CNC machining

Module name: CNC machining

Purpose of module: Introduce pupils to CNC machining

Achievable results/ learning outcomes:

- Pupils understand Mach3 software's features and user interface;
- Can creating a two-dimensional sketch, using assistive tools and understands the functions;
- Can prepare the product for CNC machining;
- Pupils can prepare G-code;
- Can produce parts with CNC machines.

Tasks

- *Teach the basics for 2D/3D modeling*
- *Make a 2D/3D model for 3D printing.*
- *Edit chosen 2D/3D model*
- *Teach the basics CNC machining*
- *Analyze materials and machining tools*
- *Prepare 3D models for CNC machining*
- *Make a part/assembly*

Length of module

4 – 6 academic hours

Name of learning subject in which module can be used:

- Mathematics
- Physics
- Informatics

1. **Computer assisted design**
   1. Achievable results/ learning outcomes
      - *Pupils can create and edit 2D/3D models.*
   2. Tasks
      - *Teach the basics for 2D/3D modeling*
      - *Make a 2D/3D model for 3D printing.*
      - *Edit chosen 2D/3D model*

   3) Length of theme
      - *2 academic hours*

   4) Name of learning subject in which module can be used
      - *Mathematics*

- *Physics*
- *Informatics*

2. **CNC machining principles**
   1. Achievable results/ learning outcomes
      - *Pupils understands CNC machining principles*
   2. Tasks
      - *Teach the basics CNC machining*
      - *Analyze materials and machining tools*

   3) Length of theme
      - *1 academic hours*

   4) Name of learning subject in which module can be used
      - *Physics*

3. **Computer assisted machining**
   1. Achievable results/ learning outcomes
      - *Pupils can create and edit CNC programs*
   2. Tasks
      - *Prepare 3D models for CNC machining*
      - *Make a part/assembly*

   3) Length of theme
      - *2-3 academic hours*

   4) Name of learning subject in which module can be used
      - *Physics*
      - *Informatics*

1. Computer-assisted design

Computer-aided design (CAD) refers to computers being used to assist the design process in all sorts of industries. With CAD software, it's possible to build an entire model in an imaginary space, letting you visualize properties like height, width, distance, material, or colour before the model is used for a particular application.

It was 1962 when the computer scientist Ivan Sutherland created the first computer graphic program, known as "SketchPad", which allowed people to write or draw simple figures directly on a screen with the help of a special pencil. This marked the start of all future CAD software.

At first, CAD was used only for research purposes, but in the 1970s, big automotive and aerospace engineering companies started developing their software. Thus, expanding its applications to other industries in the 1980s. It wasn't until the 1990s that tools like CATIA and AutoCAD were born, making them possible to be used in many professional sectors.

There are several benefits of using CAD as a design and analysis tool:

- **Allows the user to easily imagine the result:** It allows you to create and visualize 2D or 3D objects and make as many changes as you need with less effort than drawing it on paper with a pencil.
- **The user can make their work as detailed as they want:** Digital representation in CAD closely resembles real life, making it accurate up to a certain level. You can also add as much fine detail as needed.
- **Permits optimization:** Finding mistakes during the design process is usually quite difficult. Although it is not perfect, however, CAD software can help to solve that issue. The more sophisticated CAD programs even allow you to run simulations to test for possible imperfections.
- **Can be easily adapted to be used in many professional settings:** CAD software is available for almost every professional sector with specialized features and suitable tools, making it easy to apply to different fields.
- **Provides tangible results:** You have the possibility of bringing your digital design to the real world in the form of a physical object with the help of fabrication technologies and CAM software, which would be more difficult and expensive with traditional fabrication methods.

Why is this technology so important for many professionals? The biggest sectors that often use CAD are:

- **Architecture:** When talking about CAD, Architecture is one of the most demanding subjects. To fully accomplish the project and include all the small design details in it, architects often rely on software.
    - Example: Large design companies usually work with BIM (Building information modelling) software like Revit or ArchiCAD to work more effectively, but small design firms more typically combine different tools. For example Architect Eric Reinholdt, who runs a YouTube channel and owns a studio called 30×40 Design Workshop, claims to use AutoCAD, SketchUp Pro, Adobe Photoshop, and Lightroom for his daily work.

- **Product design:** Industrial designers use CAD software not only to visualize an object but also to understand and verify its functions. Tools like Fusion 360, Inventor, or SolidWorks are the most commonly used.
    - Example: Grovemade is a company focused on developing high-quality wooden products. Their CAD and CAM tool of choice is Fusion 360 as it makes their work more efficient.

- **Graphic design:** Professional graphic design also makes use of 2D or 3D CAD software to create visualizations. This kind of software allows typography, adding shapes and effects, and choosing different backgrounds to improve the visuals.
- Example: Matthew Encina is a designer and content creator who uses Adobe Photoshop, Illustrator, and After Effects as his main tools to develop branding material and provide an interactive experience for his clients.

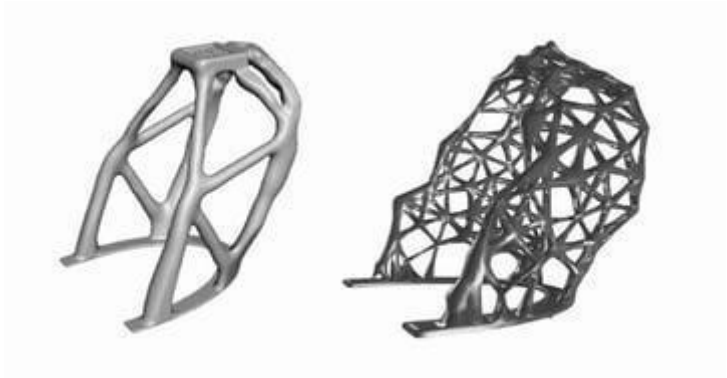
- **Engineering:** Given the many and diverse engineering fields, the types of CAD programs used by engineers are also many and varied. Some of the most common

subjects include infrastructure, buildings, circuits, telecommunication networks, thermodynamics, mechanical parts, medical devices, and manufacturing.

- Example: The Engineering Research Center of Brown University was designed using BIM. This complex project was finished by the architecture firm Kieran Timberlake**,** and the company named BuroHappold Engineering. They both worked on the design and the construction together and used Revit models.

CAD has proven to be a problem solver for many professional areas, so it's generally difficult to find drawbacks. There are, however, some disadvantages to using it:

- **Licensing:** Higher-end tools typically come with steep prices, whether subscription-based or one-time fees. The main exception to this is if they're being used for educational purposes.
- **Time:** Learning how to use CAD and CAM tools takes time. Creating and executing suitable designs has its cost, including the time spent on training.
- **Appliances:** To perform at their best, CAD and CAM tools often require powerful (and expensive) equipment.



