

SISTEMAS DINÂMICOS II: VIBRAÇÕES

- Marcilio
- maralves@usp.br

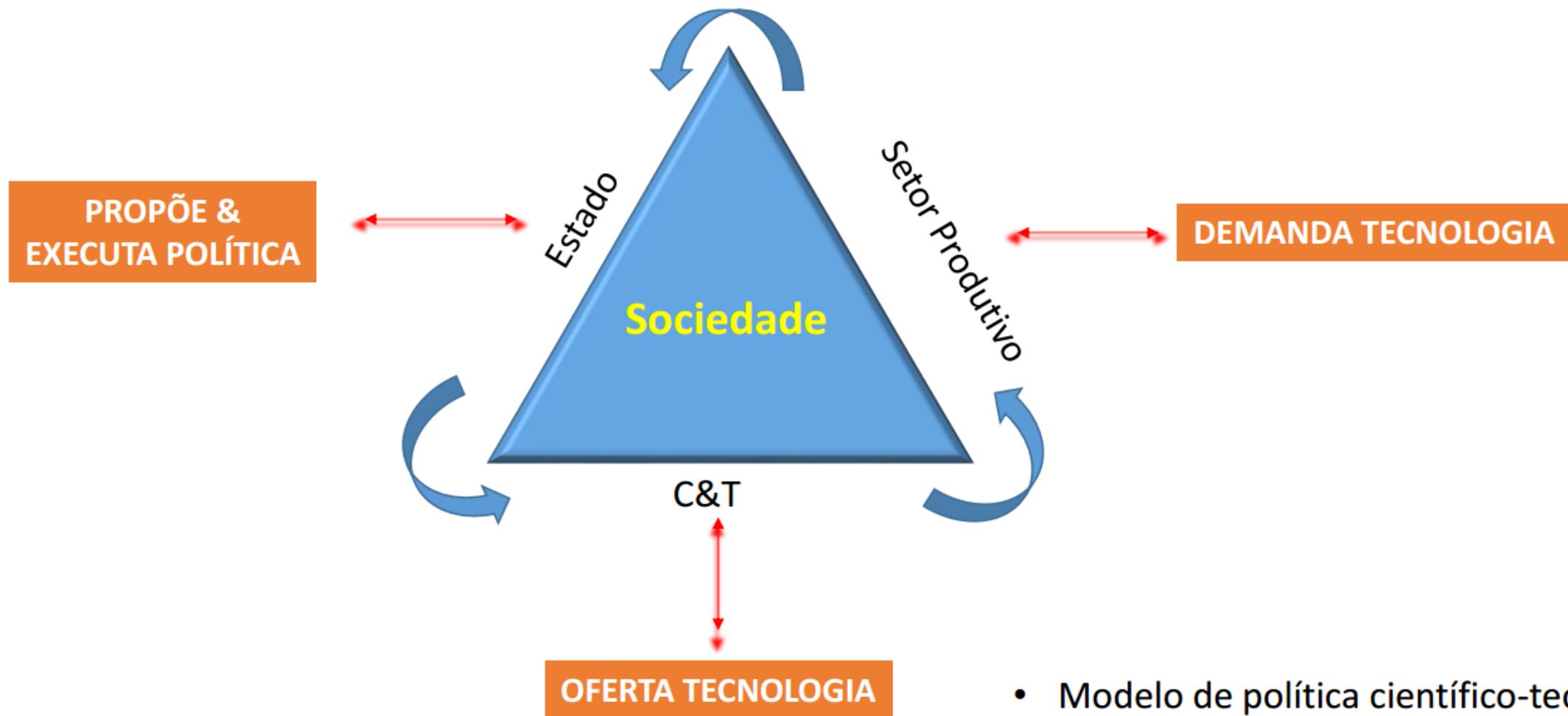
VIBRAÇÕES: visão geral do curso

- 1GL
- 2GL
- Hastes
- Vigas
- Estruturas complexas

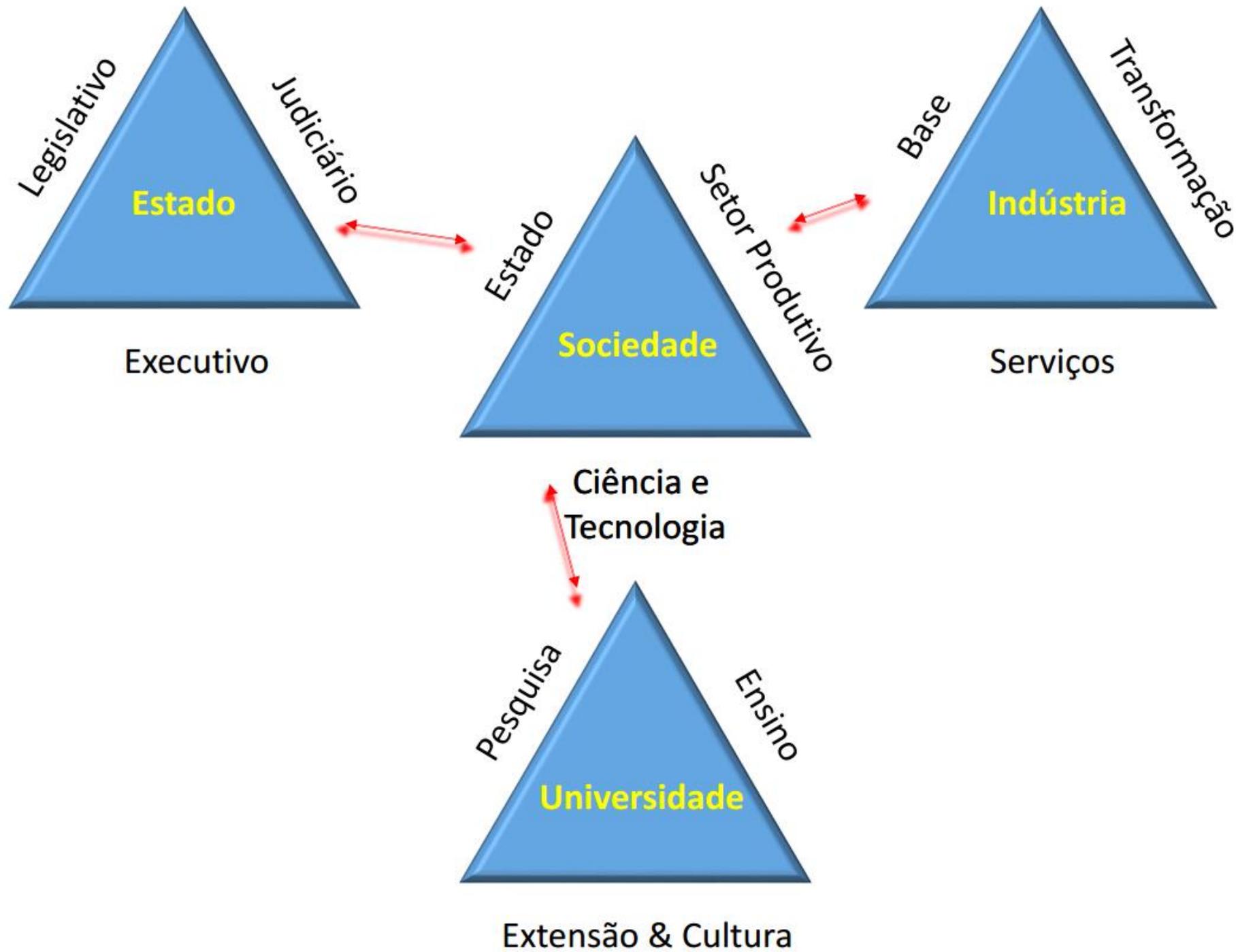
Competência vs Conteúdo

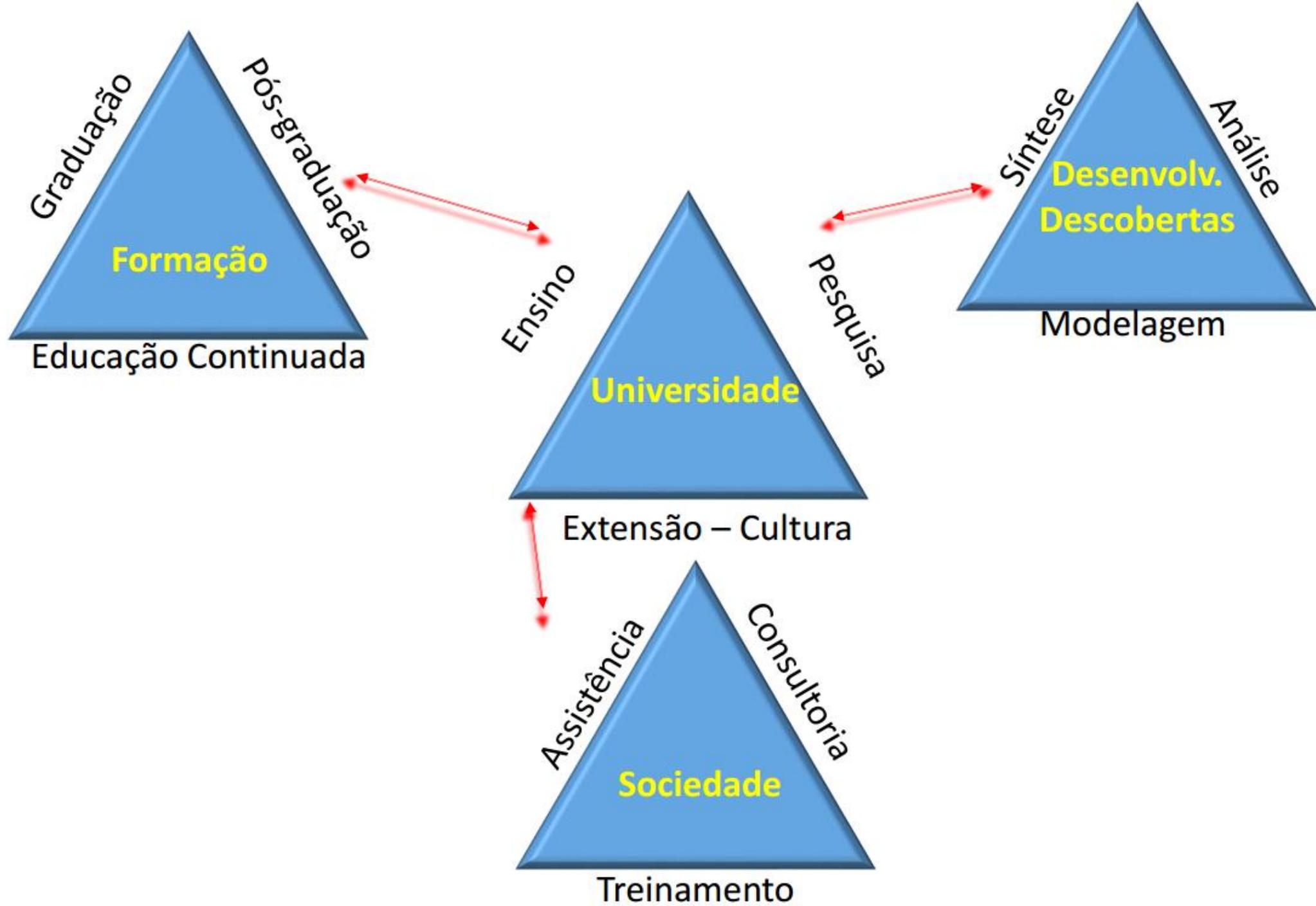
- Competência: qualidade de quem é capaz de apreciar e resolver certo assunto, fazer determinada coisa; capacidade, habilidade, aptidão
- Conteúdo: necessário à competência
- Habilidade: aplicação da competência, desenvolvidas na busca das competências
- Desempenho: indicador da competência [mal desempenho não significa incompetência]
- Avaliações: propositivas / acompanhamento / organização / guia

