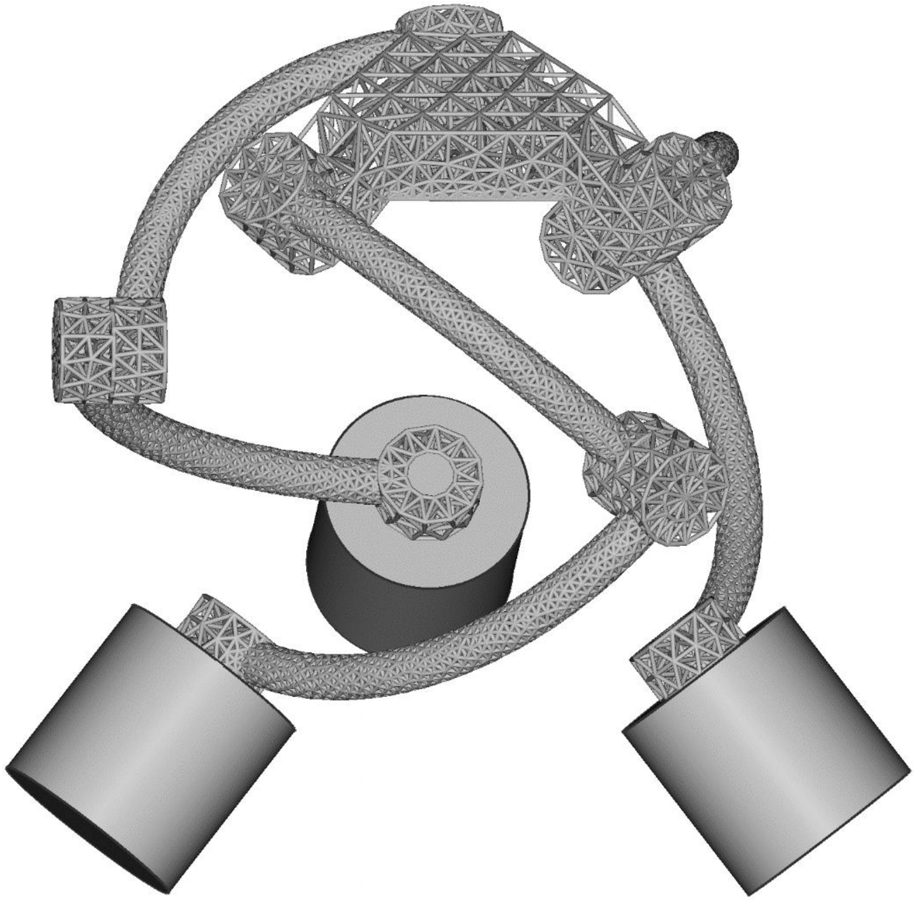
(Automatic Dynamic Analysis of Mechanical Systems)



