050 – FABRICATION AND WELDING

EXAMINATION STRUCTURE

The examination for this syllabus wills cover two major area of module groupings:

- Sheet Metal/Structural Steel Work (CFW 11 and 14) and
- Arc and Gas Welding (CFW 12 and 13) with 193 Engineering Drawing (CTD 11 –13) and 194, Basic Electricity as Trade Related Course.

EXAMINATION SCHEME

51 – Fabrication and Welding

This subject grouping consists of two papers:

51-1 – PAPER I : This will consists of two sections, viz Section A (Objectives) and Section B (Essay).

SECTION A: will comprise forty (40) multiple choice objective questions to be answered in 40 minutes. This section carries forty (40) marks.

SECTION B: will comprise seven (7) ESSAY questions and students are to answer five questions in 2½ hours. This Section carries sixty marks.

51-2 PAPER II: PRACTICAL: The practical examination will require the candidates to compulsorily complete two projects works in Sheet Metal/ Structural Steel work and Arc and Gas Welding over a period of 30 hours for 100 marks each. This paper will be released to the candidates THREE WEEKS before the examination date.

SHEET METAL(CFW 11) /STRUCTURAL STEEL WORK (CFW 14)

S/N	TOPICS/OBJECTIVE	CONTENT	ACTIVITIES/REMARK
1.	**Marking, Cutting and Forming of Sheet Metals** 1. Mark out, cut sheet metal to sizes and form to shape according to specifications. 2. Calculate and sketch joints, also allowance for making joints in sheet metal. 3. Identify rivets with riveting operation and state common faults in riveting.	1. a) Mark out of projects on sheet metal materials e.g. i. funnels ii. cylindrical objects iii. rectangular objects b) Tools: i. steel rule ii. centre punch iii. scriber iv. spring divider v. try square etc. a) Techniques b) Safety precautions. 2. Cutting materials to given sizes with the use of tools and equipment. a) hacksaw b) cold chisel – flat, cross cut, diamond half round. c) Shears-snips (straight universal and curved) d) Guillotine e) Grinding machine f) Drilling machine etc. 3. Forming of sheet metal to given shapes with the following; a) mallets – wooden, hide and rubber. b) Stakes – mandrel, bic iron, hatchet, pipe, half moon, creasing iron, funnel etc. 4. Calculation of allowance for different joints. 5. Sketching of joint allowance on materials and notching the joint. 6. Joint production e.g. i. solid corner joint ii. grooved seam joint iii. panned down joint iv. knocked up joint 7. Types of rivets e.g. i. snap or cup head ii. pan head iii. counter sunk iv. conical v. flat head etc. 8. Faults in riveting i. over-lapping ii. cracked rivet iii. uneven ends. 9. Production of holes for riveting 10. Correct sets for riveting joints. i. hand drilling machine ii. po riveting machine iii. hammer etc.	1. Use tools to mark out on a rectangular piece of metal, an object consisting of flat and semi-circular ends. 2. Odn the rectangular piece, using appropriate tools, drill holes at the centre of the diameters of the semi circular shape. 3. Cut out small pieces of thick sheet metal using a hacksaw and the chisel. 4. mark out the pattern for a cylindrical container (circumference = IID or 22IIr) having in mind that the cylinder will be grooved and with a knocked up joint at the bottom. Carry out operation gradually and with great care. 5. Develop pattern of the cylindrical container on activity four above add allowance for grooving and the knocked up joints. For the panned down and knocked up joints, the instructor should specify the allowance to be used. 6. Notch edges as appropriate, fold grooving allowances fold cylinder and groove. Use suitable stake and groover. Careful operation is very important. 7. Using two pieces of sheet metal: i. turn two single hems on opposite sides of the pieces to given an easy fit; ii. pane the joint so formed down gently; iii. on a suitable stake using a mallet, knock the joint up; iv. draw the various rivets showing their

