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Automotive Design A New Approach Using Autodesk Fusion 360

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ABSTRACT
Fusion 360" helps students and educators prepare for the future of design. It's the first 3D CAD, CAM, and CAE tool of its kind, connecting the entire product development process into one cloud-based platform.
"Fusion 360" helps mechanical engineers and automotive designers to break the limit on existing workflows and engineer their parts with a complete set of 3D modeling tools that include parametric, freeform, direct, and surface modeling.
It also helps them to simultaneously generate multiple options of their design while consolidating parts, reducing weight, and improving overall product performance.
After design and modeling comes the simulation process. "Fusion 360" is equipped with great tools to test the designs and ensure they will survive real world conditions using one model, in one affordable cloud-based platform.

I. AUTODESK FUSION 360 INTRODUCTION AND HISTORY

"Autodesk Fusion 360"is a relatively new software from "Autodesk", it combines modeling, simulation, documentation and even manufacturing into a single integrated environment that is built on collaborative workflow from the ground up. In short terms it is a CAD-CAM-CAE software.

It was introduced originally in 2012 with "Autodesk Inventor" under the name "Inventor Fusion" as a free technology preview and it offered then a handful of surface and solid modeling tools. It also supported parametric modeling tools as well as direct manipulation approach.

In 2014 the company discontinued "Inventor Fusion" and graduated the technology preview into what is now called "Autodesk Fusion 360" and since then, "Autodesk" has continued to improve "Fusion 360" with so many frequent updates to the degree it surpassed many of itsoriginal father's "Autodesk Inventor" capabilities.

At first the software was sold into two different packages: "Standard" and "Ultimate". Both provided a full stack of tools for modeling, simulation, documentation and manufacturing as well as tools for data management and cloud collaboration.

But the "Ultimate" edition had more advanced simulation tools like stress simulations and also support for generative design workflows and of course it was costly compared to the "Standard" edition.

Recently in 2018 "Autodesk" took the decision to combine both versions into a single product that does everything with a unique and incomparable price tag, the new version includes many advanced simulations, support for generative design workflows, and also a multi-axis machining.

Like most of "Autodesk" products, you can download a free trial of "Fusion 360" that gives you full access to its full stack of tools for 30 days, students and hobbyists making less than 100K USD annually can continue to use "Fusion 360" for free for 3 more years, while commercial users must pay a monthly or annual subscription fee.

"Autodesk Fusion 360" is a very impressive piece of software. It provides a full suite of remarkable tools into a single package that works on PCs and MACs. "Fusion 360" also interoperable with files from different software programs like Alias, CATIA, Creo, Rhino, and SolidWorks.

The company has a vision to keep "Fusion 360" affordable and powerful at the same time. Also, to keep it super simple to work in teams and from different places and devices.

The company has struggled for years to enter the mechanical design and manufacturing market and its original software "Inventor" wasn't doing the job because of the huge success of its competitor "SolidWorks" but now finally it seems that "Autodesk" finally got it the right way with "Fusion 360".

II. AUTODESK FUSION 360 USER'S INTERFACE AND USER'S EXPERIENCE

At first look, the software "Fusion 360" looks quite different and revolutionary compared to other CAD-CAM-CAE software packages. The interface has an "Application Bar" in the upper part that provides tools for files handling (New/Save/Close), Exporting, 3DPrinting, as well as Undo and Redo.

Under this bar is the "Tabs" area which lets us switch between currently open projects very fast. Below the "Tabs" comes the tools area that appears in the horizonal "Toolbar" with its modern design called "The Ribbon".

To simplify things further, the software capabilities are grouped into what is called "Workspaces". When we select a specific "Workspace", we see tools and commands specific to that "Workspace".We may think of "Workspaces" like the main operations or tasks the software does, each "Workspace" has a specific operation to make or a specific task to achieve.

For Example, the "Model Workspace" provides tools for placing 3D solids and for sketching and converting sketches into features, exactly like what we would find in a traditional 3D CAD program.

