Student's Assessment Number.....

THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

FORM TWO NATIONAL ASSESSMENT

090 MECHANICAL ENGINEERING

Time: 2:30 Hours **ANSWERS** **Year: 2015**

Instructions

1. This paper consists of Section **A, B** and **C** with a total of **eight (8)** questions
2. Answer **al**l questions in section **A** and **B,** and one question from section C.
3. Section **A** carries **ten (10)** marks, section **B** carries **thirty (30)** marks and Section C carries **sixty (60)** marks.
4. Cellular phones and unauthorized materials are not allowed in the assessment room
5. Write your **Examination Number** at the top right-hand corner of every page.

FOR ASSESSOR'S USE ONLY		
QUESTION NUMBER	SCORE	ASSESSOR'S INITIALS
1		
2		
3		
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8		
TOTAL		
CHECKER'S INITIALS		

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(i) Identify the part of the blast furnace at which the highest temperature occurs.
A. Throat
B. Bosh
C. Hearth
D. Hopper
Correct Answer: B. Bosh
Reason:
In a blast furnace, the bosh is located just above the hearth and is where the hot gases from the tuyeres mix with descending materials. It is at this region where temperatures reach their highest, typically around 1500°C to 1600°C, allowing for the reduction reactions to effectively take place.

(ii) Identify the property of rubber which allows it to be used for vibration dampers of machines.
A. Ductility property
B. Tenacity property
C. Malleability property
D. Elastic property
Correct Answer: D. Elastic property
Reason:
Rubber is highly elastic, meaning it can deform under stress (such as vibration) and return to its original shape when the stress is removed. This property makes it ideal for vibration dampers, as it absorbs and dissipates mechanical energy effectively.

(iii) Identify the group of instruments under which a divider falls.
A. Drawing tools
B. Measuring tools
C. Marking tools
D. Measuring instruments
Correct Answer: C. Marking tools
Reason:
A divider is used in workshops to scribe circles, arcs, or transfer measurements directly onto a workpiece, especially on metals or wood, for layout work before machining or cutting. It belongs to marking tools, not drawing or measuring tools.

(iv) Which tool is mainly used to measure the diameter of a cylindrical object?
A. Vernier calliper
B. Screwdriver
C. Hammer
D. Hacksaw
Correct Answer: A. Vernier calliper
Reason:
A Vernier calliper is a precision measuring instrument designed to measure both the internal and external

diameters of objects, as well as depths. It offers greater accuracy than a ruler and is ideal for measuring cylindrical components.

(v) Which property of a material defines its ability to withstand sudden shocks without breaking?
A. Hardness
B. Toughness
C. Elasticity
D. Ductility
Correct Answer: B. Toughness
Reason:
Toughness is the ability of a material to absorb energy and plastically deform without fracturing, especially under sudden or impact loading. Materials with high toughness resist breakage under shock or impact, which is distinct from hardness (resistance to surface indentation) or elasticity (ability to return to original shape).

2. Match each item in **list A** with a correct response in **list B** by writing its letter below the number of the corresponding item in the table provided.

LIST A	**LIST B**
(i) A material which improves machinability of steel (ii) A metal which have the ability of cutting other metals. (iii) A material which is suitable for the manufacture of chemical containers. (iv) A non-metal used to improve the hardness of steel (v) Used for production of pig iron	A. Nonferrous metal B. Blast furnace C. Carbon D. Ductility E. Plastic F. Copper G. Nodular iron H. HSS

List A	(i)	(ii)	(iii)	(iv)	(v)
List B	F	H	E	C	B

3 (a) (i) Mention five main uses of copper

- ✓ Used in electrical wiring and cables due to its excellent electrical conductivity.
- ✓ Used in plumbing systems for water pipes and fittings because of its corrosion resistance.
- ✓ Used in making heat exchangers and radiators due to its good thermal conductivity.
- ✓ Used for making coins, medals, and ornaments because it is easy to shape and polish.
- ✓ Used in manufacturing of electrical motors and generators as windings and components.

(ii) List five elements which are used for production of alloy steel

- ✓ Chromium
- ✓ Nickel
- ✓ Manganese
- ✓ Vanadium
- ✓ Molybdenum

These elements are added to carbon steel to improve specific properties like hardness, strength, toughness, and corrosion resistance.

