MID SEMESTER EXAM-2018 (Winter)

CAD/CAM (Code: 021730)

SEMESTER – VII

(SESSION: 2018-19)

Time: 2 hours   *Branch: Mechanical Engineering*   *Full Marks: 20*

1)

  a) Explain briefly product life cycle with a neat flowchart.

Ans. For any product to be developed, the major areas to be looked into would be designing, manufacturing and marketing. The synchronization between these processes plays a great role in defining product success.

Here CAD/CAM revolutionizes the process of the traditional design and cut costs of any mechanical part. CAD/CAM drastically reduces the design time for a new product. This gives it so much edge on the traditional design process that nowadays, traditional design with pen and paper is almost extinct. Automobile industry is the best example of this improved design time and product cycle.

Product life cycle (PLC) Like human beings, products also have a life-cycle. From birth to death, human beings pass through various stages e.g. birth, growth, maturity, decline and death. A similar life-cycle is seen in the case of products. The product life cycle goes through multiple phases, involves many professional disciplines, and requires many skills, tools and processes. Product life cycle (PLC) has to do with the life of a product in the market with respect to business/commercial costs and sales measures. To say that a product has a life cycle is to assert three things:

- Products have a limited life,
- Product sales pass through distinct stages, each posing different challenges, opportunities, and problems to the seller,
- Products require different marketing, financing, manufacturing, purchasing, and human resource strategies in each life cycle stage.

**The Traditional Design Process:**

Traditionally, the design process contains the following steps:

1. Recognition of Need
2. Definition of Problem
3. Synthesis
4. Analysis and Optimization
5. Evaluation
6. Presentation

Here is the iteration between step 3 and 4 we analyze, find the fault, then again synthesize, again analyze and iterate and iterate again until we would be able to get satisfactory result. After we analyze and optimize the design again if we are not satisfied after evaluation, we again iterate i.e. we again goes to the synthesis.

After all these steps, we finally make a prototype of the part which we are designing. If that fails or does not fulfill our needs, the whole process will start again.

This is what traditional design process does. Here CAD/CAM comes into the picture. If we use computer for the problem of synthesis like we are designing the things with the help of a computer, all the analysis and synthesis will be done on computer and the process consumes much lesser time than a traditional design process.
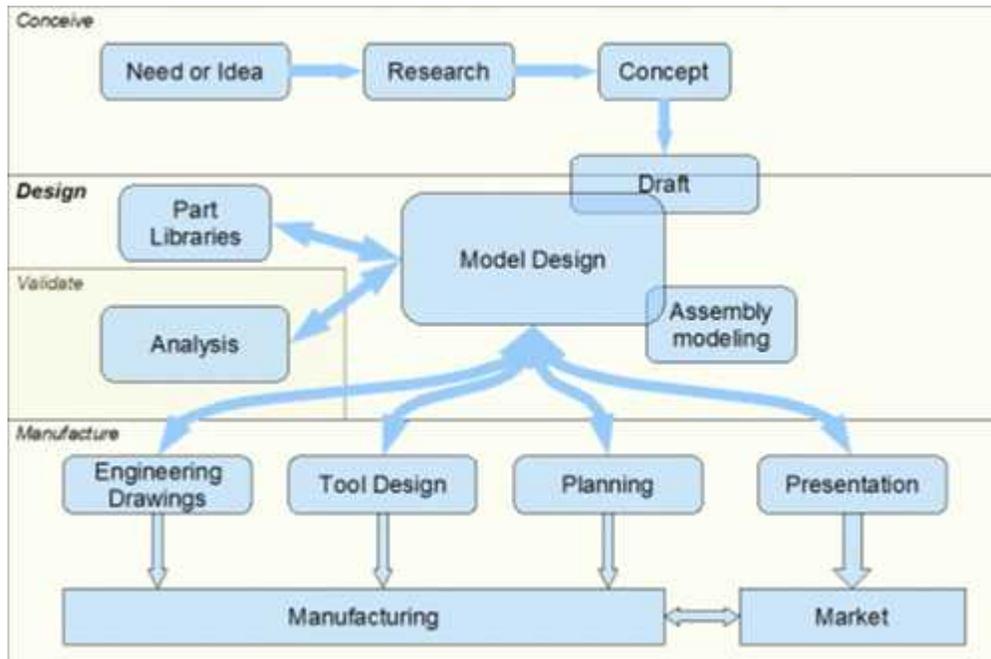
b) What are different applications of CAD/CAM.