After selecting a tool within the current "Workspace", we work on the design in the canvas area, A right click in the canvas gives us a "Marketing Menu" that contains frequently used commands.

Also, a "ViewCube" in the upper-right corner of the canvas lets us orbit the design or view it from a set of standard viewpoints. A "Navigation Bar" near the bottom of the canvas contains commands used for Pan, Zoom, and alike commands.

A floatable "Browser" palette in the left side lists the objects in our design and lets us control their visibility. A "Timeline" across the bottom lists the operations performed on our design and enables us to easily alter any part of the design process.
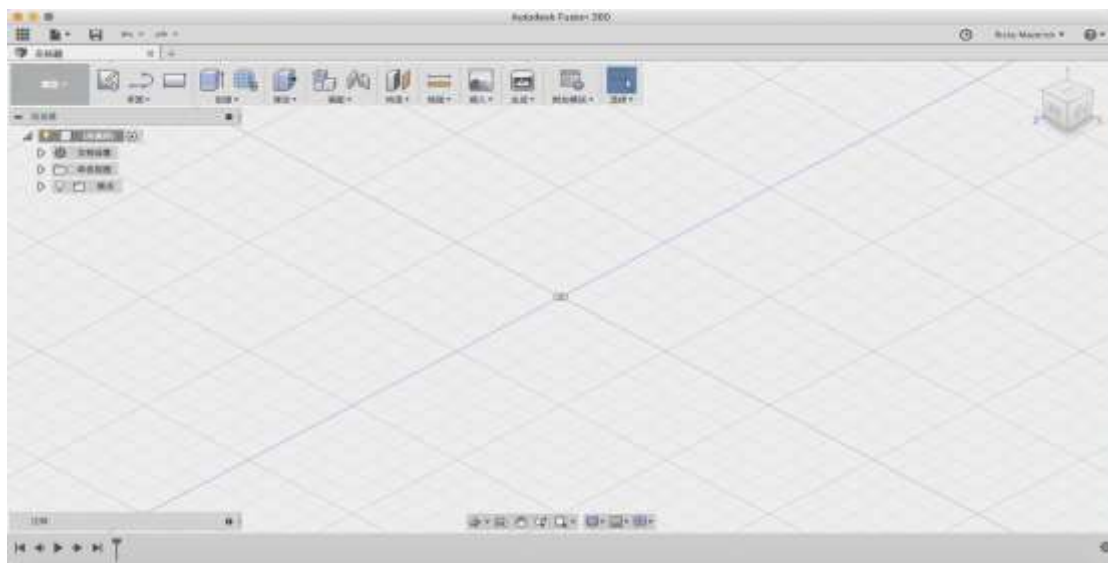
III. THE NEW WAY OF COLLABORATION (AUTODESK CLOUD)

In "Fusion 360", we create projects to contain our design data, then if only we want to, we invite people into the project domain to collaborate, and this is where "Fusion 360" really excels.
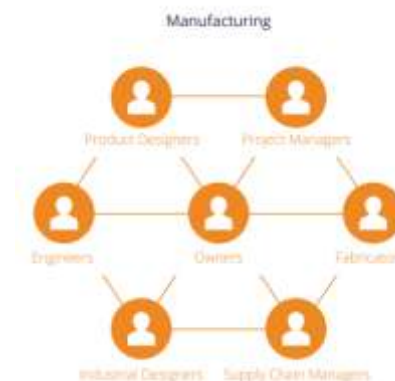
Although the software runs locally, all designs are saved to Autodesk's cloud. If we lost access to the internet while working, we can still use "Fusion 360" in offline mode, thought we won't be able to perform some file operations and simulations.

The last-saved version of the file changed while in offline mode will be synced to the cloud once the connection is back.

"Autodesk" cloud service is called "A360", and "Fusion 360" depends heavily on integration with "A360" for user access and data management.

