



GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
DIRECTORATE GENERAL OF TRAINING

COMPETENCY BASED CURRICULUM

CERTIFICATE COURSE ON
**FUNDAMENTALS OF CNC
PROGRAMMING AND
OPERATION**



NSQF LEVEL- 3.5

SECTOR - CAPITAL GOODS AND MANUFACTURING

FUNDAMENTALS OF CNC PROGRAMMING AND OPERATION

Duration: 240 Hours

NSQF LEVEL- 3.5
(Version: 1.0)

Designed in 2024

Developed By

Ministry of Skill Development and Entrepreneurship

Directorate General of Training

&

CENTRAL STAFF TRAINING AND RESEARCH INSTITUTE

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CONTENTS

S No.	Topics	Page No.
1.	Course Information	1
2.	Job Role	2
3.	General Information	3
4.	Learning Outcome	4
5.	Trade Syllabus	5
6.	Assessment Criteria	12
7.	Tools and Equipment (Annexure-I)	14
8.	List of Experts (Annexure-II)	16

1. COURSE INFORMATION

1.1 GENERAL

This course has been developed for CTS/ CITS trainees to take up as optional courses during course of study for technical and behavioural upgradation of trainees to meet industry related job roles. During the 240 hours duration of CNC Programming & Operation Assistant course, a candidate is trained on professional skills & knowledge related to job role. The Broad components covered during the course are given below:

Basic CNC Programming and Operation sets up and operates metal-cutting machinery to build tools and parts of various machinery. Their duties include studying blueprints and creating the design, cutting metal and manipulating it to build the project, and performing regular maintenance on their machinery.

1.2 COURSE STRUCTURE

Table below depicts the distribution of training hours across various course elements during a period of 6 weeks: -

S No.	Course Element	Notional Training Hours
1.	Professional Skill (Trade Practical)	180
2.	Professional Knowledge (Trade Theory)	60
	Total	240

1.3 ASSESSMENT & CERTIFICATION

The trainee will be tested for his skill, knowledge and attitude during the period of course through assessment at the end of the course through skill testing at Training Center & CBT through examination conducted by DGT.

The minimum pass percentage for skill test is 60% and for theory will be 33% as in main CTS examination.

2. JOB ROLE

CNC Setter cum Operator-Turning; CNC Setter cum Operator-Turning sets up the CNC turning machine, its work holding devices, tooling, loading the machine operating programs, conducting trial runs and correcting faults, in order to ensure that the work output is produced as per specification.

CNC Setter cum Operator-Vertical Machining Centre; CNC Operator-Vertical Machining Centre produces components that combine a number of different features, such as flat faces, parallel faces, faces square to each other, faces at an angle, steps/shoulders, open and enclosed slots, drilled, bored and reamed holes, internal threads, and special forms. It involves continuously monitoring, inspecting the components and meeting production targets.

CNC Operator-Machinist; A CNC Operator is responsible for maintaining and operating CNC machine. The individual monitors gauges and dials. The individual must be proficient in programming and setting CNC machinery.

Reference NCO-2015:

- 1) 7223.6001
- 2) 7223.5005
- 3) 7223.5003

Mapped NOS:

- 1) CSC/N9583

3. GENERAL INFORMATION

Name of the Trade	FUNDAMENTALS of CNC PROGRAMMING & OPERATION
Reference NCO - 2015	7223.6001, 7223.5005, 7223.5003
NOS Covered	CSC/N9583
NSQF Level	3.5
Duration of Craftsmen Training	240 Hours
Entry Qualification	10 th Class passed and perusing/ passed out CTS Fitter, Turner, Machinist, Machinist Grinder, TDM /CITS Candidates of Fitter, Turner, Machinist, Machinist Grinder Trades
Unit Strength (No. of Student), Space & Power Norms	As per CNC Machining Technician trade under CTS
Instructors Qualification	B. Voc/ Degree/ Post Graduate in Mechanical Engineering / Mechatronics / Automotive / Production / Industrial Engg from AICTE/UGC recognized Engineering College/ university with one-year experience in the relevant field. OR 03 years Diploma in Mechanical Engineering from AICTE recognized board of technical education or relevant Advanced Diploma (Vocational) from DGT with two years' experience in the relevant field. OR NTC/NAC passed in the Trade of "CNC Machining Technician" with three years' experience in the relevant field. Essential Qualification: Relevant Regular/RPL variants of National Craft Instructor Certificate (NCIC) under DGT.
List of Tools and Equipment	As per Annexure – I

4. LEARNING OUTCOME

Learning outcomes are a reflection of total competencies of a trainee and assessment will be carried out as per the assessment criteria.

