The Suite Life: Autodesk® Product Design Suite Workflows for Machine Design

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MA3204 - In this class, we will take you on a tour of Autodesk® Product Design Suite 2013. We will show you what you can do with this flexible set of tools that are specialized in 3D mechanical design, simulation, tooling, electrical design, visualization, documentation, and collaboration. Using the design suite tools, you can evaluate and optimize machines while exchanging information with others throughout the design workflow. You will learn what you can accomplish by combining the Digital Prototyping capabilities of Autodesk® Inventor® software with enhanced design, visualization, and cloud services tools to reduce development costs and get machine designs to your clients faster and with less rework.

Learning Objectives
At the end of this class, you will be able to:

- Use conceptual design tools in the preplanning stages
- Use Product Design Suite software for large assembly review and project planning
- Elevate your design intent into a 3D parametric digital prototype
- Create high-quality visualizations for presentations and electronic media

About the Speakers:
Mark has been using Autodesk® products since 1999 in many different manufacturing environments. He has implemented Autodesk products for many diverse industries. Autodesk® Inventor® has profoundly augmented Mark's abilities, allowing him to bring 3D digital prototyping to the forefront of the industries with which he has interacted. Mark has extensive experience and a comprehensive understanding of the technical and practical business and human dimensions of implementation. His expertise has helped his clients maximize their project's effectiveness and return on investment. He is an effective and skillful communicator, consulting with his clients to help achieve their business objectives. Mark provides training, support, and implementation on all Autodesk manufacturing solutions.

Caleb Funk began his career as a professional CAD instructor after a short stint as a production draftsman, and has 10+ yrs CAD experience starting with AutoCAD R12. He enjoys sharing his knowledge of drafting and solid modeling best practices, and is well known for his versatility and extensive knowledge of CAD software. He is a Solid Modeling Expert; MicroStation Certified Instructor, and has Authored MicroStation courseware for the Florida Department of Transportation. Caleb is PSE and ATC Certified in AutoCAD®, AutoCAD® Mechanical, AutoCAD® Electrical, and Autodesk Inventor.

Autodesk Product Design Suite

Autodesk® Product Design Suite (PrDS) 2013 is a comprehensive solution for Digital Prototyping, delivering design, visualization, and simulation tools to complete your entire product design process.

PrDS provides a flexible set of tools specializing in 3D mechanical design, simulation, surface modeling, tooling, electrical design, visualization, documentation, and collaboration which enables users to digitally evaluate and optimize conceptual designs while seamlessly exchanging engineering information throughout the design workflow.

The Product Design Suite comes in three different packages for flexible licensing choices; Standard, Premium, and Ultimate with products specialized for different aspects of the digital prototype.

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The Suite also comes with a Product Launcher to aid in workflow usage. Inside the Suite launcher are subsets of the workflow for either Machine Design or Plastic Part Design. This class will focus on the Machine Design workflow nodes. Some predefined options can also be set for some of the nodes.
Reuse 2D Data – AutoCAD & Inventor

The quality of existing 2D data should always be considered before moving it to 3D. AutoCAD has been around since the early 80’s and a tremendous amount of data could exist in this format for existing companies. Over that period of time, that 2D data crossed many engineers and designers throughout the product’s lifecycle. It is not uncommon for a wayward user under the pressure of a deadline to “fudge” a dimension.

Some of the ideal conditions for the migration of 2D data are that the geometry is correctly placed on corresponding layers, correct 1 to 1 scaling, and valid multi-view projections. Other considerations are that end points meet correctly (proper use of Object Snaps); geometry that overlaps incorrectly, and varying elevations of lines.

Ensuring that these guidelines meet your 2D data will make the process of importing the data into Inventor much easier. If not done correctly up front the geometry requires extra attention once it reaches a parametric sketch. It is often a recommended approach to take a sampling of your 2D data and examine it in this manner before making your final decision about the reuse and migration of your existing data.

There are three choices when it comes to migration of 2D data into the realm of 3D; to utilize the existing data, to recreate it, or to categorize it as legacy. The selection depends on a few factors such as the released state of the legacy data, whether it needs modified for the new design, as well as the complexity of the model. For instance the sketch to the right is a complex legacy 2D print, but we would like to use it in 3D Modeling. Ideally this shape will not change from its released state, so we can just bring it in and lock it in place inside Inventor as to avoid heavy rework until necessary.
Modify 3D Geometry – Inventor

Inventor Fusion allows the direct manipulation of 3D data without regard for parametric history or complicated relationships inside of a traditionally design parametric 3D model. Inventor Fusion really is just about the geometry. This freedom is useful in the design process in numerous ways and it is quite hard not to find an Autodesk product that hasn’t tried to incorporate Fusion in some way.