"A360" offers very unique set of features not available in most other 3D CAD software yet like 2D/3D viewer, easy file sharing, real-time preview, metadata, mobile access, data hub, security, and access rights features.
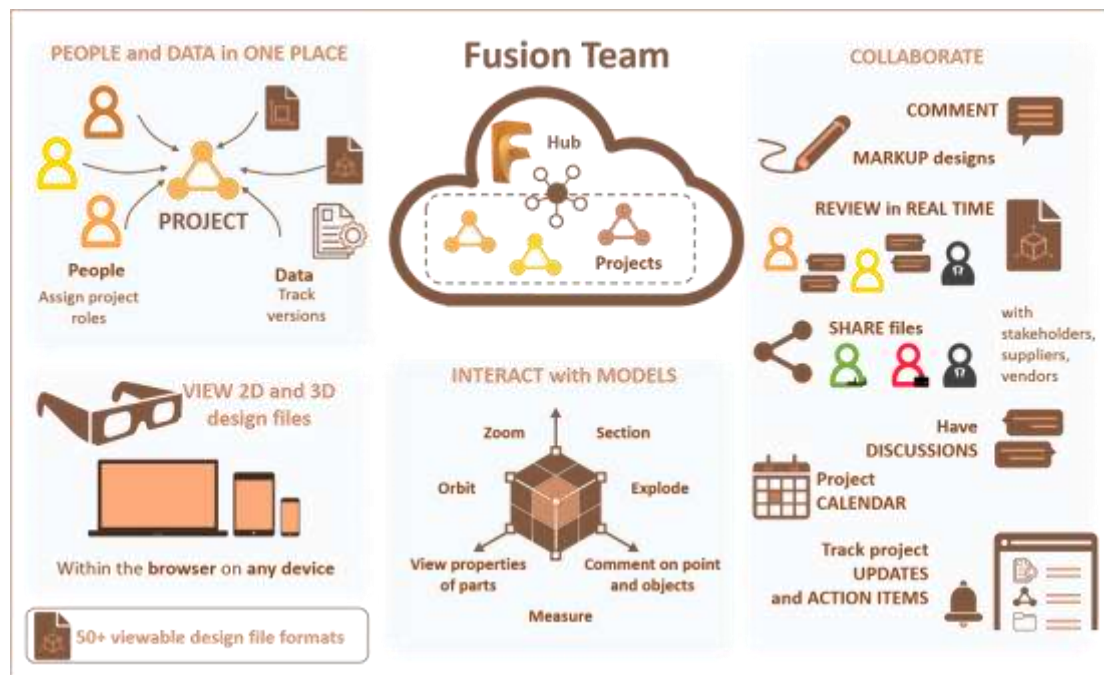
IV.   AUTODESK FUSION 360 VS. SOLIDWORKS

For longtime "SolidWorks" has been the industry standard for 3D CAD modeling. Then, few years ago, "Fusion 360" launched, a new cloud-based CAD modeling software that has been built specially to challenge the industry leader.

Both "SolidWorks" and "Fusion 360" are both software programs used for the exact same thing: 3D Design and Modeling. However, they have few differences and each has its own strong points over the other. That said, it's time to make the comparison.

A) Part Modeling:
- Part modeling is where these two programs are really different than each other.
- "SolidWorks" is an assembly software. That means it builds parts individually before assembling them. This is an advantage when parts are used in many assemblies.
- In the other side "Fusion 360"' uses a component system, where components (a component consists of multiple parts) of an assembly are usually built and assembled in the same file.

B) Mechanical Design:
- Many people can do 3D Design and Modeling. But there is a difference between hobbyists and expert mechanical designers.
- Mechanical design isfocused on the manufacturability of a product rather than its look and feel.
- "Fusion 360" is great for non-technical designers with basic and easy-to-use simulations but lacks some of the more advanced features.
- "SolidWorks" still is a better choice for technical designers with its sophisticated analysis and simulations tools.

C) Advanced Mesh Modeling:
- Another important feature for designers is mesh modeling. This is where points along a surface can be "pushed" or "pulled" to create organic geometry and surfaces.
- Unlike "SolidWorks", "Fusion 360" excels in this area.

