bleed the brake system to ensure proper operation. In some cases, a rebuild kit may be an option, but replacement is often more reliable.

Improperly adjusted brake components, particularly in drum brake systems, can lead to excessive clearance between the brake shoes and the drum, causing the pedal to travel further before braking occurs. The remedy is to adjust the brake shoes using the adjuster mechanism (often a star wheel) to reduce the clearance between the shoes and the drum, ensuring proper contact when the pedal is pressed. If the vehicle has a self-adjusting mechanism, check if it's functioning correctly and repair or replace it if needed.

(b) Briefly explain the following as encountered in motor vehicle with regard to their configuration and operations.

(i) Rack and pinion gear boxes

Rack and pinion gear boxes are a common steering system in modern vehicles, consisting of a pinion gear connected to the steering shaft that meshes with a linear rack. When the steering wheel is turned, the pinion rotates, moving the rack side to side, which turns the wheels via tie rods. This system is simple, lightweight, and provides direct, responsive steering, making it ideal for passenger cars.

(ii) Recirculation ball gear boxes

Recirculation ball gear boxes use a worm gear and a ball nut mechanism, where the steering shaft turns a worm gear, moving a ball nut with ball bearings inside to reduce friction along the worm. The ball nut is connected to a sector shaft that moves the steering linkage to turn the wheels. This system is durable and often used in heavier vehicles like trucks due to its ability to handle higher loads, though it's less direct than rack and pinion.

(iii) Worm and roller gear boxes

Worm and roller gear boxes feature a worm gear on the steering shaft that engages with a roller, a cylindrical component mounted on a sector shaft. As the worm rotates, the roller moves, turning the sector shaft to steer the wheels. This system provides smooth operation with reduced friction compared to older worm gear systems and was commonly used in older vehicles and some heavy-duty applications.

(iv) Screw and nut gear boxes

Screw and nut gear boxes consist of a screw on the steering shaft that engages with a nut connected to the steering linkage. As the screw rotates, the nut moves linearly along the screw, transferring motion to the wheels. This design is simpler but has higher friction, making it less common in modern vehicles, though it was used in some older cars and industrial applications.

(v) Cam and peg gear boxes

Cam and peg gear boxes use a cam, an irregularly shaped component on the steering shaft, that engages with a peg or follower on a sector shaft. As the cam rotates, the peg follows its contour, moving the sector shaft to steer the wheels. This system provides precise control but is complex and less common in modern vehicles, often found in vintage or specialized vehicles.

13. (a) (i) What is firing order of a motor vehicle engine?

The firing order of a motor vehicle engine is the specific sequence in which the cylinders of an internal combustion engine ignite their air-fuel mixture to produce power. For example, in a 4-cylinder engine, a common firing order might be 1-3-4-2, meaning the first cylinder fires, then the third, followed by the fourth, and finally the second. This sequence ensures smooth operation and balanced power delivery.

(ii) What is the importance of firing order of an engine?

The firing order is important because it ensures even distribution of power strokes across the engine's crankshaft rotation, minimizing vibrations and maximizing smoothness. It also helps in balancing the engine's thermal and mechanical loads, reducing wear on components, and optimizing exhaust and intake flow in the engine.

(iii) Briefly explain the problems that might rise in the engine if improper firing order is applied.

An improper firing order can cause several issues in an engine, each explained in its own paragraph.

Increased vibrations occur because if cylinders fire in an unbalanced sequence, the crankshaft experiences uneven power delivery, leading to excessive vibrations that can damage engine components and reduce driver comfort.

Reduced power and efficiency result from the engine not running smoothly, leading to misfires, incomplete combustion, or backfiring, which reduces power output and fuel efficiency.

Overheating and component stress happen when uneven firing causes some cylinders to work harder than others, leading to localized overheating, increased wear on pistons, bearings, and the crankshaft, and potential engine failure.

Exhaust and intake interference can occur as improper firing disrupts the scavenging process in the exhaust and intake manifolds, causing exhaust gases to backflow into the intake or unburned fuel to be expelled, leading to poor performance and higher emissions.

(b) (i) Sketch and label an elevation with side cam of an arrangement for operating overhead valve constituting the following parts.