In the PrDS world we can do many things with this free product (that’s right, it’s actually free for PC and Mac). Consider these sample scenarios to include Fusion in the design process...

- Importing non Autodesk supplier files for easy modification for your new design to propose the change that needs to be scoped for the supplier. This can be done free of PrDS licensing so site visits can scope the concept without the heavier Inventor license.

- Quickly taking a current model and tweaking it free of the parametric history to convey a revision or a new concept for a part, then having an engineer approve those changes to be automatically incorporated into the parametric history of the model.

- Creating a Fluid Part for use in CFD Software rather than complex traditional Inventor steps
3D Parametric Design – Inventor

Autodesk Inventor 3D CAD software products offer a comprehensive, flexible set of software for 3D mechanical design, product simulation, tooling creation, engineer to order, and design communication. Inventor takes you beyond 3D to Digital Prototyping by enabling you to produce an accurate 3D model that can help you design, visualize, and simulate your products before they are built. Digital Prototyping with Inventor helps companies design better products, reduce development costs, and get to market faster.

Inventor is essentially a parametric history based modeling program, which means that a part evolves by creating features one by one until the design is complete. Changes made to the part’s history or design criteria will affect its geometry to enable quick modification to the design.

There are primarily two types of features you can create with Inventor’s modeling environment, those which require 2D profiles to create (Sketched Features) and those that only require existing geometry (Pick and Place).

Sketched Features are created by sketching its shape or profile and can be any shape or size. To create a sketched feature, you must sketch a 2D cross section on the placement surface or plane and add dimensions and constraints to define and locate the sketched geometry with respect to the model.

Here a few examples of some base features and their required sketches; with some features it is necessary to have more than one sketch.
Pick and place features are features for which a shape has been predefined. To create a pick and place feature you must define the location of the feature and the references required to locate it with respect to existing geometry. Examples of some pick and place features are Fillets, Drafts, Chamfers, Shell, and some Holes.

The history of these features, whether they are sketched or pick and place is stored in the Model Browser of the modeling file. Consider the following set of features and their order...
From this model the tree below is automatically created for this history. Modifications can be made to the earlier features to affect changes to the latter features in the history. Any change to the Extrusion 1 will affect change to the entire part since it is the Base feature as well as positioning of latter features depending on how they were created.

The same power that grants this highly functional type of design is also somewhat of a pitfall for new users. For instance what if one of the features was deleted? What would happen to the above model if the Shell in step 4 or Extrusion in step 5 were deleted from the history? Anything dependent upon those features such as Steps 6-9 would either become sick or destroyed.

These types of relationships that are created by referencing already created geometry or a feature is known as Parent-Child relationships. For example Hole1 is parent to Mirror1. Modification of Hole1 directly affects Mirror1, but modification of Fillet2 does not directly affect Hole1 or Mirror1 since it was not referenced for either subsequent feature.

Models built in Part mode can be used as components in an assembly file. Assemblies are created by constraining components with respect to one another. The addition of constraints creates relationships between components and builds intelligent assemblies.

Open degrees of freedom will allow users to check desired motion in designs before locking them down. In this example the yellow linkage piece is too short to allow the red link to go a full 360 degrees (1 & 2). But activating the part in the assembly and changing the length of the yellow link to allow for full rotation can be done without ever leaving the assembly (3).
Once components are assembled they can also be checked for interference in design. Here the red shows a PCB board (green) overlapping into the plastic walls of this part. Corrective measures for design flaws can be taken care of before a part ever gets to the mold or the physical prototype stage. In traditional 2D drafting these types of interferences could be very hard to see and often missed before a prototype is created.

The Automatic Bills of Material tracking for designs ensures all components are accounted for and that the design criteria for each part are being correctly populated for data tracking. If not, changes can be made here to enact change to the part files Material selection, BOM Structure, and other tracking data known as iProperties.

Beyond this simple look at Inventor there are other numerous toolsets available to the users including Sheet Metal. Multiple Design Workflows exist for different mindsets, such as a machining mindset versus an additive one.
Cable & Wire Harness – Inventor Routed Systems

The Cable & Harness add-in to Autodesk Inventor provides the means to create and manipulate three-dimensional wire harnesses in the context of a standard Autodesk Inventor assembly as well as work in a bidirectional manner with AutoCAD Electrical schematics for point to point wiring. This allows schematic diagram data to be reused in the 3D digital prototype to ensure proper routing and procurement efficiencies.