These days, CAD is constantly changing, bringing updates and new features in with every new version of a particular tool. And that is excluding the huge range of options available for professional use.

Tools are becoming more powerful by the year. Among the new projects, some even involve AI, as is the case with Autodesk's experimental software Dreamcatcher. It is not only a visualization tool but also a design program that suggests the best solution when given specific variables.

According to Andreas Vlahinos, CTO at Advanced Engineering Solutions, someday we'll need CAD software to reproduce human intelligence to complete certain tasks. Thus, it is likely that "smart" CAD software will be created in the near future.

Questions

1. What are the main disadvantages of CAD?

Correct answers: Licensing fees, it takes time to learn how to use it, and using CAD requires powerful equipment.

2. Name the biggest sectors that make use of CAD nearly every day?

Correct answer: Architecture, graphic design, product design and engineering.

2. CNC machining principles

CNC stands for Computerized Numerical Control. It is a computerized manufacturing process in which pre-programmed software and code control the movements of the production equipment. CNC machining controls a range of complex machinery, such as grinders, lathes, and turning mills. All of them are used to cut, shape, and create different parts and prototypes. Each and every day, CNC machinists combine elements of mechanical design, technical drawings, mathematics, and computer programming skills to produce a variety of metal and plastic parts. CNC operators can take a sheet of metal and turn it into a vital part that will be used in the process of making an aeroplane or a car.

Computer Numerical Control machines are automatic machines. They are operated by computers executing pre-programmed sequences of controlled commands. CNC machines are essentially the opposite of "old-school" devices that are manually controlled by hand wheels or levers, or mechanically automated by cams alone. Today's modern CNC machines understand and function using CNC machining language called the G-code. This code notifies the machines of the precise measurements for production such as feed rate, speed, location, and coordination.

Today's design and mechanical parts for CNC systems are highly automated – unlike the old, dangerous, factory machines you'd think of back in the day. The parts' mechanical dimensions are defined using computer-aided design (CAD) software and then translated into manufacturing directives by computer-aided manufacturing (CAM) software. Therefore, it is important to have

some knowledgeable CNC machinists and programmers in the industry as they need to know how to operate this high-tech machinery.

Manufacturers in Connecticut are the leaders within the industry: they make products that are essential such as jet engines, helicopters, and submarines. And thanks to recent technological advancements, gone are the days of gritty factory life. Workers today use their machining skills in a clean, professional setting with advanced and cutting-edge technology. Those pursuing CNC operator careers enjoy working in a hands-on, never-a-dull-moment and ever-growing field.

With proper CNC machining training, both machinists and operators help to create a vast array of manufactured products, thereby playing a crucial role in Connecticut's booming manufacturing industry and the overall economy. These skilled CNC Machinists see a product through each phase of its creation from the start of an initial concept to design, to code and then to the finished product. In this way, CNC machining is not *just* a typical manufacturing job; it is a hands-on, creative, valuable career path for innovators who like to see the lifecycle of their work.

The usual daily duties for CNC operators may include:

- Reading blueprints, sketches, or computer-aided design (CAD) and computer-aided manufacturing (CAM) files
- Setting up, operating, and disassembling manual, automatic, and computer numerically controlled (CNC) machine tools
- Aligning, securing, and adjusting cutting tools and workpieces
- Monitoring the feed and speed of machines
- Turning, milling, drilling, shaping, and grinding machine parts to a certain measurement (specifications)
- Measuring, examining, and testing completed products for any defects
- Smoothing the surfaces of the parts or the products
- Presenting finished workpieces to customers and making modifications if needed.

For aspiring machinists looking to start an exciting career in this growing field, earning an associate degree and/or certificate from a respectable manufacturing school is a great investment in the future! For those looking to become a CNC machinist in Connecticut, Goodwin College is recognized for the various CNC programs they offer.

Whether at the certificate or degree level, Goodwin College's CNC machine training gives students a thorough understanding of manufacturing processes, materials, and manufacturing mathematics. You'll also gain competence in technical drawings, specifications, and computer-

aided machining. Perhaps most importantly, you'll also acquire practical experience with modern CNC technologies.

Goodwin College combines classroom education with hands-on experience and training. Students are taught on a new CNC 3-axis milling and turning machines, to provide the skills, know-how and experience needed to be successful in the industry. Thanks to the extensive CNC operator training, students also walk away with an understanding of advanced Mastercam skills needed for programming tool location, motion, feeds and speeds.

Upon completion of these programs, students are ready to take on the National Institute for Metalworking Skills (NIMS) credential to become a CNC operators.

Questions

1. What American state was mentioned in relation to CNC manufacturing?

2. Is it true that CNC operators can manufacture parts for submarines?

3. Computer-assisted machining

In a world full of physical stuff – whether that is products, parts, or places – Computer Aided Manufacturing (CAM) makes it all possible. We're the ones that give the power of flight to aeroplanes or the rumble of horsepower to automobiles. When you need something made, not just designed, CAM is your answer. What happens behind the scenes? Keep reading, and you'll find out.

What is CAM? Computer Aided Manufacturing (CAM) is the use of software and computer-controlled machinery to automate a manufacturing process.

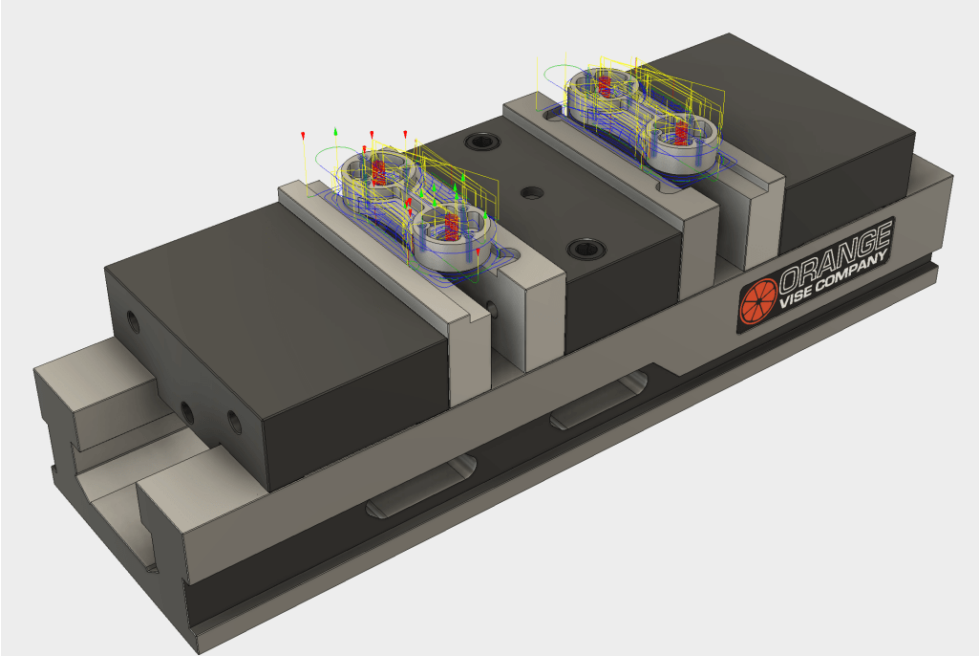
Based on that definition, you need three things for a CAM system to work:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post Processing converts toolpaths into a language machines can understand.