Ans. **Main Applications of Computer Aided Design (CAD)**

Solid Modelling

This process is used to create solid components of desired shape by joining and cutting different solid volumes. The final solid model is a virtual replica of an actual product but it can be seen and rotated like a real product.
There are two main types:

· direct where the model can be edited by undoing or modifying the model directly on the 3D;

· parametric where the model is constructed using parameters (variable quantities such as measurements) and the model can be edited at any point in its history.

Surface Modelling
This process is used to create surfaces of desired shape by trimming, stitching and joining different surfaces to create a final shape model.

Assembly
This process is used to assemble the models created in solid or surface modelling to create a final assembly. This is used to see the actual fitment of all models and see the actual working of assembly.

Drafting Detailing
This process is used to create the 2D drawings of components or assemblies; usually directly from a 3D model, although 2D CAD can create 2D drawings directly.

Reverse Engineering
This process is used to convert the real component into 3D CAD Model. Different types of instruments such as laser scanner, white light scanner, CMM (coordinate measuring machine) etc. are used to measure or decode the shape of real model. The virtual model obtained can then be modified in a CAD program.

Main Applications of Computer Aided Manufacture (CAM)
Plotter/cutters
Using 2D CAD or graphics software these machines can draw or cut 2D shapes on paper, card or self-adhesive vinyl sheets.

Laser cutting
Using 2D CAD or graphics software these machines can cut or engrave a wide variety of materials such as card, plywood, acrylic sheet, textiles, glass.

2.5D Milling
Typically 2.5D machining uses 2D CAD files as the source and cuts in x and y directions (parallel to the machine bed) while lowering the tool progressively through several steps to cut out an object using a rotating tool. Setting tool paths is generally simple and the part cut rapidly.

3D Milling
3d machining typically used STL files from 3D CAD programs as a source and requires all three axes of the mill to be able to move simultaneously. 3D machining can take a very long time even on fast, modern machines and especially if a high quality finish is required. A fourth or rotary axis can also be added to create turned parts.

Turning
CAM software automates traditional turning on a lathe including roughing, grooving, threading and finishing for faster, more accurate results.

3D printing
3D printing is a process of making a three-dimensional object of virtually any shape from a digital model. It is achieved using an additive process where successive layers of material (usually thermoplastic) are laid down. Each layer is a thinly sliced, horizontal cross-section of the eventual object. Each object begins with a CAD file, created with a 3D modelling programme, or by reverse engineering.

The key benefits of CAD/CAM
· increased range of design ideas
· improved accuracy
· ease of modification
· repeatability of output
· quality of output
· reduction of wastage

2)

   a) Name and explain any five hardware devices used in computer aided design system.

   Ans:

   1. *Design Workstations*. The workstation is the interface between computer and user in the CAD system. Its functions are the following: (1) communicate with the CPU. (2) continuously generate a graphic image. (3) provide digital descriptions of the image, (5) translate user commands into operating functions, and (5) facilitate interaction between the user and the system.

   The design of the CAD workstation and its available features have an important influence on the convenience, productivity. and quality of the user's output. The workstation must include a graphics display terminal and a set of user input devices. The display terminal must be capable of showing both graphic~ and alphanumeric text. It is the principal means by which the system communicates with the user. For optimum graphics display, the monitor should have a large color screen with high resolution.

   The user input devices permit the operator to communicate with the system. To operate the *CAD* system, the user must be able to accomplish the following: (1) enter alphanumeric data, (2) enter commends to the system (0 perform various graphics operations, and (3) control the cursor position on the display screen. To enter alphanumeric data, an alphanumeric keyboard is provided. A conventional type writer like keyboard allows the designer to input numerical and alphabetic characters into the system. The alphanumeric keyboard can also be used to enter commands and instructions to the system. However. other input devices accomplish this function more conveniently. Special *function keypads* have been developed to allow entry of a command in only one or two keystrokes. These special keypads have from 10 to 50 function keys, depending on the system. However, each key provides more than one function, depending on the combination of keys pressed or which software is being used. Another input device for entering commands to a CAD system is the *electronic tablet,* an electronically sensitive board on which an instruction set is displayed, arid commands arc entered using a puck or electronic pen.