- "Fusion 360" can directly import a model into its sculptingenvironment, where a user can instantly start modeling meshes with a very easy-to-use interface.
- "SolidWorks" offers a similar feature using its surfacing tools, but it's very hard, unintuitive, and no way close to what "Fusion 360" has.

 "Autodesk Fusion 360" as a 3D Design and Modeling Tool:
- "Fusion 360" was built to increase creativity and ability to quickly createmultiple design versions (iterations).

"Autodesk Fusion 360" as a Simulation Tool:
- "Fusion 360" allows us to test our designs early in the development process to determine usability and uncover flaws.

"Autodesk Fusion 360" as a Generative Design Tool:
- "Fusion 360" expands our ability to innovate by quickly generating design alternatives from a set of manufacturing and material constraints (Generative Design or Generative Modeling).

"Autodesk Fusion 360" as a Documentation Tool:
- Once a 3D model has been made, we can easily extract 2D drawings directly from our 3D model to ensure consistency and manufacturing accuracy.

"Autodesk Fusion 360" in Team Work and Collaboration:
- We can easily collaborate with all stakeholders without location constraints, time zones constraints, and exhausting reviewing process.

"Autodesk Fusion 360" as a Manufacturing Tool:
- The software utilizes HSM methods to generate paths that saves cycle times, reduce machine and tool tear, and produce high quality final parts from a single operation.

Autodesk Fusion 360, An In-Depth Look
"Autodesk" advertises "Fusion 360" as a software to eliminate disconnected product development. Also, to unify design, engineering, and manufacturing into a single platform.

V. AUTODESK FUSION 360 AS A 3D DESIGN AND MODELING TOOL
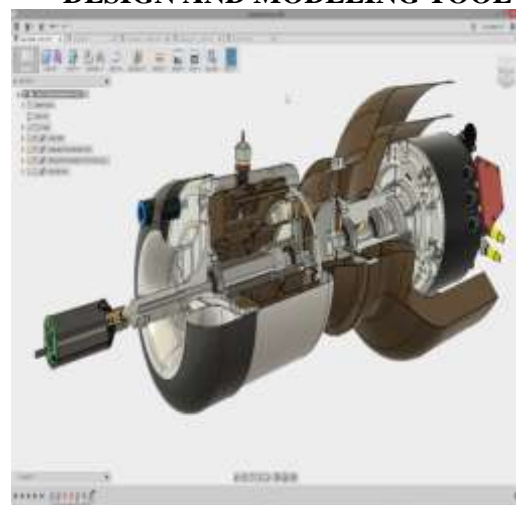
"Fusion 360" allows us to engineer products with a comprehensive set of modeling tools ensuring form, fit and function of our designs.

We can easily use sketches and put parameters and/or constraints to make them behave the way we want.

We can also utilize history-based features, including extrude, revolve, loft, sweep, etc., that update with design changes.

Also, importing non-native formats is easy because we have direct modeling tools to be able to make changes at any time without worrying about time-based features.

"Fusion 360" excels in freeform modeling which allows us to create complexsurfaces with T-Splines and edit them with intuitive push-pull commands.

Also, the software has many tools especially for surface modeling. We can easily create and edit complex parametric surfaces for designing or repairing.

Like most CAD-CAM software packages, "Fusion 360" can design sheet metal parts, make documents using 2D drawings and DXFs, and

manufacture them with specific strategies for water jet or laser cutter.

Also, we can easily import scans or meshes, including STL and OBJ files and repair them directly in "Fusion 360".

We can easily assemble designs with any traditional method like bottom-to-top, top-to-bottom, or middle-to-out. And we can easily analyze motions and limitations.