These three things are glued together with human labour and skill. As an industry, we've spent years building and refining the best manufacturing machinery around. Today, no design is too tough for any capable machinist shop to handle.

Without CAM, there is no CAD. CAD focuses on the design of a product or part. How it looks, how it functions. CAM focuses on how to make it. You can design the most elegant part in your CAD tool, but if you can't efficiently make it with a CAM system, then you're better off kicking rocks.

The start of every engineering process begins in the world of CAD. Engineers will make either a 2D or 3D drawing, whether that's a crankshaft for an automobile, the inner skeleton of a kitchen faucet, or the hidden electronics in a circuit board. In CAD, any design is called a model and contains a set of physical properties that will be used by a CAM system.



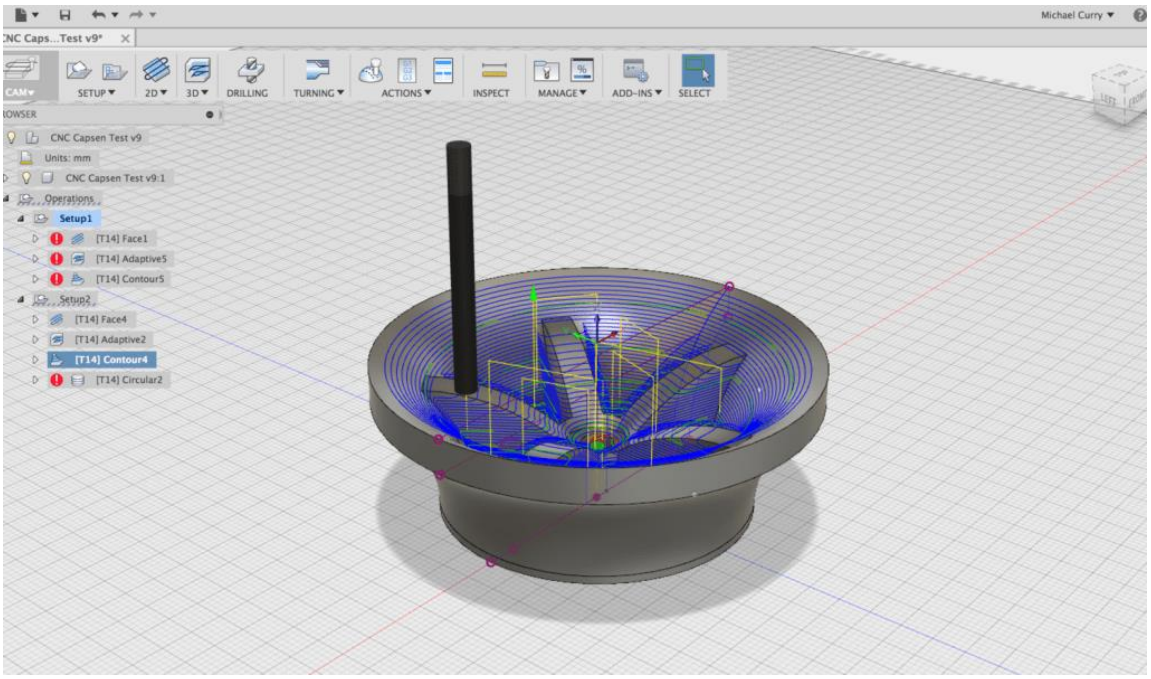
When a design is complete in CAD, it can then be loaded into CAM. This is traditionally done by exporting a CAD file and then importing it into CAM software. If you're using a tool like Fusion 360, both CAD and CAM exist in the same world, so there's no import/export required.

Once your CAD model is imported into CAM, the software starts preparing the model for machining. Machining is the controlled process of transforming raw material into a defined shape through actions like cutting, drilling, or boring.

Computer Aided Manufacturing software prepares a model for machining by working through several actions, including:

- Checking if the model has any geometry errors that will impact the manufacturing process.

- Creating a toolpath for the model (a set of coordinates the machine will follow during the machining process).
- Setting any required machine parameters, including cutting speed, voltage, cut/pierce height, etc.
- Configuring nesting where the CAM system will decide the best orientation for a part to maximize machining efficiency.



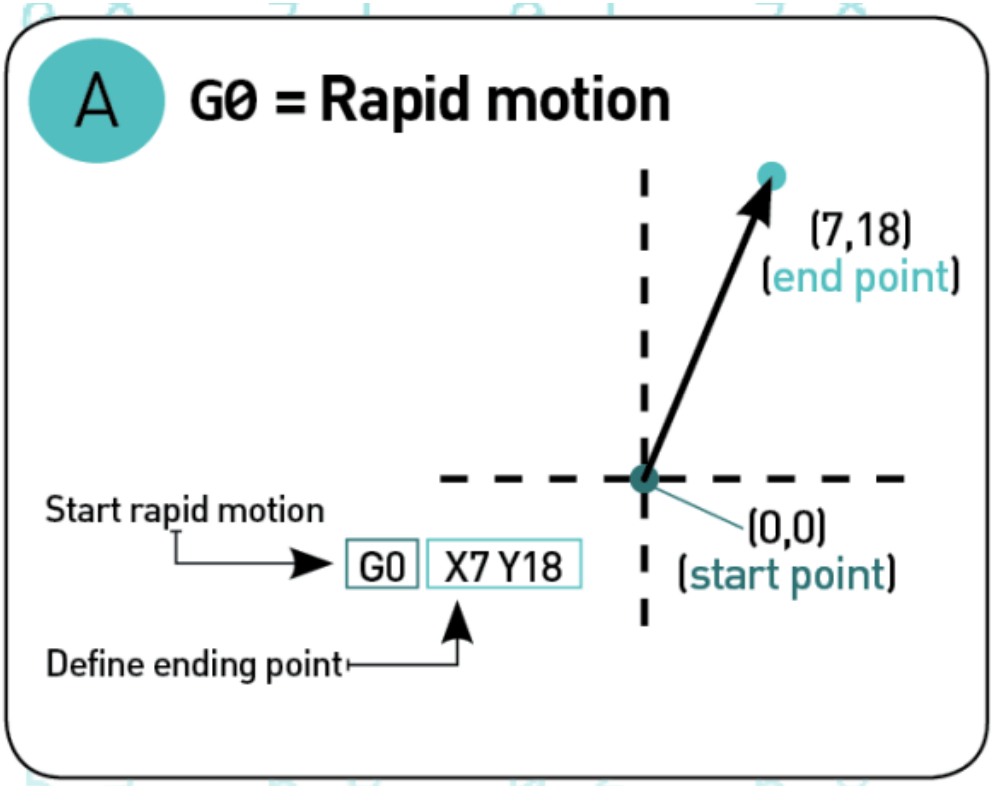
Once the model is prepared for machining, all information is sent to a machine to start producing the part physically. However, we can't just give a machine a bunch of instructions in English. We need to speak the machine's language. To do this, we convert all of our machining information to a language called G-code. This is the set of instructions that controls a machine's actions including speed, feed rate, coolants, etc.