   Cursor control permits the operator to position the cursor on the screen to identify a location where some function is to be executed. For example, to draw a straight line on the screen, the endpoints of the line can be identified by locating the cursor in sequence at the two points and giving the command to construct the line. There are various cursor control devices used in CAD, inducting pucks, mouse's, joysticks, trackballs, thumbwheels, light pens, and electronic tablets. An input device for entering coordinates from an existing drawing into the CAD system is a *digit/t.er,* which consists of a large flat board and an electronic tracking element such as a puck that can be moved across the surface of the board to record x and y-coordinate positions.

   2. **Digital Computer**. CAD applications require a digital computer with a high-speed central processing unit (CPU), math coprocessor to perform computation intensive operations, and large internal memory. Today's commercial systems have 32bit processors, which permit high-speed execution of CAD graphics and engineering analysis applications.

   Several CAD system configurations are available within the general arrangement shown in Figure 24.5. Let us identify three principal configurations, illustrated in Figure 24.6: (a) host and terminal, (b) engineering workstation, and (c) CAD system based on a personal computer (PC).

The *host and terminal* was the original CAD configuration in the Ig70s and early 1980s when the technology was first developing. For many years, it was the only configuration available. In this arrangement, a large mainframe computer or a minicomputer serves as the host for one or more graphics terminals. These systems were expensive, each installation typically representing an investment of a million dollars or more. The powerful microprocessors and high-density memory devices that are so common today were not available at that time. The only way to meet the computational requirements for graphics processing and related CAD applications was to use a mainframe connected 10 multiple terminals operating on a timesharing basis. Host and terminal CAD systems are still used today in the automotive industry and other industries in which it is deemed necessary to operate a large central database.

An *engineering workstation* is a standalone computer system that is dedicated to one user and capable of executing graphics software and other programs requiring high-speed computational power. The graphics display is a high-resolution monitor with a large screen. As shown in our figure, engineering workstations are often networked to permit exchange of data files and programs between users and to share plotters and data storage devices.

A *PC-based CAD system* is a PC with a high-performance CPU and medium to high resolution graphics display screen. The computer is equipped with a large random access memory (RAM), math coprocessor, and large capacity hard disk for storage of the large applications software packages used for CAD. PC-based CAD systems can be networked 10 share file" output devices, and for other purposes. Starting around 1996, CAD software developers began offering products that utilize the excellent graphics environment of Microsoft Windows NT, thus enhancing the popularity and familiarity of PC-based CAD.

When the engineering workstation is compared with the PC-based system, the former is superior in terms of most performance criteria. Its capacity to efficiently accomplish 3D geometric modeling and execute other advanced software exceeds that of a PC, and this makes the workstation more responsive and interactive than a PC-based CAD System. However, the performance characteristics of PCS are improving each year, and the prices of engineering workstations are dropping each year, so that the distinction between the two types is becoming blurred.

3. Plotter:

Pen plotters. These are .x *y* plotters of various types used to produce high accuracy line drawings.

Electrostatic plotters. These are faster device, based on the same technology as photocopying. The resolution of the drawings from electrostatic plotters is generally lower than those made by a pen plotter.

4. Printers:

Dot-matrix printers. In the operation of these printers, small hammers strike an ink ribbon against the paper to form a drawing consisting of many ink dots.

Inkjet printers. These arc similar to dot-matrix printers except that the dots arc formed by high-speed jets of ink impacting the paper.

5. *Storage Devices*. Storage peripherals are used in CAD systems to store programs and data files. The storage medium is usually a magnetic disk or magnetic tape, Files can be retrieved more quickly from magnetic disks, which facilitates loading and exchange of files between CPU and disk. Magnetic tape is less expensive, but more time is required to access a given file due to the sequential file storage on the tape. His suited to disk backup, archival files, and data transfer to output devices.

b) Explain working principal of Cathode Ray Tube display device with neat sketch.

