Física 2 – Ciências Moleculares

Caetano R. Miranda

AULA 2 – 26/02/2025

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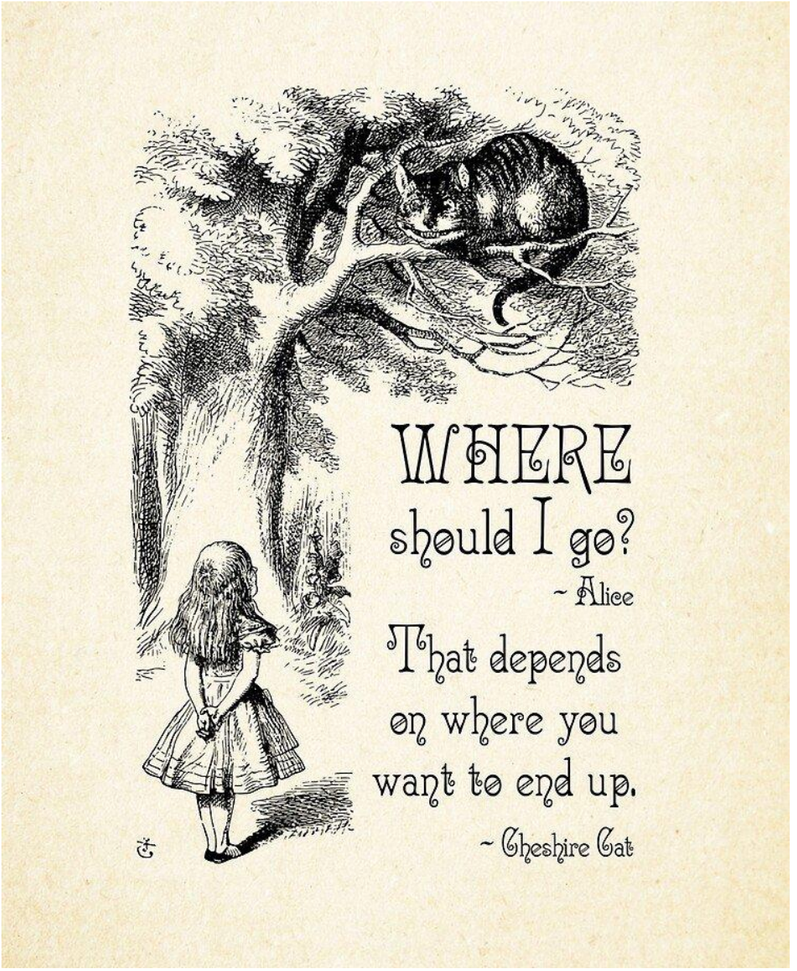
Aula 2 (26/02/2025)

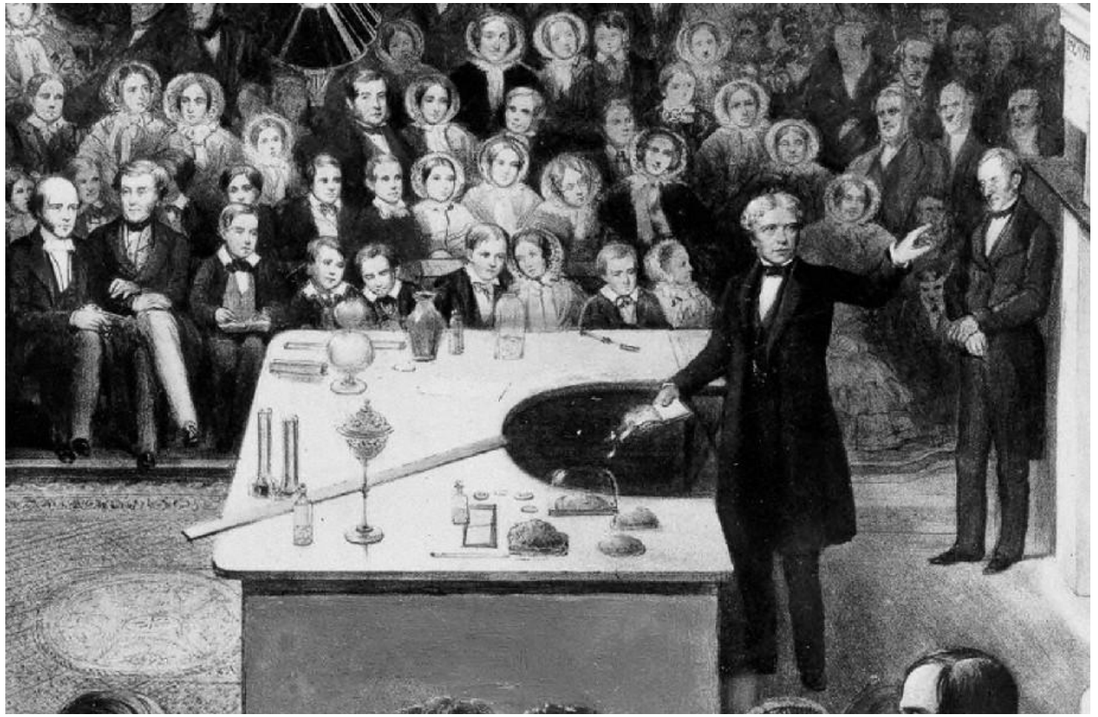
- Aplicações de fronteira em Física II
- Tour sobre as atividades a serem realizadas
- Definição Projetos

"Mas eu não quero ir para o meio de gente louca!"

ITINERÁRIO: PROGRAMAÇÃO E DINÂMICA



Novas e velhas formas



Sala Invertida - The Feynman Lectures on Physics

SESSÃO CINEMA

Richard Feynman's Lecture: Entropy (Part 01)

EduBloq
793 inscritos
Inscrever-se
1,3 mil
Compartilhar

[Richard Feynman's Lecture: Entropy (Part 01) (youtube.com)]

Física II - CCM

- NOTA: 0.25*(P1 + P2 + Média_Entregas + Projeto)

Aprovado(a) se NOTA ≥ 5.0

Recuperação se NOTA ≥ 3.0 (REGRA USP)

Média Final = 0.5*(NOTA + REC) - (REGRA IFUSP*)

Aprovado(a) se Média Final ≥ 5.0

Cronograma

CRONOGRAMA TENTATIVO - FÍSICA II - CCM

DATA	aula nº	Segundas (16h - 18h)	aula nº	Quartas (09h - 12h)	DATA	
24/2	1	Apresentação do curso	2	Projeto - Definição	26/2	
3/3	Feriado	Carnaval	Feriado	Carnaval	5/3	
10/3	3	Revisão matemática	4	Projeto - Ideação	12/3	
17/3	5	DEMO 1 - Pressão	6	Estática dos Fluidos	19/3	
24/3	7	DEMO 2 - Hidrodinamica	8	Hidrodinâmica	26/3	
31/3	9	DEMO 3 - Hidrodinamica II	10	Hidrodinâmica	2/4	
7/4	11	Revisão - P1	12	PROVA 1	9/4	ENTREGA 1
14/4	Feriado	Semana Santa	Feriado	Semana Santa	16/4	
21/4	Feriado	Tiradentes	13	Oscilações I	23/4	
28/4	14	DEMO 4 - Corda vibrante / Molas / Ondulatória	15	Oscilações II	30/4	
5/5	16	Ondas	17	Ondas	7/5	
12/5	18	DEMO 5 - Barulhinho bom	19	Som	14/5	
19/5	20	Revisão - P2	21	PROVA 2	21/5	ENTREGA 2
26/5	22	DEMO 6 - Fenômenos Térmicos e Gases	23	Primeira Lei e Gases	28/5	
2/6	24	DEMO 7 - Máquinas térmicas	25	Segunda Lei	4/6	
9/6	26	DEMO 8 - Cinética & Mecânica Estatística	27	Cinética dos Gases e Mecânica Estatística	11/6	
16/6	Feriado	Corpus Christi	Feriado	Corpus Christi	18/6	
23/6	28	Projeto	29	Apresentações	25/6	ENTREGA 3
30/6	30	PROVA SUB	31	VISTA	2/7	

Cronograma

Fevereiro / Março / Abril / Maio / Junho

Fluídos

Hidrodinâmica

Oscilações

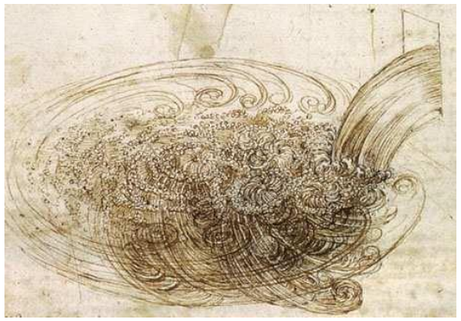
Ondas

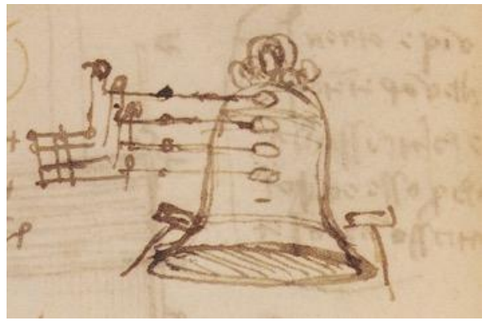
Termodinâmica

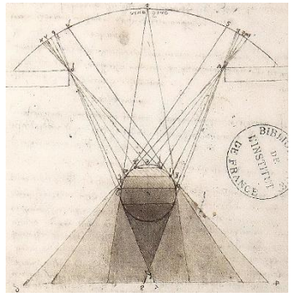
Mecânica Estatística

Projeto

Finalização







ENTREGA 1 – 13/04

PROVA I – 09/04

ENTREGA 2 – 28/05

PROVA II – 21/05

ENTREGA 3 – 22/06

PROJETO – 25/06

AGENDA DE COMPROMISSOS

Provas:* *09/04 e 21/05

Coerência & Consistência:

2 Questões das listas sugeridas
1 Questão conceitual ou articulada com as demonstrações

Entregas:* *13/04 – 28/05 – 22/06
Relatório
Demonstrações (Presença obrigatória)

Projetos:* *25/06

Visita ao Sirius – Agendar

REALIDADE VIRTUAL NO MUNDO NANO

FLUÍDOS SOB CONFINAMENTO
"POR MARES NUNCA DANTES NAVEGADOS"

In collaboration with:

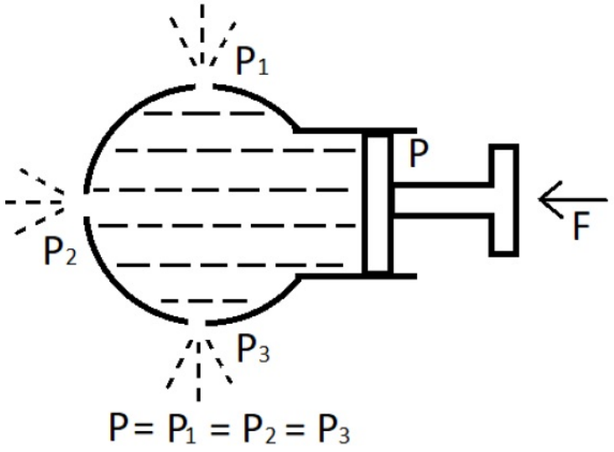
A. Kirch, T. Lanna, N. Razmara, J. Meneghini,

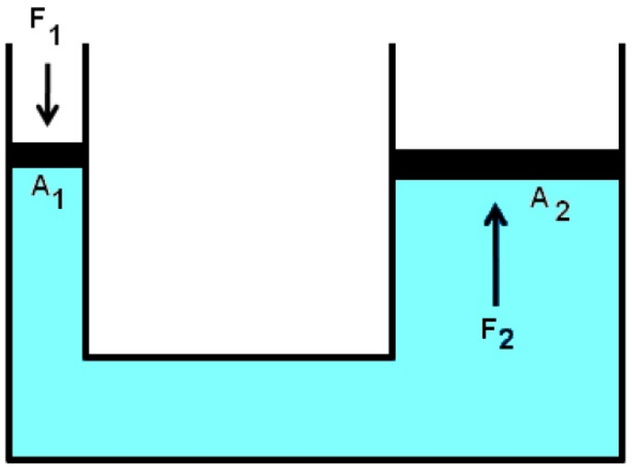
ESTATICA DE FLUIDOS E HIDRODINÂMICA

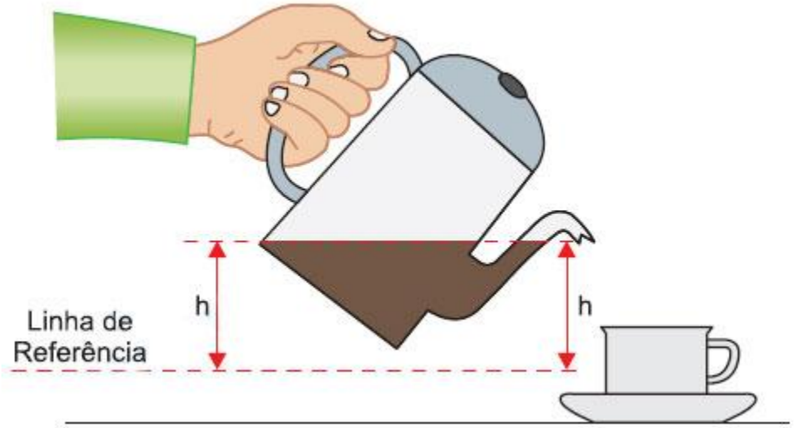
Pressão e hidrostática

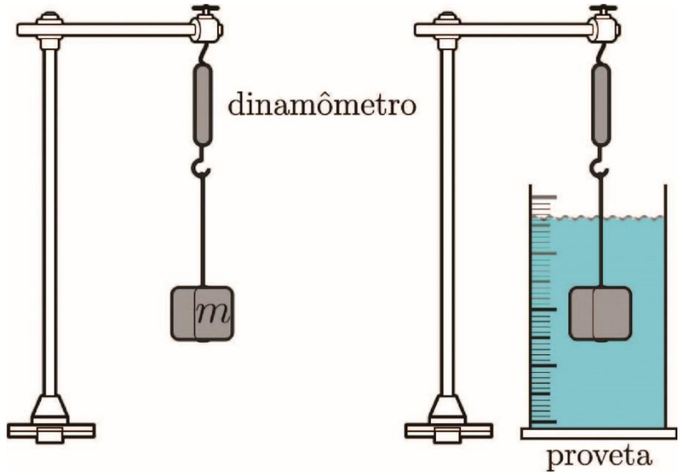
"Logo ela começou a afundar na água salgada, e percebeu que estava no lago de lágrimas que havia chorado quando tinha nove metros de altura."