The two software products of the suite talk to each other through XML files exported or imported through either program. AutoCAD Electrical will read the connector (Insert Connector from List) and wire information from Inventor to place schematic connector references and automatically wire them with appropriate routing to the connector’s pins. Inventor will do the same (Import Harness Data) but in a 3D world it is also important to properly route the wires through and around obstacles in the design. Inventor will also calculate accurate total wire lengths which becomes increasingly important for large harness jobs.
Stress Analysis – Inventor Professional

The Autodesk Inventor software provides a combination of industry-specific commands. It extends the capabilities of Autodesk Inventor for completing complex machinery and other product designs. Static Analysis provides the means to simulate stress, strain, and deformation. Modal Analysis provides means to find natural frequencies of vibration and mode shapes of mechanical designs.

The Inventor linear stress / strain solver will allow users to add various types of forces, including Bearing and Pressure, to a parts and assemblies as well as apply contacts to properly isolate design information required for FEA analysis.

You can visualize the effects in 3D volume plots, create reports for any results, and perform parametric studies to refine your design. Inventor will also save out the animations to a video file for use in collaboration and stakeholder meetings for necessary design changes.

The parametric table shown above can iterate Simulations across different design criteria, but its solver is limited to the computer running it.

The incredible benefit with this functionality is that it will not tie up an Inventor machine for the entire processing time and it will also be completed faster than a desktop simulation.
Autodesk Inventor Professional provides commands to simulate and analyze the dynamic characteristics of an existing assembly in motion under various load conditions. The simulation reveals how parts respond from a structural point of view to dynamic loads at any point in the range of motion of the assembly. You can even export load conditions at any time step during the motion to Stress Analysis.

There are many things that can be examined in Dynamic Simulation to aid in overall design process, such as the forces needed to perform movement or prevent movement in a design.

Dynamic Simulation has two key graphers, the input and output grapher. The Input grapher will allow forces and other variables to change magnitude over the desired time period.

The output grapher will plot trace trajectories, forces, stresses, velocities, positions, accelerations, and many other recordable variables in a simulation over the time steps used to perform the action. The trace elements can even be exported to create modeling geometry from the trace lines.
Technical Drawing – AutoCAD or Inventor

A drawing communicates engineering design to manufacturing, purchasing, customer service, and others. Each company has standards for drawing content, based on the type of product and on established internal processes. Product Design Suite leverages multiple documentation tools to allow the best flexibility in the collaborative process.

The Technical Drawing task node allows for two separate documentation techniques and will prompt you to choose whether you wish to document your 3D modeling geometry in Inventor or AutoCAD Mechanical (technically AutoCAD would also work here, but doesn’t install by default with the Suite and has to be downloaded for free later).

There are positive aspects of the documentation being completed in AutoCAD Mechanical but the positive aspects of performing the documentation in Inventor far outweigh the AutoCAD Mechanical component.

Inventor drawings have considerably more control over visibility, part display options, and model linked information in contrast to AutoCAD Mechanical, which is very functional for prints that will find their way outside of engineering and to supplier or vendor for sourcing. The AutoCAD Mechanical drawing will still update based on the Inventor model, but should only be considered for possible outgoing documentation at this time.

While not in the Suite workflow task nodes, another clever usage of model documentation exists for machine builders. Industrial machine manufacturers commonly are asked for their designs to be placed in a factory layout or general arrangement for production planning or material flow analysis.

Once the consumer of the mechanical asset has a copy of the Inventor DWG, they can use Design Center in AutoCAD to place one or more of the views that were placed in the Inventor drawing as a very accurate 2D representation of the machine.
Interactive Design Review – Showcase

The Autodesk Showcase software is a visualization, presentation, and communication package used for design presentation of 3D CAD data. It can be used to create high quality single frame still imagery of virtually any size (including large format) presentation graphics. It can transform your CAD geometry into movies and real-time presentations. It can also be used to create variations of background, materials, lighting, and positions and then create ultra-photorealistic renderings of these variations.

The benefit the Suite adds to the Showcase utilization resides in the quick creation of a set Showcase environment through a template setting designed in Inventor. This template can be set for Realistic, Conceptual, or Constrain Animations and all sorts of settings in between.

Once inside of Showcase, users have the power to perform interactive presentations that are beneficial at stakeholder review meetings, trade shows, and marketing events. Inventor constraints can be directly mapped to Showcase behaviors and triggered by simply clicking on the object in the model to begin the movement. The Showcase Organizer makes the model hierarchy readily understandable to engineering and marketing personnel.
Photorealistic Rendering – 3Ds Max Design

Create accurate and highly realistic visualizations of industrial machinery, automotive designs, and consumer product digital prototypes, and reduce the need for costly physical prototypes and photo shoots. Whether you work in AutoCAD, Autodesk Inventor, Autodesk Alias, or CATIA software, you can produce professional-quality images and animations with 3ds Max Design more easily than ever before.