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AGENDA

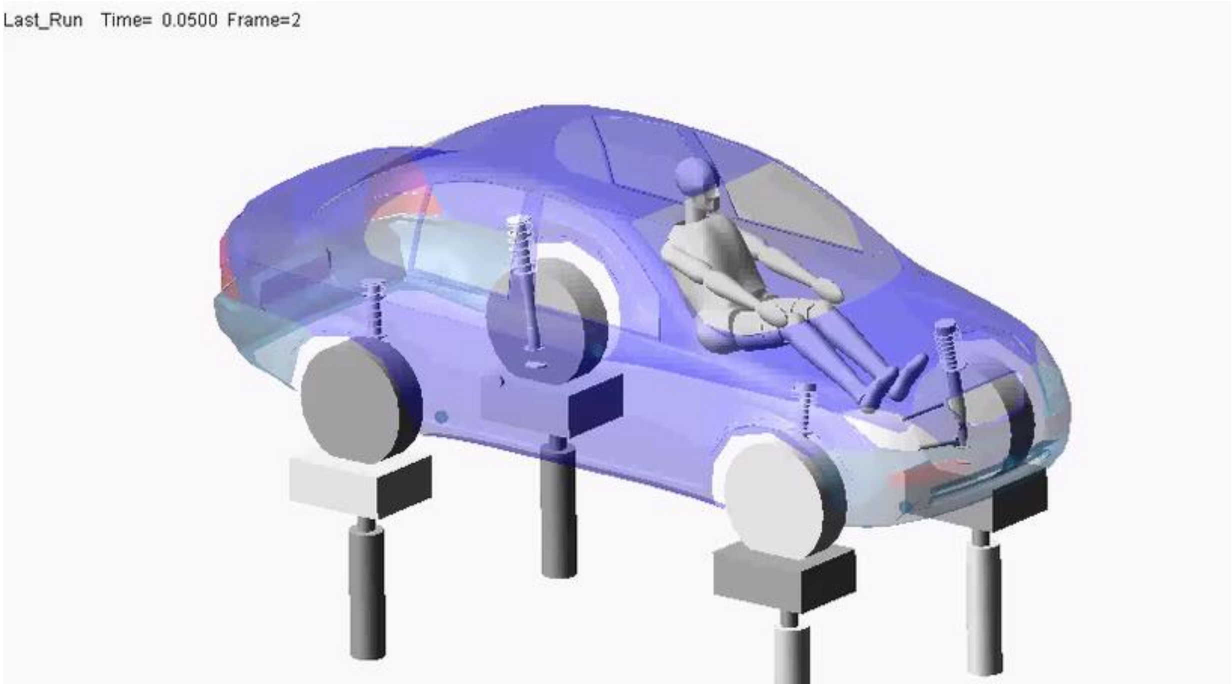
- **Part I. A brief answer to these questions:**
  - Why do we need another tool to analyze dynamics and vibrations?
  - How to access the software?
  - Available resources to learn the software?

- **Part II. A few Demos:**
  - Human Head and Neck Modeling
  - Spherical Parallel Mechanism Simulation

- **Part III A Brief Intro to the Software**
  - Software environment
  - A Mass-Spring-Damper Example

Why do we need another tool to analyze dynamics and vibrations?

- Virtual prototyping can save time and money.
- Sometimes visual simulation can help to understand the dynamic behaviour of a system better.
- Equations of Motion can get very complicated, due to high DOF, Complex Geometry, Flexible systems, Non-linear behaviour.



A Very Simple Model of the Car (8 DOF)