G-code is easy to read once you understand the format. An example looks like this:

G01 X1 Y1 F20 T01 S500

This breaks down from left to right as:

- G01 indicates a linear move based on coordinates X1 and Y1.
- F20 sets a feed rate, which is the distance the machine travels in one spindle revolution.
- T01 tells the machine to use Tool 1, and S500 sets the spindle speed.



Once the G-code is loaded into the machine, and an operator hits start, our job is done. Now it's time to let the machine do the job of executing G-code to transform a raw material block into a finished product.

Up until this point, we've talked about the machinery in a CAM system as simple machines, but that doesn't do them justice. Watching a Haas milling machine slide through a block of metal like it's a piece of butter puts a smile on my face every time. Without these machines, my job would be impossible.

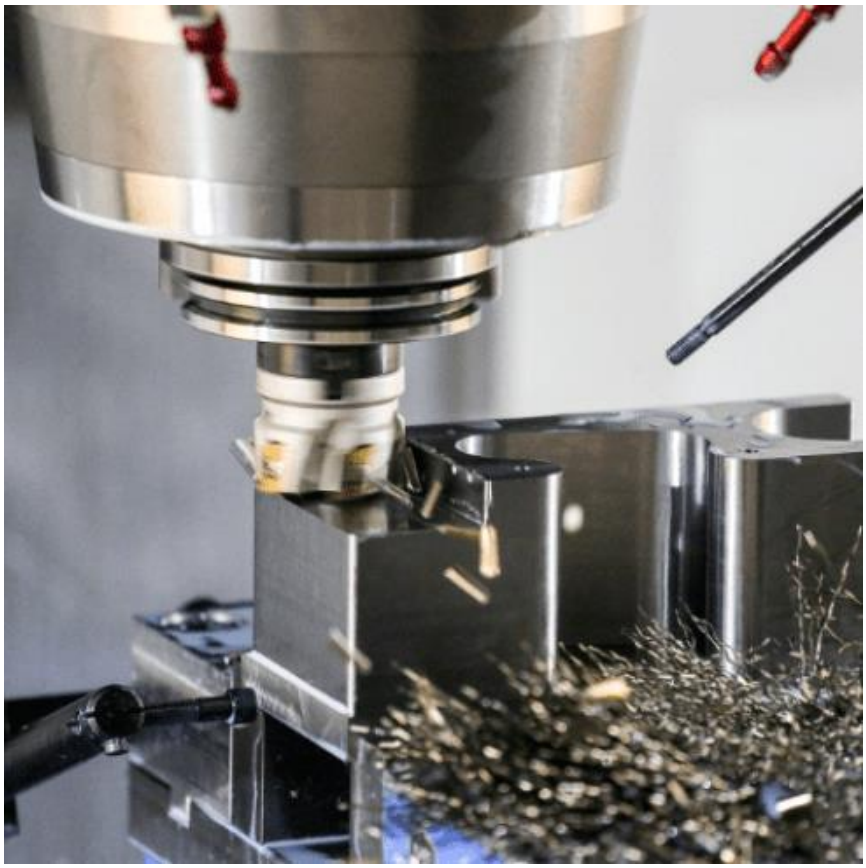
Questions:

1. When does CAM software start to prepare the model for machining?

Correct answer: Once the finished CAD model is imported into CAM.

2. When talking about G-code, what does S stand for? Example: 'S500'.

Correct answer: Speed.



All modern manufacturing centres will be running various Computer Numerical Control (CNC) machines to produce engineered parts. The process of programming a CNC machine to perform specific actions is called CNC machining.

Before CNC machines came to be, manufacturing centres were operated manually by experienced machinists. Of course, with the growing application of computers, automation soon followed. These days the only human intervention required for running a CNC machine is loading a program, inserting a raw material, and then unloading a finished product.

Over at the Autodesk Pier 9 workshop, we have a decent sample of CNC machines, including:

4. CNC Routers

These machines cut parts and carve out a variety of shapes using high-speed spinning parts. For example, a CNC router used for woodworking can make the work of cutting plywood into cabinet parts relatively easy. It can also easily tackle complex decorative engraving on a door panel. CNC routers have triple-axis cutting capabilities, which allow them to move along the X, Y, and Z axes.

5. Water, Plasma & Laser Cutters

These machines use precise lasers, high-pressure water, or a plasma torch to complete a controlled cut or engraved finish. Manual engraving techniques can take months to complete by hand, but one of these machines can complete the same work in hours or days. Plasma cutters are useful for cutting through an electrically conductive material such as metals.

