



# COM783 – Mecânica de Sistemas Inteligentes: Introdução

Prof. Luã G. Costa

Universidade Federal do Rio de Janeiro (COPPE/UFRJ)

Programa de Engenharia Mecânica (PEM)

# Informações do Curso

lgcosta.com

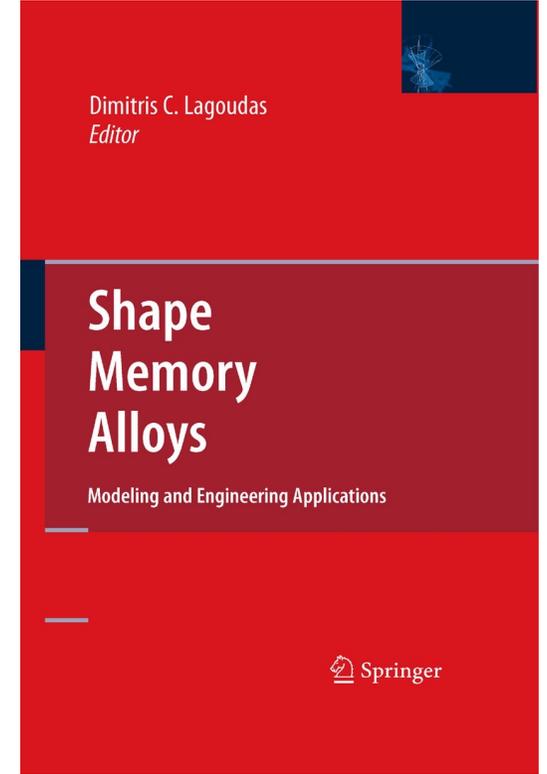
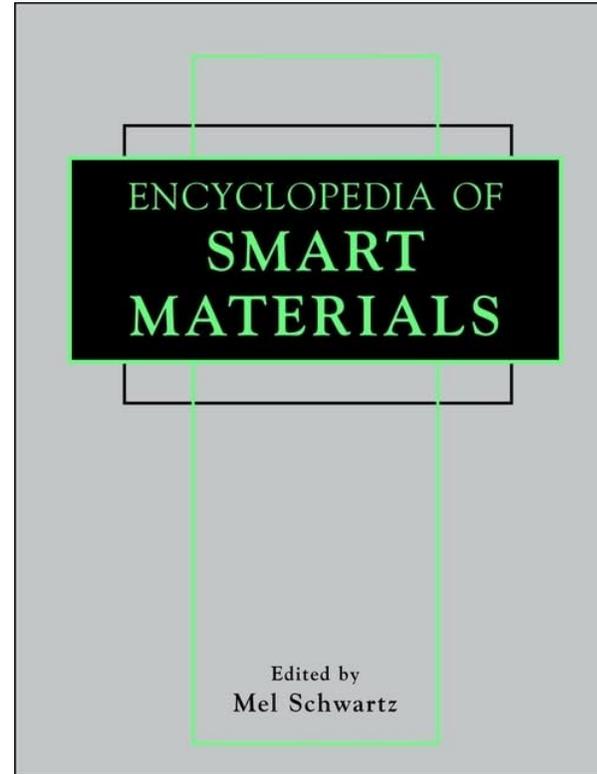
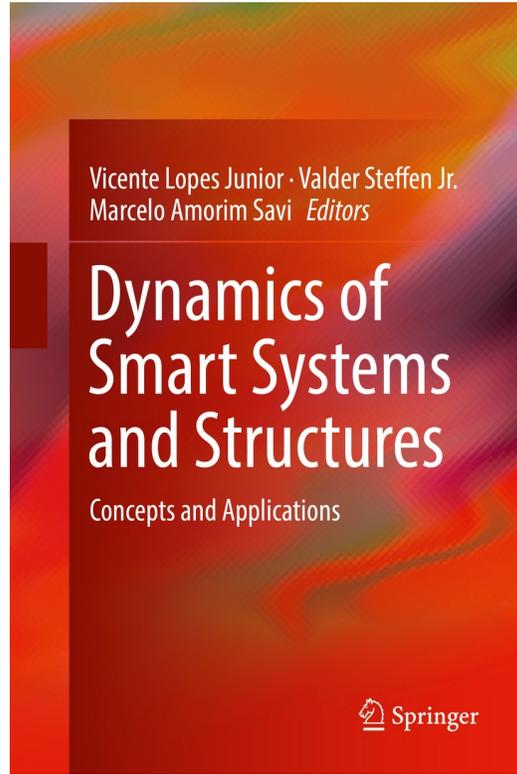
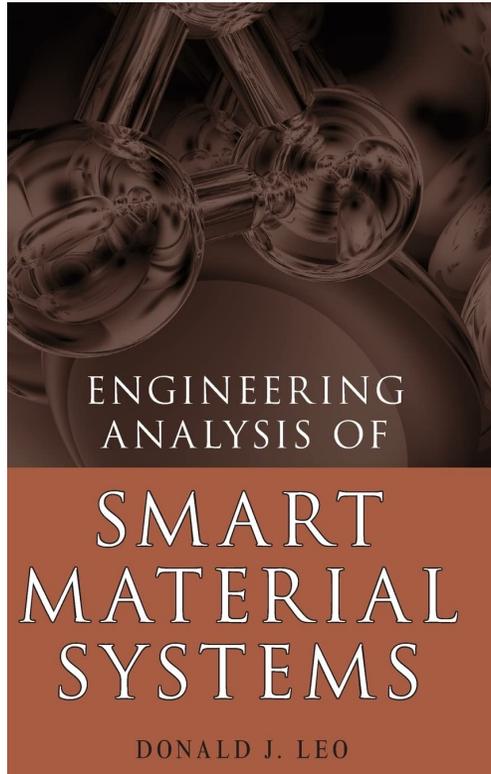


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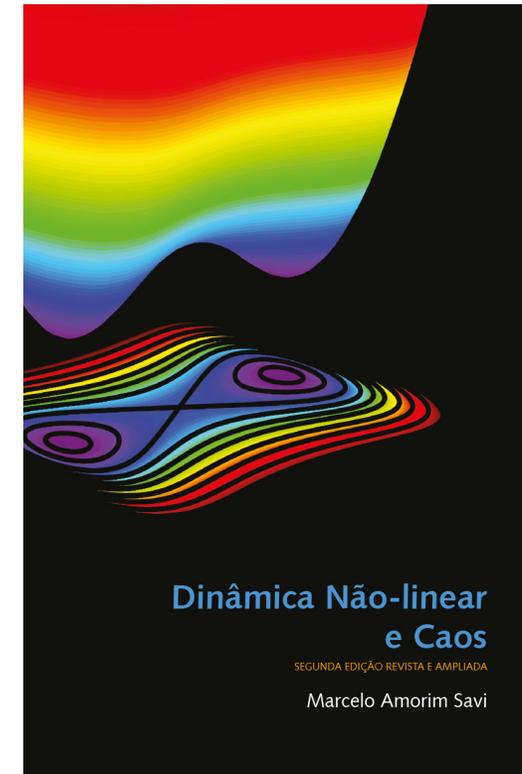
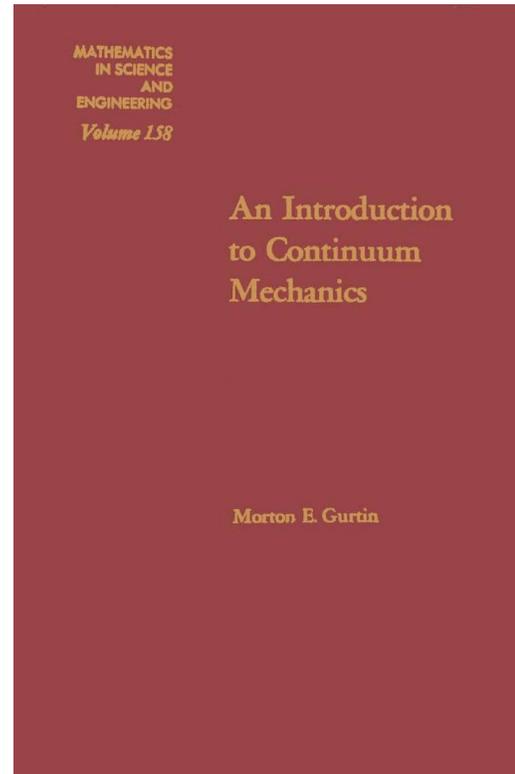
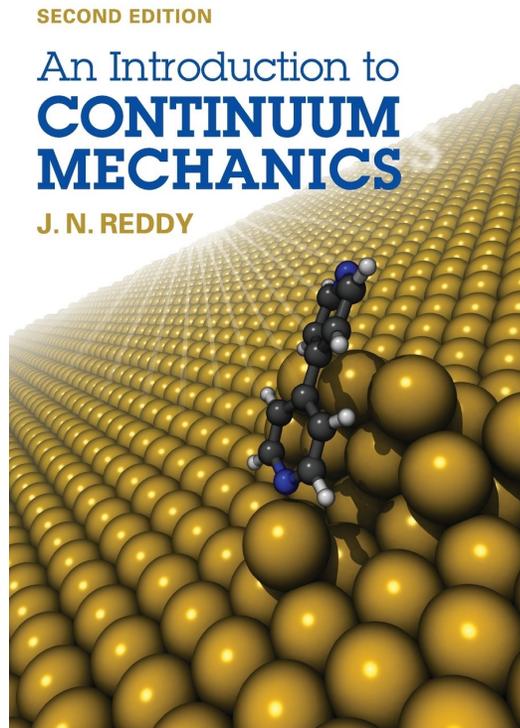
- **3 Listas:** Contendo exercícios de implementação computacional
- **1 Prova:** Sobre o conteúdo do curso

Composição	Nota	Conceito	Situação
$NF = \frac{L1 + L2 + L3 + P}{4}$	8.5 – 10.0	<i>A</i>	Aprovado <input checked="" type="checkbox"/>
	7.0 – 8.4	<i>B</i>	Aprovado <input checked="" type="checkbox"/>
	5.0 – 6.9	<i>C</i>	Aprovado <input checked="" type="checkbox"/>
	< 5.0	<i>D</i>	Reprovado <input type="checkbox"/>
	–	<i>I</i>	Reprovado <input type="checkbox"/>

# Referências



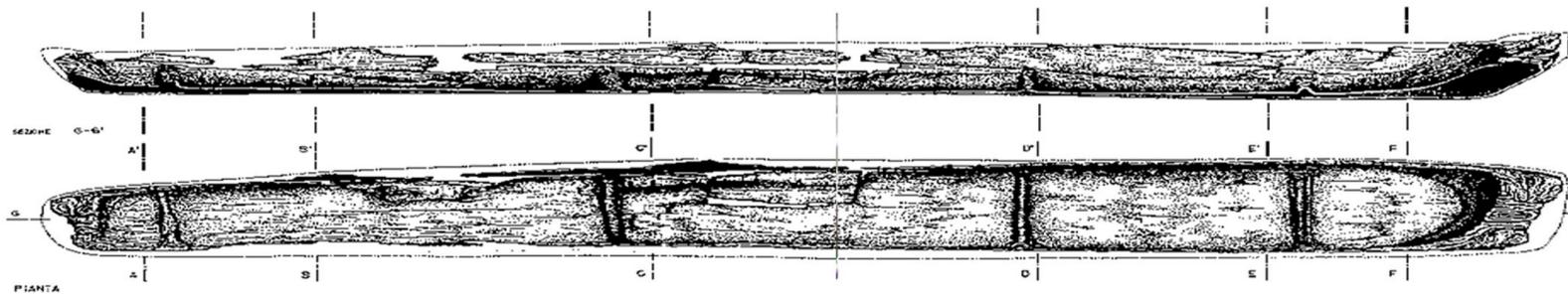
# Referências



# Contexto Histórico (Pré-História) – Idade da Pedra



# Contexto Histórico (Pré-História) – Idade da Pedra



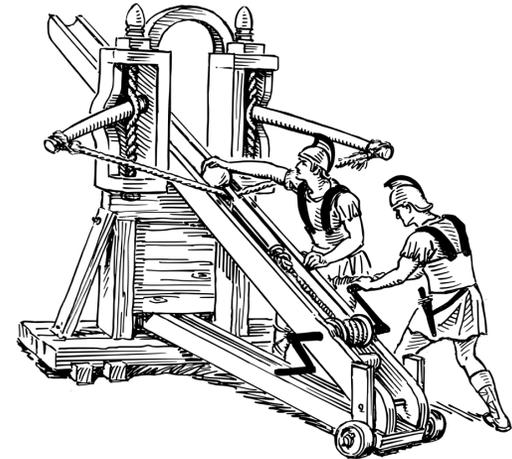
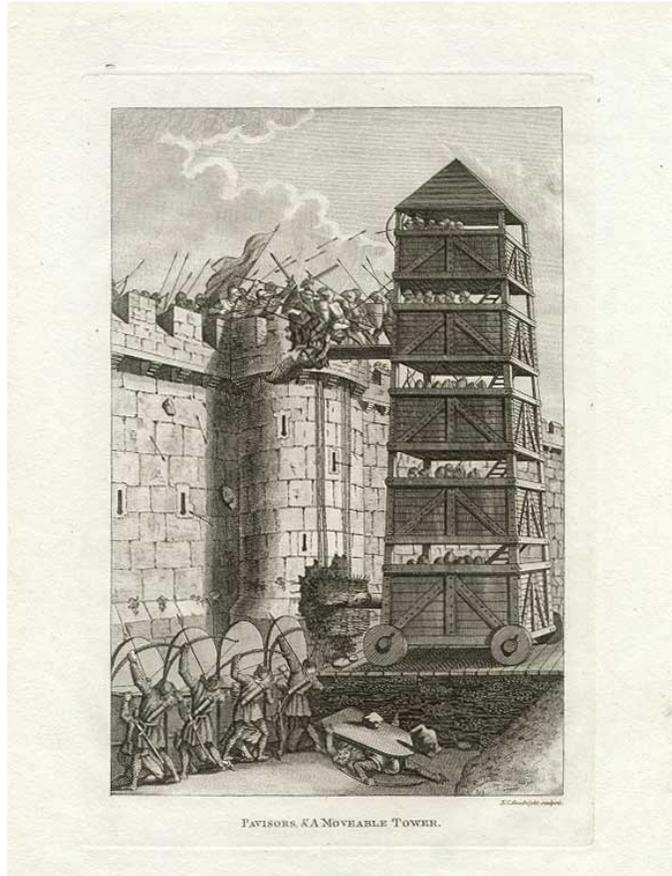
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# Contexto Histórico (Antiguidade)