(b) (i) State five characteristics of a good lubricant

- ✓ High thermal stability to withstand high operating temperatures.
- ✓ Low volatility to reduce evaporation losses at elevated temperatures.
- ✓ High viscosity index to maintain consistent thickness under different temperatures.
- ✓ Good adhesion to metal surfaces to prevent metal-to-metal contact.
- ✓ High resistance to oxidation and corrosion to protect machine parts.

(ii) Name two materials which are commonly used to make hacksaw blades

- ✓ High-speed steel (HSS)
- ✓ Carbon steel

These materials provide hardness, wear resistance, and the ability to retain a sharp cutting edge.

(iii) Mention the ores from which aluminium, zinc and lead are extracted

- Aluminium — Bauxite
- Zinc — Zinc blende (also called sphalerite)
- Lead — Galena

(c) (i) Explain with the aid of sketches the difference between a square bar and a square pipe
A square bar is a solid piece of metal with a square cross-section.
A square pipe is a hollow section metal with a square outer profile and an empty inner space.
Simple sketches:

(ii) Define the terms:

- Pig Iron:
  The crude form of iron obtained directly from the blast furnace, containing high carbon content and impurities like silicon, manganese, sulphur, and phosphorus.
- Ingot:
  A large block of cast metal, typically rectangular in shape, produced by pouring molten metal into molds. Ingots are later processed by rolling, forging, or machining.
- Cementite:
  A hard and brittle intermetallic compound of iron and carbon with the chemical formula Fe_3C. It is one of the key constituents in steel and cast iron, contributing to hardness and strength.

4 (a) (i) Show by means of a sketch how a try square is used to produce parallel lines on work piece
The try square is placed with its blade flush against the edge of the workpiece.
A scriber or pencil is used to mark a line along the blade, ensuring it is parallel to the edge.
The try square is slid along the edge to mark additional parallel lines as needed.
Simple sketch: [Try square with blade against workpiece edge, scriber marking a line parallel to the edge.]

(ii) Outline four operations which can be done using a lathe machine
Turning: Reducing the diameter of a workpiece by rotating it against a cutting tool.
Facing: Creating a flat surface on the end of a workpiece.
Threading: Cutting screw threads on a workpiece.
Drilling: Creating holes in a workpiece using a drill bit held in the tailstock.

(iii) Give three methods on how the drill is held and three on how the work is held when drilling
• Drill held:
Chuck: Secures the drill bit in the spindle.
Collet: Provides precise gripping for smaller drill bits.
Drill sleeve: Adapts larger drill bits to the spindle.

• Work held:
Vice: Clamps the workpiece securely.
Clamp: Fixes the workpiece to the drilling table.
Jig: Guides the drill and holds the workpiece in position.

(b) (i) Define the terms cutting speed and feed as used in relation to turning operations
• Cutting speed:
The speed at which the workpiece surface moves past the cutting tool, typically measured in meters per minute.
• Feed:
The distance the cutting tool advances along the workpiece per revolution, usually measured in mm/rev.

(ii) Explain the function of chuck, tailstock, carriage and tool post of the lathe machine
Chuck: Holds and rotates the workpiece securely during machining.
Tailstock: Supports the free end of long workpieces or holds tools like drills for operations.
Carriage: Moves the cutting tool along the lathe bed for longitudinal or cross-feed cutting.
Tool post: Secures the cutting tool in position for machining operations.

(iii) Name three taps comprised in a set of hand taps
Taper tap: Has a gradual taper for starting threads easily.
Intermediate tap: Has fewer tapered threads for continuing threading.
Plug tap: Has minimal taper for finishing threads to full depth.

(c) (i) Differentiate between single cut file and double cut file, cross filing and draw filing
• Single cut file:
Has single rows of parallel teeth, used for smooth finishing and light material removal.
• Double cut file:
Has two sets of crisscrossing teeth, used for rapid material removal and rough filing.
• Cross filing:
Filing at an angle across the workpiece to remove material quickly.
• Draw filing:
Pulling the file along the workpiece length for a smooth, polished finish.

(ii) List four types of chisels
Flat chisel: Used for cutting and shaping flat surfaces.
Cross-cut chisel: Used for cutting grooves or slots.
Diamond-point chisel: Used for cutting V-shaped grooves.
Round-nose chisel: Used for cutting curved or semi-circular grooves.
(iii) Write four general causes of accidents in a fitting and turning workshop
Poor housekeeping leading to clutter and tripping hazards.
Improper handling of tools causing cuts or injuries.
Lack of personal protective equipment like gloves or goggles.
Inadequate training resulting in misuse of machinery.