Ans: Cathode Ray Tube (CRT) is a computer display screen, used to display the output in a standard composite video signal. The working of CRT depends on movement of an electron beam which moves back and forth across the back of the screen. The source of the electron beam is the electron gun; the gun is located in the narrow, cylindrical neck at the extreme rear of a CRT which produces a stream of electrons through thermionic emission. Usually, A CRT has a fluorescent screen to display the output signal. A simple CRT is shown in below.
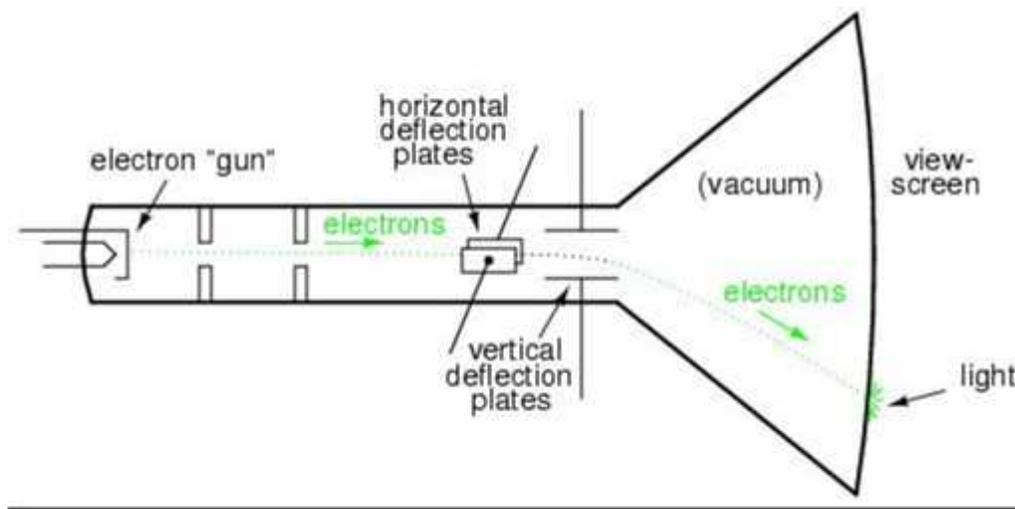
Cathode Ray Tube

The operation of a CRT monitor is basically very simple. A cathode ray tube consists of one or more electron guns, possibly internal electrostatic deflection plates and a phosphor target. CRT has three electron beams – one for each (Red, Green, and Blue) is clearly shown in figure. The electron beam produces a tiny, bright visible spot when it strikes the phosphor-coated screen. In every monitor device the entire front area of the tube is scanned repetitively and systematically in a fixed pattern called a raster. An image (raster) is displayed by scanning the electron beam across the screen. The phosphor's targets are begins to fade after a short time, the image needs to be refreshed continuously. Thus CRT produces the three color images which are primary colors. Here we used a 50 Hz rate to eliminate the flicker by refreshing the screen.

Cathode

The heater keeps the cathode at a higher temperature and electrons flow from the heated cathode towards the surface of the cathode. The accelerating anode has a small hole at its center and is maintained at a high potential, which is of positive polarity. The order of this voltage is 1 to 20 kV, relative to the cathode. This potential difference creates an electric field directed from right to left in the region between the accelerating anode and the cathode. Electrons pass through the hole in the anode travel with constant horizontal velocity from the anode to the fluorescent screen. The electrons strike the screen area and it glows brightly.

The Control Grid

The control grid regulates the brightness of the spot on the screen. By controlling the number of electrons by the anode and hence the focusing anode ensures that electrons leaving the cathode in slightly different directions are focused down to a narrow beam and all arrive at the same spot on the screen. The whole assembly of cathode, control grid, focusing anode, and accelerating electrode is called the electron gun.

Deflecting Plates

Two pairs of deflecting plates allow the beam of electrons. An electric field between the first pair of plates deflects the electrons horizontally, and an electric field between the second pair deflects them vertically, the electrons travel in a straight line from the hole in the accelerating anode to the center of the screen when no deflecting fields are present, where they produce a bright spot.

Screen

This may be circular or rectangular. Screen is coated with special type of fluorescent material. Fluorescent material absorbs its energy and re-emits light in the form of photons when electron beam hits the screen. When it happens some of them bounces back just like bouncing of cricket ball from a wall. These are called as secondary electrons. They must be absorbed and returned back to cathode, if it is not so they accumulate near screen and produce space charge or electrons cloud. To avoid this, aquadag coating is applied on funnel part of CRT from inside.

3) Explain geometric modelling and finite element analysis in CAD.

Ans: **Geometric modeling** is a branch of applied mathematics and computational geometry that studies methods and algorithms for the mathematical description of shapes.