VI. AUTODESK FUSION 360 AS A SIMULATION TOOL
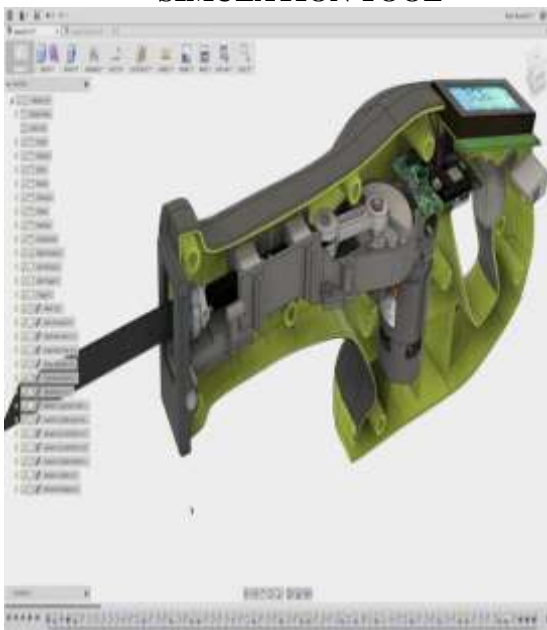
Simulations are design tests to ensure the design will thrive in real world conditions.

"Fusion 360" has near-perfect physical validators that can reduce the cost of prototyping saving effort, cost, and time.

Simulations runs in the cloud and requires cloud credit. Users can purchase 100 credits from their "Autodesk" account management console.

we can easily setup multiple simulations and leave them to run without the need for specific expensive hardware and without having to wait long for processing times.

"Fusion 360" studies breadth by testing for up to eight different failure criterions, including nonlinear, event, and more.

Simulations results can be easily viewed and compared and we can easily visualize four different design iterations in a single viewport.

By simulating static stress, we can determine displacements, stresses and other effects resulting from static loads on parts or assemblies.

Also,doing thermal and thermal stress analysis is a snap, we can easily understand thermal distributions their impact inside the model.

We can easily test our designs against buckling, by predicting unexpected failure modes for slender members under compression.

Also, a set of shape optimization simulations is available to identify unnecessary regions in our design for weight-lightening purposes.

VII. AUTODESK FUSION 360 AS A GENERATIVEDESIGN TOOL
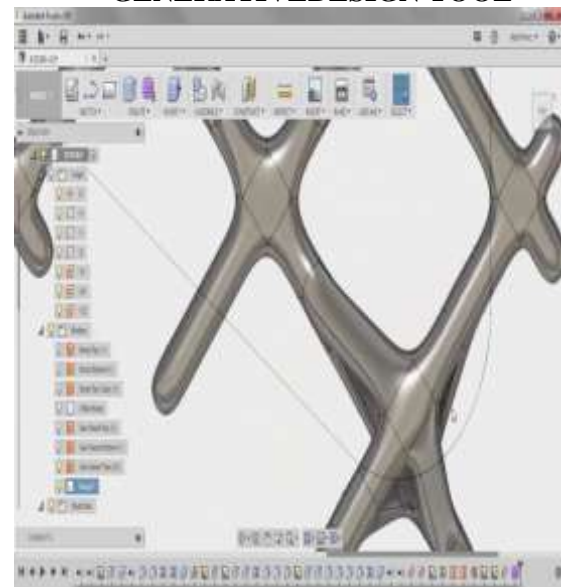
Generative design is a design exploration process.

Designers or engineers input design goals into the generative design software, along with parameters such as performance, spatial requirements, materials, manufacturing methods, and cost constraints.

The software explores all the possible permutations of a solution and quickly generates design alternatives. It tests and learns from each iteration what works and what does not.

From light-weighting components to parts consolidation, "Autodesk" generative design is being used by companies shaping the future of the automotive industry.

"Fusion 360" allows us to explore multiple manufacturing-ready outcomes that meet our design specifications while reducing weight, improving performance, and consolidating parts.

We start by identifying our design requirements, constrains, materials, and manufacturing options to generate manufacturing-ready designs.

Then we simultaneously generate multiple options of our design in order to have a variety of options to select from.

Then we could easily choose a design outcome to export and import the CAD-ready mesh into "Fusion 360". The results can be edited with

T-splines tools for more adjustments and saved to the cloud for further work and simulations.

