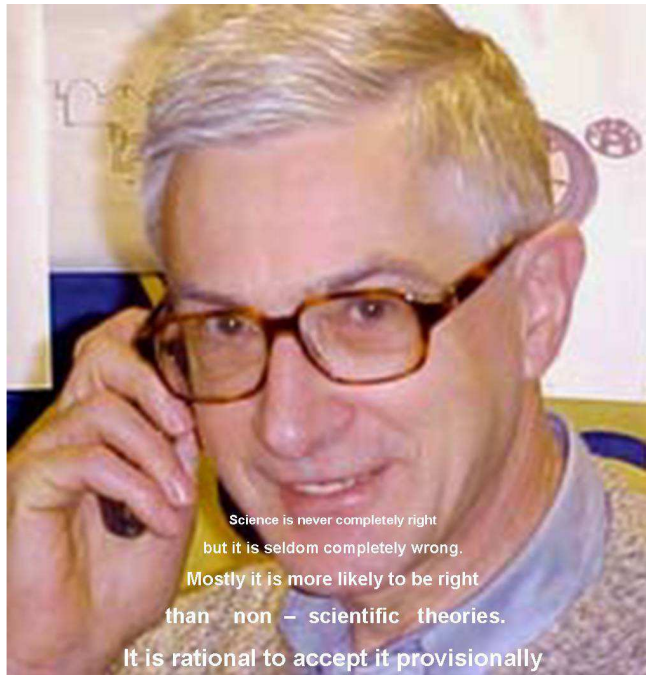


Science



Science is never completely right
but it is seldom completely wrong.
Mostly it is more likely to be right
than non – scientific theories.
It is rational to accept it provisionally

Bertrand Russell



Things should be made as intricate
as necessary but not more

Me



Unbelievable?
Believe in science

Willie Van Peer

Tout ce qui existe dans l'univers est le produit du hasard et de la necessite (Democritos)

Necessite = onvermijdbaarheid

All that exists in the universe is an accident to happen

Amours necessaires et amours contingents (Noli me tangere, casual)(Sartre-de Beauvoir)

"L'homme sait enfin qu'il est seul dans l'indifference de l'Univers d'ou il a emergé par hasard. Non plus que son destin, son devoir n'est écrit nulle part. A lui de choisir entre le Royaume ("esprit") et les ténèbres ("vitalisme" "diep geheim" "hushbush")"



Boltzmann constant

- What and where from
 - From distribution of velocity gas molecules (for N2 the max is 400 m/s at 300K)
 - De Bock p241 from gaslaw

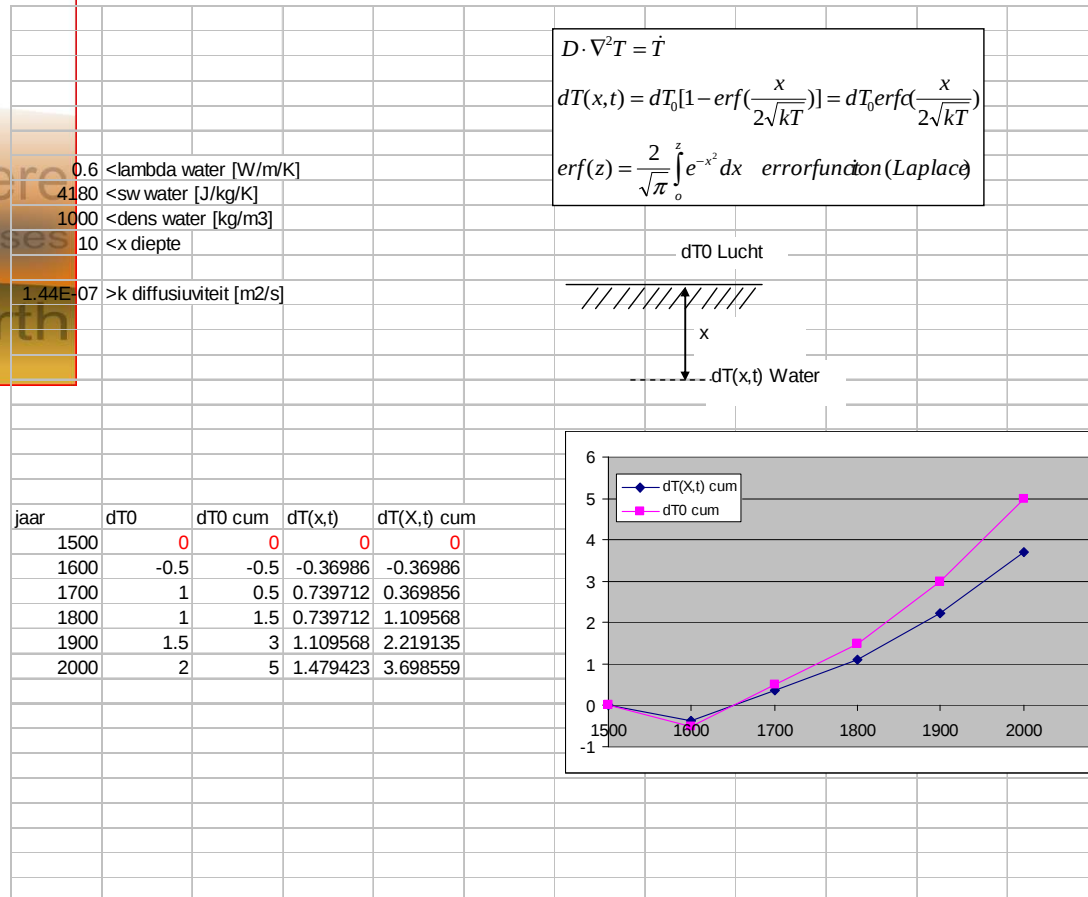
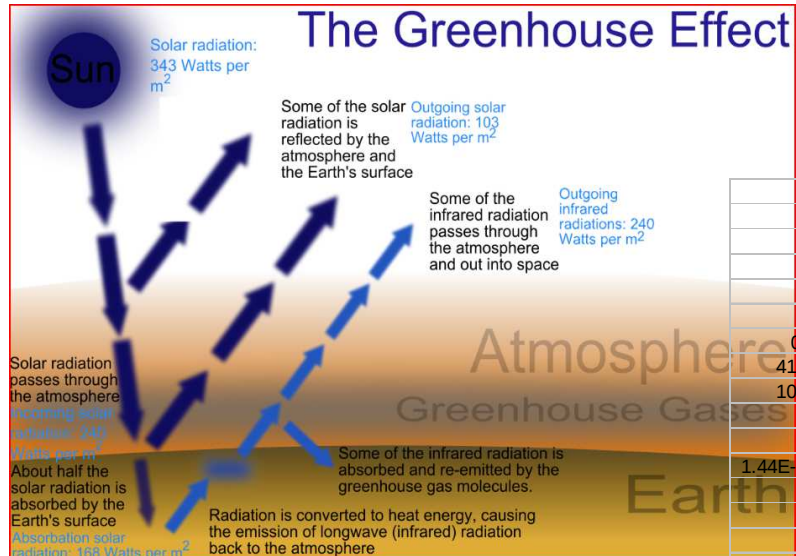
$$v_m = \sqrt{\frac{3kT}{m}}$$

$$\frac{kT}{2} = \frac{1}{3} \frac{mv^2}{2} = \textit{kin energy per DOF}$$

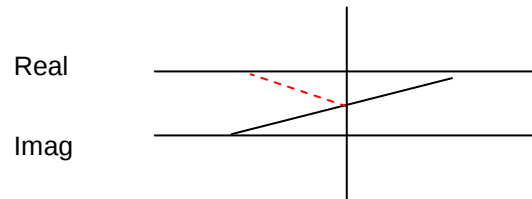
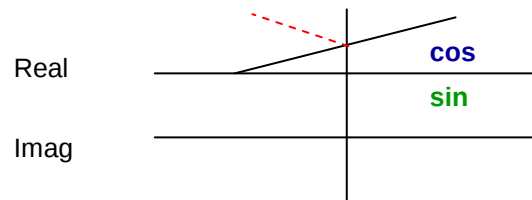
Planck + Einstein = de Broglie

$$\left. \begin{array}{ll} E = \hbar \cdot \omega & \text{Planck} \\ E = mc^2 & \text{Einstein} \end{array} \right\} p = \hbar \cdot k \quad \text{deBroglie}$$

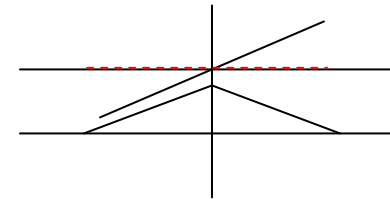
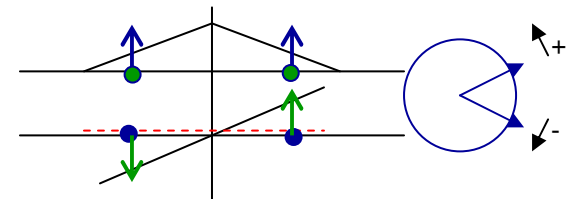
Earth warm-up (Andre)



Fourier transform



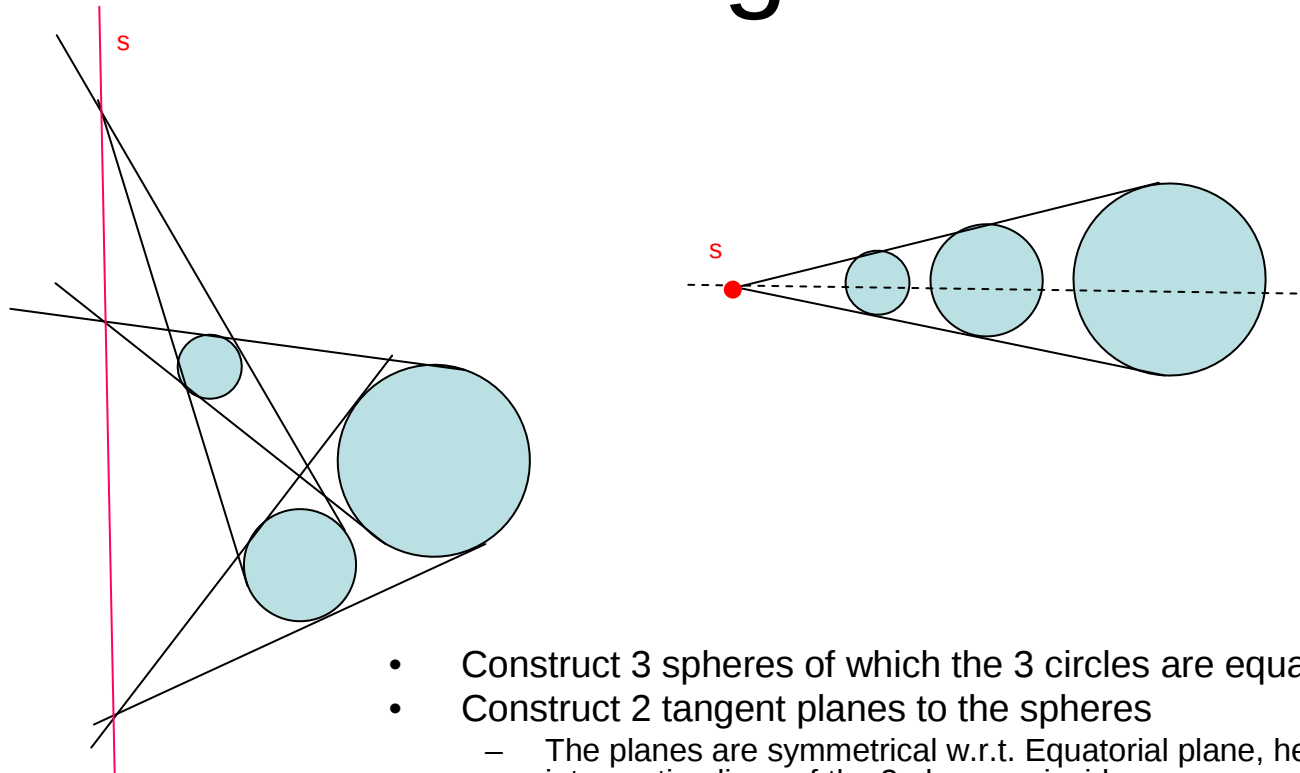
Time domain



Frq domain

[illegible]

Monge



- Construct 3 spheres of which the 3 circles are equatorial
- Construct 2 tangent planes to the spheres
 - The planes are symmetrical w.r.t. Equatorial plane, hence the intersecting lines of the 3 planes coincide
- Connect the intersecting points of the tangent planes
 - Upper and lower lines are symmetrical
- Connect the centers of the spheres
- Rotate the intersecting lines 90 deg about their respective centerlines

Sound p and v

Beranek 35-36

- Freely traveling plane wave (infinite tube)
 - p and v in phase
 - $Z_{\text{spec}} = \rho_0 c$ real
- Freely traveling spherical wave
 - p and v in phase only far field, 90 deg out of phase near field
 - p: Near and far field $\sim 1/r$
 - v: Near field $\sim 1/r^2$ (“bassy”) far field $\sim 1/r$
 - Z_{spec} complex and $= \rho_0 c$ real only for far field
- Wrap-up
 - p and v always $\sim 1/r$ and in-phase
 - Except near field spherical: p and v out of phase and v $\sim 1/r^2$
- Bernoulli (steady state): high v $\rightarrow$ low p

Powers Machten

(Tera pico > twaalf)

Multiples and Submultiples Prefixes Tables

Symbol	Name	Factor	Symbol	Name	Factor
Y	yotta	10^{24}	y	yokto	10^{-24}
Z	zetta	10^{21}	z	zepto	10^{-21}
E	exa	10^{18}	a	atto	10^{-18}
P	peta	10^{15}	f	femto	10^{-15}
T	tera	10^{12}	p	pico	10^{-12}
G	giga	10^9	n	nano	10^{-9}
M	mega	10^6	μ	micro	10^{-6}
k	kilo	10^3	m	milli	10^{-3}
h	hecto	10^2	c	centi	10^{-2}
da	deka	10^1	d	deci	10^{-1}

Poensgen and Lang

- Steady-state: Poensgen = Guarded Hot Plate
- Transient: Lang = conductivity
 - Hoe deed Ruud het? (dT constant)
 - Wiki Heat flux sensor
 - Cfr indringdiepte

Heat (Spatial curvature $\propto$ "velocity") $[q] = \frac{W}{m^2} [Q] = \frac{W}{m^3} (\text{internal})$

$\nabla \cdot q + C \cdot \dot{T} = Q$ (Bouck21) $[\frac{W}{m^3}]$ $[C = \rho \cdot c_p = \text{Capacity}] = \frac{J}{K \cdot m^3}$ (Energy out – in over ∂x + accumulated = internal)

With Fourier: $D \cdot \nabla^2 T = \dot{T} - \frac{Q}{C}$ $[\frac{K}{s}]$ $D = \frac{\lambda}{\rho \cdot c_p} [\frac{m^2}{s}]$

FEM: $C \cdot \dot{T} + (\frac{\lambda}{dx^2} + \frac{htc}{dx}) \cdot T = Q$ $[\frac{W}{m^3}]$ $() = k_{wall} / dx, \text{ solver Crank – Nicolson (EN)}$

Rekhson

$$\Delta V / V \equiv \varepsilon = \varepsilon_1 + \varepsilon_2 + \varepsilon_3. \quad (4)$$

If $\sigma_{11} = \sigma_{22} = \sigma_{33} = -P$, the hydrostatic pressure, we have

$$P = -K \Delta V / V, \quad (5)$$

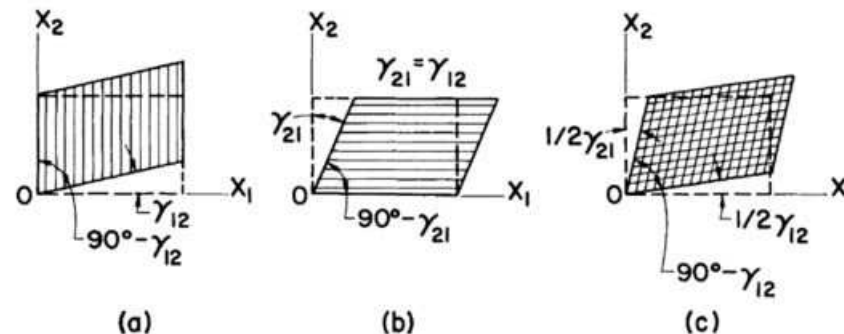
where K is the bulk modulus. The shear stress σ_{ij} , $i \neq j$, produces a shear strain γ_{ij} developed by an edge originally parallel to the direction i turning toward the edge parallel to the direction j (see Fig. 5). The relationship between these quantities is given by

$$\sigma_{12} = G\gamma_{12}, \quad \sigma_{23} = G\gamma_{23}, \quad \text{and} \quad \sigma_{31} = G\gamma_{31}, \quad (6)$$

where G is the shear modulus and γ_{ij} is related to the displacements as

$$\gamma_{12} = \frac{\partial U_1}{\partial x_2} + \frac{\partial U_2}{\partial x_1}, \quad \gamma_{23} = \frac{\partial U_2}{\partial x_3} + \frac{\partial U_3}{\partial x_2}, \quad \text{and} \quad \gamma_{31} = \frac{\partial U_3}{\partial x_1} + \frac{\partial U_1}{\partial x_3}. \quad (7)$$

Shear strain can be represented in three different ways shown in Fig. 5. They are equivalent because they can be obtained one from another simply



Lame (Bouckaert p54)

$$\sigma_{ij} = 2\mu\epsilon_{ij} + \lambda\epsilon\delta_{ij} \quad \lambda = \frac{\nu E}{(1+\nu)(1-2\nu)} \quad \epsilon = \epsilon_{11} + \epsilon_{22} + \epsilon_{33} = \frac{\Delta V}{V} = \text{dilatation or vol strain}$$

$$\sigma_{ij} = \frac{E}{1+\nu} \left(\epsilon_{ij} + \frac{\nu}{1-2\nu} \epsilon \delta_{ij} \right)$$

$$\mu = G = \frac{E}{2(1+\nu)}$$

$$\text{for } \nu = 0.33 \quad \lambda / E \approx 0.73$$

Tensile test isotropic material :

$$\epsilon \Rightarrow \epsilon - 2\epsilon\nu = \epsilon(1-2\nu)$$

$$\sigma = \epsilon E$$

Vierkantswortel Frederik Boits

- Vierkantswortel van 12 (Kareltje?)--
 - >Babylonische methode
 - Doe een schatting: 3
 - $(3+12/3)/2=3.5$ (kwadraat is 12.25)
 - Voor 37: $(6+37/6)/2=6.08$ (kwadraat is 36.96)
 - De formule is dus $(\text{schatting}+\text{getal}/\text{schatting})/2$
 - Werkt ook als je te hoog schat, bv.
 $(15+170/15)/2=13.16$ (kw=173.4)
 - Volgens mij is geen Taylor reeks geschikt (met 1/2!
Etc)

Truss beam membrane shell

NL	EN	DE		Static	Harmonic
koord		Seite			
staaf	truss bar	Stab			
balk	beam	Balken	Bouckaert p11	$D \cdot \nabla^2 u = m \quad [Nm] \quad D = \frac{E \cdot th^3 \cdot b}{12} \quad [Nm^2]$ $D \cdot \nabla^3 u = f \quad [N]$ $D \cdot \nabla^4 u = \nabla \cdot f \quad [\frac{N}{m}]$	
membraan vlies	membrane	Membran	Hütte p607, de Zwart p27	$ST \cdot \nabla^2 u = p(u) \quad [\frac{N}{m^2}]$ (Poisson)	$c^2 \cdot \nabla^2 u = \ddot{u} \quad [\frac{m}{s^2}] \quad c = \sqrt{\frac{T}{\rho}}$
plaat schaal	shell	Platte	Hütte p607		$D \cdot \nabla^4 u + \ddot{u} = 0 \quad [\frac{m}{s^2}] \quad D = \frac{E \cdot th^2}{12\rho(1-\nu^2)}$

Numbers

- Universe

- Hertog p154: 70-25-4 (dust)-0.6 (stars)-0.3 (neutrino's)-0.03 (heavy elements) from CMB peaks (T vs angle)

- Earlier it was 68-27-5

- Within sd 68% has IQ between 85 and 115 (Gaussian distr)

- $\exp(-0.5)=0.606\dots$ (inflection point of Gaussian distr)

- $1/\sqrt{2\pi}=0.400$ (pre-coef Normal Gauss Distr)

- $1/e=0.367\dots$

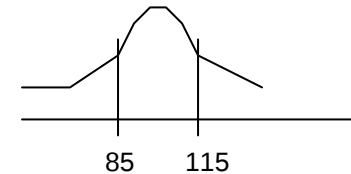
- $\sqrt{2}=1.41\dots$

- $1/\sqrt{2}=0.707\dots$

- Sabine 0.161

- Golden cut 1.618

- 0 K = -273.15 CMB is 2.726 (?!?)