5 (a) (i) State two functions of the welding regulators and welding torch
• Welding regulators:
Control gas pressure to ensure safe and consistent flow.
Adjust gas flow rate for precise welding conditions.
• Welding torch:
Directs the flame to melt the workpiece or filler material.
Mixes fuel gas and oxygen to produce the desired flame.

(ii) Give four precautions to be taken in storing oxygen and acetylene cylinders
Store cylinders upright to prevent tipping and damage.
Keep cylinders away from heat sources to avoid pressure buildup.
Store oxygen and acetylene cylinders separately to prevent reactions.
Ensure proper ventilation to avoid gas accumulation.

(iii) State the four functions of the soldering flux
Cleans metal surfaces by removing oxides and impurities.
Prevents oxidation during soldering by forming a protective layer.
Improves solder flow for better joint formation.
Enhances joint strength by ensuring proper bonding.

(b) (i) Write two examples of permanent joints and four examples of temporary joints
• Permanent joints:
Welded joint
Riveted joint
• Temporary joints:
Bolted joint
Screwed joint
Pinned joint
Clamped joint

(ii) Identify the colour codes given for the cylinders carrying acetylene, propane, oxygen gases
• Acetylene: Maroon
• Propane: Red
• Oxygen: Green
(iii) Differentiate between low pressure welding system and high-pressure welding system
• Low-pressure welding system:
Uses acetylene at low pressure with an injector torch, simpler and suitable for thin materials.
• High-pressure welding system:
Uses high-pressure gases, offers precise flame control, suitable for thicker materials and heavy-duty welding.

(c) (i) Name five tools used in arc welding
Welding electrode holder
Ground clamp
Welding helmet
Wire brush
Chipping hammer

(ii) Define the terms fusion welding, tack welding and resistance welding
• Fusion welding:
Joining metals by melting them together with or without filler material.
• Tack welding:
Small, temporary welds to hold workpieces in place before final welding.
• Resistance welding:
Joining metals using heat from electrical resistance and applied pressure, without filler.
(iii) Differentiate between carburizing flame and oxidizing flame by using sketches and give one use for each
• Carburizing flame:
Excess acetylene, yellow and sooty, used for welding high-carbon steel.
[Sketch: Conical flame with yellow, feathery tip.]
• Oxidizing flame:

Excess oxygen, sharp blue flame, used for cutting metals.
[Sketch: Sharp, pointed blue flame with defined inner cone.]

6 (a) (i) Give the number of revolutions a crankshaft makes in order to complete one cycle for a two strokes cycle engine and for a four strokes cycle engine
• Two-stroke engine: One crankshaft revolution per cycle.
• Four-stroke engine: Two crankshaft revolutions per cycle.

(ii) Explain what happens in a cylinder of a diesel engine during compression stroke
The piston moves upward, compressing the air in the cylinder.
The compression increases the air temperature and pressure significantly.
High temperature prepares the air for spontaneous ignition when fuel is injected.

(iii) Mention four parts in the engine which rotate when the engine is working
Crankshaft
Camshaft
Flywheel
Timing gears

(iv) Write four advantages of a two-stroke compression ignition engine over a four-stroke compression ignition engine
Simpler design with fewer moving parts, reducing maintenance.
Higher power-to-weight ratio, producing more power per unit weight.
Faster acceleration due to power stroke in every revolution.
Compact size, suitable for smaller applications.

(b) (i) State engine classification according to fuel, cooling and ignition system and give two classes in each case
• Fuel:
Petrol
Diesel
• Cooling:
Air-cooled
Water-cooled
• Ignition:
Spark ignition
Compression ignition

(ii) Write three functions of an engine flywheel
Stores rotational energy to maintain smooth engine operation.
Smooths power delivery by reducing fluctuations in crankshaft speed.
Assists in starting the engine and balancing the crankshaft.

(iii) List four main components of the fuel supply system of a compression ignition engine
Fuel tank
Fuel pump
Fuel filter
Injector

(c) (i) Calculate the volume of the combustion chamber if a petrol engine has a cylinder bore of 95 mm and a stroke of 120 mm and the compression ratio is 9 to 1
Swept volume = $\pi \times (\text{bore}/2)^2 \times \text{stroke} = \pi \times (95/2)^2 \times 120 \approx 849{,}487\ \text{mm}^3$.
Compression ratio = (swept volume + clearance volume) / clearance volume = 9/1.
Clearance volume = 849,487 / (9-1) ≈ 106,186 mm^3 (combustion chamber volume).