The shapes studied in geometric modeling are mostly two- or three-dimensional, although many of its tools and principles can be applied to sets of any finite dimension. Today most geometric modeling is done with computers and for computer-based applications. Two-dimensional models are important in computer typography and technical drawing. Three-dimensional models are central to computer-aided design and manufacturing (CAD/CAM), and widely used in many applied technical fields such as civil and mechanical engineering, architecture, geology and medical image processing.[1]

Geometric models are usually distinguished from procedural and object-oriented models, which define the shape implicitly by an opaque algorithm that generates its appearance. They are also contrasted with digital

images and volumetric models which represent the shape as a subset of a fine regular partition of space; and with fractal models that give an infinitely recursive definition of the shape. However, these distinctions are often blurred: for instance, a digital image can be interpreted as a collection of colored squares; and geometric shapes such as circles are defined by implicit mathematical equations. Also, a fractal model yields a parametric or implicit model when its recursive definition is truncated to a finite depth.

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.

It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc. Most of these processes are described using Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical techniques have been developed over the last few decades and one of the prominent ones, today, is the Finite Element Analysis.

Differential equations can not only describe processes of nature but also physical phenomena encountered in engineering mechanics. These partial differential equations (PDEs) are complicated equations that need to be solved in order to compute relevant quantities of a structure (like stresses ($\epsilon\epsilon$), strains ($\epsilon\epsilon$), etc.) in order to estimate a certain behavior of the investigated component under a given load. It is important to know that FEA only gives an approximate solution of the problem and is a numerical approach to get the real result of these partial differential equations. Simplified, FEA is a numerical method used for the prediction of how a part or assembly behaves under given conditions. It is used as the basis for modern simulation software and helps engineers to find weak spots, areas of tension, etc. in their designs. The results of a simulation based on the FEA method are usually depicted via a color scale that shows for example the pressure distribution over the object.

4) Write short notes on Automatic guided vehicles and NC systems.

Ans: An **automated guided vehicle** or **automatic guided vehicle** (AGV) is a portable robot that follows markers or wires in the floor, or uses vision, magnets, or lasers for navigation. They are most often used in industrial applications to move materials around a manufacturing facility or warehouse.

Numerical control (**NC**) (also **computer numerical control** (**CNC**)) is the automated control of machining tools (drills, boring tools, lathes) by means of a computer. An NC machine transforms a piece of material (metal, plastic, wood, ceramic, or composite) according to instructions from a computer programmed to precise specifications.

NC machines combine a motorized maneuverable tool and often a motorized maneuverable platform, which are both controlled by a computer core, according to specific input instructions. Instructions are delivered to an NC machine in the form of graphical computer-aided design (CAD) files, which are transformed into a sequential program of machine control instructions, and then executed.

NC is a major advance in machining, and is a vast improvement over non-computer type machining that requires manual control, by hand wheels or levers, or mechanical control by fabricated pattern guides (cams). In modern CNC systems, the design of a mechanical part and its manufacturing program is highly automated. The part's mechanical dimensions are defined using CAD software, and then translated into manufacturing directives by computer-aided manufacturing (CAM) software. The resulting directives are transformed (by

"post processor" software) into the specific commands necessary for a particular machine to produce the component, and then are loaded into the CNC machine.

Since any particular component might require the use of a number of different tools – drills, saws, etc. – modern machines often combine multiple tools into a single "cell". In other installations, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD.

5) What are different advantages of CAD/CAM Systems.

Ans: 1. Increase Programming Potential

By adding CAD-CAM software to your CNC toolkit, you can open up possibilities for your business that may not have been there before. An example of this is gaining the ability to take on harder, more complex 3 Axis machining jobs. CAD-CAM can help a shop manage and create toolpath and NC programs for complex machining projects such as mold work. These types of jobs are next to impossible to calculate by hand or even through using machine canned cycles. A CAD-CAM system completely automates the process.

2. Makes You More Accessible by Clients

By having a CAD-CAM software product in your shop, you can receive CAD models from clients faster and easier than ever before. You will be able to open CAD files easily, setup the toolpath for machining and perform simulations that provide valuable information for you in the quoting process such as the calculation of cycle times. Manufacturing can deliver products to market faster and more affordable than ever before. This has a lot to do with technological advancements in CNC machining and in CAD-CAM software. The software allows users to design faster, manage projects, test and simulate as well as machine faster than ever.

3. Improved Control Over Job Programming

Modern CAD-CAM functionality includes a CAM Tree Manager that allows you to track the job from beginning to end. You have full control over post processing, stock, work coordinates, material and tooling as well as access to machining operations that determine how the part will be machined as well as the output of the NC Program. The CAM Tree has many built-in benefits such as saving and loading machining templates, copying and pasting machining operations, reordering how the job is sequenced, toolpath associativity so that if a CAD edit is made to the part, all of the toolpaths are updated and much more. Higher control capabilities lead to perfectly finished parts being completed faster.