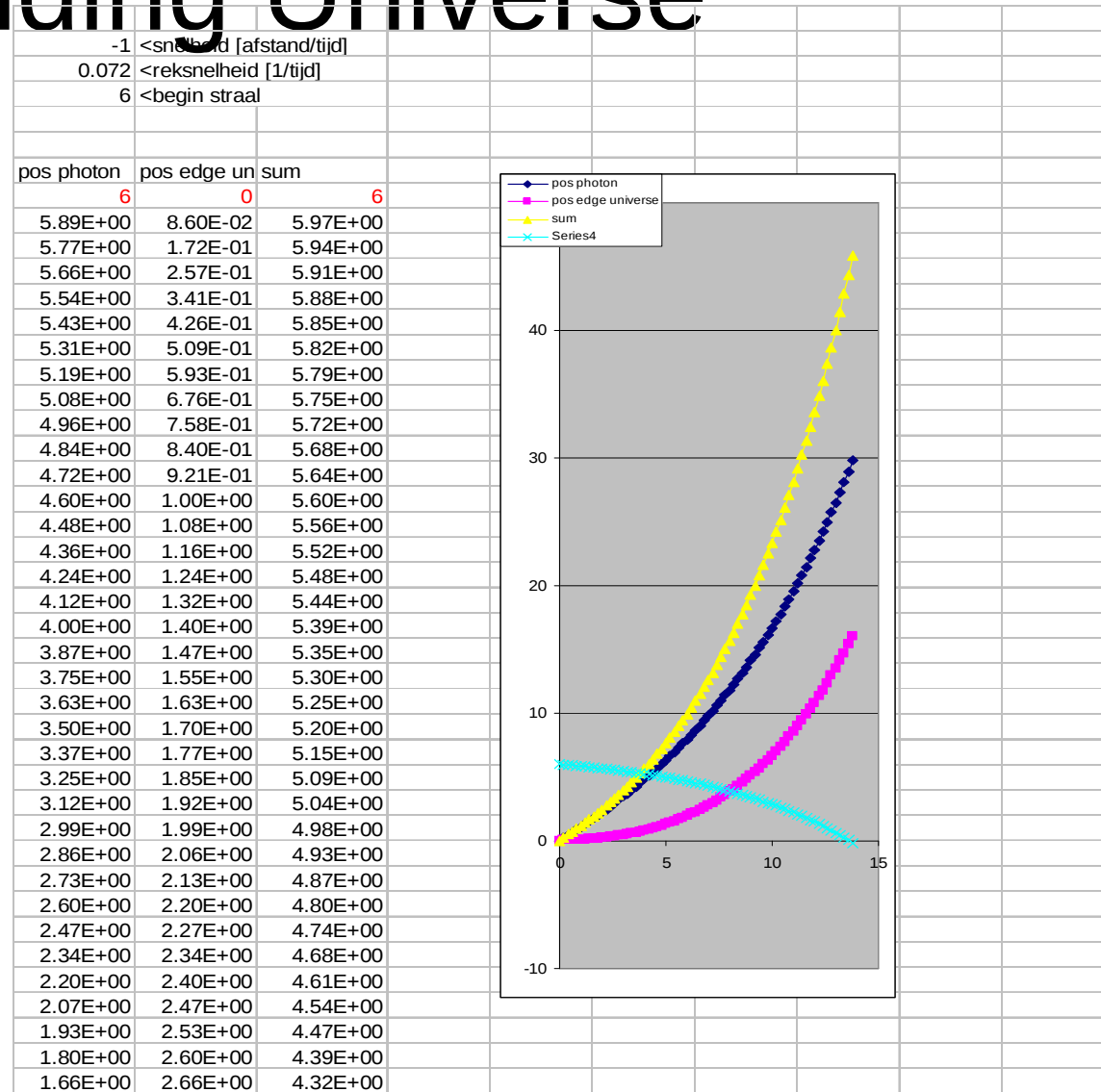


Moments

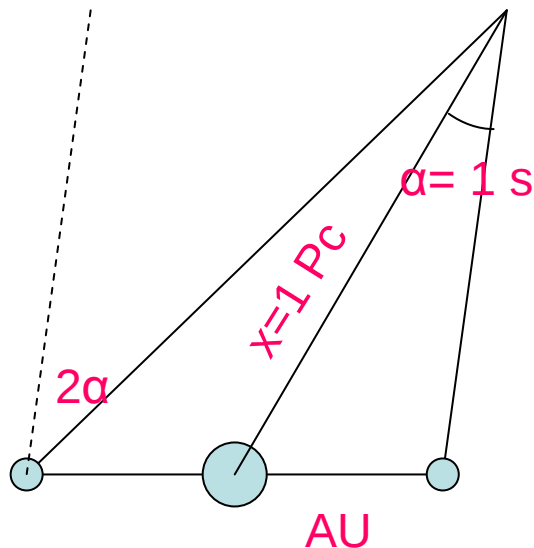
Newton momentum			mv		
Bending moment			$EI_{xx} \frac{d^2 y}{dz^2}$		
Section moment	Area moment	Geom traagheidsmoment (De Bock p108)	$I_{xx} = dA \cdot y^2$		
Mass moment	Inertia moment		$dm \cdot y^2$		
Torsion moment					
Impuls moment	h.v.b. moment	rotatiemoment	$mv \cdot r$		
Force moment		draaimoment? koppel?	$f \cdot r$		

Expanding Universe

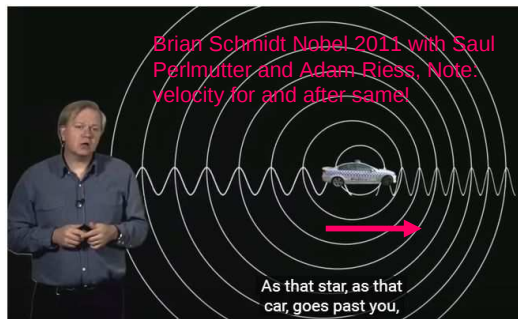
- Time axis is imaginary
- Einstein Lambda
 - Introduced to prevent gravitational collaps and keep universe static
 - Removed when became apparent universe expands
 - Re-introduced and positive for accelerated expansion (Hertog: lambda neg, gravity pos)
- Outward pressure from inhibited tunneling $\sim 1/r^2$
- Inward pressure from gravity $\sim 1/r^4$
- BB gravitaty singularity causes compressive stress in boundary
- This stress relaxes and causes expansion at $c+$ velocity
- When mass crashes against photon wall this expansion halts and new black hole singularities restore compressive stress in boundary so that net expansion is zero
- At -7 Gy crash is complete and relaxation resumes
- Note: Hubble stress is caused by non-isotropic expansion



Parsec-Expansion Universe-Hubble



- Is parallax Sun-Earth, NOT Earth-Earth
- Triangle is isosceles [ai'sosili:z](gelijkbenig)
- AU=150 Gm (AU=astronom. Unit)
- $\alpha = \pi/180/60/60$ (1 sec)(0.05 gr)
- $AU \approx x \cdot \alpha$ (cfr boogformule) $\rightarrow 1 \text{ pc} \approx AU/\alpha = 3.3 \text{ ly}$
- 1 Ly = 947 Ts
- Alpha Centauri (A, B, Proxima met de planeet) is at 4.4 ly
- The (light) particle horizon (boundary of the observable universe) has radius of 50 Gly
 - Is NOT 13.8 Gly * c (universe age*light velocity)
 - Is Conformal universe age * c (with stretched time according to FLRW (Friedman-Lemaitre-Robertson-Walker metric))
- Doppler shift formula
 - Velocities relative to medium
 - c=medium; s=source; o=observer; Δ rel to source
- Hubble parameter from cepheid is higher than from Planck satellite



$$\frac{f_o}{f_s} = \frac{c - v_o}{c + v_s} \rightarrow \frac{\Delta f}{f_s} = -\frac{v_s}{c} \text{ if } v_o = 0 \text{ and } v_s \text{ smal}$$

v_s is pos if source moves away from observer. U19 Schmidt

$$\text{Cepheid Hubble parameter} = \frac{\dot{d}}{d} = 73.04 \text{ km/s/MPc} \pm 1.04 (= 2.3 \cdot 10^{-18} [1/\text{s}] = 0.072 [1/\text{Gy}] \text{ OK wiki})$$

$$T = \frac{1}{H} = 13.8 \text{ Gy}$$

Slide 18

U19

Physik griffbereit p34, met $\theta_1=180$, $\theta_2=0$, dus beweging volgens verbindinglijn tussen source en observer. Hoeken t.o.v. vector van 2 naar 1

User, 1/8/2020

My cosmology

- Dark energy and expansion Universe pressure $\Lambda > 0$) $\leftarrow$ tunneling of hydrogen atoms
 - Acceleration $\leftarrow$ tunneling pressure $>$ gravity pressure
- Dark mass $\leftarrow$ primordial black holes
 - Arising from universe crashing against free photon wall
- Hubble tension (Cepheid $>$ CMB) $\leftarrow$ asymmetric expansion
 - Our observable universe is larger than mean
- Final state Universe and interior black holes $\leftarrow$ Bose-Einstein condensate

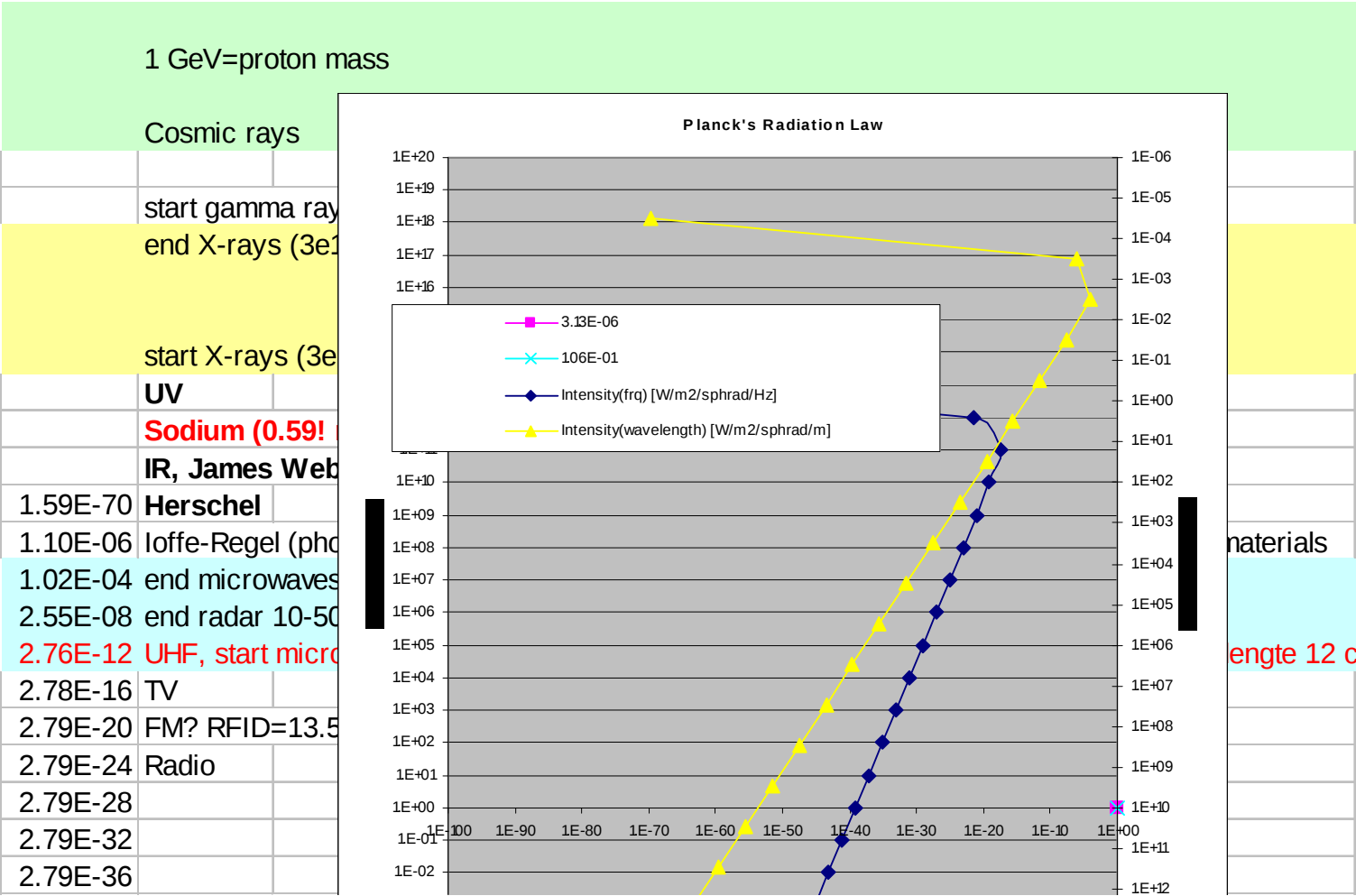
Physics

	Missed					
O		Optics	Newton			
P		Particle				
Q		Quantum	Planck	Chip		
EM		El-Magn	Maxwell	Radio Engineers		
R		Relativity	Einstein	Cosmology		
	D	Discrete math		FEM		
	F	Fluid	Navier-Stokes			
	I	Information	Shannon	DSP, circuits, filters, PSD, Lapla		
	QI	Quantum Information				
	S	Solids	Cauchy, constitutive (Bouckaert)			
	St	Statistical	Boltzmann	Engines, ensembles		

De postulaten

- Er was een *verstoring* (lijdensfluctuatie) van het *niets* zonder *oorzaak* en zonder netto *energie* (QM)
- Deze verstoring is een *eindig* heelal in 4 dimensies (Fourier, Heisenberg → discreet, digitaal, ruis)
- Deze verstoring wil zichzelf herstellen (→inflatie heelal)
- De enige *referentie* in het heelal is haar gemiddelde kromming of vacuumdruk (Newton, Mach, Einstein)
- De absolute invarianten zijn π , 0, 1, i en e
- Elk proces impliceert interacties die veranderingen in het systeem aanbrengen
- Er is chaotische ruis op de (gewone?) invarianten
- De (tijds)processen in het heelal hebben geen inherent *doel* (objectiviteit) en worden geleid door een “*zuinigste weg*” mechanisme (Lagrange, Darwin selectieve evolutie, “the winner takes it all”)
- De *wanorde* (entropie) in het heelal kan niet verminderen (Clausius)
- Verloren orde (negatieve entropie) is informatie (smartness) (Monod)) en deze kan niet verloren gaan (Hawking)
- De symmetrie-elementen van de oorzaken worden overgedragen in de geproduceerde effecten (Curie)
- Elke symmetrie resulteert in een behoudswet (invarianten)(Noether)
- Informatie resulteert in intelligent leven (angstschreeuw, begrijpen, herinneren, manipuleren)
- De drager van *alle* informatie is de *bit* (Shannon)
- Informatie leidt via de *semiotiek* tot super-informatie (de tweede evolutie)(taal, symboliek, cultuur, wiskunde, exacte wetenschap)
- Hierdoor kan intelligent leven ingrijpen op de heelalprocessen en hen *doelgericht* maken
- Angst voor de heelal afgrond, goed en kwaad, onrecht, gerechtigheid als invariant
- Animisme (“groot geheim”)
- Zelfbewustzijn, moraliteit, geweten (innere stem, God?), weerloos verdriet
- Meliorisme???
- Moest God bewijsbaar zijn zou de mens zijn vrijheid verliezen, moest er geen dood zijn zou het heelal saai zijn

Planck radiation



De rechtvaardige staat

- Iedereen 600,- per maand levenslang onbelast en zonder formaliteiten (“geboorterecht”, kost 80G)
 - Geen kindergeld, dop, pensioen, invaliden, weduwen
 - ASLK voor gegarandeerd pensioen (begrensd, niet aftrekbaar, niet belast later)
 - Curatele uitkering OCMW voor wie aantoonbaar niet toekomt met 600,-
- Vlak belastingstarief 10% prive en bedrijven
 - Sociale zekerheidsbijdragen afgeschaft
 - Afschaffing meeste aftrekposten, ook kinderlast, hypotheek en leningen (ook voor bedrijven)
 - Volledig afzonderlijke belasting echtgenoten/partners
- Wereldvermogensbelasting boven 500k per persoon
 - Geen RV en erf belasting
 - Via jaarlijks door regering te bepalen rekenrente (gedifferentieerd volgens het soort vermogen)
 - Incl. vastgoed, edelmetalen, auto's, boten, kunst, obligaties, spaargeld, inboedel (evt forfaitair), etc
 - Aandelen
 - Indien beursgenoteerd: ALLE aandelen gewaardeerd aan beurskoers, ook die van bedrijfsleider(s)
 - Indien niet beursgenoteerd: a rato eigen vermogen van het bedrijf
- Gratis gezondheidszorg en onderwijs tot 18 j
 - Algemene prestatiestudiebeurs en/of – lening voor hogere studie
 - Prive ziekteverzekering blijft mogelijk maar niet fiscaal aftrekbaar
- Lage-instap huizen in elke wijk voor:
 - De “papieren”
 - Het gezondheidszorgsteam onder leiding van een Hoofddokter, “shoppen” niet mogelijk
- Afschaffing meeste subsidies (vooral industrie) en aftrekposten
 - Aftrek prive ziekte-, pensioenverzekering, hypotheekaire leningen
- BTW afschaffen en veel meer belasting (accijnzen) om verbruik te remmen en het klimaat te redden
- Essentiële algemene diensten terug verstaatsen (gas, electr, post, spoor)
 - Jaarlijkse onafhankelijke visitatie om inefficiëntie tegen te gaan
- Algemene indexatie gebonden aan BNP van afgelopen jaar
- Vennootschappen enkel voor echte business???

600 < leefloon		
	2019	
Leefloon		79.2
Consumentenbelasting		-20
Wereldvermogensbelasting		-10
Minderinkomsten belasting		20
Extra OCMW		10
Pensioene	52.5	0
Gezondhe	36.1	50
Onderwijs	29.3	35
Economie	18.2	18.2
Overheid	17.1	10
Inval ziekte	16.5	0
Vervoer	13.6	13.6
Werkloosh	11.2	0
Gezin	10.4	0
Staatsschu	10.2	10.2
Orde veilig	8	8
Milieu	6.1	6.1
Cult Godsc	6	6
Fund onde	5.6	5.6
Defensie	3.8	3.8
Andere	3.3	3.3
	247.9	249

The 10 commandments

	De 10 geboden van God	De 10 geboden van de sossen
	Joden	Rousseau
Geloof in jezelf	Bovenal bemin een God	Bemin je beste vriend, jezelf, en sta toe dat
Wees eerlijk	Zweer niet ijdel vloek noch spot	Geef de anderen de schuld van je ongeluk
Geniet van elke dag alsof het je laatste is	Heilig steeds de dag des heren	Geniet van elke dag, alsof het de laatste is
Respecteer je ouders	Vader moeder zult gij eren	Word geen vader of moeder
Leef je leven voluit en doe dat met passie	Dood niet, geef geen ergernis	Stel duidelijk en verdedig je eigen grenzen
Hou woord	Doe nooit wat onkuisheid is	Geniet van sex met mate
Werk hard om te slagen, maar niet ten	Vlucht het stelen en bedriegen	Laat je niet bestelen of beduvelen
Wees tolerant jegens andermans	Ook de achterklap en 't liegen	Een leugentje om bestwil mag
Wees gelukkig en optimistisch, zelfs in	Wees steeds kuis in uw gemoed	Geloof in de niet-dogmatische wetenschap, v
Creëer, vernietig niet	En begeer nooit iemands goed	Met jaloersheid kun je veel stemmen winnen
		Kom overeen met iedereen
		Maak geen cirkelredeneringen
		Volg de weg van de minste weerstand (moin
		Stop de rat-race
		Zoek de fout in jezelf
		Neem de bluts met de buil
		Doe zoals de anderen
		Stop Darwin
		Ofwel heb ik ongelijk en de wereld gelijk, ofv
		Let fate lead you before it drags you
		De 10 geboden van de rat-race dienstwe

Wohltemperiert Equal temperament

zie ook www.logosfoundation.org Godfried-Willem Raes

7			34.6	35.0	35.6							
8	D1		36.7	37.0	37.7							
9			38.9	39.2	39.9	40	1.277955					
10	E1		41.2		42.3							
11	F1		43.7	44.0	44.8							
12			46.2	46.6	47.4							
13	D1		49.0	49.4	50.2	50	1.25					
14			51.9	52.3	53.2							
15	A1		55.0	55.4	56.4							
16		la#	58.3	58.7	59.7							
17	B1	si	61.7	62.2	63.2	63	1.26					
18	C2	do	65.4	65.8	67.0							
19		do#	69.3	69.7	71.0							
20	D2	re	73.4	73.9	75.2							
21		re#	77.8	78.2	79.6	80	1.269841					
22	E2	mi	82.4	82.9	84.3							6 boven
23	F2	fa	87.3	87.8	89.3							
24		fa#	92.5	93.0	94.6							
25	G2	sol	98.0	98.5	100.2	100	1.25					
26		sol#	103.8	104.3	106.2							
27	A2	la	110.0	110.5	112.5							5
28		la#	116.5	117.1	119.1							
29	B2	si	123.5	124.0	126.2							
30	C3	do	130.8	131.4	133.7							
31		do#	138.6	139.1	141.6							
32	D3	re	146.8	147.4	150.0							4
33		re#	155.6	156.1	158.9							
34	E3	mi	164.8	165.4	168.3				41.5			
35	F3	fa	174.6	175.2	178.3							
36		fa#	185.0	185.5	188.8							
37	G3	sol	196.0	196.5	200.0							3
38		sol#	207.7	208.2	211.9							
39	A3	la	220.0	220.5	224.4							
40		la#	233.1	233.6	237.7							
41	B3	si	246.9	247.4	251.8							2
42	C4	do	261.6	262.1	266.7			x				
43		do#	277.2	277.6	282.5							
44	D4	re	293.7	294.1	299.2							
45		re#	311.1	311.5	317.0							
46	E4	mi	329.6	330.0	335.8							1 onder
47	F4	fa	349.2	349.5	355.7							
48		fa#	370.0	370.2	376.7							
49	G4	sol	392.0	392.2	399.1			x	1.496236			

Piano is 1/12 oct of 40 per decade

Grote tert is 4 noten (do-mi)

Een kwart is 5 noten (do-fa)

Quint is 7 noten (do-sol)

Octave is 12 noten

First fret left (not counting the "nut")

EADGBE en alle dagen ge-bakken eieren (Of een aap die geen bananen eet) standaard gitaar tuning

$$String : c = \sqrt{\frac{f}{m/l}} = \sqrt{\frac{\sigma}{\rho}}$$

$$At \text{ fund } frq \quad l = \frac{\lambda}{2} = \frac{1}{2 frq} \sqrt{\frac{\sigma}{\rho}}$$

$$big \text{ terts} : \frac{frq_4}{frq} = 1.25 \Rightarrow \frac{l_4}{l} = \frac{1}{1.25} = 0.8$$

$$Quarter : \frac{frq_5}{frq} = 1.33 \Rightarrow \frac{l_5}{l} = \frac{1}{1.25} = 0.75$$

$$quint : \frac{frq_7}{frq} = 1.5 \Rightarrow \frac{l_7}{l} = \frac{1}{1.5} = 0.66...$$

independent of frq

Impedance units and Rayl

[-]	Zm/S/(rho0*c0)	Imp plots Beranek						
Ns/m	Zm=f/v		c=mech resist	b=fdrag/v	for pipe of length l=8πrηl	mech ohm		
Ns/m2	dvis							
Ns/m3=Rayl	Zm/S	rho0.c	Zsp (spec, per m2) or Zch (char e.g. 415 for ai	Free plane/spherica (r>>) wave impedance				
Ns/m4	drag=fvol/v	Darcy zie	/3WIN en /edp-emdp/coupled_acoustics/emdp			flow resistivity		
Ns/m5	Za=p/wol=Zm/S^2					ac ohm		
N/m2	Bulk mod	rho0.c^2=γ.p0=0.14 MPa (see wave equation)						
W/m2	Intensity	p^2/(rho.c)						
	imp phase							
plane wave	0		(Note: p and u 90 deg, cfr Bernouilli)					
sph we	90	near field						
	0	far field						