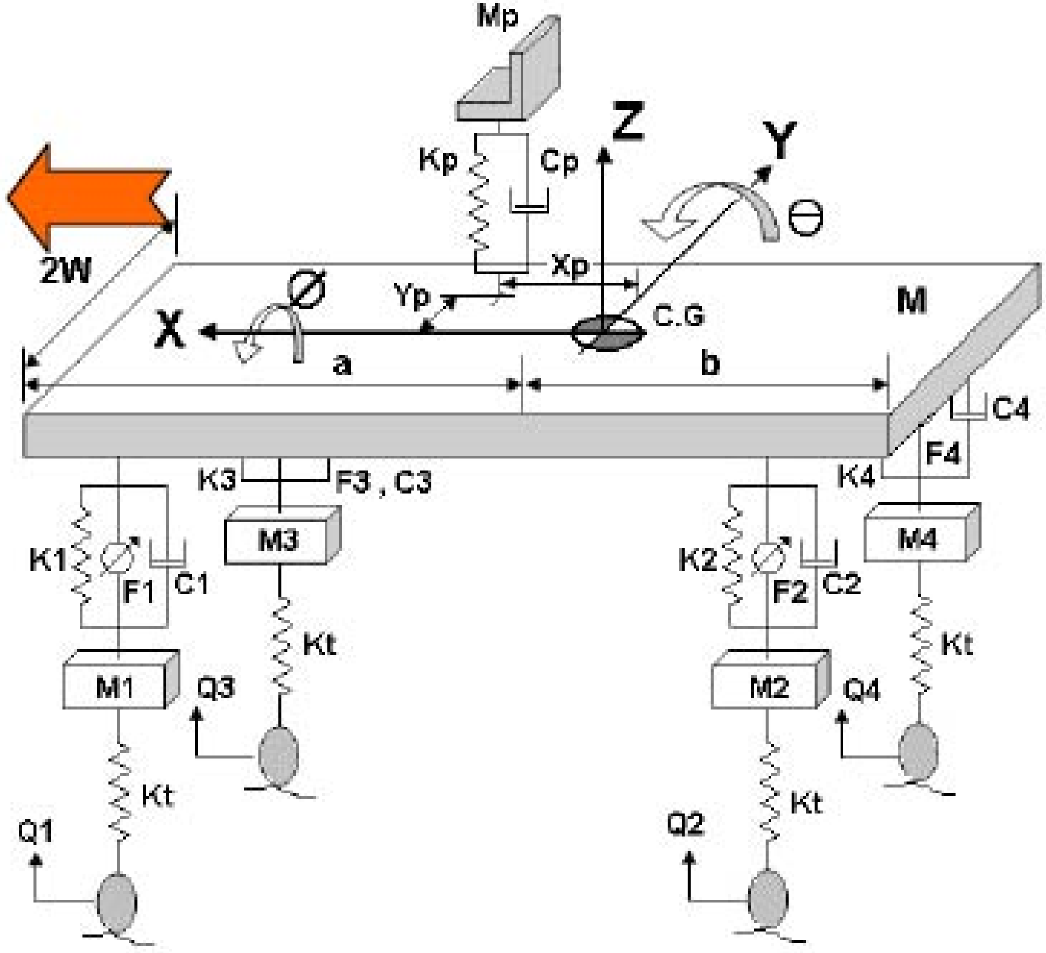


Figure 1. Full car model.

Figure from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1678-58782008000100010

We need to consider the complex geometry of the chassis!