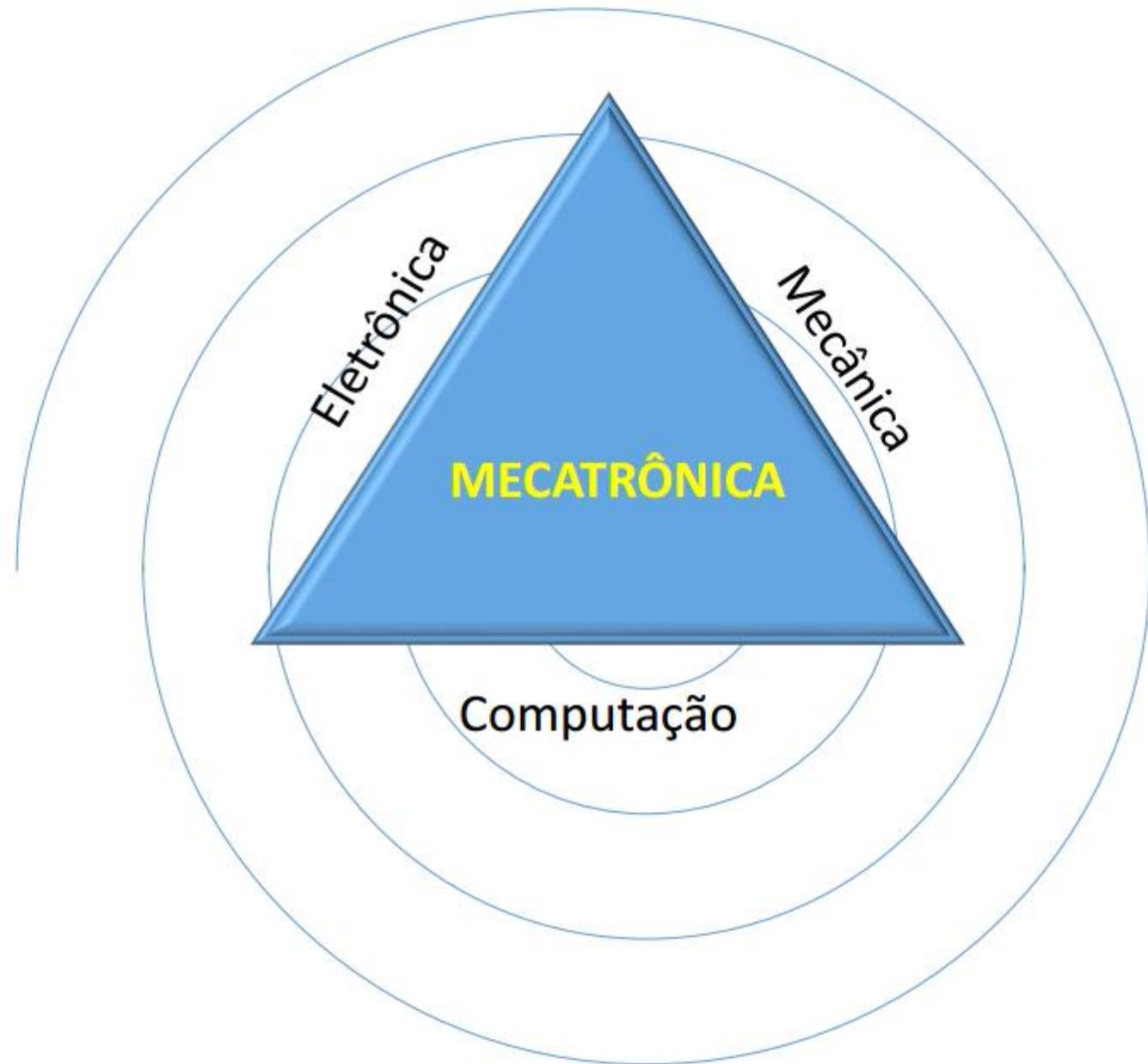
Triângulo de (Jorge) Sábato / (John) Galbraith



- Modelo de política científico-tecnológica
- Estratégia para desenvolvimento países com setores industriais dependentes
- Mais atual é o conceito de “hélice tripla”







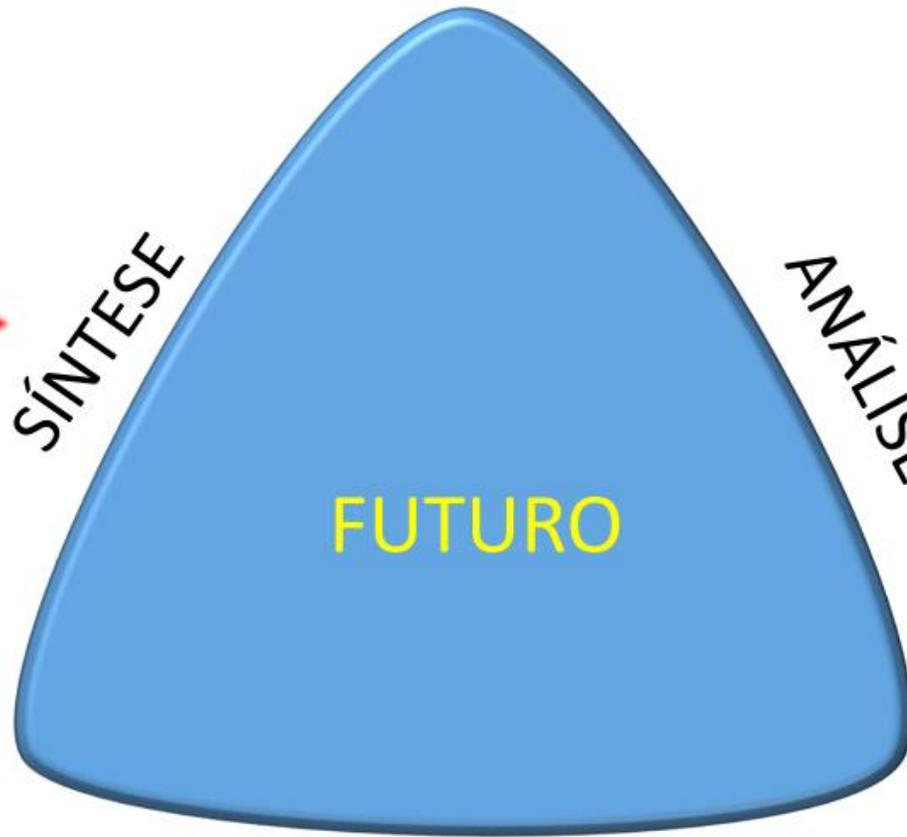
SINERGIA

ROBÔS

- Manufatura aditiva
- Drones



SÍNTESE



FUTURO



INTELIGÊNCIA ARTIFICIAL

- Bigdata
- Internet das coisas

MODELAGEM

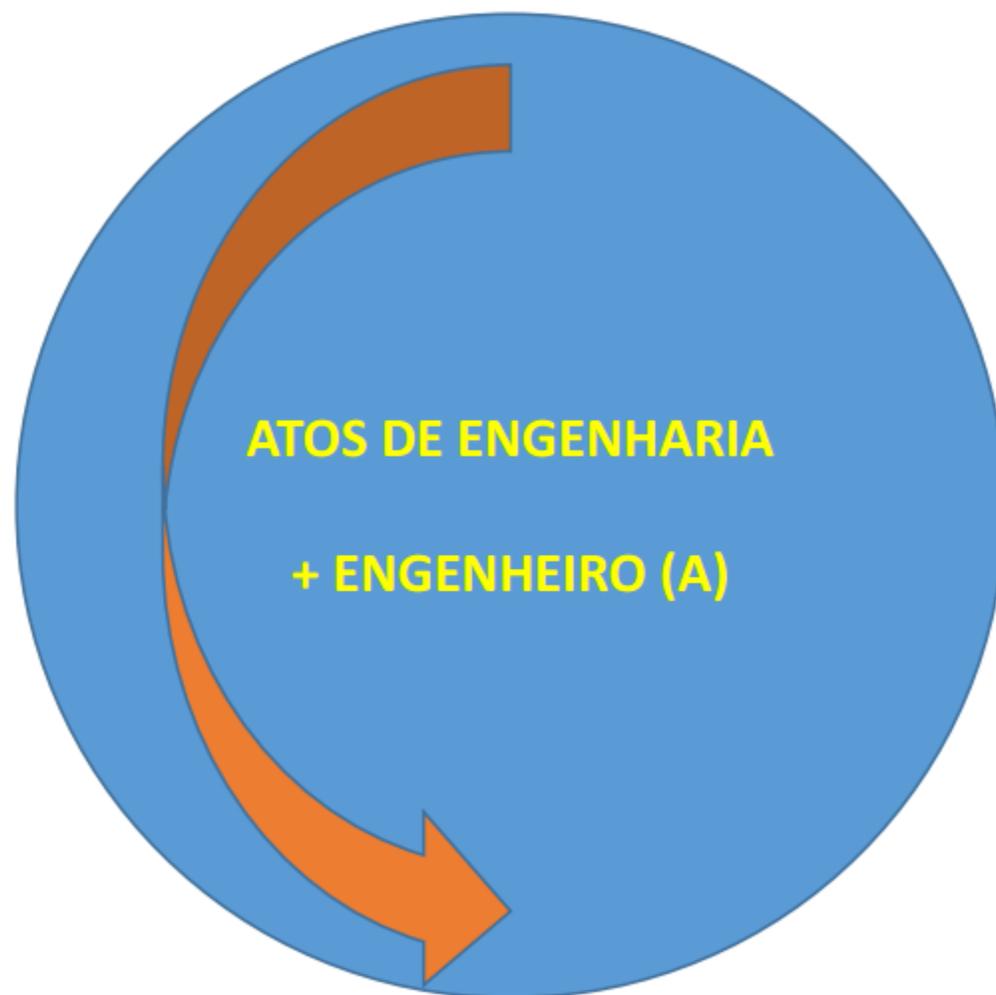


MULTIFÍSICA

- Otimização
- Corpo humano

ROBÓTICA E I.A.
SERÃO MAIS DESORDENADORAS
QUE VAPOR – ELETRIC – COMPUTADOR
Rajiv Kumar

CRIATIVO e EMPREENDEDOR



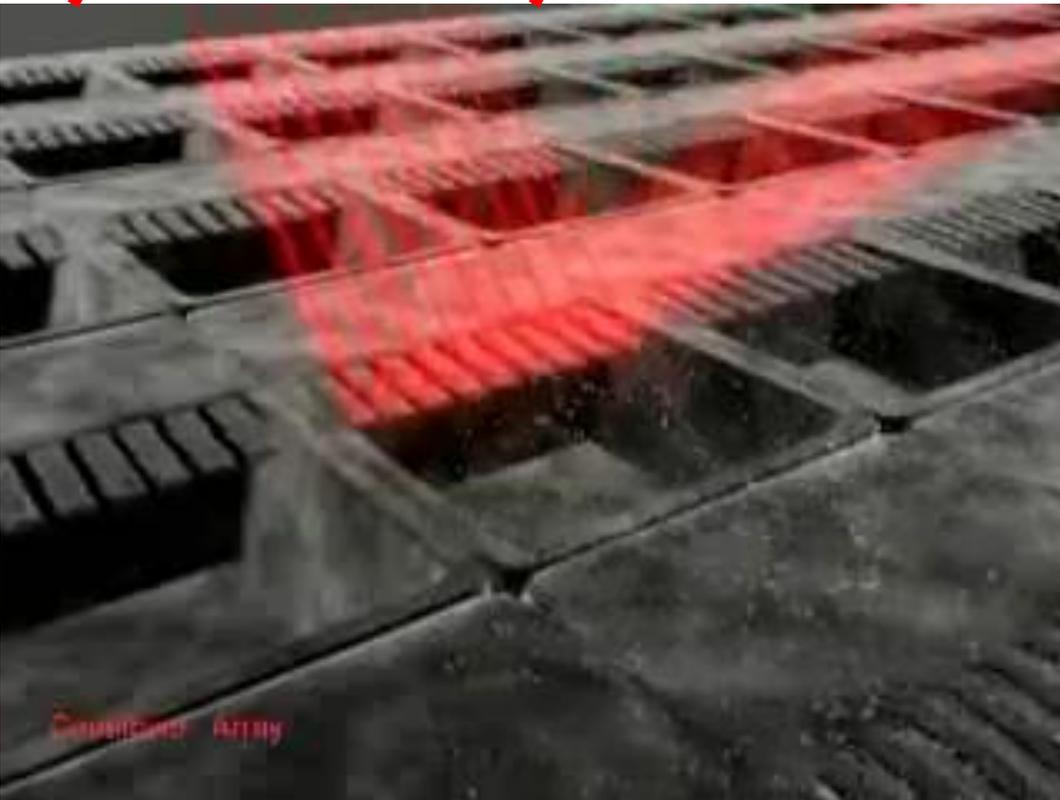
REFLEXIVO

Sinergia

ÉTICO



SÍNTESE INTERDISCIPLINAR: nano-balança

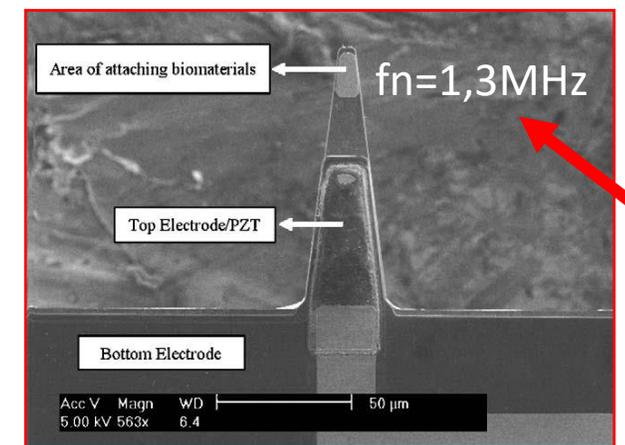


Dimensões típicas:

$H=0,2-1\mu\text{m}$

$B=20-100\mu\text{m}$

$L=100-500\mu\text{m}$



- Viga opera na frequência natural via circuito oscilador
- Anticorpo anti-insulina é imobilizado no sensor
- Sensor é imerso na solução teste
- Insulina se liga ao anticorpo aumentando massa
- Insulina é detectada por um contador de frequência.
- **$\Delta f=217\text{Hz}$, $\Delta m=0,45821\text{E}-15\text{g}$**
- contra $0,595\text{E}-15\text{g}$ experimental

Interdisciplinar: modelagem e análise do coração humano: mec. + elétr. + fluidos

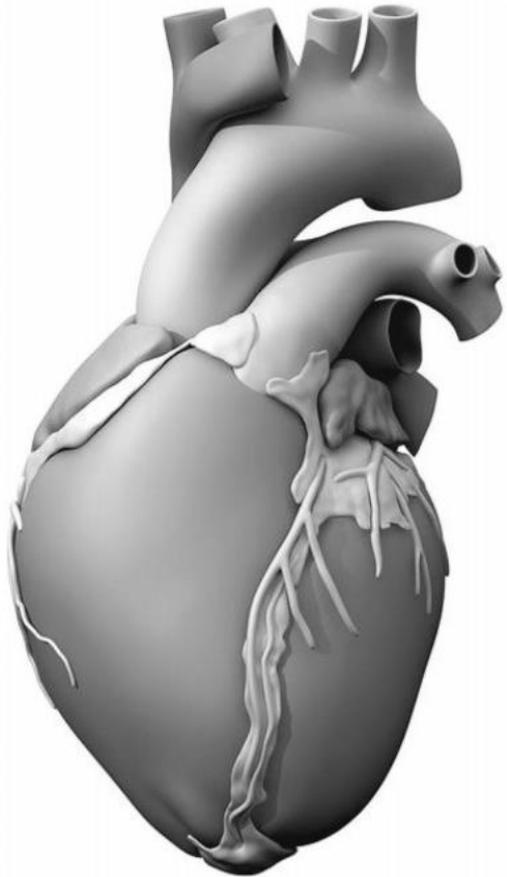


FIGURE 1. Solid model of the human heart used as the basis for our improved model. It was created from computed tomography and magnetic resonance imaging; adapted with permission from (Zygo Media Group and Inc., 2014).