VIII. AUTODESK FUSION 360 AS A DOCUMENTATION TOOL
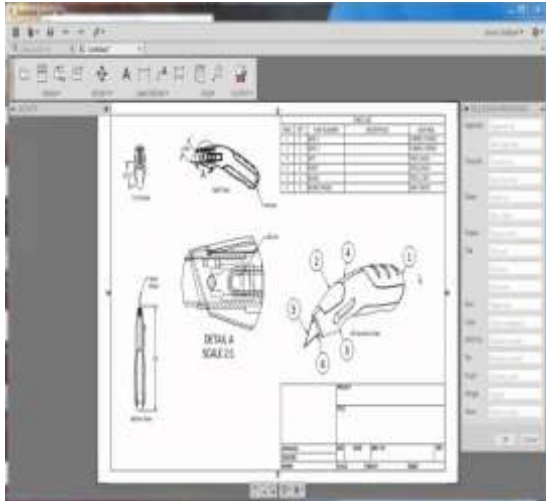
Classic design and prototyping tools used to have two different separated workflows for design and documentation.

Back then, we used to design the 3D model first, then find a way to draft the views of this 3D model and produce documents for it.

This separation between design and documentation may easily lead to errors in manufacturing, let alone the time wasted for documentation editing, proofing, and cross-referencing when the model changes.

The new way of work using "Autodesk Fusion 360" and alike software is that we get views directly from the model, this ensures consistency and bi-directional connectivity between the actual 3D model geometry and the 2D views.

Using "Autodesk Fusion 360" we could easily communicate designs to internal or external stakeholders with 2D manufacturing drawings, renderings, and animations.

We could easily convert our assemblies and parts into 2D drawings and annotate them with text, dimensions, and information to product a set ready to be shared or printed.

Also using "Fusion 360" we could create high quality photo-realistic images of our models by doing rendering either locally or in the cloud using cloud rendering.

If an image worth a thousand words, an animation worth a thousand images. "Fusion 360" allows us to communicate our design even further with 3D exploded views and animations to show assemblies and parts movements and constraints.

IX. AUTODESK FUSION 360 IN TEAM WORK AND COLLABORATION

Collaboration idea is what differentiates "Fusion 360" a lot from the competition and even from its own father "Autodesk Inventor".

Old design sharing and review tools were very slow and inefficient. Also, the need to export the design outside its naïve application to be able to get reviews or comments wasn't the best way of work.

The team at "Autodesk" did a great job by reinventing everything that is related to collaboration and team work tools and introduced a whole new way of thinking in this important modern area.

"Fusion 360" removes all these problems from traditional reviewing process and utilize a modern environment that is based on cloud computing.

We begin with user management; we can easily invite all stakeholders in our development process and manage how users interact with data via project administration control panel either from a browser or even from inside the software.

Also, we could easily invite teams across various departments and locations, and even across different operating systems. All working and reviewing at the same time.

We could share feedback from any device, directly on the design itself using comments, redlines, and specific review objects like markups.

"Fusion 360" gives unlimited access to data on cloud, also there is an ability to work offline and synchronize data to cloud when finished.

X.   AUTODESK FUSION 360 AS A MANUFACTURING TOOL
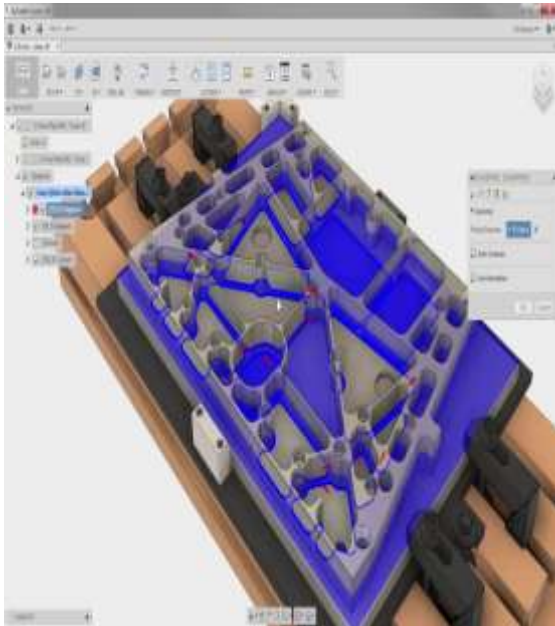
From high-end roughing with adaptive clearing to easy control of multi-axis machines with tool orientation, "Autodesk Fusion 360" makes it easy to program our CNC machine.