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			heads; v. through simple practical demonstrate, show the difference in the strength of the various rivets. 8. Determine rivet size for a given sheet metal d = ½ where D = rivet diameter and ½ = thickness of metals to be joined. 9. Take a piece of metal, observe the burr resulting from the drilling and use a bigger drill to cleverly remove the burr. Demonstrate manually before using a drilling machine. 10. Identify the correct size of rivet considering clearance allowance of 1/6 d.d = Diameter of rivet. 11. Practice proper use of the rivet set. Lap two pieces of sheet metal and join them together by riveting. Proper a butt joint with single cover and single riveted.
2.	**Soldering and Brazing** 1. Identify and describe types of solder including tools and fluxes involved. 2. Prepare joints for soldering and outline hazards associated with the operation. 3. Differentiate hard and soft soldering and carry out neat brazing operations observing all precautions.	1. a) Types of solders used in sheet metal work and their composition, e.g. Tinman solder self flux solder resin core solder etc. b) heating and melting together. 2. Properties of soldering fluxes in metal work e.g. i. Corrosive fluxes ii. Non-corrosive fluxes 3. Types of soldering iron – straight, hatched and electric soldering iron; Features: i. wooden handle ii. iron or steel rod iii. copper bit. 4. a) Hazards involved in soldering e.g. i. burns ii. toxic fumes iii. electric shocks 5. Preparation of joints for soldering e.g i. cleaning ii. tinning etc. 6. a) Soldering of joints	1. Melt tin and lead together to form soft solder. 2. Prepare killed spirit by dropping zinc in commercial hydrochloric acid. 3. Through simple practical demonstration show the effect of active and inactive fluxes on surfaces to be soldered. 4. Carry out some soldering operation applying different soldering bits. 5. head a soldering iron. Dip it into the flux and watch how the fume is propduced. 6. Inspect an electrical soldering iron and discuss possible area where there could be current leakages. 7. Cut two pieces of thin

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		b) Operation and safety precautions to be observed: i. prepare the joint ii. tin the soldering iron iii. flux the joint. 7. Finishing of soldered surface e.g. i. soapy water ii. warm water 8. a) The difference between hard soldering and soft soldering b) application of flux i. system of brazing ii. application of brazing rod or solder 9. Composition of brazing fluxes and rods i. powder, paste, liquid. Rod mostly solid. ii. Fluxes-boric acid, borates, fluorides, flouroborater, chloride etc. iii. Rod: copper zinc, aluminium silicon etc. 10. Production of brazed joints and their safety precautions 11. Cleaning up of flux residue on brazed joint.	sheet metal (mild steel). Prepare the edges to be soldered. 8. Heat and tin the soldering iron in readiness for the soldering operation. 9. Cut and solder two pieces of light sheet metal (mild steel) together. 10. Wash soldered joint with soapy water or warm water. Allow job to druy gradually. 11. Allow flux to remain on a soldered joints for some days. Watch its effect on the joints. 12. State the areas of differences – soldering and brazing, mention some areas where each could be preferred to the other. 13. Demonstrate how powdered and paste fluxes are applied in the process of brazing. 14. Talking about appearance and use, explain the difference between a suitable rod for brazing aluminium and the one that could be used for mild steel. 15. Using pieces of aluminium and mild steel, prepare simple tee, butt and lap joints. Compare the operations involved in the brazing of the mild steel pieces to that of the aluminium pieces. 16. Use appropriate flame and flux and rod to carry out hand/soft soldering.
3.	**<u>Sheet Metal Operation</u>** 1. Explain and apply various processes of sheet metal operation. 2. State mechanical properties of materials used and produce discs for various processes in sheet metal work. 3. Develop pattern and cut	1. Explanation of the following terms: i. annealing ii. beating iii. plating iv. raising etc v. stand blasting vi. pickling vii. painting viii. lacquering ix. galvanizing	1. Demonstrate the operations of hollowing, raising and blocking. Necessary precaution should be emphasized. 2. Calculate the wiring allowance for a wire of 12mm diameter. Pressure of swage should be properly controlled to

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	with appropriate tools and equipment to produce bowls. 4. Apply various tools to remove dents from metal surfaces for finishing.	x. blandishing xi. blocking etc 2. a) Calculation of allowances for edge stiffening; b) Application – edge stiffening e. g. hemming, raising etc. 3. Marking out for edge-stiffening using the calculated allowance. 4. Mechanical properties – brittleness, ductility, elasticity, elongation, hardness, malleability, plasticity, strength, toughness. Operation: definition and practical application 5. materials – Development of discs for making bowls in the workshop. 6. Description of the following processes: i. raising ii. sinking etc. 7. Calculation of size of blank for raising and polishing i. raising ii. sinking etc. 8. Drawing and cutting out blanks for raising, sinking and hollowing processes. 9. Appropriate tools and equipment e.g. i. form forage ii. hollowing hammer and block etc. 10. Production of bowls using the following process: i. raising-overhead wooden mallet. ii. Hollowing-pipe or cylinder 11. Removal of dents from metal surfaces with the use of: i. sanding ii. pickling with acid iii. sand blasting etc. iv. cleaning v. polishing vi. edge-forming 12. Finishing of projects – protection and beautification. Operation: i. dipping ii. electrolytic conversion iii. brushing/spraying	avoid any damage to the work piece. 3. Demonstrate the difference between the single and double helm. 4. Cut a piece of metal and on one end mark out the allowance that would be require for wiring a 12mm diameter wire. On other end mark out allowance for a single helm of 6mm. Sheet metal forming should involved: iv. blank size estimation v. blank preparation vi. heat treatment (annealing) vii. application of appropriate forming processes 5. Prepare a cylindrical piece. Bead the top either by wiring folding or other methods and swage the centre using any suitable swage. 6. Through practical demonstrtations explain the importance of the various mechanical properties. Compare ductility, malleability and plasticity. 7. Using the workshop method develop a disc for making a bowl of 8cm diameter. Cut out the disc. 8. Use the calculation method to derive the diameter of the disc. 9. Using the appropriate diameter mark out the disc for a hemispherical bowl of 8cm diameter. Cut pout the disc. 10. a) using any of the three methods raising, hollowing and blocking, form a bow. b) Use simple demonstration to