Milling Machines

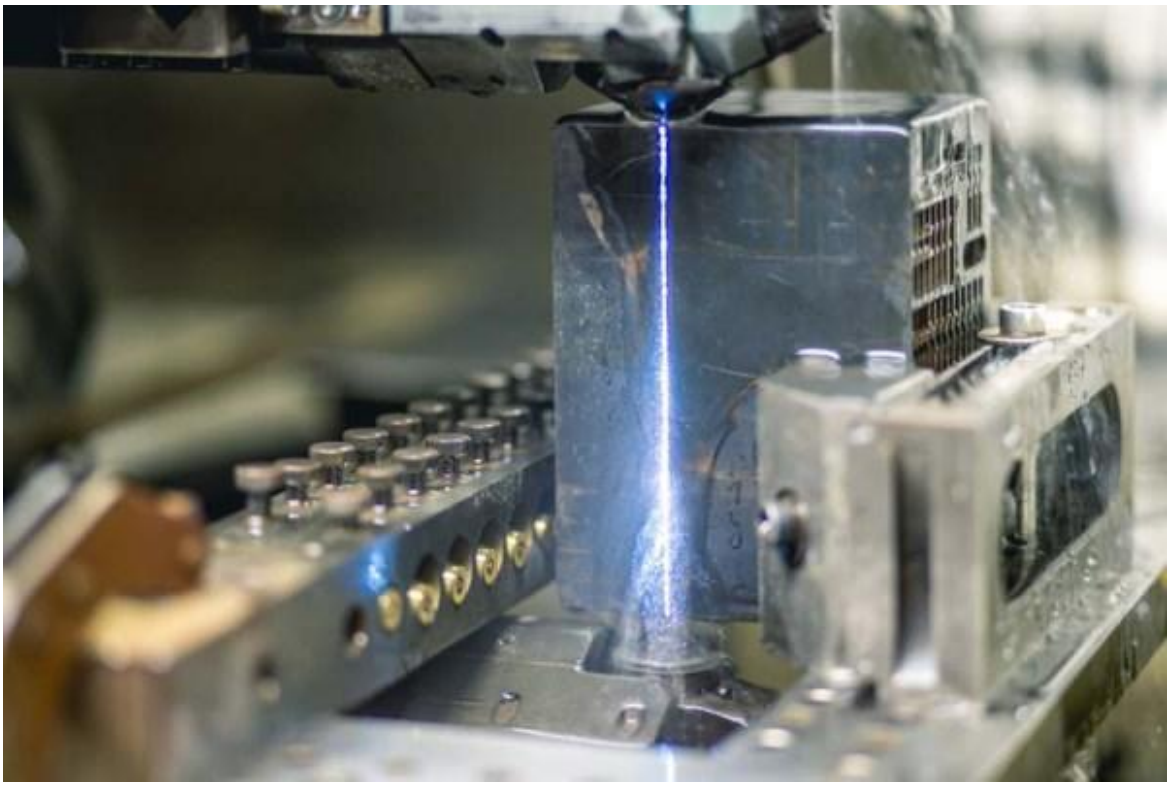
These machines chip away at a variety of materials such as metal, wood, composites, etc. Milling machines have an enormous versatility with a variety of tools that can accomplish the particular shape and material requirements. A milling machine's overall goal is to remove mass from a raw block of material as efficiently as possible.

Lathes

These machines also chip away at raw materials like milling machines do, however, they work differently. A milling machine has a spinning tool and stationary material, whereas a lathe spins the material and cuts it with a stationary tool.

6. Electrical Discharge Machines (EDM)

These machines cut the desired shape out of raw material through an electrical discharge. An electrical spark is created between an electrode and raw material. The spark's temperature can reach from 8,000 to 12,000 degrees Celsius. This allows an EDM to melt through nearly anything as it is a controlled and ultra-precise process.

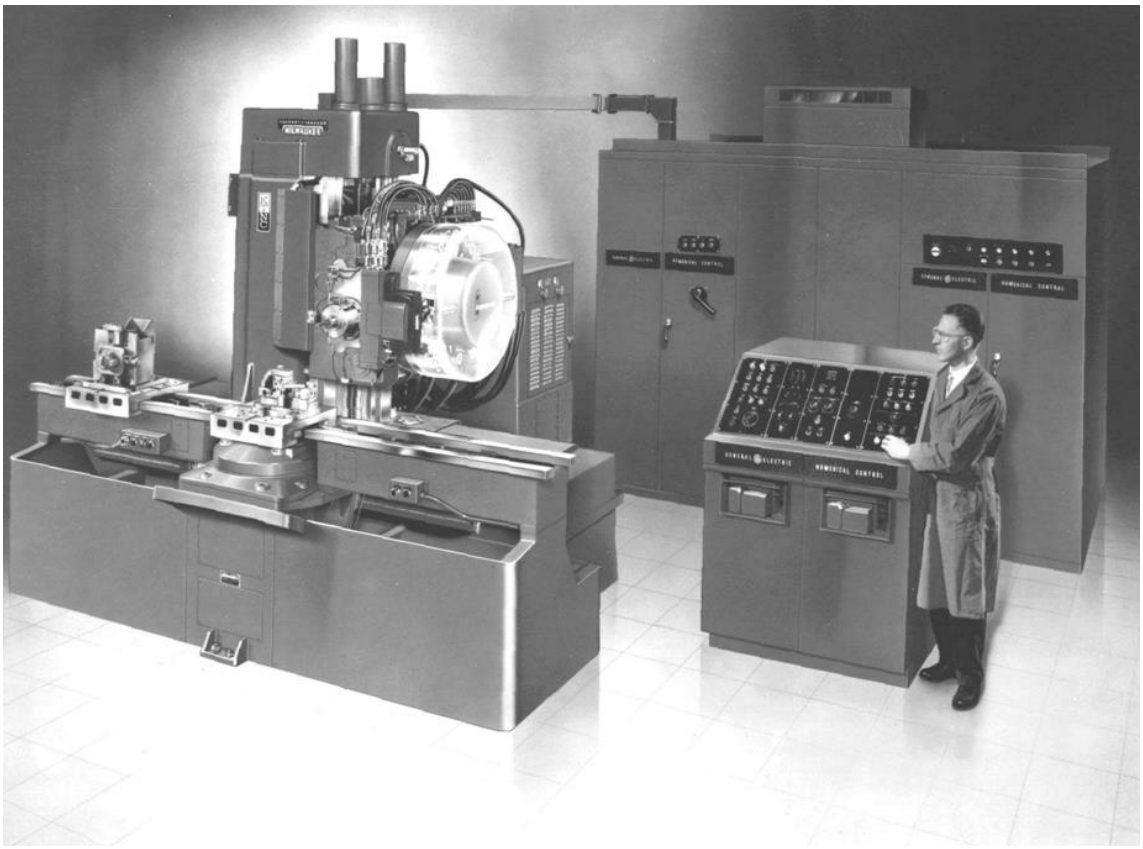


We have John T. Parsons to thank for introducing a punch card method to program and automate machinery. In 1949 the United States Air Force was funded by Mr Parsons so he could build an automated machine that could outperform manual NC machines. With some help from MIT, Parsons was able to develop the first NC prototype.

Question:

What is the maximum temperature the electrical spark can reach?

Correct answer: 12, 000 degrees Celsius.



From there on, the world of CNC machining started to take off. In the 1950s, the United States Army bought NC machines and loaned them out to manufacturers. The idea was to encourage companies to adopt the new technology and use it during the manufacturing process. Furthermore, around this time, MIT developed the first universal programming language for CNC machines: G-code.