Cardiac Engineering and Technology (© 2015)
DOI: 10.1007/s13239-015-0214-z

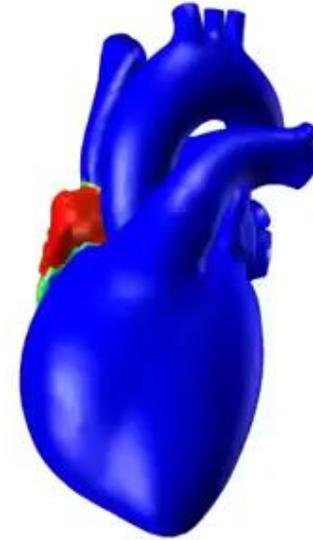


Human Cardiac Function Simulator for the Optimal Design of a Novel Annuloplasty Ring with a Sub-valvular Element for Correction of Ischemic Mitral Regurgitation

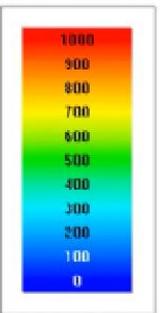
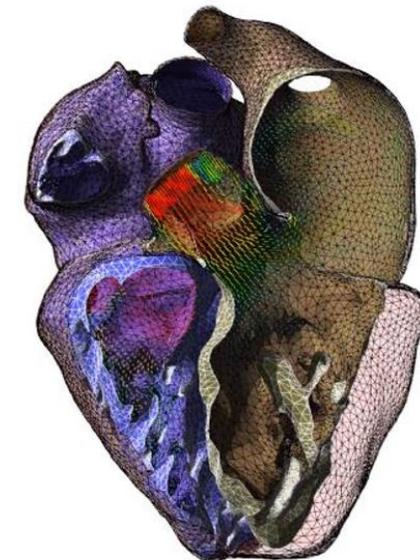
BRIAN BALLARGEON,¹ IVAN COSTA,² JOSEPH R. LEACH,³ LIK CHUAN LEE,⁴ MARTIN GENET,^{5,6}
ARNAUD TOUTAIN,⁶ JONATHAN F. WIENK,⁷ MANUEL K. RAUSCH,⁸ NUNO REBELO,¹
GABRIEL ACEVEDO-BOLTON,^{3,9} ELLEN KUH,⁹ JOSE L. NAVIA,⁷ and JULIUS M. GUCCIONE,^{6,10}



FIGURE 4. Mechanical finite element model of the human heart discretized with 449,560 linear tetrahedral elements, 12,915 linear quadrilateral shells, 7577 linear triangular shells, 636 linear truss elements, 16,824 rigid triangular elements, 130,290 nodes, and 443,564 mechanical degrees of freedom.



The
Living
Heart
Project



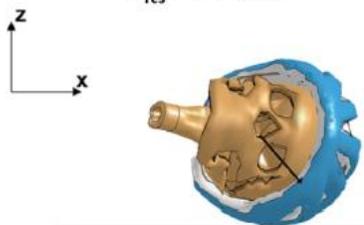
Velocity
[mm/s]

Uso de capacetes de bicicletas protegem contra:

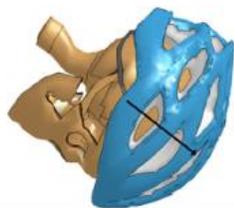
> dano no cérebro (-) e fraturas (+)

> redução de tensões de 80 MPa para 15 MPa

$v_{res} = 5.3 \text{ m/s}$
 $w_{res} = 4.7 \text{ rad/s}$



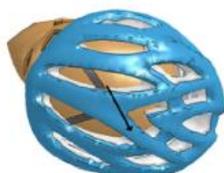
$v_{res} = 7.2 \text{ m/s}$
 $w_{res} = 1.8 \text{ rad/s}$



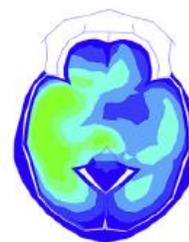
$v_{res} = 4.3 \text{ m/s}$
 $w_{res} = 2.2 \text{ rad/s}$



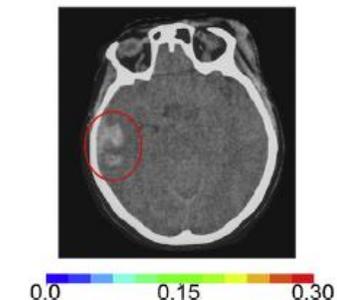
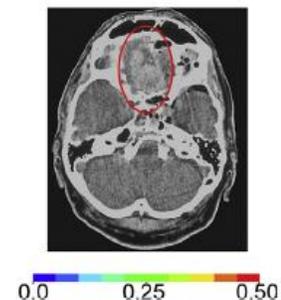
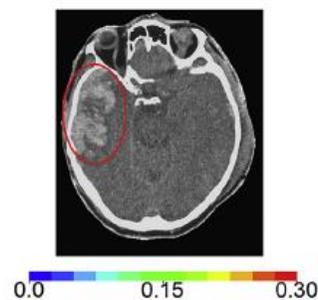
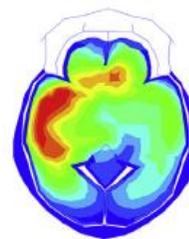
z
 y



Helmet



No
Helmet



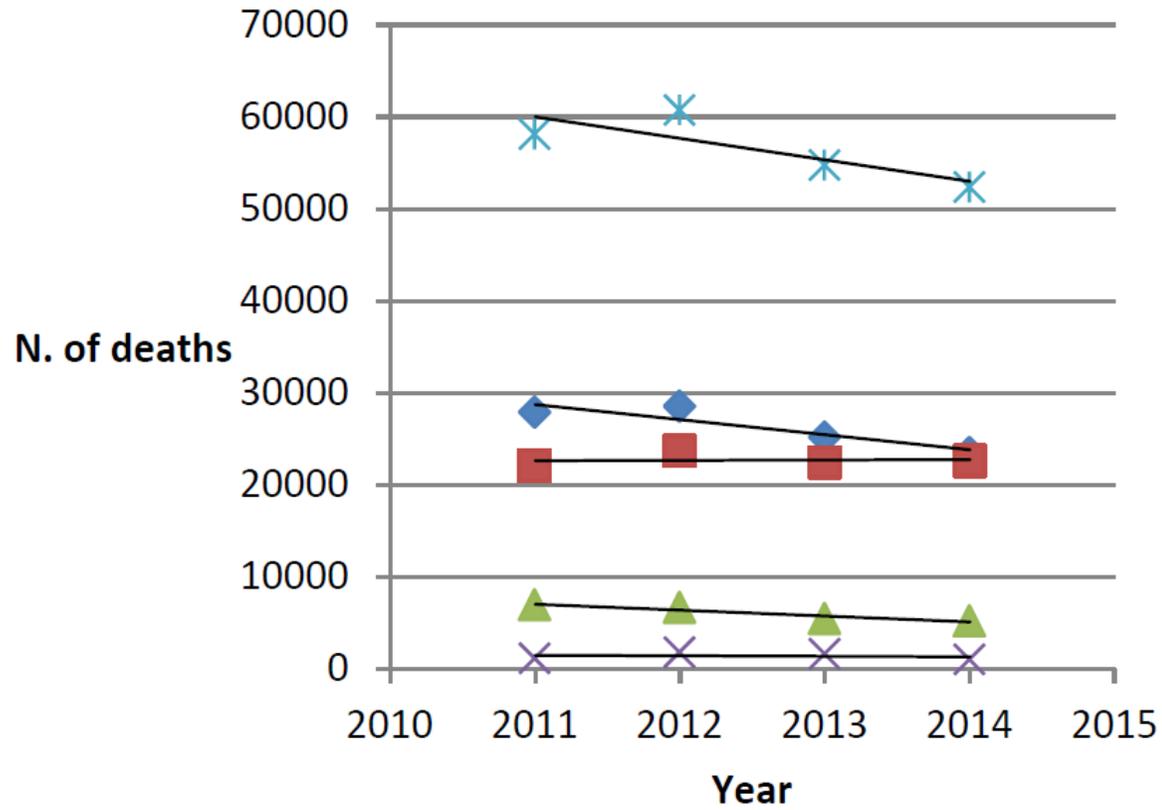
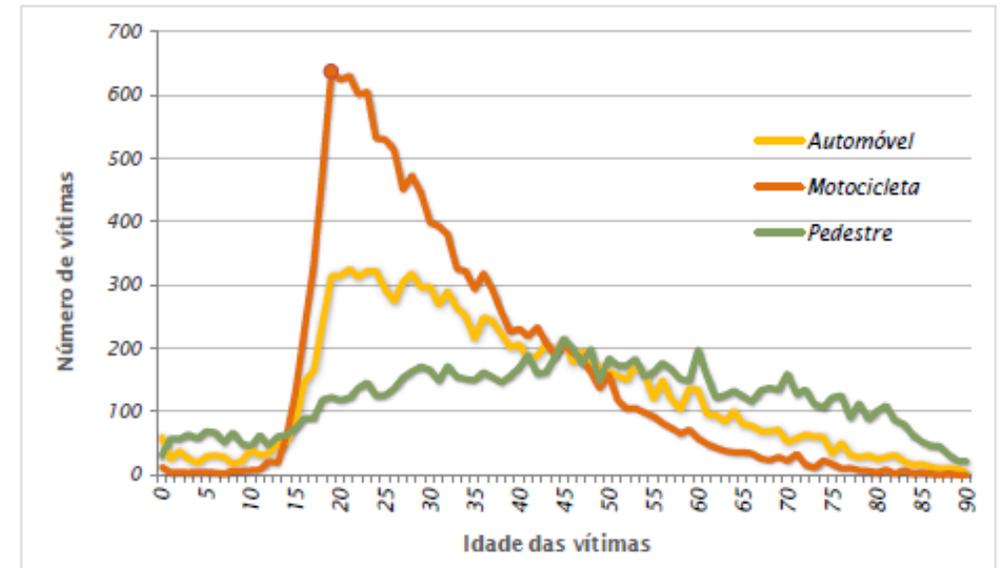
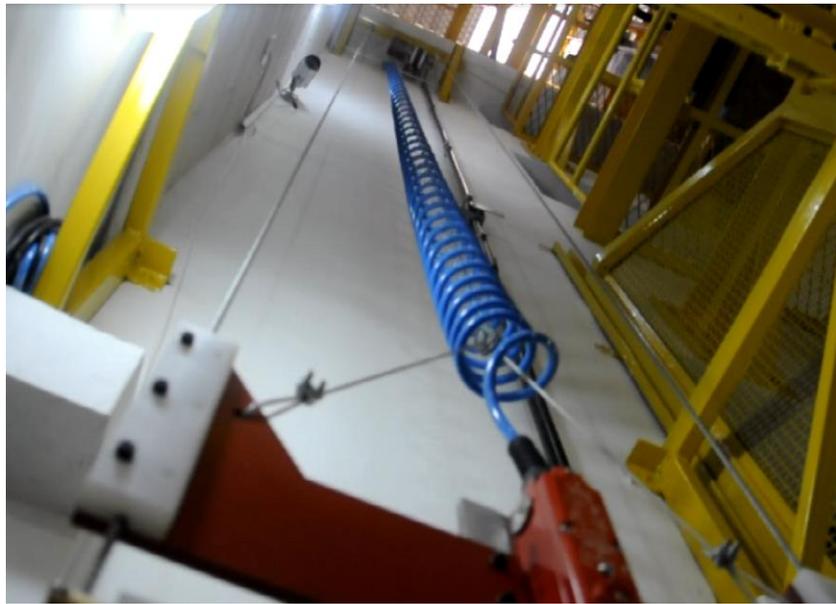


Gráfico 10.1.1. Número de óbitos em acidentes de trânsito por idades simples e categoria 1. Brasil. 2011.