4.1 LEARNING OUTCOMES

1. Understanding basics of CNC Technology.
2. Familiarize and practice on Hands sessions of CNC lathe on-off, features, functional lays, drive setting, jog, MDI, EDIT, auto all modes.
3. Set (both job and tool) CNC turning centre / Simulator and produce components as per drawing by preparing part program using G & M Codes.
4. Set (both job and tool) CNC Milling centre / Simulator and produce components as per drawing by preparing part program using G & M Codes.
5. Create and analyse programs in CAM and post process to Machine / CNC Simulator.
6. Use of I/O device, common parameters setting, basic maintenance, lub oil level check, hydro-oil level check, battery alarm etc.

5. SYLLABUS

SYLLABUS – FUNDAMENTALS OF CNC PROGRAMMING & OPERATION

Duration: 240 Hours

Duration Weeks	Reference Learning outcome	Professional Skills (Trade Practical)	Professional Knowledge (Trade Theory)
Practical 20 Hrs Theory 10 Hrs	Understanding basics of CNC Technology	1. Demonstration of CNC - lathe & milling and its parts bed, spindle motor and drive, chuck, tailstock, turret, console, control switches, coolant system, hydraulic system, steady rest. 2. Panel screen, key board, axis structures. 3. Working of parts explained using simulator for CNC parts shown on machine. 4. Identify machine over travel limits and emergency stop.	• Difference between CNC and conventional lathes/ milling. • Advantages and disadvantages of CNC lathe & milling machines over conventional machines. • Machine model, control system and specification. Axes convention of CNC , lathe & milling machine – • Machine axes identification for CNC turn centre & Mill centre, thumb rule.
Practical 20 Hrs Theory 10 Hrs	Familiarize and practice on Hands sessions of CNC lathe on-off, features, functional lays, drive setting, jog, MDI, EDIT, auto all modes	5. Hands on session in CNC machine, on-off, power, main switch, stabilizer, machine position, ABS machine value. 6. Check on screen, screen reading, page finding 7. Familiarization of keys, functions of keyboards, DNC system, all modes of switches.	• Flow chart of on-off methods, referencing/ home position methods, details of axes movement. • Working details, functions of all keys, measuring of all parts and switches of panel of different control system (snches, FANUC, Sinumerics etc.)
Practical 50 Hrs Theory 10 Hrs	Set (both job and tool) CNC turning centre / Simulator and produce components as per drawing by preparing pa rt program using G & M Codes	8. Decide tool path for turning, facing, grooving, threading, drilling. Identification of safety switches and interlocking of DIH modes.	• Machining operations and the tool paths in them – stock removal in turning and facing, grooving, face grooving, threading, drilling.
		9. Identify common tool holder and insert shapes by ISO nomenclature.	• Concept of Co-ordinate geometry, concept of machine coordinate axis,

		10. Select cutting tool and insert for each operation. 11. Fix inserts and tools in tool holders. 12. Decide cutting tool material for various applications. 13. Write CNC programs for simple tool motions and parts using linear and circular interpolation, check on program verification/ simulation software. 14. Write CNC part programs using canned cycles for stock removal, grooving, threading operations, with drilling and finish turning. Use TNRC commands for finish turning. Check simulation on program verification/ simulation software.	axes convention on CNC lathes, work zero, machine zero. Converting part diameters and lengths into co-ordinate system points. Absolute and incremental programming. • Programming – sequence, formats, different codes and words. ISO G codes and M codes for CNC turning. Describe CNC interpolation, open and close loop control systems. • Co-ordinate systems and Points. Program execution in different modes like MDI, single block and auto. • Canned cycles for stock removal (turning/facing), grooving, threading, for external and internal operations. • Tool nose radius compensation (TNRC) and why it is necessary. Find the geometry page in CNC machine. • Cutting tool materials, application of various materials.
		15. Starting the machine, do homing on CNC simulator. 16. Entering the CNC program in EDIT mode for an exercise on Simple turning & Facing (step turning) without using canned cycles, on CNC simulator. 17. Determining work and tool offsets using JOG, MDI, MPG modes, on CNC simulator. 18. Entering the tool offsets, tool nose radii and orientation for TNRC in offsets page, on CNC	• Program execution in different modes like MDI, single block and auto. • Process planning & sequencing, tool layout& selection and cutting parameters selection. • Machine operation modes – Jog, MDI, MPG, Edit, Memory. Entering and editing programs on machine console, entering offsets data in offsets page. • Use of Emergency stop, Reset, Feed rate override, spindle speed override,