Code	Group	Description	Modal	Page
G00	1	Rapid Move	Y	10
G01	1	Linear Feed Move	Y	10
G02	1	Clockwise Arc Feed Move	Y	11
G03	1	Counter Clockwise Arc Feed Move	Y	11
G04	0	Dwell	N	14
G09	0	Exact stop	N	14
G10	0	Fixture and Tool Offset Setting	N	15
G12	1	Clockwise Circle	Y	18
G13	1	Counter Clockwise Circle	Y	18
G15	11	Polar Coordinate Cancel	Y	18
G16	11	Polar Coordinate	Y	18
G17	2	XY Plane Select	Y	20
G18	2	ZX Plane Select	Y	20
G19	2	YZ Plane Select	Y	20
G20	6	Inch	Y	20
G21	6	Millimeter	Y	20
G28	0	Zero Return	N	21
G30	0	2nd, 3rd, 4^{th}Zero Return	N	22
G31	1	Probe function	N	22
G32	1	Threading*	N	23
G40	7	Cutter Compensation Cancel	Y	23
G41	7	Cutter Compensation Left	Y	25
G42	7	Cutter Compensation Right	Y	25
G43	8	Tool Length Offset + Enable	Y	25
G44	8	Tool Length Offset - Enable	Y	25
G49	8	Tool Length Offset Cancel	Y	25
G50	9	Cancel Scaling	Y	25
G51	9	Scale Axes	Y	25
G52	0	Local Coordinate System Shift	Y	26

The universal G-code system

The 1990s brought CAD and CAM's introduction to personal computers and has completely revolutionized how we approach manufacturing today. The earliest CAD and CAM jobs were only meant for expensive automotive and aerospace industry use whereas today software like Fusion 360 is available for manufacturing shops of any shape and size.

Since the beginning of its existence, CAM has delivered many improvements to the manufacturing process, including:

- Improved machine capabilities. CAM systems can take advantage of advanced 5-axis machinery to deliver more sophisticated, higher-quality parts.
- Improved efficiency of the machines. Today's CAM software provides high-speed machine tool paths that help us manufacture parts faster than ever.
- Improved material usage. With additive machinery and CAM systems, we can produce complex geometries with minimal waste, which means lower costs.

Of course, these benefits have some trade-offs. Computer Aided Manufacturing systems and machinery require a high investment and it needs to be done in advance. For example, a Haas VF-1 machine costs about $45k out the door; now imagine an entire shop floor of those. There's also the problem of employee change. With machine operation becoming less of a skilled trade, it is difficult to attract and keep good talent.

CAM isn't just about controlling machines on a shop floor. It's about bringing together software, machines, processes, and skilled people to build great parts. If this is your first time diving into the world of CAM, I highly encourage you to reach out to a local shop to get an inside tour. Feel the hum of the CNC machines in your feet, or slide your hand across a part fresh out of the machine. It's an incredible experience that I hope future generations get to enjoy. CAM is all about the human touch.

Questions:

1. Does utilise Computer Aided Manufacturing requires a high investment?

Correct answer: Yes because the systems and manufacturing are expensive.

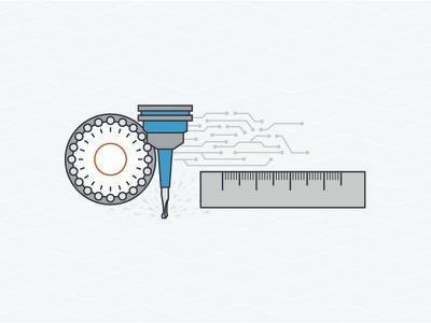
2. Who bought the NC machines and loaned them out to manufacturers in the 1950s in the United States?

Correct answer: The United States Army.

SKILLS AND ABILITIES

CNC operators must possess these skills and abilities:

- Communicate well and speak clearly
- Read and understand work-related materials
- Attentively listen to others and ask questions
- Understand spoken and written information
- Write clearly so others can understand
- Be able to manage oneself and manage other people



- Have great time management skills
- Be able to get along with people and work as a part of the team
- Manage equipment, materials and other work-related things and do not lose them

Have good reasoning and problem-solving abilities:

- Analyze ideas and determine their strengths and weaknesses by using logic
- Notice when something is wrong or anticipate what is likely to go wrong.
- Be able to follow guidelines to arrange objects or actions in a certain order.
- Concentrate while performing a task.
- Recognize the nature of a problem.
- Judge the perceived costs and benefits of a particular action.
- Use reasoning to discover answers to problems that may arise
- Understand new information or materials by studying them
- Develop certain rules that help to group items in various ways.
- Combine several pieces of information and conclude it.

Have a good knowledge of math and science:

- Add, subtract, multiply, and divide quickly and correctly.
- Be able to apply mathematical methods or formulas to solve certain problems.

Be able to work with machinery and various tools

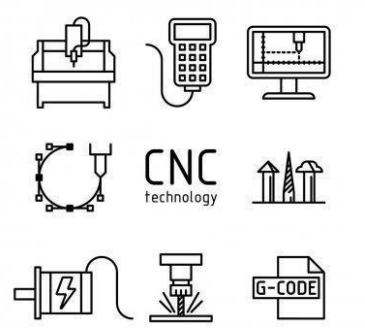
- Watch gauges, dials, and output to make sure the machine is working correctly
- Inspect and evaluate the quality of products.
- Control and operate equipment
- Determine the causes of technical problems and find solutions for them.
- Repair machines or systems, if required
- Determine what tools and equipment are needed to complete a task
- Determine when and what kind of maintenance is needed for the equipment

Be able to perceive and visualize things

- Identify a pattern (it could be a figure, an object, a word, or a sound) that is difficult to find or is hidden in distracting material.
- Imagine how a product will look if it is moved around or its parts were rearranged.
- Quickly and accurately compare letters, numbers, objects, pictures, or patterns.

CNC machine operators should be knowledgeable in the following areas:

- Mechanical: The design, use, and repair of machines and tools.
- Mathematics: The rules and formulas that could be useful.
- Design: Making and using plans, blueprints, drawings, and models.
- Production and Processing: The ins and outs of manufacturing and distribution.
- Computers and Electronics: Computer hardware and software.
- Engineering and Technology: Good computer skills and following the rules of engineering to design and manufacture goods and provide services.
- English Language: The meaning and use of the English language.
- Physics: The features and laws of matter and energy.
- Chemistry: The properties of substances and the changes that occur when they interact.



WORKING CONDITIONS

The description for the usual work settings for CNC operators or technologists includes:

- They have a medium level of social contact as they spend a lot of time working with machines but may also discuss ongoing projects with their coworkers therefore they communicate with others mostly through face-to-face discussions.
- They are also responsible for the work done by other operators and often work as part of a team.

- CNC operators often work indoors. Some workplaces may not have appropriate air conditioning installed.
- Operators are often exposed to noise levels that could be uncomfortable but they can wear ear plugs to protect their hearing.
- Due to the daily work specifics, they are often exposed to contaminants and various chemicals which can cause allergies in the long term.
- They are regularly exposed to hazardous situations and equipment, such as high-speed machines.
- They must wear protective gear such as safety glasses, face masks, or breathing equipment daily.
- Must be extra thorough when performing their job and be sure everything is done as most errors may cause a manufacturing delay and as a result, could incur a loss for the company.
- Operators must work according to the pace that is set by the speed of the machinery.
- CNC operators repeat the same physical and mental tasks so there is a routine, to an extent.

- Often seek input and opinions from supervisors and programmers before making decisions and setting daily tasks and goals.
- CNC operators work in a relatively stressful environment because they must meet daily deadlines.
- Work time usually consists of 40 hours per week. Schedules are usually established.
- May work nights and weekends or on a rotating schedule.