Bulk modulus from gaslaw $p_0 V^\gamma = nRT$

$$dp \cdot V^\gamma + p_0 \gamma V^{\gamma-1} dV = 0 \text{ etc}$$

$$B = \frac{dp}{dV/V} = -\gamma \cdot p_0 = 140000 = 0.14 \text{ MPa} \quad [\text{adiabatic}]$$

$$k_{\text{box}} = \frac{f}{u} = \frac{p/S}{dV/S} = \frac{p}{dV \cdot S^2} = \frac{140000 \cdot S^2}{V}$$

$$\text{Note: } \gamma \cdot p_0 = \rho \cdot c^2 = 140000 \text{ Pa}$$

To do te doen

- MFB (wiki), is piezo acc?
- Ellips en brandpunt

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$
$$c = \sqrt{a^2 - b^2}$$

General Relativity Einstein

Gravity Mechanics

$$R_{ij} - \frac{R}{2} g_{ij} = \frac{8\pi G}{c^4} T_{ij} - \Lambda g_{ij} \left[\frac{1}{m^2} \right]$$

$$T^2 = (pc)^2 + (m_0 c^2)^2$$

- Linkerlid is geometrie, rechterlid fysica, "IEMAND" heeft die "SCHEIDINSRIMPEL" "BEDACHT" (het WOORD?) (NIET "FIRST MOVER" want daar je de tijd voor nodig)
- Linkerlid is lokaal waarneembaar (ONS) krommingsexces (passief), rechterlid is lokaal (ONS) waarneembaar drukexces (actief)
- R_{ij} =Ricci-kromming (symm tensor)(mate waarin ruimte verschilt van euclidische)
- $R/2$ is wsl de 2de invariant van R_{ij} (equivalent aan von Mises stress)
 - Gemiddelde kromming van het ganse heelal (cfr Mach)
- T =energie-momentum ("levende kracht") van sterren (0.4%), dust (3.6%) and cold dark matter (CDM) (22%). Totaal 26%
- G =gravitatieconstante
- g =metriek tensor (Bouckaert p24 doch i en j gaan van 1 tot 4)
- Λ =kosmologische constante of vacuum druk (pos, antigravitatie) of dark energy (74%)
 - Surface tension of empty space (Vanderwaals, Henk Casimir effect?)
 - Gemiddelde energie van het ganse heelal die zich verzet tegen de kromming
- Op dit ogenblik is ons waarneembaar heelal te weinig gekromd (ligt achter op de gemiddelde kromming van het heelal) en is de massadruk lager dan de gemiddelde druk van het heelal, vandaar de accelererende expansie
- Als beide leden van de vergelijking nul zijn is het heelal in rust (en entropie nul)
- Het intelligente leven is een toeval dat moest gebeuren door de wet van de zuinigste weg, ingesteld door "IEMAND"
- Dat "IEMAND" is wsl de duivel, want hoe kan een god bewust zoveel ellende organiseren
- Er is een parallelisme tussen wiskunde en fysica
- Het fysisch equivalent van Kurt Goedels' onvolledigheidstheorema (waar, onwaar, onbeslisbaar) is (waar, onwaar, onverifieerbaar). Onverifieerbare theorieën zoals stringtheorie horen thuis in de klasse van het theïsme en de onjuistheid ervan moet niet worden bewezen (Russell)

Expansion Universe

3.16E-09	1.00E-16	4.00E+05	3.79E+05	4.00E-11	9.47E-01
3.16E-08	1.00E-15	4.00E+05	3.79E+06	4.00E-10	9.47E+00
3.16E-07	1.00E-14	4.00E+05	3.79E+07	4.00E-09	9.47E+01
3.16E-06	1.00E-13	4.00E+05	3.79E+08	4.00E-08	9.47E+02

3.16E+11	10000	4.00E+05	3.79E+25	4.00E+09	9.47E+19				
3.16E+12	100000	4.00E+05	3.79E+26	4.00E+10	9.47E+20				
9.47E+12	300000	1	3.79E+26	4.00E+10	2.84E+21	6.5689E+09	<<<start relic radiation		
3.16E+13	1.E+06	0.1	3.79E+26	4.00E+10	9.47E+21	6.5688E+09	<<<vanaf hier snelheid lager dan lichtsnelhe		
3.16E+14	10000000	0.2	3.79E+26	4.00E+10	9.47E+22	6.5670E+09			
3.16E+15	100000000	0.3	3.79E+26	4.00E+10	9.47E+23	6.5400E+09			
3.16E+16	1000000000	0.4	3.82E+26	4.04E+10	9.47E+24	6.1800E+09			
3.16E+17	10000000000	0.5	4.25E+26	4.49E+10	9.47E+25	1.6800E+09			
4.04E+17	1.28E+10	0.6	4.41E+26	4.66E+10	1.21E+26	0.0000E+00	<<<nu	3.38E+01	

The U according to U

- $|\Delta t| \leftarrow$ ----understood $\rightarrow$ ratio (head) ----- $|$ --not understood $\rightarrow$ intuition (heart) -- $\rightarrow$?
- $\leftarrow$ ----meten is weten ----- $|$ --gissen is missen $-- \rightarrow$?
- This is a log t scale
- There is always (quantum) noise
- If there were a “good” god, he should have known his “free will/love experiment” would result in death, pain and evil even if there is salvation and eventually more Good than Bad
- The U is a spontaneous (without cause) quantum fluctuation
 - The U is finite, “Outside U” does not exist
 - The positive energy is matter-energy, negative energy is gravitation, sum is and remains zero
 - Because global entropy (chaos) always increases, time can only increase
- The sequel
 - According to LA (least action)
 - Including evolution, many worlds, natural selection, “winner takes it all”, intelligent life with free will, Good, Bad, Value, Suffering (applies to the whole U, but cannot be proven because of distance)
 - The “reward” of entropy increase is I increase (e.g. More intricate structures: atoms, (macro-)molecules), life, consciousness)
 - consciousness consists of rational (sciences, ethics, art) and irrational (not yet understood phenomena,

The TOE according to U

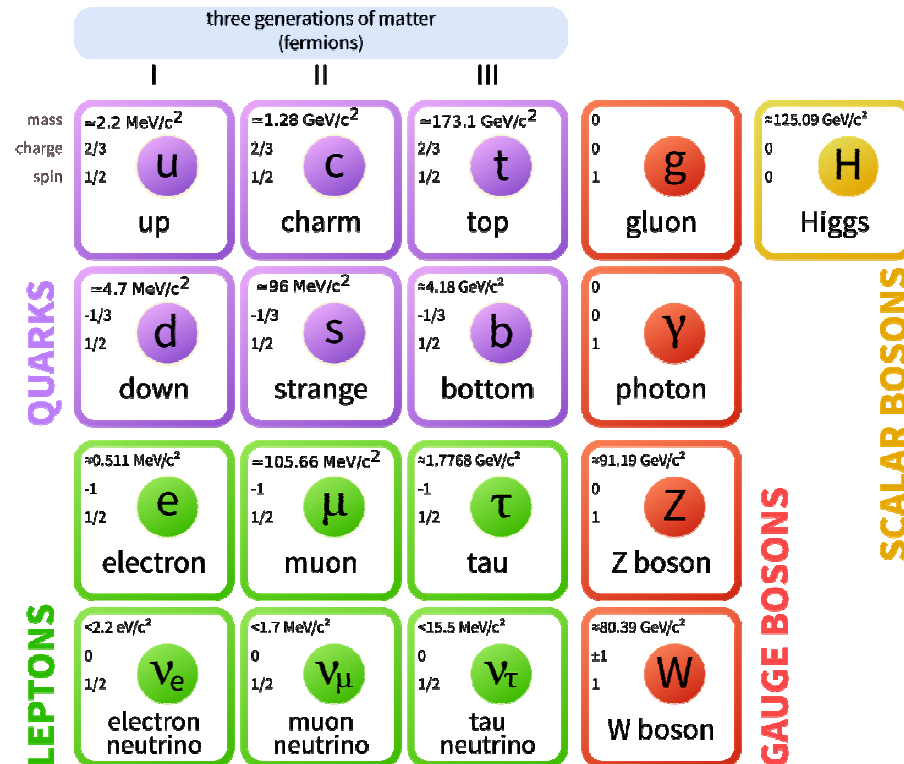
- The Force is $S' > 0$ guided by Least action (LA)
 - Dead matter evolves to intelligent matter (IM)
 - IM takes over the the guiding role of LA
- Fysica is een schema om beetje orde op zaken te stellen

Start of the Universe

- Trial space (Probeer ruimte voor Lagrange moindre action)
- ΔL . $\Delta R > h$ (Godsrijk Liefde vs Heelalrij Rationaliteit)
- Space-time, discrete, noise
- Chance, large numbers, $e^{i\pi} + 1 = 0$
- Dualism
 - Reduction<>emergence
 - Intensive<>extensive
 - Fields<>particles
 - Concrete<>abstract
 - Induction<>deduction
- Least action, evolution<>intelligence
- The winner takes it all
- Self starting tackle (Verhofstadt cliquet)
- Entropy, chaos<>the “vector”, noise
- Semiotiek (tabel>matrix rekenen)

The standard model

Standard Model of Elementary Particles



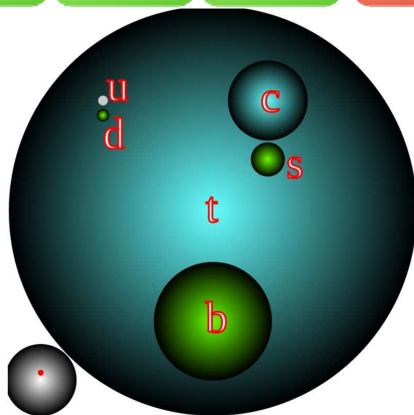
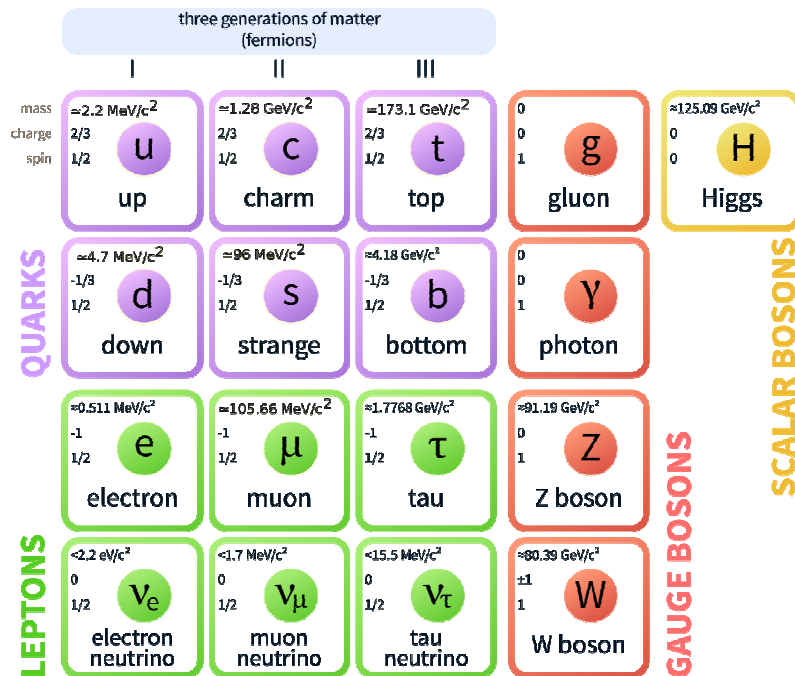
All bosons, incl. photon have spin 1, except Higgs
EM force $\equiv$ Weak nuclear force (Hertog)

Red: no charge

Scalar? (no spin) Only Higgs

Standaardmodel

Standard Model of Elementary Particles



Een vergelijking van de massa van de zes verschillende smaken van quarks: de t (top) quark is veruit de zwaarste, de b (bottom) quark de op een na zwaarste, gevolgd door de c (charm) quark, de s (strange) quark, de d (down) quark en ten slotte de u (up) quark. Voor de schaal staan er links onderaan een proton (rood) en een elektron (rood) afgebeeld.

Source: MIT/Stanford/COMPASS

De derde generatie deeltjes hebben de hoogste massa

Alle bosonen hebben spin 1, behalve Higgs 0

Fermionen staan niet vermeld

Massaloze deeltjes reizen aan lichtsnelheid, hun tijd staat stil (ook in zwart gat)

Er zijn 2 klassen: fermionen en bosonen

Gauge bosonen heten ook Force carriers

Higgs veld "plakt" aan deeltje, als het plaksel te veel wordt scheidt het deeltje zich af

Aug13: Definitief bewezen: neutrino's veranderen van soort

Het standaard model ($4 \times 4 = 6 + 6 + 4$), bestaan hiervan nog antideeltjes? Alle leptonen en quarks: JA (ook die met lading 0)

Het Higgs boson staat hier NIET bij

Quarks bestaan uit 3 generaties (enkel de massa verschilt, gluonen dragen kleurlading van de ene naar de andere quark) en 2 flavours

Proton bestaat uit 2 bosonen: up en down

Lepton betekent klein

Fermion → half-tallige spin + uitsluitingsprincipe Pauli

Boson → heeltallige spin (ook nul), mediate weak interactions (also strong? Cf. Gluon)

Hadron bestaat uitsluitend uit quarks (bv. proton cfr LHC Large Hadron Collider)

Thesis Halzen gaat over hadronen (in het NL)

Baryon bestaat uit 3 q zodat de "kleur" wit is (proton, neutron) (Hawking)

Baryonslierten verbinden sterrenstelsels (galaxien?)

Densiteit neutron is $1 \times 10^{17} \text{ kg/m}^3$

Meson bestaat uit een 2 q (q en een anti-q) (onstabiel) (massa tussen electron en proton)

Pion = $u + \bar{d}$

Neutrino is enkel linksdraaiend (zgn chiraliteit), heeft enkel zwakke wisselwerking (Catherine De Clercq VUB Icecube emeritus)

Kosmische stralen zijn protonen, zijn niet afkomstig van Gamma Ray Bursts (1 per dag)

Schroedinger cat

- Particle can exist in more than one state at the same time when not observed
 - Virus in space is dead and alive at the same time
- QM superposition does not apply to macroscopic things

Arrhenius equation

$$A \cdot e^{-\frac{E_{act}}{UGC} \frac{1}{TK}}$$

8.3143	<UGC [J/K/mol]	
50000	<Eact [J/mol]	
20	<TCref [C]	
273.15		
6013.7354	>Eact/UGC	
6013.7354	>overgangstemp [K]	
TC	1/TK	
1	0.003647638	0.241294129
2	0.003634381	0.261318554
4	0.003608154	0.305962124
8	0.00355682	0.416618848
16	0.003458413	0.752927634
32	0.003277077	2.240544691
64	0.002966039	14.5445911
128	0.002492833	250.3733833
256	0.001889823	9407.802908
512	0.001273642	382638.5671
1024	0.000770921	7866138.825
2048	0.000430821	60815113.52
4096	0.000228877	204848945.7
8192	0.000118131	398724392.7
16384	6.00343E-05	565466540.8
32768	3.02653E-05	676325148.7
65536	1.51955E-05	740480981.2
131072	7.61353E-06	775025284

Graph showing the relationship between 1/T (Y-axis, ranging from 0 to 9,000,000) and T (X-axis, ranging from 0 to 1200). The data points show a sharp increase in 1/T as T approaches the transition temperature (around 1000 K).

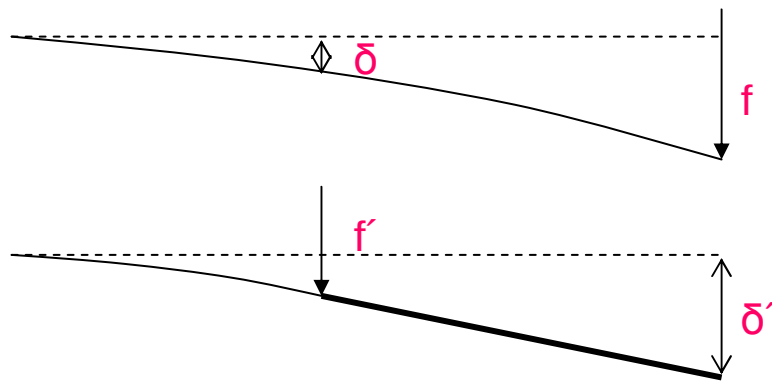
Graph showing the relationship between ln(1/T) (Y-axis, ranging from 0.1 to 10,000,000,000) and 1/T (X-axis, ranging from 0 to 0.004). The data points show a linear relationship, indicating a first-order transition.

Lightlensing by gravity

- The photon has no mass, how can its path be influenced by gravity?
- Because space is curved by mass and the photon path follows the shortest way (Lagrange Least Action)

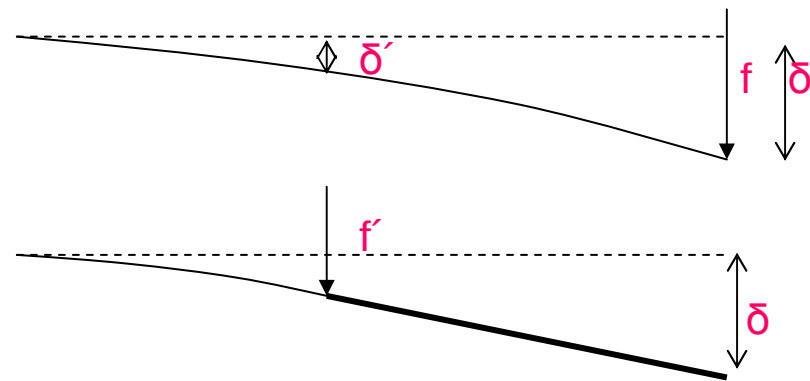
Glass hardening/quenching

Maxwell-Betti theorem (wiki)



$$f' \cdot \delta = f \cdot \delta'$$

$$f' = f \frac{\delta'}{\delta}$$



$$f' \cdot \delta' = f \cdot \delta$$

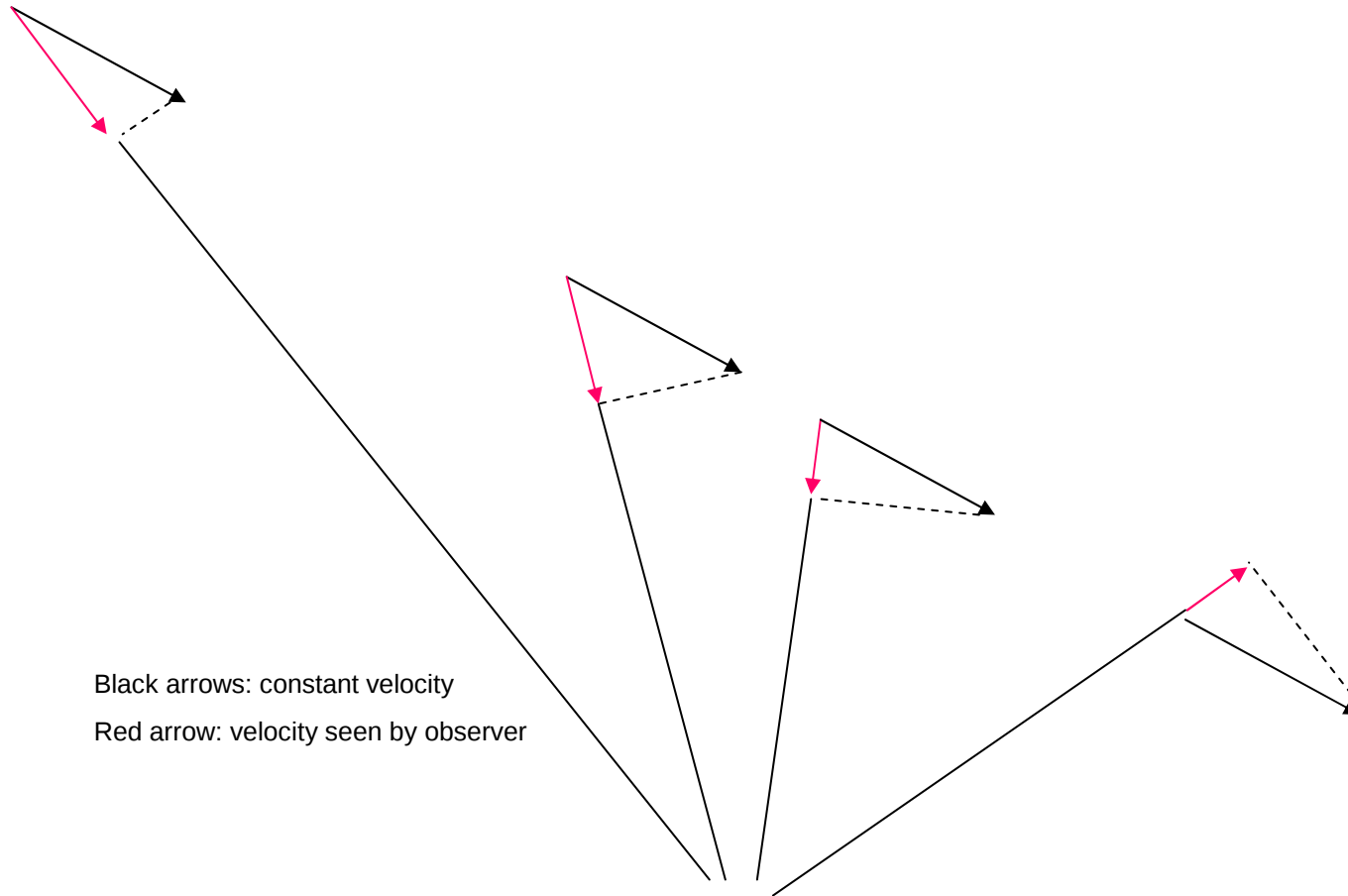
$$f' = f \frac{\delta}{\delta'}$$

Castigliano

$$\delta u = \frac{\partial U}{\partial f}$$

Capitalism big bang

Doppler

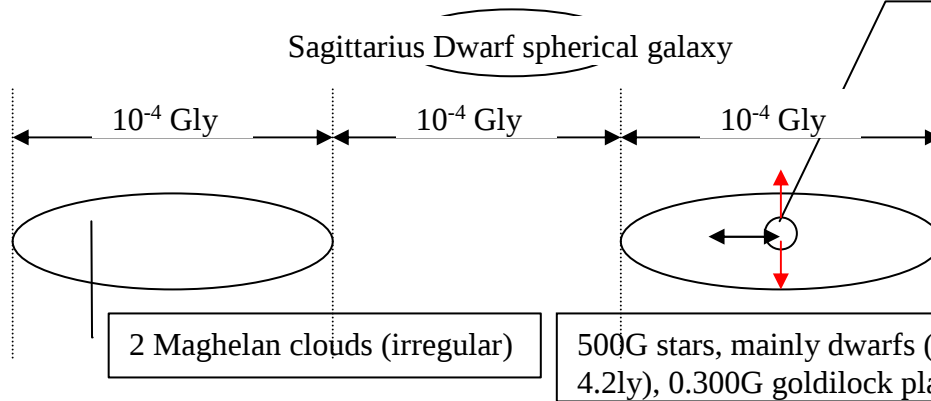


Galaxy

(bron nl.doc onder “simpelweg Einstein”)