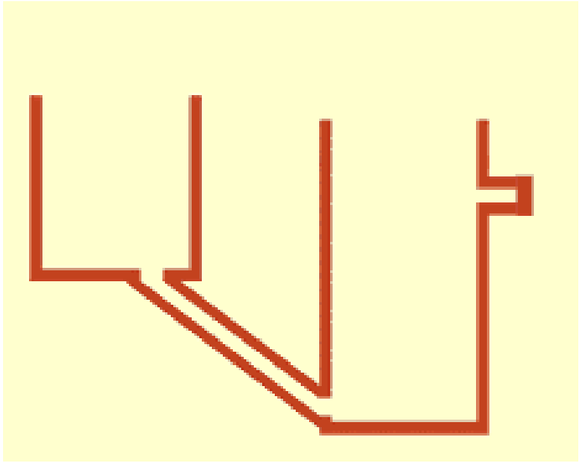
Demo 1 - Pressão

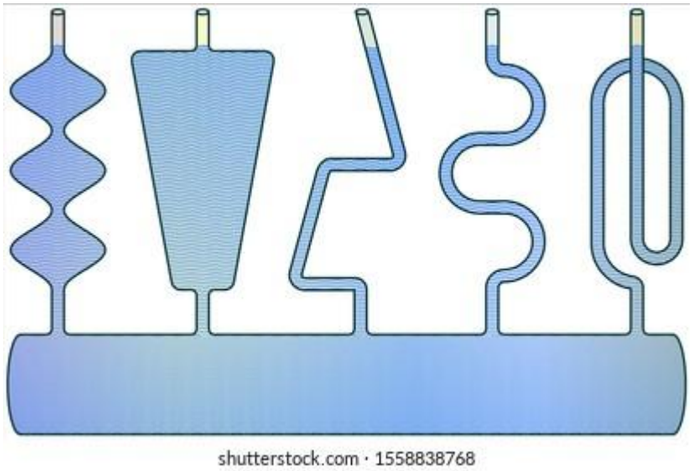




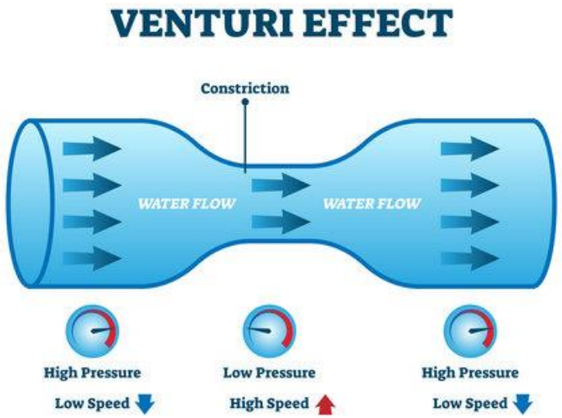


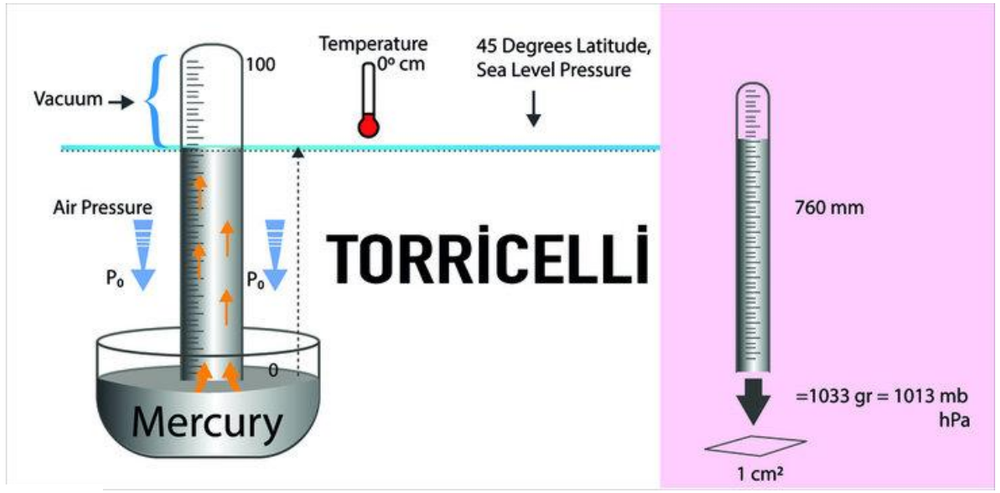


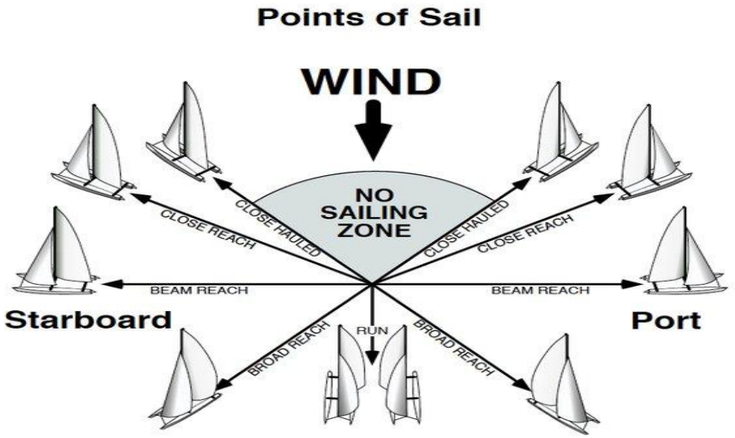


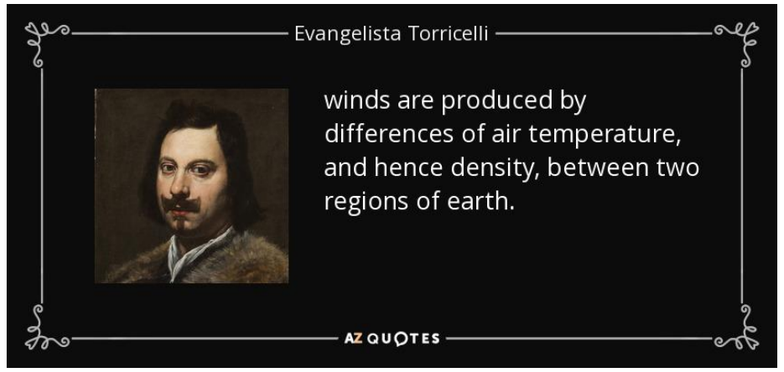


Demo 2 e 3 - Hidrostática



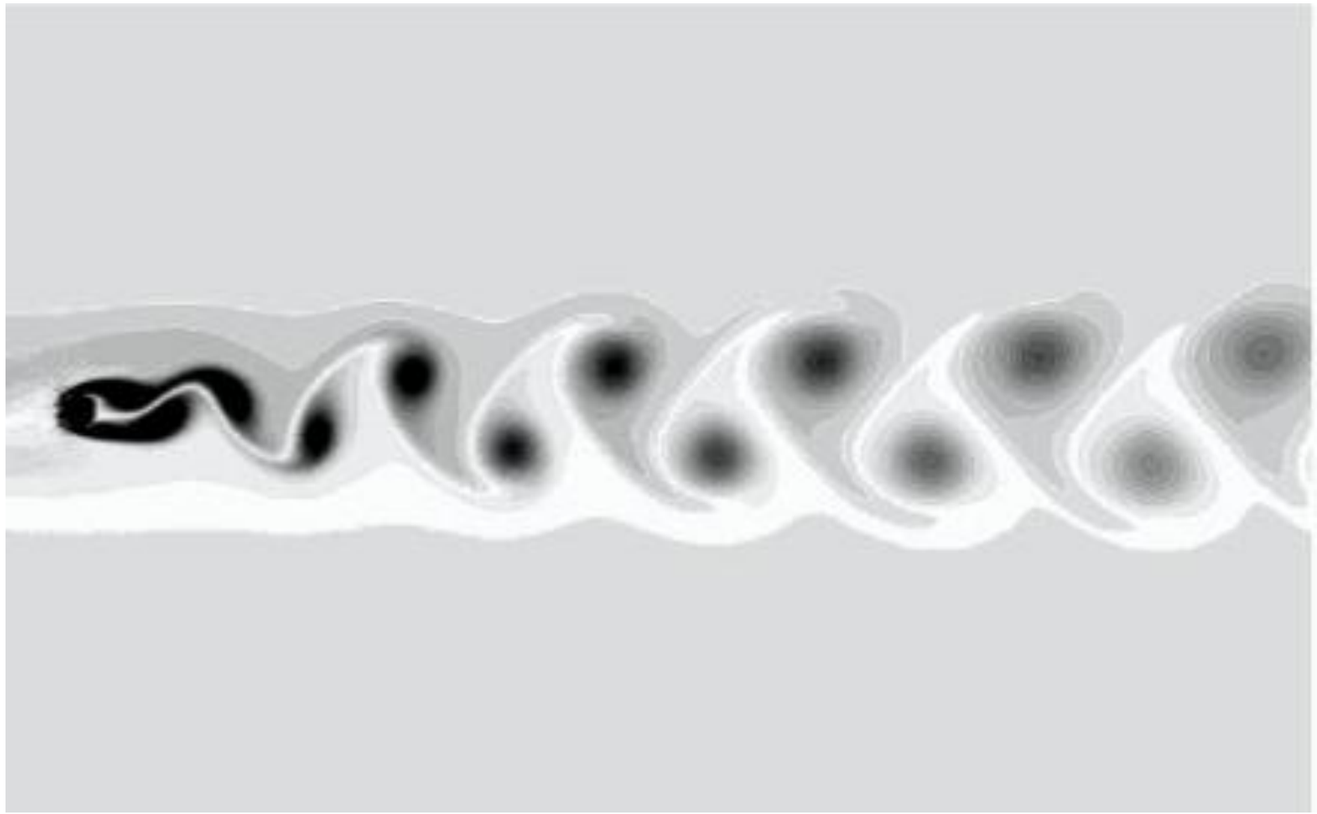






Hidrodinâmica - Circulação

Turbulência

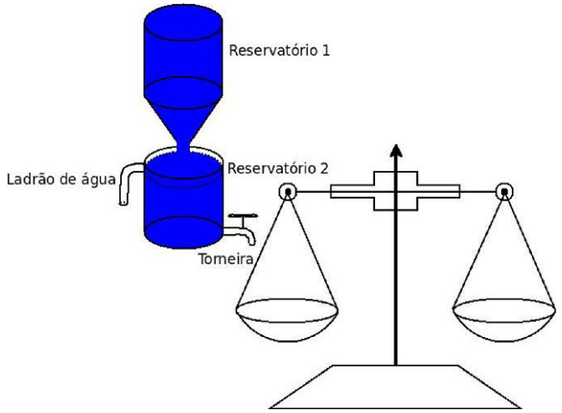


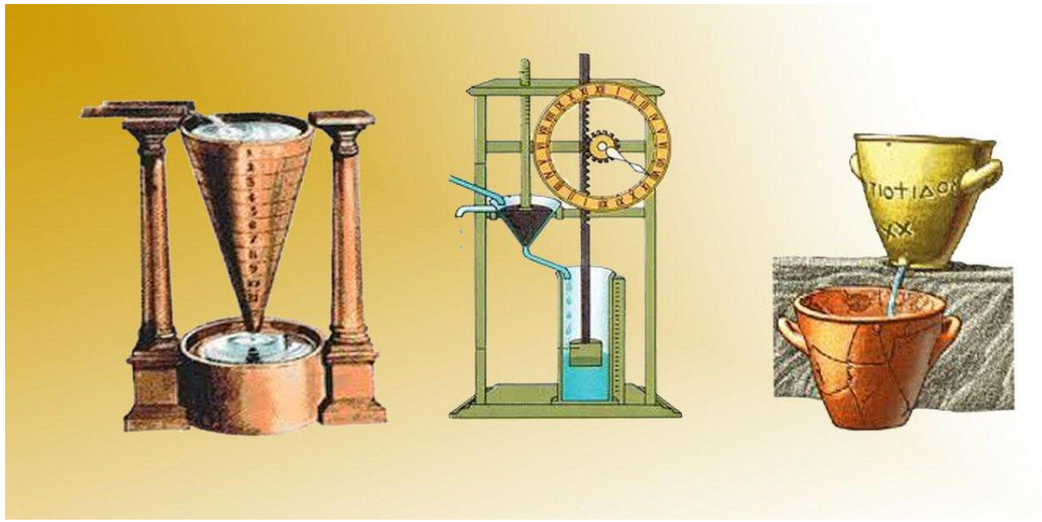
Grandes Num Reynolds:

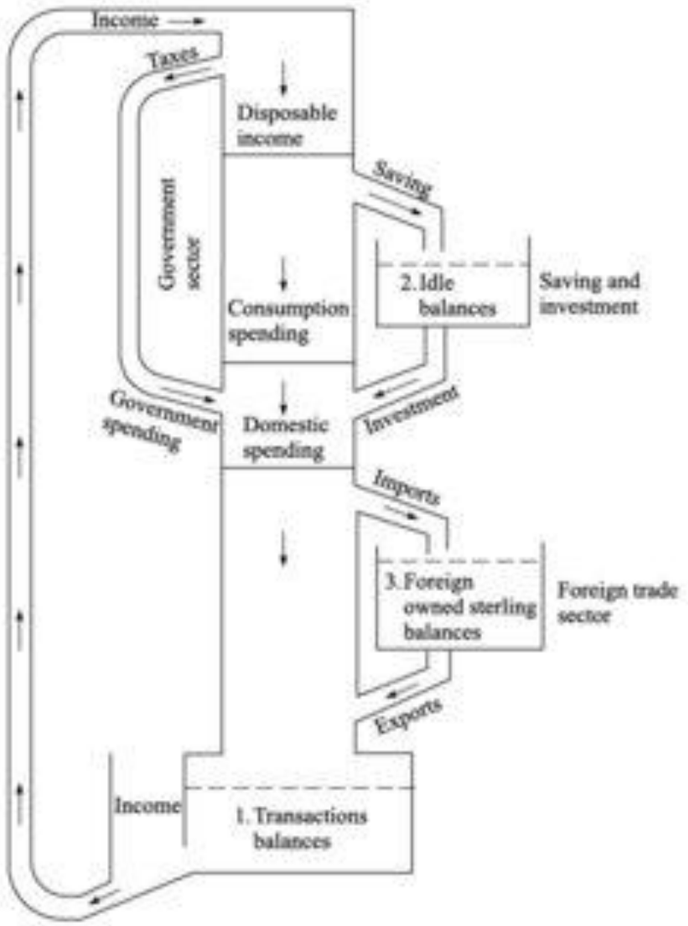
$$Re = \frac{uL}{\nu}$$

Fluxo

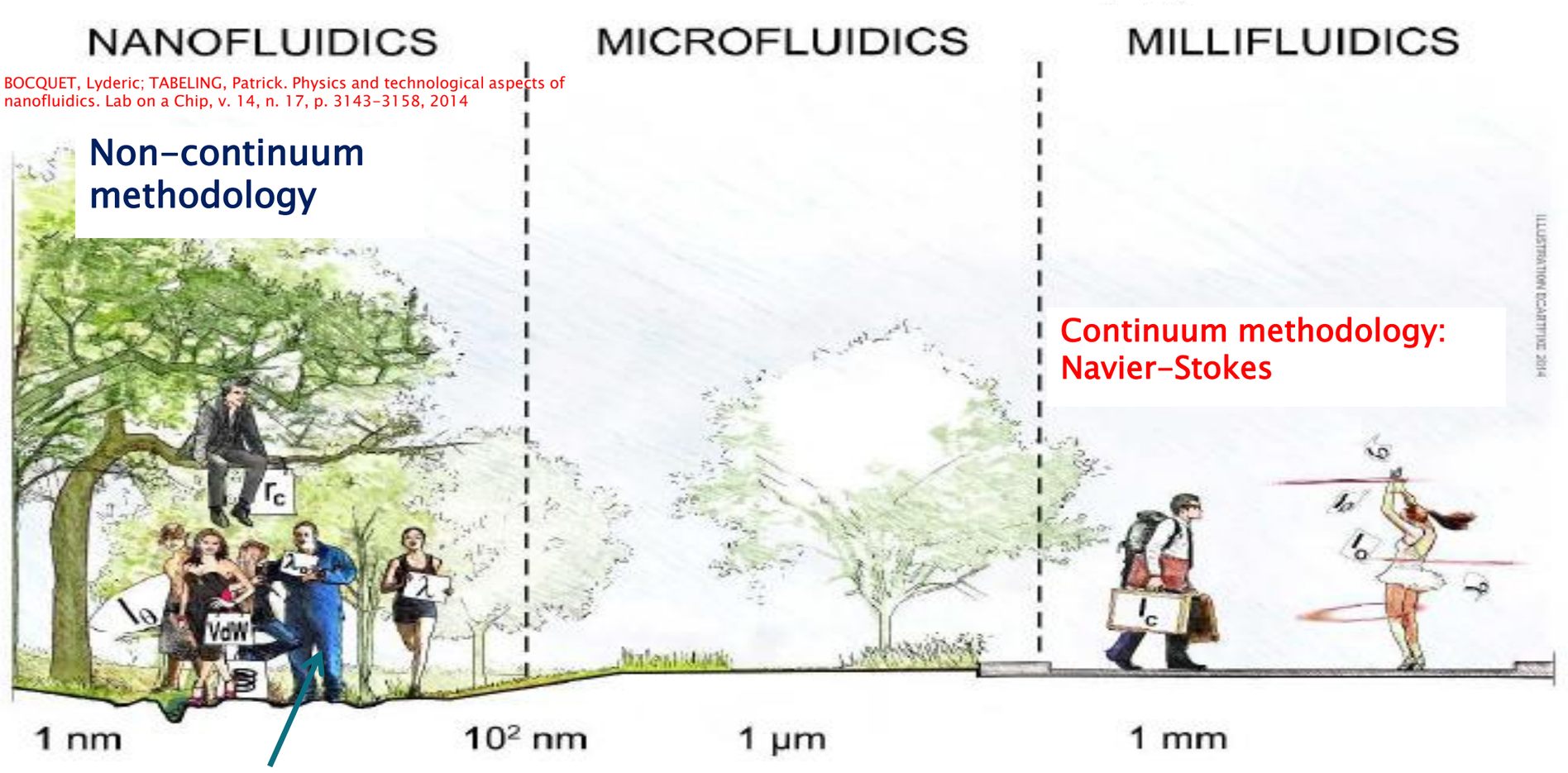
FLUIDOS I - MONIAC - $$$ - computador analógico






Income
Taxes
Disposable income
Government sector
Saving
2. Idle balances
Saving and investment
Consumption spending
Government spending
Domestic spending
Investment
Imports
3. Foreign owned sterling balances
Foreign trade sector
Exports
Income
1. Transactions balances

Nanofluídica

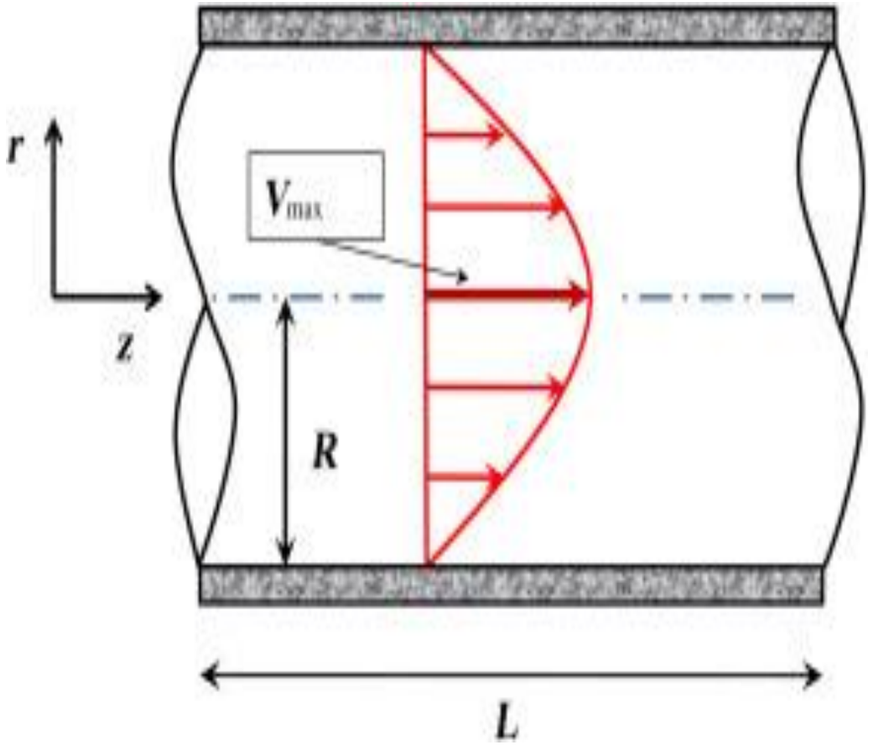


- Noncontinuum description
- Surface-dominated
- Low Reynolds number
- Multiscale and multiphysics

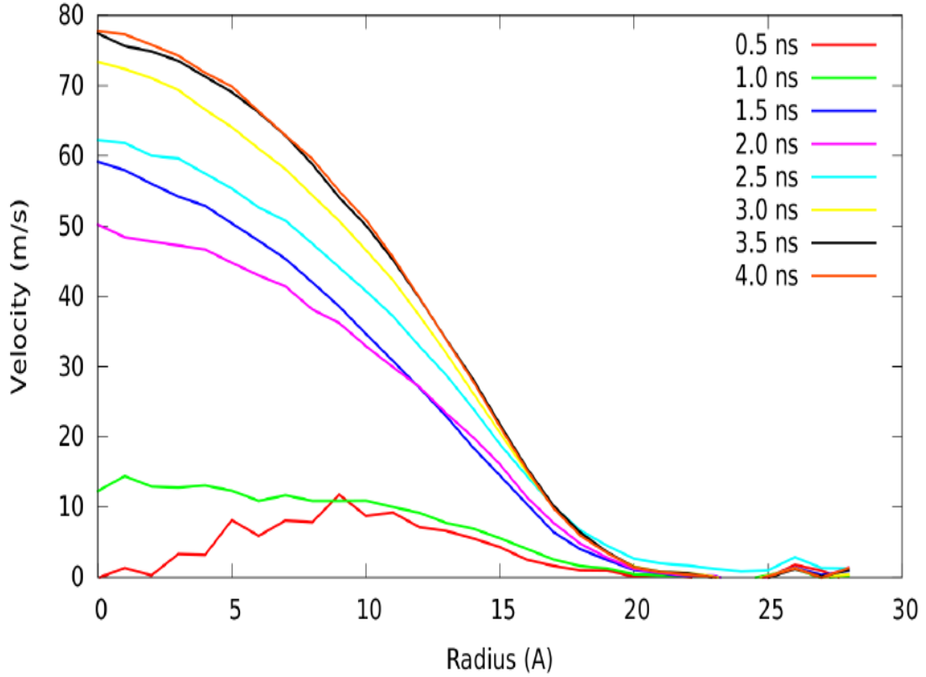
How the characteristic scales pertaining to the 1-100 nm range interfere with the system size ?

Can they combine together to produce new physical effects ?