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			show the difference in the performance of the three processes. 11. a) Demonstrate the operation of smoothening using a wheeling machine. b) Smoothen a hollowed bowel by planishing 12. a) From simple practical operations explain the difference between sand blasting and picking. b) Clean the surfaces of a copper bowl by sanding. 13. a) Using practical demonstrations, differentiate between lacquering, galvanizing, plating and painting; Emphasize safety precautions in the processes. b) explain where each process would be preferable to the others and explain why. Metal surfaces to be worked on include: bowls, car fenders, metal boxes and other containers.
4.	**Templates** 1. Produce, read blue prints and develop templates for various sheet metal projects.	1. Production and reading of blue prints in metal projects. 2. Development of templates using different methods. 3. a) production of various sheet metal item e.g. b) sketch pattern on sheet metal: using appropriate drawing methods: i. Add allowances for joining etc. ii. Cut on pattern iii. Notch as necessary iv. Form as necessary	1. Make a layout drawing of sheet metal ducting for use in central air conditioning. 2. Using common objects and simple sketches explain the difference between the parallel line and the radial line methods of construction. 3. Produce the template for the construction of rectangular box of 4 x 8cm and 3cm deep. Add wiring allowance to the top and knocked up allowance on the sides.

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			4. Make a simple drawing in the office by a technical teacher. 5. Materials for templates: i. cardboard paper ii. plastic sheet iii. metal sheet iv. fibre v. wooden template.

STRUCTURAL STEEL WORK

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5.	**Safety Precautions** Apply appropriate precautions and wears used in the structural steel work	1. Selection, use and care for protective wears: i. goggles – eyes ii. apron – body iii. boots – legs iv. gloves hands safety 2. a) Cylinders: i. stand vertically ii. no exposure to heat – furnace open iii. close valve iv. cover cylinder with cap b) Lifting structural steel: i. fork lift, cranes chain hand gloves etc. ii. equipment in good condition iii. operator well positioned and protected c) Transportation: i. within working area ii. on the highway – trailers or adequate vehicle, triangles (safety) ribbon etc. 3. Application of safety rules in carrying out operation i.e. welding of tanks containing inflammable materials e.g petrol.	1. Demonstrate how they are used and explain their usefulness. 2. Explain the importance of observing these safety rules and what will result if not strictly observed.
6.	**Tools and Equipment** Using appropriate tools and equipment, maintain and take care of all the tools and equipment use in structural steel work.	1. a) Classification of the tools and their uses. i. Driving tools – hammers, spanners screw drivers etc. ii. Boring tools – drills, punches etc. iii. Shearing – chisels, punches etc. iv. Supporting and holding – pliers, strips, dogs, dice dollies etc. b) Types – hammer (ball pein, Cross pein, sledge etc.); Spanner (flat, ring, socket etc); Screw drivers (flat, star etc). c) Uses – Power tools for riveting, supporting, grinder, gripping, tightening and ensuring straightness.	1. Through simple practical demonstrations show how the tools are used in workshop. 2. Identify the power tools listed on performance objective. 3. Demonstrate the use of the tools by producing a project in the workshop. 4. Emphasize on the care of tools and apply oils and grease to tools. 5. Field/site or industrial visits should be routinely undertaken.