Andromeda (=Messier 31, bar with 2 spirals at both ends)

2.5^e-3 Gly



2 Maghelan clouds (irregular)

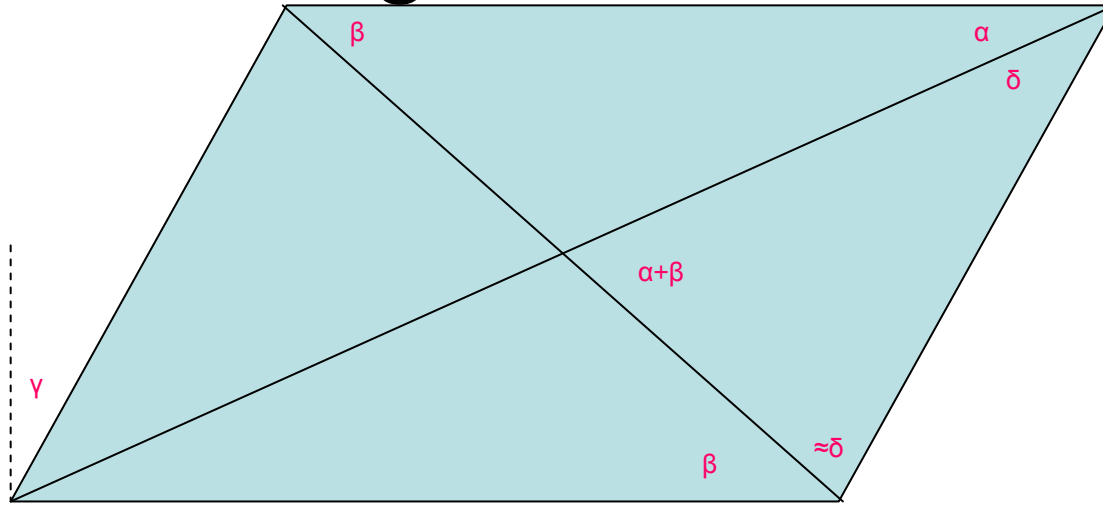
Sagittarius Dwarf spherical galaxy

Zwart gat in SagiTTarius A* (Boogschutter) op 26000 ly van aarde, met pooljets van geladen deeltjes, 4Mzon massa, omgeven door oude sterren

500G stars, mainly dwarfs (as Proxima Centauri 4.2ly), 0.300G goldilock planets

100G galaxies in visible universe, 5.10²² stars, 100 x more than sand grains on earth

Simple shear Fout! Waar heb ik dit
gehaald? kwl

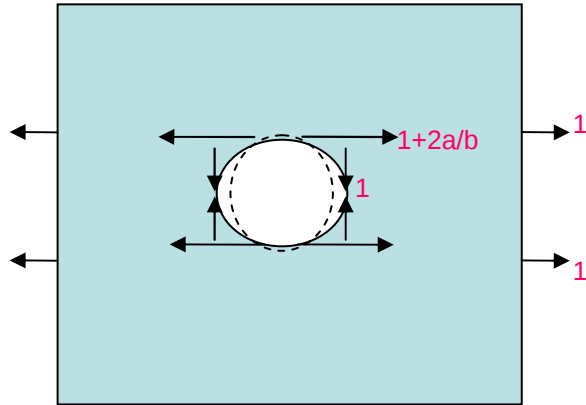


$$2\delta \approx \pi - \alpha - \beta$$

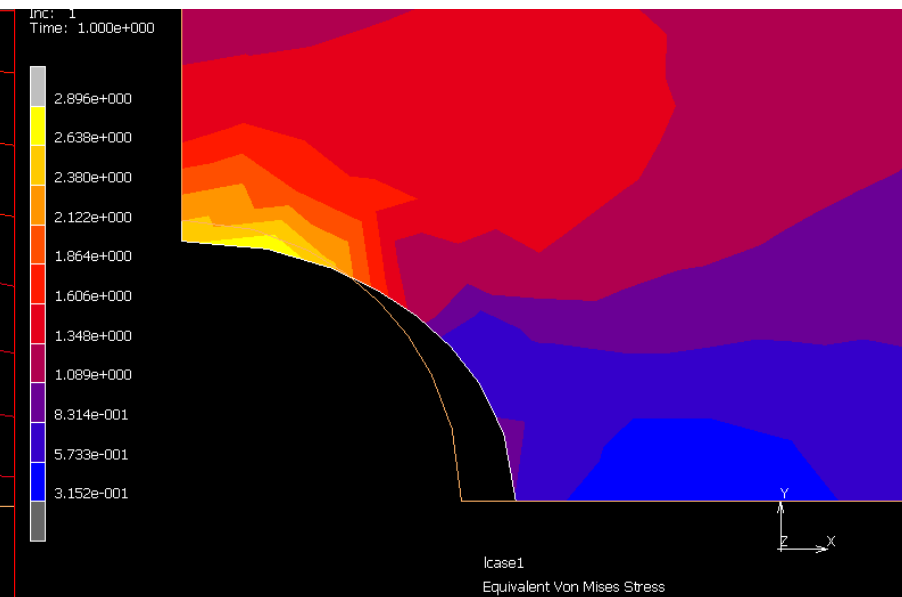
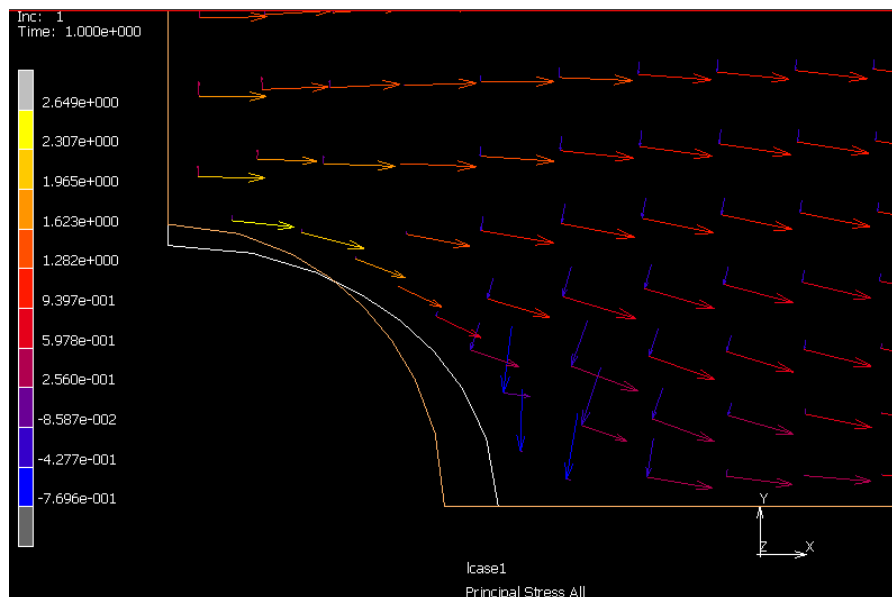
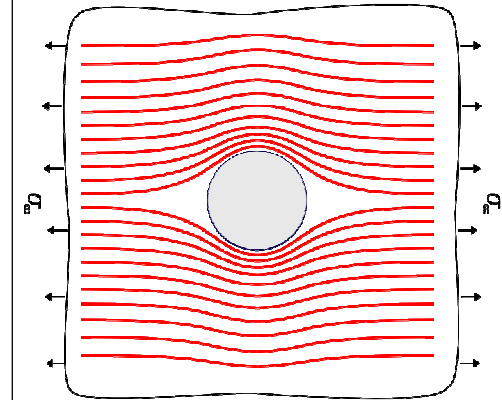
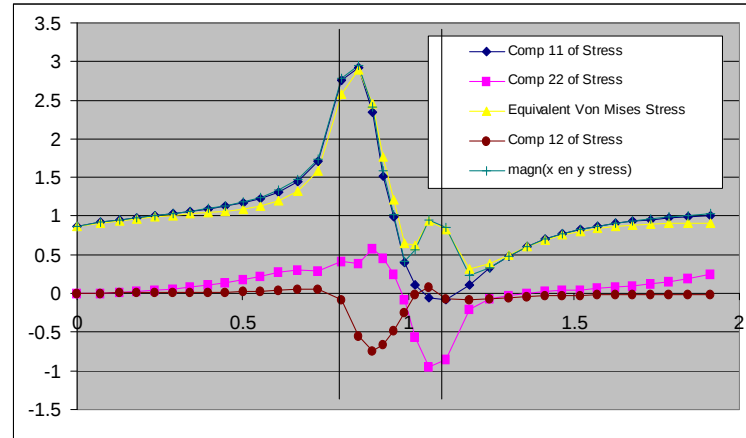
$$\pi \approx \beta + (\pi - \alpha - \beta)/2 + \pi/2 - \gamma$$

$$\alpha + \beta \approx 2\gamma$$

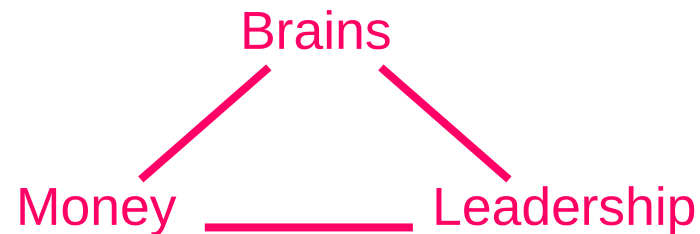
Stress concentration hole



Bouckaert (p141) completely contra-intuitive!



Het ideale evolutie tridium-triumviraat

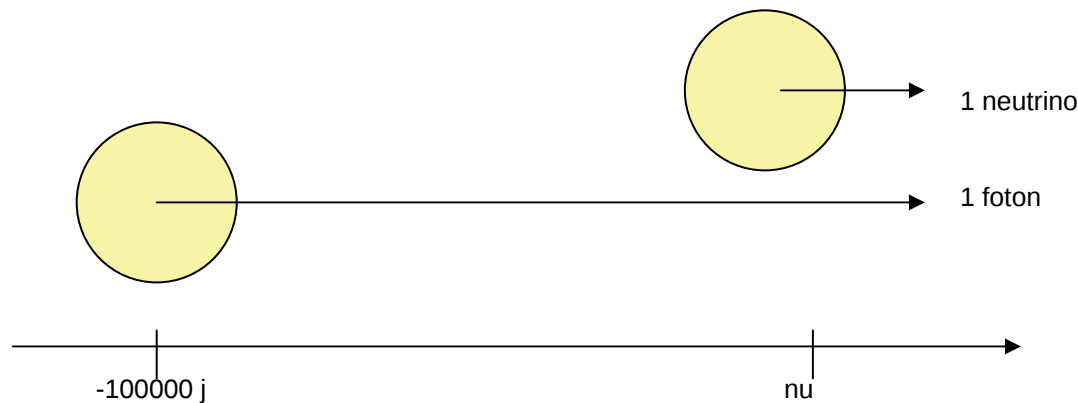


	Brains hersenchemie, wetenschap, techniek, God, geloof	Money Brandstof, beloning	Leadership management, brengt de 2 andere samen en doet ze in de pas lopen
Caesar	God vindt het goed	Buit, pensioen	Ik, Caesar kun je vertrouwen
Hitler	Herrenvolk	1000-jarig rijk	Der Fuehrer
Silicon Valley	Idee	Venture capital	Management
James Cook	Nieuwsgierigheid	Kolonien	King

Vermeersch noemt dit WTK (Wetenschap-Techniek-Kapitaal

Of in het Engels STC

IJstijd



- Bij kernfusie komen bv. evenveel fotonen als neutrino's vrij
- De fotonen doen er 100000 j over om naar het zonoppervlak te komen
- De neutrino's komen direct
- Op aarde worden evenveel "oude" fotonen als "nieuwe" neutrino's gedetecteerd
- Dus de zonneactiviteit is de laatste 100000 j onveranderd gebleven en kan niet de oorzaak zijn van de ijstijd

Het wordt tijd dat jij weet...

$$a \frac{d^2 y(t)}{dt^2} + b \frac{dy(t)}{dt} + c \cdot y(t) = f(t) \quad \{m \cdot \ddot{u} + c \cdot \dot{u} + k \cdot u = f\}$$

Stel $y = Ae^{\lambda t}$ en $f = 0$

Geeft $a\lambda^2 + b\lambda + c = 0$

Twee opl : $Ae^{\lambda_1 t}$ en $Ae^{\lambda_2 t}$

λ complex? Ja!

- ODE is 1 variabele ><PDE
- LODE (linear): enkel afgeleiden met coef plus eventueel een bronterm $f(t)$
- Orde: de hoogste afgeleide (N.B. y' , y'' notatie is van Lagrange)
- Homogeen: bronterm is nul $\rightarrow$ homogene oplossing
 - Het tweede lid maakt de vgl inhomogeen omdat er een andere functie in staat
 - Homogeen: vermenigv factor eruit te halen $f(\lambda x, \lambda y) = \lambda^k f(x, y)$
 - Karakteristieke vgl: n-de graads algebraïsche vgl (kan enkel bij LODE en constante coef)
 - Zie Radio Eng. P155 (RLC circuit)
- Algemene oplossing: aantal integratieconstanten = hoogste orde
- Particuliere oplossing:
 - de integratieconstanten bepaald door BC en IC OF
 - Som van de homogene oplossing (zonder bronterm) en elke algemene oplossing die niet noodzakelijk voldoet aan de IC
- Zie Bouckaert p247
- Toegepast op massa-veer systeem aangedreven door impuls:
 - Sinustrilling met ω_d met een exponentieel bovenop
- Wiki>particuliere oplossing
 - Het tweede lid is een bekende functie
 - De alg opl is som van de homogene opl en een part opl van de volledige dif vgl

Slide 48

U15

Bouckaert p151

User, 6/18/2020

Fundamental differential equations

Heat (Spatial curvature $\propto$ "velocity") (Parabolic) $[q] = \frac{W}{m^2}$ $[Q] = \frac{W}{m^3}$ (internal)

$$\nabla \cdot q + C \cdot \dot{T} = Q \quad (\text{Bouck21}) \quad \left[\frac{W}{m^3}\right] \quad [C = \rho \cdot c_p = \text{Capacity}] = \frac{J}{K \cdot m^3} \quad (\text{Energy out} - \text{in over } \partial x + \text{accumulated} = \text{internal})$$

With Fourier: $D \cdot \nabla^2 T = \dot{T} - \frac{Q}{C}$ $\left[\frac{K}{s}\right] \quad D = \frac{\lambda}{\rho \cdot c_p} \left[\frac{m^2}{s}\right]$

$$C \cdot \dot{T} + \left(\frac{\lambda}{x^2} - \frac{htc_{tot}}{x}\right) \cdot T = Q + \frac{q_{appl} - htc_{tot} T_{\infty}}{x} \quad \left[\frac{W}{m^3}\right] \quad \text{Galerkin FEM with BC}$$

$x = \text{shape function}$

$$htc_{tot} = htc + htc_{rad} = htc + emiss \cdot SB \cdot (T^2 + T_{\infty}^2) \cdot (T + T_{\infty}) [W / K / m^2]$$

Wave (Spatial curvature $\propto$ "acceleration") (Hyperbolic)

$$c^2 \cdot \nabla^2 p = \ddot{p} \left[\frac{N}{m^2 s^2}\right] \quad c^2 \cdot \nabla^2 v = \ddot{v} \left[\frac{m}{s^3}\right] \quad c = \sqrt{\frac{\gamma \cdot p_0}{\rho_0}} = \sqrt{\frac{B}{\rho_0}} \Rightarrow \rho_0 c^2 = \gamma \cdot p_0 = B = 140000 \left[\frac{N}{m^2}\right]$$

$$c^2 \cdot \nabla^2 p = -\omega^2 p \text{ or } \nabla^2 p + k^2 \cdot p = 0 \quad \left[\frac{N}{m^4}\right] \quad (\text{Harmonic} - \text{Helmholtz})$$

$$c^2 \cdot \nabla^2 E = \ddot{E} \left[\frac{V}{ms^2}\right] \quad c^2 \cdot \nabla^2 B = \ddot{B} \left[\frac{V}{m^2 s}\right] \quad c = \frac{1}{\sqrt{\epsilon \mu}}$$

Fluid (Bouck13)

$$\nabla \cdot \rho \vec{v} + \dot{\rho} = 0 \quad (\nabla \cdot \vec{v} = 0 \text{ incomp}) \quad \left[\frac{kg}{m^3 s}\right] \quad \text{or} \quad \dot{\rho} + \rho \cdot \nabla \cdot \vec{v} + \vec{v} \cdot \nabla \rho = 0$$

Charge (Bouck24)

$$\nabla \cdot \vec{\sigma} + \dot{\sigma} = 0 \quad (\sigma = \text{charge dens}) \quad \left[\frac{C}{m^3 s}\right]$$

Euler momentum eq (Beranek18, Franssen PVDF 3)

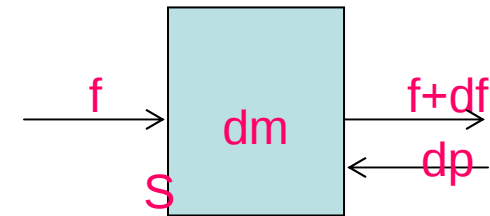
$$\rho \ddot{u} + \nabla p = 0 \quad \text{or} \quad \rho \ddot{u} - \nabla \sigma = 0 \quad \left[\frac{N}{m^3}\right]$$

Poisson eq

$$\nabla^2 \phi = f \text{ or } 0 \text{ (Laplace) solve by Green } \phi = -\iiint \frac{f(r')}{4\pi |r - r'|} d^3 r'$$

$$\text{Gravity } \nabla^2 \phi = 4\pi G \rho \xrightarrow{\text{Green}} \phi(r) = -\frac{G \cdot m}{r} \text{ (Newton)}$$

$$\text{El. Stat. } \nabla^2 \phi = -\frac{\sigma}{\epsilon} \xrightarrow{\text{Green}} \phi(r) = \frac{Q}{4\pi \epsilon \cdot r} \text{ (Coulomb)}$$



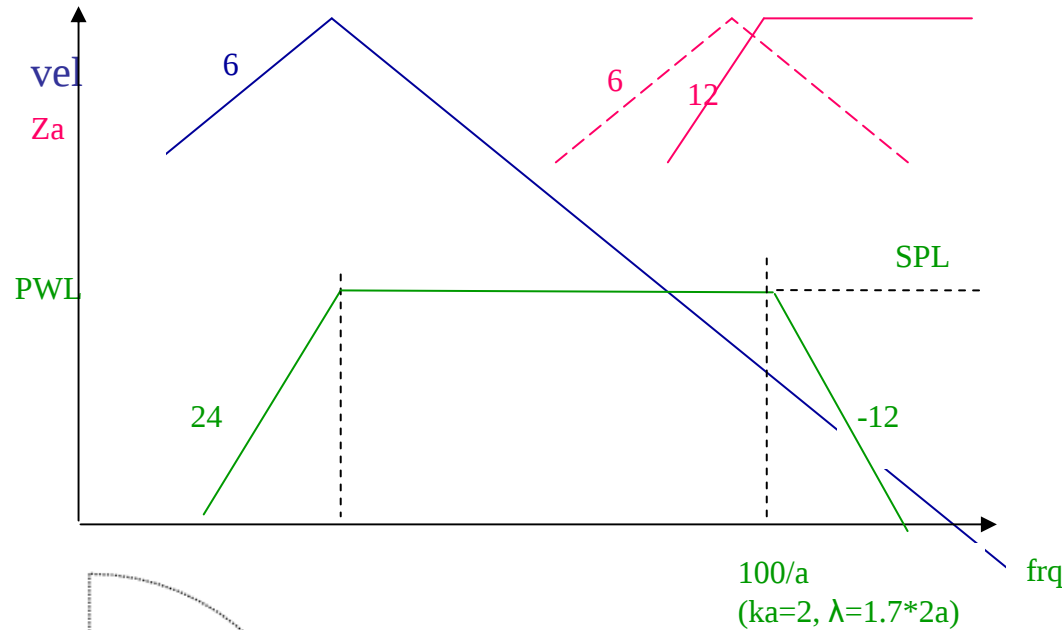
$$dm \cdot \ddot{u} + df = 0$$

$$\frac{dm}{dx} \ddot{u} + \frac{df}{dx} = 0 \quad \text{divide by } S$$

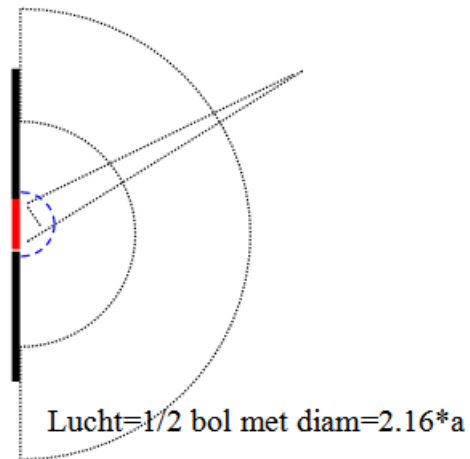
$$\rho \cdot \ddot{u} + \nabla p = 0$$

Loudspeaker power = $v^2 Z_m$

(zie compen/vlakke piston.doc)



