Fidget Spinner Project

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The University of Texas at Austin

Introduction to Engineering Design and Graphics

ME 302 Section#18575

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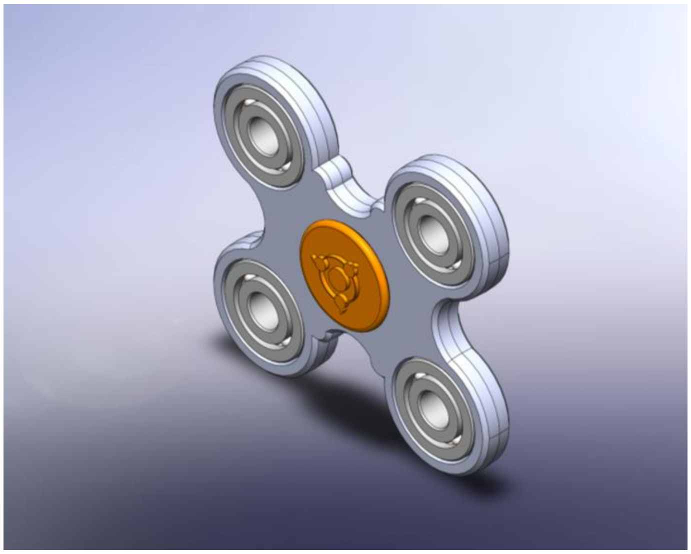

Executive Summary

The goal for the project of this course is to design and manufacture a plastic fidget spinner all while implementing introductory and basic design and manufacturing techniques that are learned from this course though the labs and lectures. A fidget spinner consists of a main body that is designed to have a set number of arms, typically between 2 to 5 arms. Each of the arms from the main body should be able to hold a kind of weight, for this course's purpose we were given ball bearings as our weight. This equal weight distribution among the arms and the bearings permits for the fidget spinner for extensive periods of time without much effort. The central bearing of the body also holds a ball bearing and is encapsuled by two bearing caps that serve the purpose of making it easier to hold the spinner without interfering with its spin. The first step of the design portion of this project is to come up with a creative design for the main body and bearing caps, this is done through brainstorming and transmitting those ideas to a 2-dimensional sketch on paper. This sketch is then replicated in Solidworks and made into a 3-dimensional digital model that follows the imported ball bearing specifications and constraints is then implemented. I was able to design a 4-arm spinner that uses curved and circular geometries and press fit bearing caps. My design was then submitted to a finite element analysis (FEA) that consisted of a drop test in the Solidworks software. Geometric dimensioning and tolerancing (GD&T) drawings of main body were implemented in order to be able to design a mold for plastic injection molding. The mold designs were imported to Autodesk Fusion 360 were a computer aided manufacturing (CAM) was produced. Teams were then made to create a selection of fidget spinner designs that will be manufactured by the respective teams through the means of injection molding. The teams then also used 3D printing in order to manufacture the bearing caps for the central bearing. With this all the parts needed for the final assembly were finished and ready for assembly. This consisted of inserting and press fitting the ball bearings and bearing caps into the main body of the fidget spinner.

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Design Problem and Objectives

As mentioned before, the goal for the project of this course is to create plastic fidget spinner all while implementing introductory design/manufacturing techniques that are learned from this course. This fidget spinner design had to follow these specifications and constraints:

- The main body could have 2 to 5 arms.
- The hole for the central ball bearing needed to be 22 mm in diameter.
- The ball bearings needed to have an inner diameter of 8 mm.
- The ball bearings needed to have an outer diameter of 22 mm.
- The main body needed a length and width that was less than 100 mm per side.
- The thickness of the ball bearings and the main body needed to be 7 mm.