Hagen–Poiseuille equation



$$u(x) = \frac{3g\left[(d/2)^2 - (x - x_{max})^2\right]}{2(\tau - 1/2)}$$



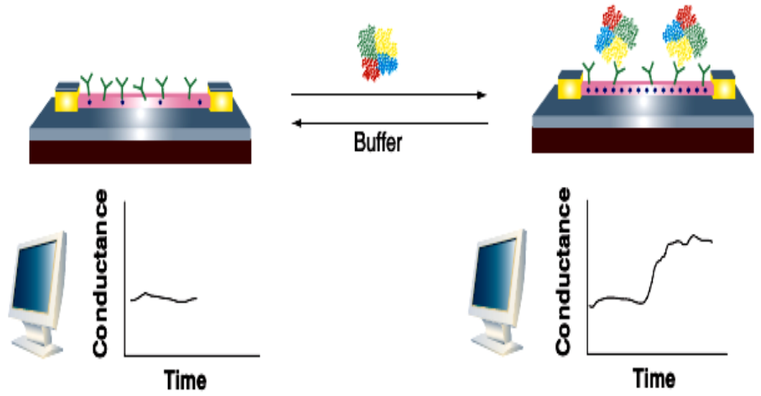
Applied acceleration

$$\eta = -\frac{\vec{a}\rho}{\left(\frac{d^2 v(\vec{r})}{dr^2}\right)},$$

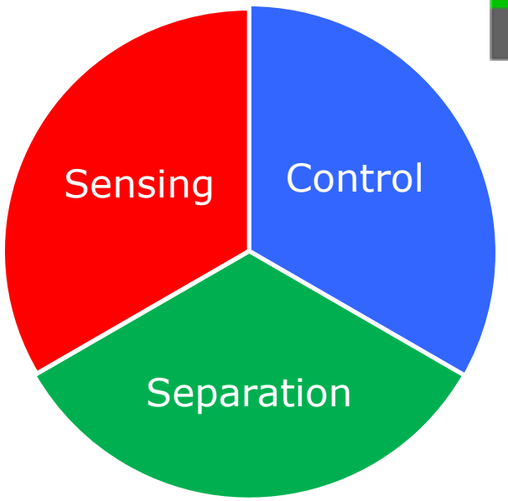
Density

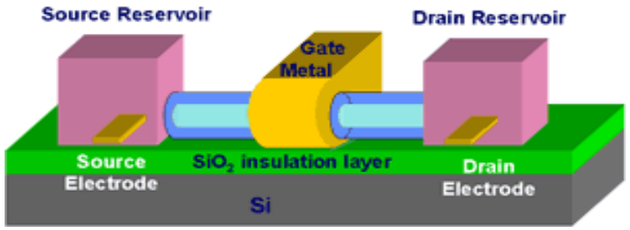
Second derivative of the parabolic velocity profile

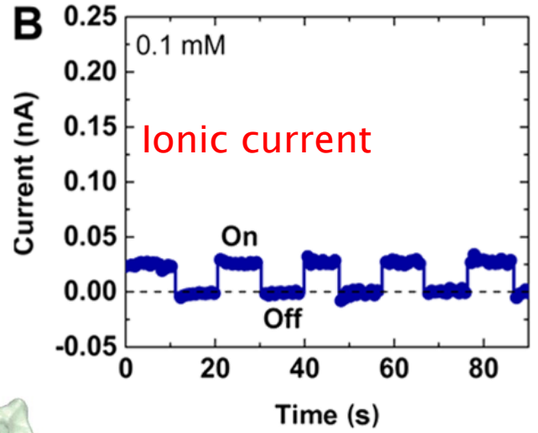
Nanofluídica



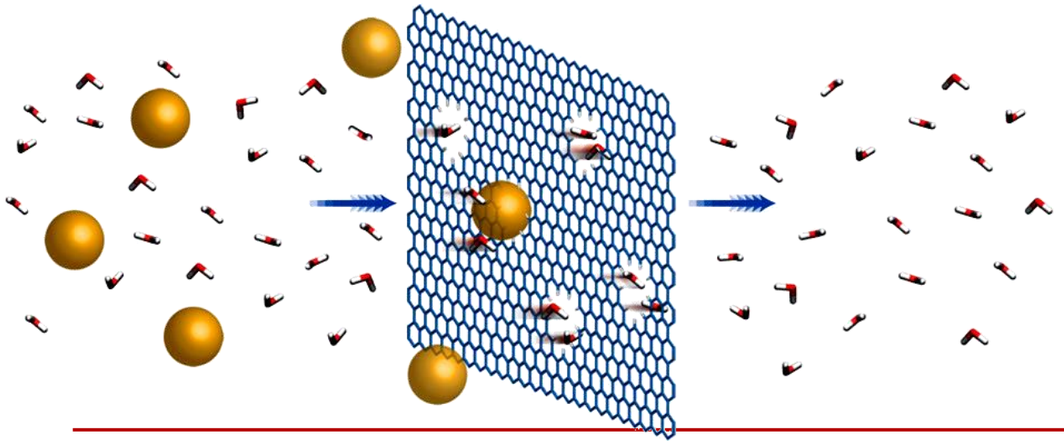
PATOLSKY, Fernando; ZHENG, Gengfeng; LIEBER, Charles M. Nanowire sensors for medicine and the life sciences. 2006.

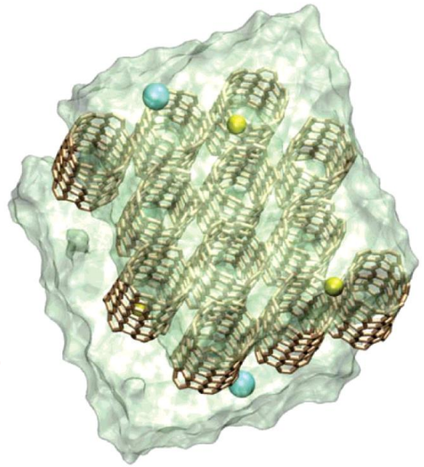






FUEST, Marie et al. A three-state nanofluidic field effect switch. **Nano letters**, v. 15, n. 4, p. 2365-2371, 2015.





- Projetando Membranas de Nanotubos de Carbono para Dessalinização Eficiente de Água

WANG, Evelyn N.; KARNIK, Rohit. Water desalination: Graphene cleans up water. **Nature nanotechnology**, v. 7, n. 9, p. 552-554, 2012.

Single-ion sensor

Geiger Counter

nature COMMUNICATIONS

ARTICLE

Received 12 Jul 2015 | Accepted 11 Dec 2015 | Published 25 Jan 2016

DOI: 10.1038/ncomms10475 OPEN

Single-ion adsorption and switching in carbon nanotubes

Adam W. Bushmaker[1], Vanessa Oklejas[1], Don Walker[1], Alan R. Hopkins[1], Jihan Chen[2] & Stephen B. Cronin[2]

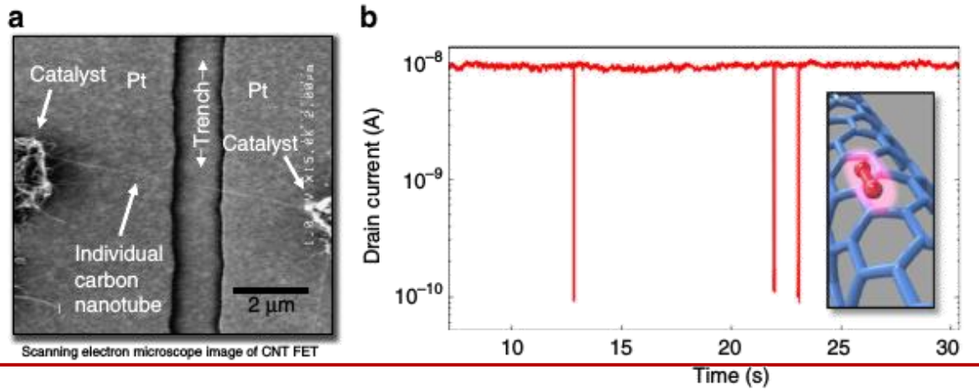
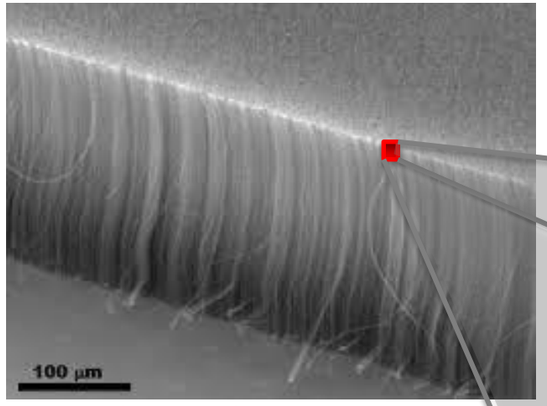


Figure 1 | Device layout and switching transients caused by single-ion adsorption. (**a**) Scanning electron microscope image of CNT FET device and (**b**) plot of drain current versus time showing switching transients observed during ionized gas exposure. The inset shows a cartoon image of a gas molecule adsorbed on the surface of a carbon nanotube.

Dinâmica de fluídos em nanoporos

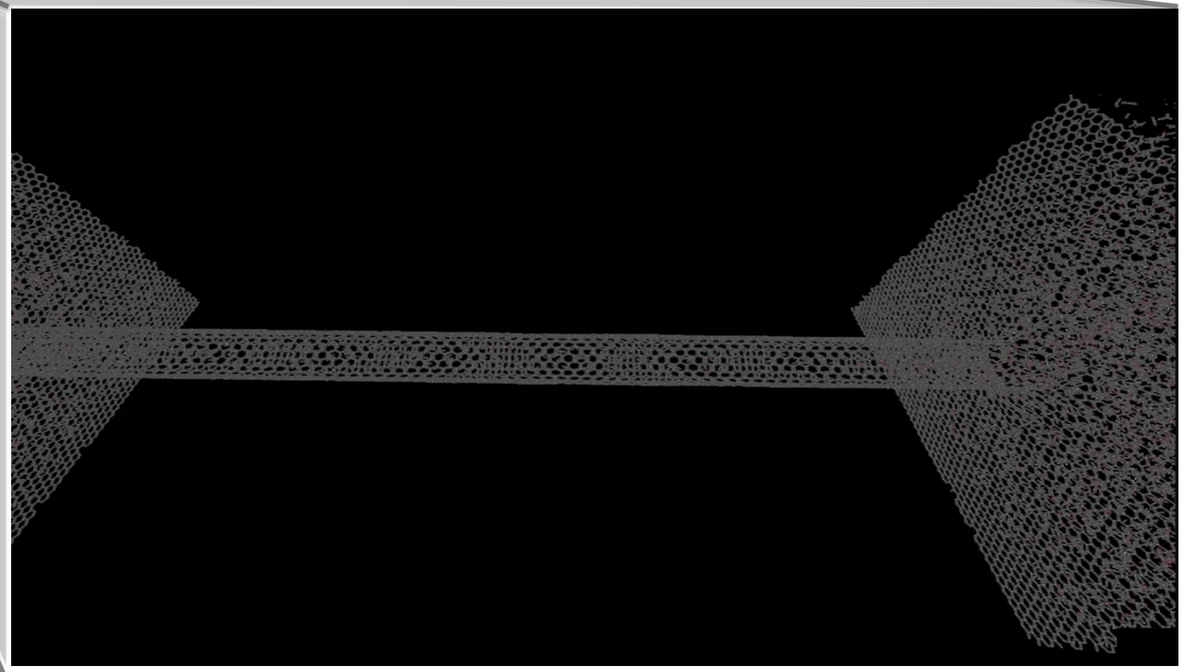


Experimental

Seletividade $N_2/CO_2/CH_4/O_2$

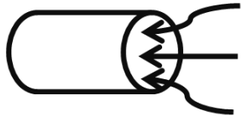
Tube diameter: 1.6 nm

Molecular Model



- Size effects

- Fluid flow



- Gas compostion

A. Kirch, T. Lanna, N. Razmara, J. Meneghini, C. Miranda, Bulletin of the American Physical Society, 2019

Confinement and hydrophilicity effects on geologically relevant fluids in silica nanopores

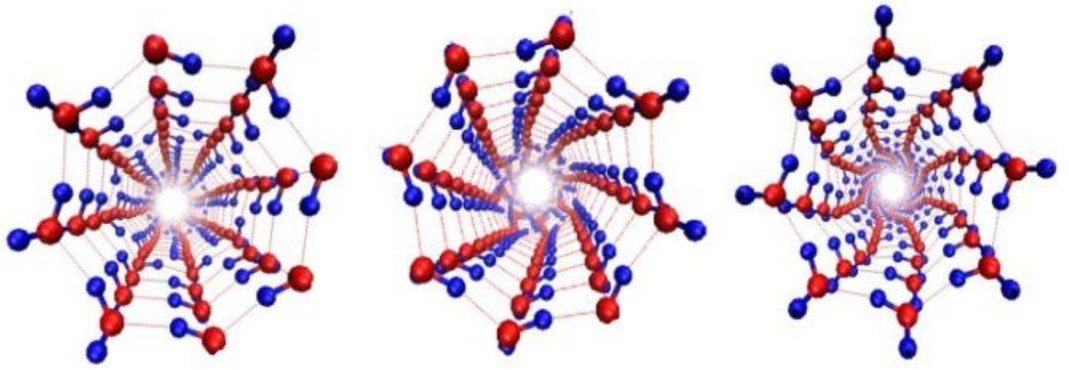
James M. de Almeida and
Caetano R. Miranda

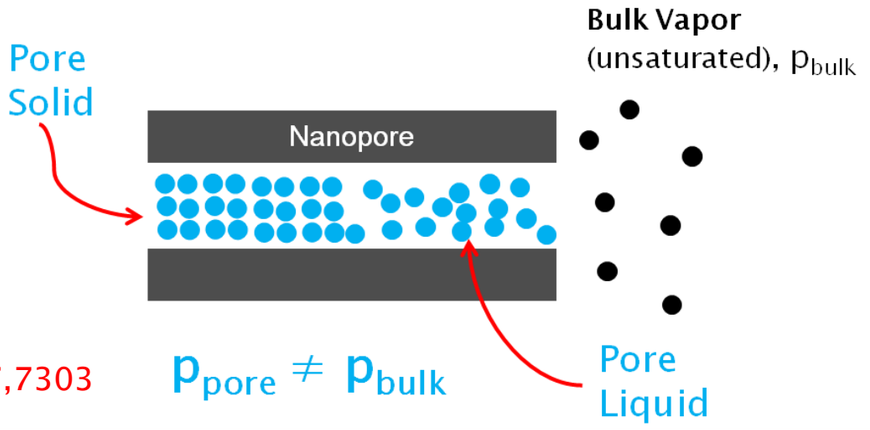
Work under review

Nanofluídica

Water structuring

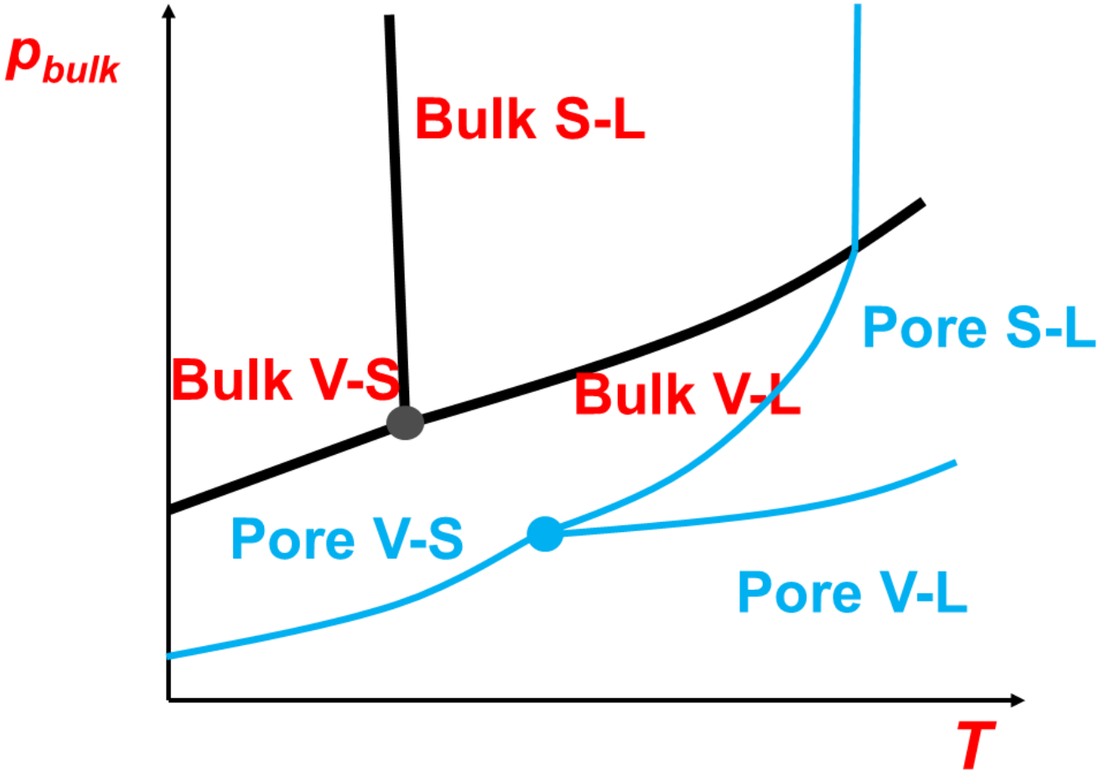
300K, 1atm





Phys. Chem,2015,17,7303

Phase Diagram



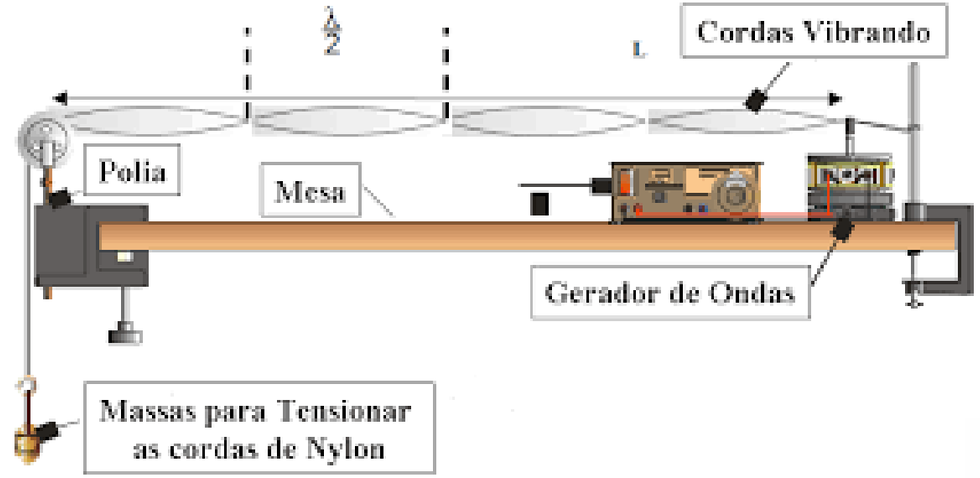
OSCILAÇÕES, ONDAS E SOM

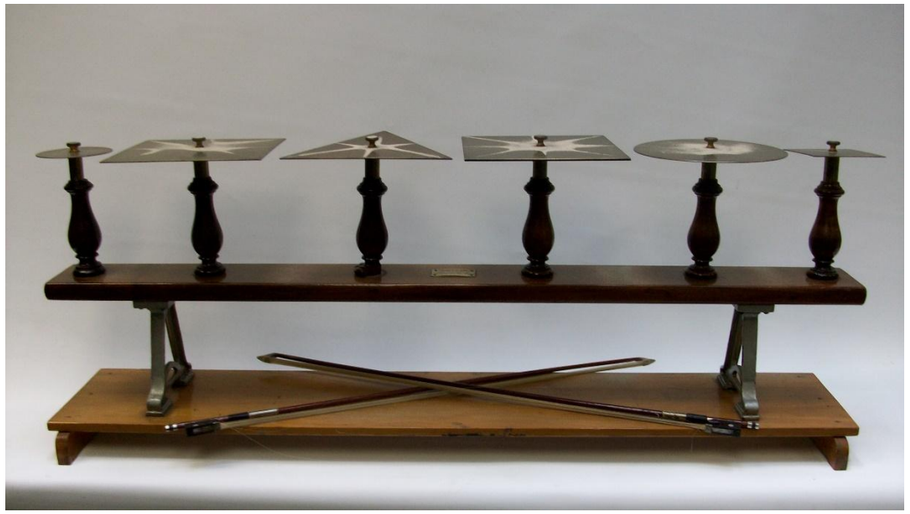
Oscilações e Ondas

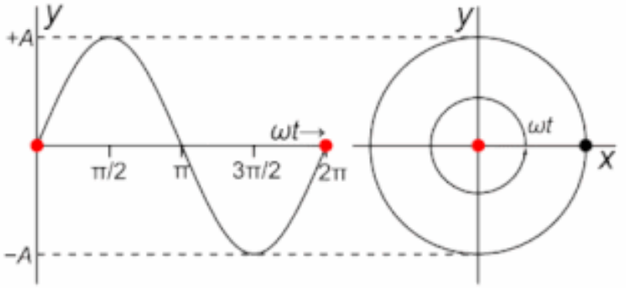
"Às vezes eu acho que cheguei a algum lugar, mas logo percebo que estou de volta onde comecei.“

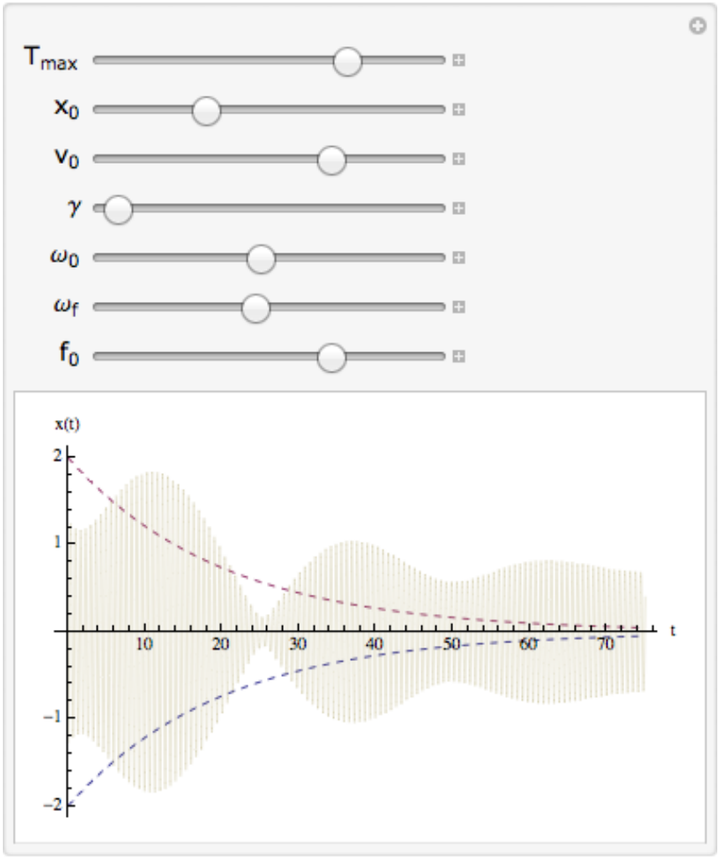
"Ora, agora eu sou maior que você, e agora sou menor! Como pode isso?"