# Contexto Histórico (Antiguidade)



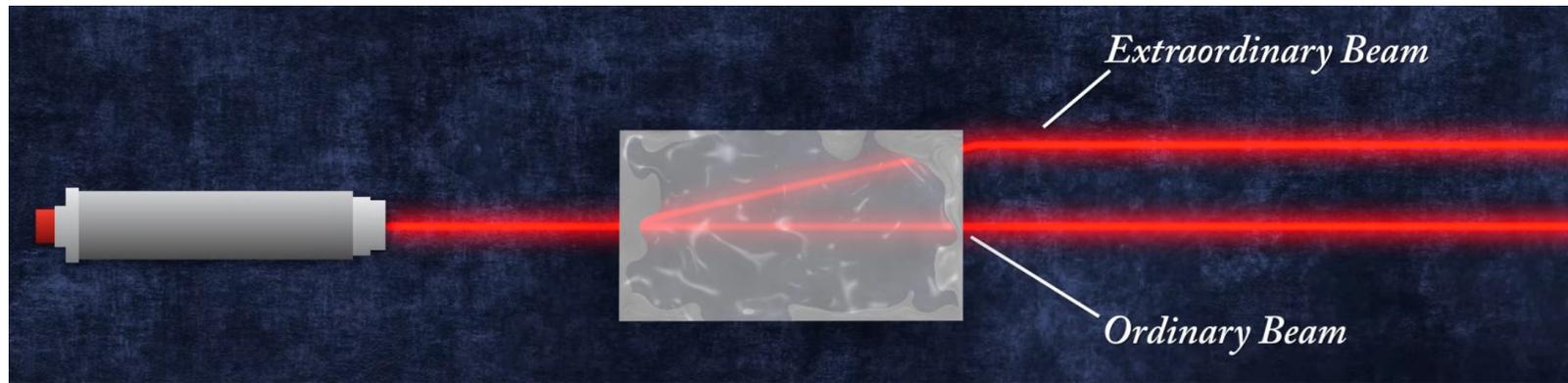
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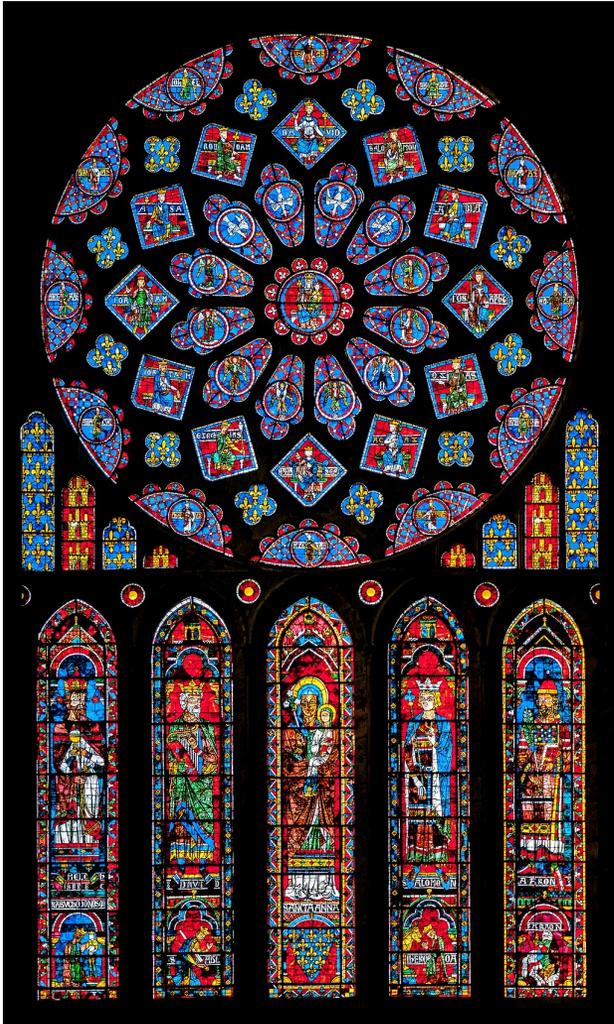
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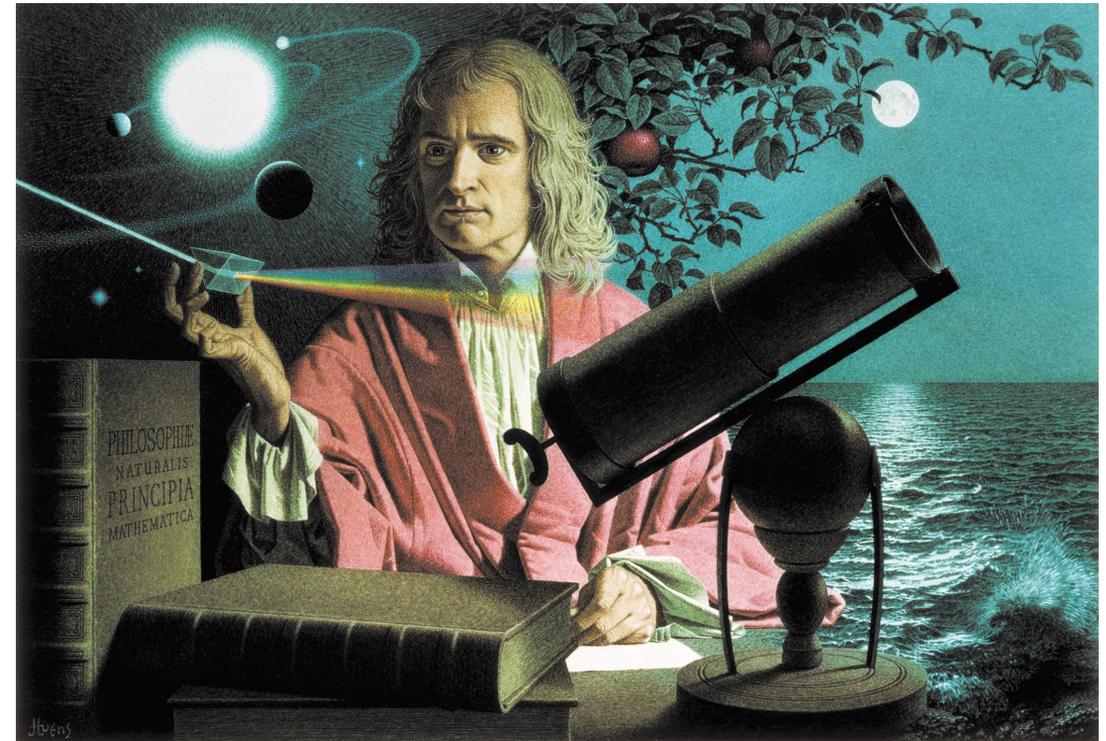
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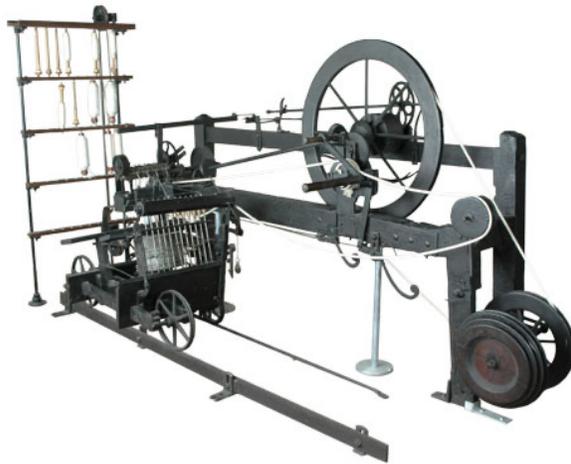
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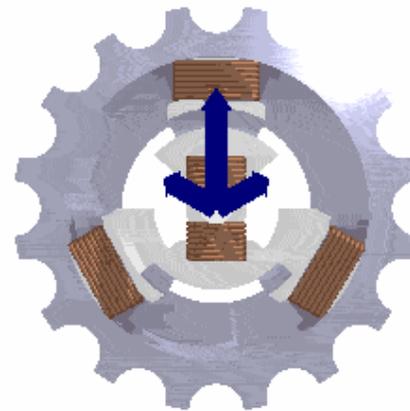
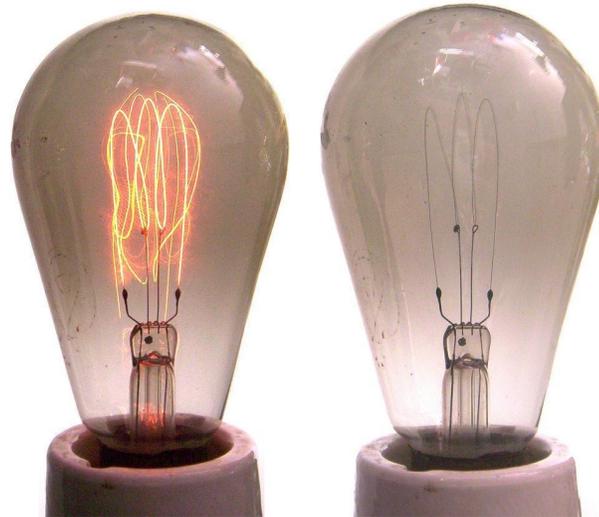
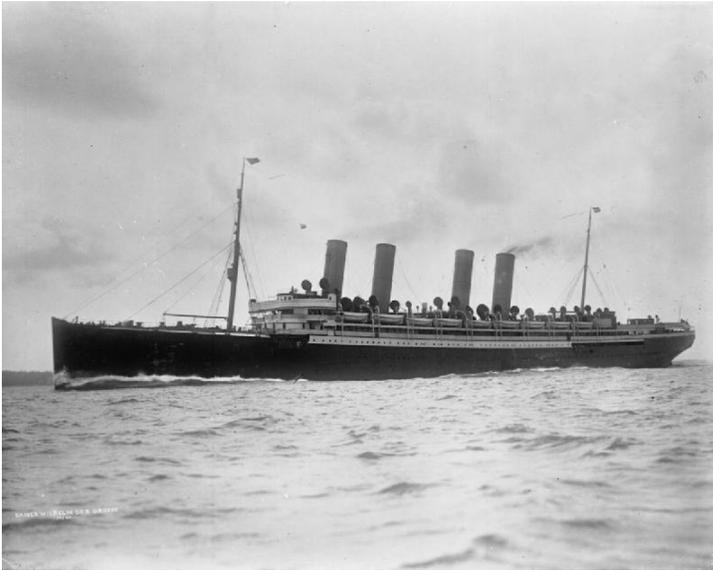
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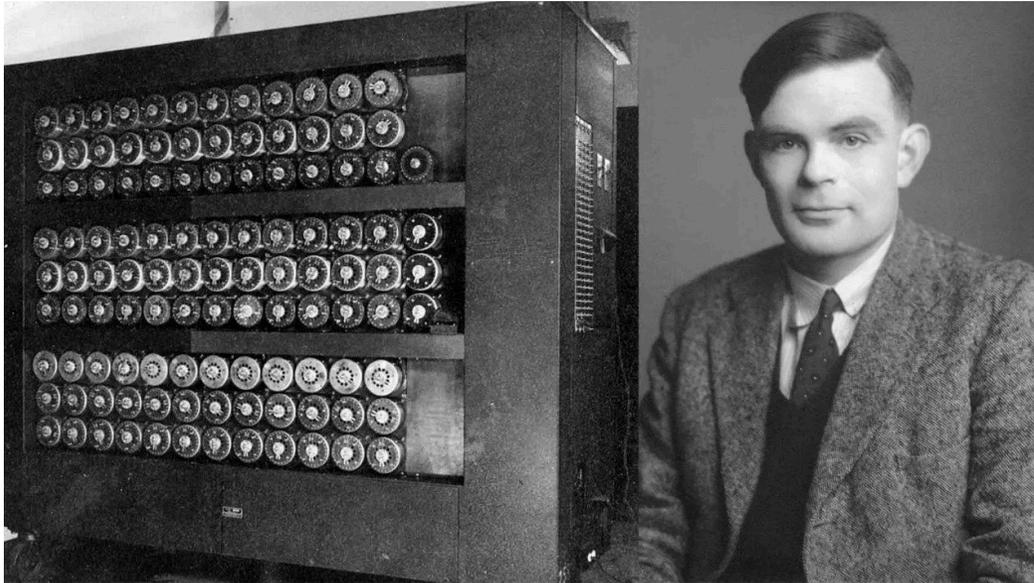
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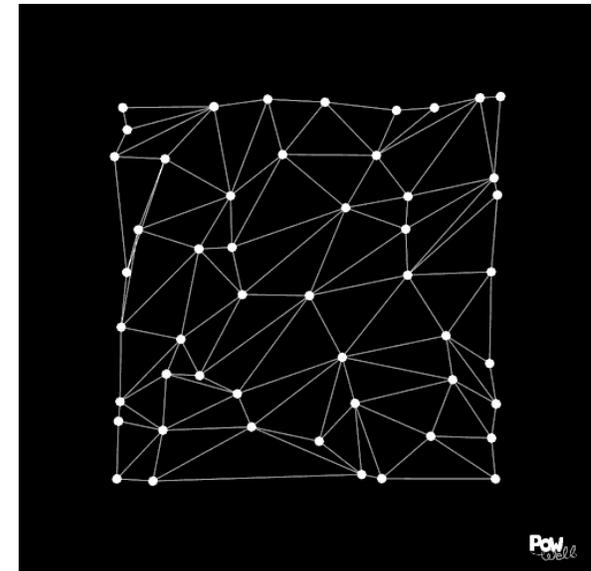
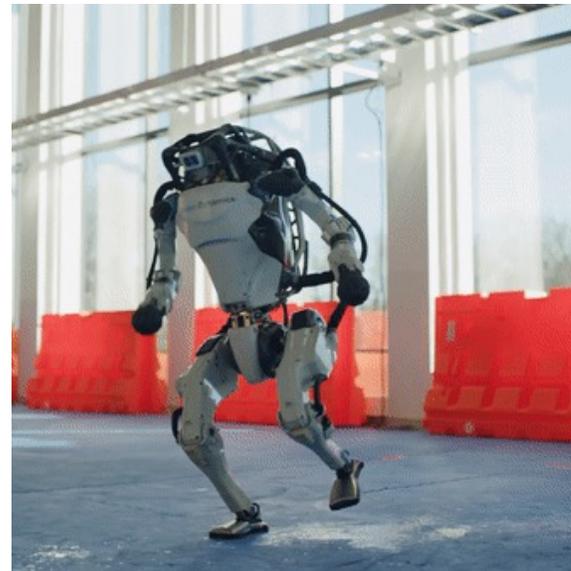
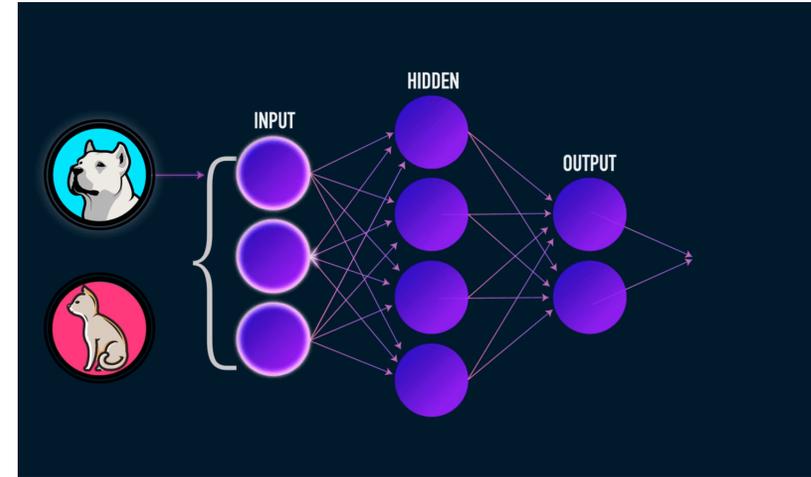
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# Contexto Histórico (Idade Contemporânea – Era da Informação)