Fonte: SIM/SVS/MS



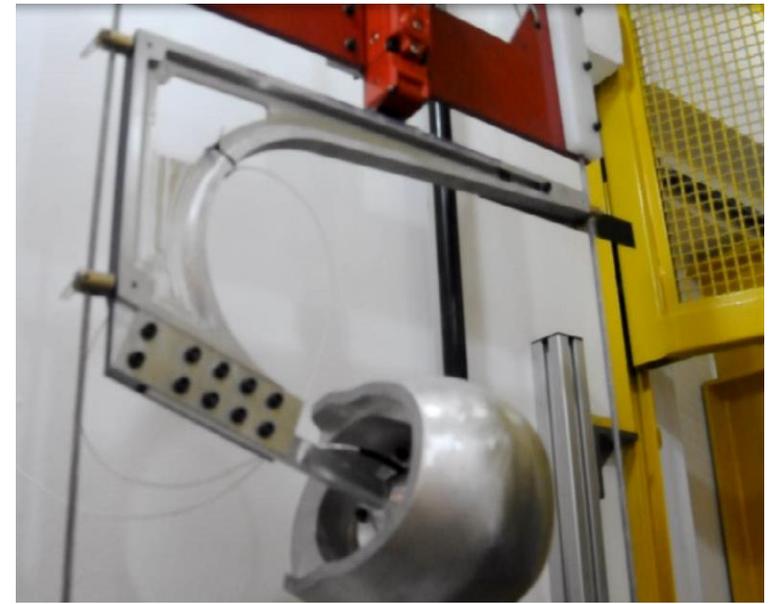


UN
BRASIL

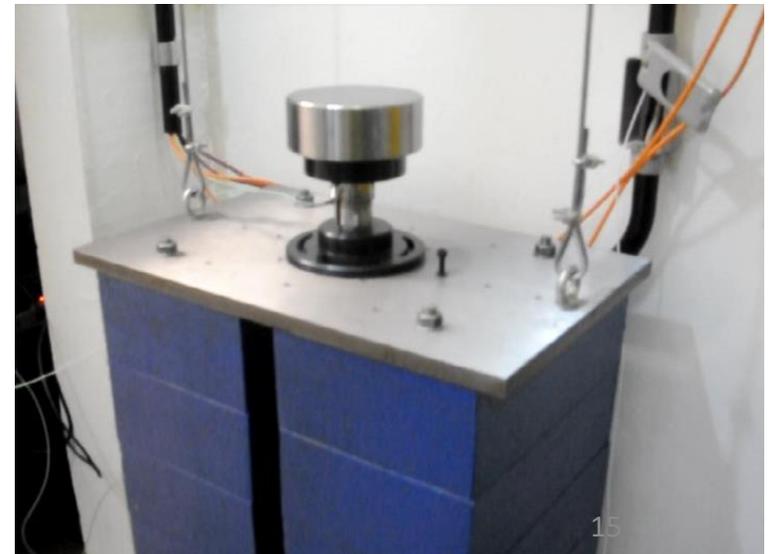
27.0 km/h = 7.5 m/s
25.2 km/h = 7.0 m/s

$a_{max} = 275 \text{ g}$ e $\text{HIC} < 2400$
 $a_{max} = 300 \text{ g}$ e $< 150 \text{ g @ 5 ms}$

Flat + Kerbstone R = 15 mm
Flat + Hemispherical R = 50 mm



| Type | Origin | EXPEC RESULTS |
|----------------------|--------|--------------------|
| AGV K3 | IMP | ★★★★★ |
| Shark S700 | IMP | ★★★★★ |
| LS2 FF358 | IMP | ★★★★ 4 Stars in EU |
| Protork Evolution 3G | BR | ★★★★ |
| EBF <u>Rox</u> | BR | 0 |
| Taurus San Marino | BR | 0 |
| EBF E8 | BR | 0 |
| NORISK FF391 | IMP | 0 |
| Protork Liberty 4 | BR | - |
| Taurus <u>Zaref</u> | BR | 0 |



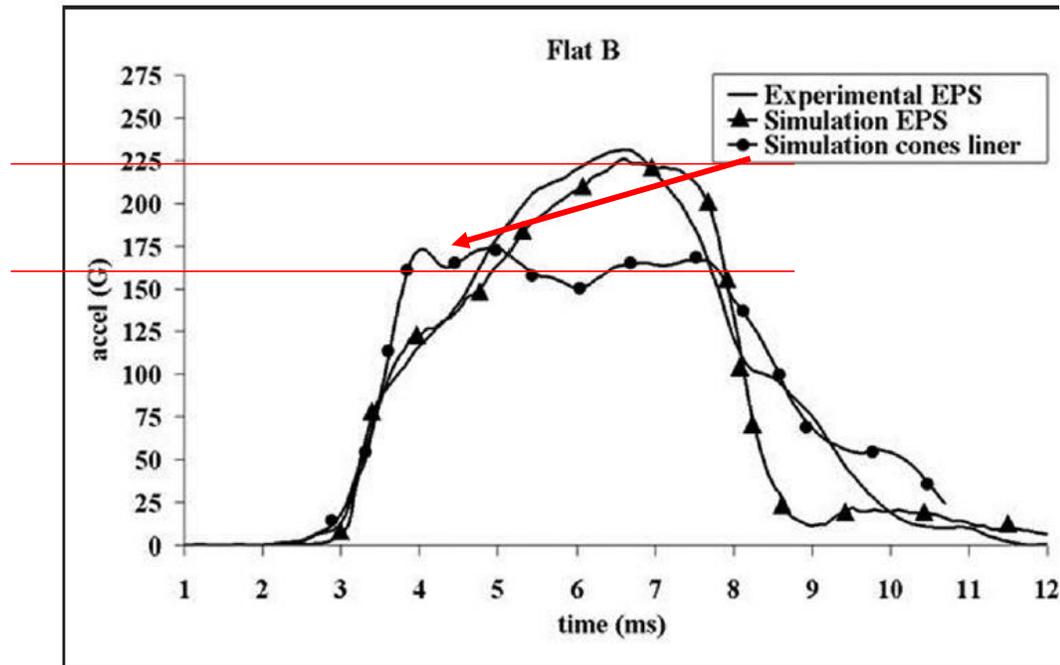
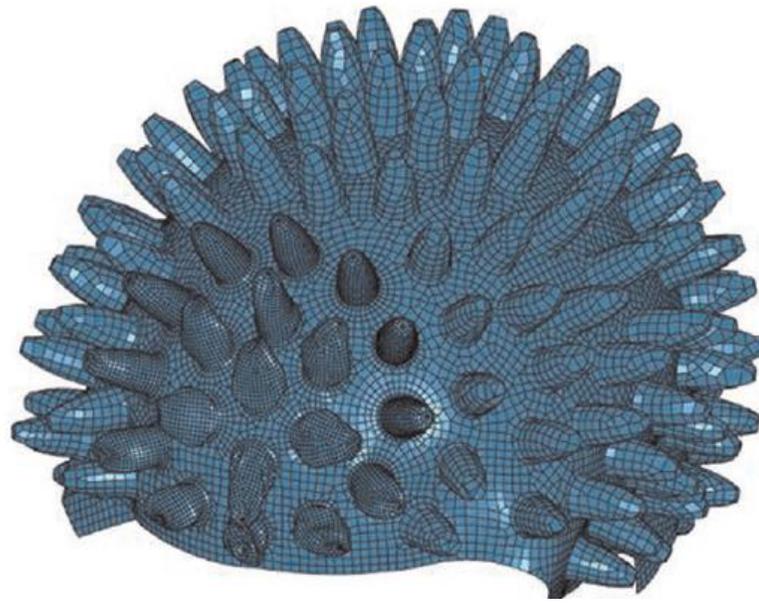
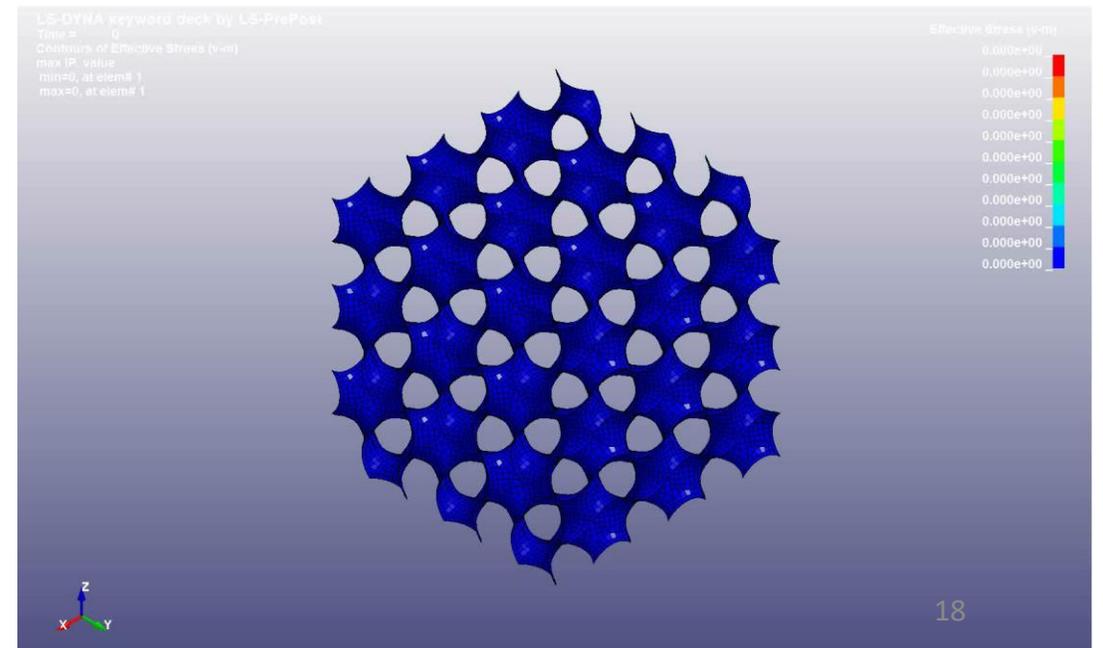
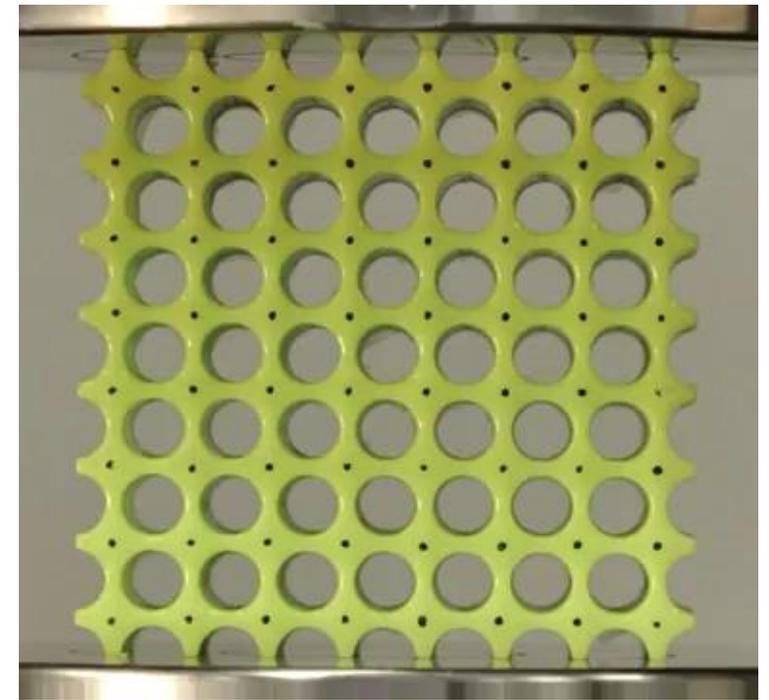


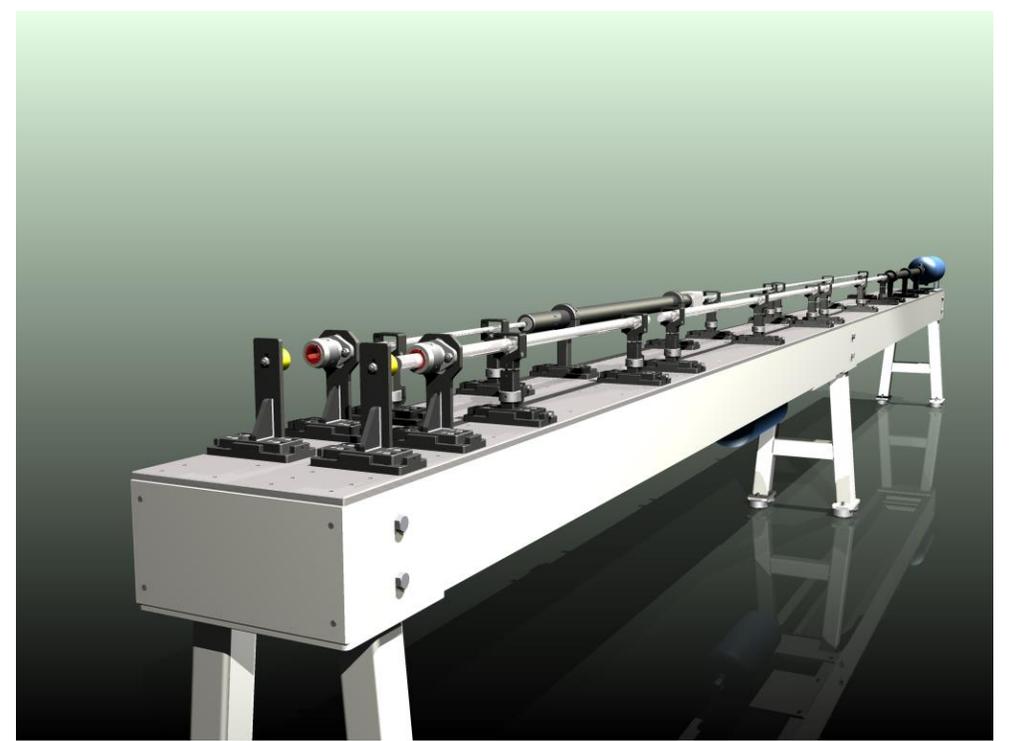
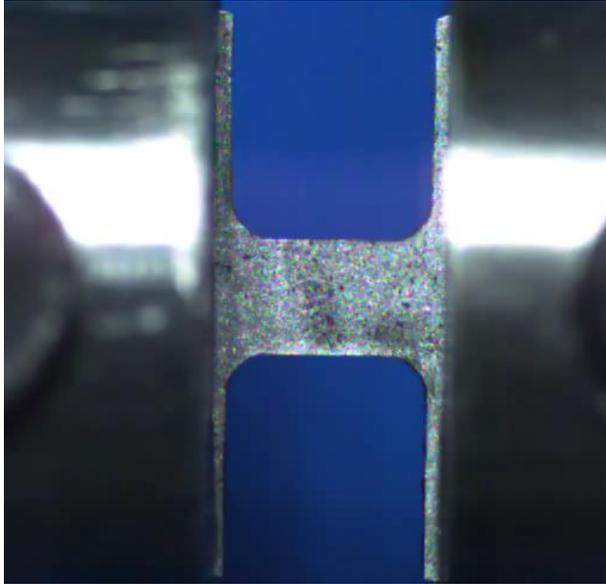
Figure 17. Comparison between experimental and numerical data for impact at point B. EPS: expanded polystyrene.

