**METALWORK**

**PREAMBLE**

The examination is designed to test candidate’s skill in basic design, practical work and entrepreneurship. It will also assess their knowledge of tools, equipment and materials and understanding of those areas of creative thinking which can be expressed and developed through planning and working primarily on metals as part of general education. The test will also assess candidate’s competency in the fundamentals of manufacturing to pursue higher education in science and technology.

**AIM**

The aim of the syllabus is to test candidate’s acquisition of the requisite knowledge andskills needed to pursue further education and self development in science and technology.

**OBJECTIVES**

Candidates will be expected to

(1) observe safe working practices in the workshop;

(2) demonstrate knowledge and understanding of tools, material and equipment;

(3) apply basic processes for the care and maintenance of hand and machine tools;

(4) have ability in identifying, analysing and evaluating a problem;

(5) apply their knowledge of processes and materials to the solution of problems;

(6) demonstrate basic skills of good craftsmanship;

(7) apply knowledge of career opportunities in metalwork;

(8) have ability to translate an idea into a project design.

**SCHEME OF EXAMINATION**

The examination shall consist of three papers, Papers 1, 2 and 3, all of which must be taken. Papers 1 and 2 will be a composite paper to be taken at one sitting.

Paper 1: Will consist of forty compulsory multiple choice objective questions. Candidates will be allowed 1 hour to answer the questions. The paper will carry 40 marks.

Paper 2: Will consist of five questions out of which candidates will be expected to answer four in 1½ hours. The paper will carry 60 marks. All questions will carry equal marks.

Paper 3: Will be a practical test of 3 hours. 10 minutes shall be given prior to the commencement of the examination for the study of the drawings. The paper will consist of two questions out of which candidates will be expected to answer one. They will be required to make a test piece for which the appropriate drawings will be supplied. The paper will carry 100 marks. Schools will be required to supply materials that will be needed for the practical test.