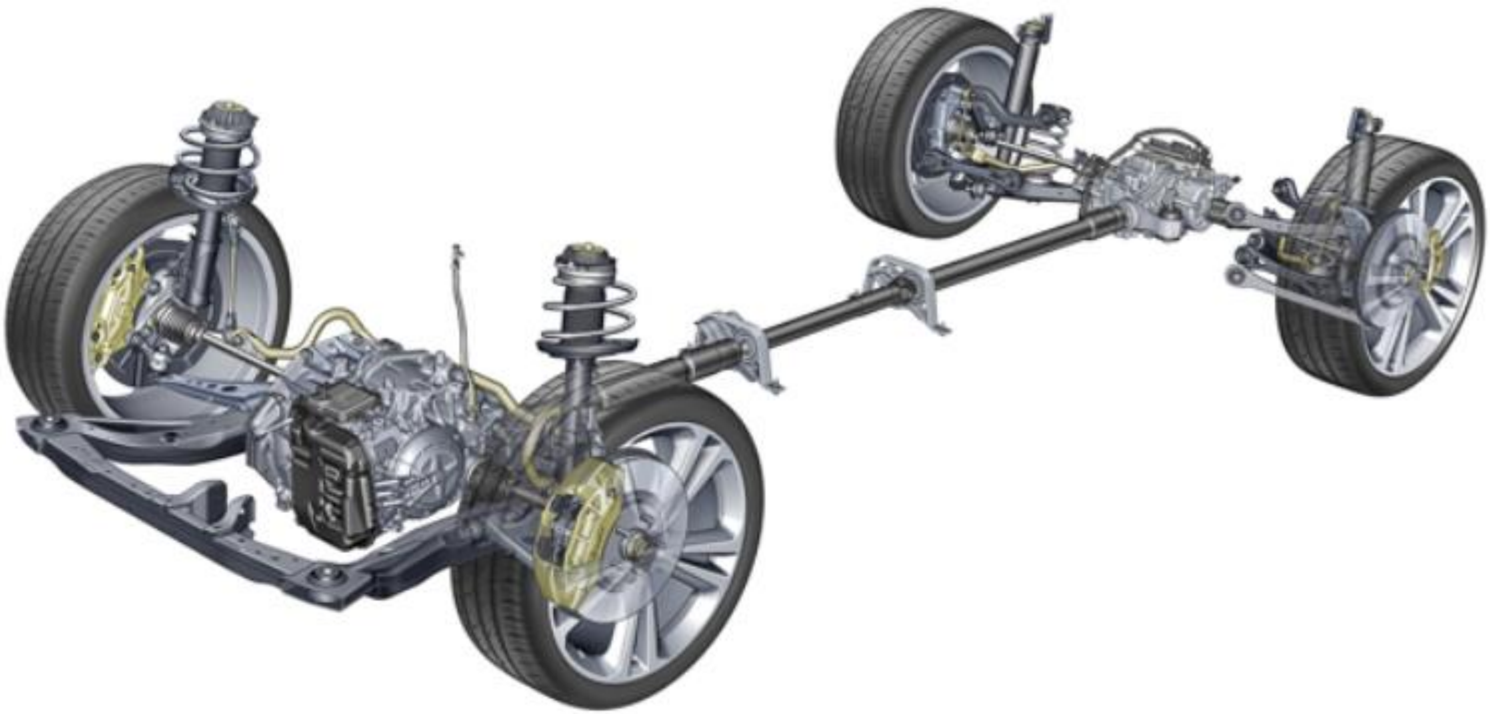
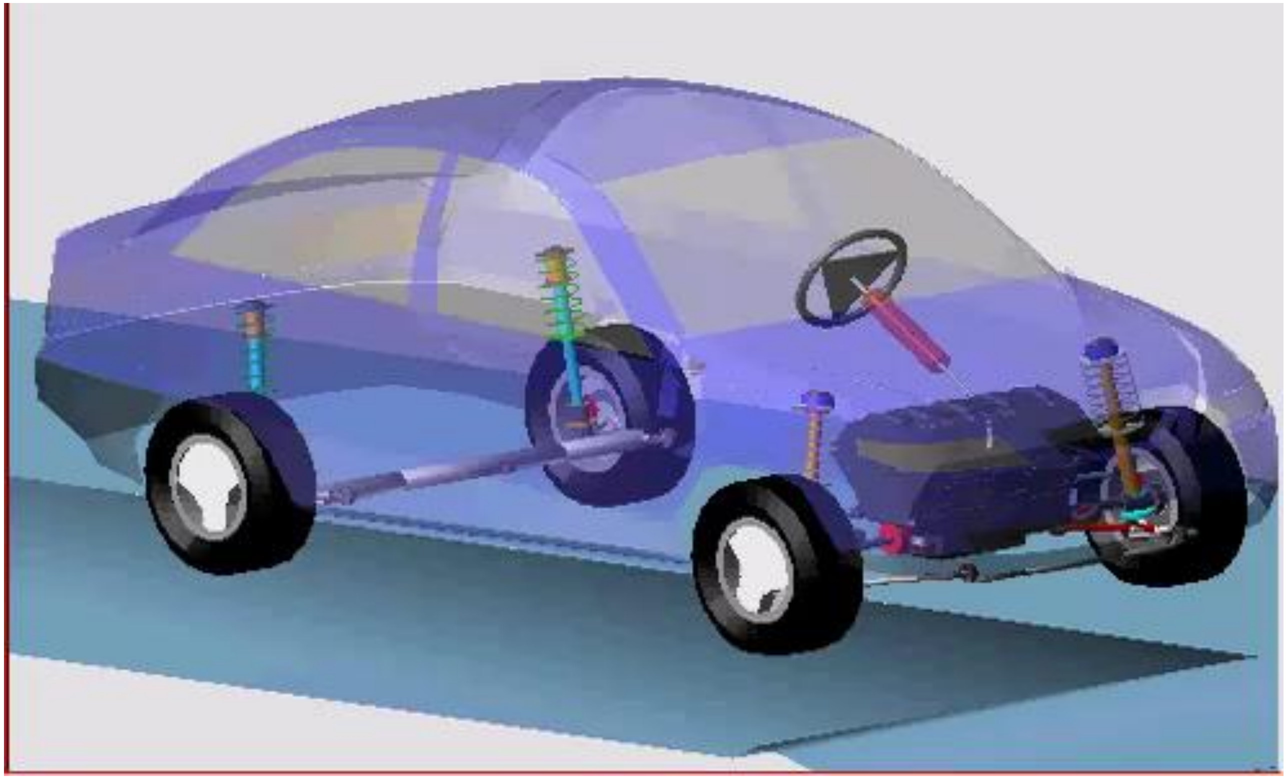