(ii) Explain the meaning of thermal efficiency, firing order, combustion and carburation
• Thermal efficiency:
Ratio of useful work output to heat energy input, expressed as a percentage.
• Firing order:
Sequence in which cylinders ignite in a multi-cylinder engine to ensure smooth operation.
• Combustion:
Chemical reaction between fuel and air, producing heat and power.
• Carburation:
Mixing of air and fuel in a carburetor for efficient combustion in petrol engines.

7 (a) (i) Define the terms: generator, insulator and e.m.f.
• Generator:
Device converting mechanical energy into electrical energy using electromagnetic induction.
• Insulator:
Material that resists the flow of electric current, used to prevent unwanted conduction.
• E.m.f.:
Electromotive force, the voltage generated by a power source like a battery or generator.

(ii) Identify the type of battery which is mostly used in automobiles
Lead-acid battery

(iii) State the functions of spark plug, condenser, ignition coil, alternator and contact breaker point
Spark plug: Ignites the air-fuel mixture in the cylinder.
Condenser: Prevents arcing at contact points in the ignition system.
Ignition coil: Converts low battery voltage to high voltage for sparking.
Alternator: Generates electrical power to charge the battery and power systems.
Contact breaker point: Controls the timing of the spark in the ignition system.

(b) (i) Mention four main electric circuits of a car
Starting circuit

Charging circuit
Ignition circuit
Lighting circuit

(ii) Calculate the equivalent resistance, the total current flowing in the circuit and the voltage across each resistor, given three resistors of 2, 3 and 4 ohms which are connected in parallel to a battery of 12 volts
Equivalent resistance: $1/Req = 1/2 + 1/3 + 1/4 = 0.5 + 0.333 + 0.25 = 1.083$, $Req \approx 0.923$ ohms.
Total current: $I = V/Req = 12/0.923 \approx 13$ A.
Voltage across each resistor: 12 V (same in parallel circuit).

(c) (i) Define the term 'relay' as used in auto electrics
• Relay:
An electromagnetic switch that controls high-power circuits using a low-power signal.
(ii) Name five parts of the ignition coil
Primary winding
Secondary winding
Iron core
Insulated casing
Terminal connectors

(iii) Identify the names of components represented by the given symbols
• [Without specific symbols provided, common ignition components include:]
Battery: Parallel lines of unequal length.
Resistor: Zigzag line.
Capacitor: Two parallel lines.
Diode: Arrow with a perpendicular line.
Switch: Break in a line with a pivot.

8 (a) (i) Define the terms heat and pressure
• Heat:
Form of energy transferred between objects due to a temperature difference.
• Pressure:
Force applied per unit area, typically measured in pascals or bars.

(ii) Name two instruments which are used to measure temperature
Thermometer
Thermocouple

(iii) Mention four methods which are used to preserve foods apart from refrigerators
Canning
Drying

Salting
Freezing

(iv) Convert -20 °C and 35 °C to kelvin scale
-20 °C = -20 + 273 = 253 K
35 °C = 35 + 273 = 308 K

(b) (i) State Boyle's law of gases
• Boyle's law:
For a fixed amount of gas at constant temperature, the pressure is inversely proportional to the volume (P1V1 = P2V2).
(ii) Define the term secondary refrigerant
• Secondary refrigerant:
A fluid, such as brine or water, used to transfer heat from the refrigerated space to the primary refrigerant in a refrigeration system.
(iii) Define the terms: air conditioning, humidity, pressure and psychrometer

• Air conditioning:
Process of controlling temperature, humidity, and air quality in an enclosed space.
• Humidity:
Amount of water vapor present in the air, often expressed as a percentage.
• Pressure:
Force per unit area, measured in pascals or bars.
• Psychrometer:
Instrument measuring humidity using the temperature difference between wet and dry bulb thermometers.

(c) (i) Mention five places where air conditioning systems are commonly used
Homes
Offices
Hospitals
Data centers
Vehicles

(ii) Write the purpose of using a spanner, hacksaw, pinch off tool, flaring tool, pliers and tongs in refrigeration and air conditioning
Spanner: Tightens or loosens nuts and bolts in system components.
Hacksaw: Cuts metal pipes or fittings during installation or repair.
Pinch off tool: Seals copper tubing to prevent refrigerant leaks.
Flaring tool: Shapes tube ends to create leak-proof connections with fittings.
Pliers: Grips and bends small components or wires during assembly.
Tongs: Handles hot or delicate parts safely during maintenance.