Push rod

Valve spring

Rocker arm

Valve guide

Adjusting screw

Tappet or follower

Valve

Camshaft

Start with a horizontal shaft at the bottom with a cam, an egg-shaped lobe, on it, and label this as the camshaft. Above the cam, draw a small cylindrical component that rests on the cam lobe, labeling it as the tappet or follower, which moves up and down as the cam rotates. Draw a vertical rod extending upward from the tappet, labeling it as the push rod, which transfers motion from the tappet to the rocker arm. At the top of the push rod, draw a pivoting lever, like a seesaw, mounted on a pivot point, and label it as the rocker arm, with one end contacting the push rod and the other end contacting the valve. On the rocker arm, near the push rod end, draw a small screw that adjusts the clearance, labeling it as the adjusting screw. On the other end of the rocker arm, draw a vertical valve stem with a valve head at the bottom, shaped like a mushroom, labeling it as the valve, with the valve head sitting in the engine's combustion chamber, which you can indicate with a simple line representing the cylinder head. Around the valve stem, draw a coiled spring that pushes the valve upward to close it, labeling it as the valve spring. Finally, draw a cylindrical sleeve around the valve stem, above the valve head, to guide its movement, labeling it as the valve guide.

The arrangement shows how the camshaft's rotation lifts the tappet, which pushes the rod, rocks the rocker arm, and opens the valve against the spring's force, with the spring closing the valve when the cam lobe moves away.

(ii) Briefly explain the importance of air cleaner in the carburettor system.

The air cleaner, or air filter, in a carburetor system is crucial because it removes dust, dirt, and debris from the air before it enters the carburetor to mix with fuel. This ensures that only clean air is used in the combustion process, preventing contaminants from entering the engine, which could cause wear on components like pistons, cylinders, and valves. A clean air supply also helps maintain the proper air-fuel ratio for efficient combustion, improving engine performance and reducing emissions.

(iii) Explain the effect of the excessive valve clearance in an engine.

Excessive valve clearance in an engine, which is the gap between the rocker arm and valve stem or tappet, can lead to several issues, each explained in its own paragraph.

Noisy operation occurs because excessive clearance causes a tapping or clicking noise, often called valve lash, as the components strike each other with more force during operation.

Reduced engine performance results from the valve not opening fully or for the correct duration, reducing the amount of air-fuel mixture entering the cylinder for the intake valve or exhaust gases exiting for the exhaust valve, leading to incomplete combustion, lower power output, and poor fuel efficiency.

Increased wear happens because the larger gap increases the impact force between components like the rocker arm, valve stem, and tappet, accelerating wear and potentially damaging these parts over time.

Misfiring or backfiring can occur if the valve timing is disrupted due to improper opening and closing, causing misfires or backfiring, further affecting engine smoothness and performance.

(c) Why the camshaft does not rotate at the same speed as the crankshaft?

The camshaft does not rotate at the same speed as the crankshaft because it is designed to open and close the engine's valves once for every two revolutions of the crankshaft in a four-stroke engine. The crankshaft completes two full rotations, or 720 degrees, to complete one four-stroke cycle—intake, compression, power, and exhaust—while the camshaft only needs to rotate once, or 360 degrees, to operate the valves for that cycle. This 2:1 ratio is achieved through the timing mechanism, typically a timing belt or chain, where the crankshaft gear is half the size of the camshaft gear.

14. (a) (i) At which part of the braking system is the brake pressure valve fitted in a motor vehicle of the brake pressure control/regulating valve fitted in a motor vehicle?

The brake pressure control or regulating valve, often called a proportioning valve, is typically fitted in the hydraulic brake system, between the master cylinder and the rear brakes. It regulates the brake fluid pressure to the rear wheels to prevent them from locking up during braking.

(ii) What is the importance of the brake pressure control/regulating valve fitted in a motor car?

The brake pressure control valve is important because it balances the braking force between the front and rear wheels. During braking, the vehicle's weight shifts forward, reducing the load on the rear wheels, and the valve reduces pressure to the rear brakes to prevent them from locking up, ensuring better control and stability.

(iii) Briefly elaborate how brake pressure control/regulating valve operates.

The brake pressure control valve operates by monitoring the hydraulic pressure in the brake system. When the driver applies the brakes, the master cylinder sends fluid to both the front and rear brakes, and the valve, often a spring-loaded piston mechanism, allows full pressure to the front brakes but limits the pressure to the rear brakes after a certain threshold. This threshold is determined by the vehicle's weight distribution and braking dynamics, ensuring the rear wheels don't lock up and cause a skid.

(b) (i) What is 'asbestos-friction materials' as used in brake and clutch systems?Asbestos-friction materials were historically used in brake and clutch systems as a lining material for brake pads, shoes, and clutch plates. Asbestos, a heat-resistant and durable mineral fiber, was mixed with other materials to create a friction surface that could withstand high temperatures and provide good grip. However, due to health risks, as asbestos is a carcinogen linked to lung diseases like mesothelioma, its use has been largely phased out in modern vehicles and replaced with safer alternatives like ceramic or organic compounds.