Metamateriais [futuro]

Metamateriais: propriedades macroscópicas vêm + de sua subestrutura e – da composição química

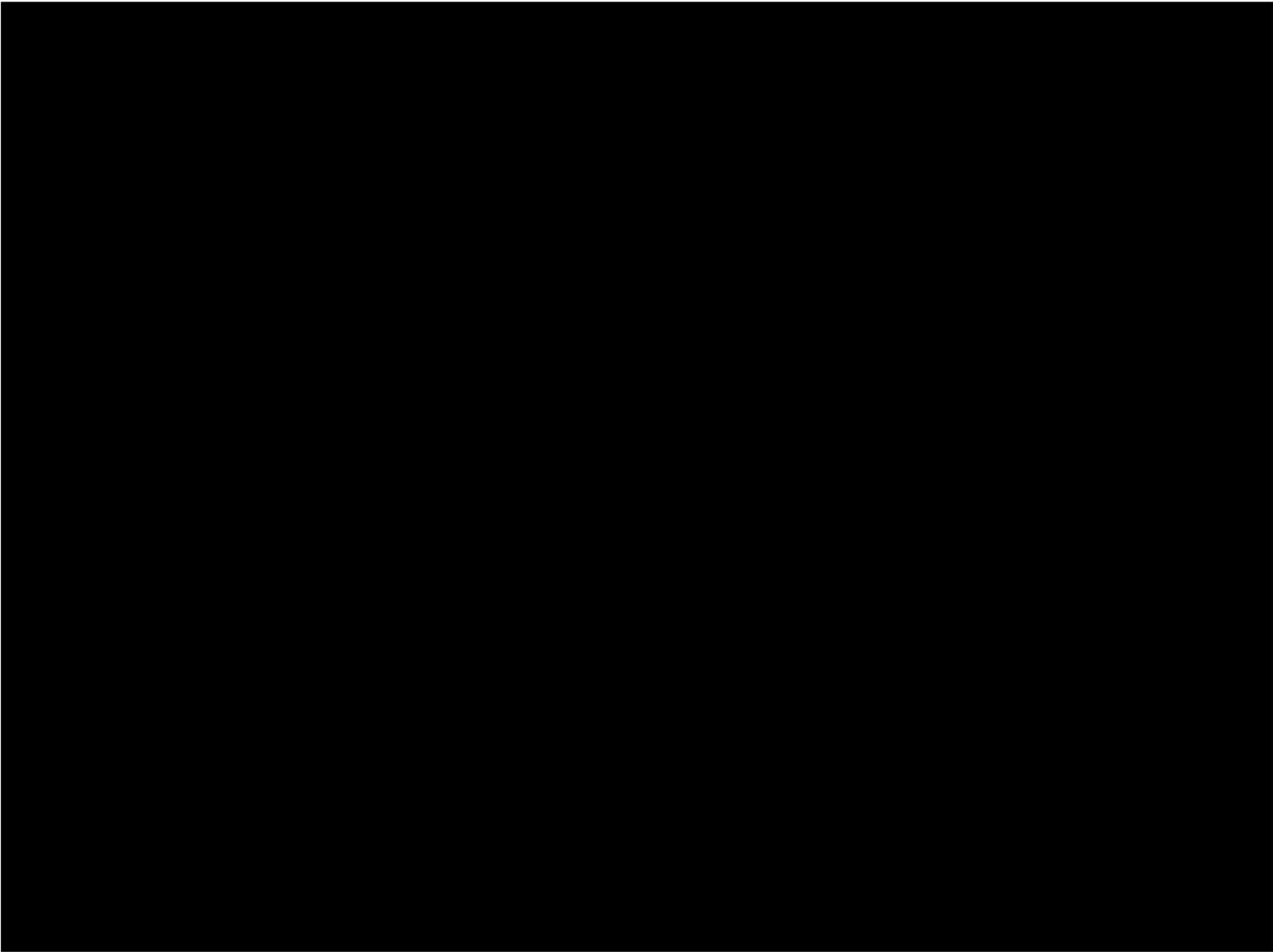


Barra de Hopkinson: síntese como um *ato de engenharia*



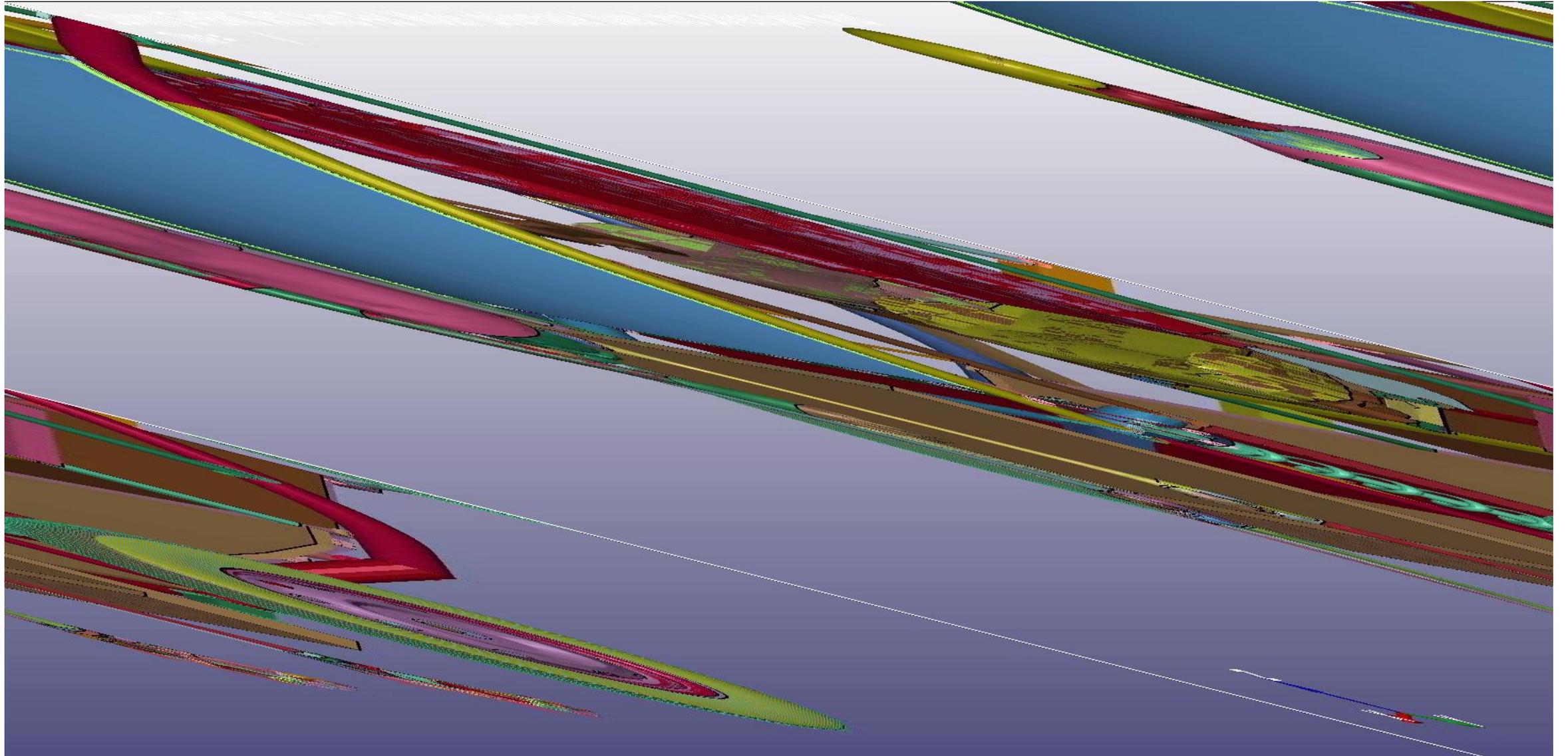
FASTCAM-APX RS 25...
30000 fps
1/30000 sec
384 x 176
frame : -11600
-00:00:00.386667sec
Photron

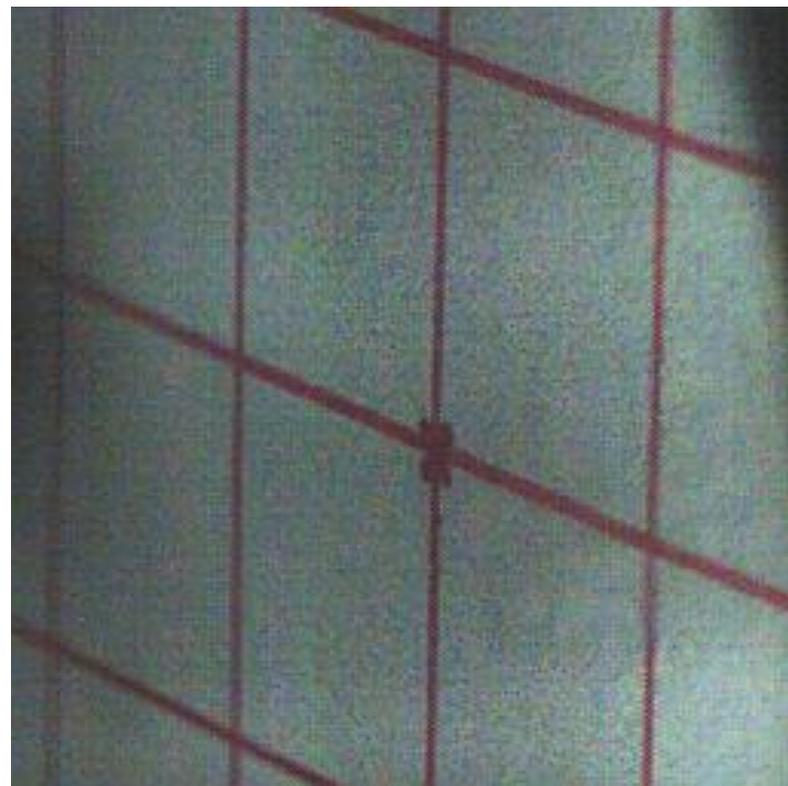
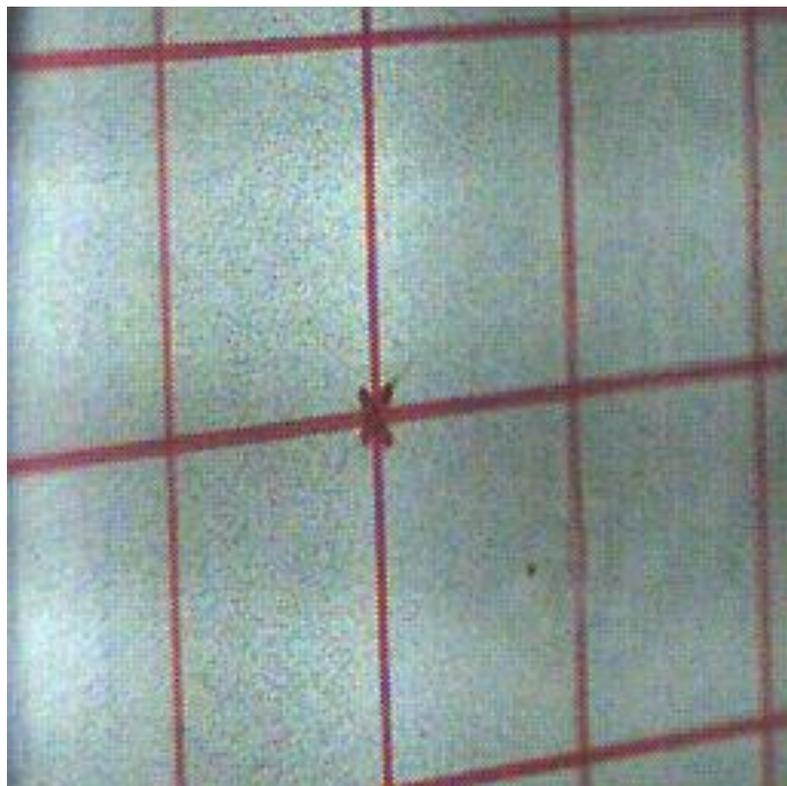
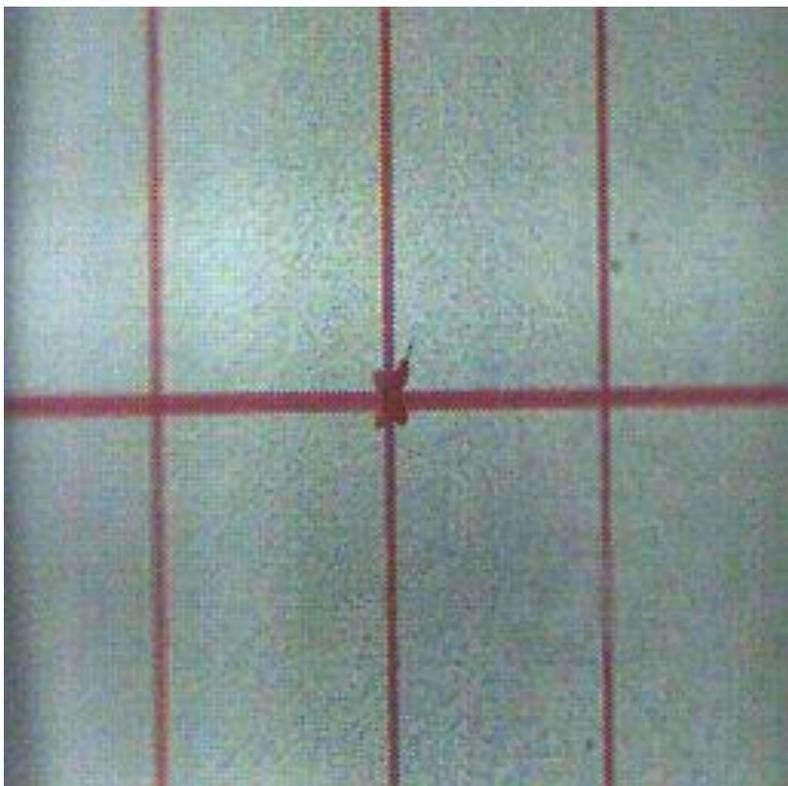