Dit is voor
oneindige baffle,
uitbreiden naar
flexibele konus,
randdip, box



Rayleigh integral on infinite baffle

Skudrzyk p496, 512

$$p = \rho_0 \int_S a_n \frac{e^{-ikd}}{2\pi d} dS \quad k = \frac{\omega}{c} \quad (\text{for sphere : divide by 2})$$

$$\text{for } f = 1, d = 1 \Rightarrow |p^*| = \frac{\rho_0}{2\pi(sm)} \approx \frac{0.2}{sm} \propto 94\text{dB for } sm = 0.2$$

$$k_{\text{box}} = \frac{140000 \cdot S^2}{V}$$

•3 dB/oct	10 dB/dec	x3.3
-----------	-----------	------

•6 dB/oct	20 dB/dec	x10
-----------	-----------	-----

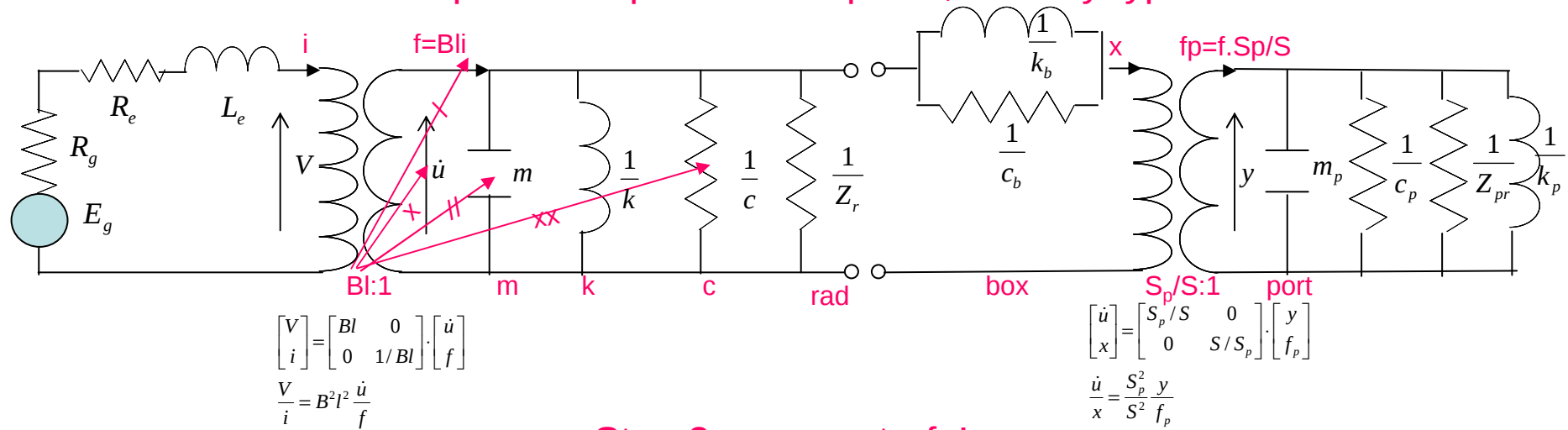
•12 dB/oct	40 dB/dec	x100
------------	-----------	------

•1/3 oct	x10 ^{1/10}
----------	---------------------

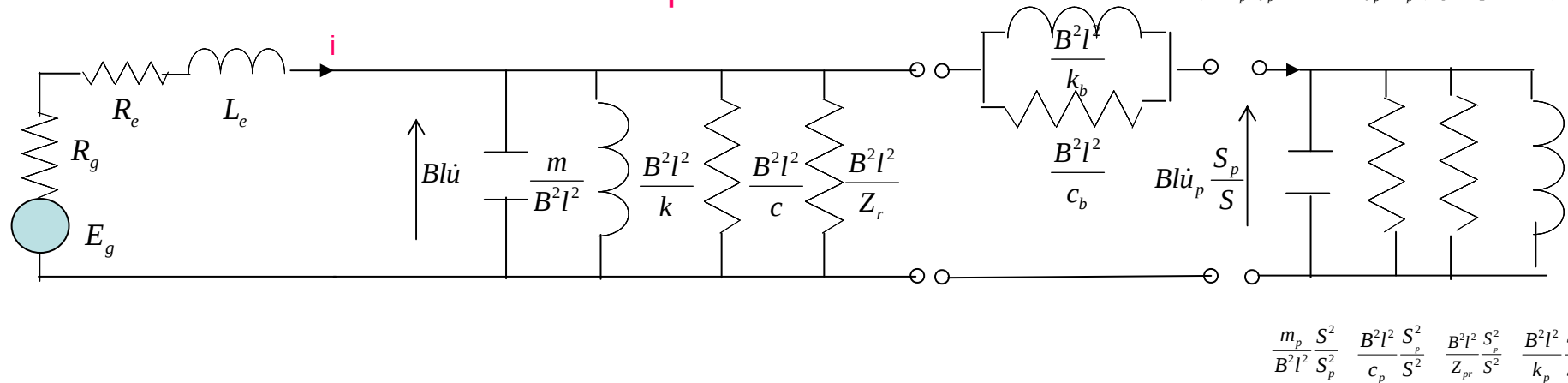
•1/12 oct	x10 ^{1/40}
-----------	---------------------

Loudspeaker (Nieuwendijk III-1b)

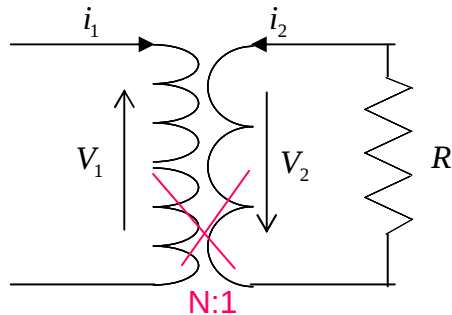
Step 1: use optical "trick" pVI-1, mobility type



Step 2: remove trafo's



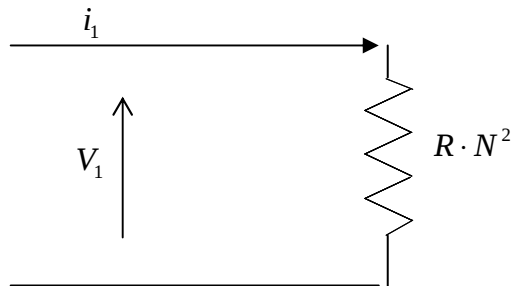
Trafo



$$\text{Power in } R = i_2^2 R$$

$$\frac{N}{1} = \frac{V_1}{V_2} = \frac{i_2}{i_1} \Rightarrow i_2 = i_1 N \quad V_2 = V_1 / N$$

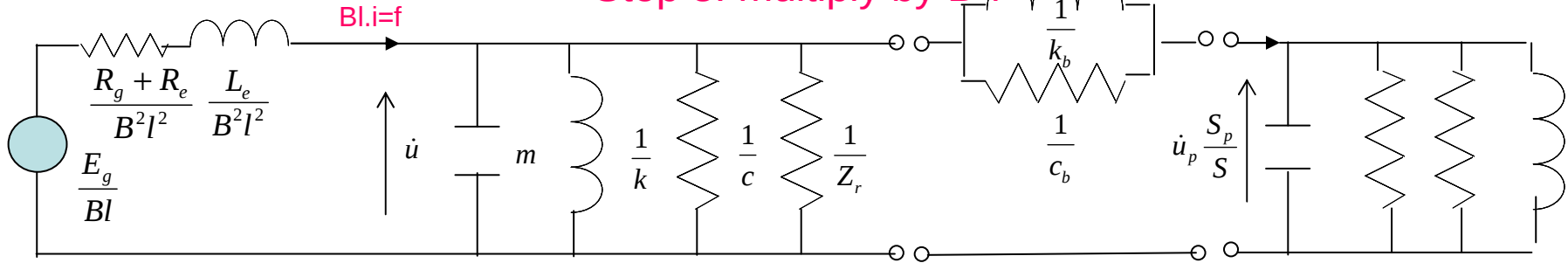
$$\text{Power in } R = N^2 i_1^2 R$$



- N is aantal wikkelingen
- Je wil rechts op spanningsnivo van links brengen
- Dus moet je rechts optransformeren
- De spanning rechts wordt groter, dan moet de stroom kleiner worden (behoud energie)
 - Spanning rechts x N, stroom / N
- Dat kan alleen door de impedanties rechts te vergroten (kwadratisch)
 - Dus R en L vermenigvuldigen, C delen

Loudspeaker

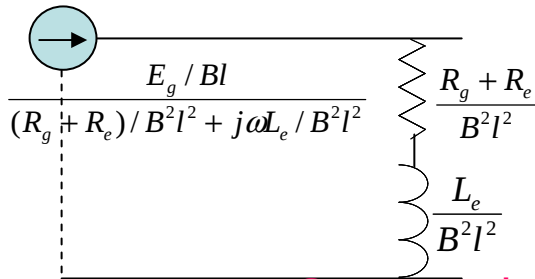
Step 3: multiply by $B^2 l^2$



Step 4: Beranek trick p187

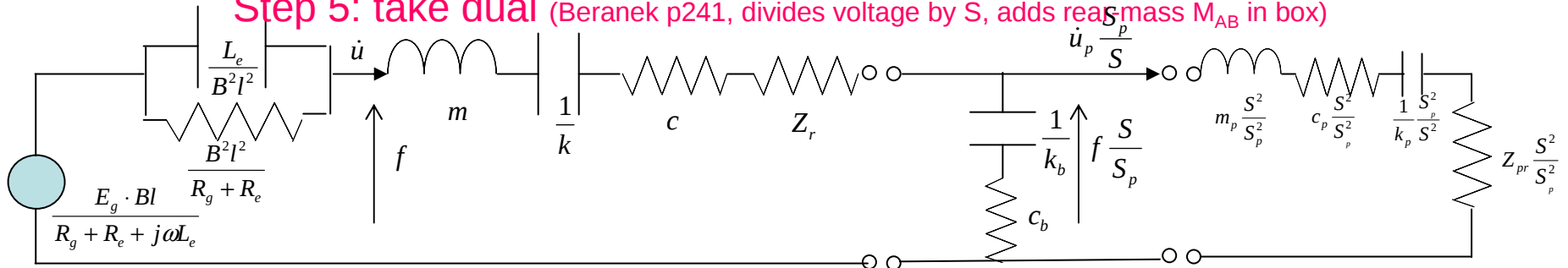
Series imp $\rightarrow$ par imp

Voltage source $\rightarrow$ Current source/series imp



$$m_p \frac{S^2}{S_p^2} \quad \frac{1}{c_p} \frac{S_p^2}{S^2} \quad \frac{1}{Z_{pr}} \frac{S_p^2}{S^2} \quad \frac{1}{k_p} \frac{S_p^2}{S^2}$$

Step 5: take dual (Beranek p241, divides voltage by S, adds reactance mass M_{AB} in box)



Symmetric 4-pole (=gyrator)

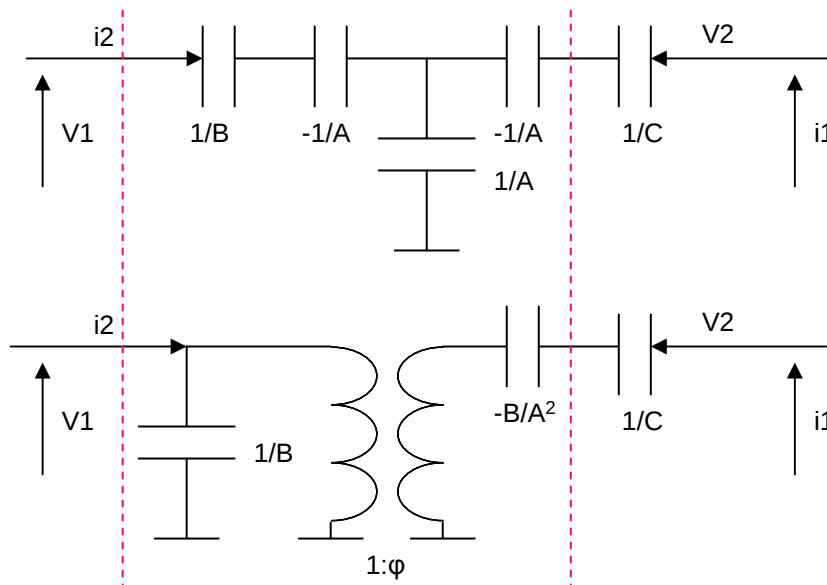
Radio Eng Handbook p143, Starr p293, canonic equations



$$\begin{bmatrix} V1 \\ i1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V2 \\ i2 \end{bmatrix} \quad \begin{bmatrix} V2 \\ -i2 \end{bmatrix} = \frac{1}{\det} \begin{bmatrix} D & B \\ C & A \end{bmatrix} \begin{bmatrix} V1 \\ -i1 \end{bmatrix}$$

sym: $A = D$

$$\varphi = \frac{A}{B} \quad \kappa^2 = \frac{A^2}{BC}$$



Piezo (Philips notation)

$$\varepsilon_1 = d_{31} \cdot E_3 + \frac{1}{Y_1^E} \sigma_1 \quad [-]$$

$$D_3 = \zeta_{33}^\sigma \cdot E_3 + d_{31} \cdot \sigma_1 \quad [C/m^2]$$

$$\begin{bmatrix} \varepsilon_1 \\ D_3 \end{bmatrix} = \begin{bmatrix} d_{31} & \frac{1}{Y_1^E} \\ \zeta_{33}^\sigma & d_{31} \end{bmatrix} \begin{bmatrix} E_3 \\ \sigma_1 \end{bmatrix}$$

$$d_{31} = \text{piezo const} \quad [C/N]$$

$$\zeta = \text{permittivity} \quad [C/V/m]$$

$$\varphi = d_{31} \cdot Y_1^E \quad [N/V]$$

$$\kappa^2 = \frac{d_{31}^2}{\frac{\zeta_{33}^\sigma}{Y_1^E}} = \text{coupling factor} \quad [-]$$

See Franssen L: \piezo\

ESL

$$e_g = n \cdot E_0 \cdot u + \frac{n}{C_0} Q \quad [N]$$

$$f = k \cdot u + n \cdot E_0 \cdot Q \quad [V]$$

$$\begin{bmatrix} e_g \\ f \end{bmatrix} = \begin{bmatrix} n \cdot E_0 & \frac{n}{C_0} \\ k & n \cdot E_0 \end{bmatrix} \begin{bmatrix} u \\ Q \end{bmatrix}$$

$$E_0 = \text{electric field} \quad [V/m]$$

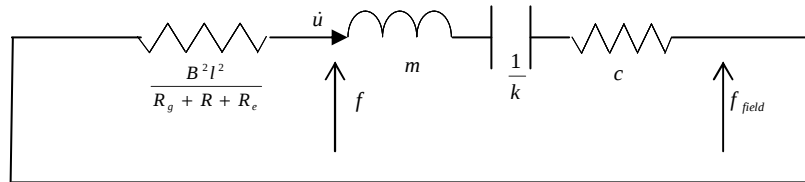
$$Q = \text{charge} \quad [C]$$

$$\varphi = E_0 \cdot C_0 \quad [C/m]$$

$$\kappa^2 = \frac{(n \cdot E_0)^2}{\frac{n}{C_0} k} = \text{coupling factor} \quad [-]$$

See Franssen Hogere Akoestiek

Electrodynamic damper

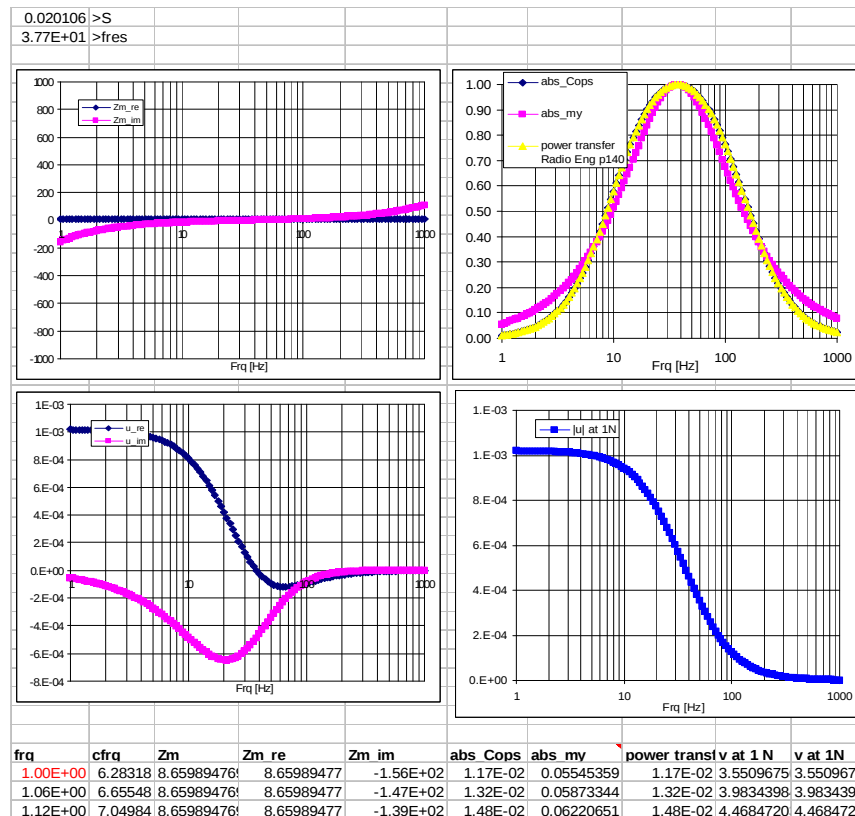


$$Z_m = c + \frac{B^2 l^2}{R_g + R + R_e} + i(\omega \cdot m - \frac{k}{\omega})$$

(MARC uses i , see vola p363, also / emdp / test_USPRNG_har. f)

$$\text{MARC } k = -\omega \cdot Z_m^{im}$$

$$\text{MARC } c = Z_m^{re}$$



$$\text{ratk}(1) = -\text{cfrq} * (\text{cfrq} * \text{xm} - \text{xk} / \text{cfrq})$$

$$\text{ratk}(2) = \text{bl}^2 / (\text{re} + \text{r})$$

$$\text{f}(1) = \text{ratk}(1) * \text{u}(3) - \text{ratk}(2) * \text{cfrq} * \text{u}(4)$$

$$\text{f}(2) = \text{ratk}(1) * \text{u}(4) + \text{ratk}(2) * \text{cfrq} * \text{u}(3)$$

$$\text{xv} = \text{cmplx}(0, -\text{cfrq}) * \text{cmplx}(\text{u}(3), \text{u}(4))$$

C ... minteken wegens complex toegevoegde voor power hierna

$$\text{xf} = \text{cmplx}(\text{f}(1), \text{f}(2))$$

$$\text{xpwr} = \text{real}(\text{xv} * \text{xf})$$

Zm Mechanical impedance at res = $B^2 l^2 / (R_e + R)$ [Ns/m]

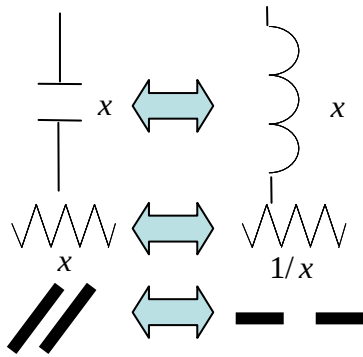
Zsp Spec impedance at res = previous/S [Rayl=Ns/m³]

AD8066W4: about 6 Ns/m resp. 383 Rayl at res

AD12100W8: about 43 Ns/m resp. 617 Rayl at res

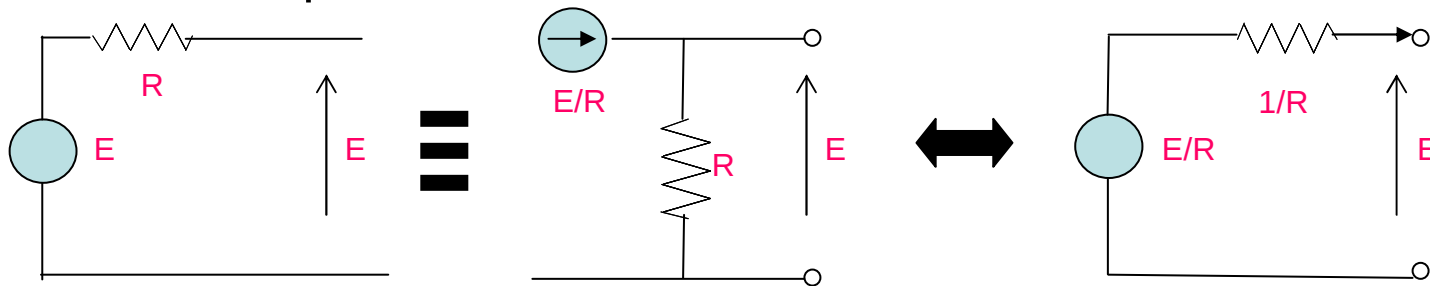
$$\text{Power transfer (Radio Eng p140)} = 4 \cdot R_1 \cdot R_2 / ((R_1 + R_2)^2 + (X_1 + X_2)^2)$$

Loudspeaker



- Dual (only 1 inversion):

- Voltage source
 - Induction
 - Resistance
 - Series (loop)
 - Trafo
 - Beranek p187 trick:
- current source (same value)
 capacitor (same value)
 resistance (1/value)
 parallel (junction) (Merhaut, v d Waeteren)
 $N1 \cdot i1 = N2 \cdot i2$

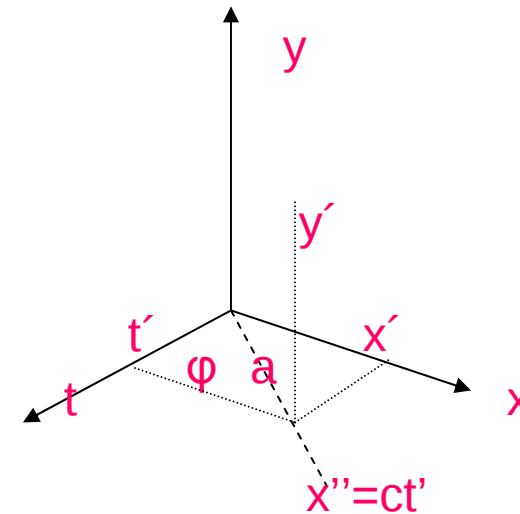
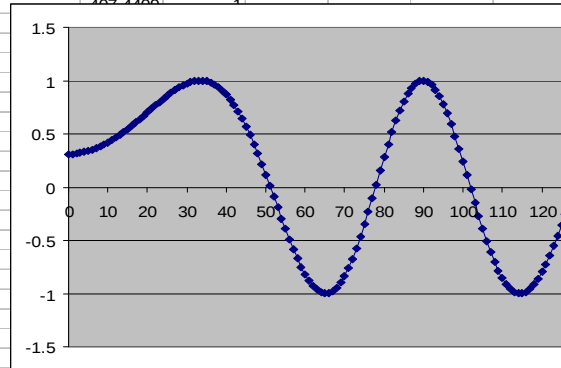


Scheiding der machten

- | | | |
|----------------------|-------|------------------|
| • Wetgevende macht | God | Parlement+koning |
| • Uitvoerende macht | Geest | Koning+regering |
| • Rechterlijke macht | Jezus | Gerecht |