		simulator.	edits lock on/off buttons and keys.
		19. Checking finish size by over sizing through tool offsets, on the machine. 20. Machining parts on CNC lathe with combination step, taper, radius turning, grooving & threading, with external and internal operations, first and second operation, on the machine. 21. Machining long part on CNC lathe held in chuck and tailstock (between centers). 22. Starting from interruption due to power shutdown, tool breakage. 23. Changing wear offsets to take into account tool wear. 24. Part program preparation, Simulation & Automatic Mode Execution of CNC Machine for the exercise on Blue print programming contours with TNRC. 25. Carryout Drilling/Boring cycles in CNC Turning. (First 60% of the practice is on CNC machine simulator, followed by 40% on machine.)	• First part checking: Program checking in single block and dry run modes – necessity and method. • Tool offsets adjustment on first part for close tolerance dimensions, by over sizing (for outside dimensions) or under sizing (for inside dimensions) the dimension to prevent part rejection. • Wear offset setting – necessity, relationship with tool wear, entering in offsets page. Process and tool selection related to grooving, drilling, boring and threading. • Axes over travel, recovering from over travel. • Collisions due to improper machine setup and operation – causes and effects. Recovering from collisions. • Find out alarm codes and meaning of those codes.
Practical 50 Hrs Theory 10 Hrs	Set (both job and tool) CNC Milling centre / Simulator and produce components as per drawing by preparing part program using G	26. Decide tool path for Face milling, Side milling, Pocket milling, Drilling, Counter sinking, tapping, Reaming, Rough boring, Finish boring, Spot facing.	• Machining operations and the tool paths in them - Face milling, Side milling, Pocket milling, Drilling, Countersinking, Rigid tapping, floating tapping Reaming, Rough boring, Finish boring, Spot facing.

	& M Codes.		
		27. Write CNC programs for simple parts using linear and circular interpolation, absolute and incremental modes, check on program verification software. 28. Write CNC part programs for parts with face milling, pocket milling with subprograms. Check on program verification software. 29. Write CNC part programs for pocket milling, drilling with canned cycle, countersinking with canned cycle, tapping with canned cycle. Check on program verification software.	• Concept of Co-ordinate geometry & polar coordinate points, concept of machine axis, axes convention on CNC lathes, work zero, machine zero. • Converting part dimensions into coordinate system points. Absolute and incremental programming. • Programming - sequence, formats, different codes and words. ISO G and M codes for CNC milling. • Canned cycles for drilling, peck drilling, reaming, tapping, finish boring. • Subprograms, Cutter radius compensation (CRC) and why it is necessary. Cutting tool materials, application of various materials. • Cutting tool geometry for face mill, end mill, drill, countersink, tap, finish bore, reamer. Insert holding methods face mill, insert type end mill and insert type drill. • Insert cutting edge geometry. Cutting parameters- cutting speed, feed rate, depth of cut. Tool wear, tool life, relative effect of each cutting parameter on tool life.
		30. Starting the machine, do homing on CNC simulator. 31. Entering the CNC program in EDIT mode for an exercise on face milling and drilling without using canned cycles, on CNC	• Program execution in different modes like manual, single block and auto. • Process planning & sequencing, tool layout & selection and cutting parameters selection. Work