**DETAILED SYLLABUS**

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| **TOPIC** | **THEORY** | **PRACTICALS** |
| 1. General safety in the workshop. | 1.1 Potential sources of accidents.  Measures to avoid accidents.  1.2 Personal safety. Safety clothings: goggles apron, gloves, bootswith hard toe caps, helmet.  1.3 Safety rules and precautions in a metal workshop. |  |
| 2. Metals. | 2.1 Description of metals: physical and          mechanical properties.  2.2  Types of Metals:  -Ferrous metals: pig iron, wrought iron, cast iron and steels.   * Non Ferrous Metals: aluminium, zinc,        copper, tin and lead. * Non-ferrous alloys: brass, bronze,        solders and duralumin. * Constituents and properties.   2.3  Uses of Metals: Construction of auto bodies, frames,structural members of  building and bridges.   * Selection of suitable metals for specific  jobs.   2.4 Production of Metals          - Types of metals and their ores:                          copper-pyrite, aluminium –          bauxite, iron – hematite, zinc –                           calamine, lead – gelina,tin – tin ore                 (cassiterite) .  - Methods of extraction: open pit and         underground.  - Processes of smelting and refining:         Blast furnace, Bessemer converter,         open hearth, crucible, cupola electric         arc and high frequency induction         furnace and reverberating furnace.  - Forms of metal supply: billets, blooms         and slabs. | 2.1.1 Identification:  - file test.  - spark test. |
| 3. Hand Tools and  Bench Work. | 3.1 Hand tools.  - Hand tools: care and maintenance.   * Measuring tools: linear and angular. * Steel rule, angle plate and scriber, etc. * Bench vice, hand vice, G-clamp, chuck, etc. * Cold chisels, hacksaw, files, taps and dies. * Engineers’ hammers, mallets. * Screwdrivers, spanners, drifts, etc.   3.2 Benchwork   * Filing, chiselling, threading and sawing.   3.3 Care and maintenance of tools   * Need for maintenance. | 3.1.1 Practical exercises           involving the uses of           handTools.  3.3.1 Practical exercises            involving care and  Maintenance  – oiling, cleaning,               greasing of   hand tools. |
| 4. Heat treatment  of metals. | 4.1 Importance of heat treatment of metals.  4.2 Heat Treatment processes.         - Annealing         - Case hardening        - Hardening        - Tempering        - Normalizing  4.3 Materials and Equipment for heat treatment        of metals.       - Materials used as cooling media for heat treatment of metals:coal, brine, water, air, oil and ash.   * Equipment: furnaces, pyrometer, oven quenching tanks, blacksmith forge, oxy-acetylene flame.   4.4 Tempering colours and temperature          ranges.  4.5 Safety precautions. | 4.2.1 Heat treatment of             hand tools.  4.4.1 Use of colour charts. |
| 5. Hand forging. | 5.1 Principles of forging        - Definition of forging        - Importance of forging         - Types of forging: cold, hot and drop                forging.  5.2 Forging tools and Equipment.  - anvil, hammer, top and bottom swages, hardies, fullers, tongs and heart forge.  5.3 Forging operations  – fullering, upsetting, bending, drawing down, punching, flattening, cutting, twisting and swaging.  5.4 Safety precautions. | 5.3.1 Forging of chisels,            centre punch,             scriber, door  bolts, hinges, hoes, pokers, etc. |
| 6. Foundry Work. | 6.1 Principles of Casting:  - Definition and importance of casting.  - Method of casting: sand casting.  6.2 Materials and equipment for sand casting.  6.3 Processes: pattern making (single piece, split and flat back), moulding, melting and pouring, dismantling and fettling.  6.4 Core making (box, sand).  6.5 Casting defects (types and causes)  6.6 Safety precautions. | 6.3.1 Mould making and            metal pouring.  6.3.2 Simple pattern            making. |
| 7. Metal Joining | 7.1 Types: temporary and permanent.   * Temporary metal joining processes. * Explanation, identification and uses of common fasteners: Bolts, Nuts, Pins and Screws.   7.2 Soft Soldering   * Tools and equipment. Types of joints and processes.   7.3 Hard soldering   * Tools and equipment .Types of joints and processes. Procedure for making hard soldered joints.   7.4 Gas and Electric Arc Welding.   * Welding equipment, welding operation, welding flames. Welding techniques and safety.   7.5 Riveting   * Tools and equipment, types of rivets and joints.   7.6 Safety precautions. | 7.2.1 Design and make an artifact involving soft soldering. |
| 8. Sheet  Metalwork. | 8.1 Selection of materials,  - Low carbon sheet, galvanised sheet,                 tin plate, copper,aluminium and                 brass sheet.  - Standard gauges.  8.2 Tools and Equipment:  - Stakes, Hammers, Mallets, Snips,                 Hand lever, Shears, Folding bar,                 Sand bag and Slip roll.  8.3 Pattern development and cutting .  - Methods of Pattern development: types,              layout, and cutting out of patterns.  8.4 Basic Fabrication processes: Bending,          Raising, Hallowing,Sinking, Expanding and         Contracting.  8.5 Joints and joining   * Types of joints: lap, grooves, seams. * Methods of joining: * Self – tapping screw. * Soft soldering. * Seaming   8.6 Safety precautions. | 8.4.1 Production of             simple articles e.g.             cans, funnelsand             bowls. |
| 9. Machine Tools  and processes. | 9.1 Drilling, Drilling machines and reaming   * Description, types of tools and setting up. * Types of drilling machines: sensitive, pillar and radial. * Drilling faults & remedies   9.2 Grinding, Description of grinding operations.   * Types of grinding wheels and setting up of grinding operation.   9.3 Power sawing:   * Description, types of tools and machines. * Setting up of machinefor power sawing.   9.4 Lathe and lathe turning operations.   * Parts and functions of the centre lathe:  the bed, headstock, tailstock, carriage feed and thread cutting mechanism.   - Operations on the centre lathe:                parting off, knurling and taper - turning.  - Work holding devices: 3 and 4 – jaw      chucks, collets, face plates, catch      plates and mandrels.  other accessories, steadies and               centres.  9.5 Shaping Machines  - Types of shapers: swivel, tilting and            universal table  - Parts of a shaping machine and their             functions        Pedestal, ram, saddle, table and             driving mechanism.  - Cutting tools materials and holders.  9.6 Cutting lubricants and coolants (soluble           oil, straightcutting oil, soda solution).  9.7 Care, maintenance and safety           precautions. | 9.1.1 Exercises on              drilling machine:  drilling, reaming,              countersinking  and counterboring.  9.2.1 Grinding of single              point tools, e.g.  scribers, chisels              and lathe tool bits.  9.3.1 Using the power              saws to cut    materials for              projects.  9.4.1 Operation                            sequence,               exercises  involving step                turning, drilling,  boring, taper                turning, knurling,  vee thread-               cutting and                parting off. |
| 10. Finishes and  decorative  processes. | 10.1 Types of finishes and decorative                     processes  – polishing and buffing, spot facing, planishing, colouring, plating, etching, lacquering, pickling and enamelling | 10.1.1 Application of  finishes on projects. |
| 11. Design. | 11.1 Identifying the Problem   * Problem areas: market, classroom, lorry park,workshop. * Problem definition:benefits to be derived from finding solution(s) to the problem identified.   11.2 Generating possible solutions   * Investigation procedures and possible solutions: interviews, observation, visits, reading journals, books, photographs, sketches of solution alternatives. * Generation of possible solution. Selecting the best solution by: simplicity/ complexity, availability of materials and cost. * Freehand sketching, working drawings, prototype, testing and production. | 11.2.1 Produce a folio and realise the artifact. |