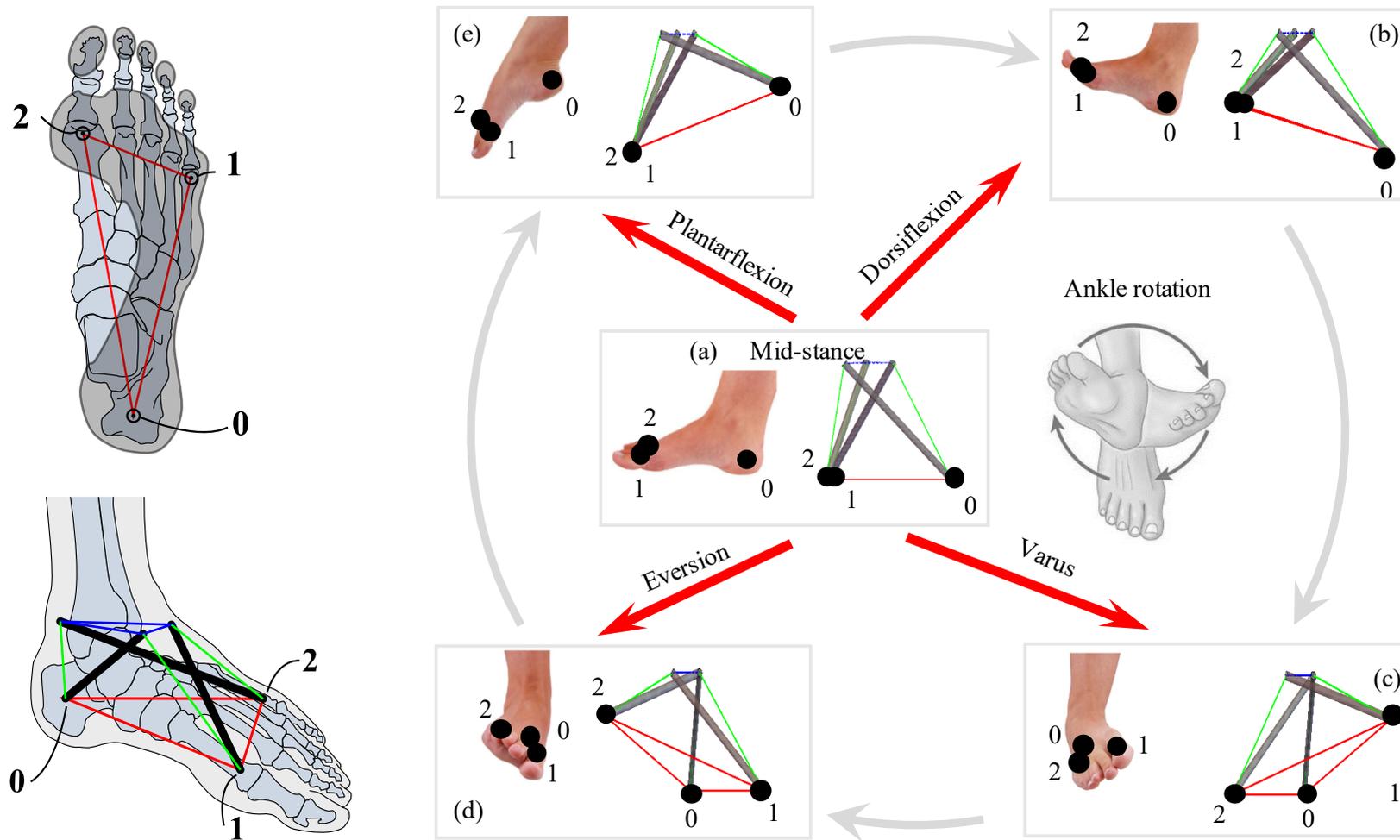
# Contexto Histórico (Idade Contemporânea – Indústria 4.0)



# Sistemas Bioinspirados

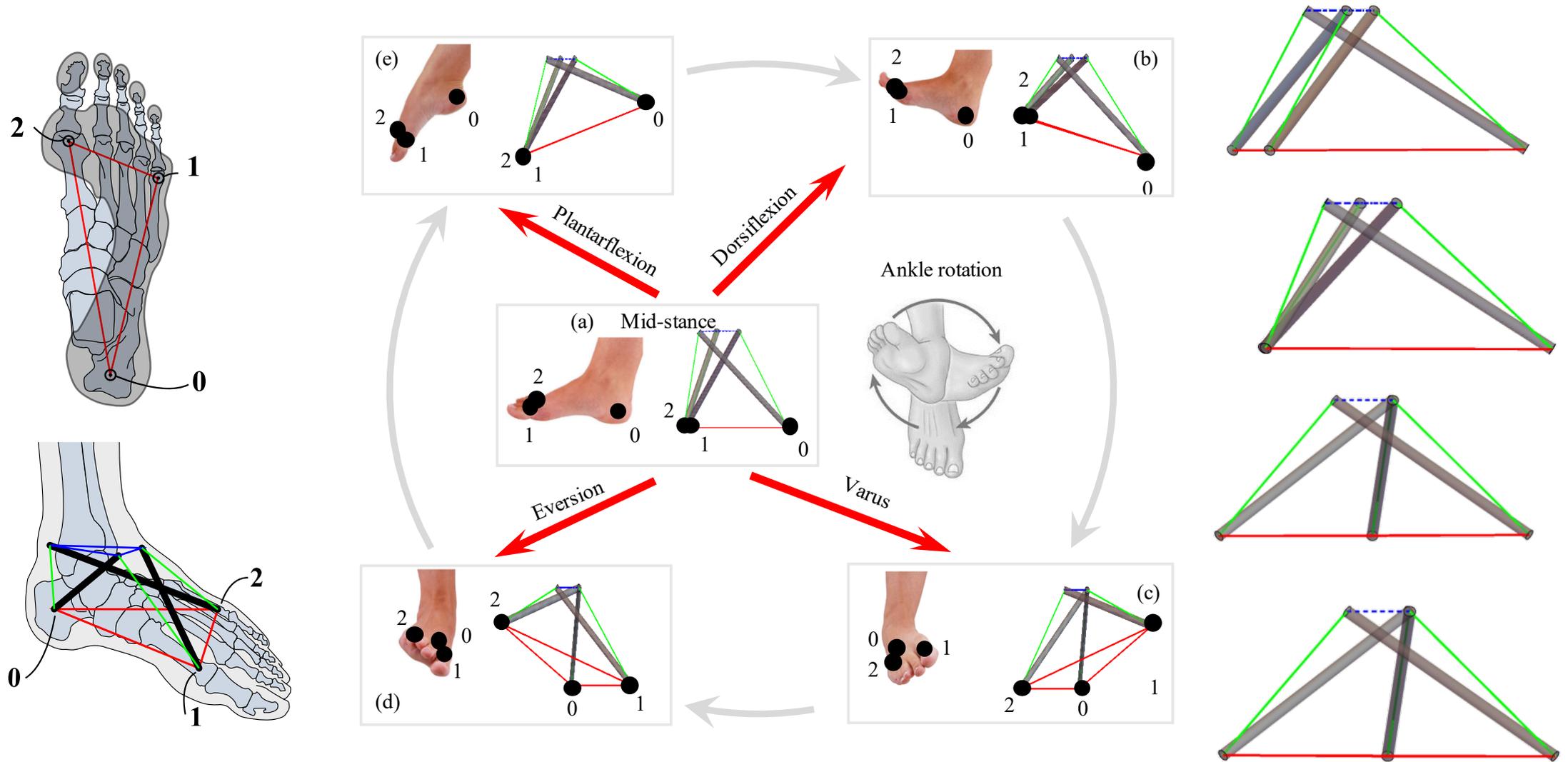


# Sistemas Bioinspirados – Biotensengridade com Memória



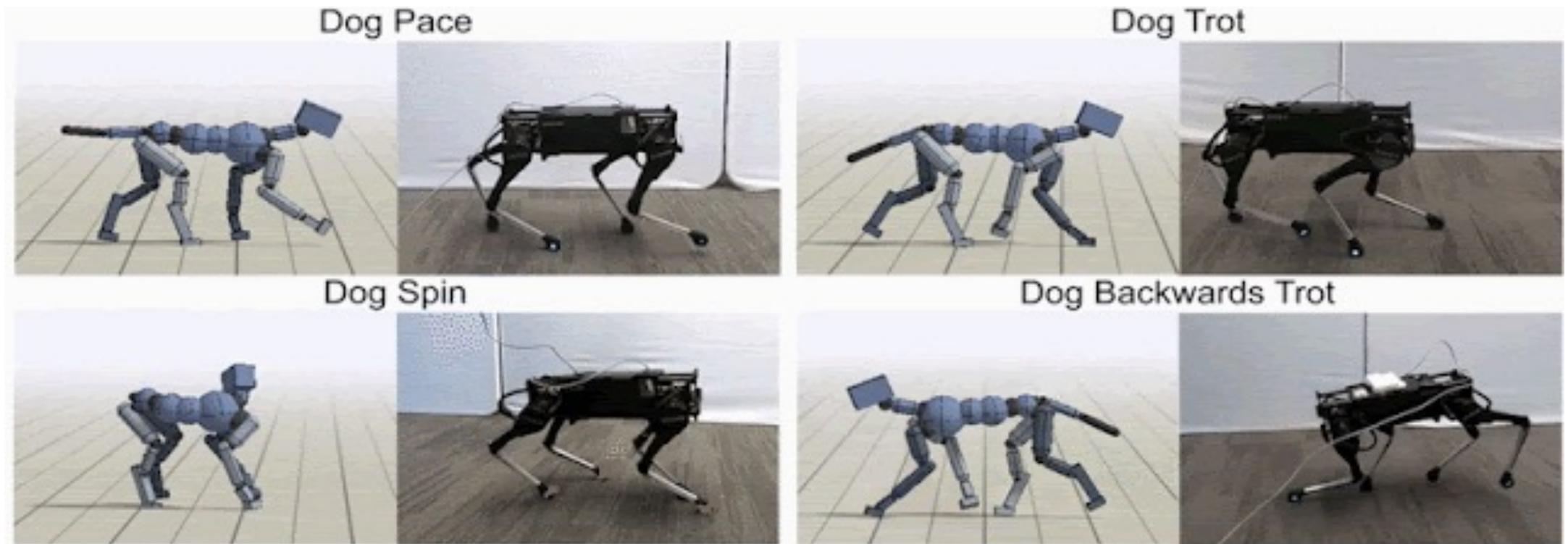
Brandão & Savi (2022)

# Sistemas Bioinspirados – Biotensengridade com Memória

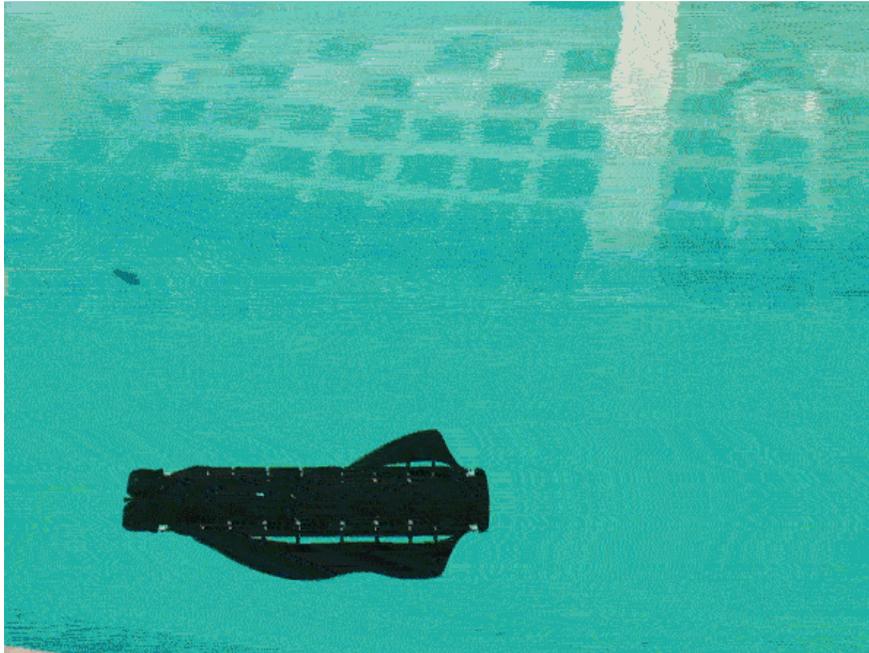


Brandão & Savi (2022)