		simulator. 32. Mounting tools on the ATC according to part and process requirement, on CNC simulator & CNC machine. 33. Determining work and tool offsets using JOG, MDI, MPG modes, on CNC simulator& CNC machine. 34. Tool change in CNC milling and JOG, MDI, MPG mode operation.	offset, tool length offset, tool radius offset. • Work holding with temporary holding and fixtures. Truing of part and fixture. Machine operation modes - Jog, MDI, MPG, Edit, Memory. • Entering and editing programs on machine console, entering offsets data in offsets page. • Use of Emergency stop, Reset, Feed rate override, spindle speed override, edit lock on/off buttons and keys.
		35. Prepare part programme, enter, edit and simulate 36. Carryout tool path simulation, Recovering from axes over travel, on virtual machine simulator, Part program writing, setup, checking	• First part checking: Program checking in single block and dry run modes - necessity and method. • Tool offsets adjustment on first part for close tolerance dimensions, by oversizing (for outside dimensions) or under sizing (for inside dimensions) the dimension to prevent part rejection. • Axes over travel, recovering from over travel. Collisions due to improper machine setup and operation - causes and effects. • Recovering from collisions. State the importance of Helical inter-polar and thread milling, advantage and limitation in CNC machine.
		37. Machining part on CNC VMC with face milling, drilling. 38. Machining parts on CNC VMC with combination face milling, side milling with CRC, drilling,	• Tool wear and necessity for wear offsets change, entering wear offsets in offsets page. • Effects of sudden machine stoppage due to power shutdown or use of emergency stop. Restarting

		countersinking, tapping. Use canned cycles and subprograms wherever possible. 39. Machining of part with closely controlled slot dimension using CRC, Machining of part with pockets, End milling with polar coordinates, Part programs & Simulation Automatic Mode Execution of CNC Machine for the exercise on End milling with polar coordinates and practical on Simple drilling- G 81, 40. Practical on Chamfer and counter-sink drilling, Carryout Deep hole drilling G 83, Perform Threading and tapping G 84 41. Carryout Boring cycles G 85 - G 42. Preparations of part programs for thread cutting/thread milling for CNC machining centres. 43. Drilling milling patterns, Thread milling etc. 44. Circular and rectangular pockets machining. 45. Practice at least one macro program for repetition of cutting in Z axis.	machine from sudden stoppage. Means of program transfer through electronic media. • Overview macro program system • Overview of repetition of program auto mode.
Practical 20 Hrs Theory 10 Hrs	Create and analyze programs in CAM and post process to CNC Machine / Simulator.	CAM: 46. Importance of 3D models 47. Selection of tools for manufacturing. 48. Methods of machining. 49. Sequence of operations. 50. Simulation 51. Generation of Program/Post processor (3/4/5 Axis) 52. Sending program to the machining.	CAM: • Importance of CAM • Introduction of 2D Sketch & 3D Surface & Solid Models, Part , drafting, assembly and motion analysis feature inbuilt in CAM . • Manufacturing machining selection • Tool selection. • Tool path movements

		53. Machining side Execute program. 54. Import the Model 2D or 3D. 55. Write, enter, and Debug programs 56. File format - STL, IGES, Export, Import Files.	• Selection of Speed, Feed, Depth of cut, Work Offsets & Tool offsets. • Manufacturing procedure. • Use short cuts to improve productivity.
Practical 20 Hrs Theory 10 Hrs	Use of I/O device, common parameters setting, basic maintenance, lub oil level check, hydro-oil level check, battery alarm etc.	57. Use of part on CNC machine, data transfer method, DNC system. 58. CAM program transforming method, small program of CNC generated by CAM running into the machine and unit the job. 59. Lub oil level check method, alarm read, hydraulic oil level check and method of program 60. Check battery alarm, position of battery 61. Cooling fan check etc.	• Method of data transfer , pendrive, SD card, technical mode etc. DNC method, process of program transfer from CAM to CNC machine & both turning/milling. • Basics maintenance of CNC, such as lub oil charge, hydraulic oil check alarm, battery alarm, cooling fan, radiator fan etc.

