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|  | |  | | --- | | **Simulation of UGV mk 3\_sim**  **Date: 28 January 2021 Designer: Solidworks**  **Study name: Drop Test 4**  **Analysis type: Drop Test** | | Table of Contents  [Description 1](#_Toc62767215)  [Assumptions 2](#_Toc62767216)  [Model Information 2](#_Toc62767217)  [Study Properties 6](#_Toc62767218)  [Units 6](#_Toc62767219)  [Material Properties 7](#_Toc62767220)  [Contact Information 8](#_Toc62767221)  [Mesh information 9](#_Toc62767222)  [Study Results 11](#_Toc62767223)  [Conclusion 13](#_Toc62767224) | |
| Description No Data |

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| Assumptions |

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| Model Information  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  | | --- | |  |   ****Model name:** UGV mk 3\_sim**  ****Current Configuration:** Default** | | | | | ****Solid Bodies**** | | | | | ****Document Name and Reference**** | ****Treated As**** | ****Volumetric Properties**** | ****Document Path/Date Modified**** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.224014 kg****  ****Volume:2.85005e-05 m^3****  ****Density:7,860 kg/m^3****  ****Weight:2.19534 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Axle - Rear.SLDPRT****  **Jan 28 22:21:01 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.032111 kg****  ****Volume:3.77777e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.314688 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Mark 3 - Simulation\Axle-ugv bushing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.032111 kg****  ****Volume:3.77777e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.314688 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Mark 3 - Simulation\Axle-ugv bushing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Cut-Extrude5** | **Solid Body** | ****Mass:1.16021 kg****  ****Volume:0.00113746 m^3****  ****Density:1,020 kg/m^3****  ****Weight:11.3701 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Chassis mk 2.SLDPRT****  **Jan 28 22:21:01 2021** | | **Fillet4** | **Solid Body** | ****Mass:0.498454 kg****  ****Volume:6.34165e-05 m^3****  ****Density:7,860 kg/m^3****  ****Weight:4.88484 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Motor-L.SLDPRT****  **Jan 28 22:21:01 2021** | | **Fillet4** | **Solid Body** | ****Mass:0.498454 kg****  ****Volume:6.34165e-05 m^3****  ****Density:7,860 kg/m^3****  ****Weight:4.88484 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Motor-R.SLDPRT****  **Jan 28 22:21:00 2021** | | **Cut-Extrude1** | **Solid Body** | ****Mass:0.0198524 kg****  ****Volume:2.33558e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.194554 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Motor-wheel bearing - L.SLDPRT****  **Jan 28 22:21:00 2021** | | **Cut-Extrude1** | **Solid Body** | ****Mass:0.0198524 kg****  ****Volume:2.33558e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.194554 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Motor-wheel bearing - R.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.53295 kg****  ****Volume:0.0005225 m^3****  ****Density:1,020 kg/m^3****  ****Weight:5.22291 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Sliding door top.SLDPRT****  **Jan 28 22:21:00 2021** | | **Cut-Extrude3** | **Solid Body** | ****Mass:0.331418 kg****  ****Volume:0.000324919 m^3****  ****Density:1,020 kg/m^3****  ****Weight:3.24789 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Wheel mk 2.SLDPRT****  **Jan 28 22:21:01 2021** | | **Cut-Extrude3** | **Solid Body** | ****Mass:0.331418 kg****  ****Volume:0.000324919 m^3****  ****Density:1,020 kg/m^3****  ****Weight:3.24789 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Wheel mk 2.SLDPRT****  **Jan 28 22:21:01 2021** | | **Cut-Extrude3** | **Solid Body** | ****Mass:0.331418 kg****  ****Volume:0.000324919 m^3****  ****Density:1,020 kg/m^3****  ****Weight:3.24789 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Wheel mk 2.SLDPRT****  **Jan 28 22:21:01 2021** | | **Cut-Extrude3** | **Solid Body** | ****Mass:0.331418 kg****  ****Volume:0.000324919 m^3****  ****Density:1,020 kg/m^3****  ****Weight:3.24789 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Wheel mk 2.SLDPRT****  **Jan 28 22:21:01 2021** | | **Boss-Extrude2** | **Solid Body** | ****Mass:0.0455246 kg****  ****Volume:5.35584e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.446141 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Mark 3 - Simulation\motor-ugv-shaft bushing 2.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude2** | **Solid Body** | ****Mass:0.0455246 kg****  ****Volume:5.35584e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.446141 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Mark 3 - Simulation\motor-ugv-shaft bushing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.0385332 kg****  ****Volume:4.53332e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.377625 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\wheel\_shaft bearing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.0385332 kg****  ****Volume:4.53332e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.377625 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\wheel\_shaft bearing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.0385332 kg****  ****Volume:4.53332e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.377625 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\wheel\_shaft bearing.SLDPRT****  **Jan 28 22:21:00 2021** | | **Boss-Extrude1** | **Solid Body** | ****Mass:0.0385332 kg****  ****Volume:4.53332e-06 m^3****  ****Density:8,500 kg/m^3****  ****Weight:0.377625 N**** | ****D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\wheel\_shaft bearing.SLDPRT****  **Jan 28 22:21:00 2021** | |