Demo 4a – Cordas vibrantes e oscilações







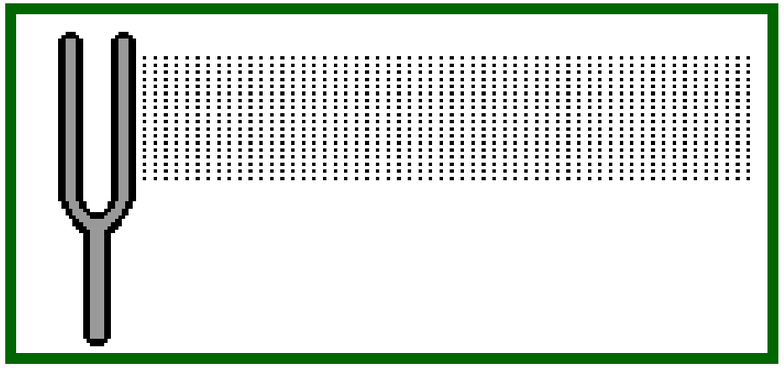


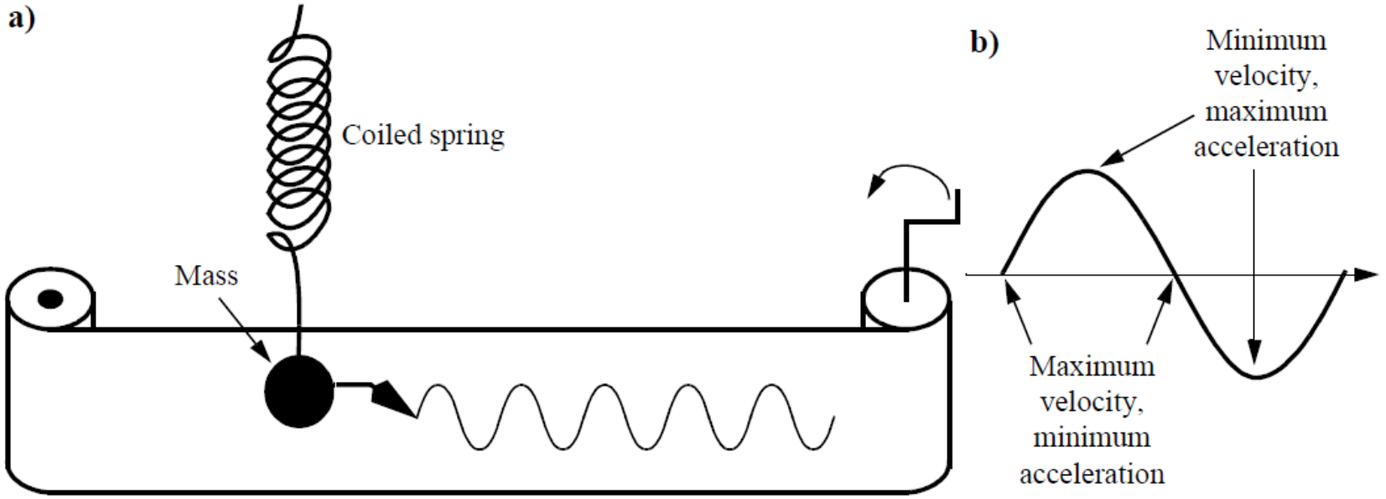
Demo 4b – Fenômenos ondulatórios

Cuba de ondas

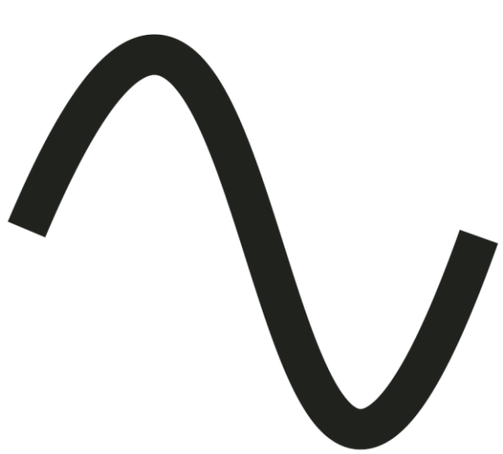
Onda harmônica

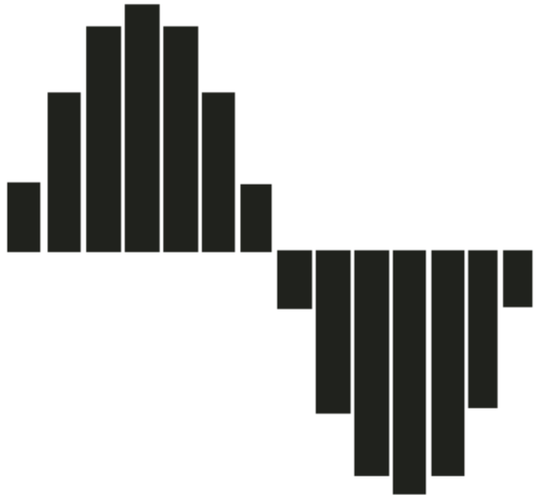
- Fundamental – Onda harmônica
- A primeira é uma onda senoidal em **440Hz**.
- O segundo adiciona um harmônico em **880Hz.**
- A terceira adiciona outro harmônico em **1760 Hz.**

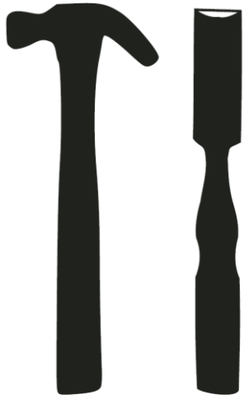




Sintetizando som …



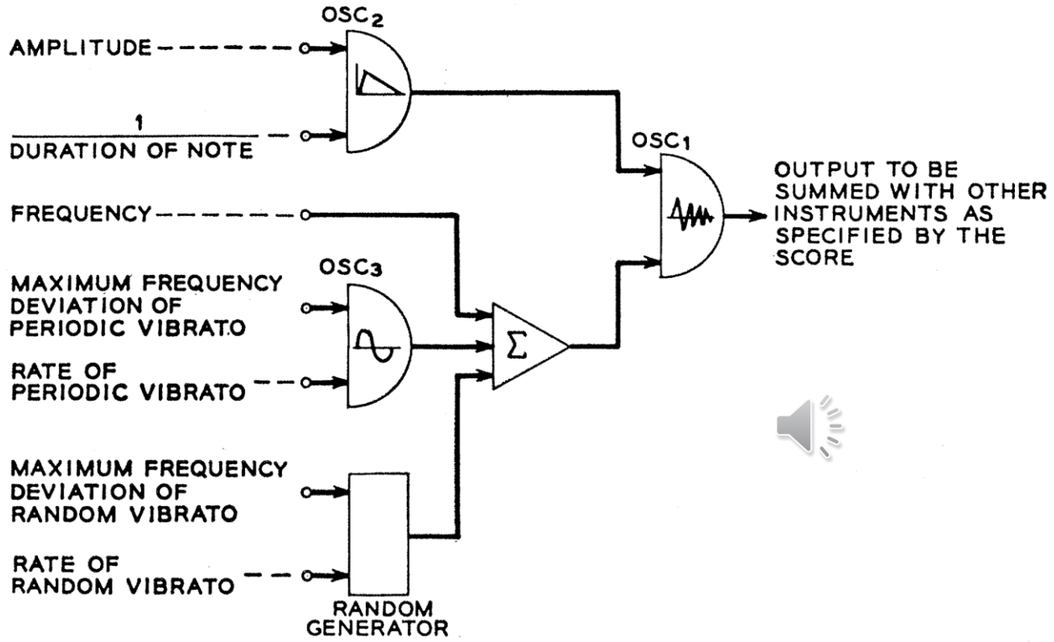




Science – 01/11/1963

The Digital Computer as a Musical Instrument

A computer can be programmed to play "instrumental" music, to aid the composer, or to compose unaided.



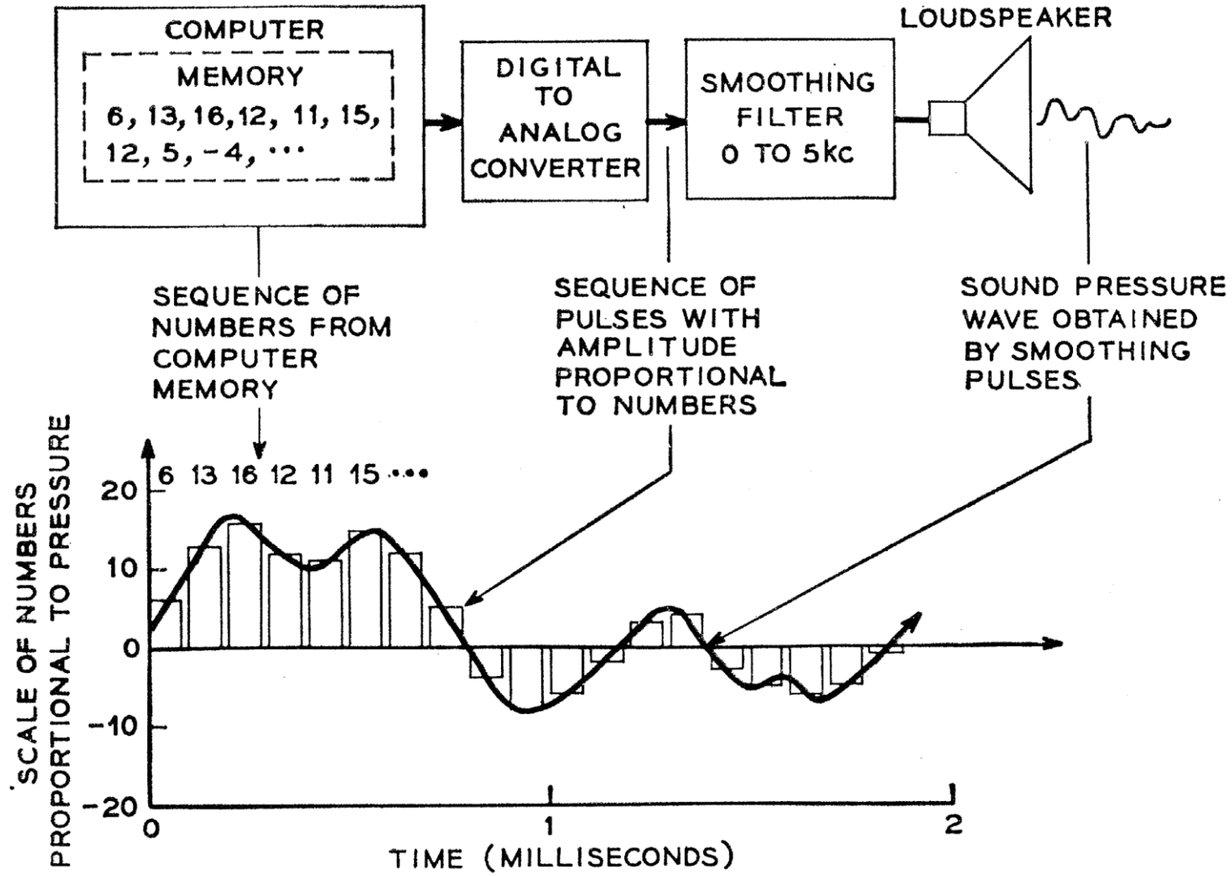
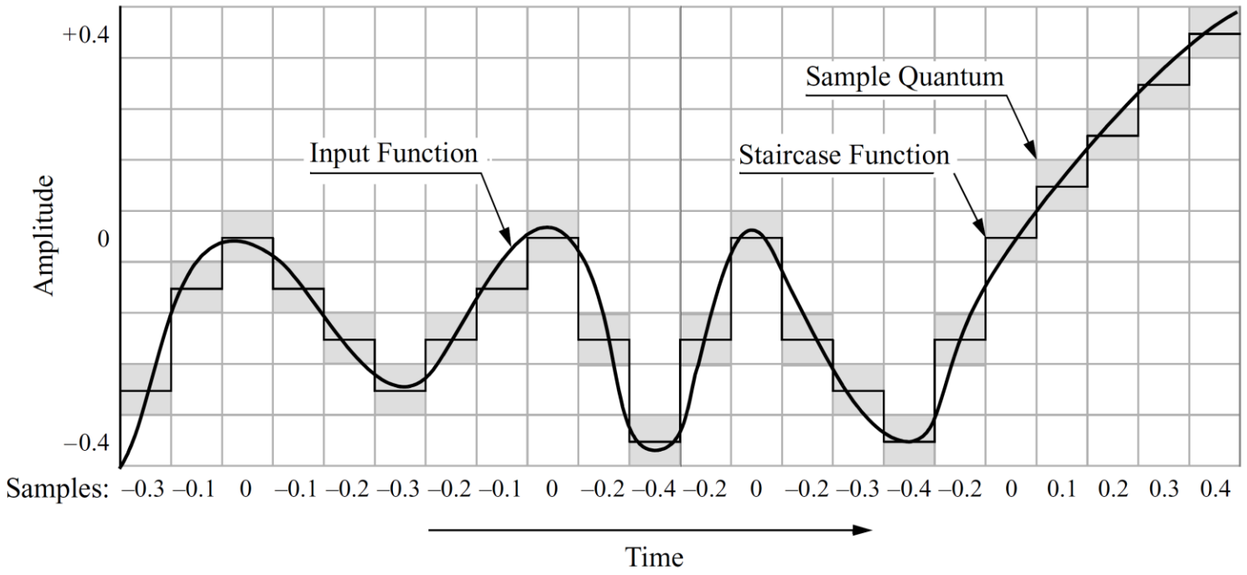
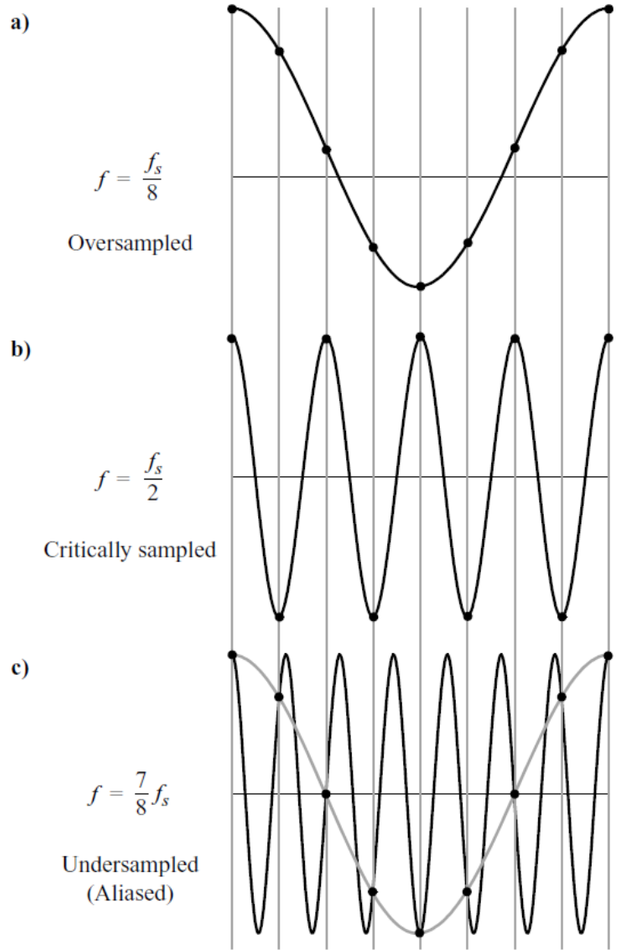


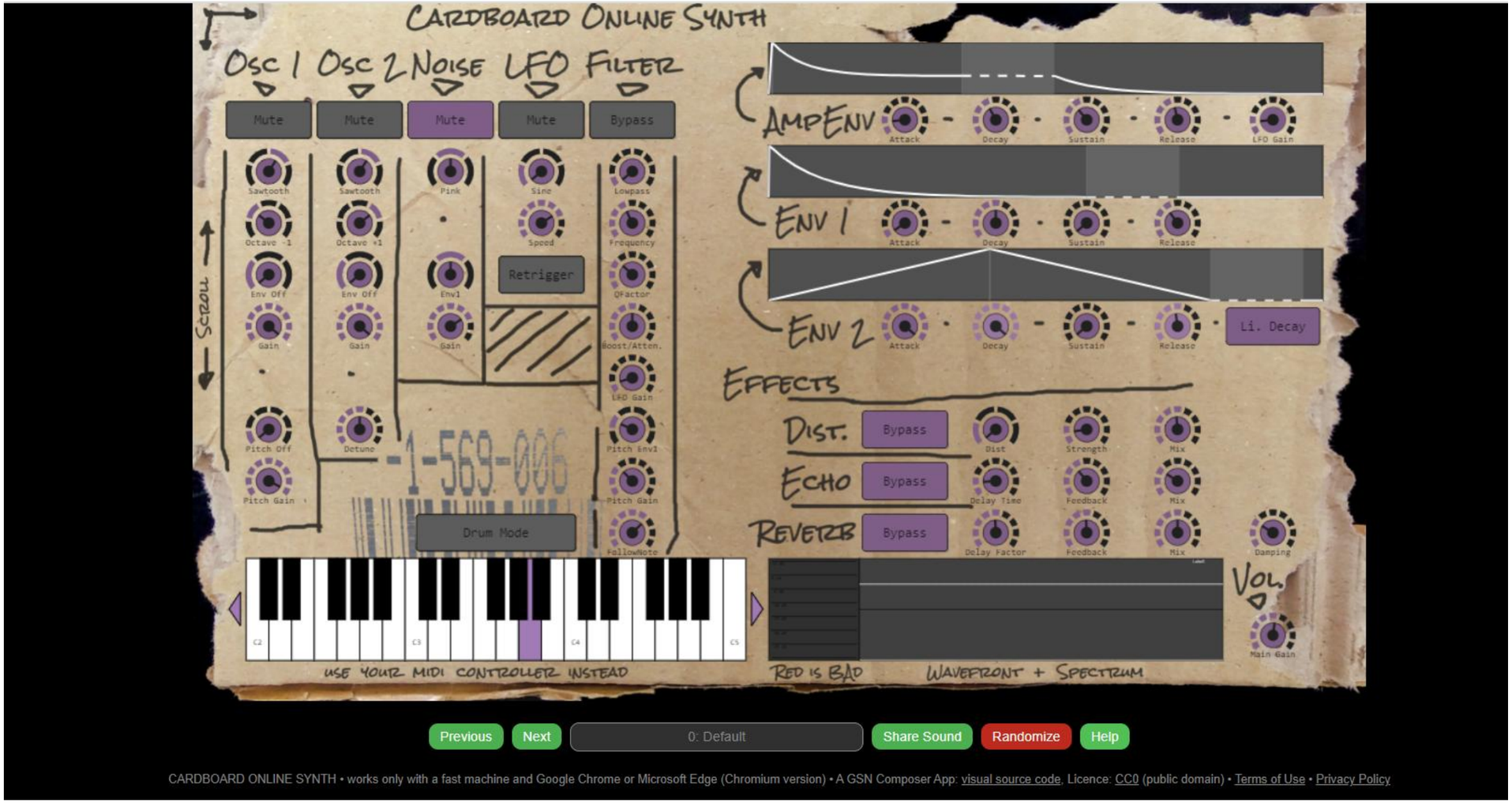
Fig. 1. Schematic diagram depicting the conversion of a sequence of numbers stored in a computer memory to a sound pressure wave form. The sampling rate is 10,000 numbers per second to yield a bandwidth of 5000 cycles per second for the sound wave.