6. ASSESSMENT CRITERIA

LEARNING OUTCOME	ASSESSMENT CRITERIA
1. Understanding basics of CNC Technology	What is CNC technology, Binary system, 2Axis & 3 Axis machines. Purpose of CNC Mcs in industry.
	Demonstrate the Different parts of CNC Lathe Mc & CNC Milling Mc Key Features, different mode of operation and use of emergency switches.
2. Familiarize and practice on Hands sessions of CNC lathe on-off, features, functional lays, drive setting, jog, MDI, EDIT, auto all modes.	Purpose of different keyboard, their uses and page findings process, page reading and use of parameters.
	Demonstrate the Different mode of Keys, Data input methods, function of Keys and features of different mode, page details, machine start / stop, Referencing , use of Jog mode/ MDI mode and edit mode.
3. Set (both job and tool) CNC turning centre / Simulator and produce components as per drawing by preparing part program using G & M Codes.	Interpret purpose and function of various G codes and M codes and Words.
	Demonstrating the ability to identify and troubleshoot issues related to G codes and M codes, such as incorrect syntax, incompatible codes, or programming errors.
	Make a virtual part program of CNC Lathe.
	Perform the program entry into the CNC Lathe machine and check the simulation.
4. Set (both job and tool) CNC Milling centre / Simulator and produce components as per drawing by preparing part program using G & M Codes.	Interpret purpose and function of various G codes and M codes and Words.
	Demonstrating the ability to identify and troubleshoot issues related to G codes and M codes, such as incorrect syntax, incompatible codes, or programming errors.
	Make a virtual part program of CNC Milling.
	Perform the program entry into the CNC Milling machine and check the simulation.
5. Create and analyse programs in CAM and post process to Machine / CNC Simulator.	Create 2D sketches using appropriate tools and techniques within the CAM software such as lines, arcs, splines etc.
	Create 3D Model using the CAM software's.
	Create and define various features such as holes, pockets, fillets, chamfers, and threads within the 3D models.
	Make the part program and transfer to the machine.
6. Use of I/O device, common parameters setting, basic maintenance, lub oil level check, hydro-oil level	Interpret the PLC parameters, Common set up and alarm reading process, message searching methods.
	Demonstrating the ability to identify and troubleshoot issues related

check, battery alarm etc.

to Machine Over Traveled, Lub Oil level low, Hydraulic Oil level check and others drive errors.

ANNEXURE-I

LIST OF TOOLS & EQUIPMENT			
FUNDAMENTALS OF CNC PROGRAMMING & OPERATION			
S No.	Name of the Tools and Equipment	Specification	Quantity
Same as Advanced CNC Machining Technician Trade under CTS			
Additional Tools & Equipment required			
1.	Desktop Computers	Desktop Computers I5/I7 CPU/16 GB RAM/500GB SDD/2GB Graphics Card	12 Nos.
2.	Interactive Panel with OPS	Panel 75/86" with OPS I5/I7 CPU/16 GB RAM/500GB SDD/2GB Graphics Card	1 No.
3.	CNC Machine Simulator	Multimedia based simulator for CNC technology and interactive CNC part programming software for turning & milling with virtual machine operation and simulation using popular operation control system such as Fanuc, Siemens, etc. (Web- based or licensed based) (20 trainees + 1faculty) With help of this software the trainees should be able to Write, Edit, Verify & Simulate, Also run and Test CAM generated program	12 Nos.
4.	CAM Software with Inbuilt CAD Software facility	CAM Software having Milling- 2-axis, 3-axis, and 5-axis positional and simultaneous machining & rotary 4-axis integration. Lathe- 2-Axis , Mill-Turn programming including C & Y axis operations, Back Spindle Programming. Inbuilt CAD Facility-Full design capabilities covering Part Design, Assembly, Drafting & Motion Analysis. Router for Artwork Programming - Specialized programming techniques for artistic and decorative works.	12 Nos.

		Wire EDM for Wire Cut Programming, Post Processor- Comprehensive Post Processors for Fanuc, Mitsubishi, Siemens (Above 828D), and Heidenhain Controls.	
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ANNEXURE-II

The DGT sincerely acknowledges contributions of the Industries, State Directorates, Trade Experts, Domain Experts and all others who contributed in designing/ revising the curriculum. Special acknowledgement is extended by DGT to the following expert members who had contributed immensely in this curriculum.