$\cos(kx - \omega t)$

1.2	<a										
1	<f										
340	<c										
0.01848	>k										
6.283185	>om										
89.83148	>phi waarbij x=c*t										
phi	phi rad	t'	x'	y' = cos(k*x' - om*t')	x'' = ct'	cos(k*x'' - om*t')					
0	0	0	1.2	0	0.309017	1					
1	0.017453	1.199817	0.020943	0.310477	407.9379	1					
2	0.034907	1.199269	0.041879	0.314117	407.7515	1					
3	0.05236	1.198355	0.062803	0.319927	407.4409	1					
4	0.069813	1.197077	0.083708	0.327893							
5	0.087266	1.195434	0.104587	0.337993							
6	0.10472	1.193426	0.125434	0.350197							
7	0.122173	1.191055	0.146243	0.364469							
8	0.139626	1.188322	0.167008	0.380764							
9	0.15708	1.185226	0.187721	0.399028							
10	0.174533	1.181769	0.208378	0.419194							
11	0.191986	1.177953	0.228971	0.441185							
12	0.20944	1.173777	0.249494	0.46491							
13	0.226893	1.169244	0.269941	0.490264							
14	0.244346	1.164355	0.290306	0.517125							
15	0.261799	1.159111	0.310583	0.545355							
16	0.279253	1.153514	0.330765	0.574793							
17	0.296706	1.147566	0.350846	0.605264							
18	0.314159	1.141268	0.37082	0.636566							
19	0.331613	1.134622	0.390682	0.668477							
20	0.349066	1.127631	0.410424	0.700752							
21	0.366519	1.120297	0.430042	0.73312							
22	0.383972	1.112621	0.449528	0.765287	378.291	1					
23	0.401426	1.104606	0.468877	0.796935	375.566	1					
24	0.418879	1.096255	0.488084	0.827719	372.7265	1					
25	0.436332	1.087569	0.507142	0.857275	369.7736	1					
26	0.453786	1.078553	0.526045	0.885215	366.708	1					
27	0.471239	1.069208	0.544789	0.91113	363.5307	1					
28	0.488692	1.059537	0.563366	0.934597	360.2426	1					
29	0.506145	1.049544	0.581772	0.955177	356.8448	1					
30	0.523599	1.03923	0.6	0.97242	353.3384	1					
31	0.541052	1.028601	0.618046	0.985874	349.7243	1					
32	0.558505	1.017658	0.635903	0.995084	346.0036	1					



Newton's time +1727

- **Elizabeth I** +1603
- **James (Jacobus) I** +1625 (zoon van de door haar onthoofde Mary Stuart) Guy Fawkes
- Newton *1642 (Juliaans, 4jan1643 Gregoriaans)(UPMG 301 y later, Galilei +1j ervoor)
- Annus Mirabilis during the pest 1665-66 (mijn annus mirabilis was 1963-64)
- **Charles I Stuart** +1649 (Van Dijck **white horse** at the gate, Anglican!, civil wars, beheaded)
- Oliver and Richard **Cromwell** (Protectors)(achter-familie Thomas Cromwell Henry VIII)
- 1667 Paradise Lost (John Milton) opstand Lucifer
- 1682 Scheepsramp oostkust HMS Gloucester met aan boord kroonprins James II en John Churchill (Marlborough), was op weg naar Schotland
- **Charles II Stuart** +1685 ("the merry monarch" met vele bastards die nu nog eem club vormen, doodsbedbeking tot RK)(ballingschap Brugge 1656 met een gevolg van 175 pp, werd lid van de schuttersgilde, VL "eerlijkste volk")
- **James II** +1688 (broer van voorgaande) Jacobus, katholiek, hiermee kwam hij in botsing > 2 daughters (Mary and Anne), werd afgezet in 1688 door Glorious Revolution en Bill of Rights (macht naar parlement)
- Principia 1687 (44 y old)
- Warden (toezichthouder) of the Mint 1696
- **William III** (Willem Oranje +1702) x Mary II Stuart (niet deze die onthoofd werd door Elizabeth I)(sindsdien MOETEN de koningen protestant zijn)
 - Wars against LXIV
 - Glorious revolution (1688)
 - Bank of England first banknotes
- 1704 Opticks
- 1706 Slag van Ramillies (Marlborough><LXIV) de kiem van België
- **Anne Stuart** +1714 (last Stuart, 18 pregnancies all dead before 11 y, Newton knight in 1705)
- **George I** (verbleef meestal in Hannover) +1727
- Napier (Neper, Edinburgh) +1617
- Descartes +1650 (Stockholm)
- Newton overspannen in 1693 (na ruzie met de rijkeluiszoontje Zwitser Fatio de Duillier, die later berooid zal sterven)
- Huyghens +1695 (66 y) Purcell (+1695)
- Locke +1704
- **Louis XIV** +1715
- Leibniz +1716 (plots, weinig volk op begrafenis)
- Rolle (FR +1719)
- John Churchill Marlborough +1722
- Wren +1723
- Newton +1727 (84 y)(Voltaire was aanwezig)
- Daniel Defoe +1731 Robinson CrusOE
- Jonathan Swift +1745 Gulliver's Travels
- Bach +1750, Händel +1759
- Euler +1783

1302, Avignon etc

- 1302 Battle of the Golden Spurs
- 1307 Friday 13 october gevangenneming Jaques de Moley etc in Chinon door Philippe IV le Bel (The Fair, had veel schuld). Dit is de “ongeluksdag”
- 1309 Begin Avignon
- 1314 Trage verbranding Jaques de Moley etc op het ile des Juifs (nu geincorporeerd in het Notre Dame eiland). Ze weigerden alle voorstellen tot intrekking. Enkele maanden nadien waren de paus en de koning dood. Al zijn (Capet) opvolgers stierven kinderloos en het huis ging over naar Valois (later Bourbon)

De Vlaamse vrouwen

- Mathilde van Vlaanderen (+1083)
 - Dochter van Boudewijn V, volle nicht van Henri I van FR, getrouwd met Willem de veroveraar, een “power” koppel
 - Was actief betrokken bij de verovering van Engeland en werd koningin van Engeland
 - Tapijt van Bayeux is NIET van haar, het is in Engeland vervaardigd
 - Geboren in Brugge, begraven in Caen
- Maria van Bourgondie (“ziede daar die reiger” (Tom Waes) Brugge +1482)
 - Dochter van Karel De Stoute, aartsvijand van LXI (de spinkoning) en Isabella van Bourbon
 - Trouwt met Maximiliaan Oostenrijk (en Castilie)
 - Zoon Philips de Schone (x Joh Castilie waanzinnig, dochter Isabella en Ferdinand Reconquistq Columbus) en dochter Maria Oostenrijk
 - Grootmoeder van Karel V
- Maria van Oostenrijk (Mechelen) (+1530)
 - Dochter van Maria, tante van Karel V
 - Anna Boleyn verbleef bij haar tijdens haar jeugd
 - Begraven bij Philibert van Brou en Bresse
- Opgevolgd door Maria van Hongarije (+1556), zuster van Karel V, en verhuist naar Brussel
- Margaretha van Parma (dochter van Maria van der Gheynst Oudenaarde en Karel V) (+1586 Palazzo Madama Rome, nu de Italiaanse senaat)
 - Trad af wegens Alva
 - Zoon Alexander Farnese neemt Antwerpen in (tegen Filips van Marnix van Sint-Aldegonde1585)(de Spaanse furie was in 1575 omdat de soldaten geen soldij meer ontvingen)
- (Albrecht en) Isabella (+1633)
 - Dochter van Filips II die de Vlamingen “vals onderdanig, geen handen aan te steken” vond
 - Eindigde als Clarisse in klooster van Tervuren

Slide 62

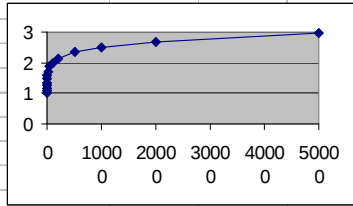
U17

G>sun internal pressure

User, 1/30/2020

Dark matter Messier

1.8	<n					
r	v					
1	1					
2	1.071773					
5	1.174619					
10	1.258925					
20	1.349283					
50	1.478758					
100	1.584893					
200	1.698646					
500	1.861646					
1000	1.995262					
2000	2.138469					
5000	2.343673					
10000	2.511886					
20000	2.692173					
50000	2.950509					

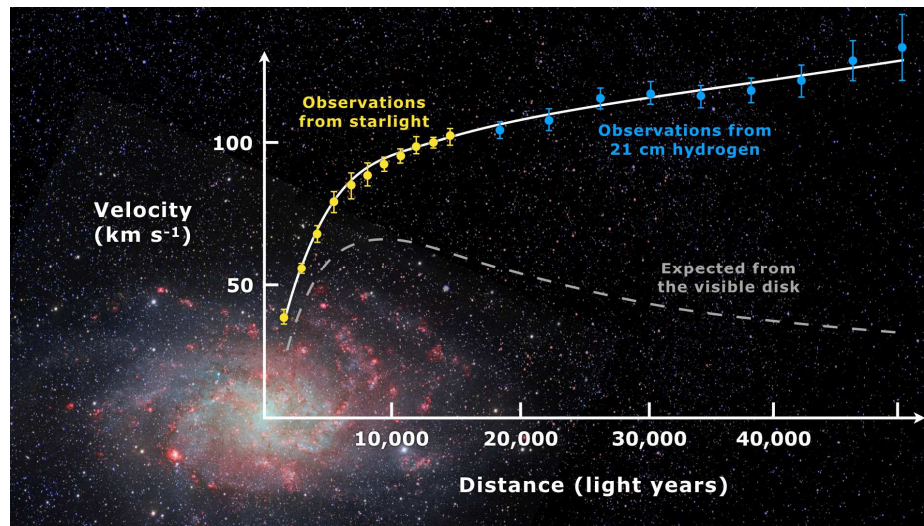


$$a = G \frac{M}{r^2} = r \cdot \omega^2$$

$$\omega^2 \propto \frac{M}{r^3}$$

$$v^2 = (r \cdot \omega)^2 \propto \frac{M}{r} \propto \frac{\rho \cdot r^3}{r} \propto \frac{r^3}{r^{n+1}} \left(\rho \propto \frac{1}{r^n} \right) = r^{2-n}$$

$$v \propto r^{1-n/2}$$



Bell inequalities, Penrose tessellation

U8

Slide 64

U8

G>sun internal pressure

User, 1/30/2020

U7

- Pressure is between 3.4×10^8 and 2.25×10^{11} atm $\rightarrow$ take 1×10^{10} atm = 1×10^{15} Pa
- Ymod steel is 2×10^{11} Pa (=pressure/strain)
- Difference is factor 5000

[illegible]

Slide 65

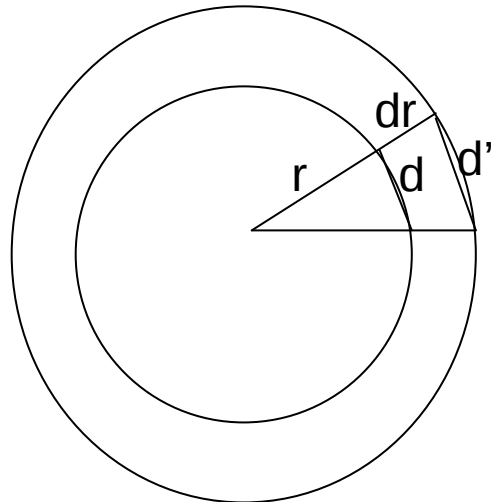
U7

G>sun internal pressure

User, 1/30/2020

Poisson Gauss distribution examples

Balloon expansion



$$d = 2r \cdot \sin(\alpha/2)$$

$$d' = 2(r + \Delta r) \cdot \sin(\alpha/2)$$

$$\frac{d'}{d} = 1 + \frac{\Delta r}{r}$$

$$\frac{\Delta d / \Delta t}{d} = \frac{\Delta r / \Delta t}{r}$$

$$\frac{\dot{d}}{d} = \frac{\dot{r}}{r}$$

For universe, left hand side increases $\rightarrow dr/r$ increases

Hubble constant is 70 km/s/Mpc = $70 \cdot 1000 / 3.08 \cdot 10^{22}$ m/s/m = $2.3 \cdot 10^{-18}$ [1/s]

1 Parsec $\approx$ 3 Ly

1 Ly = $1 \cdot 10^{16}$ m

Dus een galaxy op 10 Gly heeft snelheid van 231000 km/s ($c = 300000$ km/s)

2.30E-18	<Hubble constant [1/s]					
3.00E+08	<c=Lichtsnelheid [m/s]					
9.47E+15	>Lichtjaar [m]					
Objectafst	id in m	rel snelheid t.o.v c				
10	9.47E+25	0.725825				

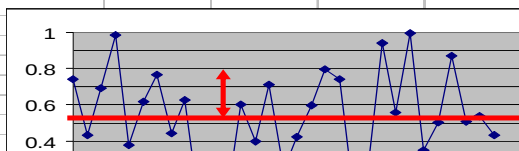
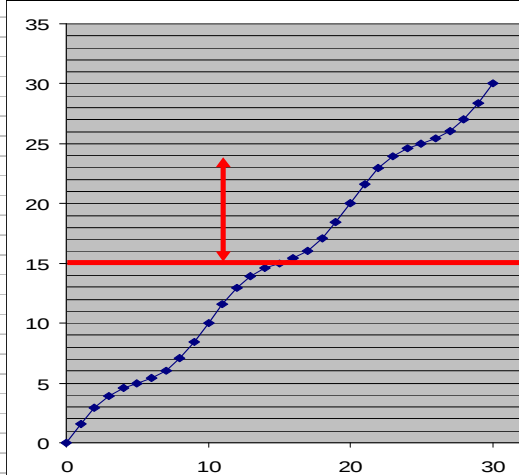
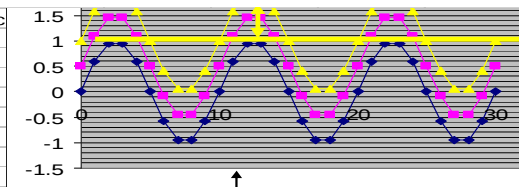
Root Mean Square (RMS)

$$\textit{Literal definition : } RMS = \sqrt{\frac{1}{t_{\max}} \int_0^{t_{\max}} [x(t) - x_{\text{avg}}]^2 dt}$$

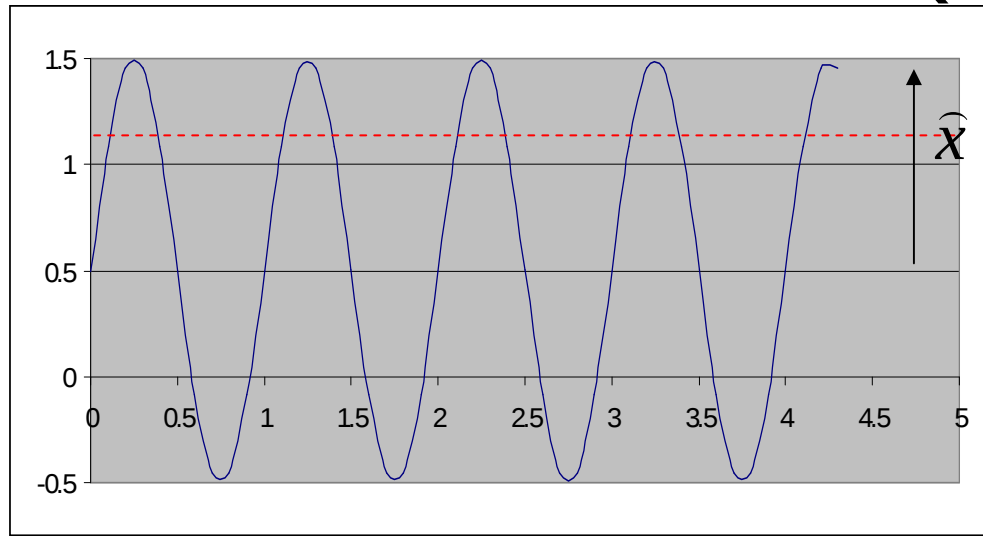
- Sometimes RMS^2 is called “Variance”
- x_{avg} is also called “expectation value”

RMS

					Random (press F) to c	
0	0	0.5	1	0	0.793613	
1	0.587785252	1.087785	1.587785	1.587785	0.900427	
2	0.951056516	1.451057	1.951057	2.951057	0.886795	
3	0.951056516	1.451057	1.951057	3.951057	0.484858	
4	0.587785252	1.087785	1.587785	4.587785	0.645145	
5	-2.20505E-15	0.5	1	5	0.446085	
6	-0.587785252	-0.08779	0.412215	5.412215	0.290535	
7	-0.951056516	-0.45106	0.048943	6.048943	0.089766	
8	-0.951056516	-0.45106	0.048943	7.048943	0.288914	
9	-0.587785252	-0.08779	0.412215	8.412215	0.067671	
10	4.4101E-15	0.5	1	10	0.512194	
11	0.587785252	1.087785	1.587785	11.58779	0.093983	
12	0.951056516	1.451057	1.951057	12.95106	0.17718	
13	0.951056516	1.451057	1.951057	13.95106	0.817098	
14	0.587785252	1.087785	1.587785	14.58779	0.861662	
15	-1.37206E-14	0.5	1	15	0.06329	
16	-0.587785252	-0.08779	0.412215	15.41221	0.235562	
17	-0.951056516	-0.45106	0.048943	16.04894	0.458728	
18	-0.951056516	-0.45106	0.048943	17.04894	0.748509	
19	-0.587785252	-0.08779	0.412215	18.41221	0.618201	
20	8.8202E-15	0.5	1	20	0.90895	
21	0.587785252	1.087785	1.587785	21.58779	0.349882	
22	0.951056516	1.451057	1.951057	22.95106	0.48265	
23	0.951056516	1.451057	1.951057	23.95106	0.01548	
24	0.587785252	1.087785	1.587785	24.58779	0.879439	
25	-3.91982E-15	0.5	1	25	0.905781	
26	-0.587785252	-0.08779	0.412215	25.41221	0.346245	
27	-0.951056516	-0.45106	0.048943	26.04894	0.372693	
28	-0.951056516	-0.45106	0.048943	27.04894	0.968581	
29	-0.587785252	-0.08779	0.412215	28.41221	0.428837	
30	2.74412E-14	0.5	1	30	0.156454	
	2.15483E-16	0.5	1	15	0.493394	<avg
	0.5	0.5	0.5	80.08898	0.093908	<var
	0.707106781	0.707107	0.707107	8.949245	0.306445	<sd



RMS for sine (1 freq)



→ RMS

→ x_{avg}

$$\begin{aligned}
 RMS^2 &= \frac{1}{T} \int_0^T [x(t) - x_{avg}]^2 dt = \frac{1}{T} \int_0^T [\hat{x} \sin(\omega t)]^2 dt \\
 &= \frac{\hat{x}^2}{2T} \int_0^T [1 - \cos(2\omega t)] dt = \frac{\hat{x}^2}{2T} \left[\int_0^T dt - \frac{1}{2\omega} \int_0^T \cos(2\omega t) d(2\omega t) \right] = \frac{\hat{x}^2}{2T} \left[T - \frac{\sin(2\omega T)}{2\omega} \right] = \frac{\hat{x}^2}{2} \text{ because } \omega T = 2\pi
 \end{aligned}$$

U2

Hence $RMS = 0.707 \times \text{amplitude}$ *corrected for average*

RMS^2 is proportional to the power

If x is excited by y and $X(\omega) = TF(\omega) \cdot Y(\omega)$, then $RMS_x = |TF(\omega)| \cdot RMS_y$

Slide 70

U2

Wiki>Root mean square

User, 1/8/2020

RMS for many freqs $\rightarrow$ PSD

$$RMS_{tot}^2 = \sum \frac{\hat{x}_i^2}{2} = \sum RMS_i^2 \quad (\text{Not } RMS = \sum RMS_i)$$

$$PSD(\omega) = RMS^2 \text{ per band} = \frac{\hat{x}_i^2}{2\Delta\omega}$$

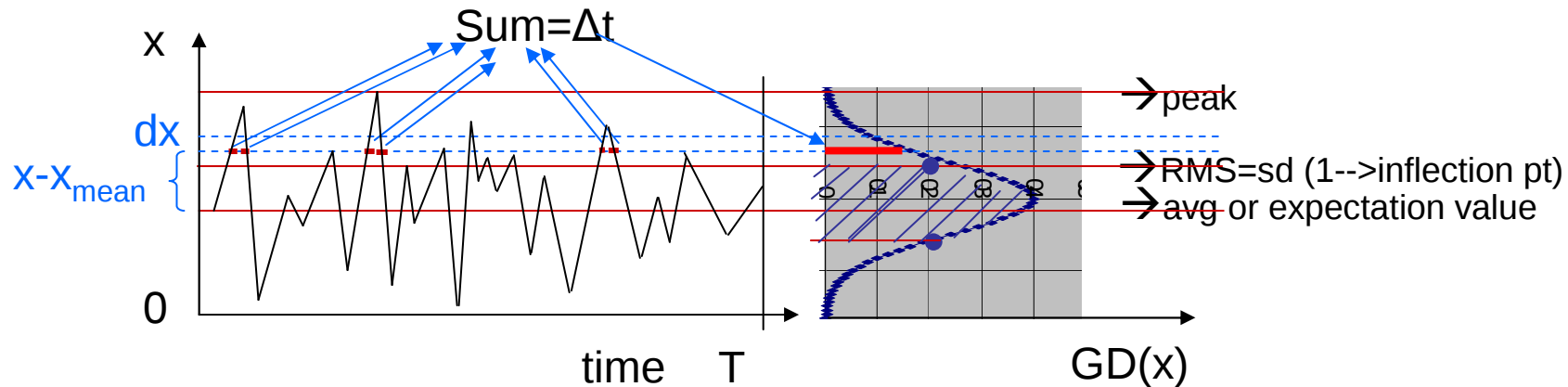
$$RMS_{tot}^2 = \sum PSD(\omega) \cdot \Delta\omega$$

If x is excited by y and $X(\omega) = TF(\omega) \cdot Y(\omega)$

$$PSD_x = |TF(\omega)| \cdot PSD_y$$

RMS for Gaussian noise

(B&K Frequency Analysis Randall p33)



General GD property : $sd^2 = \int_{-\infty}^{\infty} (x - x_{avg})^2 NGD(x - x_{avg}) dx$

Because $NGD(x - x_{avg}) \cdot dx$ is the probability of x lying in dx range $= \frac{\Delta t}{T}$

sd^2 can be written as $\int_{-\infty}^{\infty} (x - x_{avg})^2 \frac{\Delta t}{T}$