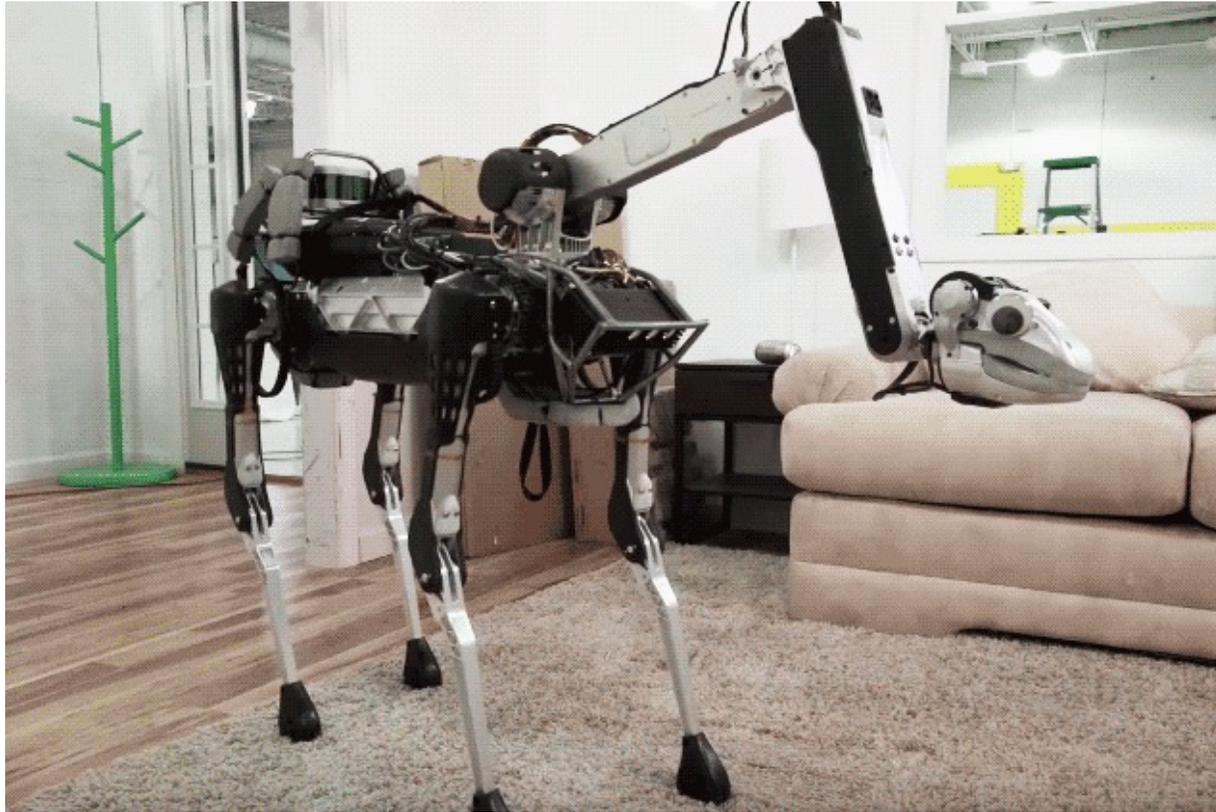
# Sistemas Bioinspirados - Robôs



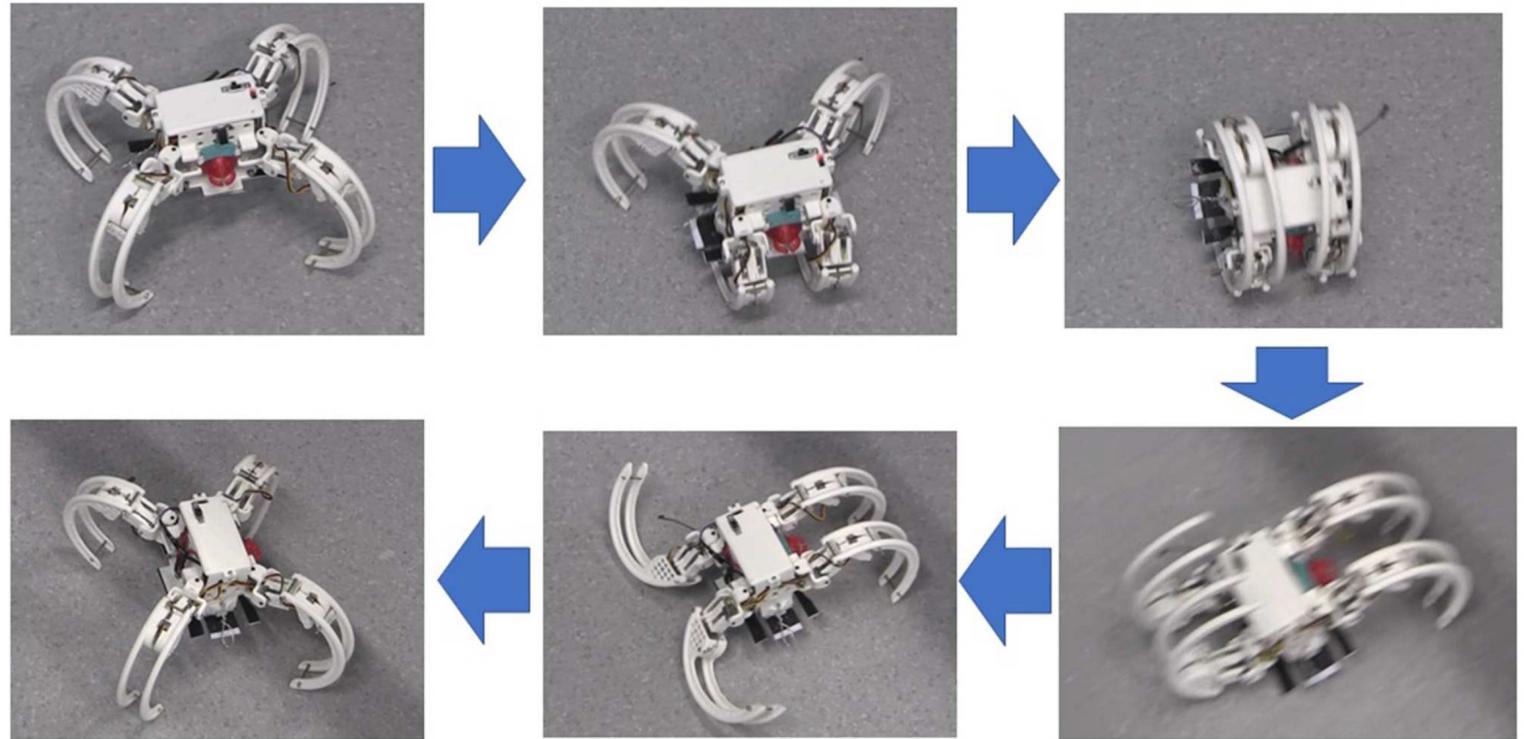
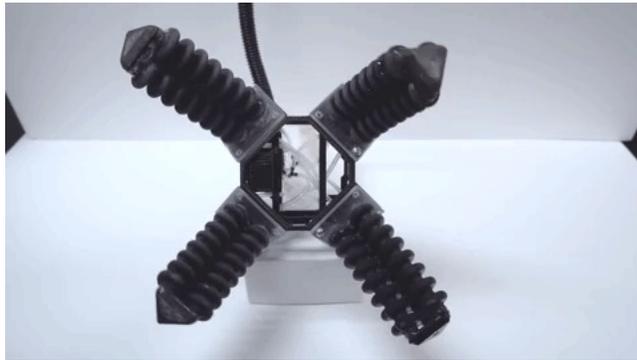
## Sistemas Bioinspirados – Velox



## Sistemas Bioinspirados – Estabilidade

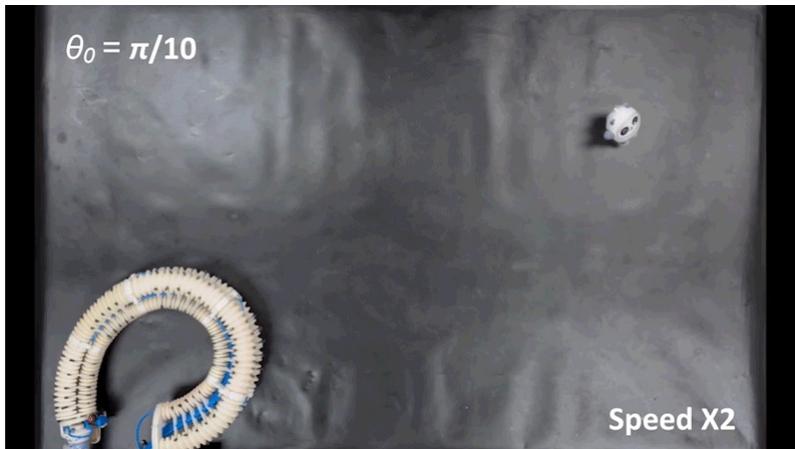
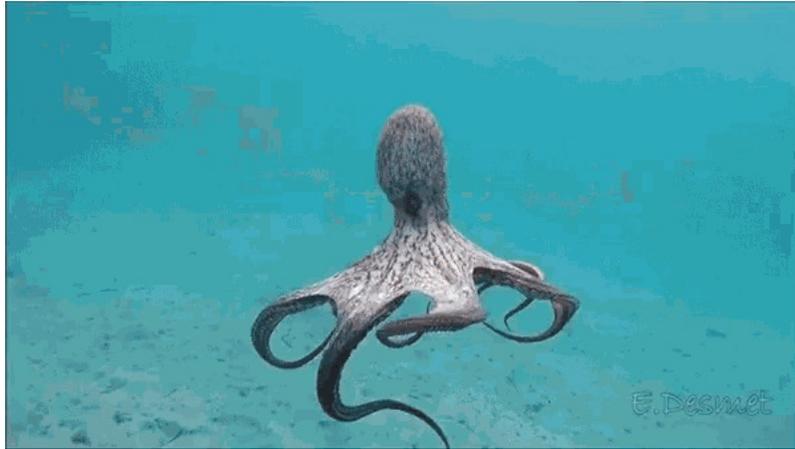


# Sistemas Bioinspirados – Atuadores

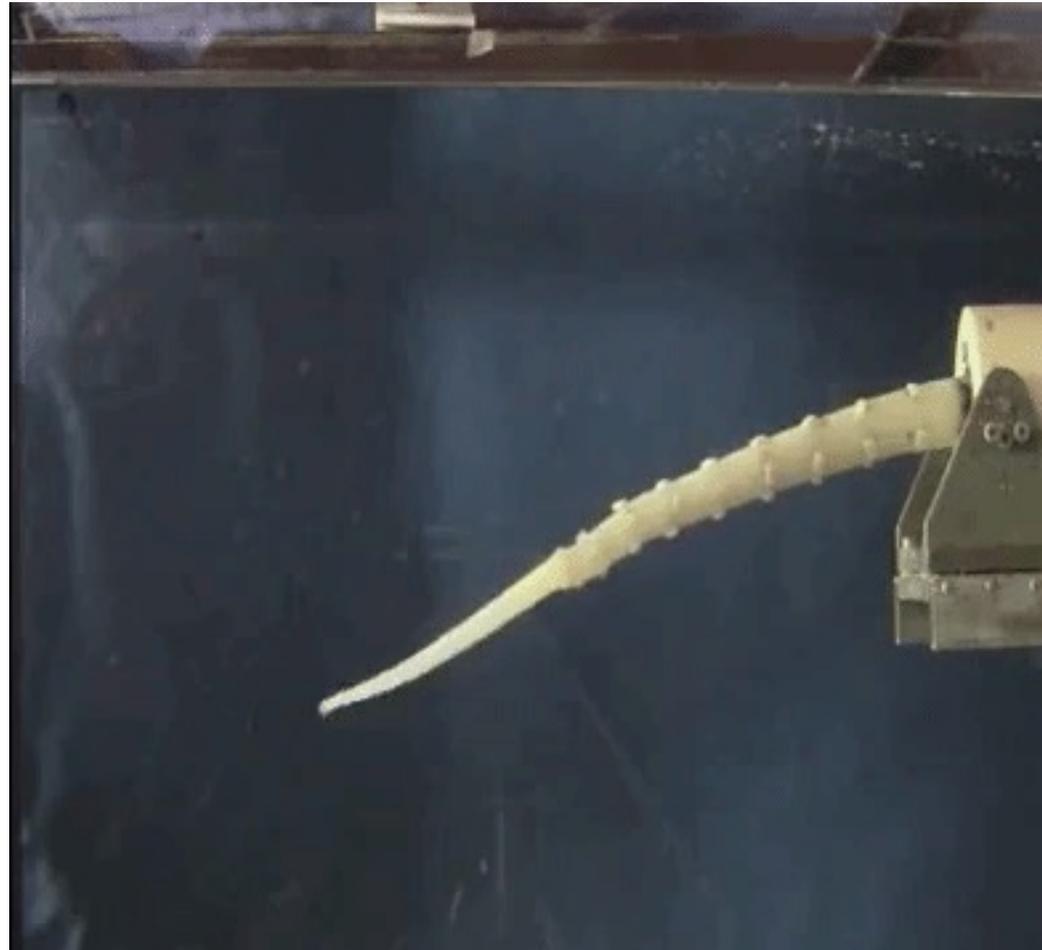


Tan et al. (2019)

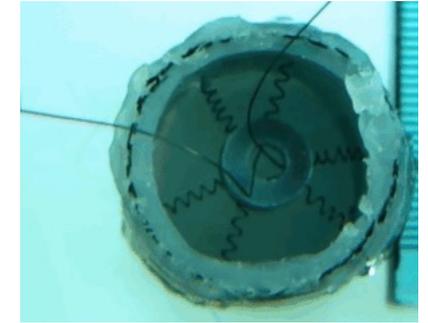
# Sistemas Bioinspirados – Músculos Robóticos



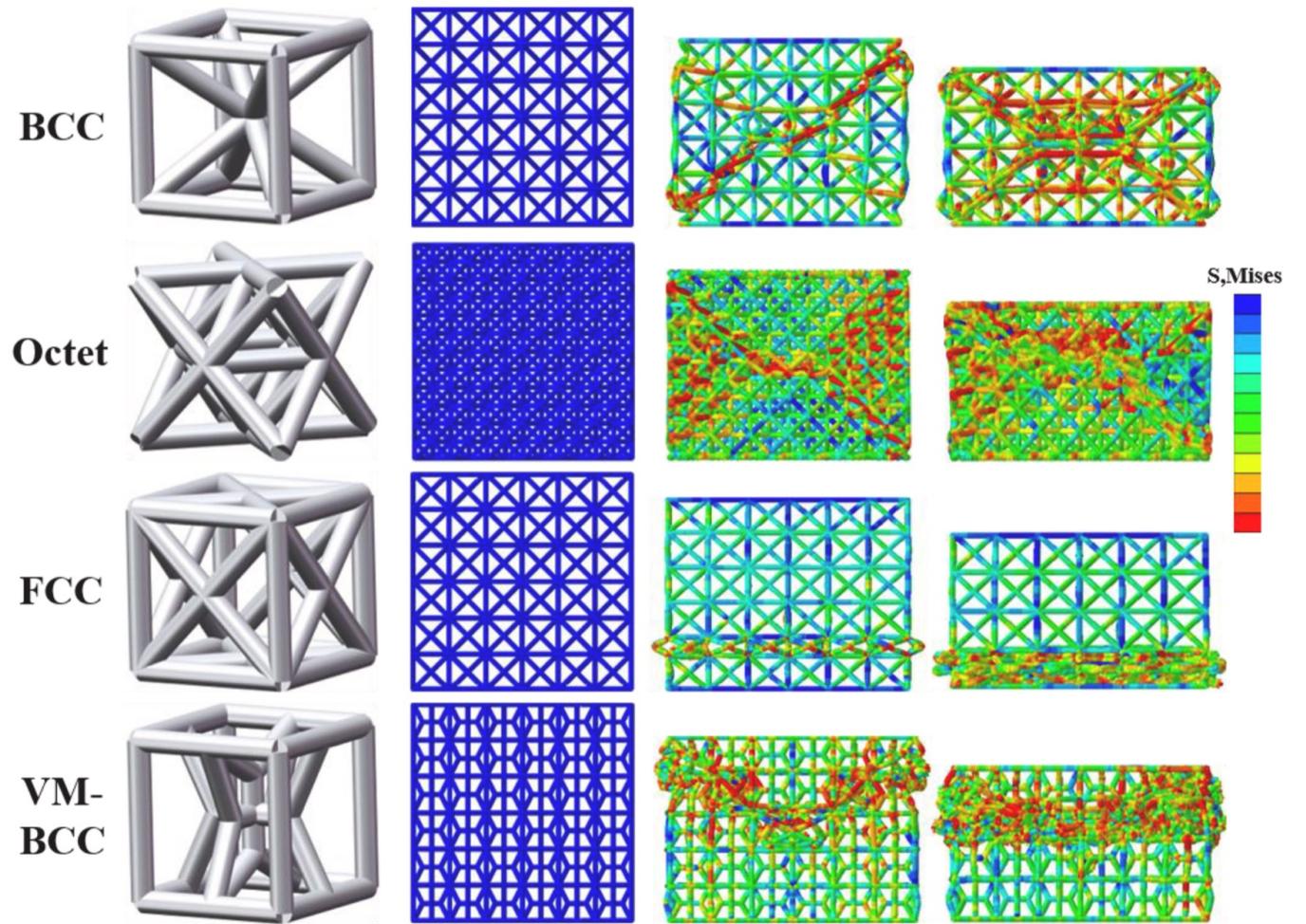
Xie et al. (2023)