- Create virtual photography and cinematography that is nearly indistinguishable from reality, and market your product in print, on the web, and in television commercials
- Add animated characters to scenes; animate products and exploded diagrams; and place products in their context

The true advantage with 3Ds Max design is internalizing expensive contract photo shoots and even more expensive physical prototypes for those photo shoots. The award winning animation aspects of 3Ds Max more than speaks for itself. The bottleneck to fully utilizing this software technology is spending the time to acclimate to the software and its complexities in order to fully benefit from the software. New personnel or proper training is usually required to realize the benefits.
Suite Workflow Manager – Showcase & 3Ds Max

Inside Autodesk Inventor’s Application Menu, users can access the Suite Workflow tools to create fast interaction with two of the more intricate Visualization tools available to the Product Design Suite. Autodesk Inventor users can quickly access the Showcase and 3Ds Max direct export and launch to quickly take the model they are working on into those high end visualization products.

Inventor has six predefined templates to get you started, but if that is where you stop, then you are really missing out on some easy automation to make your transition into those programs much easier. By selecting the Workflow Manager, you can create your own templates that will appear in the Suite Workflows menu after creation. The exports with the blue arrows are the default supplied import settings for the two products and the orange arrows are user created templates which can be shared with other users as well by copying the .workflow files.
Large Assembly Review – Navisworks

Autodesk Navisworks Simulate software provides advanced tools for simulation and powerful features to help you better communicate project information. Multidisciplinary design data created in a broad range of Building Information Modeling (BIM), digital prototypes, and process plant design applications can be combined into a single, integrated project model. Comprehensive schedule, cost, animation, and visualization capabilities assist users in demonstrating design intent and simulating construction, helping to improve insight and predictability.

Real-time navigation combines with a review toolset to support collaboration among the project team. Entire project models can be published and viewed in NWD and DWF file formats to provide valuable digital assets from design through construction planning. The NWD models can then be viewed in Navisworks Freedom for live sectioning, animations, flythrough and comment review.

Where Navisworks really shines for the Machine Design minded workflow is in the construction process and the ability to scope out the 4D Time Simulation for project stakeholders involved in the installation of a large piece of capital equipment. The Navisworks TimeLiner will export the project Gantt chart installation milestones to Microsoft Project and the TimeLiner animation can also be viewed in Freedom by clients wanting to visualize the projected time line of installation tasks. We can even utilize existing data from our clients such as facilities done in Revit or Microstation. It may also be very important to a machine installation to know if other machines need to be broken down and moved or if another machine needs installed first based on space limitations in a facility.
Keeping it all Together – Autodesk Vault

Autodesk Vault data management software helps organize, manage, and track data creation, simulation, and documentation processes for design and engineering workgroups. Get more control over design data with revision management capabilities and quickly find and reuse design data, for easier management of your design and engineering information.

Tightly integrated with Autodesk Digital Prototyping applications, Autodesk Vault data management software helps manufacturers, engineers, architects, and construction teams to more efficiently collaborate and meet tight deadlines.
Review

Develop more innovative designs with an integrated suite of tools that help to seamlessly transfer information and meet the demands of each phase of engineering, from design through simulation and visualization. Integrate industrial design aesthetics into your products using a wide range of modeling tools, giving your products a competitive edge.

With a broad set of easy-to-use, interoperable design tools, your engineering design teams can work more relatively and manage their processes more efficiently. As ideas move from concept to engineering, the need to remodel concepts is minimized as engineers can work from conceptual designs. And with everyone using a common set of tools, you improve collaboration across all phases of development.

Optimize and validate product performance before the product is built. With cloud-based Autodesk 360 services and integrated simulation tools, Product Design Suite helps you reduce the chance of errors, validate design intent through the entire process, and select low-cost, low-impact materials to aid in sustainability. Tight integration with the 3D design software helps make it cost-effective to use simulation throughout the design process.

Use Autodesk Product Design Suite to more easily generate and share production-ready documentation from a validated digital prototype, helping reduce errors and deliver designs in less time. Turn your design data into photorealistic renderings and cinematic-quality animations, helping give you the edge over your competition and provide visually stunning design concepts to customers. Enhance engineering design review and collaboration by integrating supply chain data to create complete large-scale digital mock-ups.