The fidget spinner was first designed in paper as a 2D sketch and then implemented into Solidworks to have a digital 2D sketch of both the main body and bearing caps. With this a 3D design was then produced, I was able to design a 4-arm spinner that uses curved and geometries and press fit bearing caps. A ball bearing model was imported and used for the 3D assembly in Solidworks, which consisted of the bottom and top bearing caps, the main body, and 5 ball bearing weights. My design was then submitted to a finite element analysis (FEA) that consisted of a drop test in the Solidworks software. GD&T drawings of the main body were implemented to design a mold for plastic injection molding. The mold designs were imported to Autodesk Fusion 360 were CAM that used CNC mills was implemented. The aluminum mold design had to follow these specifications:

- The molds had to measure 100 mm x 100 mm x 12.7 mm in length, width, and height, respectively.
- An injection hole had to exist 0.898 in below and 1.5 in from the center of the top left corner hole.
- An adapter plate was given with the same corner dimensions, but with an injection site 1.469 in below the top left corner hole.
- The molds had to have holes in each corner for ¼-20 screw and a counterbore for a ¼-20 screw that measured 0.38 inches (in) in diameter and were located 0.5 in from each edge and 3 in from one another.

Teams were then made to create a selection of fidget spinner designs that will be manufactured by the respective teams through the means of injection molding. The teams then also used 3D printing in order to manufacture the bearing caps for the central bearing. With this all the parts needed for the final assembly were finished and ready for assembly. This consisted of inserting and press fitting the ball bearings and bearing caps into the main body of the fidget spinner.

Detailed Design Documentation

2 Dimensional Designs:

The first step in designing the fidget spinner was to sketch a design on paper. In Figure 1, a prospective design of a four-arm spinner is shown. The next step was to translate these designs into a digital format in Solidworks. In Figure 2, a sketch of a four-armed fidget spinner is shown.

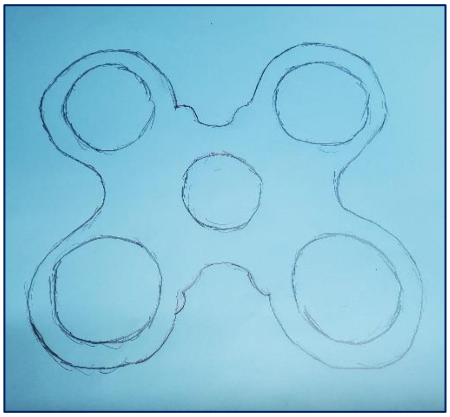

Figure 1: Paper Sketch

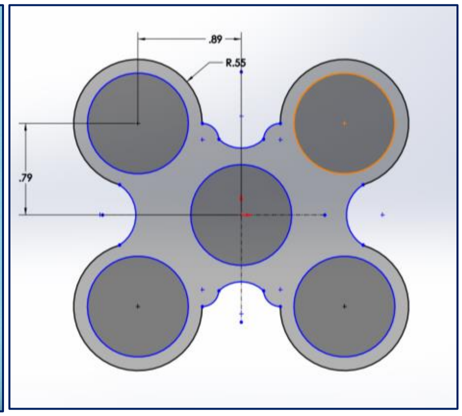

Figure 2: Solidworks Sketch

3 Dimensional Designs:

Main Body

The 2D designs produced a 3D design of the main body in Solidworks, this 3D model was also implemented with boss extrusion and chamfers. Figure 3.3 also includes the GDT from using DimExpert. These dimensions are imported into the drawing as shown.