We could manufacture with 2.5-axis milling, 3-axis milling, 4-axismilling, and 5-axis milling along with other manufacturing operations like probing, turning, and profilingpaired with a powerful post engine.

All of this are already included behind professional design tools so only one software can design, simulate and manufacture at the same time.

It also gives options to leverage in-machine touch probes to shift work offsets and simplify our setup processes.

We could also program 3D turned parts and verify our turning toolpaths with simulations to identify errors or collisions with the model, stock, tools and holds.

Moreover, we could generate toolpaths from solid model features including flattened sheet metal componentsto plasma cutting machines, laser cutting machines, and water jet machines.

The software also comes with a free post processing library that enables users toprogram post tasks in seconds.

"Fusion 360" also comes with ability to utilize third party extensions, plug-ins or add-ons that extends the software capabilities even further.

Automotive Design with Fusion 360 (Case Study 1)

In 2017, "Autodesk" organized an automotive design competition **"DESIGN FOR AUTOMOTIVE"**to be fully made with the relatively-new software "Fusion 360".

"Autodesk" organized the competition to be made especially for today's students which will become tomorrow's engineers and designers.

"Autodesk" has challenged students to design what they called "Race Car of the Future" using only "AutodeskFusion 360" software with no other design tool whatsoever.

They encouraged the students to consider aerodynamics, driver safety, aesthetics and brand identity for their designs and try to define a whole new class of race cars which students actually succeeded into doing to an excellent degree.

The requirements were to submit a "Fusion 360" original design file with at least one photo-realistic rendering to showcase the design.

Using any other software to enter the competition was prohibited, also importing ready meshes and existing CAD data was not allowed.

The steps were for students to download free version of the software, then license it as a three-year free educational license, then a bunch of videos can help the students get their feet wet.

Also "Autodesk" provided a sample file to start with instead of starting from scratch, after finishing the designs, students used cloud service to save their designs along with the renders and any other related files or documents.

Also, a voting system was introduced on the website just to encourage students to share designs and vote for it, however, online voting wasn't a factor in final designs selection by the jury.

A set of very strict rules and requirements were published in the competition website that all students must follow and adapt to, students failed to work based on these rules were immediately terminated.

"Autodesk" along with "Sqore" (The event organizer) hired three industry leaders as judges in order to evaluate designs and select the top designs to be awarded.

Judge 1 was "Ian Green" from "Nissan Motors", Judge 2 was "Ben Eaton" from "Mercedes Benz", and Judge 3 was "Andrew Denford" from "Formula1 in Schools".

The judges categorized winners between four categories: 1^{st}place winners, 2^{nd}place winners, 3^{rd}place winners, and 4^{th}place winners. Each got a collection of cash prizes, physical prizes, along with media recognition.

"Autodesk" awarded 20 students from many different countries and age segments and published their original work in the competition website.
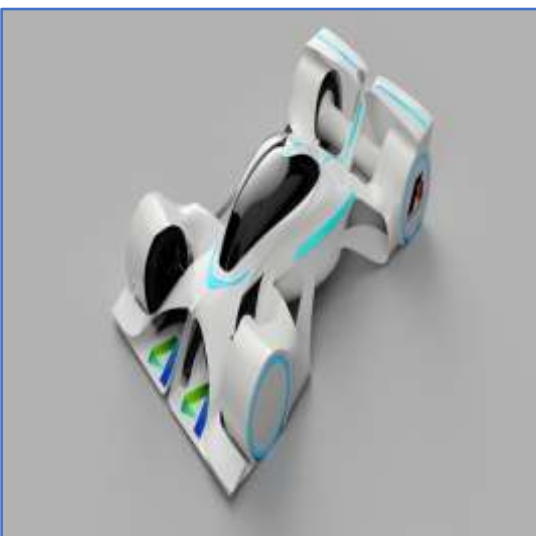
A Design By/ Xenia Thalassini

A Design By/ Shiv Singh

A Design By/ Rukeem Collins

A Design By/ Nikhil Singh Pundir

A Design By/ Daria Yakovenko

A Design By/ Andy K.