Meet an employee of Lithuanian Railways who works with sheet metal guillotine: https://www.delfi.lt/partnerio-turinys/naujienos/prie-giljotinos-dirbantis-lietuvos-gelezinkeliu-didvyris.d?id=84041105

CAREER PATH

Most entry-level CNC machinists start as machine operators, gaining skills and experience as they progress. They must develop an in-depth knowledge of how the machines operate, get to know the properties of metal, and gain several years of practical experience.

Later on, many machinists transition into a set-up machinist who is in charge of setting-up CNC machines. This includes understanding GD&T (geometric dimensioning and tolerancing) and making changes to the CNC machine's controller.

As they gain even more experience, the set-up machinists can move up and become CNC programmers. A programmer can create the code that tells the CNC systems how to make

the part you need. This includes programming, designing parts and optimizing performance. Often, programmers also inspect manufactured parts.

After gaining enough experience in the field, they can eventually lead and manage other employees. Managers are in charge of the training, they also teach the proper use of equipment, enforce safety regulations, assign tasks, and oversee employees' work. They also interpret blueprints and develop plans for completing the project. They are in charge of upgrading and maintaining machinery, ordering parts, and making sure repair records are up to date.

Many CNC operators enjoy their various job responsibilities: taking on mechanical challenges, setting up equipment, controlling quality, and using hand tools and precision measuring instruments. CNC operators usually have plenty of job opportunities and earn healthy wages as CNC machinists are in high demand (especially those with programming skills and knowledge of advanced machinery).

WHERE TO START AND HOW TO BECOME A CNC OPERATOR?

To work as a numerical control machine operator, you need to have a high school diploma or equivalent and complete on-the-job training.

No formal education is required beyond high school. Many numerical control machine operators learn their skills and gain experience while on the job. In certain cases, depending on the workplace, an experienced worker leads the training. At others, the employer provides a formal training program. Training usually lasts from several months up to a year.

On-the-job training can be combined with classes in math, 3D design, blueprint reading, and specialized CNC operator training at local technical schools or community colleges.

It is also possible to participate in an apprenticeship programme: it will pair businesses with students who are studying, then they start to work and are paid at the same time. Apprenticeships allow businesses to retain workers who have a clear career path and the ability to earn more pay.

Those seeking to increase their skill set may want to consider getting a certification. Many schools and organizations offer certification for the industry. These types of specializations along with experience can make a machinist more valuable in the eyes of an employer.

Computer numerical control machine operator course may be suitable for students who:

- Prefer realistic interests and enjoy activities that include a practical, hands-on attitude and approach.
- They are interested in solving problems and enjoy looking for solutions.
- They like to work with physical materials such as wood, tools, and machinery.

- They tend to enjoy school subjects such as math and science.

Introduction to CNC machining:
https://www.youtube.com/watch?v=FNYEXjRmDtI&ab_channel=ConcerningReality (EN)

CNC Basics - What You Need To Get Started:
https://www.youtube.com/watch?v=lQ-MYnyxh7M&ab_channel=ProductDesignOnline (EN)

CNC machine working:
https://www.youtube.com/watch?v=i-PgeWbDgq4&ab_channel=StarTechTV

Designing a drink coaster:
https://www.youtube.com/watch?v=gQ5sFgMiNJg&ab_channel=StepcraftInc (EN)

CNC Mill Tutorial:
https://www.youtube.com/watch?v=dFDOZcznm68&ab_channel=Learn%40MINES (EN)

Part III

Colleges and vocational schools offer several certificates and degree programs that teach the skills that are needed for CNC machine operators. Some CNC operator certificate programmes take weeks or months to complete. It depends on the programme but a high school diploma is usually required to apply for the CNC courses.

The list of vocational education schools in Lithuania that currently provide CNC courses (in Lithuanian language):

Vilniaus Jeruzalės Darbo rinkos mokymo centras

https://www.vjdrmc.lt/mokymo-programa-5/

Kauno Technikos Profesinio mokymo centras
http://kautech.lt/specialybes-2/inzinerija-ir-inzinerines-profesijos/metalo-apdirbimo-staklininko-moduline-profesinio-mokymo-programa/
Vilniaus Technologijų Mokymo Centras
https://www.vtmc.lt/programa/pirminis-profesinis-mokymas/inzinerijos-kryptis/Metalo-apdirbimo-staklininkas-e/
Marijampolės Profesinio Rengimo Centras
https://mprc.lt/stojantiesiems/mokymo-programos/testinis-mokymas/statybos-ir-mechanikos-skyrius/metalo-apdirbimo-staklininko-moduline-profesinio-mokymo-programa-turintiems-pagrindinu-vidurini-issilavinima-ir-kvalifikacija/
Ukmergės Technologijų ir Verslo mokykla

http://www.ukvm.lt/?fbclid=IwAR0XzRiX9T1mRk1Xi98EStLItXNXX3iah-9YPtlfLIO7Y_HnF--DAIMf3Y4
Visagino Technologijos ir Verslo profesinio mokymo centras
https://www.vpm.lt/metalo-apdirbimo-staklininkas/
Jūrinio sektoriaus darbuotojų rengimo centras
https://jsdrc.lt/specialybe/metalo-apdirbimo-staklininkas/
Alytaus Profesinio rengimo centras
https://www.aprc.lt/uploads/2021/programos_PDF/Metalo_apdirbimo_staklininkas_M32071501_T32071501_2018.pdf

Useful resources:
http://www.mukis.lt/mod/sarasai/aprasai_prof/ifr.php?id=1113

https://www.youtube.com/watch?v=viUhuanfc2g&ab_channel=utenosrpmc

https://www.grokiskis.lt/laikrascio-archyvas/leonas-kilius-visi-turi-aukstaji-issilavinima-o-dirbti-nera-kam

https://www.ukzinios.lt/gyvenimas/aktualijos/16976-mokykla-atvira-naujovems-ir-naujokams
https://www.facebook.com/watch/?v=911269596330005

Sources:
https://technologystudent.com/despro2/cncsys1.htm

https://wdrfree.com/stock-vector/download/vector-set-cnc-milling-machine-241155748

https://dribbble.com/tags/cnc_machine

https://dribbble.com/shots/3403392-CNC-Machining

https://apps.illinoisworknet.com/cis/clusters/OccupationDetails/100048?parentId=111300&section=conditions&sectionTitle=Working%20Conditions

https://www.steckermachine.com/blog/cnc-operator

https://www.trscraftservices.com/blogs/2020-9/what-is-the-career-path-for-a-cnc-machinist

https://iotbusinessnews.com/2020/02/03/15951-how-the-iot-will-change-cnc-machining/

Questions for the final test: CNC

1. The first computer graphic program created in the 1960s was called …….

Correct answer: “SketchPad”

2. Fill in the blanks:
……. is the use of ……. (or workstations) to …… in the creation, modification, analysis, or optimization of a design.