Conversão analógico digital



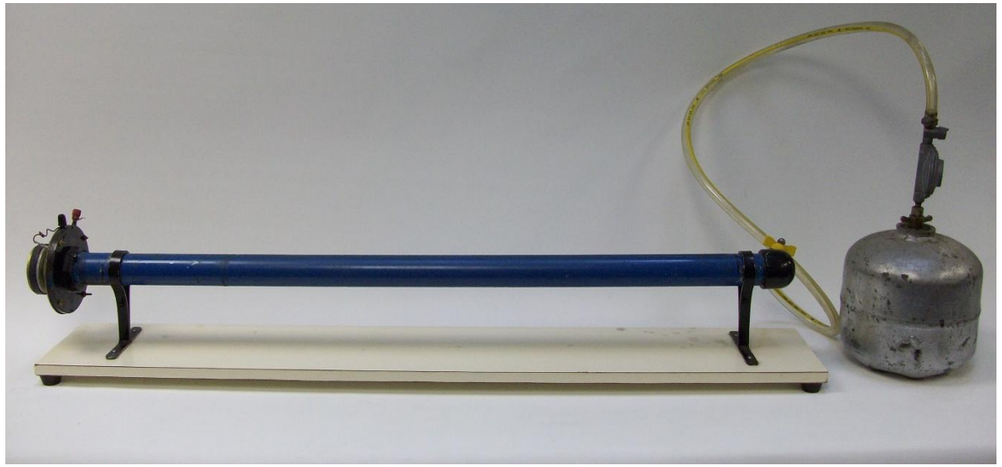


Sintetizador básico



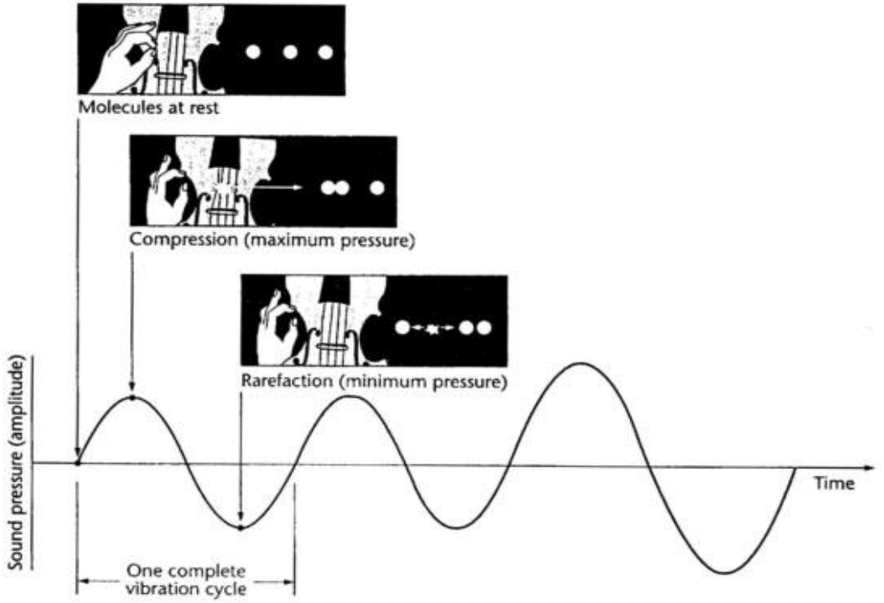
EXPERIMENTAÇÕES SONORAS

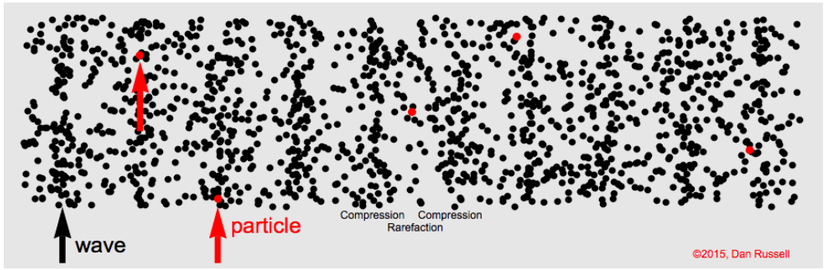
Demo 5 – Barulhinho bom

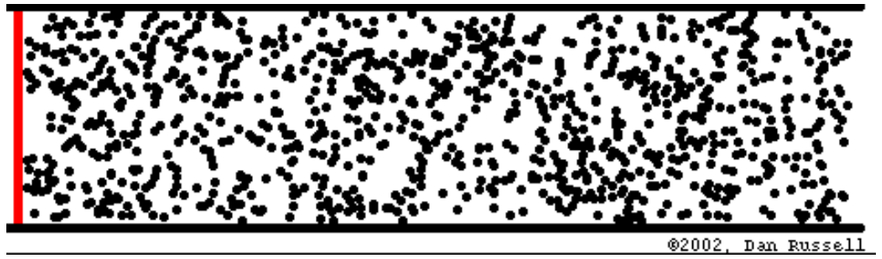


Música e Física

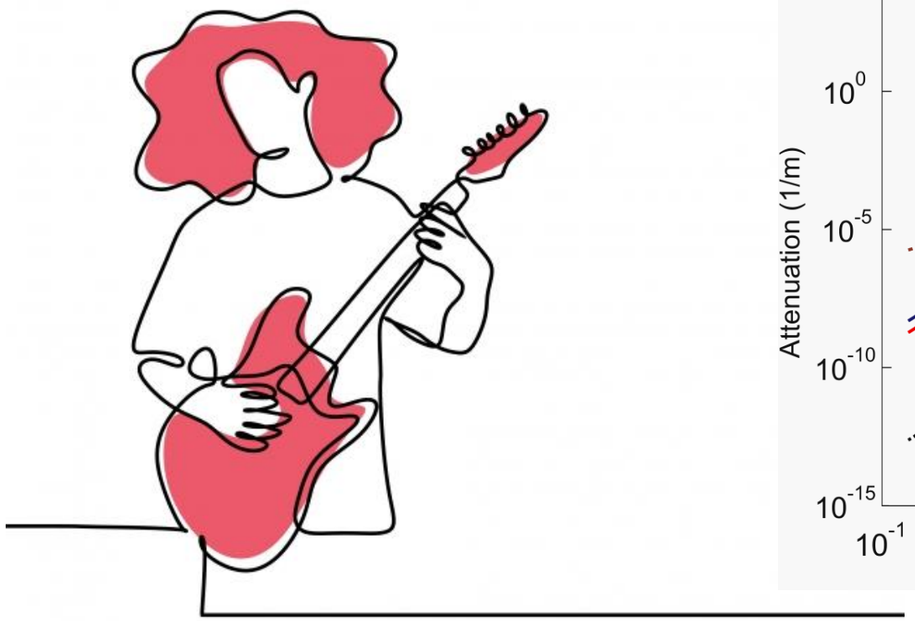
Fonte: https://www.calendarr.com/brasil/dia-internacional-da-musica/

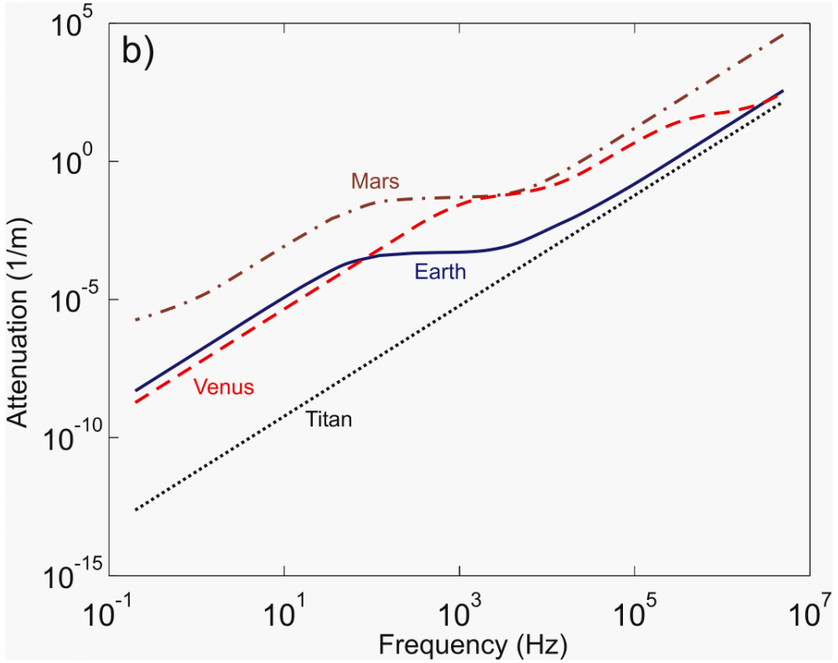


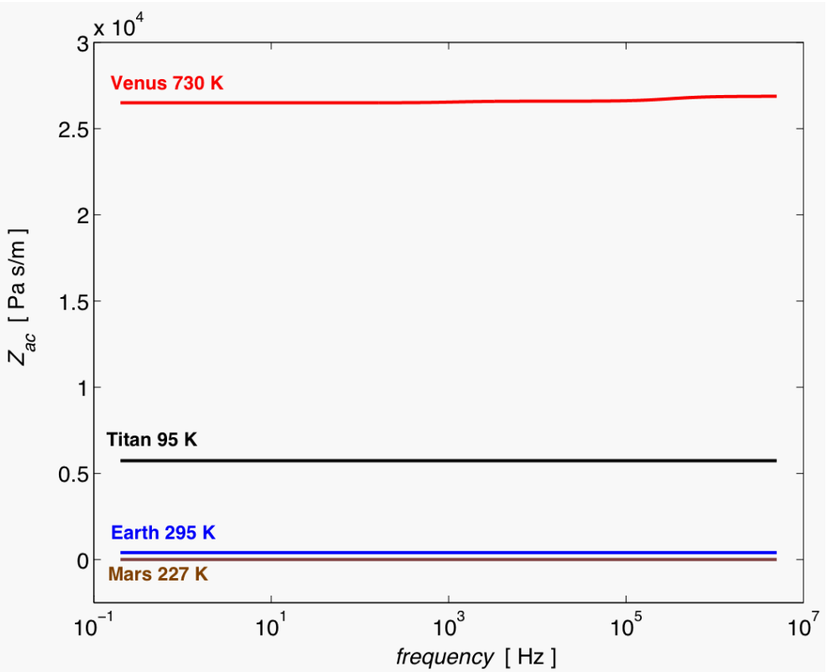




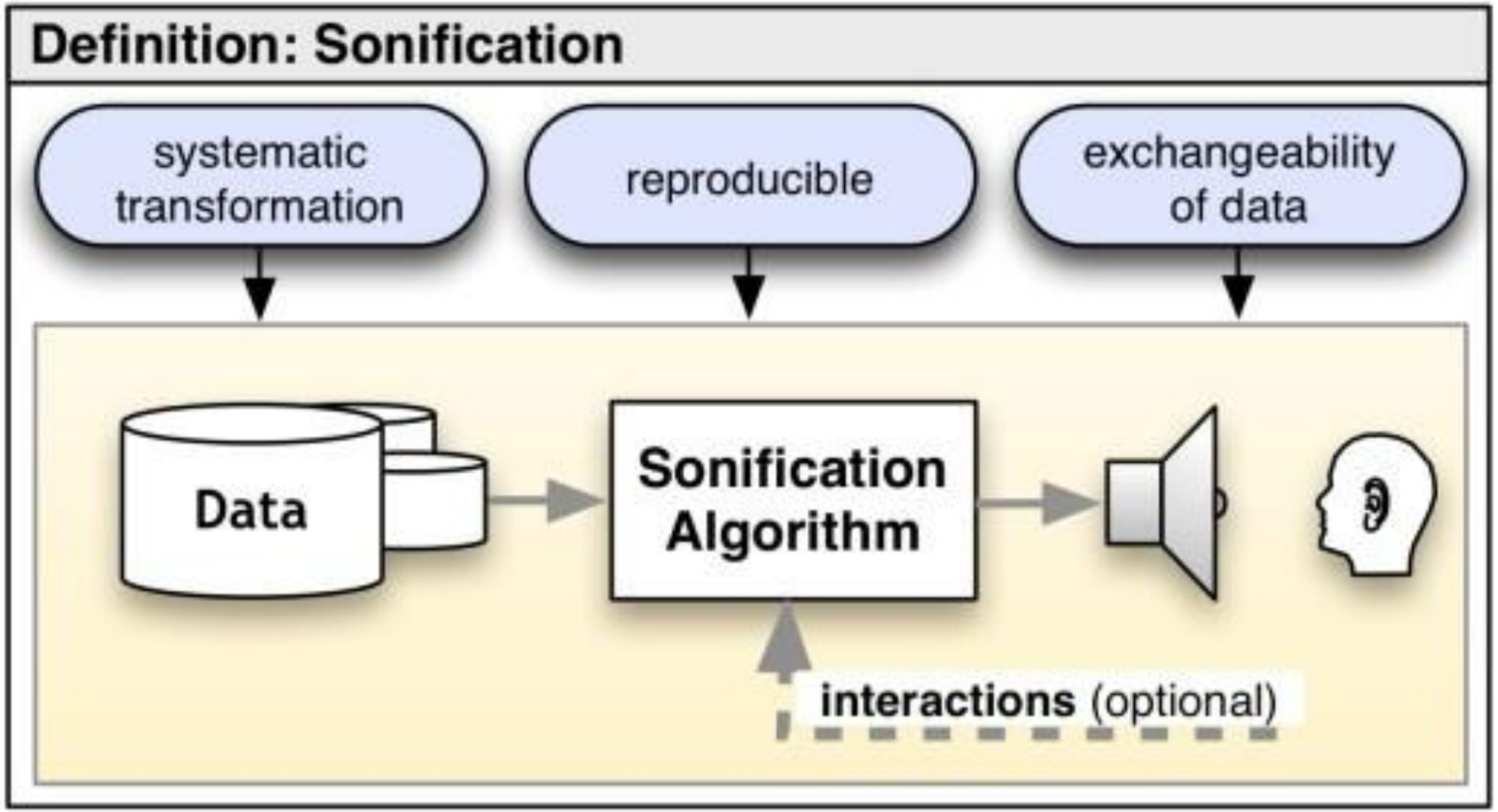
Ondas acústicas em atmosferas alienígenas





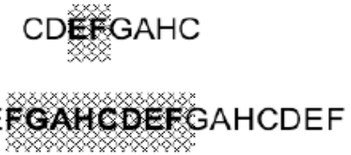
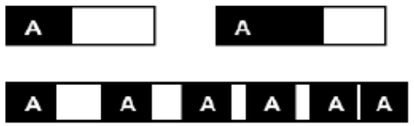


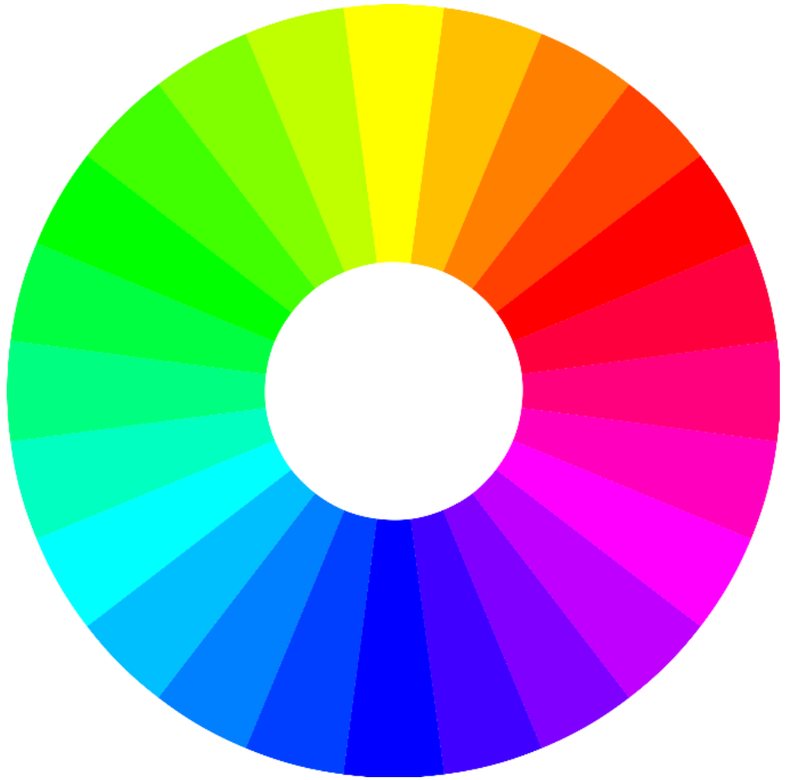
Sonificação



Source as adapted from: Thomas, H. (2008), “Taxonomy and definitions for sonification and auditory display.” Proceedings of the 14th International Conference on Auditory Display, Paris, France

Paleta de Som

Location (Spatialisation)	
Loudness (Amplitude)	
Pitch: Relative Highness/Lowness Register (Frequency Band)	
Melody (sequence of sounds)	CDEFG CEDFG
Timbre: Sound quality (e.g. different instruments) Attack/Decay (often decides timbre)	
Rhythm: Duration (of sound and pauses) Rate of change	



Extracted from “Sonification in computational physics” by Katharina Vogt – SysMus08 - Based on xSonify

Motivações

Forma alternativa de representar e analisar dados

Exploração e percepção multidimensional intuitiva

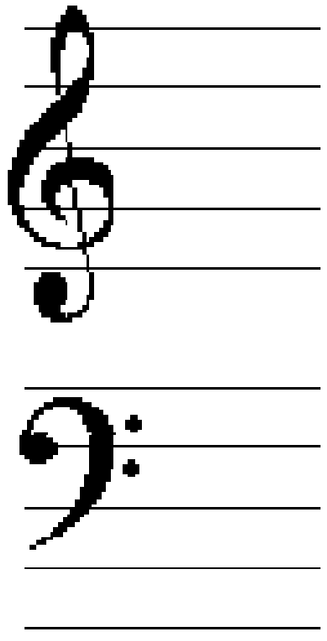
Representando o invisível

Disseminação científica e inclusão

Integrar / complementar experiências de imersão (Sound design)

Conexão com a arte (música)

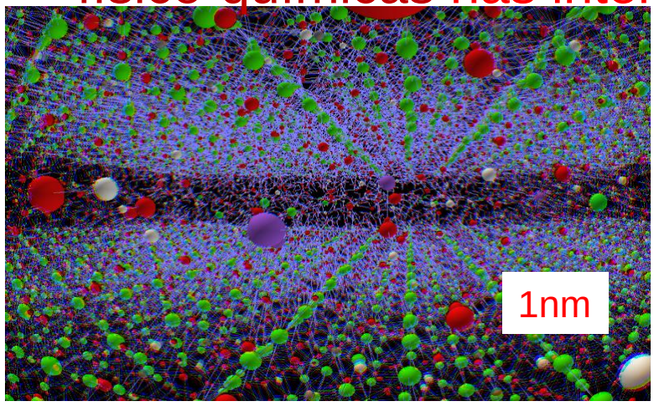
Sonificação – primeiros passos



Frequency		Keyboard	Note name	MIDI number	
	4186.0		C8		108
	3951.1		B7		107
3729.3	3520.0		A7	106	105
3322.4	3136.0		G7	104	103
2960.0	2793.8		F7	102	101
	2637.0		E7		100
2489.0	2349.3		D7	99	98
2217.5	2093.0		C7	97	96
	1975.5		B6		95
1864.7	1760.0		A6	94	93
1661.2	1568.0		G6	92	91
1480.0	1396.9		F6	90	89
	1318.5		E6		88
1244.5	1174.7		D6	87	86
1108.7	1046.5		C6	85	84
	987.77		B5		83
932.33	880.00		A5	82	81
830.61	783.99		G5	80	79
739.99	698.46		F5	78	77
	659.26		E5		76
622.25	587.33		D5	75	74
554.37	523.25		C5	73	72
	493.88		B4		71
466.16	**440.0**		**A4**	70	**69**
415.30	392.00		G4	68	67
369.99	349.23		F4	66	65
	329.63		E4		64
311.13	293.67		D4	63	62
277.18	**261.6**		**C4**	61	**60**
	246.94		B3		59
233.08	220.00		A3	58	57
207.65	196.00		G3	56	55
185.00	174.61		F3	54	53
	164.81		E3		52
155.56	146.83		D3	51	50
138.59	130.81		C3	49	48
	123.47		B2		47
116.54	110.00		A2	46	45
103.83	97.999		G2	44	43
92.499	87.307		F2	42	41
	82.407		E2		40
77.782	73.416		D2	39	38
69.296	65.406		C2	37	36
	61.735		B1		35
58.270	55.000		A1	34	33
51.913	48.999		G1	32	31
46.249	43.654		F1	30	29
	41.203		E1		28
38.891	36.708		D1	27	26
34.648	32.703		C1	25	24
	30.868		B0		23
29.135	27.500	T. Wolfe, UNSW	A0	22	21