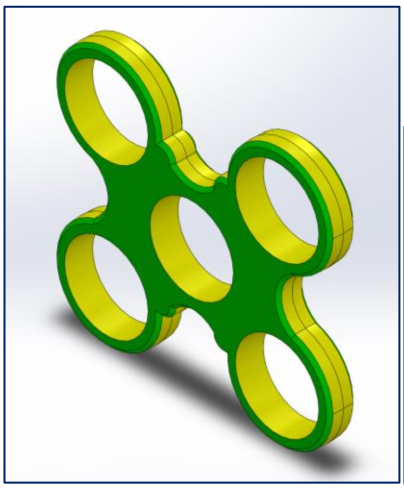

Figure 3.1: Isometric View Main Body

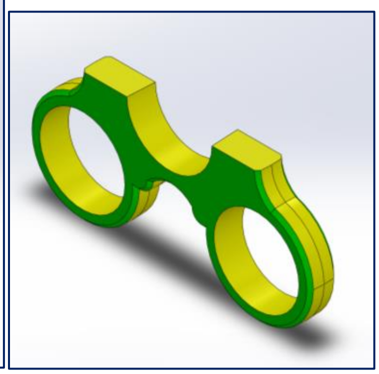

Figure 3.2: Section View Main Body

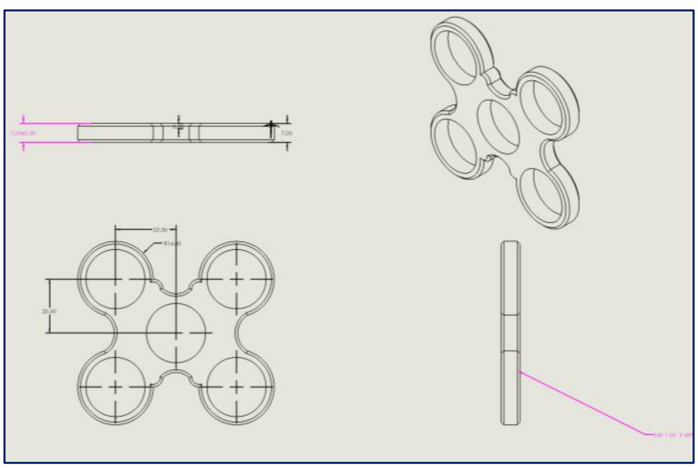

Figure 3.3: Standard 3 View Main Body

Bearing Caps

3D models of the bearing caps that encapsule the central ball bearing and the main body were also designed in Solidworks. As well as the main body they have GDT dimensions from DimExpert. These are shown in Figures 4.1 and 4.2. These dimensions are also imported into the drawing as shown in Figure 3.3

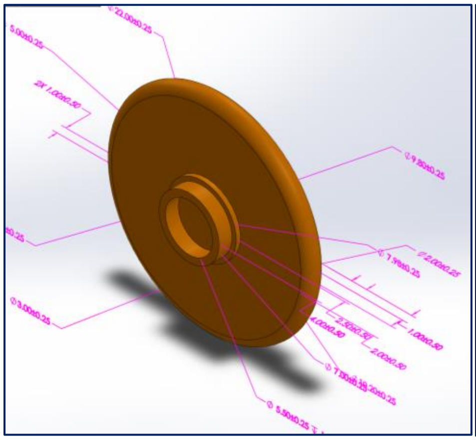

Figure 4.1: Isometric View Bearing Caps

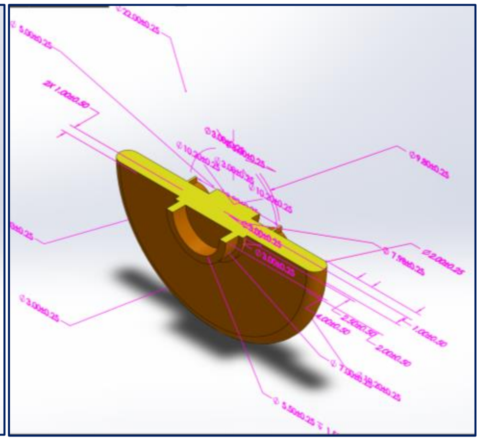

Figure 4.2: Section View Bearing Caps

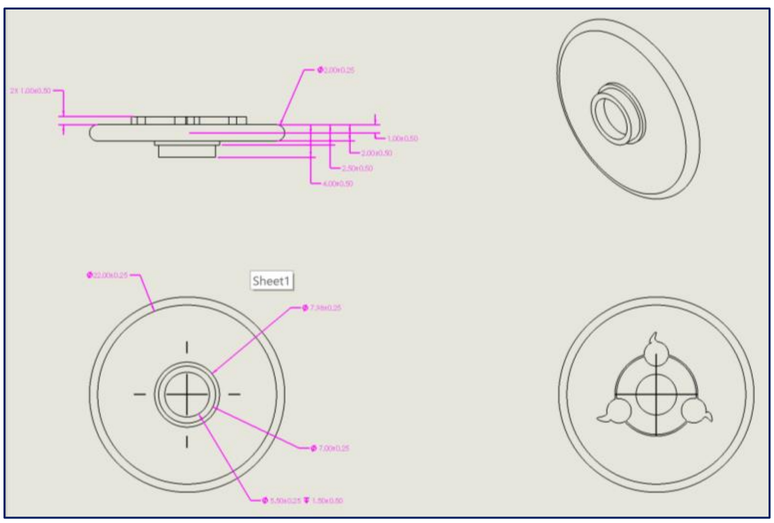

Figure 4.3: Standard 3 View Bearing Caps

Ball Bearings

The designs for the ball bearings were provided by Dr. Rylander so we were able to import them into Solidworks. The dimensions and constraints for these ball bearings that were used (5 total) are shown in the Figures below.