Trade committee meeting to finalize the syllabus of “FUNDAMENTALS of CNC Programming and Operation” held on 16.04.2024 at CSTARI.			
Sl. No.	Name and Designation (Shri/Smt./Kumari)	Organization with Address	Remarks
1.	G C Saha, Jt. Director	CSTARI, Kolkata	Chairman
2.	Brindaban Das, Dy. Director	CSTARI, Kolkata	Member
3.	Joydeb Roy Chowdhury, Instructor	Govt. ITI, Tollygaunge	Member
4.	Binoy Krishna Biswas, Asst. Professor	B.P.P. Institute of Management & Technology, Kolkata – 700 052	Member
5.	Dilip Kumar Chattopadhyay, Ex-ADT	46 A/8, Shibpur Road, Howrah – 2	Member
6.	Rounak Bandopadhyay,	Zreyas Technology. New Town, Kolkata	Member
7.	Subrata Pully, Supervisor	Govt. ITI, Gariahat	Member
8.	Jayanta Koley,	ITI Durgapur	Member
9.	Jaharlal Maity, Instructor (RAC)	Govt. ITI, Gariahat	Member
10.	Atanu Ghosh, Training Officer	NSTI, BBSR, Odisha	Member
11.	Anurag Chakraborti, Asst. Professor	Techno Engineering Collage, Banipur, Habra	Member
12.	Subhankar Bhattacharjee, Asst. Professor	Techno Engineering Collage, Banipur, Habra	Member
13.	Amaresh Naskar, Instructor	Govt. ITI, Tollygaunge	Member
14.	Md. Waseem Siddiqui,	VECC/DAE I/AF Bidhannagar, Kolkata – 64	Member
15.	Atanu Bhuniya, Instructor (RAC)	Govt. ITI, Howrah Homes, Santaragachi, Howrah	Member
16.	Prodip Mukhopadhyay, Former MD – Webel and Sr. Advisor - MAKAUT	Webel MAKAUT	Member
17.	B. Sharanappa, AD	CSTARI, Kolkata	Member
18.	Sk. Altaf Hossain, AD	CSTARI, Kolkata	Member
19.	Murari Barui, AD	CSTARI, Kolkata	Member
20.	Akhilesh Pandey, AD	CSTARI, Kolkata	Member
21.	Nirmalya Biswas, PA to Dir.	CSTARI, Kolkata	Member
22.	B. Biswas, TO	CSTARI, Kolkata	Member
23.	P.K. Bairagi, TO	CSTARI, Kolkata	Member

24.	B K Nigam, TO	CSTARI, Kolkata	Member
25.	K.V.S. Narayana, TO	CSTARI, Kolkata	Member
26.	Pradip Biswas, Jr. D/man	CSTARI, Kolkata	Member
27.	Hemant Kujur, Jr. D/man	CSTARI, Kolkata	Member
28.	Abhisek Mitra, HOD INCHARGE	Asansol institute of engineering and management polytechnic Kalipahari Asansol	Member
29.	SUNIL SITARAM CHORE, CMD, SIMUSOFT TECHNOLOGIES, PUNE	SIMUSOFT TECHNOLOGIES B11-1204, NEAR IBM INFOCITY, KUMAR INFENIA, PHURSUNGI, PUNE 412308	Member
30.	Makarand Joshi, Product Manager	Grok Learning Pvt. Ltd. Plot No. 29, Amba Bhavan, 3rd Floor, 'A' Wing, Sion Circle (West), Mumbai	Member
31.	Kunal Sharad Bhagat, Development Engineer	Grok Learning Pvt Ltd 3rd Floor, A-wing, Amba Bhavan, Plot No 29, Next to Bharat Petrol Pump, Sion Circle (west), Mumbai 400022	Member
32.	MANOHAR SADASHIV DESAI, Technical Head	SKILL BAHN LLP. UNIT NO. 912 / Plot-B, Lodha Supremus, Lodha Business District, Kolshet Rd, Thane, Maharashtra 400607	Member
33.	Mandar Bhate, Associate Manager	Tata Technologies Ltd Hinjewadi, Ph-1, Pune, Maharashtra	Member
34.	Ashish Kulkarni, Industrial Skill Consultant	Bhan skill Mumbai Thane Mumbai	Member