Cianchetti et al. (2014)

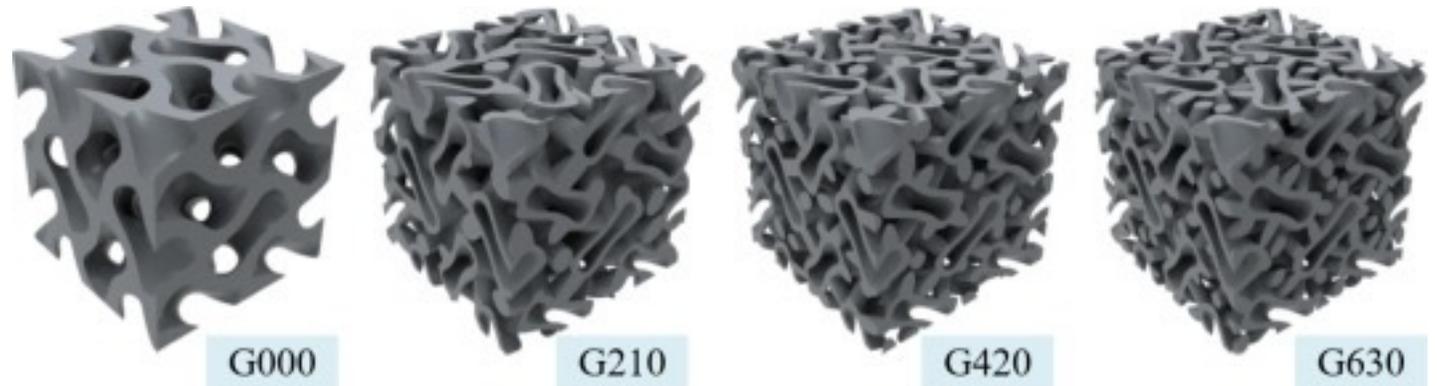


# Sistemas Bioinspirados – Metamateriais



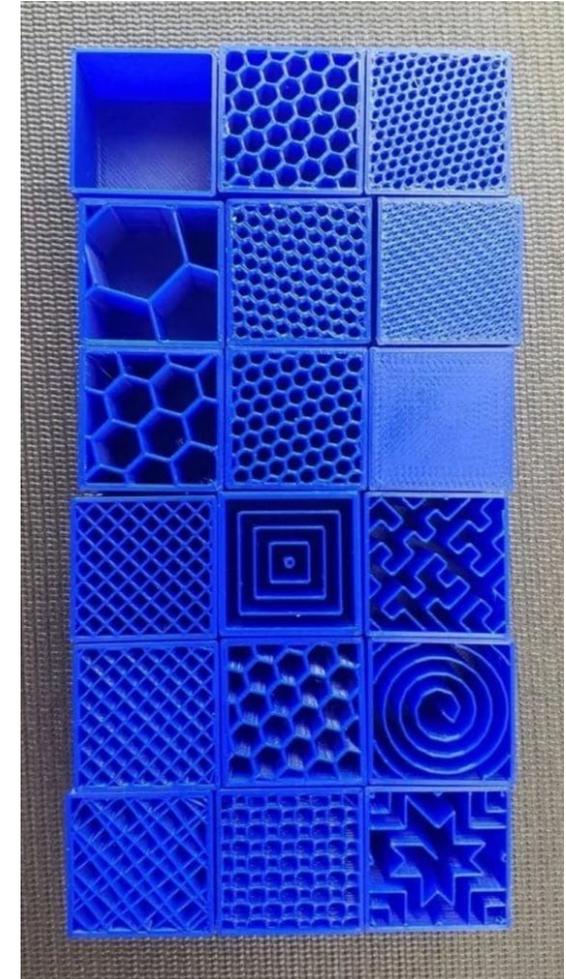
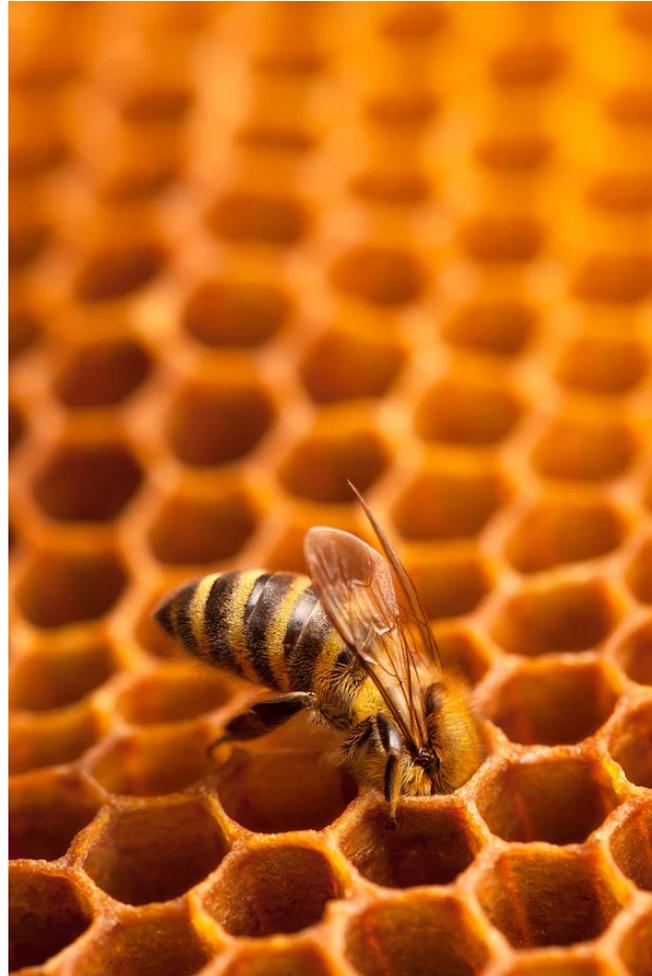
Wang et al. (2023)

# Sistemas Bioinspirados – Metamateriais



Mu et al. (2023)

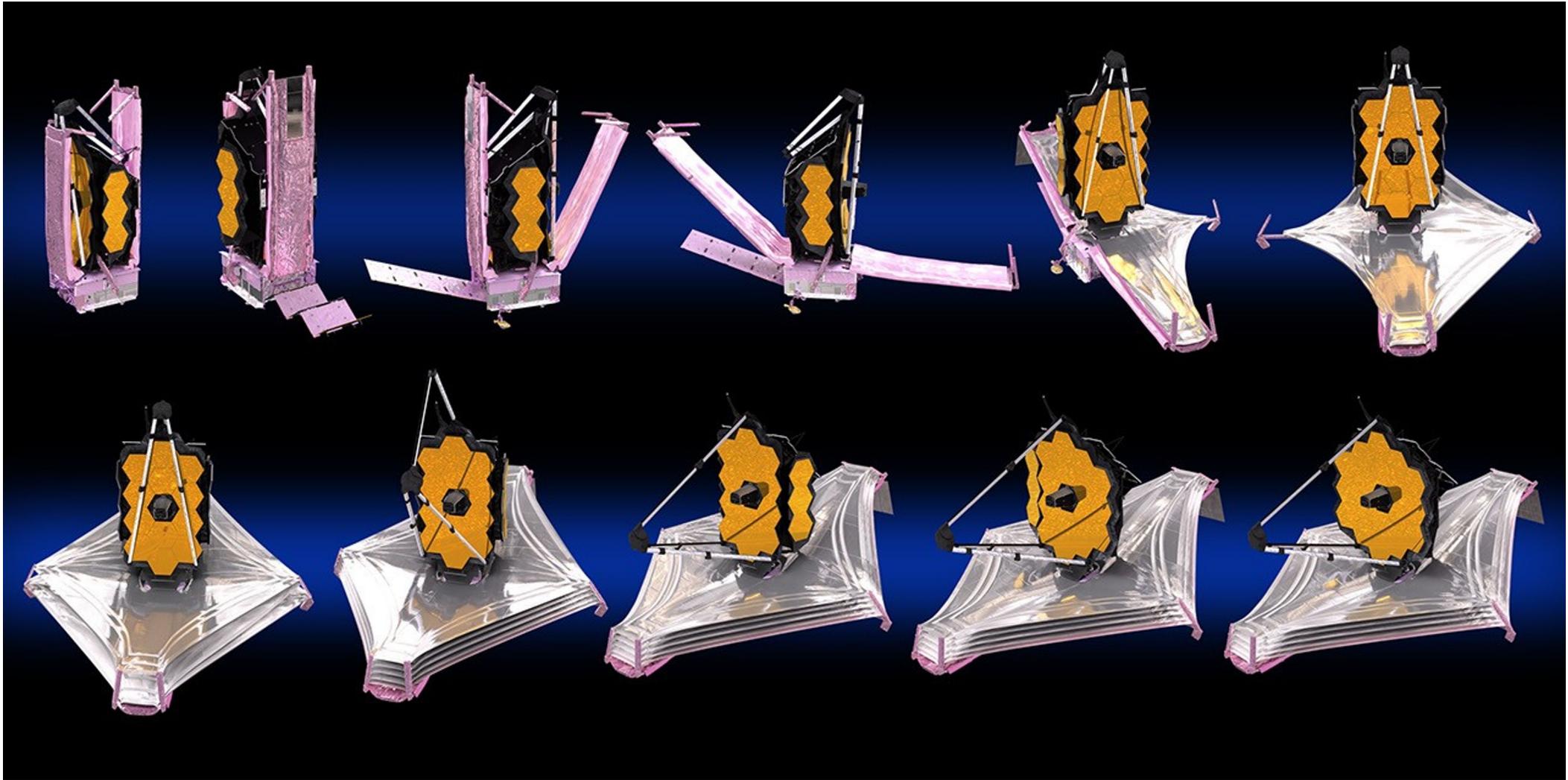
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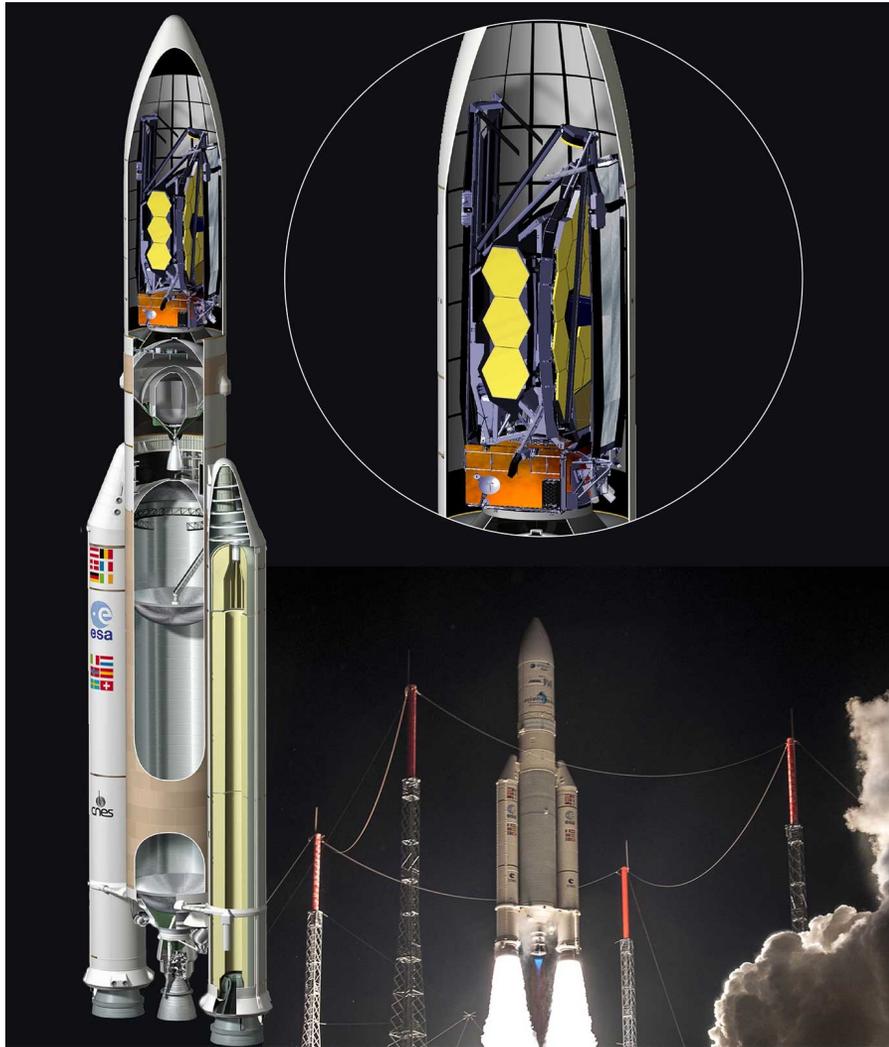
## Sistemas Bioinspirados – Impressão 3D