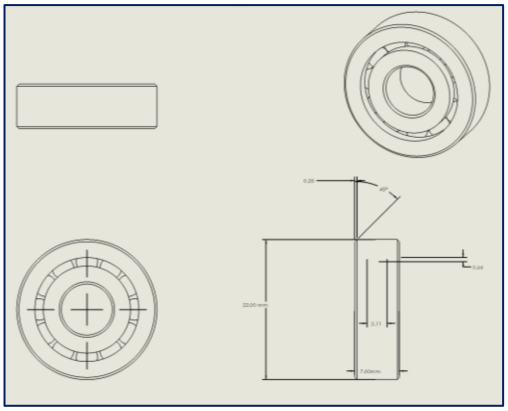

Figure 5.1: Standard 3 View Ball Bearing

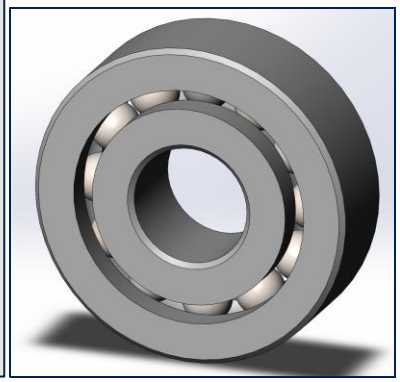

Figure 5.2: Isometric View Ball Bearing

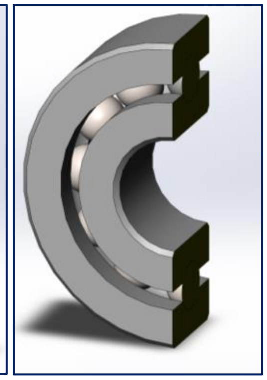

Figure 5.3: Section View Ball Bearing

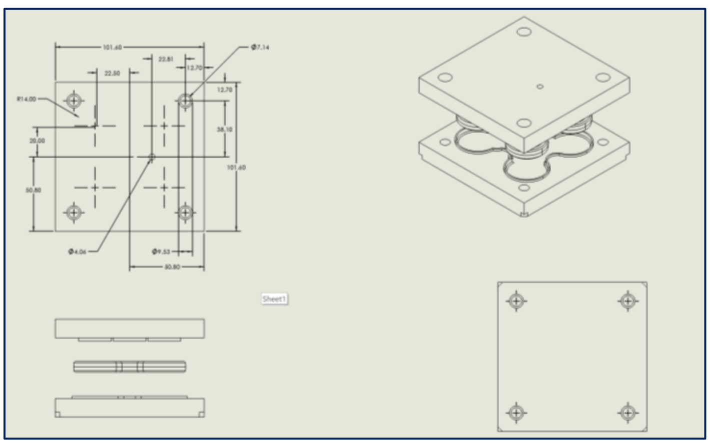

Figure 6.1: Standard 3 View Mold Core & Cavity

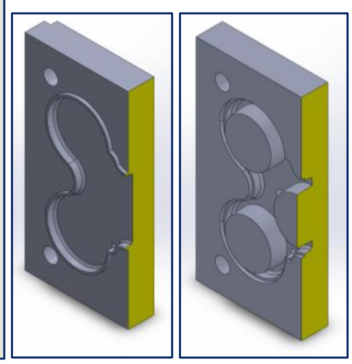

Figure 6.2: Section View Mold Core & Cavity

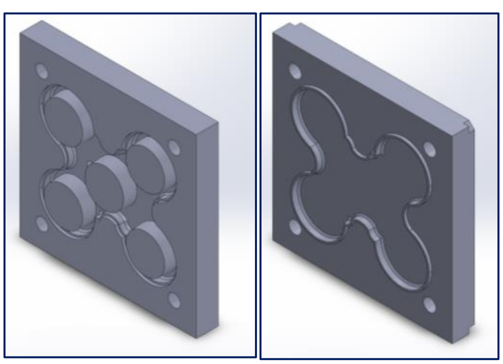

Figure 6.1: Isometric View Mold Core & Cavity

Mold Core and Cavity

The 3D model of the main body was used to implement the mold designs for the core and cavity for the plastic injection molding process, all of this was done by using Solidworks. The Mold Core & Cavity are displayed in these Figures.