4. Machining Wizards Remove The Guesswork

CAD-CAM provides the automation required to maximize programming efficiency. Machining wizards remove the guesswork from programming as they step the operator through the process of setting cutting depths, selecting tools, choosing toolpath styles, managing cutter lead-ins and lead-outs, choosing compensation settings as well as many other important parameters that have to do with creating machine toolpath. Wizards allow new programmers to be successful faster while still providing advanced programmers with the utilities and confidence to program error free parts regardless of their complexity.

5. Getting The Most Out of Your CNC Machine Tool

CAD-CAM software provides high-speed machine toolpaths that deliver a host of benefits that all equal up to reduced cycle times, less tool wear and a reduction in machine wear and tear over the long term. High-speed

toolpaths allow you to improve the quality of cutting by eliminating the stop and go actions that traditional offset toolpath creates. The rounded more circular cutting motions at higher speeds allow a constant tool engagement with the material, deeper cuts and the ability to use more of the cutting tool itself. High speed machining can improve CNC machine productivity by as much as 50%.

6. Eliminate Costly Mistakes & Waste

CAD-CAM software provides powerful simulation features. Simulation allows you to visually inspect the machining process, catch costly tool gouges and collisions before they reach the CNC machine. This alone makes adding a CAD-CAM product to the shop a good decision. Simulation also provides detailed information about the toolpath, cycle times, part deviation analysis, the ability to create simulation presentations and much more. Higher levels of simulation will allow you to use your machines kinematics to simulate machining with the actual machine tool visually.
Work holding can also be modeled and added to simulation to complete the visual inspection of the part being machined as well as everything else involved.

7. Powerful 3 Axis CNC Programming Operations

CAD-CAM software provides the ability create complex 3 Axis machine toolpath quickly and efficiently. Without CAD-CAM, programming complex parts is practically impossible as often time there are multiple toolpaths required from advanced roughing, semi-finishing and then multiple finishing toolpath strategies. In addition, the latest releases of BobCAD-CAM provide Dynamic Machining Strategies™allowing the programmer to apply multiple roughing and finishing operations to a single CAD feature.

8. Multiaxis CAM Technology Makes Complex Machining Simple and Cost Effective

Simultaneous 4 and 5 Axis CNC machining can be the most difficult to create NC programs for. CAD-CAM software provides the solutions to make these types of CNC jobs much easier than ever before. This starts with 4th Axis indexing and rotary machining jobs that require toolpath and special post processing that only a CAM system can offer. Posting can even be customized by the operator with a little training for a wide variety of 4 and 5 Axis machines. Full 5 axis toolpaths include surface-based machining operations that accommodate port milling, SWARF and undercutting type toolpath strategies as well as 3+2 programming.

Without a CAD-CAM system this level of CNC programming is nearly impossible. CAM systems can also provide full 4 & 5 Axis simulation, which is critical when programming these types of parts to visually inspect the machining process before an NC program ever reaches the machine.

9. Turn Art Into CNC Programs & Finished Parts Easily

Artistic CAD-CAM technology has evolved to support a wide range of custom applications. Two of these specialized industries would be the custom woodworking and jewelry making industry. These types applications require the ability to turn a picture into a 3D relief model that can be machined in a variety of ways. This also includes the ability to turn a picture into 2D profiles that can be used for engraving, pocket milling and profile milling. These industries have to then be able to create these programs to me machined on a CNC Mill or Router in 2, 3 and 4 Axis. Some even require 5 Axis CNC programming capabilities.

Whatever the case, CAD-CAM providers now offer artistic modules that can be added on to a machining product for creating amazing artistic CNC parts.

10. Seamless Integration with Popular CAD Design Products

Some CAD-CAM providers have teamed up with highly popular CAD vendors such as SolidWorks® to create powerful CAM machining modules that integrate into the CAD software as a plug-in. This allows existing CAD users to create the necessary machining for the part, simulate everything and create the NC programs for them. This is highly beneficial, as the CAD users do not have to completely re-learn a new CAD-CAM system; they only need to learn the machining side. By going this way, a CAD Designer can acquire more value and seek more clients for being a full service design and programming facility. Typically CAM products that plug-in to CAD systems can be easier to learn and use after some training.