Automotive Design with Fusion 360 (Case Study 2)

"F1 IN SCHOOLS" is an organization established with committed partners to provide both exciting and challenging educational journey through the appeal of Formula 1.
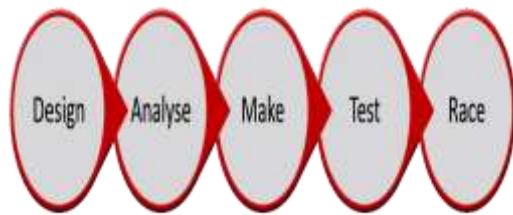
"F1 in Schools"is the only global challenge in which teams of young students can learn how to deploy CAD/CAM software to design, analyze, manufacture, test, and then race miniature cars made from F1 model blocks.

It is a unique global platform for the promotion of Formula 1 and partners to a youth market.Teams must raise sponsorship and manage budgets to fund research, travel, and accommodation.

The challenge inspires students to use IT to learn about physics, aerodynamics, design, manufacture, branding, graphics, sponsorship, marketing, teamwork, media skills, and financial strategy.

The founding constitution of F1 in Schools stipulates that it is, and shall remain, a not-for-profit organization.Funds raised through sponsorship are invested in administering, developing, and expanding the challenge.

Company's mission is to change lives around the world by spanning age ranges of 9 to 19, the company's main objective is to help change the perceptions of science, technology, engineering, and math by creating a fun and exciting learning experience for young people to develop their own views about existing technological careers.

Steps to enter the competition:
1. Form a teamof 3 – 6, think of a name, decide job roles; Team Manager, Manufacturing Engineer, Design Engineer, Graphic Designer, and Resource Manager.Now register for regional finals.
2. Plan and prepare a business plan, develop a budget and raise sponsorship. Teams are encouraged to collaborate with industry and create business links.
3. Using 3D CAD (Computer Aided Design) software, design an F1 car of the future to the specifications set by the "International Rules Committee" just like in "Formula 1".
4. Aerodynamics isanalyzed for drag coefficiency in a virtual wind tunnel using Computational Fluid Dynamics software (CFD).
5. Using 3D CAM (Computer Aided Manufacture) software, the team evaluates the most efficient machining strategy to make the car.
6. Aerodynamics is tested in wind and smoke tunnels.
7. Put together an informative display showing your work through all stages of the project. Think about your team identity.
8. Cars are submitted to "Parc Ferme" where the judges scrutinize every dimension to check they comply with the rules and regulations.
9. Judges question teams on how their cars has been manufactured and why particular designs were chosen.
10. Prepare a presentation to perform to a panel of judges covering all aspects of the challenge. This will be completed within a specific time limit.
11. put together two 10-page A3 portfolios, one enterprise portfolio (documenting your businessplan) and another engineering portfolio(documenting the construction of your car).
12. Test what your team has worked so hard together to achieve a winning car by doing an actual race.

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XI.   CONCLUSION

"Autodesk" released "Fusion 360" in 2013. It was the first cloud-based software that brought together every aspect of a project workflow.

Usable on mobile devices, the software allows collaboration with all involved in a project from anywhere and on anytime.

It is also one of the most comprehensive digital design and prototyping software packages available.

It allows users to do everything from creating designs through to fabrication.

This extends to performing testing and simulation routines for designs.

Further, the subscription model proves beneficial in several ways. It lowers the immediate cost of using the software.

Better yet, it means that users don't have to pay for updates. Instead, you get access to new features as soon as "Autodesk" releases them.

Though a relatively new player in the market, "Fusion 360" has made a lot of powerful waves.

This has led to plenty of people adopting the software.