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| Study Properties  |  |  | | --- | --- | | Study name | Drop Test 4 | | Analysis type | Drop Test | | Mesh type | Solid Mesh | | Large displacement | On | | Result folder | SOLIDWORKS document (D:\OneDrive - Indian Institute of Technology Bombay\RAKSHAK IITB\Air Delivery Design\2020-21 Designs\Mark 2) |  Setup Information  |  |  | | --- | --- | | Type | Velocity at impact | | Velocity Magnitude | 3 m/sec | | Impact Velocity Reference | Edge<1> | | Gravity | 9.81 m/s^2 | | Gravity Reference | Edge<2> | | Friction Coefficient | 0 | | Target Stiffness | Rigid target | | Critical Damping Ratio | 0 |  Result Options  |  |  | | --- | --- | | Solution Time After Impact | 1,250 microsec | | Save Results Starting From | 0 microsec | | No. of Plots | 25 | | No. of Graph Steps Per Plot | 20 | | Number of vertex | 0 | |

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| Units  |  |  | | --- | --- | | Unit system: | SI (MKS) | | Length/Displacement | mm | | Temperature | Kelvin | | Angular velocity | Rad/sec | | Pressure/Stress | N/m^2 | |

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| Material Properties  |  |  |  | | --- | --- | --- | | ****Model Reference**** | ****Properties**** | ****Components**** | |  | |  |  | | --- | --- | | ****Name:**** | **201 Annealed Stainless Steel (SS)** | | ****Model type:**** | **Plasticity - von Mises** | | ****Default failure criterion:**** | **Max von Mises Stress** | | ****Yield strength:**** | **2.92e+08 N/m^2** | | ****Hardening factor (0.0-1.0; 0.0=isotropic; 1.0=kinematic):**** | **0.85** | | ****Elastic modulus:**** | **2.07e+11 N/m^2** | | ****Poisson's ratio:**** | **0.27** | | ****Mass density:**** | **7,860 kg/m^3** | | **SolidBody 1(Boss-Extrude1)(Axle - Rear-1),**  **SolidBody 1(Fillet4)(Motor-L-1),**  **SolidBody 1(Fillet4)(Motor-R-1)** | | **Curve Data:N/A** | | | |  | |  |  | | --- | --- | | ****Name:**** | **Brass** | | ****Model type:**** | **Linear Elastic Isotropic** | | ****Default failure criterion:**** | **Max von Mises Stress** | | ****Yield strength:**** | **2.39689e+08 N/m^2** | | ****Tensile strength:**** | **4.78413e+08 N/m^2** | | ****Elastic modulus:**** | **1e+11 N/m^2** | | ****Poisson's ratio:**** | **0.33** | | ****Mass density:**** | **8,500 kg/m^3** | | ****Shear modulus:**** | **3.7e+10 N/m^2** | | ****Thermal expansion coefficient:**** | **1.8e-05 /Kelvin** | | **SolidBody 1(Boss-Extrude1)(Axle-ugv bushing-1),**  **SolidBody 1(Boss-Extrude1)(Axle-ugv bushing-2),**  **SolidBody 1(Cut-Extrude1)(Motor-wheel bearing - L-1),**  **SolidBody 1(Cut-Extrude1)(Motor-wheel bearing - R-1),**  **SolidBody 1(Boss-Extrude2)(motor-ugv-shaft bushing 2-2),**  **SolidBody 1(Boss-Extrude2)(motor-ugv-shaft