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		2. Identification of power tools i. see shape ii. see operation iii. check functions 3. a) The use and care for working equipment b) Use – clean parts, oil as necessary. Grease necessary parts (use nipples if available) 4. Maintenance of machines and equipment 5. Oiling – proper oil, proper application of oil, as directed by the manufacturer. 6. Greasing – routine maintenance, as directed by the manufacturer. 7. Regrinding – proper grinding machine; regular operation.	
7.	**Specifications and Calculations** 1. Describe with sketches forms of structural steel materials and apply various symbols with standard specifications used in structural steel work. 2. Apply Hooke's law and differentiate, stresses applied to structural steel work. 3. Calculate and read structural steel working drawings and sketches.	1. Description and sketches of forms of structural steel materials. 2. Conventional symbols and abbreviations in structural steel sections. 3. Standard specifications to structural steel work. 4. Use and limitations of structural steel materials. 5. Hooke's law in design – Definition: i. In an elastic material strain is proportional to stress. ii. The value of stress where a material ceases to obey Hooke's law is known as elastic limit 6. The difference between stresses 7. Calculation of: a) Tensile stress = Load or load . area of rivet area b) Comprehensive stress Load on a punch Load Area of punch Area 8. Reading of drawings and sketches in structural steel work details.	1. Demonstrate how the symbols in structural steel work are sketched and explain what they stand for. 2. State the use of the structural steel materials, explain the composition of the metal and then discuss possible limitations of the materials. 3. Demonstrate how Hooke's law can be applied to the design of structural element. 4. Through simple calculation, demonstrate the working of tensils, comprehensive and shear stress they concern structural steel work. 5. Demonstrate the sketching of simple structural steel work. 6. Visit structural steel work companies and study drawings.
8.	**Steel Project** 1. Using calculation in forming, develop and produce simple templates in structural steel work. 2. Reproduce jobs, sketch and produce simple working jigs in structural steel work.	1. Calculation of allowances for forming. 2. Simple projects in structural work e.g. stanchion bar or plate; and rafter bunches. 3. Development of templates with regular surfaces. 4. Cutting out of templates from materials e.g. wood, cardboard, and any other suitable materials. 5. Reproduction of jobs on structural steel materials using templates: i. trace pattern from template;	1. Demonstrate and explain the determination of the actual diameter for calculating the circumference of an angle bar ring. Take any inner diameter using angle bar of any given thickness and work out the circumference for the metal to form the ring.

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		ii. fold, bend etc as necessary; iii. join as necessary. 6. a) Sketching and production of simple working jigs. b) Importance - Assist drilling of holes, locate areas to be riveted on structural steel materials	2. Design a simple structural steel work involving the use of the materials. Ensure compliance of sketch and materials with required standard and produce the project etc. 3. Demonstrate how a template should be developed and develop one that can be used in structural steel work.
9.	**Iron and Steel Manufacturer** Sketch a blast furnace, its working principles and name the fuel with its composition.	1. Sketching of blast furnace and its working principles. 2. Name of fuel and composition: i. coke and limestone; ii. coke provides fuels, carbon; iii. limestone serves as flux (molten slag). 3. Working principles of a Bessemer process. 4. Characteristics: i. Pig Iron – produced from crude oil in the blast furnace (cast into pigs). ii. Cast Iron a) iron and carbon and small amount of silicon, phosphorus, sulphur, and manganese; b) cheap, low melting temperate, fluidity, and easily machined. c) Free graphite as lubricant. Low carbon steel. d) 0.1 – 0.3% carbon (0.1 to 1.125 dead mild 0.15 – 0.3) e) good for wire rod, thin sheet, solid drawn tables boiler plates, bridge work, structural sections.	
10.	**Assembly** Assemble simple structural components	1. a) Uses of fixtures and bolts in assembly of structural components. i. Facilities operation; ii. Holds, supports, locates operation guide, ensures uniformity etc. iii. Uniformity and accurate location of holes on structures. iv. Location of welds and components etc. b) Bolts – Fasteners hold together; Holds structural components together and in position. 2. Assembly of structural components e.g.	4.

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		rafters, canopy, roof trusses etc.	
11.	**Corrosion** Identify common causes of corrosion and describe its effect on structural steel.	1. Some causes of corrosion on steel e.g. water, atmospheric condition etc. 2. Description of effect of corrosion on structural steel e.g. weakening of structure, defacing of steel etc.	Using simple materials, explain what is corrosion.
12.	**General safety Precautions** 1. Using appropriate equipment, carry transport and store full and empty gas cylinder safety. 2. Apply appropriate precautions and wars in gas welding operations under conditions.	1. a) Carrying, transporting and storing of full and empty gas cylinders. b) Safety precautions: i. movement by rotating on the bottom edge. ii. Not to lie on a horizontal position. iii. Non-exposure to heat, furnace etc. iv. No dragging, sliding or rolling on side. v. Store in a cool place. vi. Use hand-truck to ease transportation 2. Safety precautions in carrying out gas welding in: i. confirmed spaces; ii. inflammable materials chemical emptied containers. 3. Application of protective wears e.g. welding shield, welding goggles, gloves, boots etc.	
13.	**Gas Welding Process** 1. Describe features and functions of specified gas welding equipment. 2. Differentiate and compare the oxyacetylene generators. 3. Analyse calcium carbide and generate acetylene using it. 4. Distinguish flames and describe their derivation processes. 5. Discuss welding joints and prepare plates for them.	1. a) Identification of gas welding equipment e.g. generators, regulators, regulators, blow pipes etc, nozzles, hoses, gas cylinders and their colours, economizers check valves etc. b) Features c) Functions d) Applications and care 2. Types of generators e.g. water to carbide, carbide to water generator. 3. Identifying the main parts of a generator e.g. valve purifiers, carbide trays etc. 4. Difference between high and pressure system of welding. 5. Composition of calcium carbide – calcium and carbon. 6. Generation of acetylene. 7. a) Types of welding rods – mild steel rods, aluminium rod, brass rod etc. b) Properties c) Compositions and uses 8. The difference between welding and cutting torches. 9. a) Types of ox-acetylene flames b) Equal volume of acetylene and	1. Demonstrate the connection of a welding unit given necessary apparatus. 2. Using appropriate sketches show the difference between the water to carbide and carbide to water generators. 3. Discuss the position of water in the generators to show how the water and carbide work together to justify the names of the generators. 4. Sketch and explain the working principles of a gas welding generator and discuss the functions of the main parts. 5. Through practical demonstration explain the difference in the use of the low and high pressure system of