Car crash

aus





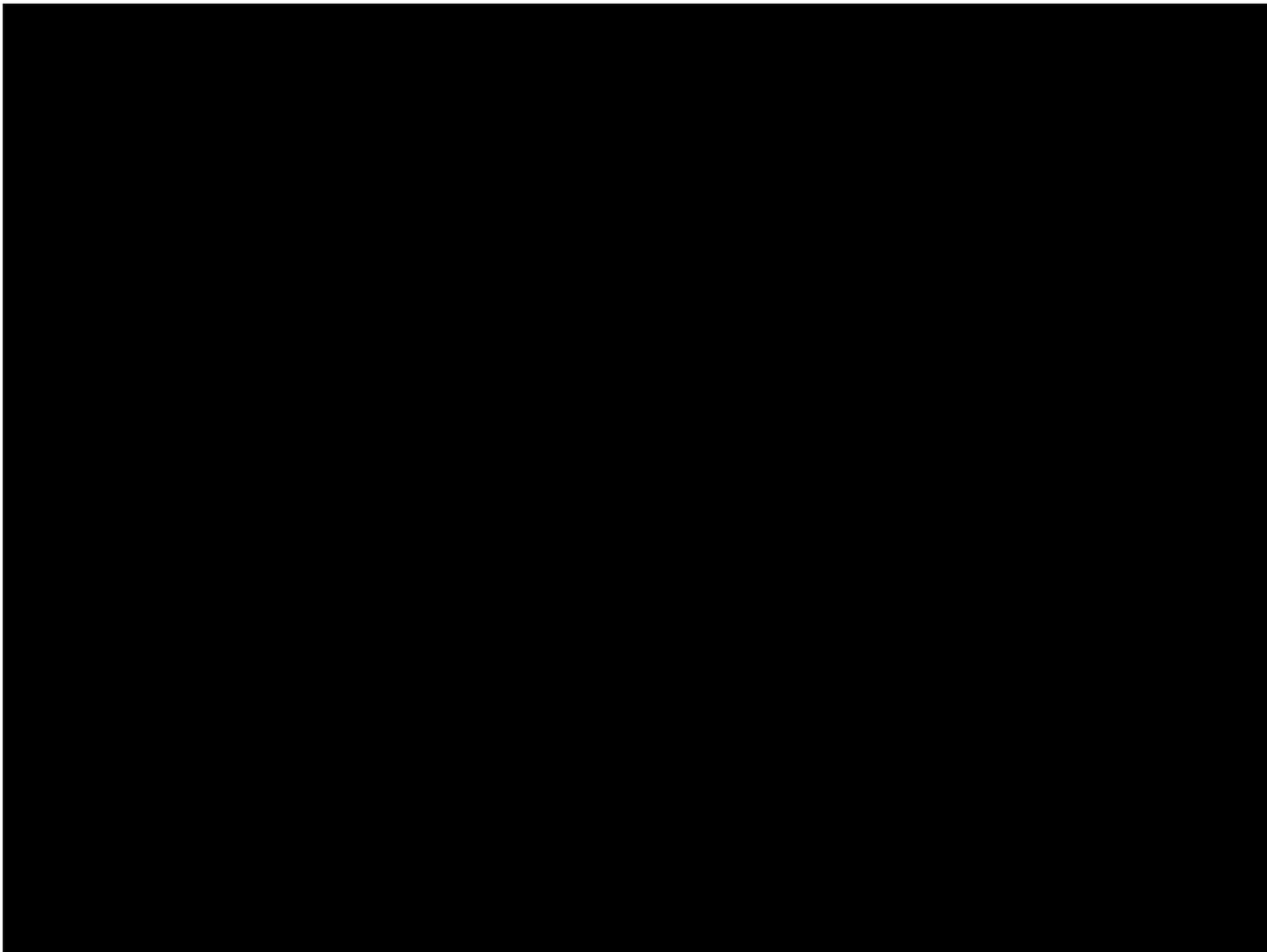
STORY OF THE

NARROWS BRIDE

— 1940

Dyn vibration absorber

- <https://www.youtube.com/watch?v=xqELmBNyWfU> [Taipei]
- <https://www.youtube.com/watch?v=cG00gZE3RfU> [stock bridge damper]



https://www.youtube.com/watch?v=eAXVa_XWZ8

<https://www.youtube.com/watch?v=gQK21572oSU> London bridge opening

The Resonant Bridge

**by Bob Barrett
Messiah College
Box 3041**

Grantham PA 17027 USA

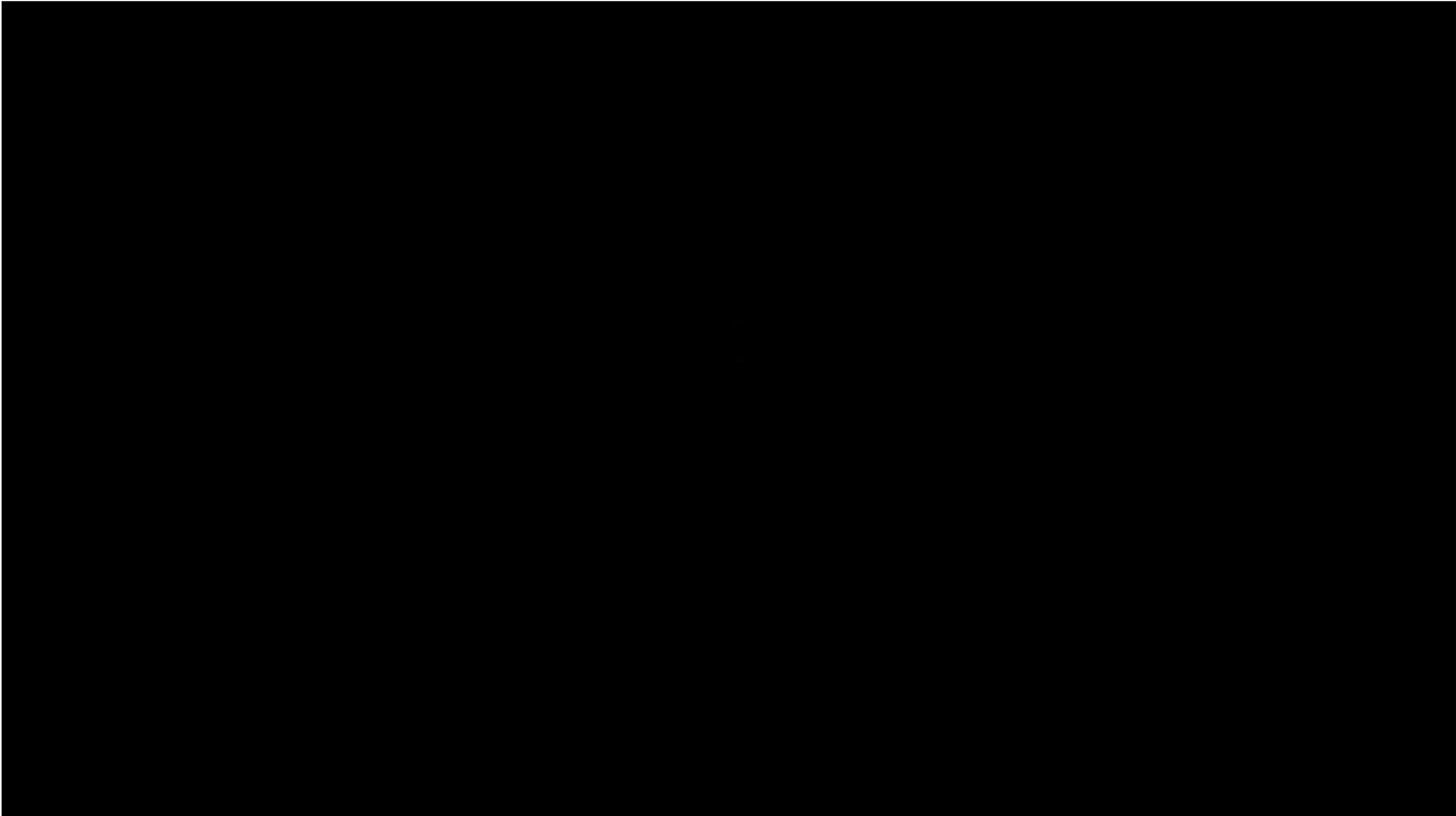


https://www.youtube.com/watch?v=uENITui5_jU water hose

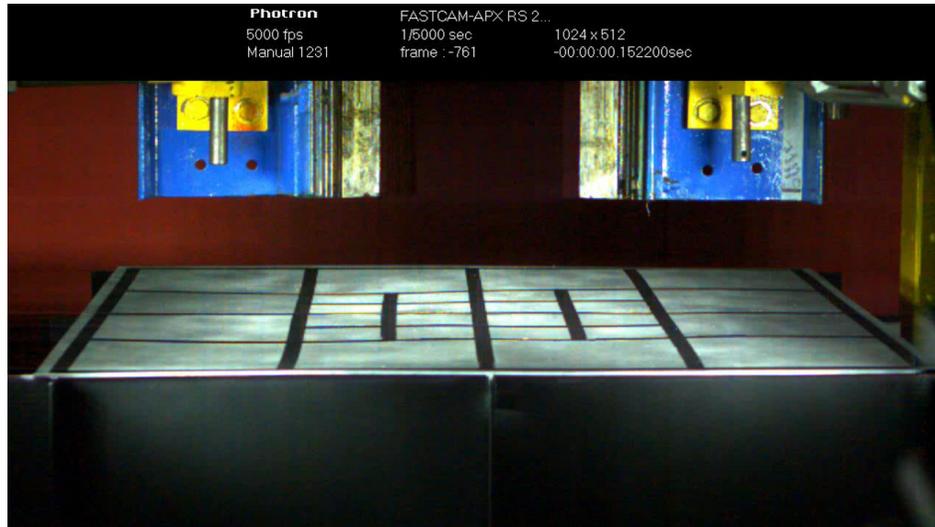
<https://www.youtube.com/watch?v=Q3oltPva9fs#t=10> cinematics

All of the experiments
in this video are real.