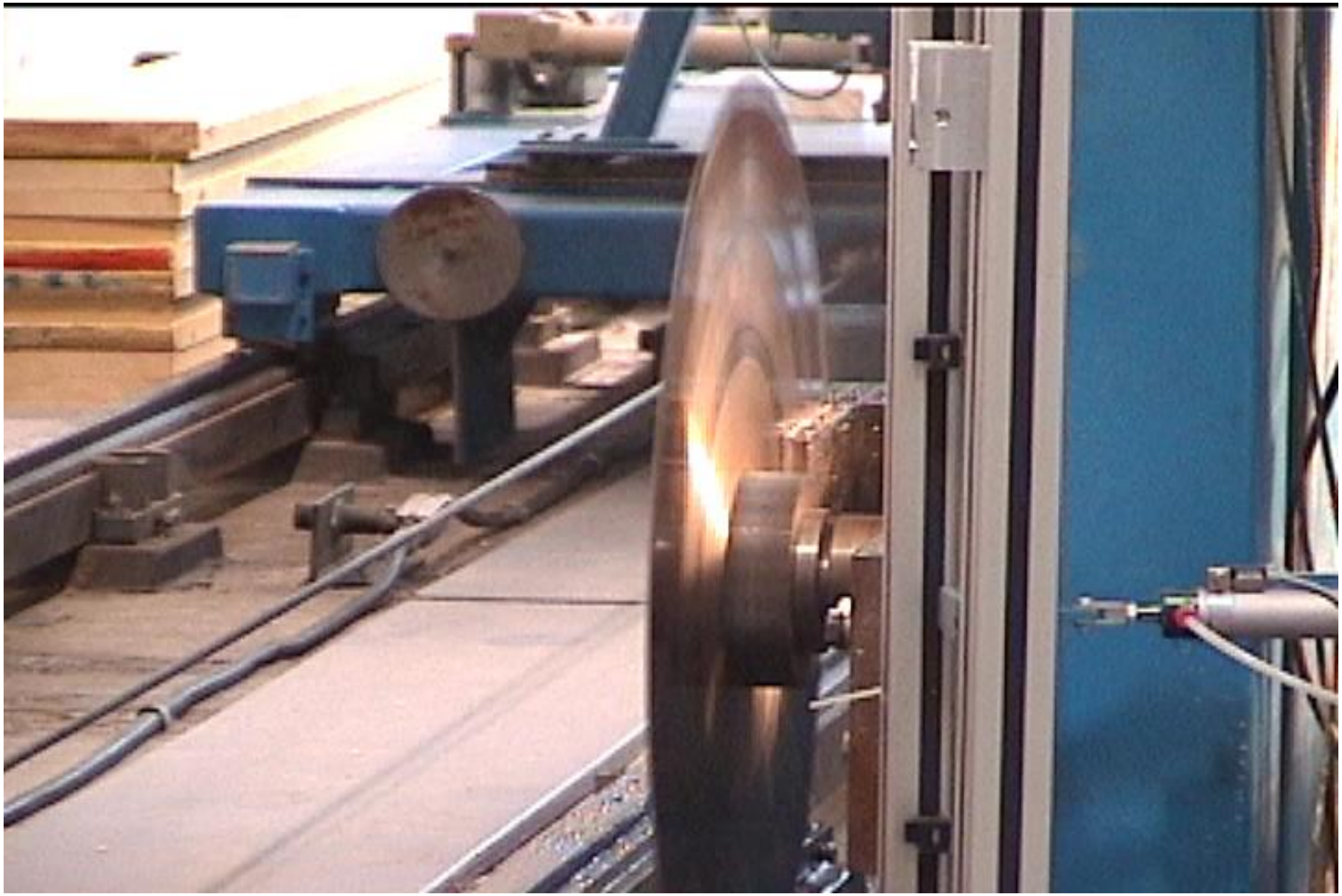