Bill of Materials

ITEM NO.	PART NAME	DESCRIPTION	SUPPLIER	QTY.
1	Main Body Bearing	Housing for bearing caps and ball bearings	Self, UT Machine Shop	1
2	Bearing Caps	Pinches the model and makes easy to hold without interfering with spin	Dr. Rylander	2
3	Ball Bearings	Weights for equal weight distribution and needed for spin	Self, Texas Invention Works	5

Assembly Plan

Step Number	Parts Involved	Tools Used	Overall Task	Direction of Movement
1	Top Bearing Cap Bottom Bearing Cap Main Body Ball Bearings x5	Hands used for layout; Sharp Object used for removal; Lubricant	Gather all parts needed for the assembly and lay them on a flat surface. With a sharp object, remove the seal on the center ball bearing. Add lubricant to the center ball bearing. This will allow for better spin.	Push in the direction of z-axis
2	Central Ball Bearing Main Body	Hands and Hammer may be used for Assembly	Insert central ball bearing in the fidget spinner. If insertion remains difficult, use a hammer to facilitate fitting.	Push in the direction of z-axis
3	Upper Right Ball Bearing Main Body	Hands and Hammer may be used for Assembly	Insert upper right ball bearing in the fidget spinner. If insertion remains difficult, use a hammer to facilitate fitting.	Push in the direction of z-axis
4	Upper Left Ball Bearing Main Body	Hands and Hammer may be used for Assembly	Insert upper left ball bearing in the fidget spinner. If insertion remains difficult, use a hammer to facilitate fitting.	Push in the direction of z-axis
5	Bottom Right Bearing Main Body	Hands and Hammer may be used for Assembly	Insert bottom right bearing ball bearing in the fidget spinner. If insertion remains difficult, use a hammer to facilitate fitting.	Push in the direction of z-axis
6	Bottom Left Bearing Main Body	Hands and Hammer may be used for Assembly	Insert bottom left bearing ball bearing in the fidget spinner. If insertion remains difficult, use a hammer to facilitate fitting.	Push in the direction of z-axis
7	Bottom Bearing Cap Main Body	Hands and Hammer may be used for Assembly	Insert the bottom bearing cap into the central hole in the central ball bearing.	Push in the direction of z-axis
8	Top Bearing Cap Main Body	Hands and Hammer may be used for Assembly	Flip the fidget spinner and insert the top bearing cap into the hole in the central ball bearing.	Rotate in the direction of the z-axis; and insert in the direction of x-axis

Computational Model (FEA Drop Test)

After the fidget spinner assembly is done, the assembly that includes the main body, 5 ball bearings, bearing caps, the assembly is to be submitted through an FEA Drop Test. Inside this Drop Test 3 types of analysis are shown stress, displacement and strain. This analysis is shown in the figures below. In Figures 7.1 and 7.2 the areas of highest stress or highest strain are the two upper arms. In Figure 7.3 the yellow/orange areas represent the highest concentration of displacement which mainly everything except the higher parts of the two upper arms.