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		oxygen c) More oxygen – Oxidizing (shorter and more pointed inner cone almost purple colour). d) More acetylene-carbonizing. 10. Application: i. Neutral – Most welding ii. Oxidizing – brazing iii. Light acetylene, add oxygen. 11. Operation: i. Flange joint, corner and lap joints. ii. 'T' joint, butt joint. 12. Sketches of conventional symbols for welding joints e.g. fillet joint, butt joint, lap joint etc. 13. Preparation of materials for welding: i. Pieces of sheet metal ii. Fire bricks iii. Welding equipment Operation: i. Form joints ii. Allow necessary gap iii. Track evenly and weld in down hand flat position. 14. a) Functions of backing bars and strips. b) Applications.	welding. Give reasons why one could be preferable to the other. 6. Using a suitable lab, demonstrate the formation of calcium carbide. 7. Demonstrate in the workshop using the common welding transformer – carbide to water system. How acetylene is formed. 8. Discuss through practical example, how to determine whether or not a rod is good or poor. 9. sketch looking like a welding and cutting torch, list the difference between the two, operate them and find out why those differences are necessary. 10. Demonstrate how the flames can be got from the adjustment of the torch and discuss the differences. 11. Demonstrate running beeds without filler rod. Prepare a 'Tee' joint and weld. 12. a) Using appropriate welding symbols, indicate a kind of weld you would want for a lap joint. Show sketch. b) Demonstrate dhow symbols are used to show how joint should be welded using appropriate sketches. 13. a) Demonstrate the preparation of the joints and carry out the welding. Compare butt joint to lap joint; b) Weld without applying a filler rod and weld adding rod. Compare the two

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			and see if there will be remarkable differences. 14. Design a suitable backing bar or strip. Use it to carry out a welding operation and explain its functions. Examine and see how the functions are preformed.
14.	**<u>Non-Ferrous and Ferrous Metal</u>** 1. Identify types of non-ferrous metals and describe the properties of materials used in fabrication engineering. 2. Identify fluxes, functions and application on cast iron welding. 3. Consider components composition and prepare them for bronze welding operation.	1. a) Types of non-ferrous metals e.g. Tin, Copper, Zinc etc. b) Compositions of non-ferrous metals. 2. The general characteristics of materials used in fabrication engineering and the physical properties e.g. hardness, ductility, Fusion etc., tenacity, distortion, toughness, strength etc. 3. Application and explanation of cast iron: i. mild steel ii. copper, alloy etc iii. high mild steel iv. common copper alloys v. aluminium alloys vi. stainless steel. 4. a) Properties and composition of fluxes for welding non-ferrous metals; b) Functions of the flanges. 5. Welding of non-ferrous metals with appropriate fluxes. 6. a) Composition of cast iron. b) Types of cast iron e.g. gray, white etc. c) Properties of cast iron. 7. preparation for cast iron welding – Grinder, diamond point chisel, wire brush etc. Flame for pre-heating operation: i. remove surface layer ii. V the edges iii. Tiny hole on each end of crack if necessary 8. Welding cast iron components. i. dull red before heating. ii. Good grade filler rod. iii. Flux to molten metal. iv. Torch in a circular motion v. Pre-heat vi. Cool slowly 9. Suitable fluxes for bronze welding and their composition. 10. Preparation of bronze components for welding. i. through cleaning	1. Using small pieces, how the differences in colour, between copper, aluminium and brass. 2. Demonstrate the welding and coding of some metals to ensure that they return their properties. 3. Weld two pieces of mild steel, cool immediately in water and observed the sudden hardness of the joint and possible cracks around it. 4. Weld pieces of non-ferrous metals using appropriate flux watch the effect of the flux on the molten metal and then explain the functions of the flux. 5. Demonstrate the application of the flux using the filler rod or apply flux with brush if using liquid flux. 6. Demonstrate fusion welding of cast iron objects or pieces. 7. Demonstrate how stainless steel components can be prepared for welding. 8. Using the appropriate rod, flux and joint preparation weld stainless steel component properly observing necessary precautions. 9. Clean up the welded