Compare with literal definition of $RMS^2 = \frac{1}{T} \sum [x(t) - x_{avg}]^2 \Delta t$

Hence $RMS \approx sd \approx (68\% \text{ for Gaussian noise})$

Slide 72

U3

B&K Mech Vibration and shock measurements p268

User, 1/8/2020

Recap Gauss GD and NGD

Central limit theorem

$$\text{GaussDensity} = \text{GD}(x) = \frac{1}{\text{sd} \sqrt{2\pi}} \exp\left[-\frac{1}{2} \left(\frac{x}{\text{sd}}\right)^2\right]$$

$$\text{NormalizedGaussDensity} = \text{NGD}(x) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2} \left(\frac{x}{\text{sd}}\right)^2\right] (\text{area below} = 1)$$

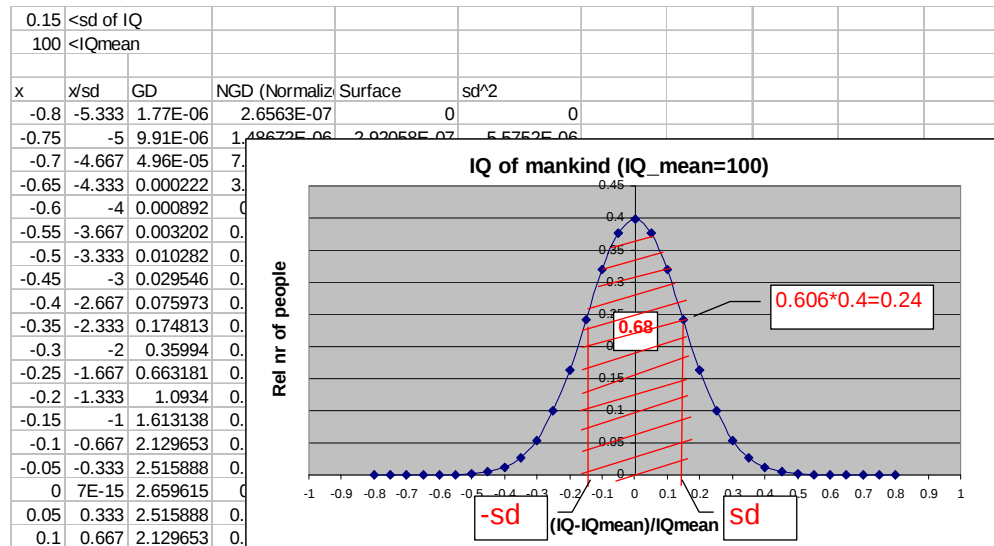
$$\text{sd}^2 = \int_{-\infty}^{\infty} x^2 \cdot \text{NGD}(x) \cdot dx \quad (\text{sd is at inflexion points})$$

Mostly $x \rightarrow x - x_{\text{mean}}$

$$\int_{-\infty}^{\infty} e^{-\beta u^2} du = \sqrt{\pi / \beta} \quad (\text{Laplace proved } \int_{-\infty}^{\infty} e^{-u^2} du = \sqrt{\pi})$$

$$\int_{-\infty}^{\infty} u e^{-\beta u^2} du = 0 \Rightarrow \text{mean, expectation value, 1st moment}$$

$$\int_{-\infty}^{\infty} u^2 e^{-\beta u^2} du = \sqrt{\pi / \beta^2 / 2} \Rightarrow \text{SD}^2, 2\text{nd moment}$$



For normalized:

- Surface under = 1
- Max value = 0.399 → 0.4
- Inflexion point coordinates (sd, 0.606 * max)
- Note: $\sqrt{2} = 1.41$, inverse = 0.707
- The surface between the inflection points (at 0.606 of max) is 0.68 (complete surface is 1)

Hermite

$$\begin{bmatrix} 3 & 2+i \\ 2-i & 1 \end{bmatrix}$$

$$A^T = \overline{A}$$

- Shear modulus/force
 - Schuifmodulus/kracht
 - Glijding-
 - Scheer-
- Stress/strain
 - Spanning/rek (><deformatie)
 - Contrainte/deformation (><displacement)

Euler

$$e^{\pm i\pi} + 1 = 0$$

$$e^{i(2n+1)\pi} + 1 = 0$$

$$\lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n = e \text{ (Jacob Bernoulli 1683)}$$

If rent is 100% (1/n=1) you get after 1 year 2,-. If you
reinvest each day, the rent is 100/365=0.2740
(1/n=0.00275=4, n=365) then you will get 2.7145

$$1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \dots = e \text{ (Euler 1748)}$$

$$\frac{n}{k} = e = 2.7182818... \text{ (n = aantal kandidaten, k = optimaal aantal kandidaten = } \frac{n}{e}$$

waarna je beste keuze kan maken)(Ionica, voor 10 kandidaten moet je stoppen na 3.68 -- > 4)

$$IMEXP("1+i") = e^{1+i} = e \cdot e^{i1} = e \cdot (\cos 1 + i \sin 1) = 1.468694 + 2.287355i$$

$$\sum \frac{1}{n^2} = \frac{\pi^2}{6} \quad \sum_{n_{\text{even}}} \frac{1}{n^2} = \frac{\pi^2}{24} \quad \sum_{n_{\text{oneven}}} \frac{1}{n^2} = \frac{\pi^2}{8} \text{ (Deligne, Rektorys393)}$$

Riemann Zeta

$$\begin{aligned}\zeta(s) &= \sum_{n=1}^{\infty} \frac{1}{n^s} \quad (s = \sigma + i\tau)(s \neq 1) \\ &= \prod_p \left(1 - \frac{1}{p^s}\right)^{-1} \quad (p \text{ prime}) \text{ if } \sigma > 1\end{aligned}$$

- Vermoeden: het reële deel van elk niet-triviaal is $1/2$
- Overleden in Italië 1866 (slechts 38 j)

Heat loss earth

Sabine law

$$t_{rev} = 0.161 \frac{V}{OW}$$

$$OW = \frac{\sum \alpha_i S_i}{\sum S_i}$$

$$OW = 0.161 \cdot V \text{ for } t_{rev} = 1$$

Shear strain

Coriolis

- Factor omega kwadraat? (Andre)

FEM-Albert Konter-Mario Clé

(All variables nodal except indicated)

$$ux_{cont} = a + b \cdot x + c \cdot y$$

$$uy_{cont} = a' + b' \cdot x + c' \cdot y$$

a, b, etc to be calculated for all nodes of each element

$$\text{Displacement field } u = N \cdot u \quad (N = \text{shape functions}) \quad \left(\text{for tria} \right) \quad N = \begin{bmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 \\ 0 & N_1 & 0 & N_2 & 0 & N_3 \end{bmatrix}$$

N_i = weighted area spanned by each side

Compatibility (strain – disp) $\Delta \varepsilon = B \cdot \Delta u$ ($B = \partial N / \partial x$ etc) [verenigbaarheid]

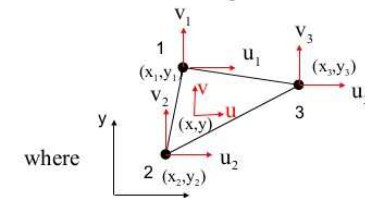
$$\text{Constitutive (stress – strain)} \quad \Delta \sigma = D \cdot \Delta \varepsilon \quad \text{e.g. for plane stress} \quad D = \frac{E}{1-\nu^2} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \quad (\text{C Bouckaert})$$

Element stiffness $B^T \cdot D \cdot B$

$$\text{Internal} = \text{external work} \quad \left(\int_V B^T \cdot D \cdot B \cdot dV \right) \cdot \Delta u = \Delta f \quad (\text{Hooke})$$

0. $u_{cont} = N \cdot u$ $N(\text{shape } f) [-]$
1. $\varepsilon = \frac{\partial u}{\partial x} = B \cdot u$ $* D \text{ (const)}$
2. $\sigma = D \varepsilon = DB \cdot u$ $* B^T (\text{comB}) [1/m]$
3. $f_{body} = B^T \sigma = B^T DB \cdot u$ $[N/m^3]$
4. $f_{body} = K \cdot u$ $K \text{ (stiffness assembly)}$
5. $$ $(\text{boundary conditions})$
6. $u = K^{-1} \cdot f_{body}$ (matrix solver)
7. see 1 and 2 $(\text{back – substitution})$

Formula for the shape functions are



$$N_1 = \frac{a_1 + b_1 x + c_1 y}{2A}$$

$$N_2 = \frac{a_2 + b_2 x + c_2 y}{2A}$$

$$N_3 = \frac{a_3 + b_3 x + c_3 y}{2A}$$

$$A = \text{area of triangle} = \frac{1}{2} \det \begin{bmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ 1 & x_3 & y_3 \end{bmatrix}$$

$$a_1 = x_2 y_3 - x_3 y_2 \quad b_1 = y_2 - y_3 \quad c_1 = x_3 - x_2$$

$$a_2 = x_3 y_1 - x_1 y_3 \quad b_2 = y_3 - y_1 \quad c_2 = x_1 - x_3$$

$$a_3 = x_1 y_2 - x_2 y_1 \quad b_3 = y_1 - y_2 \quad c_3 = x_2 - x_1$$

• Shape function N_1 of node 1 = opposite area A_1 / total area

• Sum of all shape functions is 1

$$[N] = \begin{bmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 \\ 0 & N_1 & 0 & N_2 & 0 & N_3 \end{bmatrix}$$

$$[B] = \begin{bmatrix} \frac{\partial N_1}{\partial x} & 0 & \frac{\partial N_2}{\partial x} & 0 & \frac{\partial N_3}{\partial x} & 0 \\ 0 & \frac{\partial N_1}{\partial y} & 0 & \frac{\partial N_2}{\partial y} & 0 & \frac{\partial N_3}{\partial y} \\ \frac{\partial N_1}{\partial y} & \frac{\partial N_1}{\partial x} & \frac{\partial N_2}{\partial y} & \frac{\partial N_2}{\partial x} & \frac{\partial N_3}{\partial y} & \frac{\partial N_3}{\partial x} \end{bmatrix}$$

$$D_{pstrain} = \frac{E}{1-\nu^2} \begin{bmatrix} 1 & \nu & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix}$$

FEM-Albert Konter-Mario Clé

(All variables nodal except indicated)

11-8-2023

Engineering at Alberta Courses » Triangular Elements

PAGE CONTENTS

12.3.1.1 Triangular Elements

Linear Triangular Element
(Constant Strain Triangle)

Quadratic Triangular
Elements

Video:

Page Comments

full screen view

4. Displacement and Strain

5. Stress

6. Balance Equations

7. Constitutive Laws

8. Plane Beam
Approximations

9. Energy

10. Variational Principles

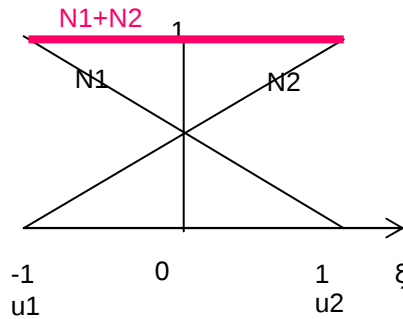
11. Approximate Methods

12. Finite Element Analysis

12.1 FEA in One Dimension

12.2 FEA in Two and Three
Dimensions

Shape function for bar element (Lagrangian)



$$N_1 = \frac{1}{2}(1 - \xi) \quad N_2 = \frac{1}{2}(1 + \xi) \quad \xi = \frac{2}{L}(x - x_1) - 1$$

$$N = [N_1 \quad N_2]$$

$$u_{cont} = [N_1 \quad N_2] \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = N \cdot u$$

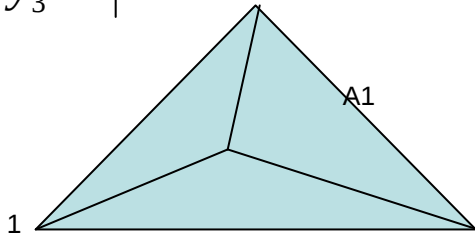
$$\varepsilon = \frac{du_{cont}}{dx} = \frac{du_{cont}}{d\xi} \frac{d\xi}{dx} = \dots = \frac{1}{L} \begin{bmatrix} -1 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = B \cdot u$$

$$\sigma = D \cdot \varepsilon = D \cdot B \cdot u$$

- Shape or interpolation function
- Each node has shape function
- Is 1 in node and 0 in other node

Triangle area

$$\frac{1}{2} \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \frac{1}{2} \begin{vmatrix} x_2 - x_1 & y_2 - y_1 \\ x_3 - x_1 & y_3 - y_1 \end{vmatrix} = \frac{1}{2} \begin{vmatrix} x_1 - x_2 & y_1 - y_2 \\ x_3 - x_2 & y_3 - y_2 \end{vmatrix} = \frac{1}{2} \begin{vmatrix} x_1 - x_3 & y_1 - y_3 \\ x_2 - x_3 & y_2 - y_3 \end{vmatrix}$$

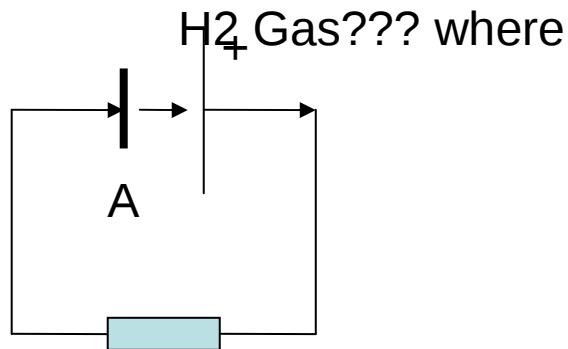
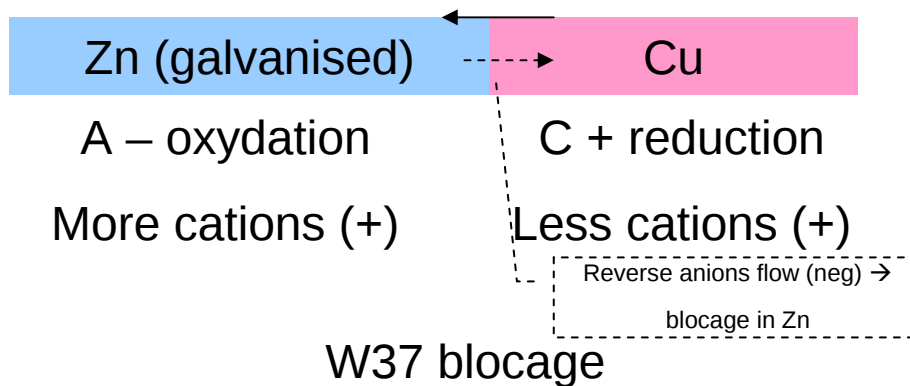


- Points ccwise (otherwise negative)
- 3x3 is volume of parallelopiped spanned by 3 vectors or triangle if all vectors end in z=1 (cfr. outproduct vectors)
- 2x2 is area of parallelogram or 2 x triangles spanned by 2 vectors
 - subtract ref point (heb dit nagerekend)

Gauss-Jordan eliminatie “vegen”

- Determinant is unchanged if
 - 2 rows/columns interchanged
 - Multiple of 1 row added to other row
- First reduce to echelon form
- Then eliminate right hand side

Metal potential-Corrosion



Diode, battery, CRT

- Wiki>Galvanische Zelle, De Bock 2.12

- Noblest material dissolves less (Nernst)(naz: maar nemen nemen electronen op of af?)

- Zn-Cu is Daniell element

- All arrows + current

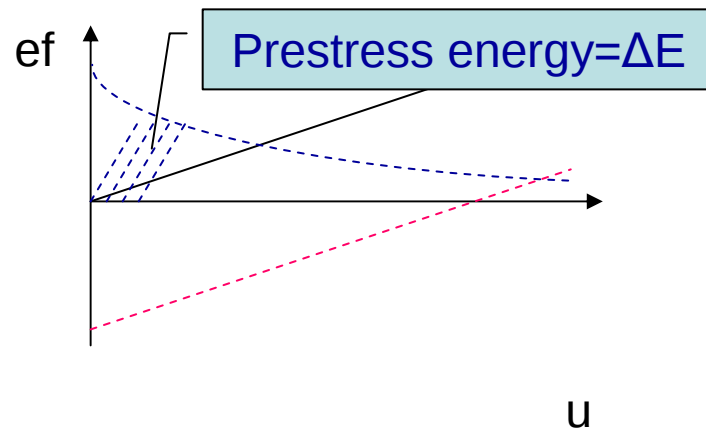
- Cathode current departs (CCD) (pos outside current)

- The “Flatte” is POSITIVE, hence cathode

- KNAPCNAP rule is only valid internally

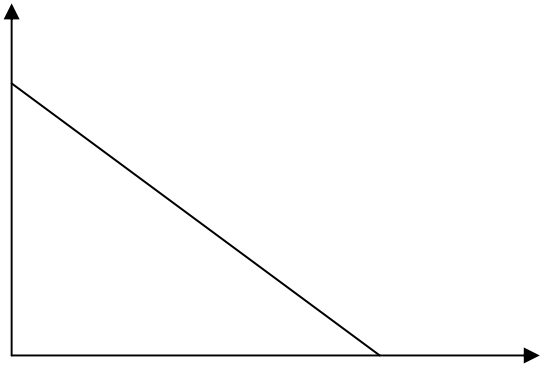
- Nog te doen: loodbatterij, Li-ion, H₂ productie, 0=waterpotentiaal, blocage, stroomrichting water, De Bock 2.12, “dood” water

The prestressed negative spring

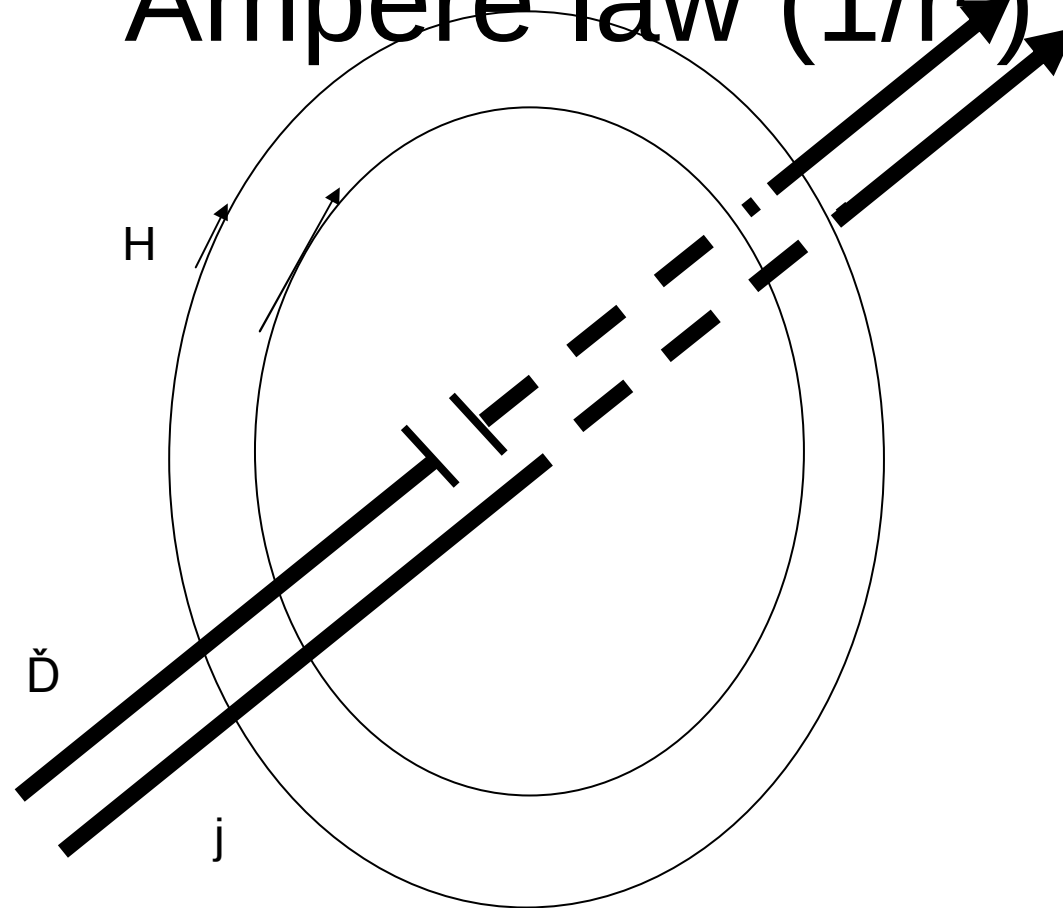


- MARC conventions, $u=0$ is initial condition
- Positive spring: f and u have same sign and prestress energy is negative (je moet trekken bij uitrekking, bij neg veer moet je terugduwen bij uitrekking)
- Gravity acts as a prestressed negative spring (smaller at greater distance)
- The prestress energy is $+\Delta E$ from the universe quantum fluctuation, the negative counterpart is the mass
- Initially, the universe can expand at a higher than lightspeed velocity because there are no interacting photons
 - When they start to interact, the expansion is decelerated. The braking energy is converted into chaotic mass distribution (higher entropy)
- ??? If the universe expands, the force for compressing it decreases
 - This comes from the increasing information, which is a result of the increasing entropy

Ventilator



Ampere law ($1/r^2$)



Magnetic field vectors and paths lie in plane perpendicular to conductor

Maxwell eq is for ENCLOSED current

Maxwell-Lorentz Differential and integral

$$\nabla \cdot \mathbf{D} = \rho \quad [As / m^3] = [C / m^3] \text{ (non - hom) (Coulomb - Gauss)}$$

$$\nabla \cdot \mathbf{B} = 0 \quad [T / m] \text{ (hom, incompr or solinoidal)} \Rightarrow \mathbf{B} = \nabla \times \mathbf{A} \text{ (A = vector potential)}$$

$$\nabla \times \mathbf{E} = 0 + (-\dot{\mathbf{B}}) \quad [V / m^2] = [T / s] \text{ (hom) if } \dot{\mathbf{B}} = 0 \Rightarrow \mathbf{E} = \nabla \Phi \text{ (}\Phi = \text{scalar potential) (Faraday - Lenz)}$$

$$\nabla \times \mathbf{H} = \mathbf{j} + \dot{\mathbf{D}} \quad [A / m^2] \text{ (non - hom) (Ampere - Biot - Savart)}$$

$$\mathbf{f} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \quad [N] \text{ (Lorentz - Laplace force) (LH screwdriver rule) } \mathbf{f}_{vol} = \rho \cdot \mathbf{E} + \mathbf{j} \times \mathbf{B} \quad [N / m^3]$$

$$c^2 \nabla^2 \mathbf{E} = \ddot{\mathbf{E}} \quad c^2 \nabla^2 \mathbf{B} = \ddot{\mathbf{B}} \quad (\text{wave eq, electro - magnetism = no current no charges}) \quad c^2 = \frac{1}{\epsilon \mu}$$

$$c^2 \nabla^2 u = \ddot{u} \quad c^2 \nabla^2 p = \ddot{p} \quad (\text{wave eq acoustics}) \quad c^2 = \frac{\gamma \cdot p_0}{\rho_0}$$