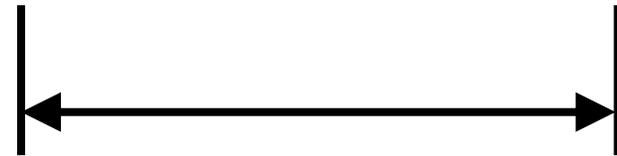
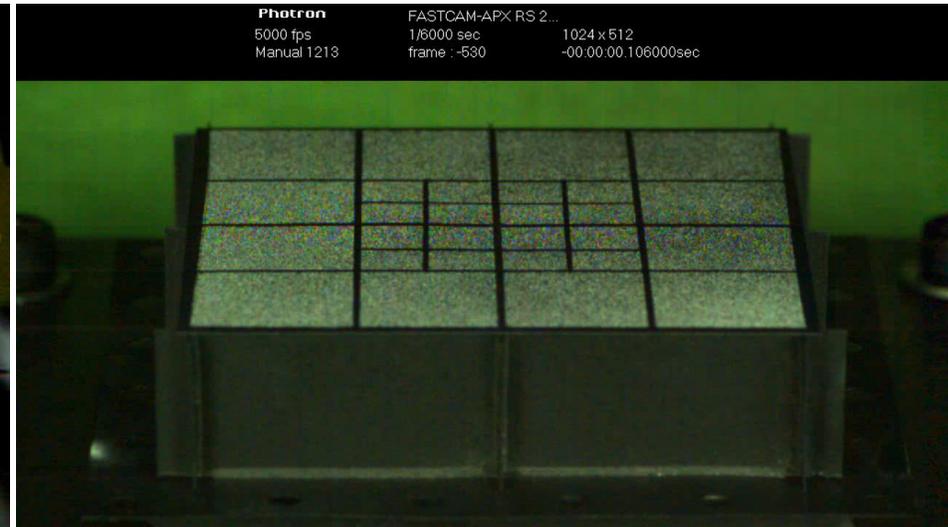
<https://www.youtube.com/watch?v=vvJAgUBF4w> plate vibration







1 m
prototype



83 mm
model





Trabalho do músculo convertido para salto, com g afetando modelo e protótipo

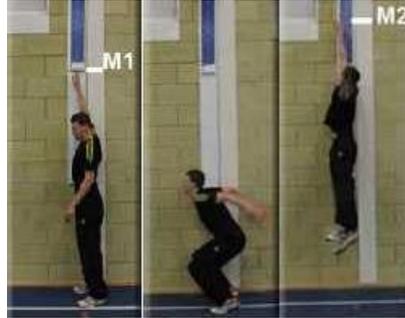
$$E_p = mgh$$

$$W = Fd$$

$$E_p = W$$

$$h = \frac{Fd}{mg}$$

$$h \propto \frac{L^2 L}{L^3} \propto L^0$$



70 kg

70 cm



3 g

59 cm



40 mg

30 cm



0,49 mg

20 cm

Todos os animais, conquanto de mesmo estilo, com suas alavancas na mesma proporção, devem saltar não à mesma posição relativa, mas à mesma posição de fato.

- Altura do salto não depende da massa
- Peso difere por mais de 100 milhões

FIG. 10

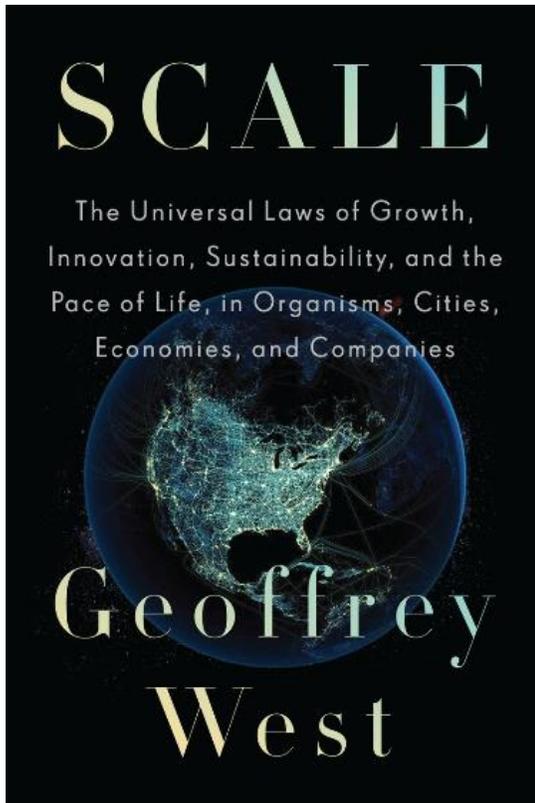
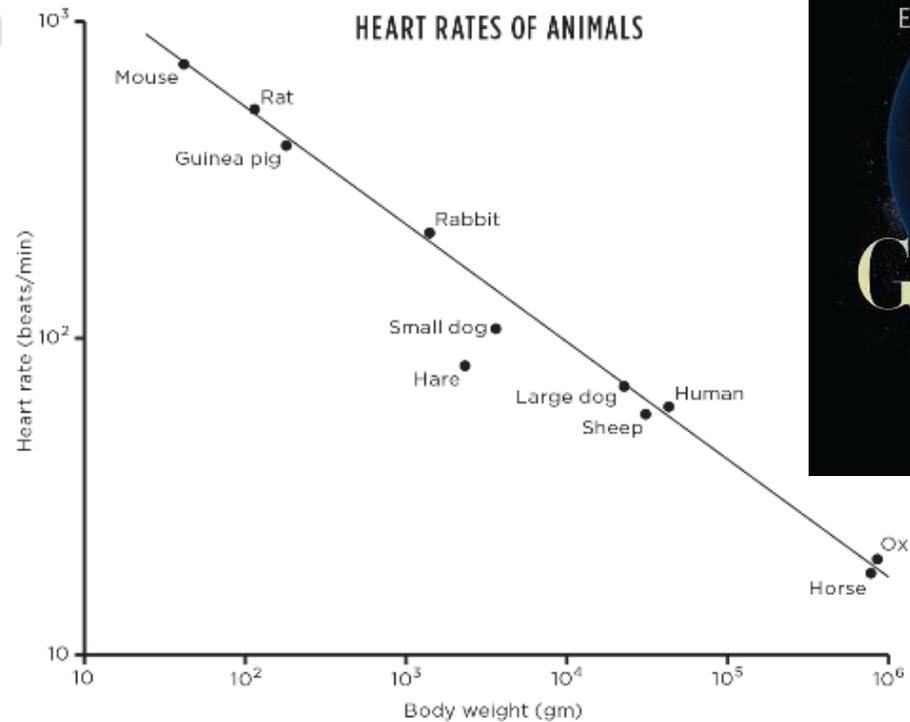