Figure from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1678-58782008000100010

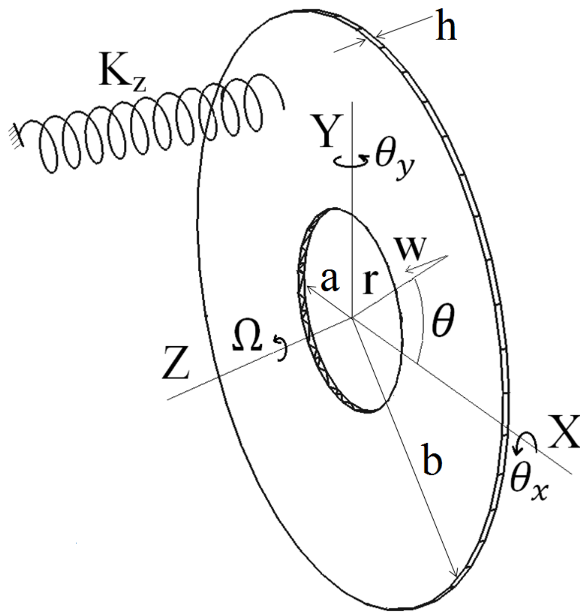
Transfer Vibrations from Road (a random input)



Vibration Analysis of a High-Speed Spinning Disk



Vibration Analysis of a High-Speed Spinning Disk



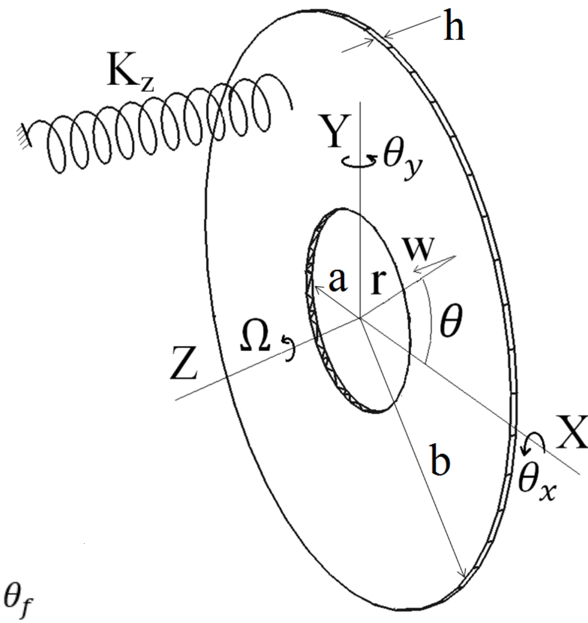
Vibration Analysis of a High-Speed Spinning Disk

$$\rho h\left(w_{,tt} + 2\Omega w_{,t\theta} + \Omega^2 w_{,\theta\theta}\right) + D\nabla^4 w - \frac{h}{r}\left(\sigma_{rr} r w_{,r}\right)_{,r} - \frac{h}{r^2}\sigma_{\theta\theta} w_{,\theta\theta} = 0$$

$$\rho h\left(w_{,tt} + 2\Omega w_{,t\theta} + \Omega^2 w_{,\theta\theta}\right) + D\nabla^4 w - \frac{h}{r}\left(\sigma_{rr} r w_{,r}\right)_{,r} - \frac{h}{r^2}\sigma_{\theta\theta} w_{,\theta\theta} + \rho h\ddot{Z}$$