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		ii. form 90°V goove iii. weld to travel on an incline. 11. Specification of bronze weld. 12. Reasons for post-heating: i. stress relief ii. avoid cracks iii. avoid distortion and composition. 13. a) types of stainless steel b) properties 14. Preparation of stainless steel components for welding; processes – flange type joints, bevel to provide a V, claps and jigs to avoid distortion and warping. 15. Welding of stainless steel with rods, techniques involved and the safety precautions: i. for hand techniques ii. torch and tip position iii. filler rod close to cone iv. appropriate flux and fluxing v. weld from one side only vi. neutral flame vii. columbium treated filler rod viii. use copper backing strips. Cleaning: i. wash joint thoroughly ii. brushing off flux residue etc.	joint thoroughly to avoid weld decay. 10. Demonstrate practically, how to weld stainless steel using stainless steel rods.
15.	**Building up of Worn Mechanic Parts** Discuss the composition and properties of worn mechanic parts and the suitable materials to carry out the operation.	1. Identifications: a) physical or as per manufacturer properties b) as per the metal used for the object build up operation: i. clean up thoroughly ii. use neutral flame iii. use appropriate flux iv. use appropriate rod v. bronze weld or fill up gradually. 2. Building up of given worn metallic surface with the application of all methods and stages of operation.	
16.	**Welded Joints, Defects and Rectification** 1. Describe and state how defect can be avoided in gas welding. 2. Apply appropriate tests and state causes of defects in welded joints with their remedies.	1. Some defects in gas welded joints. Causes: i. slow speed and too much flame; ii. flame too low and speed high; iii. atmospheric contamination iv. foreign substance in molten metal v. weld height uneven vi. insufficient weld metal above welded surface. 2. Avoidance – normal welding procedure etc. 3. Test to detect defects in welded joints a) Non-destructive: ii. by looking through a	1. Weld a double vee joint and cut for inspection of defects. 2. Demonstrate the application of the various weld testing method in the workshop practice. 3. a) demonstrate bearing in mind welding procedures and precautions, who a good weld can be carried out in a workshop.

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		magnifying glass iii. penetrating of rays iv. high frequency vibrations or ves. a) Destructive – subject to lead until there is failure. b) Types – tensile, shear, weld uniformity, etching and impact. c) Processes: i. tensile, testing machine (pulling to break) ii. Nick break and free bend tests (hultility, porosity, gas pockets, slag inclusions. Overlaps penetration etc). iii. fillet welded joint test (soundness of fillet weld) iv. etch test (soundness of weld and show boundary between the weld and base metals. 4. Rectification of welded joint defects. 5. Common causes of welding defects in gas shielded arc and ancillary welding process: i. bad joint preparation ii. too high a current iii. too low a current etc.	b) weld pieces of metal together, watch for any defect, explain why or discuss why. 4. Demonstrate the proper application of gas shielded arc and ancillary processes in welding workshop.
17.	**Safety Precautions** 1. List and explain hazards in arc welding and protective wears required for welding operations. 2. Apply appropriate safety precautions while welding in confined or dangerous areas.	1. a) some hazards in arc welding e.g. arc eye, electric shock etc. b) Causes – improper protection of eye, nose and carelessness with electricity. Solution – Observe necessary safety precautions. 2. Protective wears for welding operations e.g. hand/head shield. i. protect head, eye etc against burns; ii. radiations ray-arc-eye; iii. protect hand and body against burn radiation sparks etc. Care – wear as appropriate and keep safety after use. Precautions to be carried out: i. ventilation, exhaust system ii. thorough cleaning of all combustible substances; iii. venting container, fill with water if possible; iv. fire resisting guds, move away from inflammable materials if possible, fire extinguishers, stand-by watchers with fire extinguishers.	1. Explain the causes of the hazards in arc welding and advice on how they can be avoided. 2. Demonstrate the use of the protective wears required while carrying out arc welding operation. 3. Explain how arc welding can be carried out safely in confined spaces and near inflammable materials. 4. Demonstrate how a drum used for the storage of inflammable or toxic materials can be prepared for arc welding.
18.	**Welding Machines and Accessories**	1. Differences between AC and DC Machines.	1. Demonstrate the function of the various parts of the