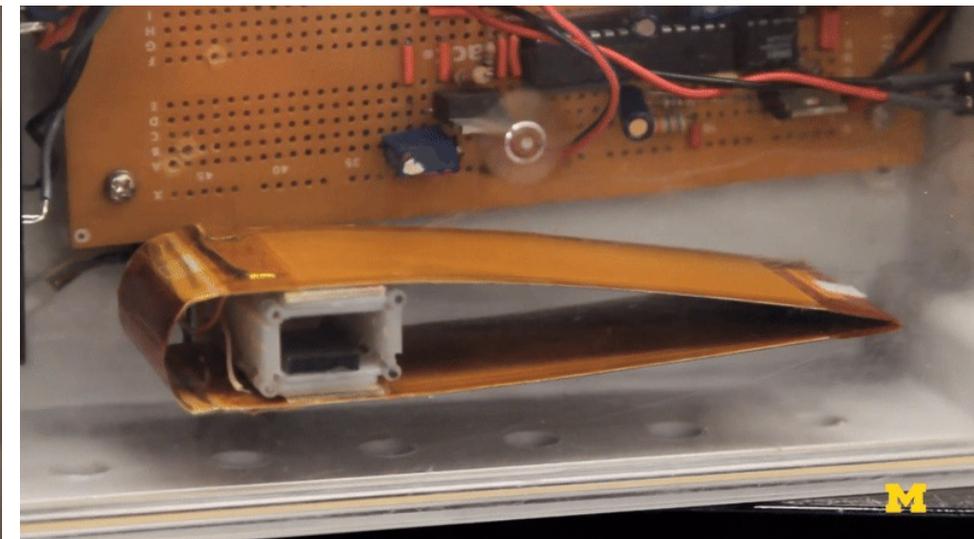
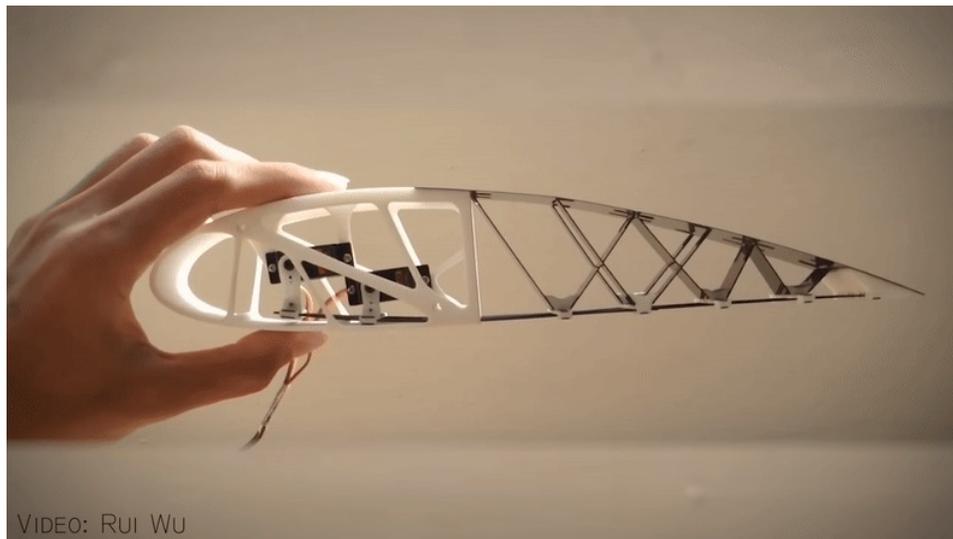
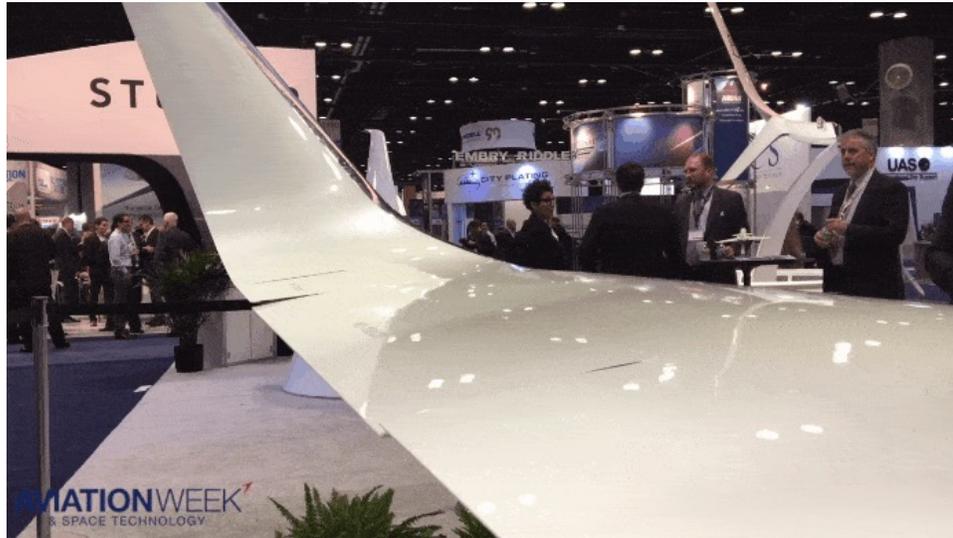
## Sistemas Bioinspirados – Telescópio James Webb



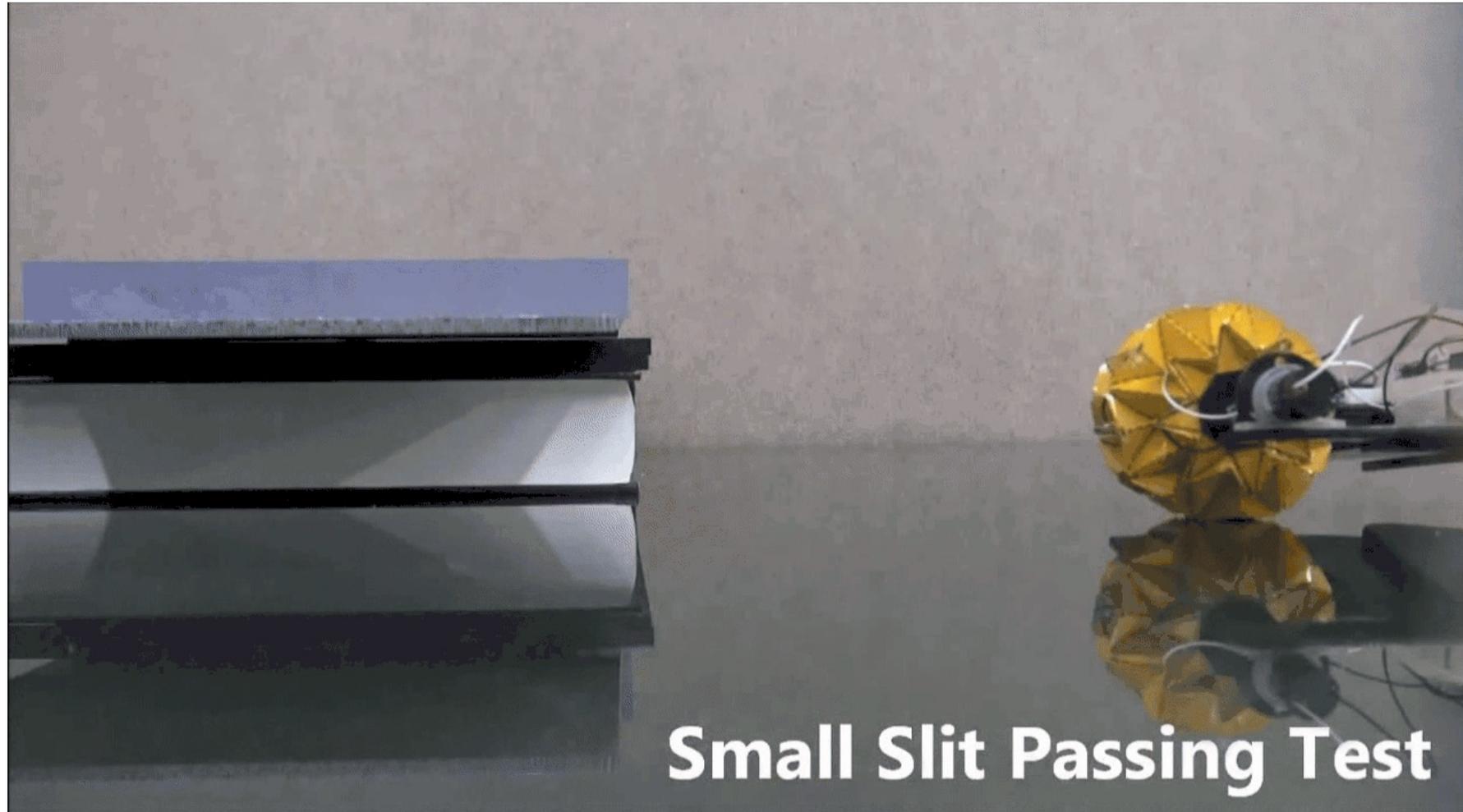
# Sistemas Bioinspirados – Telescópio James Webb



# Estruturas Adaptativas - “Morphing” de Asas

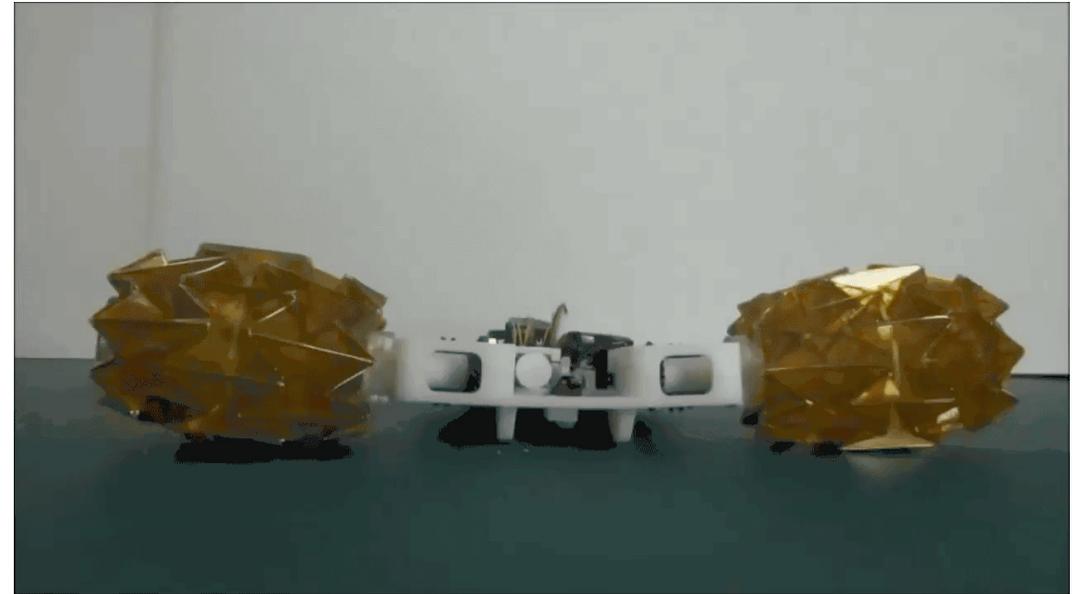


## Estruturas Adaptativas – Roda Origami com Memória

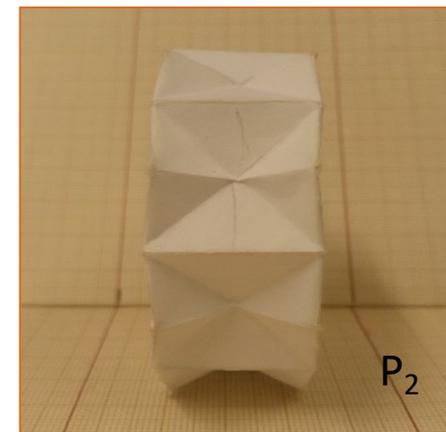
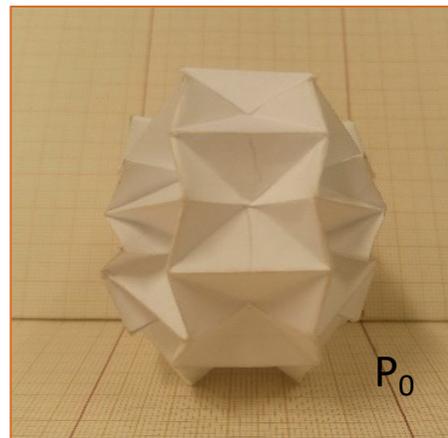
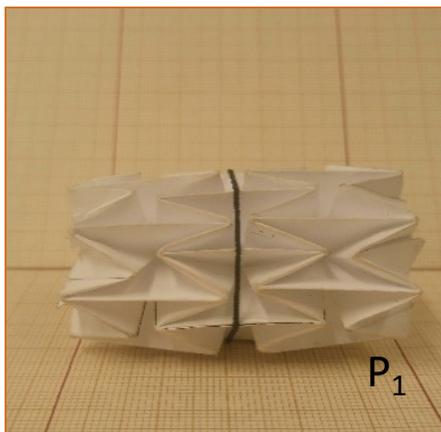


Lee et al. (2013)

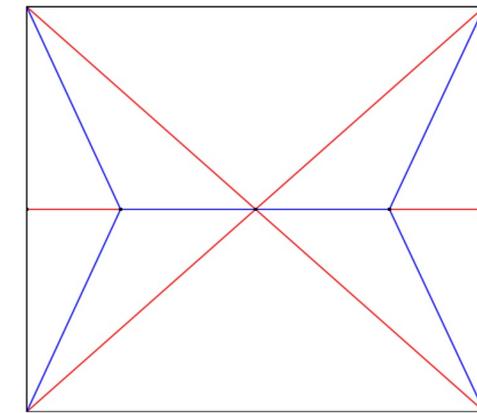
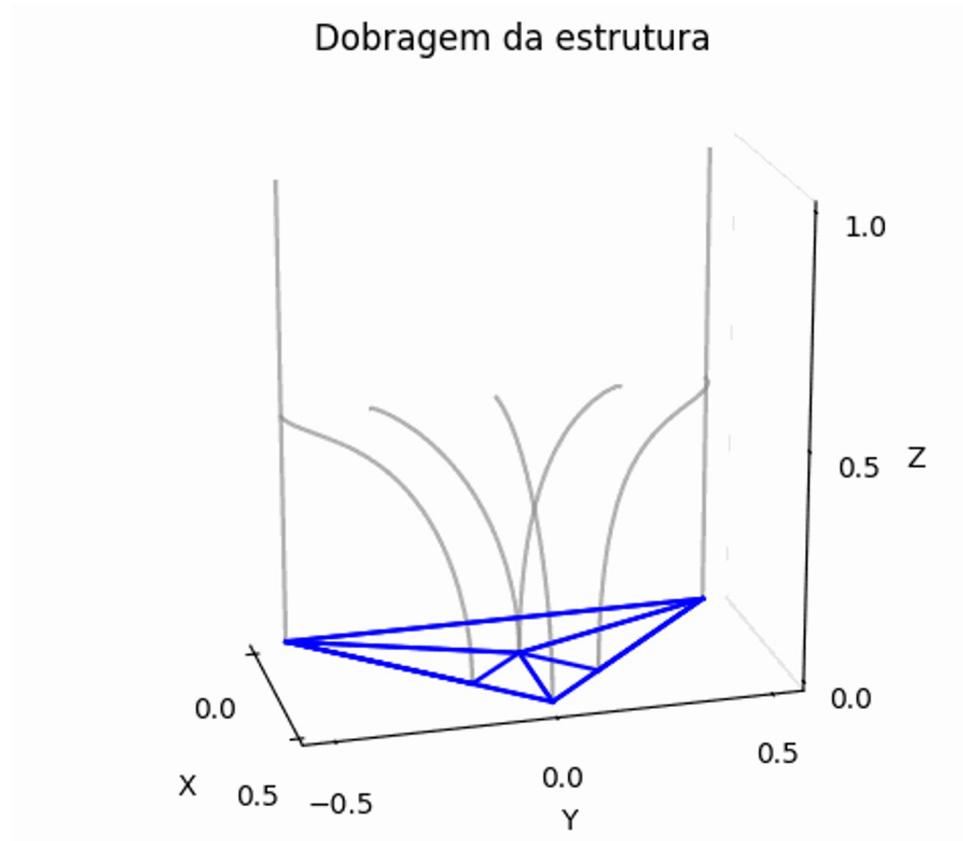
# Estruturas Adaptativas – Roda Origami com Memória