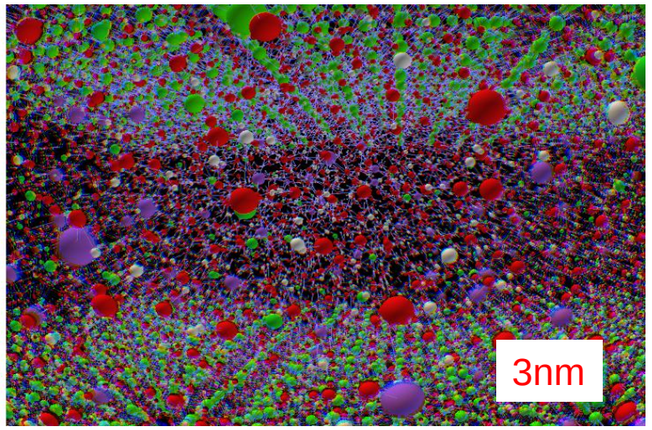
Interfaces sólido-fluído

- Explorar os mecanismos moleculares subjacentes e as propriedades físico-químicas nas interfaces fluido-sólido



O usuário de RV pode navegar nas interfaces:

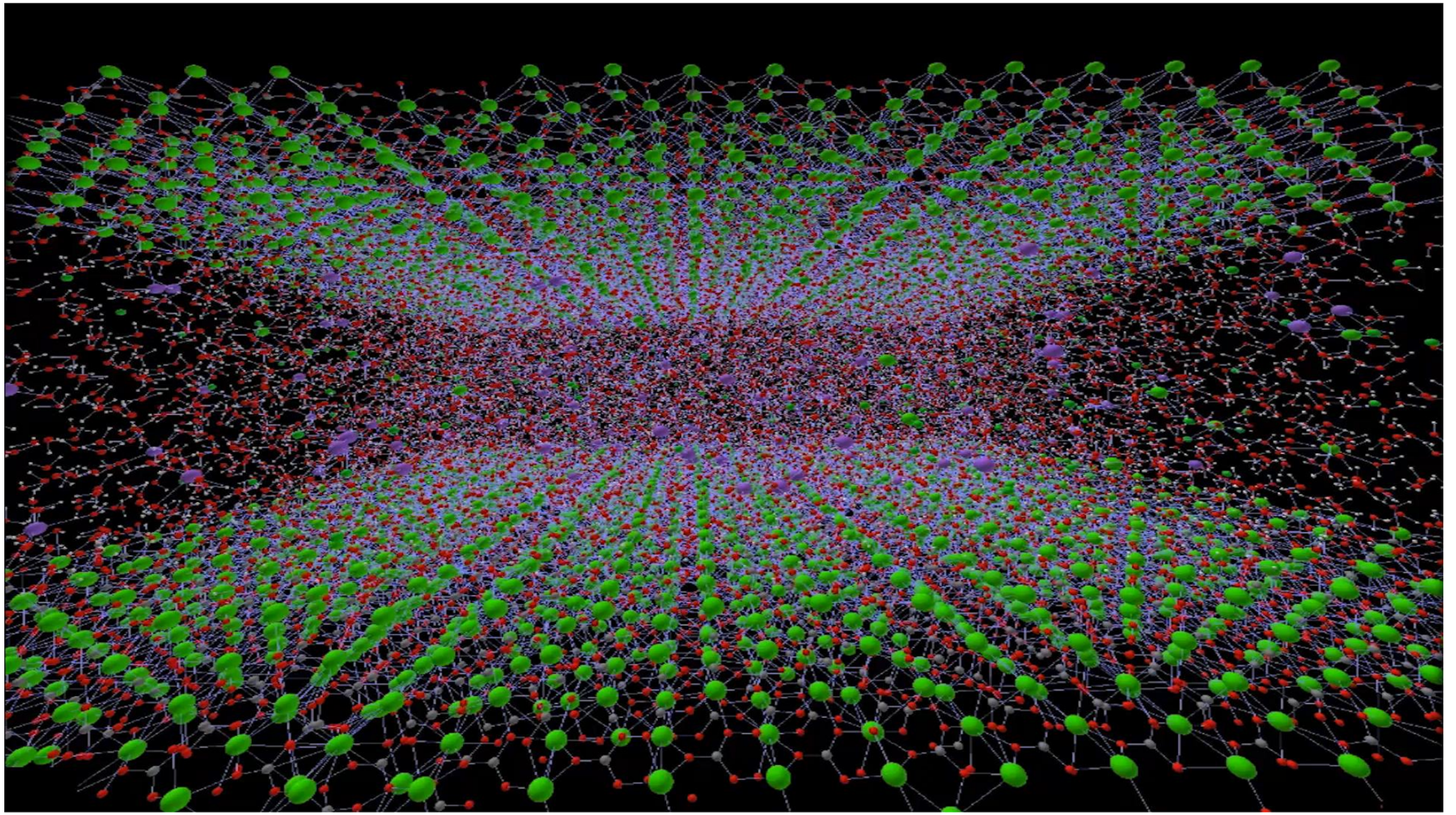
- estrutura cristalina de calcita
- estrutura da água confinada
- distribuição iônica e solvatação nos íons



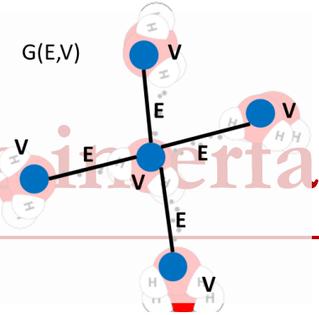
Salmoura confinada nas superfícies de calcita e cimento

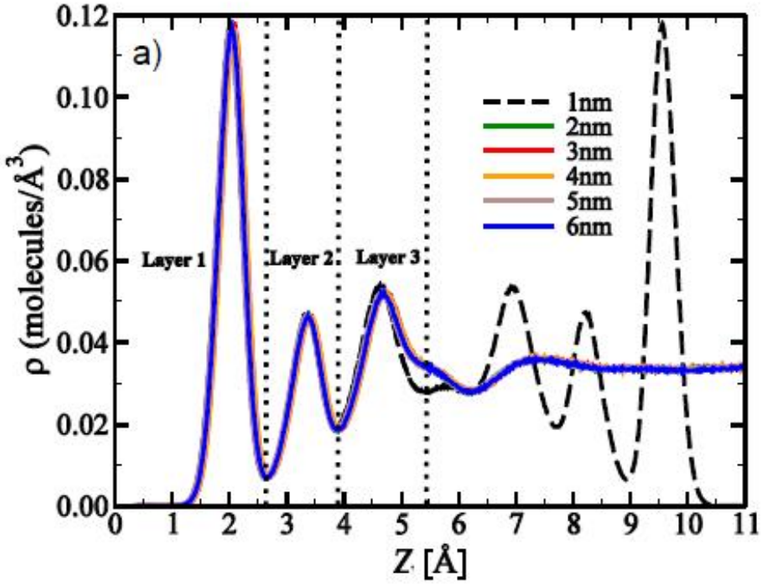
1)Nanoconfinamento
2) Injeção de fluidos com Baixa salinidade
3)Biomineralização

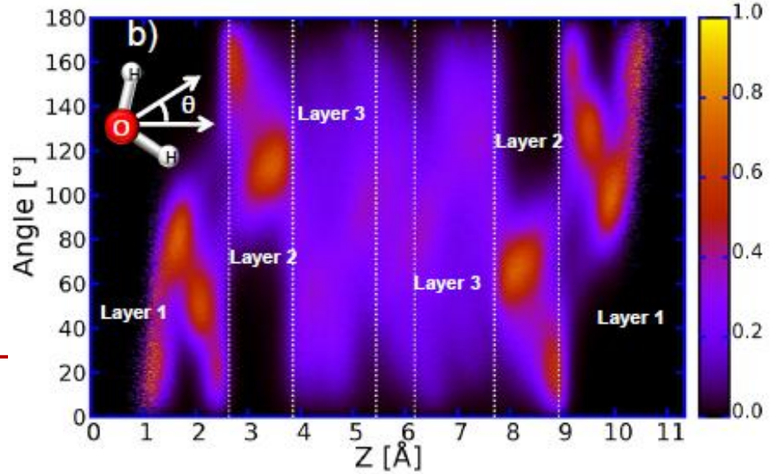
Interface calcita-salmoura

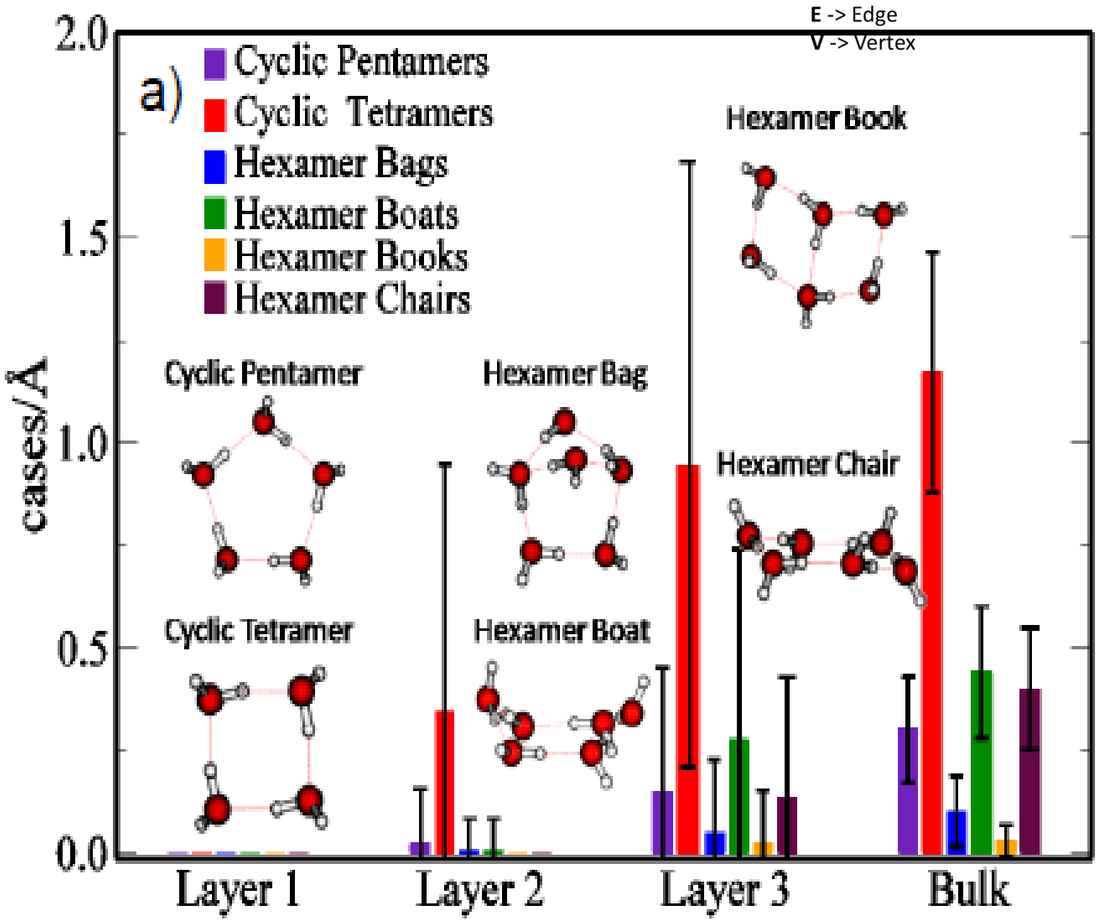


Uma visão do Google sobre os fenômenos interfaciais









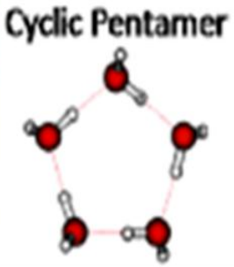
A. **Kirch**, S. M. Mutisya,V. M. Sánchez, J. M. de. Almeida, and C. R. **Miranda**

J. Phys. Chem. C, 121,6674, 2017

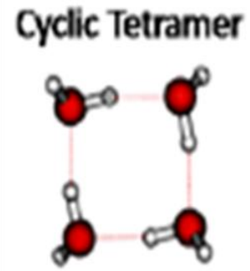
J. Phys. Chem. C,122,6117, 2018

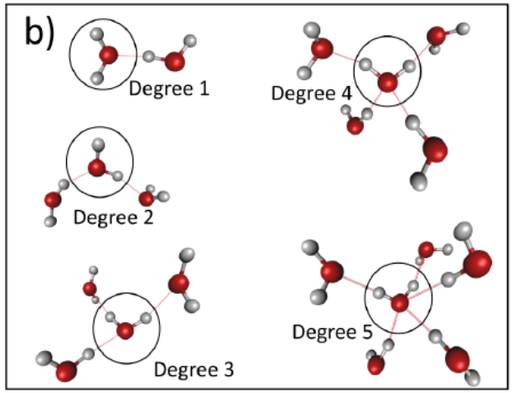
Mapeamento da Sonificação

marimba

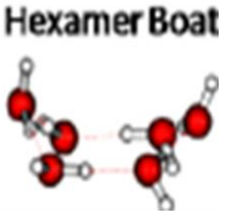


vibraphone

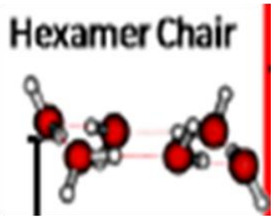


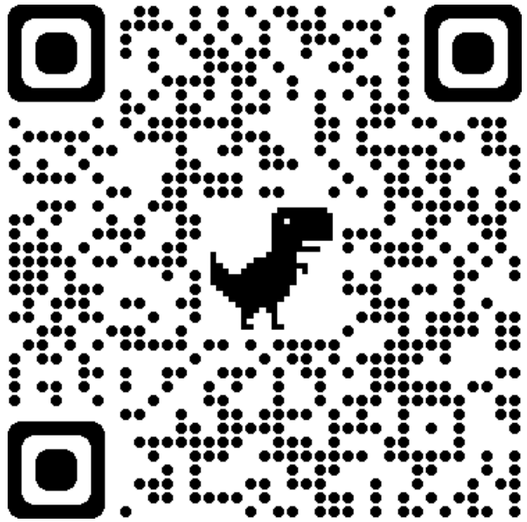


xilophone



agogo

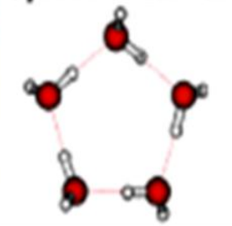




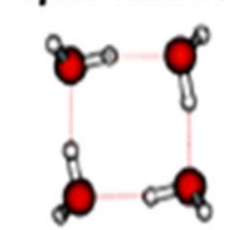
Bulk

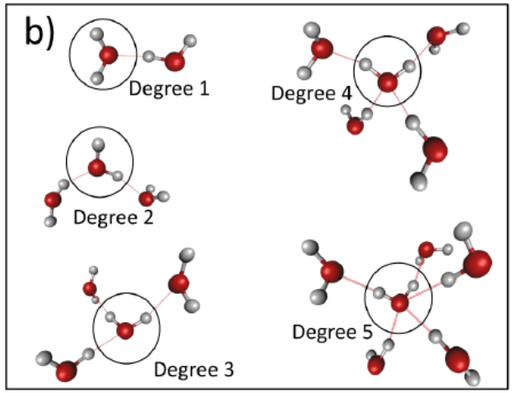
Mapeamento da Sonificação

marimba

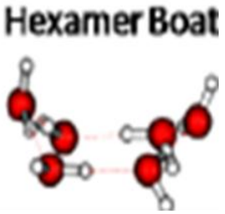


vibraphone





xilophone



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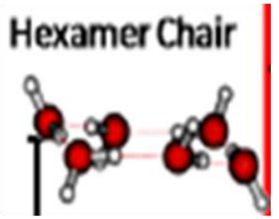
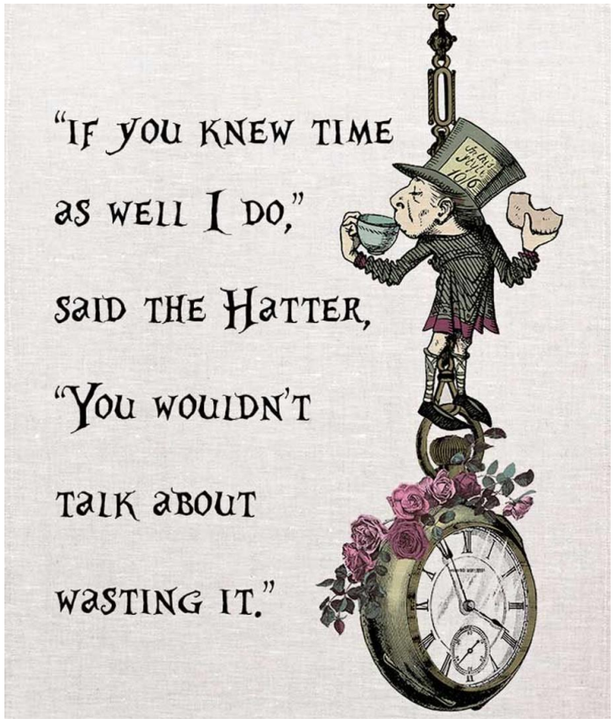