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	1. Differentiate and explain functions of arc welding equipment and its accessories spelling out advantages and disadvantages. 2. Describe materials composition and state conventional electrode classification. 3. Select electrode for welding material and technique/positions involved.	a. Source of electric power. b. Direction of flow of electric current polarity. c. Transformer type and motor generators machines. d. Rectifier e. Magnetic arc blow f. Dual control g. Operating and maintenance cost, overall electrical efficiency and noiselessness. 2. Working principles of AC and DC machines. a. source of power b. adjustment of welding current output c. arc booster switch d. the cables 3. Weld operation of D.C. a. source of power selection of polarity b. switch on control c. current selected d. dual control system welding operation. 4. Meaning and functions of welding accessories e.g. welding load – wire brush etc. 5. Advantages and disadvantages of A.C and D.C machines:– a. A.C. Advantages: cost, weight, size, arc booster, magnetic arc blow, current flow operation cost, electrical efficiency, noise etc. b. D.C. Stationary or mobile, use dual control, deeper penetration light, gauge materials. c. Disadvantages Source of power, ease of movement, operating cost of ease etc. 6. Using of AC and DC welding machines in the workshop - Machines, shield, electrode holder, glove etc. Operations: a. DC welder – set for polarity current straight or reversed. b. Control unit for amperage and voltage (for electrode). 7. Safety to observe Electrode manufacturing – Processes: a. forcing hot metal through suitable die (bare electrode); b. extruding and dipping into	machines (AC and DC). 2. Demonstrate the operation and use the AC machines by using the two in a welding operation. 3. Sketch and demonstrate how some A.C and D.C welding machines accessories function. 4. a) Demonstrate how the welding machine should be set. b) Use the machine to carry out welding of various operations in the workshop. 5. Pick a metal and select suitable electrode to weld the metal, discuss electrode selection method. 6. Demonstrate how to carefully dry, oven store and handle electrodes in the workshops. 7. Demonstrate how to strike metal arc and maintain the arc. 8. Demonstrate the process of weaving and laying of multi-runs in arc welding. 9. Safety regulations and requirements must be observed.

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		coating. Coating Substances – Cellulose Sodium, Cellulose Potassium, Tatinia Sodium, Iron Oxide etc 8. Sketch different type of electrode composition materials. 9. Classification of electrodes. a. State symbols e.g. E-600, E-7010, E-8010 etc. b. Interpret prefix E and other numbers 10. Selection of electrode material. 11. Methods of electrode materials. a. dry place, normal room temperature. b. 50% maximum room humidity handling; c. No bending, no dropping, pumping or stepping on. 12. Striking and maintaining of metal arc a. tapping or scratching b. correct arc length c. correct electrode current travel speed, electrode angle. 13. Arc loading techniques and operations a. increasing width and breadth; b. circular movement of hand; c. running more than on run.	
19.	**Welding Joints in all positions** 1. Carry out all position welding with sketches for various joints and explain factor governing selection of joints. 2. Interpret various welding symbols and prepare different joints for various techniques and all position welds. 3. Prepare and weld pipes and flanges with different methods and positions.	1. Sketches and application of joint in metal fabrication e.g. single vee, square butt etc. 2. Factors governing the selection of joints for projects e.g. type of metal thickness of metal, shape of plate, position of joint etc. 3. Various arc welding symbols and conventions e.g. single vee, fillet joint, butt joint, single u double u. etc. 4. a) Preparation of edges for welding joints. b) square butt, single vee, double vee, single u, double u. 5. Welding the prepared joints. 6. Preparation of metal surface e.g. Multi-run weld, Weaving welds etc. 7. Making of multi-run weld Operation – run first layer, remove slag and lay second layer etc. 8. Weaving of welds – weave as you weld, secure desired width fillet. 9. a) Welding joint positions – vertical position etc. c) Operational techniques: i. running of seam or line of weld – gravity pull, fast-freeze electrode. ii. Shorter arc – overlap (position	1. Sketch and weld the various joint show weld and where applicable. 2. Sketch and interpret the various arc welding symbols and convention used in engineering working drawing. Show such drawings. 3. Demonstrate the various edge preparation in welding in the workshop. 4. Weld the joint, observing normal welding procedures and safety precautions. 5. Demonstrate the preparation of metal surface for multi-run and weaving welds. 6. Demonstrate the process of making multi-run welds. 7. Demonstrate the weaving action during