Correct answers: CAD, computers, aid/help
3. CAD allows the user to build an entire model in an imaginary space and visualize properties such as ....., ..., ..., ..., and ..... before this model is used.
Correct answer: height, width, distance, material and color.
4. What are the advantages of Computer Aided Design?
1. ..... 2. ..... 3. ..... 4. ..... 5. .....
Correct answers: allows the user to easily imagine the result, the user can make their work quite detailed, permits optimization, can be easily adapted to be used in different fields, and tangible results.
5. Industrial designers use CAD software not only to visualize an object but also to understand and verify its ……...

A) Beauty
B) Design
C) Functions

Correct answer: Functions
6. What does the abbreviation "CNC" stand for?
Correct answer: Computerized Numerical Control.
7. Fill in the blanks: It is a computerized ..... process in which a pre-programmed ..... and .....controls the movements of the production equipment.
Correct answer: manufacturing, software, code

8. CNC machining controls a range of complex machinery, such as ....., lathes, and turning mills.
A) grinders
B) axes
C) revolving saws

9. Explain briefly, what is CNC machinery used for?

Correct answer: It is used to cut, shape, and create different parts and prototypes.

10. Fill in the blanks: CNC machinists combine elements of …….. design, technical …….., mathematics, and computer programming skills to produce a variety of metal and plastic parts.

Correct answer: mechanical, drawings.

11. What is CNC machining language called?

A) C-code
B) G-code
C) N-code

Correct answer: G-code

12. G-code notifies the machines of the precise measurements for production such as feed rate, speed, ..., and coordination.

A) rotation
B) location
C) angle

Correct answer: location.

13. CNC operators may turn a sheet of metal into a vital part that will be used in the process of making an aircraft or a car. Is this statement true or false?

Correct answer: True.

14. What kind of machines are CNC machines?

Correct answer: automatic.

15. Fill in the blank.
CNC machinery is operated by the computers executing pre-programmed sequences of ..... commands.

Correct answer: controlled

16. Regarding manufacturing, how were the so-called ‘old-school” devices’ controlled?

Correct answers: manually/controlled by hand.

17. Operating CNC machines is a dangerous job. True or false?

Correct answer: False.

18. Which software defines the part’s mechanical features, CAD or CAM?

Correct answer: CAD.

19. What does ‘CAM’ mean?

Correct answer: Computer-aided manufacturing.

20. ‘The part’s proportions are translated into manufacturing commands by the computer-aided manufacturing (CAM) software.’ Yes or no?

Correct answer: Yes.

21. What sort of products do manufacturers in Connecticut tend to make?

A) aeroplane engines, helicopters, and submarines
B) aeroplane and car parts
C) aircraft engines

Correct answer: aeroplane engines, helicopters, and submarines

22. Does the CNC operator work in a clean environment?

A) Yes
B) No

Correct answer: Yes.

23. Fill in the blank.
CNC operator’s career is a ……-on, exciting and constantly growing field.

A) arms
B) hands
C) head

Correct answer: hands-on

24. Do CNC machinists follow the product through each manufacturing phase, from the start of its concept to design and code to the finished product?

Correct answer: Yes.

25. CNC machining is a suitable career path for people who:

A) Like to operate high-end machinery
B) Like to utilize computers
C) Like to see the lifecycle of their work

Correct answer: Like to see the lifecycle of their work

26. As a part of their duties, are CNC operators required to check if the products have any defects?

A) Yes
B) No

Correct answer: Yes
27. CNC operators read ……., sketches, or computer-aided design (CAD) and computer-aided manufacturing (CAM) files.
A) Illustrations
B) Drawings
C) Blueprints

Correct answer: Blueprints
28. Finish the sentence. Operator aligns, secures and adjusts workpieces and cutting …….
Correct answer: tools
29. Do the daily operator's duties include smoothing the surfaces of the parts or the actual products?
A) Yes
B) No

30. If you want to be a CNC operator you must have a good understanding of:

A) manufacturing processes, materials, and manufacturing mathematics
B) manufacturing processes, machinery, and physics
C) manufacturing materials, machinery, and mathematics

Correct answer: manufacturing processes, materials, and manufacturing mathematics

31. Is understanding the programming of tool location, motion, feeds and speeds also important?

Correct answer: Yes

32. One of the things that are required for CAM software to work is:

A) A powerful computer and appropriate machinery
B) The latest technologies
C) Software that tells a machine how to make a product by generating toolpaths

Correct answer: Software that tells a machine how to make a product by generating toolpaths

33. ……. converts toolpaths into a language machines can understand.

A) Post-compressing

B) Post-writing
C) Post-processing

Correct answer: Post-processing

34. Fill in the blank.
Machinery can turn ……. material into a finished product.

A) Any
B) Raw
C) Appropriate

Correct answer: Raw

35. CAD focuses on the ……. of a product or part. How it looks, how it functions.

A) Shape
B) Outside
C) Design

Correct answer: Design

36. In CAD, any design is called a …….. and contains a set of …….. properties that will be used by a CAM system.
Correct answer: model, physical
37. Can the design be loaded into CAM before it is finished in CAD?
Correct answer: No
38. 'If you are using Fusion 360, both CAD and CAM exist within the same software, so there's no import/export required.' Is this statement true?
A) Yes
B) No

Correct answer: Yes

39. What is a toolpath?

Correct answer: a set of coordinates the machine will follow during the machining process.

40. G-code controls the machine's actions including ....., feed rate, coolants and other parameters.

A) Speed
B) Frequency
C) Noise level

Correct answer: Speed

41. An example of a G-code looks like this: G01 X1 Y1 F20 T01 S500. Is this correct?

A) Yes
B) No

Correct answer: Yes

42. CNC router is a type of machine which cuts parts and carve out a variety of shapes using high-speed ……..…….. parts.

A) Moving
B) Spinning
C) Drilling

Correct answer: Spinning
43. A milling machine's purpose is to ……. mass from a raw block of material as efficiently as possible.

Correct answer: remove

44. Finish the sentence.
A milling machine has a spinning tool and stationary material, whereas a lathe spins the material and cuts it with a tool that is ……...

Correct answer: Stationary.

45. 'Electrical discharge machines create an electrical spark between an electrode and raw material.' Is this statement true?

A) Yes
B) No

46. How much does the Haas VF-1 machine cost?

A) 47 000 $
B) 43 000 $
C) 45 000 $

47. When was the G-code developed?

A) In the 1940s
B) In the 1950s
C) In the 1960s

48. CAM has delivered several improvements to the manufacturing process, including Improved machine capabilities, higher efficiency of the machinery and improved ……. usage.

A) Time
B) Material
C) Labour

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