$$+\rho h\left(r\ddot{\theta}_x \sin\theta - r\ddot{\theta}_y \cos\theta\right) + \rho h\left(2\Omega\, r\cos\theta\,\dot{\theta}_x + 2\Omega\, r\sin\theta\,\dot{\theta}_y\right)$$

$$= -\frac{k_z}{r}\left(w + Z + r_k \sin\theta_k\,\theta_x - r_k\cos\theta_k\,\theta_y\right) + \frac{f_Z}{r}$$



$$\rho h I\left(\ddot{\theta}_x + 2\Omega\dot{\theta}_y\right) + \int_0^{2\pi}\int_a^b \rho h \sin\theta\,(w_{,tt} + 2\Omega w_{,t\theta})\, r^2 dr d\theta = f_s r_k \sin\theta_k + f_Z r_f \sin\theta_f$$

$$\rho h I\left(\ddot{\theta}_y - 2\Omega\dot{\theta}_x\right) + \int_0^{2\pi}\int_a^b \rho h \cos\theta\,(w_{,tt} + 2\Omega w_{,t\theta})\, r^2 dr d\theta = -f_s r_k \cos\theta_k - f_Z r_f \cos\theta_f$$

$$m\ddot{Z} + \int_0^{2\pi}\int_a^b \rho h(w_{,tt})\, r dr d\theta = -k_z\left(w + Z + r_k\sin\theta_k\,\theta_x - r_k\cos\theta_k\,\theta_y\right) + f_Z$$

Vibration Analysis of a High-Speed Spinning Disk

$$\rho h\left(w_{,tt} + 2\Omega w_{,t\theta} + \Omega^2 w_{,\theta\theta}\right) + D\nabla^4 w - \frac{h}{r}\left(\sigma_{rr} r w_{,r}\right)_{,r} - \frac{h}{r^2}\sigma_{\theta\theta} w_{,\theta\theta} = 0$$

$$\rho h\left(w_{,tt} + 2\Omega w_{,t\theta} + \Omega^2 w_{,\theta\theta}\right) + D\nabla^4 w - \frac{h}{r}\left(\sigma_{rr} r w_{,r}\right)_{,r} - \frac{h}{r^2}\sigma_{\theta\theta} w_{,\theta\theta} + \rho h\ddot{Z}$$

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$$= -\frac{k_z}{r}\left(w + Z + r_k \sin\theta_k\,\theta_x - r_k\cos\theta_k\,\theta_y\right) + \frac{f_Z}{r}$$

$$\rho h I\left(\ddot{\theta}_x + 2\Omega\dot{\theta}_y\right) + \int_0^{2\pi}\int_a^b \rho h \sin\theta\,(w_{,tt} + 2\Omega w_{,t\theta})\, r^2 dr d\theta = f_s r_k \sin\theta_k + f_Z r_f \sin\theta_f$$

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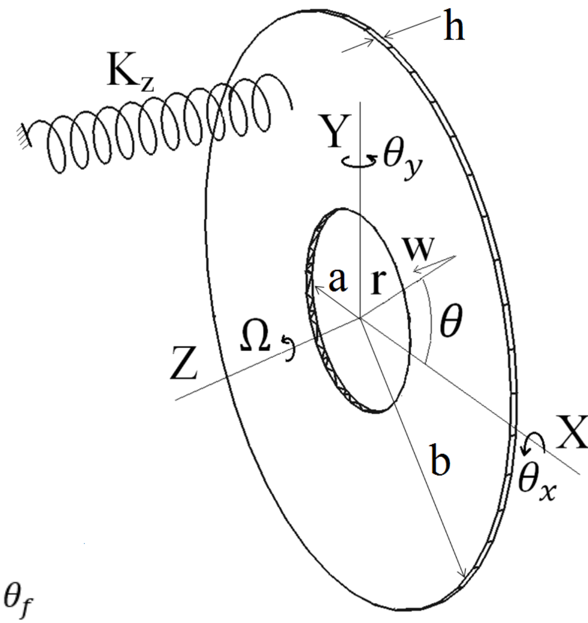
$$m\ddot{Z} + \int_0^{2\pi}\int_a^b \rho h(w_{,tt})\, r dr d\theta = -k_z\left(w + Z + r_k\sin\theta_k\,\theta_x - r_k\cos\theta_k\,\theta_y\right) + f_Z$$