Bulk

1 nm

TERMODINÂMICA & MECÂNICA ESTATÍSTICA

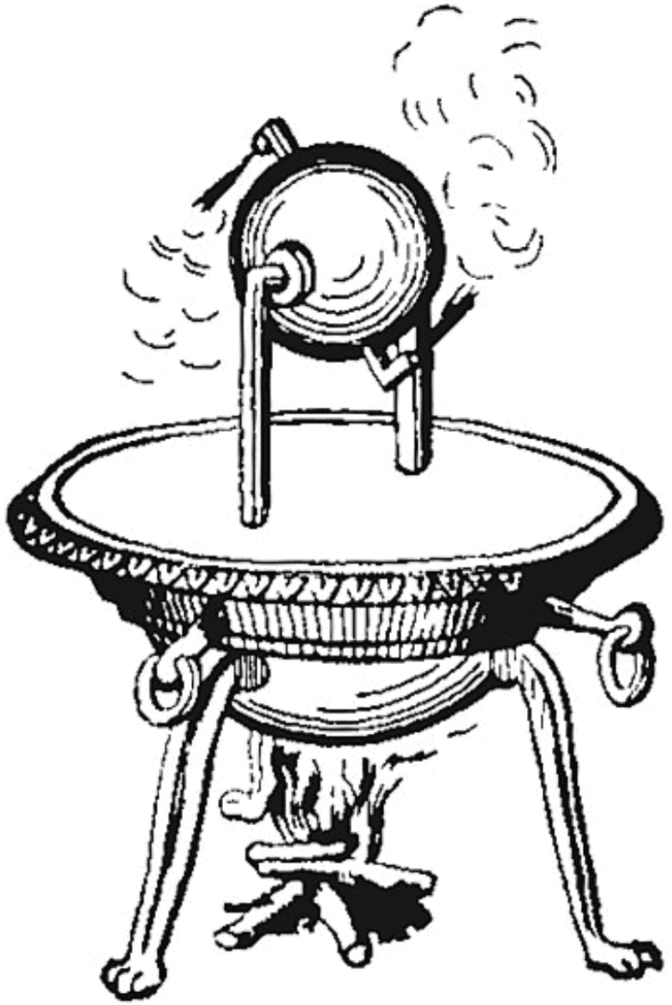
Termodinâmica e Física Estatística



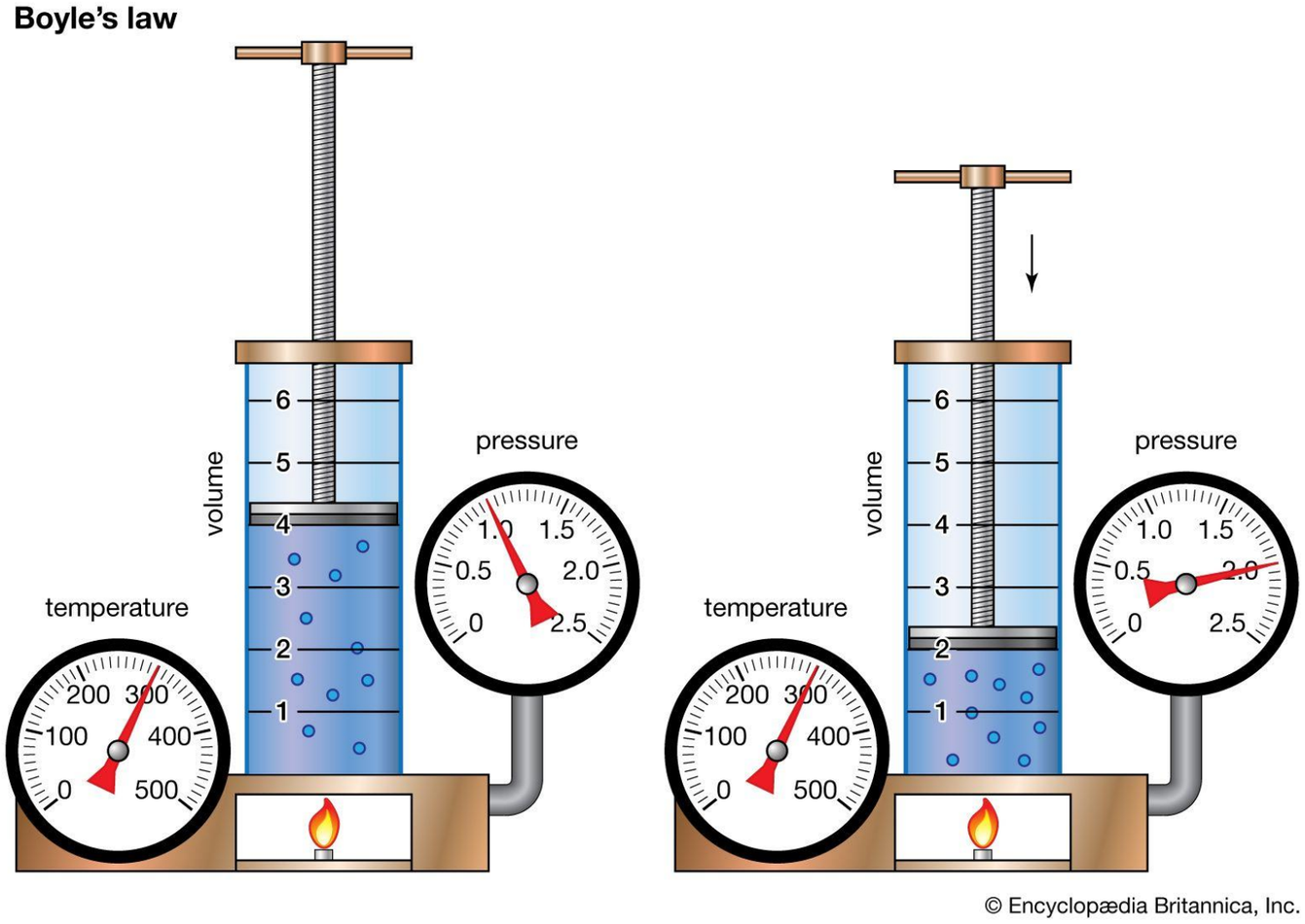
"Se você conhecesse o Tempo tão bem quanto eu, não falaria em perdê-lo.“

"Aqui você tem que correr o máximo que puder para ficar no mesmo lugar."

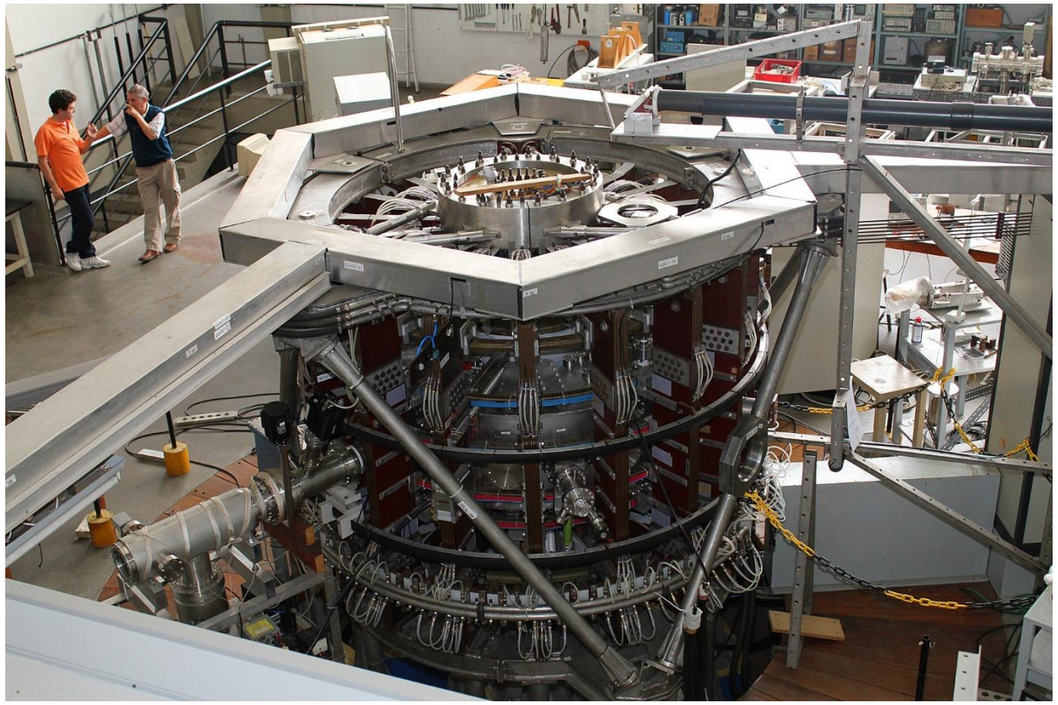
Demo 6a – Fenômenos térmicos

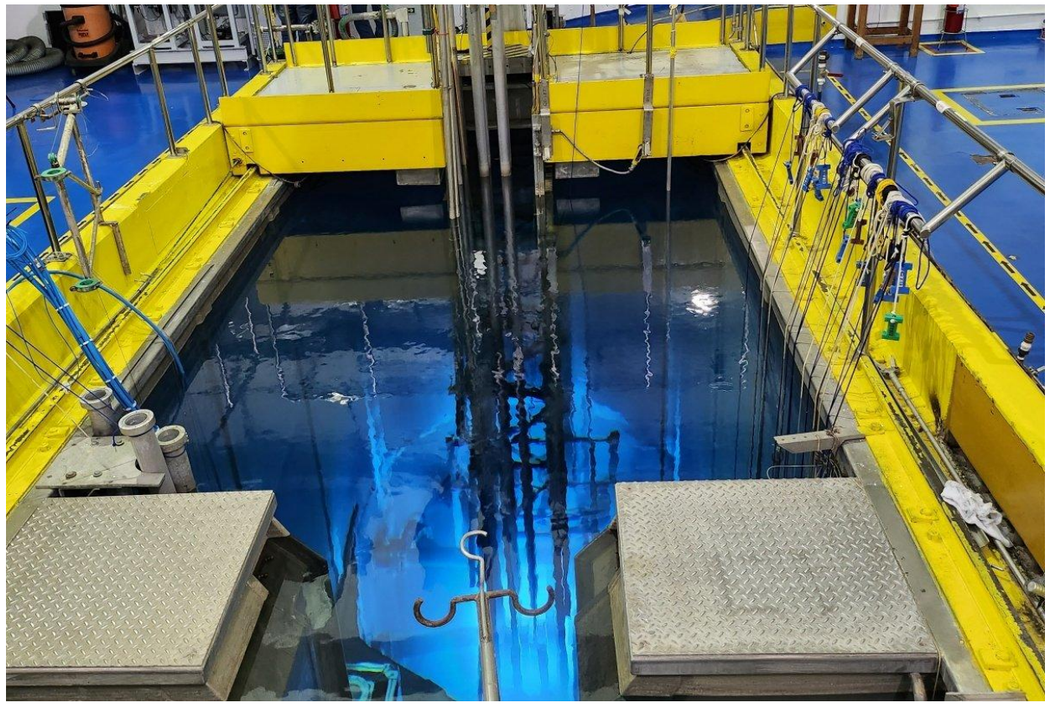


Demo 6b – Experimentos Gases

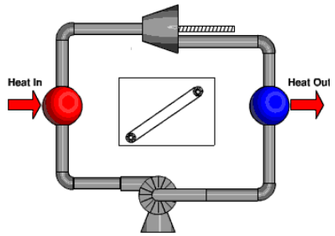


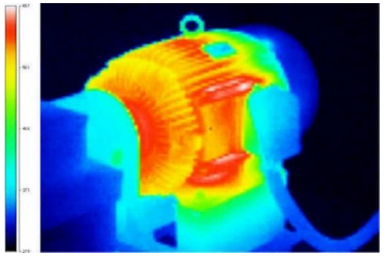
Demo 7 – Máquinas térmicas – visitas





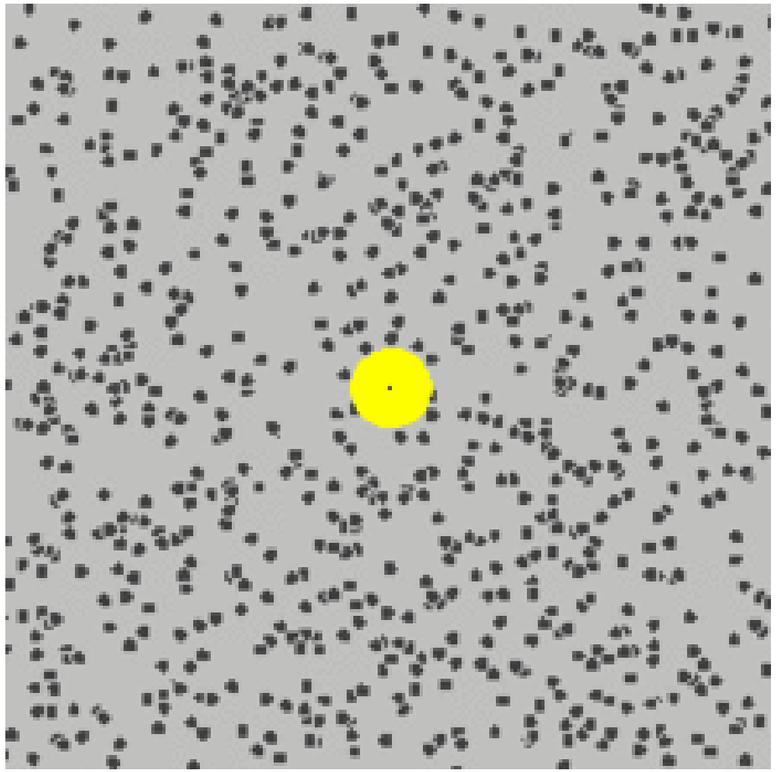
Catavento
Museu de Ciências

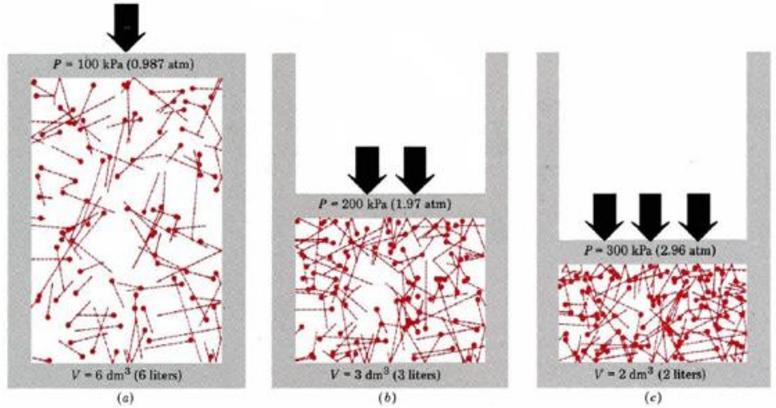


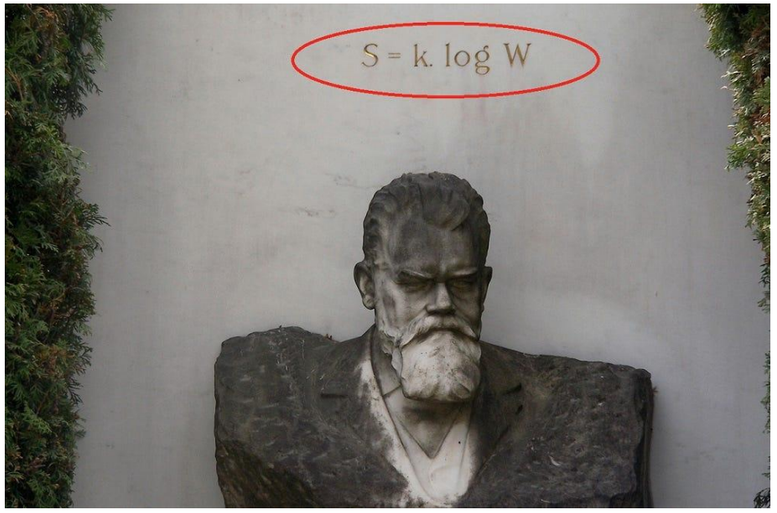


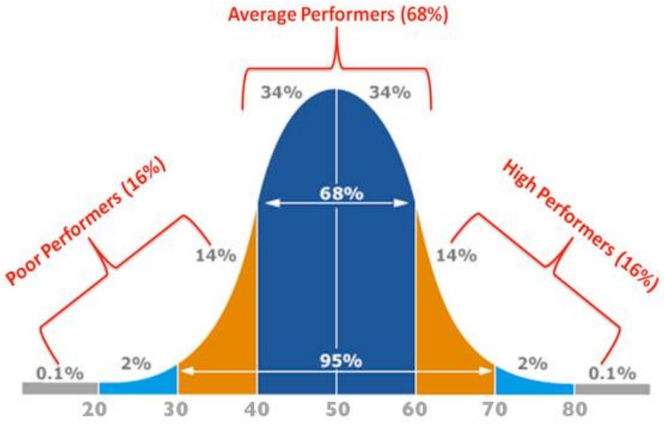
Demo 8 – Cinética e Mecânica estatística

Movimento Browniano









Inspiração 1

nature materials

Vol.7 No.4 April 2008 www.nature.com/naturematerials

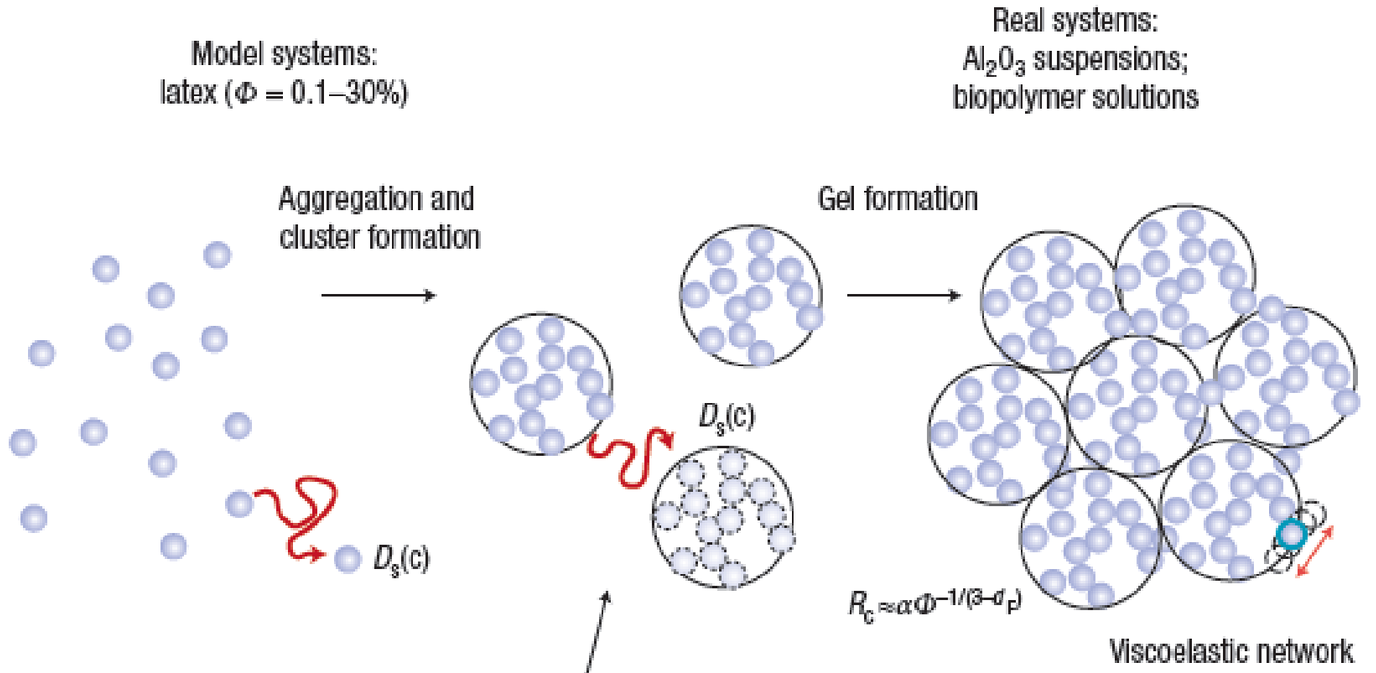
Theory in application

It's not surprising that the work of de Gennes has already found a variety of applications — understanding soft matter brings great advantages for industry.