**LIST OF MATERIALS AND EQUIPMENT FOR METAL WORK WORKSHOP**

Recommended workshop size:

Purpose-bulk 14m length x 8m width x 4m height, well ventilated and illuminated.

**Safety Equipment and Materials;**

Fire extinguishers, first aid box, buckets of sand, CO2 wall charts etc.

1. **Workshop Tools**

(a) Cutting tools: Hacksaw, drills, chisels, snips, files, stock and die, scrappers, reamers, turning tools, milling machine, shaping tools.

(b) Measuring tools: Steel rules, inside and outside callipers, combination square, micrometer screw gauges,verniergauges, vernier protractors, spirit level, dial gauges.

(c) Marking out tools: Surface gauge, surface plate, try square, vee-block, dividers, odd leg callipers, trammels, straight edge, scriber, angle plates, centre punches.

(d) Driving tools; pin punches, screwdrivers, hammers, drifts.

(e) Work holding devices: clamps, vices, pliers, mole grips, self gripping wrenches.

(f) Forging tools: hardies, fullers, tongs, swages, anvils, anvil stands, letter stamps and stakes, sand bag.

2. **Workshop Equipment**

Work benches, marking out table, blacksmith’s hearth, foundry furnace, sets of tool boxes, oil cans, computer hard ware and soft ware.

3. **Machine Tools**

Centre lathe(with accessories), sensitive and pillar drilling machines, pedestal grinder, power hacksaw, folding machine, shears, rolling machine, milling, shaping machine, etc

**Welding Equipment**

Standard arc welding machine accessories, electrodes, shields, aprons, chipping hammers, welding boots, standard oxygen and acetylene cylinders, filler rods, spark lighters, regulators, nozzles, etc.

**Materials**

Mild steel round bars (03mm – 050mm), Flat bars (of different sizes), Square bars, Hexagonal bars, Mild steel sheets and plates, Galvanized and tinned sheets. Projects may be constructed with non-ferrous metal e.g. Copper, Aluminium and Brass.

**RECOMMENDED TEXT BOOKS**

1. Workshop Technology (parts 1 and 2) - W.A.T. Chapman

2. Metalwork Technology - G. H. Thomas

3. Metal Technology - C. E. S. A. C.

4. Introductory Technology - C. E. S. A. C.

5. Welding Technology - Gourd

6. Mechanical Engineering practice - A. Green and W.H. Howe

7. Crafts Theory and Related Studies - R.T. Pritchard Vol. 1 & 2

8. Mechanical Engineering - R.I. Timings

9. Metalwork Theory, Books 1, 2, 3, & 4

(Metric Edition) - P.F. Lye – Harrap, Lon

10. Design Technology in Metal and Plastics

(Metric Edition) - G.H. Thomas-John Murray

11. Jab Metalwork Projects for African Schools

and Colleges - R. Edward – Cassel Lon

12. Basic Engineering Processes - S. Crawford

13. Metalwork - R. Sandham

& F.R. Willmers

14. Workshop Processes and Materials - J. V. Courtney

15. Metalwork Projects and Theory (S.I. Units) - K. Parkinson

16. The Theory and Practice of Metalwork

(3rd Edition) - G. Love

17. Metalwork for Schools and Colleges - J. N. Green

18. Metal Cutting Machine tools - Adejuyigbe, S. B.

19. Metalwork Technology - J.K.N. Sackey

S. K. Amoakohene.