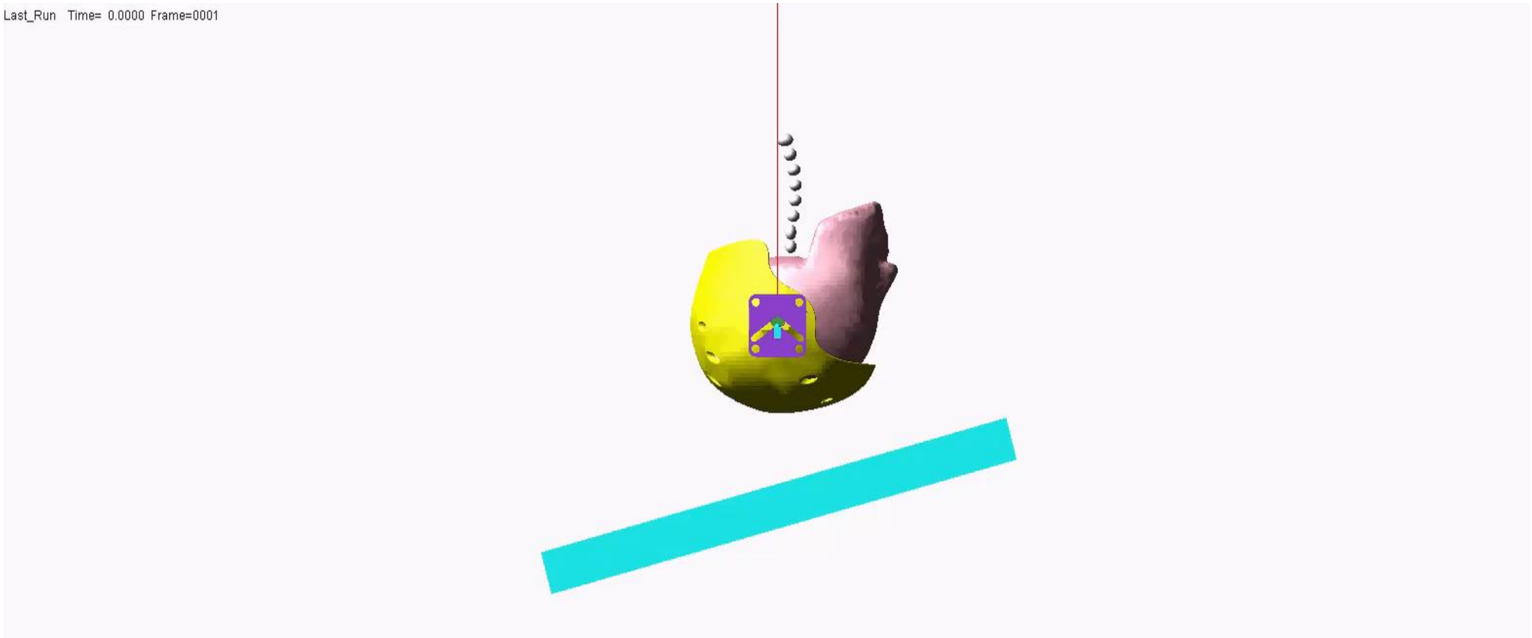


It took me over a year to solve these!

Neck Injury in Sports Simulation

Image from: https://www.sltrib.com/sports/2018/05/22/helmet-hits-make-for-legendary-nfl-films-highlights-and-this-year-players-will-be-ejected-for-it/

Simulation of Neck Injury during falling with a Helmet



- **Access the software**

Google ADAMS for students (enjoy the free license, while student!)

- **Resource to learn the software:**

I put a user manual on my website: https://AIntelligentManufacturing.com/