FIG. 11

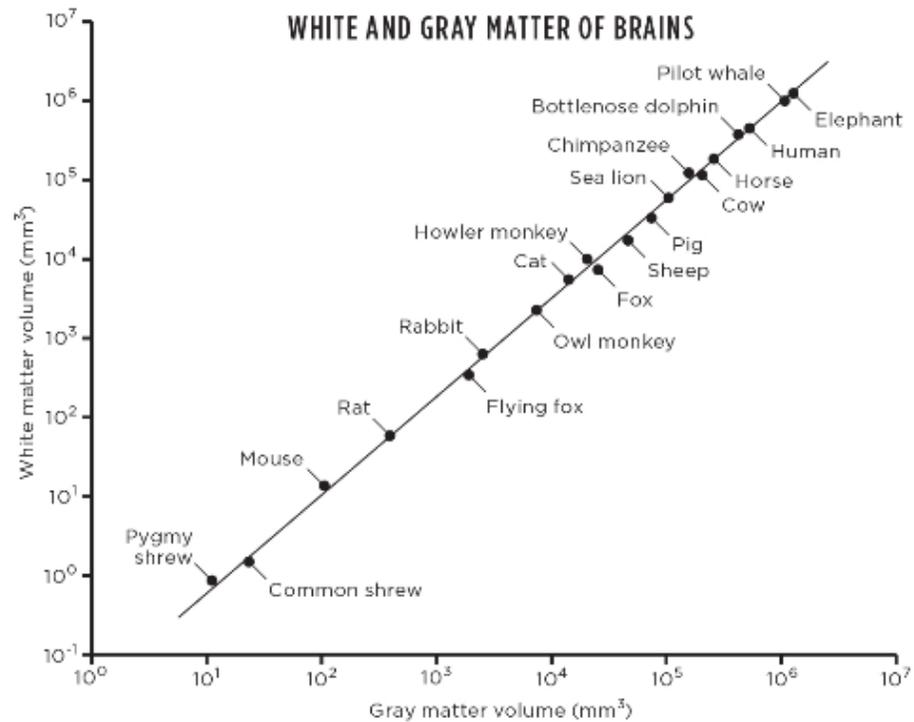


FIG. 2

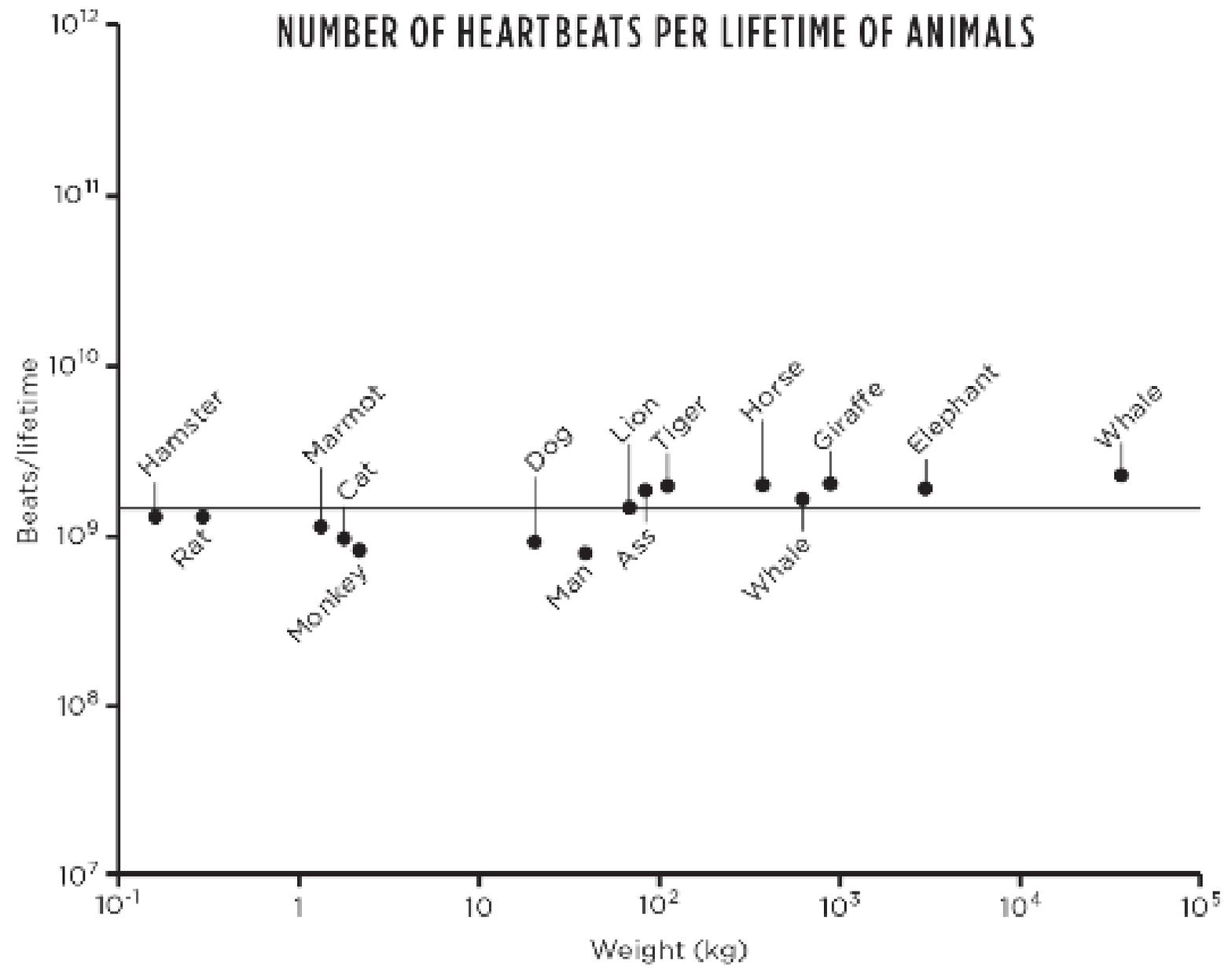


FIG. 3

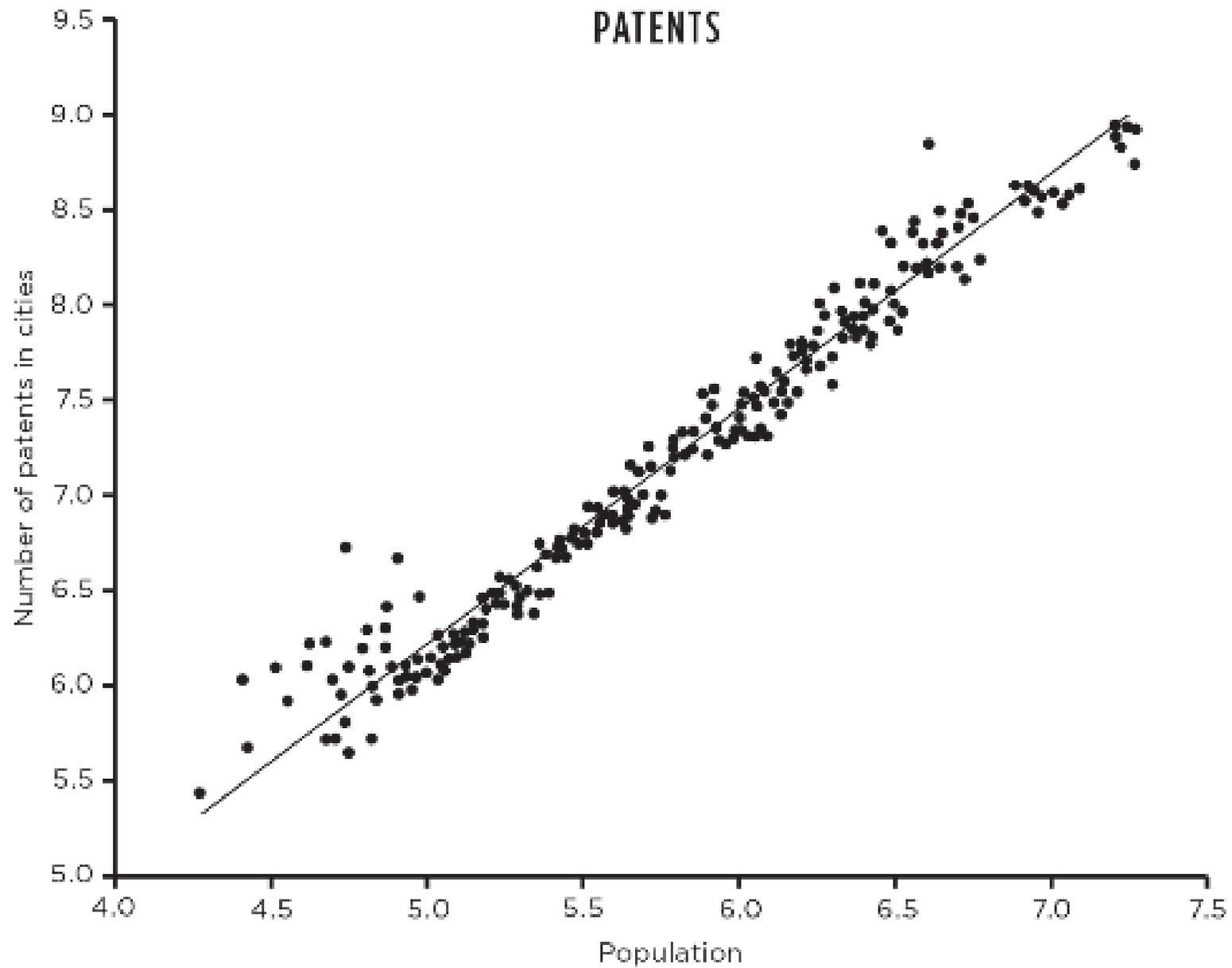


FIG. 4

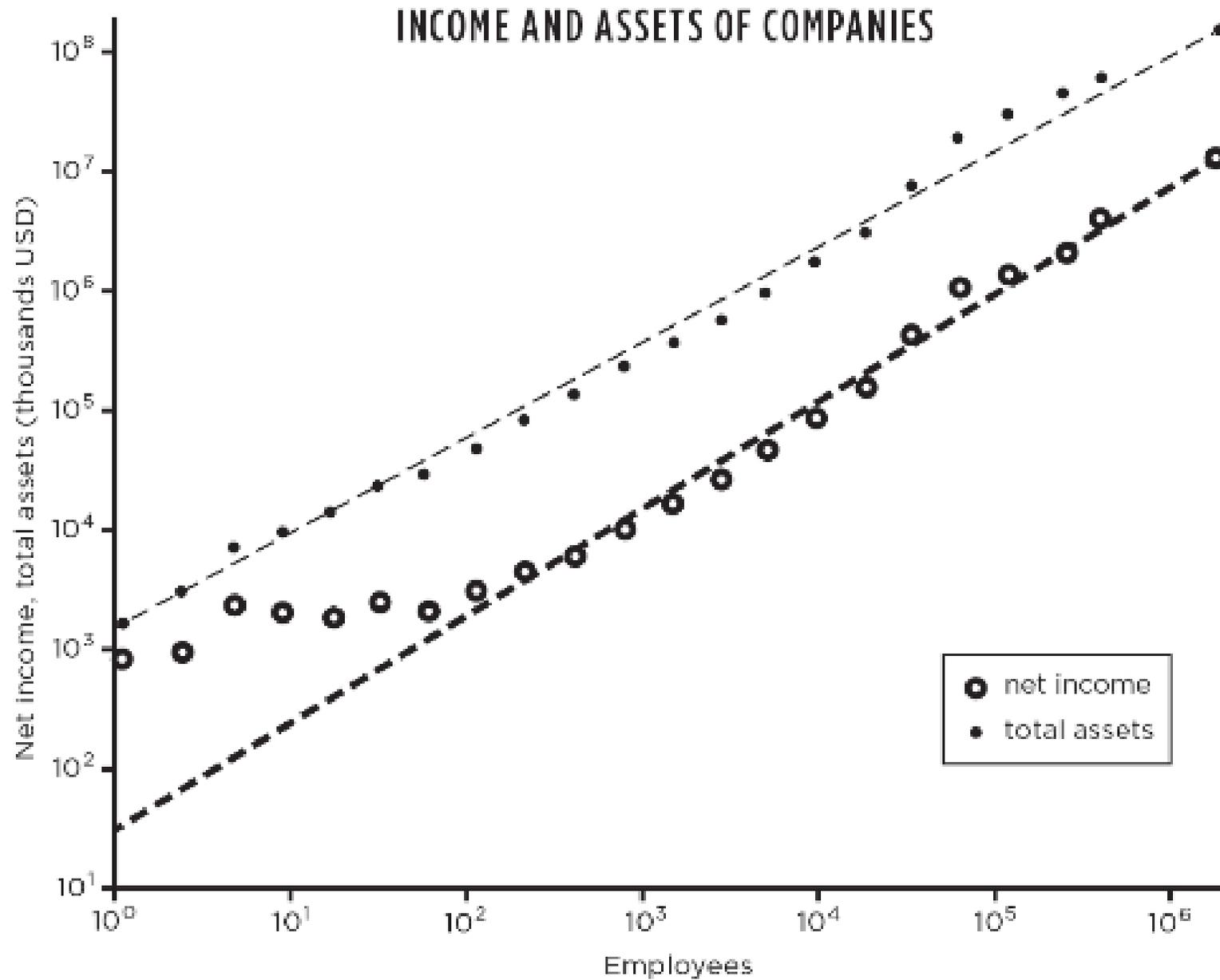
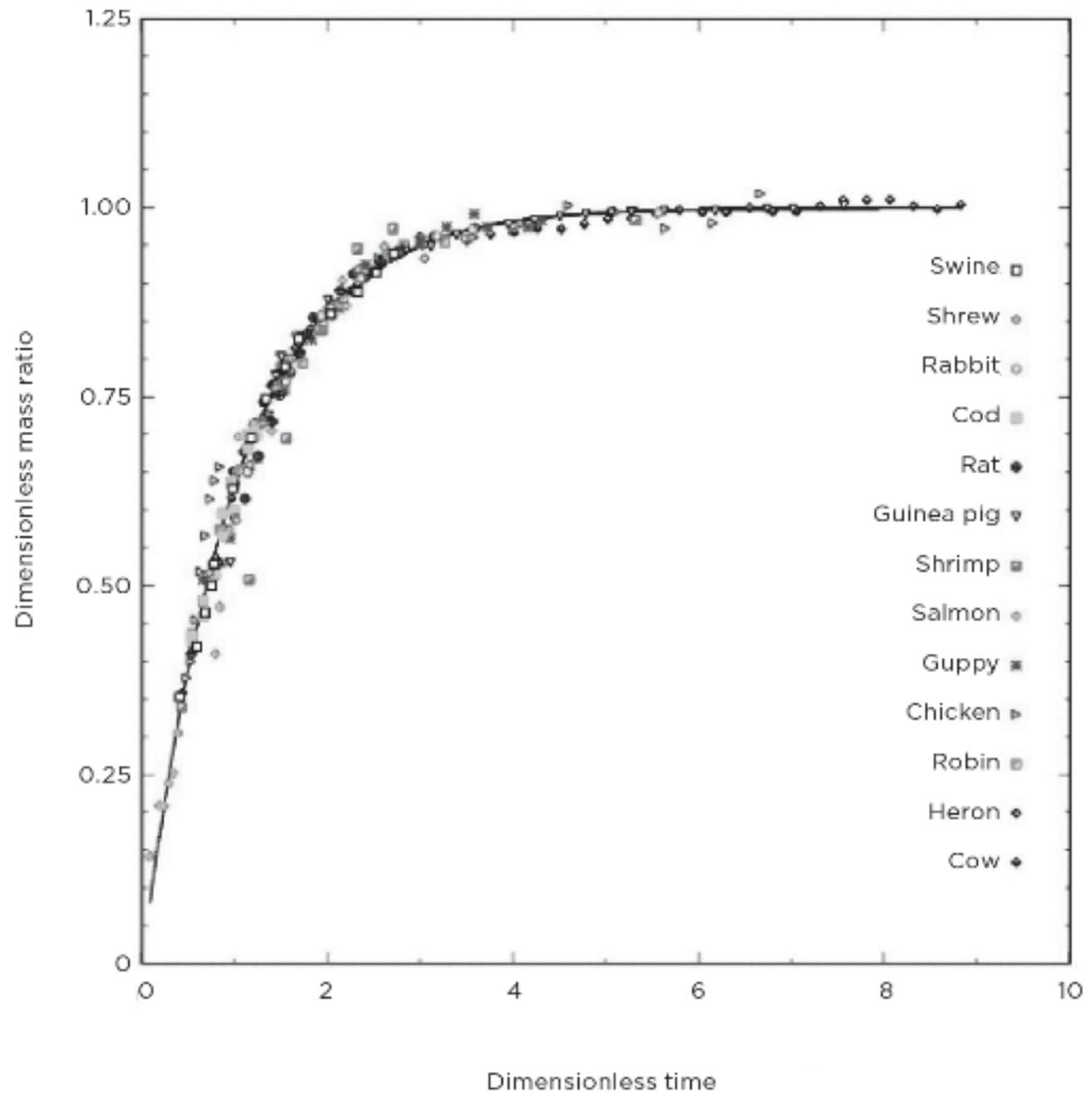


FIG. 19



The Seven Social Sins, as quoted
by Mahatma Gandhi in "Young India," 1925:

1. Politics without principles
2. Wealth without work
3. Pleasure without conscience
4. Knowledge without character
5. Commerce without morality
6. Science without humanity
7. Worship without sacrifice

Modus operandi

- Aulas expositivas gravadas e em inglês [se não houver objeções]
- Demonstrações experimentais dentro do possível
- Uso do Abaqus Student [cada um instala o seu]
- <https://academy.3ds.com/en/software/abaqus-student-edition>
- Avaliações resultam de única nota P1
- Avaliações: modelagem/análise teórica/exp/num de um sistema

Vibrações

| Aula | Data | Tema | Professor[a] |
|------|------|--|--------------|
| 1 | 18/8 | Introdução à Disciplina e a Vibrações | Marcílio |
| 2 | 19/8 | Vibrações de sistemas discretos: modelagem | Marcílio |
| 3 | 25/8 | Vibrações de sistemas discretos 1 GL | Marcílio |
| 4 | 26/8 | Vibrações de sistemas 1 GL com amortecimento | Marcílio |
| 5 | 20/8 | Vibrações de sistemas 1 GL forçado | Marcílio |
| 6 | 1/9 | Vibrações de sistemas 2 GL: absorvedores dinâmicos | Marcílio |
| 7 | 2/9 | Vibrações de hastes | Marcílio |
| 8 | 8/9 | Vibrações livres de vigas | Marcílio |
| 9 | 9/9 | Vibrações livres de vigas | Marcílio |
| 10 | 15/9 | Vibrações forçadas de vigas | Marcílio |
| 11 | 16/9 | P1 | Marcílio |

Fourier e Bode

| | | | |
|----|-------|-------------------------|---------|
| 12 | 22/9 | Transformada de Fourier | Larissa |
| 13 | 23/9 | Transformada de Fourier | Larissa |
| 14 | 29/9 | Transformada de Fourier | Larissa |
| 15 | 30/9 | Transformada de Fourier | Larissa |
| 16 | 6/10 | Diagrama de Bode | Larissa |
| 17 | 7/10 | Diagrama de Bode | Larissa |
| 18 | 13/10 | Diagrama de Bode | Larissa |
| 19 | 14/10 | Diagrama de Bode | Larissa |

Modelagem

| | | | |
|----|-------|---------------------------------------|---------|
| 20 | 20/10 | Modelagem de sistemas elétricos | Ettore |
| 21 | 21/10 | Modelagem de sistemas elétricos | Ettore |
| 22 | 27/10 | Modelagem de sistemas eletrônicos | Ettore |
| 23 | 28/10 | Modelagem de sistemas eletrônicos | Ettore |
| 24 | 3/11 | Modelagem de sistemas eletrônicos | Ettore |
| 25 | 4/11 | Modelagem de sistemas eletromecânicos | Ettore |
| 26 | 10/11 | Modelagem de sistemas eletromecânicos | Ettore |
| 27 | 11/11 | Modelagem de sistemas hidráulicos | Ettore |
| 28 | 17/11 | Modelagem de sistemas hidráulicos | Ettore |
| 29 | 18/11 | Modelagem de sistemas mecatrônicos | Ettore |
| 30 | 24/11 | Modelagem de sistemas mecatrônicos | Ettore |
| 31 | 25/11 | Modelagem de sistemas mecatrônicos | Ettore |
| 32 | 1/12 | P2 | Larissa |
| 33 | 8/12 | SUB | Larissa |