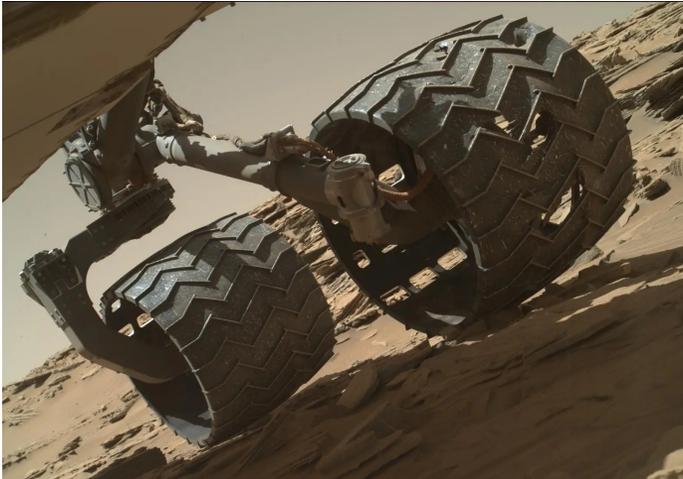
Lee et al. (2013)



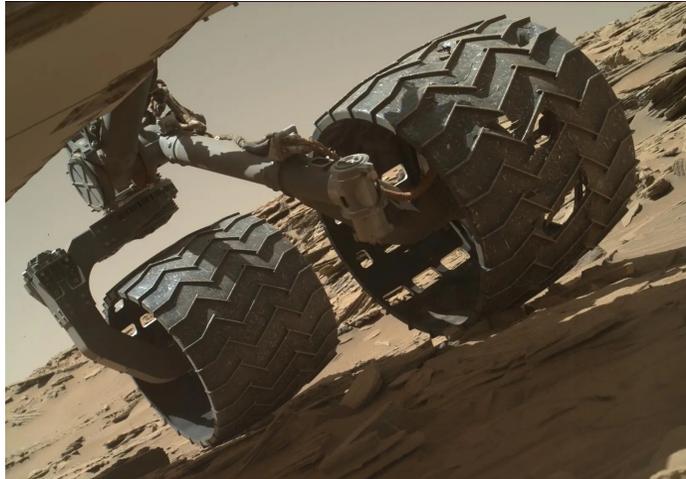
# Estruturas Adaptativas – Braço Robótico Origami



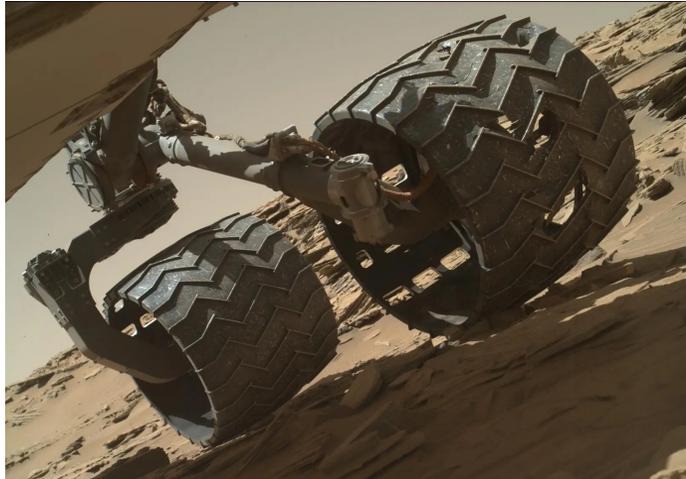
# Estruturas Adaptativas – Roda Pseudoelástica do Mars Rover



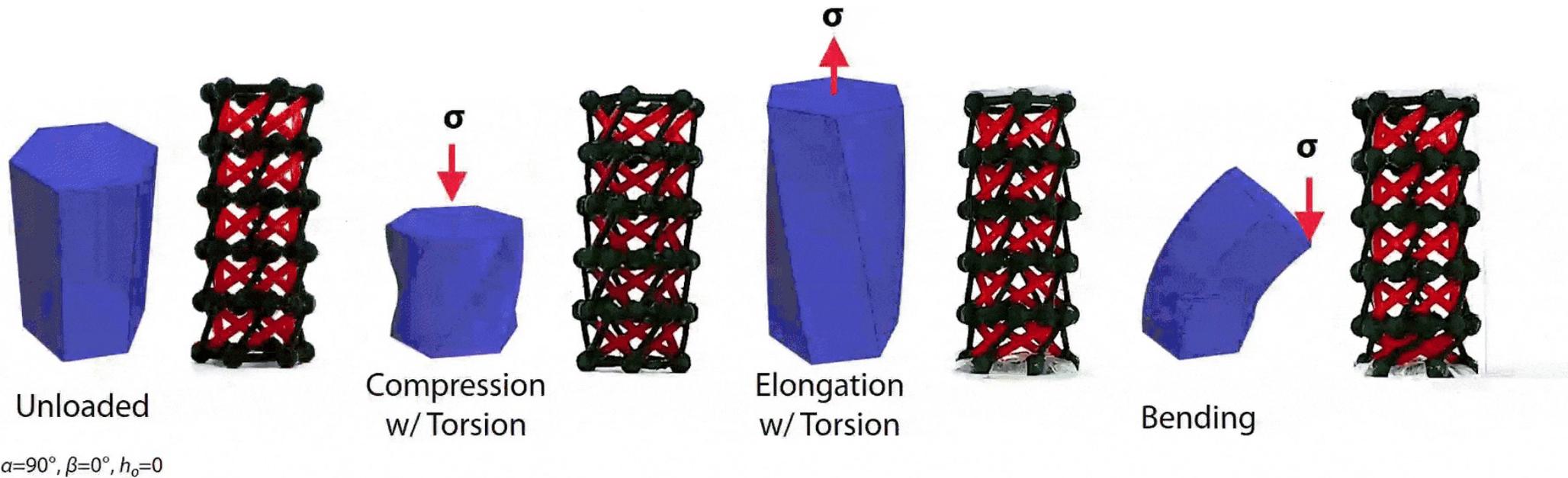
# Estruturas Adaptativas – Roda Pseudoelástica do Mars Rover



# Estruturas Adaptativas – Roda Pseudoelástica do Mars Rover



# Estruturas Adaptativas – Tensegridade Programável



Lee et al. (2024)

# Rolling-based Locomotion of CBT and CT Actuators for Particle Uptake

Xie et al. (2023)

## Estruturas Adaptativas – Tensegridade Programável

Starfish Robot Actuation  
Composed of Five Tensegrity Legs

Xie et al. (2023)

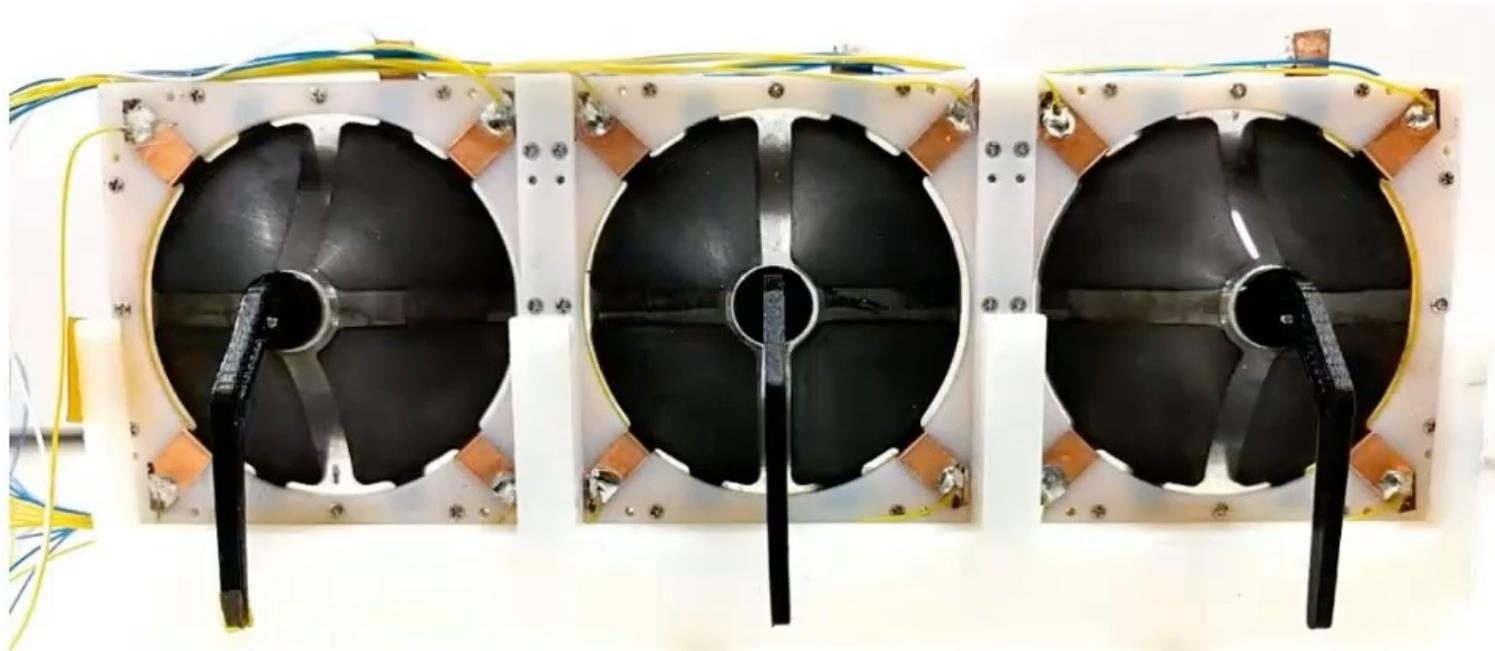
## Estruturas Adaptativas – Metabot



Zhao et al. (2025)

# Estruturas Adaptativas – Pernas Ativadas por Elastômeros

## S-Hex II legs walking cycle



Forward Walking cycle: Pushing downward => Swinging backward => Lifting upward => Swinging forward

Walking gait: Alternating tripod gait

Nguyen et al. (2017)

## Roadmap

# Roadmap on embodying mechano-intelligence and computing in functional materials and structures

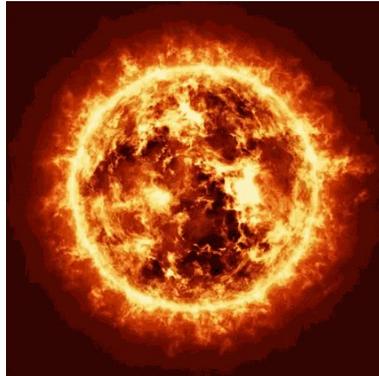
Andrea Alù<sup>1</sup> , Andres F Arrieta<sup>2</sup> , Emanuela Del Dottore<sup>3</sup> , Michael Dickey<sup>4</sup>,  
Samuele Ferracin<sup>5</sup>, Ryan Harne<sup>6</sup>, Helmut Hauser<sup>7</sup> , Qiguang He<sup>5,8</sup>,  
Jonathan B Hopkins<sup>9</sup> , Lance P Hyatt<sup>10</sup> , Suyi Li<sup>11,21,\*</sup> , Stefano Mariani<sup>3</sup> ,  
Barbara Mazzolai<sup>3</sup> , Alessio Mondini<sup>3</sup>, Aniket Pal<sup>12</sup> , Daniel J Preston<sup>13</sup> ,  
Anoop Rajappan<sup>14</sup> , Jordan R Raney<sup>5</sup> , Pedro M Reis<sup>15</sup>, Stephen A Sarles<sup>16</sup> ,  
Metin Sitti<sup>17</sup> , Uba K Ubamanyu<sup>15</sup> , Martin van Hecke<sup>18,19</sup> and K W Wang<sup>20,21,\*</sup> 

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



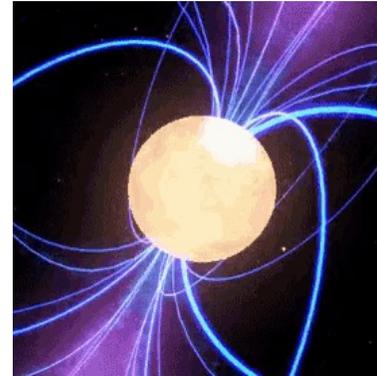
Térmico



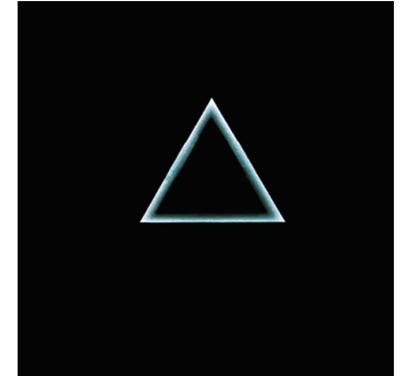
Elétrico



Magnético



Óptico

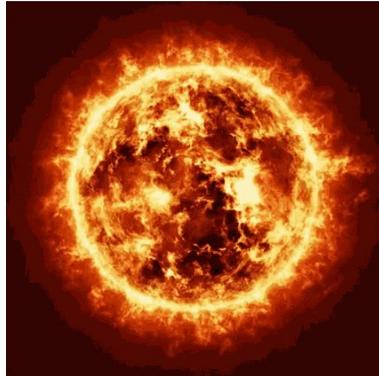


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Mecânico



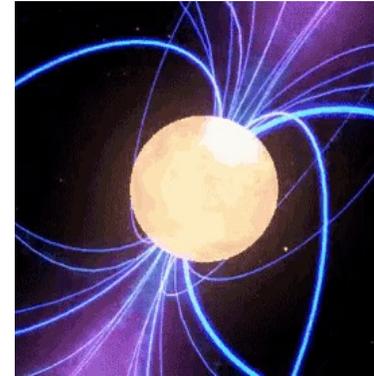
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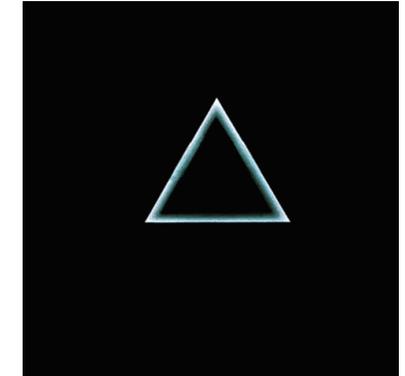
Elétrico