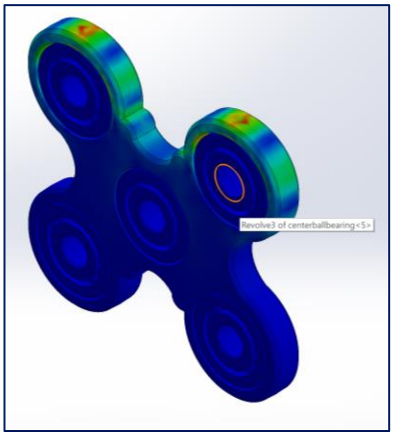

Figure 7.1: Stress Drop Test

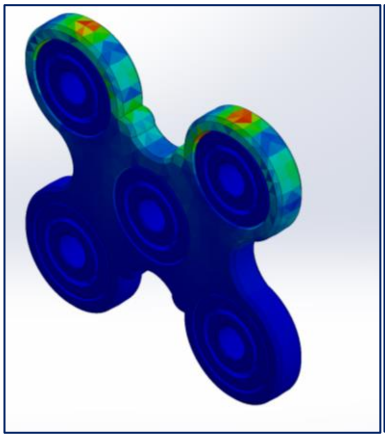

Figure 7.2: Strain Drop Test

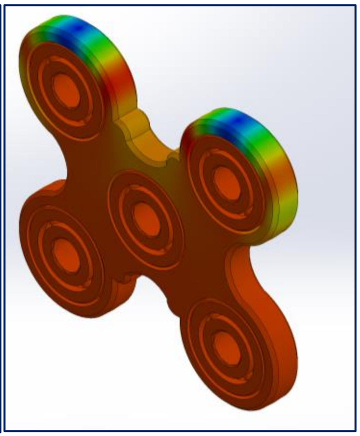

Figure 7.3: Displacement Drop Test

Physical Model

After the teams were formed and decided on a design for the team to be manufactured, they were ready to perform the plastic injection molding. The design that my team chose is shown in the Figures below. The finished molds for the core and cavity are also shown after they were put through the CNC milling commands that were specified in the CAM that was done in Autodesk Fusion 360. Our team also had the opportunity to use additive manufacturing to produce the bearing caps from one of our team members, in this case the 3D printing machines in Texas Invention Works. The final tangible assembly of this project is also shown below. The main body, bearing caps, and ball bearings can be observed.

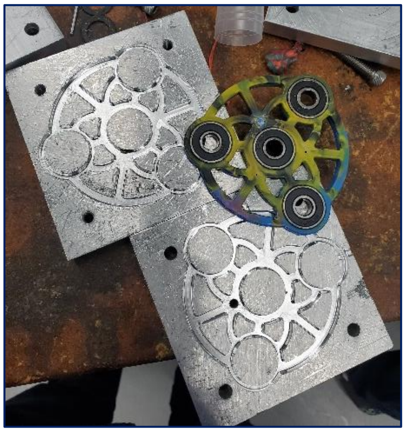

Figure 8.1: Aluminum Mold and plastic injected fidget spinner with ball bearings

Figure 8.2: Full fidget spinner assembly

Conclusion

The mot important thing to note on this project is that it provided students with the opportunity to implement the skills and knowledge learned from the lectures and labs into a tangible and achievable project. After finishing this project, the students were able to apply design skills in Solidworks and develop proficiency in the software to a certain extent. Some of the skills gained that were put into practice in this project are the transition from a paper 2-dimensional sketch to the 2-dimensional sketch in Solidworks. This skill is important to a mechanical engineer as they are often required to reverse engineer parts and being able to see an object in the real world and transforming it to a sketch in Solidworks is especially useful. Taking this 2-dimensional sketch and converting it to a 3-dimensional model by using features in Solidworks like extrusions and chamfers lets the individual have a 3D representation of his original idea into a model that can be evaluated and further used to produce drawings for manufacturing. In this case with the features from Solidworks the students were able to produce a mold of the fidget spinner so that it can be taken to the manufacturing stage, this was only achieved because we were able to produce GDT drawings through DimExpert which allowed us to have the sizes and constraints needed for manufacturing. Taking the mold design from Solidworks and importing it to Autodesk Fusion 360 allowed us to be familiarized with a different software that allowed for the CAM that was needed for the machining of the molds through the CNC mills. The formation of teams allowed us to evaluate and validate ourselves through a decision matrix, this instance also implemented teamwork which is often required in the mechanical engineering field. Finally, manufacturing the molds and the plastic injection molding allowed us to do direct manufacturing and become familiarized with different tools in the UT machine shop. Additive manufacturing through 3D printing allowed us to make the bearing caps that would have been more difficult to injection mold since they are smaller. This pushed me to be enthusiastic about 3D printing and produce some of my own projects and designs. The assembly plan and the bill of materials allowed us to successfully complete the full assembly of the project which shows the importance of documentation. If I were to start the project again, I would change the manufacturing portion of the project 3D printing the main body would have made this significantly easier. As the struggles from injection molding like the warping, misalignment of the mold halves, and breaking of the bodies would have not happened for certain students. It would also allow for everyone to produce their own spinner rather than being limited, more extravagant and creative designs could also be possible since you are not constrained by the injection molding.

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