"The Nobel Prize in Physics 1991 was awarded to Pierre-Gilles de Gennes "for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers".
Quotation from the Nobel foundation

Pierre-Gilles de Gennes

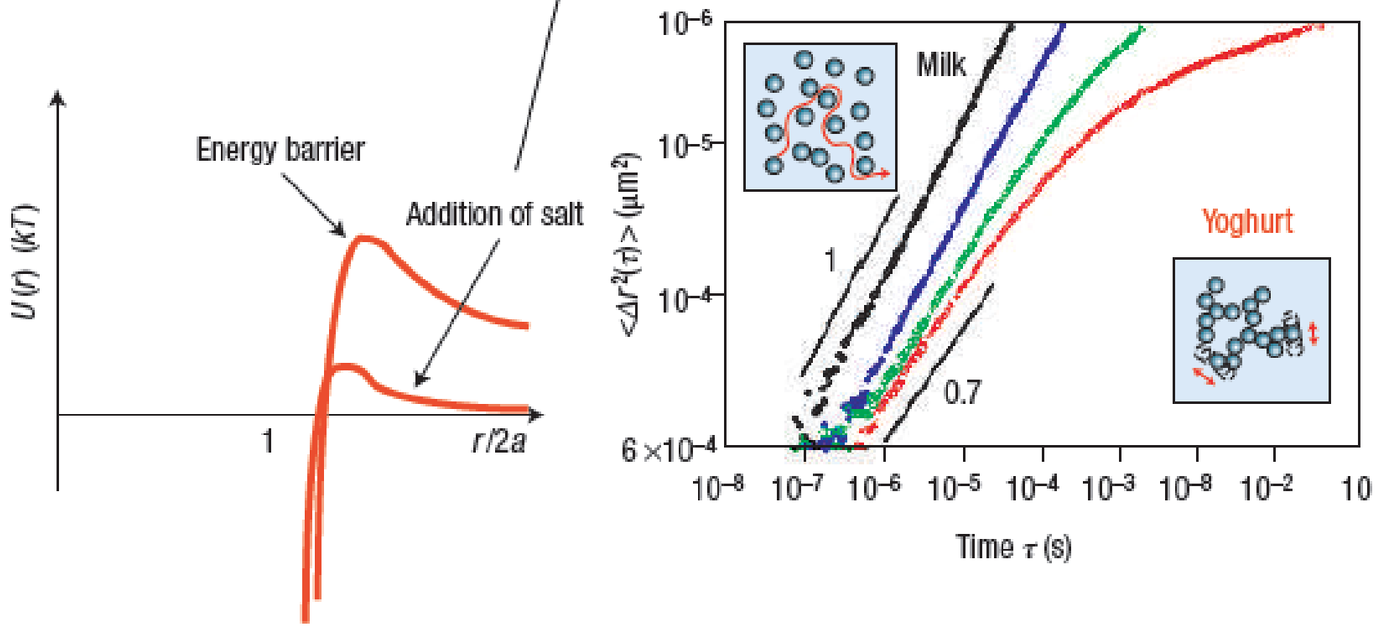
Understanding foods as soft materials
R. Mezzenga et al
Nature Materials 4, Oct 2005



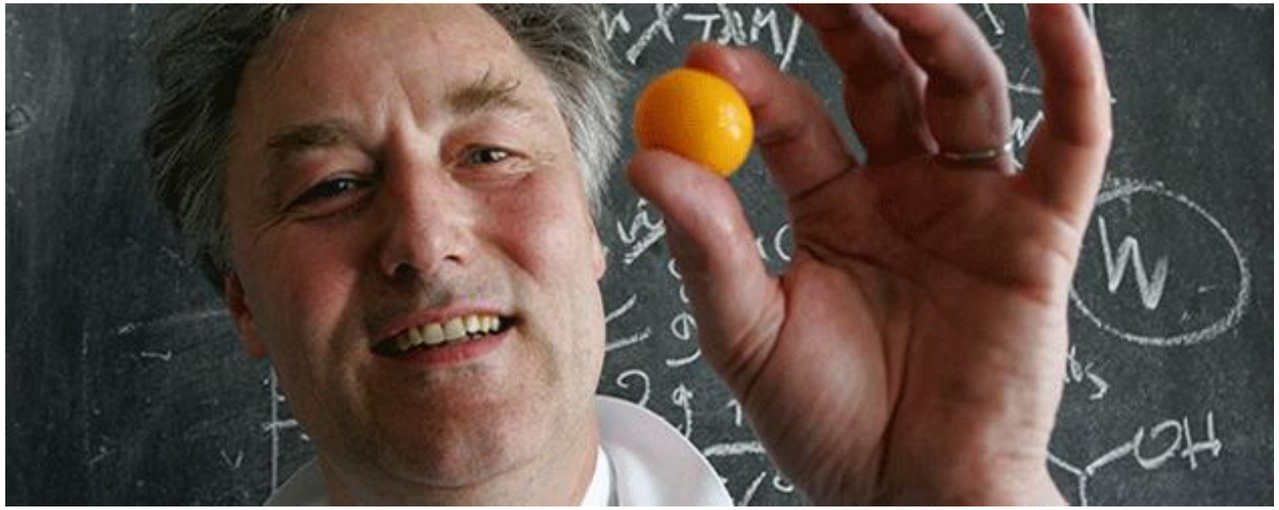
intricacy of components

different aggregation states

characteristic time and length



Inspiração 2 – Gastronomia Molecular



Nature Materials 4, 5 - 7 (2005)
doi:10.1038/nmat1303

Molecular gastronomy
Hervé This

For centuries, cooks have been applying recipes without looking for the mechanisms of the culinary transformations. A scientific discipline that explores these changes from raw ingredients to eating the final dish, is developing into its own field, termed molecular gastronomy. Here, one of the founders of the discipline discusses its aims and importance.

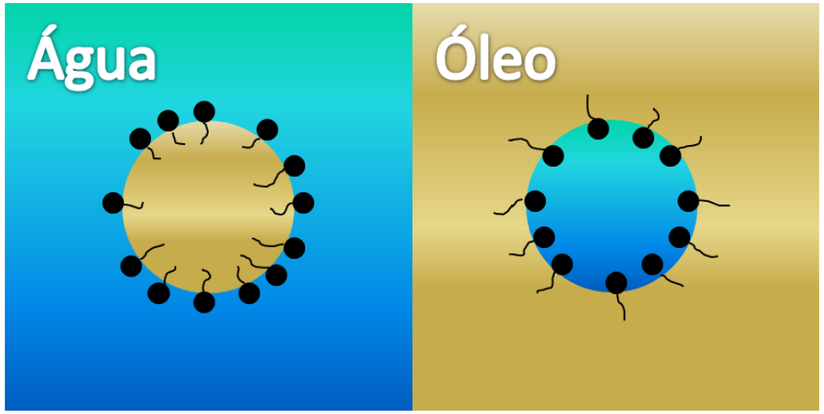
Gastronomia molecular – emulsões

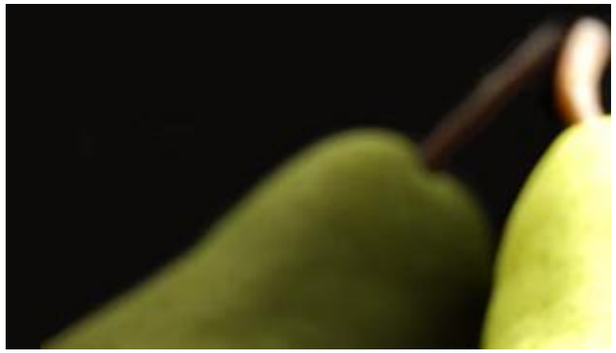
System consisting of two liquids

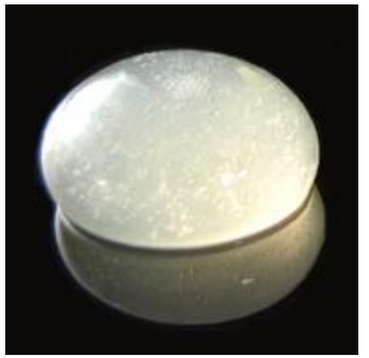
- Dispersed and continuous phases

Thermodynamic instability

Emulsifying agents







- Alternatives

- Texture, flavor and aesthetics

Esferificação

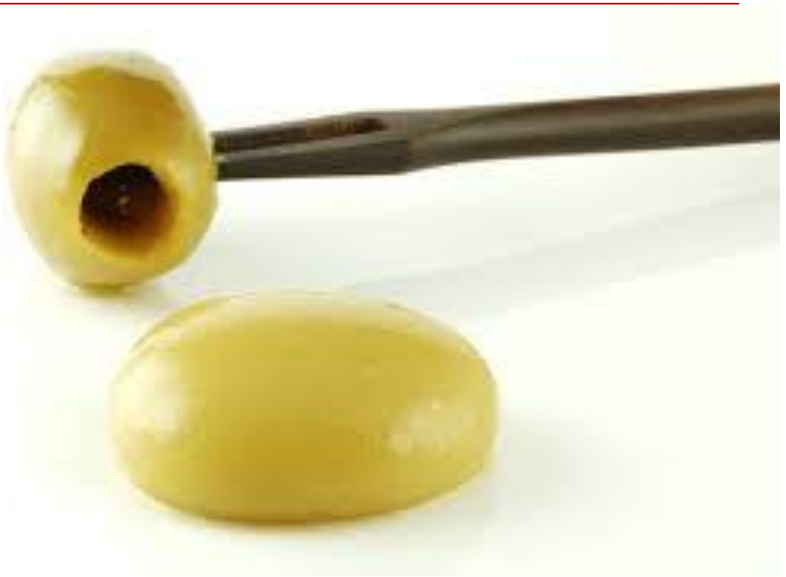
Ferran Adrià - *El Bulli*

Liquids (caviar)

Sodium Alginate

Types:

- Direct (Alginate ($NaC_6H_7O_6$) + $CaCl_2$ bath)
- Inverse (Glucolactate $C_9H_{16}CaO_{10}$ + Alginate bath)



El Bulli …

Reportagem

Restaurante que dura 3 noites e custa R$ 10 mil por pessoa marca era pop-up

Rafael Tonon Colunista de Nossa

09/02/2024 04h10

5250 pessoas para 160 vagas
5000 Euros (R$ 10000)

Albert Adrià (no centro) prepara um dos pratos do restaurante pop-up que reviveu por três noites o icônico El Bulli
Imagem: Divulgação

Ferran Adrià, à esquerda, no restaurante temporário com vagas disputadas

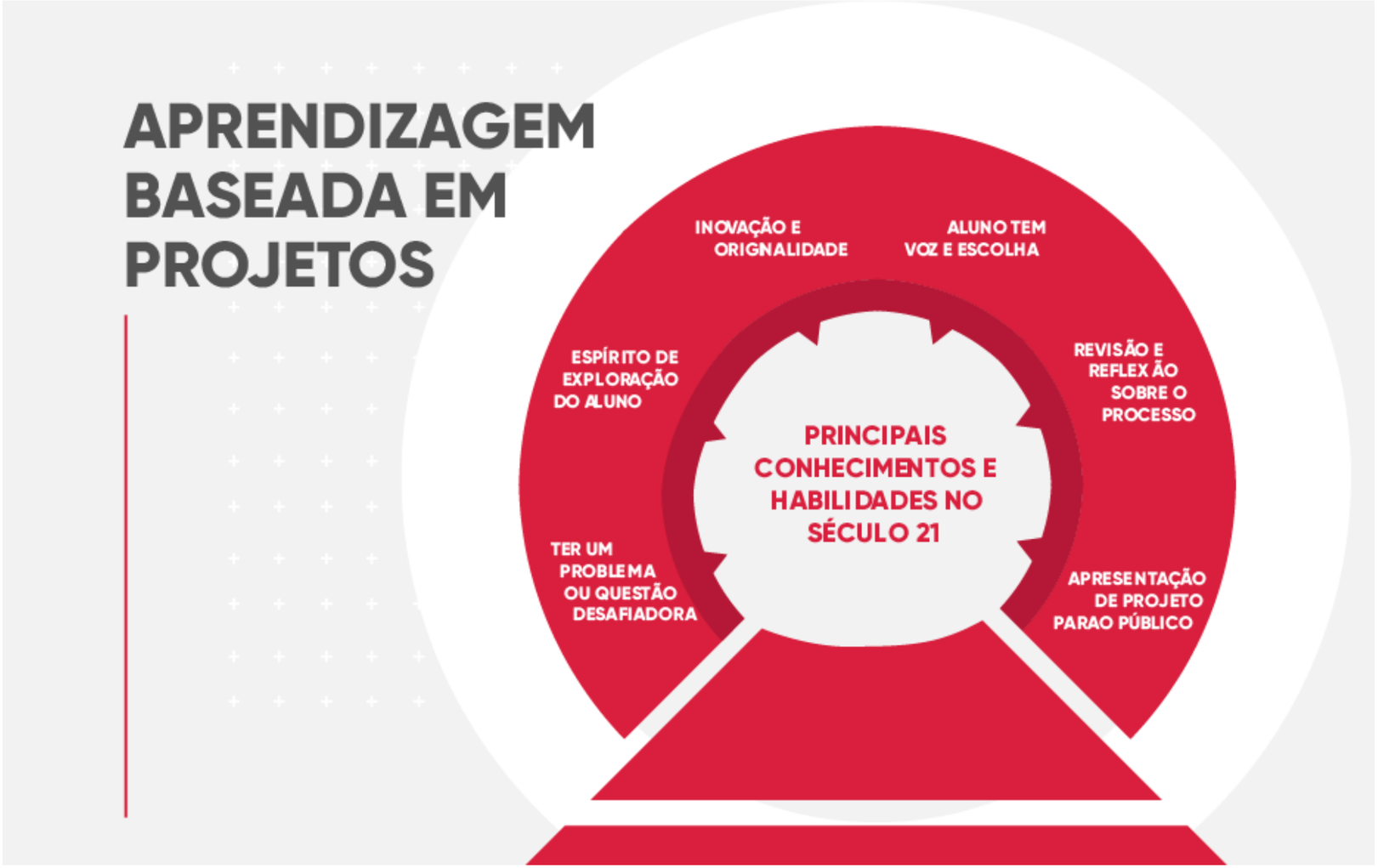
Preparando o melhor café possível …

TERMO II - Energia & Sustentabilidade

Objetivos de desenvolvimento sustentável (Agenda das Nações Unidas em 2015 para 2030)

Os Objetivos de Desenvolvimento Sustentável são uma chamada universal à ação para erradicar a pobreza, proteger o planeta e melhorar a vida e as perspectivas de todos, em todos os lugares.

PROJETO
25/06



Projeto

"Mas eu não quero ir para o meio de gente louca!" — "Ah, mas isso você não pode evitar."

Entregáveis

- Desenvolvimento de objetos de aprendizagem para Ensino Médio (Jogos, Material Educativo, …)
- Infográfico / Mangá / Wikipédia
- Divulgação científica (podcast, vídeo, …)
- PITCH

Dinâmica das demos e projetos

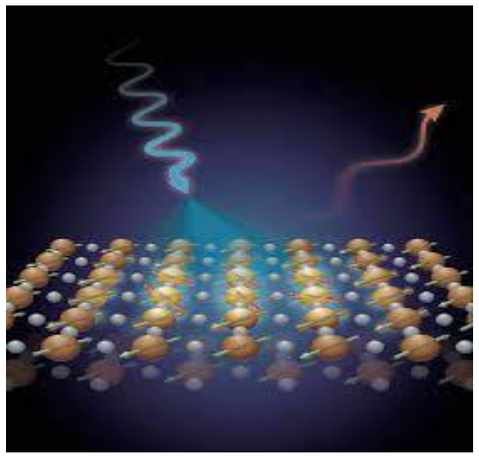
1. Formação dos grupos

7 grupos com 4 integrantes

2. Definição dos temas (Próxima aula)

De sala de aula à Wikipédia

Quanto conhecimento prévio você realmente precisa para explicar um conceito/fenômeno em física?



WIKIPÉDIA
A enciclopédia livre

1) Compartilhe seu conceito favorito com o grupo

2) Escolham a mais "interessante"

3) Identifiquem qual o conceito físico central

4) O que temos na Wikipédia sobre esse conceito ?

5) Revise a versão em português desse conceito na Wikipédia.

1. ANÁLISE GERAL DA PROPOSTA

1.1 A "Análise Geral da Proposta" deve sintetizar os 3 itens de análise deste formulário: 1. Análise do Projeto de Pesquisa; 2. Histórico acadêmico do Candidato; 3. Histórico de Pesquisa do Supervisor. Por favor preencha este item depois de preencher o restante do formulário.

2. Por favor, analise o PROJETO DE PESQUISA proposto, conforme roteiro abaixo:

2.1 Definição e pertinência dos objetivos.

2.2 Originalidade e importância da contribuição pretendida para a área do conhecimento em que o projeto proposto se insere.

2.3 Fundamentação científica e os métodos empregados.

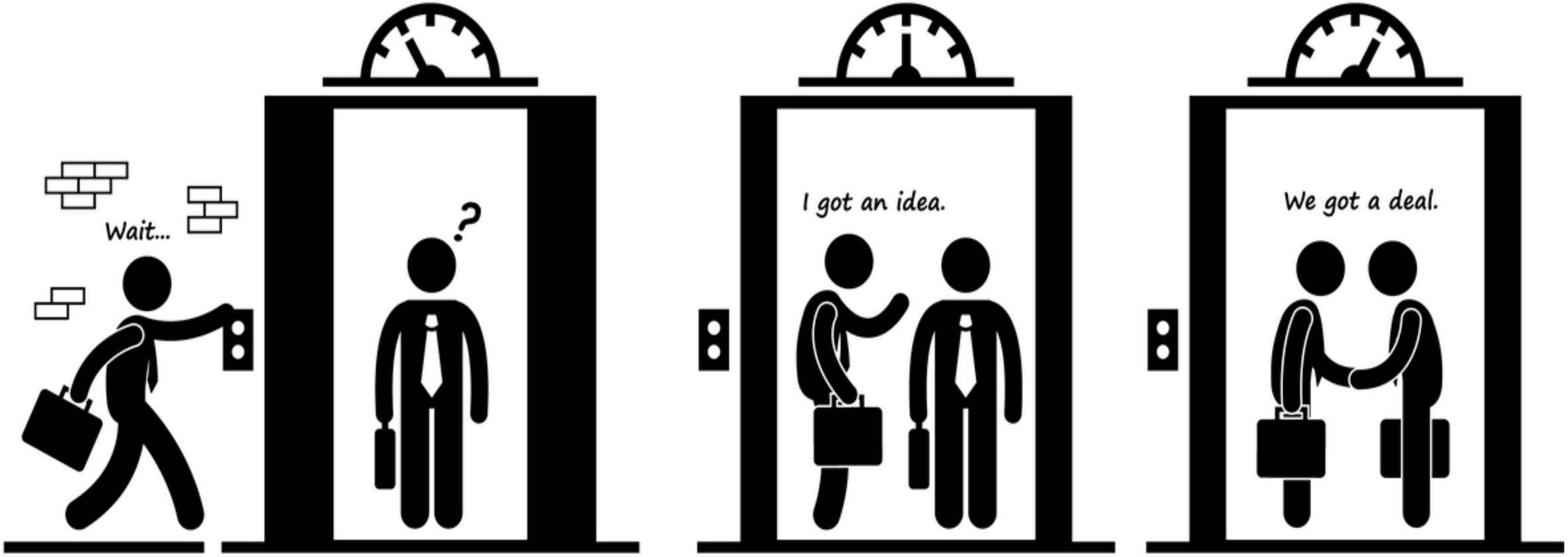
2.4 Adequação do projeto a um programa de pós-doutorado.

2.5 Análise da viabilidade da execução do projeto utilizando a infra-estrutura disponível e no prazo previsto.

2.6 Conclusão sobre a análise do Projeto de Pesquisa apresentado. (Preenchimento obrigatório)

- ( ) Excelente
- ( ) Muito boa
- ( ) Muito boa, com algumas deficiências facilmente sanáveis
- ( ) Boa
- ( ) Boa com deficiências
- ( ) Regular
- ( ) Com sérias deficiências

Pitch (3 a 10 min para nos convencer)



Pitch evaluation sheet

Team name

1 Problem to solve

BIG NO — BIG YES

- Is there a clearly defined customer segment?
- Am I confident that the team truly understands the problem?
- Do I know how the problem is currently being solved?
- Is the problem space big enough to break even at a fraction of the market?

2 Solution/offering

BIG NO — BIG YES

- Is the proposed solution clear?
- Does the proposed solution solve the problem?
- Is the solution sufficiently differentiating from existing solutions?
- Does the proposed solution fit within the strategy?

3 Value of solution/offering

BIG NO — BIG YES

- Is the business model clear and sustainable?
- Does the business model deliver value to all stakeholders?
- Do I have a solid understanding of how much value this solution will capture?
- Are the underlying assumptions about the business model clear?

4 Credibility

BIG NO — BIG YES

- Do I feel that the pitch is based on solid evidence?
- Do I understand the remaining assumptions?
- Did the team involve customers to validate assumptions?
- Do I have a good overview of why it might fail?

5 Call to action/ Next steps

BIG NO — BIG YES

- Are there clear next steps suggested?
- Do I know the amount of resources needed (people and budget)?
- Do I have clear criteria for the next stage gate?
- Do I know how the team wants to scale their solution/offering?

6 The team should continue

BIG NO — BIG YES

7 What can I offer?

Design Thinking / Design Sprint

Propostas – Definição - Hoje às 11:11

1) MONIAC
2) Microfluidica
3) Sonificação
4) Teatro de sombras
5) Gastronomia molecular
6) Energia e sustentabilidade
7) Física do Corpo Humano

Posições abertas

Jornalismo Científico

Projeto SPEC – Imperial College London

Bolsa Fapesp – 6 meses - R$ 1.080,00 - 10 hs semanais

Energia / Células Combustível / Hidrogênio

Monitor – Exposição Centenário da Eq. de Schrodinger

Projeto PRCEU – IFSC / IFUSP

Bolsa USP – 6 meses -R$ 700,00 - 10 hs semanais

Games / Tabela Periódica