(ii) Why asbestos materials are rarely applied nowadays?

Asbestos materials are rarely applied nowadays for several reasons, each explained in its own paragraph.

Health risks are a primary concern, as asbestos is a known carcinogen, and its fibers can cause serious lung diseases, including cancer, when inhaled during manufacturing, installation, or brake and clutch wear.

Environmental concerns also play a role, as asbestos dust released into the environment during use or disposal poses a pollution hazard, leading to strict regulations banning its use in many countries.

(iii) Briefly explain the new material used to substitute asbestos in brake and clutch systems with regard to their 'asbestos-friction material' strength and drawbacks.

Modern substitutes for asbestos in brake and clutch systems include several materials, each with its strengths and drawbacks, explained in separate paragraphs.

Ceramic materials, made from ceramic fibers and other compounds, have excellent heat resistance, durability, and friction properties, making them strong for high-performance braking, but they are expensive to produce, and their dust can be abrasive to rotors.

Organic materials, often called non-asbestos organic (NAO), are made from materials like rubber, Kevlar, and resins, offering quieter operation and being more environmentally friendly, but they wear out faster and perform poorly under high temperatures compared to asbestos or ceramic.

Semi-metallic materials, which include metal fibers like steel or copper mixed with friction modifiers, provide good heat dissipation and durability, making them suitable for heavy-duty applications, but they can be noisy and cause more wear on rotors or drums.

(c) (i) What is the purpose of the 'load-apportioning valve' as used in brake systems?

The load-apportioning valve, also known as a load-sensing valve, is used in brake systems to adjust the brake pressure to the rear wheels based on the vehicle's load. In vehicles like trucks or vans, the rear axle load varies depending on whether the vehicle is empty or fully loaded, and the valve ensures that the braking force is proportional to the load, preventing the rear wheels from locking up and improving stability during braking.

(ii) Analyse the effect the 'load-apportioning valve' serves in a car.

The load-apportioning valve has several effects on a car's braking system, each explained in its own paragraph.

Improved braking stability is achieved because the valve adjusts the brake pressure to the rear wheels based on the vehicle's load, preventing the rear wheels from locking up during braking, especially when the vehicle is lightly loaded, which reduces the risk of skidding.

Enhanced safety results from the valve ensuring that the braking force is distributed appropriately between the front and rear wheels, maintaining vehicle control during sudden stops, particularly in varying load conditions.

Reduced wear on brake components occurs because the valve prevents excessive pressure on the rear brakes when the vehicle is lightly loaded, reducing unnecessary wear on brake pads or shoes and extending their lifespan.

(d) Briefly describe the constant mesh and synchromesh gearboxes.

Constant mesh and synchromesh gearboxes are types of manual transmissions used in vehicles, each explained in its own paragraph.

Constant mesh gearboxes have gears that are always in mesh, meaning the gears on the main shaft and lay shaft are constantly engaged, but they use a dog clutch to engage or disengage specific gears to change the gear ratio. This system is simple and durable, often used in older vehicles or heavy-duty applications, but it can be difficult to shift smoothly without proper technique, as the gears may not be synchronized in speed.

Synchromesh gearboxes are an improvement over constant mesh, also having gears in constant mesh, but they include a synchronizing mechanism, typically a cone clutch and synchronizer ring, that matches the speed of the gears before engagement, allowing for smooth and quiet gear changes. This system is widely used in modern manual transmission vehicles, making shifting easier for the driver, though it is more complex and costly to manufacture.

15. (a) With the aid of sketches, describe three types of engine cylinder liners.

Engine cylinder liners are sleeves inserted into the engine block to form the cylinder walls where the pistons operate.

Dry liners are thin-walled sleeves that are pressed into the engine block and do not come into direct contact with the engine's coolant, as the block itself forms the outer wall of the cooling jacket. To sketch this, draw a cross-section of an engine block with a cylindrical bore, then draw a thin sleeve inside the bore, labeling it as the dry liner, and show the block material surrounding it with coolant passages outside the block material.

Wet liners are thicker sleeves that are in direct contact with the engine's coolant, forming part of the cooling jacket, and are sealed with gaskets or O-rings at the top and bottom to prevent coolant leaks. To sketch this, draw a cross-section of an engine block with a cylindrical bore, then draw a thicker sleeve inside the bore, labeling it as the wet liner, with coolant directly surrounding the outer surface of the liner and gaskets at the top and bottom.

Air-cooled liners, also called finned liners, are used in air-cooled engines and have external fins to increase the surface area for heat dissipation, typically found in motorcycles or small engines. To sketch this, draw a cylindrical sleeve with a piston inside, labeling it as the air-cooled liner, and add radi