Magnético



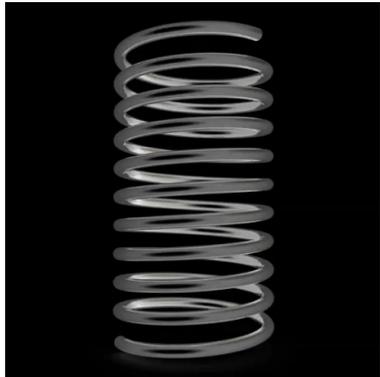
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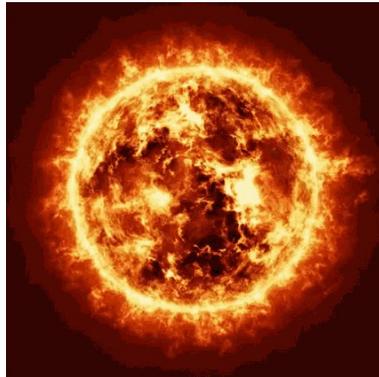
1. Atuadores
2. Sensores
3. Dispositivos de Controle
4. Dissipadores de Energia
5. Colheita de Energia

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



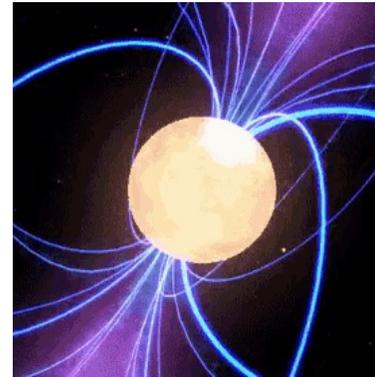
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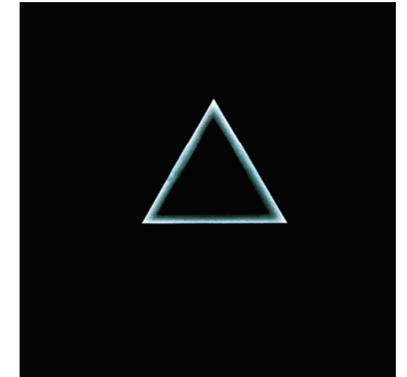
Elétrico



Magnético



Óptico

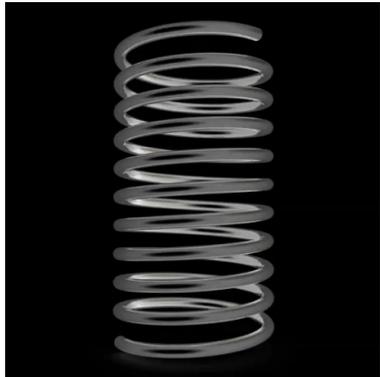


Shape Memory Alloys (SMAs)

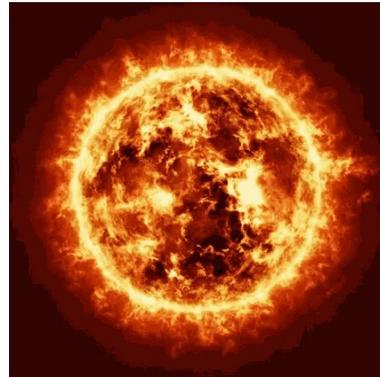
Shape Memory Polymers (SMPs)

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



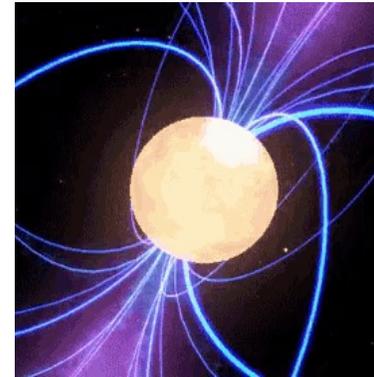
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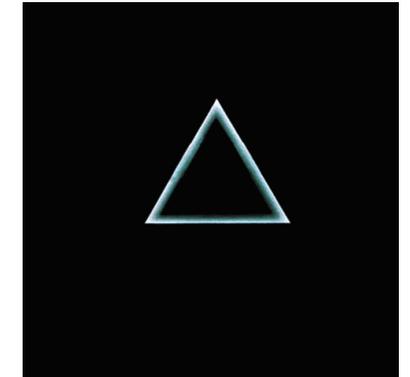
Elétrico



Magnético



Óptico



**Piezoelétricos**

**Elastômeros Dielétricos / Eletrostrictivos**

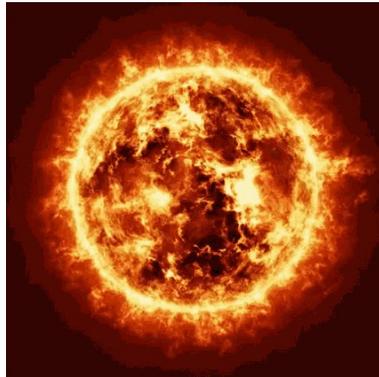
**Fluidos Eletroreológicos**

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



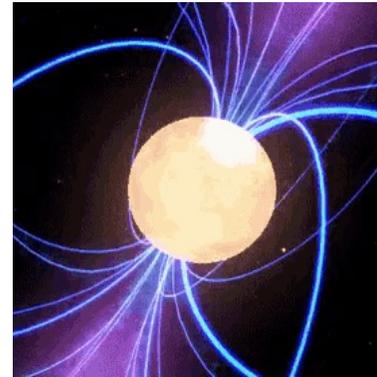
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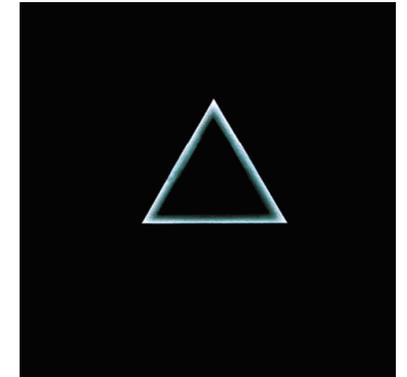
Elétrico



Magnético



Óptico

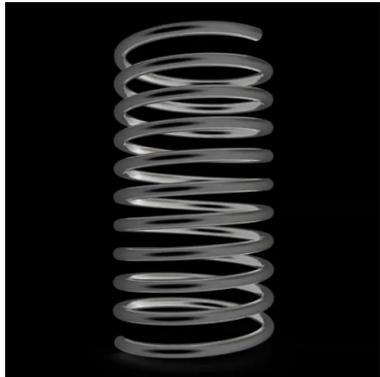


**Magnetoestrictivos**

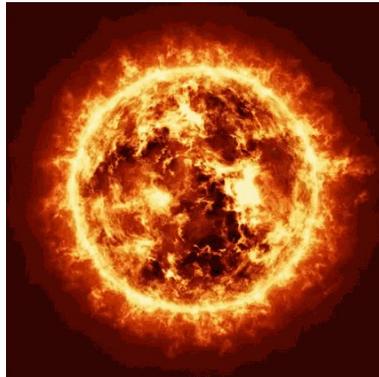
**Fluidos Magnetoreológicos / Ferrofluidos**

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



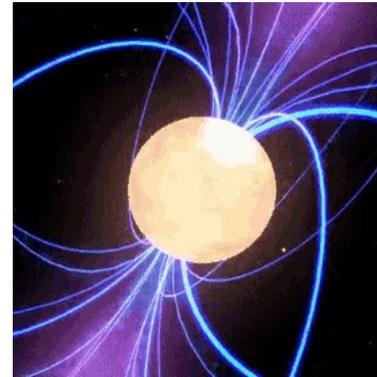
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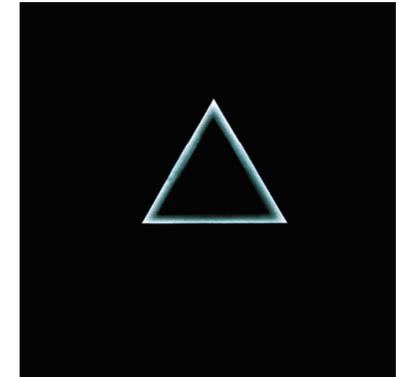
Elétrico



Magnético



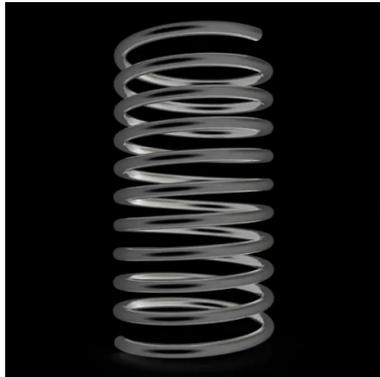
Óptico



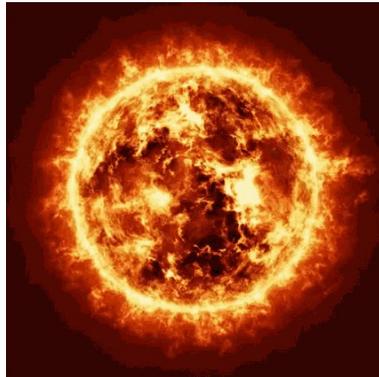
Magnetic Shape Memory Alloys (MSMAs)

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



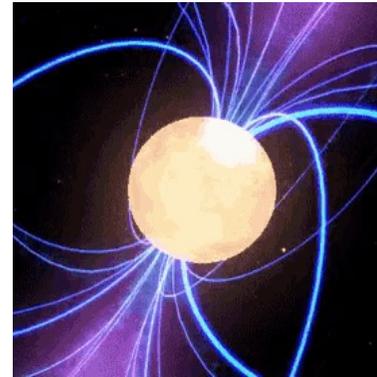
Térmico



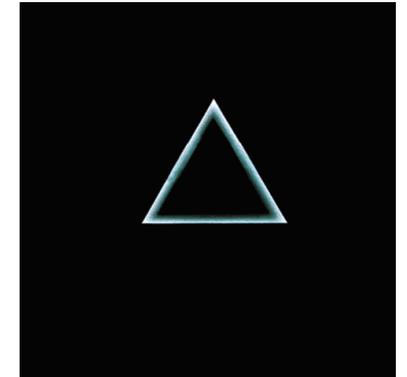
Elétrico



Magnético



Óptico



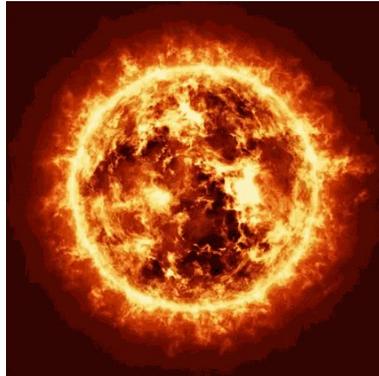
Light-Activated Shape Memory Polymers (LASMPs)

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



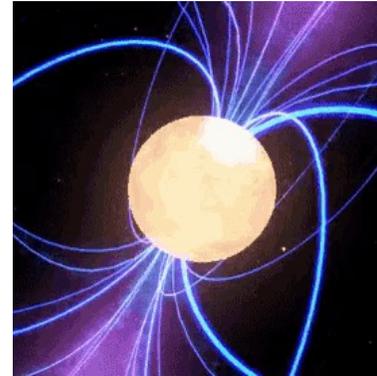
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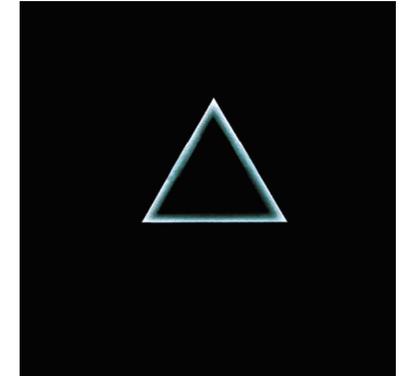
Elétrico



Magnético



Óptico



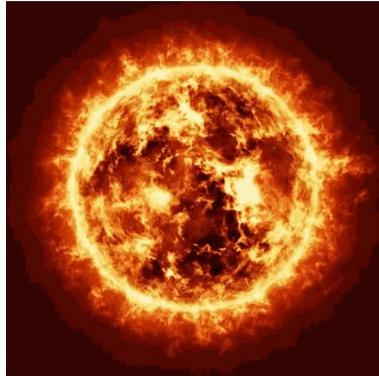
Light-Activated Shape Memory Polymers (LASMPs)

# Materiais Inteligentes: Acomplamento Multifísico

Mecânico



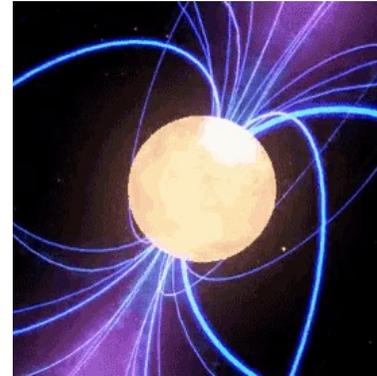
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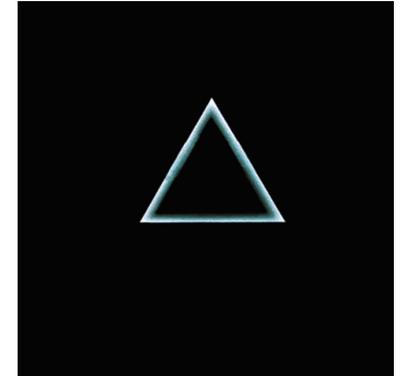
Elétrico



Magnético



Óptico



**Piroelétricos**

**Termoelétricos**