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		undercut and improperly shaped beads) iii. Most difficult – work against gravity puddles tendency to drop 10. Various position of welding pipes and flanges. Process: a. special pipe clamps b. hold up flange to pipe c. tack and weld. 11. Rotated position of welding pipes and flanges: a. lining up each section (length by length), b. welding each joint c. pipe remains stationary d. welding in various positions	welding operations. 8. a) Prepare joint for vertical, horizontal and overhead welding. b) place the jobs properly and demonstrate welding in the vertical, horizontal and over-head positions check and compare the welds. Observe areas of differences and find out why. 9. Demonstrate the process of welding pipes and flanges. 10. Demonstrate the process of welding pipes and flanges in rotated position. 11. Weld pipe using the stove method explain the difference between the fixed position, rotated position and the stove pipe.
20.	**Arc Welding Ferrous and Non-Ferrous Metal** 1. Identify by inspection types, physical properties of metals and explain their welding behaviour. 2. State the e4ffect of welding on cast iron and prepare it for various types of welding. 3. Identify types, composition and physical properties of non-ferrous metals. 4. Carry out welding operations on various non-ferrous metals using appropriate equipment and heat.	1. Identification and inspection of ferrous metals e.g. cast iron, steel etc 2. Physical properties of cast iron – conductivity, grain structure, effects when heated, hardness etc. 3. Behaviour of welded cast iron a. free welding quality b. poor welding quality 4. Procedure for carrying out welding: a. lower cooling rate of weld, likelihood of hard zone, burns, grease oil, scale, faster welding speed; b. stress relief, crack avoidance. 5. a) preparation of pieces of welding: i. removal of casting skin ii. vas necessary iii. drill 1/8 hole if necessary iv. keep casting as cool as possible v. correct electrode and amperage vi. reinforce heavy castings with studs etc. Weld as necessary b) identification of non-ferrous metals: i. colour; ii. composition; iii. copper and zinc – brass	1. Wseld piece of grey cast iron, white and malleabale cast iron. Watch and explain their behaviour in the process and after welding. 2. Demonstrate the preparation of cast iron. 3. Select susitable machine and electrode for welding non-ferrous metals and carry out welding operations in the workshop. 4. Demonstrate appropriate method for the heat treatment of a finished welding of non-ferrous metal. 5. Prepare suitable joint on non-ferrous metals weld joint using appropriate materials and precautions. Heat treatment after welding, cool and allow to remain on room temperature for

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		iv. Nickel, Chromium iron – inconel v. Nickel, Copper, iron etc - Monel 6. Composition and physical properties of non-ferrous metals e.g. ductility, fusion, distortion, fatique, tenacity, effect of heat, hardness, malleability. 7. Selection of suitable electrodes and machines for welding non-0ferrous metals. 8. Method of heat treating finished welding non-ferrous metal: i. elevated temperature ii. rapid quenching (in water) iii. keep at room temperature iv. artificial aging or precipitation hardening. 9. a) Process of welding and heat treatment of non-ferrous metals: i. prepare joint ii. clean joint iii. Appropriate rod iv. Flux and welding machine v. Weld vi. Heat and case harden a) Metals i. copper ii. bronze iii. brass iv. monel v. inconel vi. aluminium	some days.
21.	**Building up worn metallic parts** Identify composition of various worn metallic parts and discuss their properties with build up operation.	1. Composition of worn metallic shafts and other parts – gear teeth, shaft etc. 2. Properties of worn smetallic parts: a. as per the metal b. weldability c. ductility d. hardness etc. 3. Building up of worn metallic parts to specification: a. thorough cleaning b. joint formation (stud) c. appropriate rod and flux d. appropriate welding machine e. proper setting of machine f. pre-heating g. gradual-build up h. post heating	Following normal welding processes and observing safety precautions weld the worn out parts.
22.	**Arc cutting of metal** State principles application of various cutting method and identify arc cutting electrodes	1. Principles – application: i. melting heat of arc between carbon electrode and base metal, jet of compressed air blows molten metal away.	Demonstrate the cutting of metal by the different arc cutting methods.

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		ii. a melting process of forcing the molten metal down. iii. high pressure gas through the arc. As a supersonic jet, hotter than any flame, melt metal and blast molten metal through plasma – arc cutting. 2. a) Cutting electrode – carbon electrode, coated mildsteel electrode, carbon graphic electrode. b) compositions and use 3. Cutting of metals – procedures: a. proper electrode b. set machine to suit electrode c. metal preferably in a flat position d. start cutting at outside line e. good manipulation	
23.	**Welding Defects** Describe major defects in arc welding joints and state how they can be tested ad avoided.	1. Major defects in arc welding joints e.g. porosity etc. 2. Solution: a. proper welding technique and procedure b. proper current setting, current electrode, joint penetration etc. 3. a) tests to detect defects in arc welded joints non-destructive – using magnifying glass, penetration of rays, high frequency vibration of waves etc. b) Destructive: i. subject to load until there is failure types; ii. tensile, shear, weld uniformity, etching and impact. c) Process: i. Tensile testing machine (pulling to break) ii. Nick break and free bend test (ductility, porosity, gas pocket, slag inclusion, overlaps penetration etc) iii. fillet welded joint test (soundness of fillet weld). iv. impact test (absorb energy under impact without fracture) 4. Rectification of welded joints – proper welding procedure good beveling, proper heating, good arc control, adequate rod and good welding technique, proper observation of precautions.	1. Demonstrate and explain how non-destructive testing can be carried out in detecting defects in arc welding joints. 2. Test welded joint using the destructive and non-destructive testing methods. 3. Carry out a practical demonstration of such techniques and explain the proccesses.