bushing-1),**  **SolidBody 1(Boss-Extrude1)(wheel\_shaft bearing-1),**  **SolidBody 1(Boss-Extrude1)(wheel\_shaft bearing-2),**  **SolidBody 1(Boss-Extrude1)(wheel\_shaft bearing-3),**  **SolidBody 1(Boss-Extrude1)(wheel\_shaft bearing-4)** | | **Curve Data:N/A** | | | |  | |  |  | | --- | --- | | ****Name:**** | **ABS** | | ****Model type:**** | **Linear Elastic Isotropic** | | ****Default failure criterion:**** | **Unknown** | | ****Tensile strength:**** | **3e+07 N/m^2** | | ****Elastic modulus:**** | **2e+09 N/m^2** | | ****Poisson's ratio:**** | **0.394** | | ****Mass density:**** | **1,020 kg/m^3** | | ****Shear modulus:**** | **3.189e+08 N/m^2** | | **SolidBody 1(Cut-Extrude5)(Chassis mk 2-1),**  **SolidBody 1(Boss-Extrude1)(Sliding door top-1),**  **SolidBody 1(Cut-Extrude3)(Wheel mk 2-1),**  **SolidBody 1(Cut-Extrude3)(Wheel mk 2-2),**  **SolidBody 1(Cut-Extrude3)(Wheel mk 2-3),**  **SolidBody 1(Cut-Extrude3)(Wheel mk 2-4)** | | **Curve Data:N/A** | | | |

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| Contact Information  | Contact | Contact Image | Contact Properties | | --- | --- | --- | | Global Contact |  | |  |  | | --- | --- | | Type: | **Bonded** | | Components: | **1 component(s)** | | Options: | **Compatible mesh** | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Mesh information  |  |  | | --- | --- | | Mesh type | Solid Mesh | | Mesher Used: | Curvature-based mesh | | Jacobian points | 4 Points | | Maximum element size | 51.4101 mm | | Minimum element size | 10.282 mm | | Mesh Quality Plot | High | | Remesh failed parts with incompatible mesh | Off |  Mesh information - Details  |  |  | | --- | --- | | Total Nodes | 18077 | | Total Elements | 20661 | | Maximum Aspect Ratio | 27.26 | | % of elements with Aspect Ratio < 3 | 61.5 | | % of elements with Aspect Ratio > 10 | 1.24 | | % of distorted elements(Jacobian) | 0 | | Time to complete mesh(hh;mm;ss): | 00:00:02 | | Computer name: |  | |  | | |

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| Study Results  | Name | Type | Min | Max | | --- | --- | --- | --- | | Stress1 | VON: von Mises Stress | 5.616e+03 N/m^2  Node: 10118 | 2.919e+08 N/m^2  Node: 717 | | **UGV mk 3\_sim-Drop Test 4-Stress-Stress1** | | | |  | Name | Type | Min | Max | | --- | --- | --- | --- | | Displacement1 | URES: Resultant Displacement | 2.635e-03 mm  Node: 335 | 3.727e+00 mm  Node: 9957 | | **UGV mk 3\_sim-Drop Test 4-Displacement-Displacement1** | | | |  | Name | Type | Min | Max | | --- | --- | --- | --- | | Strain1 | ESTRN: Equivalent Strain | 3.473e-08  Element: 5595 | 1.479e-01  Element: 3841 | | **UGV mk 3\_sim-Drop Test 4-Strain-Strain1** | | | | |

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| Conclusion |