Note : heat eq (Fourier) is $\mathbf{D} \cdot \nabla^2 \mathbf{q} = \dot{q}$

$$\nabla \nabla \cdot \mathbf{b} = \nabla \times \mathbf{b} \times \mathbf{b} + \nabla^2 \mathbf{b} \quad (\mathbf{b} \text{ vector})$$

$$\nabla^2 \mathbf{b} = \nabla \cdot \nabla \text{ (Laplace)}$$

$$\nabla \cdot \nabla \times \mathbf{b} = 0$$

$$\nabla \cdot \text{grad} \quad (s \rightarrow v)$$

$$\nabla \cdot \text{div} \quad (v \rightarrow s)$$

$$\nabla \times \text{rot} \quad (v \rightarrow v) \text{ (tendency to rotate)}$$

$$\nabla^2 \quad (s \rightarrow s)$$

$$\nabla^2 \mathbf{b} = \nabla(\nabla \cdot \mathbf{b}) - \nabla \times (\nabla \times \mathbf{b}) \text{ (Vector Laplace)}$$

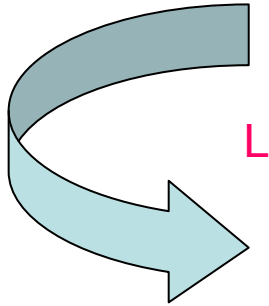
Note: Ampere law is for ENCLOSED current and is consistent with corkscrew rule

Point Form	Integral Form
$\nabla \times \mathbf{H} = \mathbf{J}_c + \frac{\partial \mathbf{D}}{\partial t}$	$\oint \mathbf{H} \cdot d\mathbf{l} = \int_S \left(\mathbf{J}_c + \frac{\partial \mathbf{D}}{\partial t} \right) \cdot d\mathbf{S} \quad (\text{Ampère's law})$
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	$\oint \mathbf{E} \cdot d\mathbf{l} = \int_S \left(-\frac{\partial \mathbf{B}}{\partial t} \right) \cdot d\mathbf{S} \quad (\text{Faraday's law; } S \text{ fixed})$
$\nabla \cdot \mathbf{D} = \rho$	$\oint_S \mathbf{D} \cdot d\mathbf{S} = \int_v \rho \, dv \quad (\text{Gauss' law})$
$\nabla \cdot \mathbf{B} = 0$	$\oint_S \mathbf{B} \cdot d\mathbf{S} = 0 \quad (\text{nonexistence of monopole})$

Sum over history (Feynman)

- Events in nature have probability P
- $P = ||\text{quantum amplitude of event } Q||^2$
 - Ampl of $Q = \sum q_h$
 - $q_h = \text{ampl of every history leading the event}$
- $q_h = \prod ||f_i||$
 - $f_i = \text{fundamental “atomic” process, can be lumped to allow renormalization}$
 - Allows Newton limit $P = \text{product of probabilities}$

The wheather

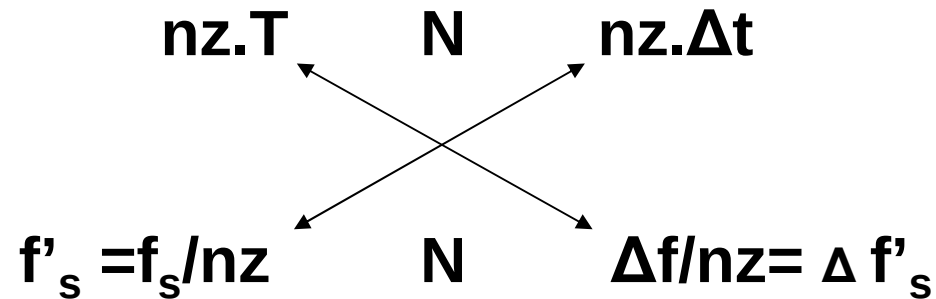
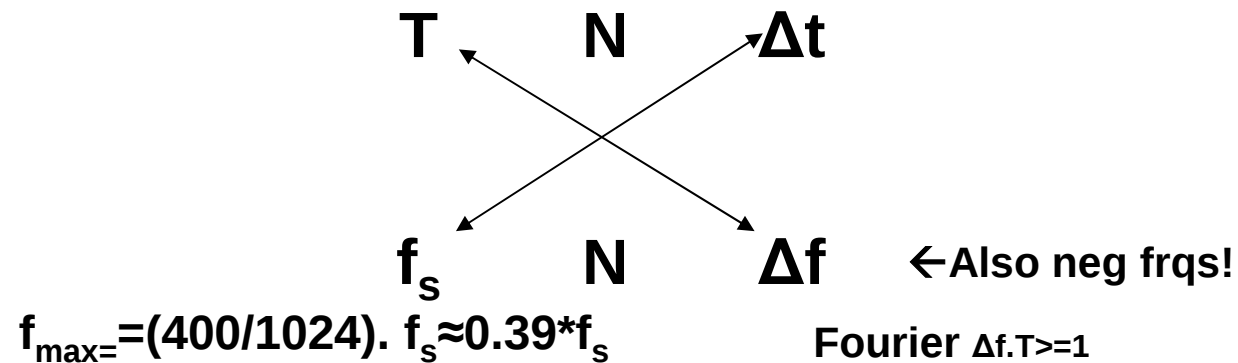


CT-MRI-Magnetron

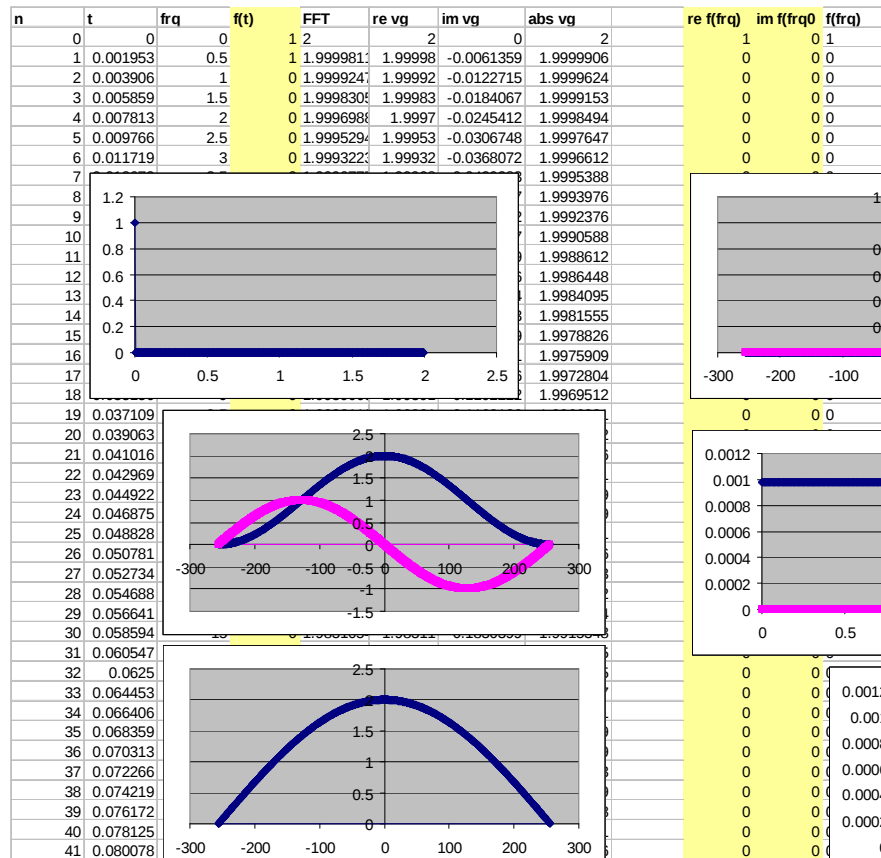
- Radium: alfa straling (He kernen)
- (N)MR(I) (nuclear magn reson imaging of kernspinresonantie): het magnetisch moment van de **waterstof kern** dat met een vast veld wordt ingesteld en via een radioveld wordt gewijzigd. De recombinatie fotonen vormen de foto. Het weefsel wordt opgewarmd (Golfmechanica p 65b?)
- Magnetron (Microwave): 2.45 GHz (UHF $\lambda \approx 0.1$ m) exciteert het **dipoolmoment van H₂O**
- CT (computertomografie): Roentgen

(Zoom)FFT (nz is for zoom)

Choice: $N=2^n$ then T or f_s

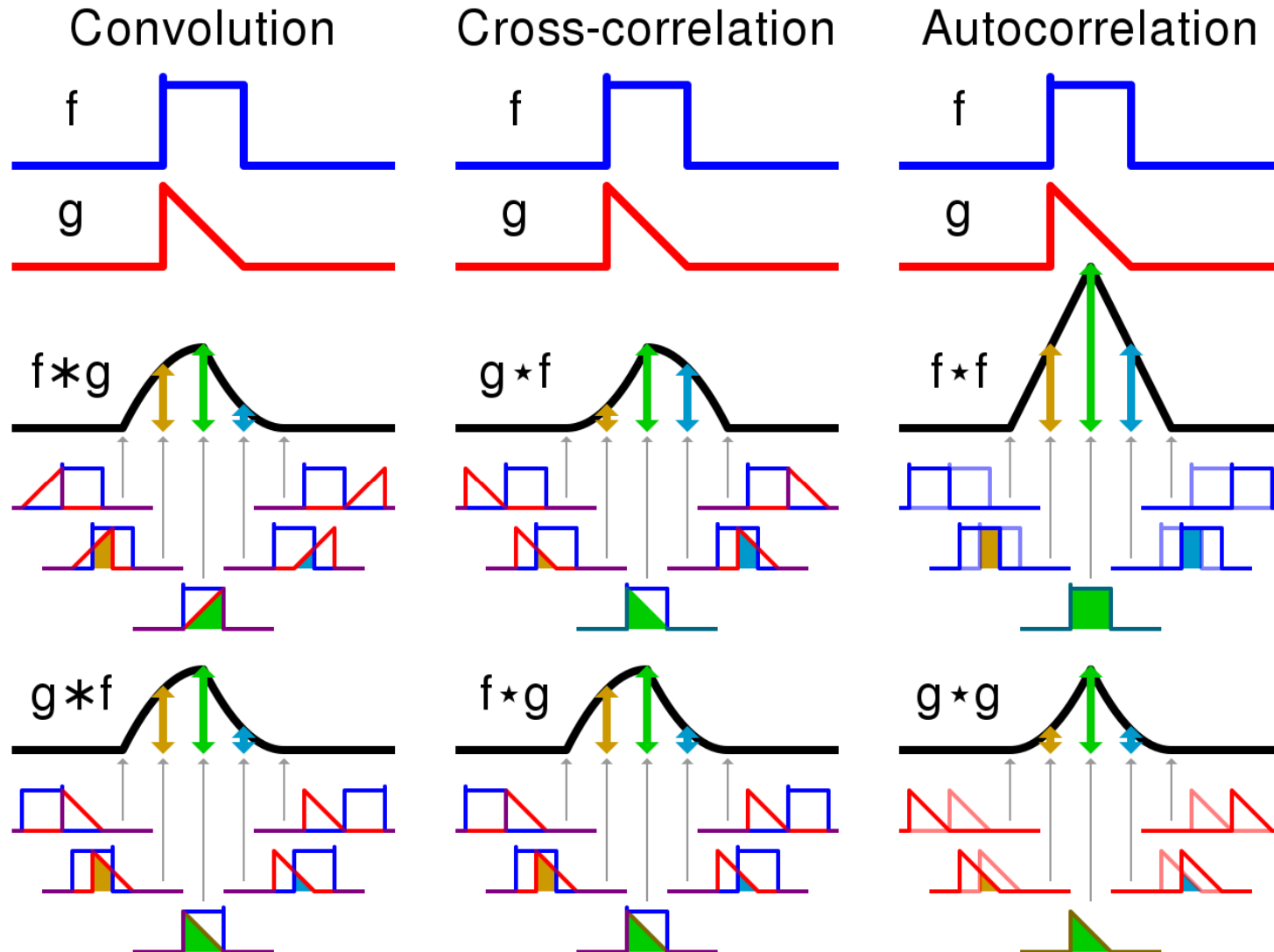


FFT Fourier in Excel



Memory convolution correlation

Con-Volvere=roll together)(Wiki example)



Memory convolution Duhamel integral

(sem93 2.7)(Enden 97)

DEZE SLIDE WEGLATEN EN
VERVANGEN DOOR VOLGENDE UIT
ALL VISCOetc???

Incoming sound comes from right to
right ear

Incoming sound stands still, The ear
moves to the right

IR is impulse resp of the ear or
viscoelastic material

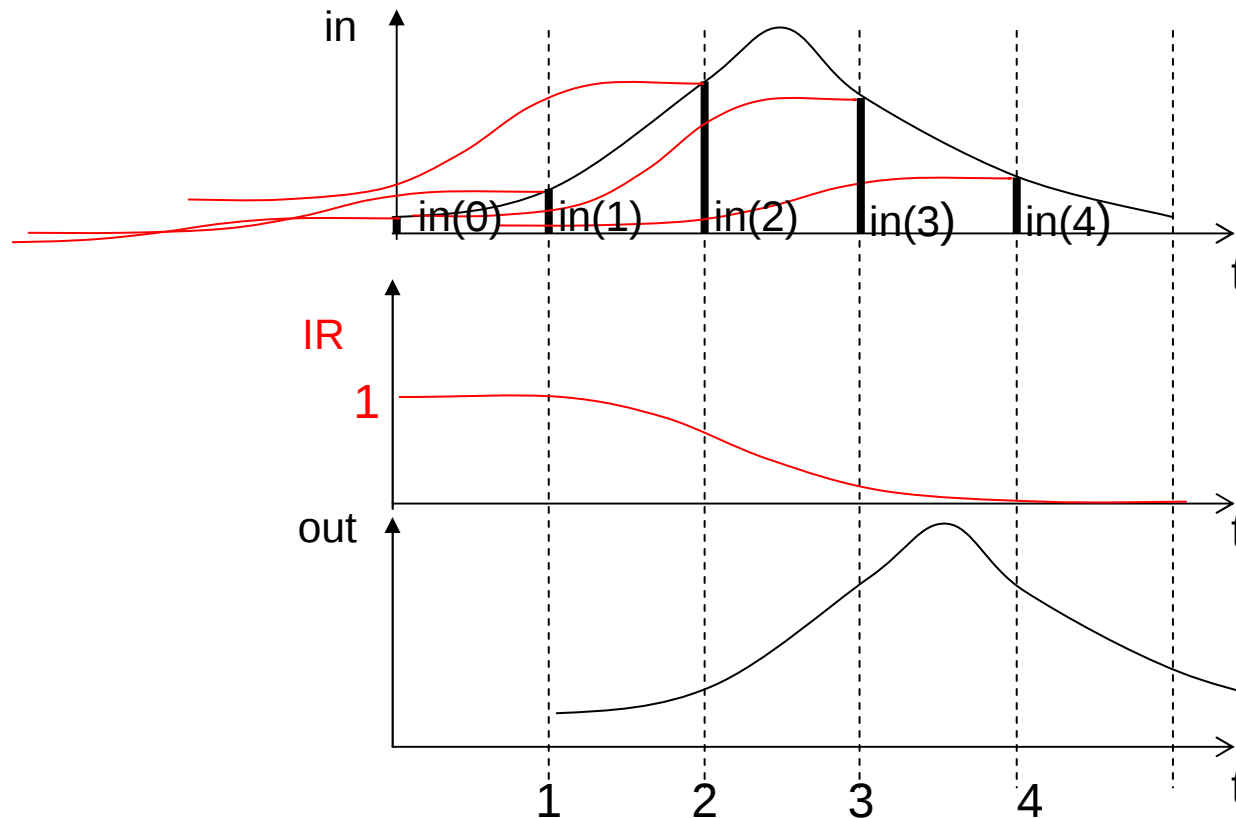
Brain sensation at $t=4$ is sum of
instantaneous input plus all earlier
relaxed input

$$\begin{aligned} out(4) = & \\ & in(4) \cdot IR(0) \cdot 1 + \\ & in(3) \cdot IR(1) \cdot 1 + \\ & in(2) \cdot IR(2) \cdot 1 + \\ & in(1) \cdot IR(3) \cdot 1 + \\ & in(0) \cdot IR(4) \cdot 1 \end{aligned}$$

$$out(4) = \sum_{i=0}^4 in(i) \cdot IR(4-i) \cdot 1$$

$$out(t) = \int_0^t in(t') \cdot IR(t-t') \cdot dt' = \int_0^t in(t-t') \cdot IR(t') \cdot dt'$$

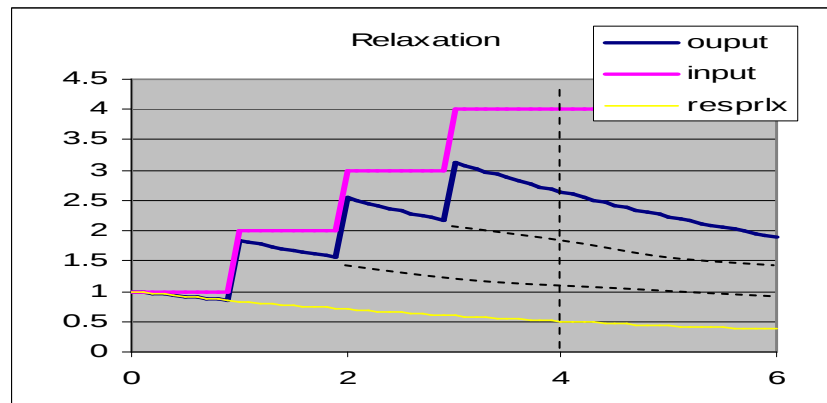
$$out(t) = \int_0^t din(t') \cdot IR(t-t')$$



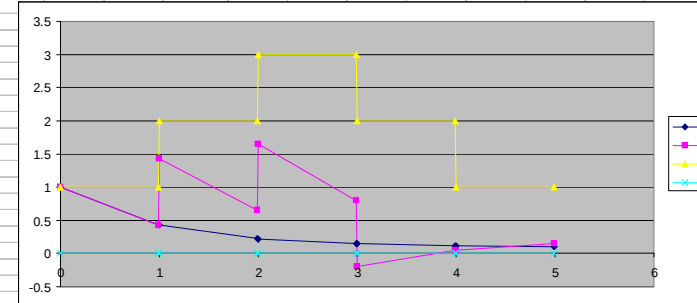
Boltzmann linear superposition

Memory-hereditary-Stieltjens-Duhamel-convolution integral

- The material “sleeps” if strain is constant but is “awakened” to its initial strength at every change of strain
- A material is characterized by the a time dependent modulus
- A dynamic system is characterized by the impulse response (IR)



3.99	0	2	0	0.11665		0.11665	0	0.145259	0	0.223026	0
4	0	1	-1	0.116484		0.116484	0	0.144808	0	0.221802	0
4.99	0	1	0	0.106125		0.106125	0	0.11665	0	0.145259	0



$$\text{Output} = \text{sum}(d_input * G_reset)$$

$$y(4) = x(0)G(4) + \Delta x(1)G(4-1) + \Delta x(2)G(4-2) + \Delta x(3)G(4-3)$$

$$y(t) = x(0) \cdot G(t) + \int_1^t dx(t') \cdot G(t-t') \Rightarrow \text{see sem96 p3.3} \Rightarrow$$

$$y(t) = x(t) \cdot G(0) + \int_1^t x(t') \cdot dG(t-t')$$

$$y(4) = x(4)G(0) + x(1)\Delta G(4-1) + x(2)\Delta G(4-2) + x(3)\Delta G(4-3)$$

$$\text{Output} = \text{sum}(d_input * G_reset)$$

$$y(4) = x(0)G(4) + \Delta x(1)G(4-1) + \Delta x(2)G(4-2) + \Delta x(3)G(4-3)$$

$$y(t) = x(0) \cdot G(t) + \int_1^t dx(t') \cdot G(t-t') \Rightarrow \text{see sem96 p3.3} \Rightarrow$$

$$y(t) = x(t) \cdot G(0) + \int_1^t x(t') \cdot dG(t-t')$$

$$y(4) = x(4)G(0) + x(1)\Delta G(4-1) + x(2)\Delta G(4-2) + x(3)\Delta G(4-3)$$

Convolution and correlation

- Convolutie—>eerst 1 signaal omklappen
- Correlation
- Beide hebben als x-as een verschuiving
- Bij elke verschuiving wordt de integraal (oppervlakte onder) van het product berekend

Sterad-srad

- Is the surface seen from certain point, projected on unit sphere
- Spherical surface = $4 \cdot \pi \cdot r^2$

$$\Omega = \iint_S \sin \theta \cdot d\theta \cdot d\varphi$$

$$\theta = \text{compl}(\text{breedtegraad})$$

$$\varphi = \text{lengtegraad}$$

Star pressure

- g =gravity at surface
- R =radius
- Earth
 - $g=10$
 - $R=6366 \cdot 10^3$
 - $sm=5000$
 - $p=3.2e11$ (Wiki $3.5e11$, 6000 K)
 - $staal E=2e11$
- Sun
 - $g=274$
 - $R=0.7e9$
 - $sm=1410$
 - $p=2.7e14$ (Wiki $2e16$, $15e6$ K te laag voor fusie $\rightarrow$ tunneleffect)
- Atm press= $100000=100$ Michellen op 1 m^2
- Note: $1 \text{ Pa}=1 \text{ J/m}^3$

$$dV = 4\pi r^2 dr$$

$$dm = sd \cdot dV$$

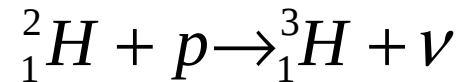
$$df = dm \cdot g \cdot \frac{r}{R}$$

$$dp = \frac{df}{4\pi r^2} = sd \cdot g \cdot \frac{r}{R} dr$$

$$p = sm \cdot g \cdot R$$

Thermofusion

2.9979245800E+08	<c			
1.6605390400E-27	<u (atomaire massa eenheid = 1/12 12C)			
6.6260701500E-34	<Planck			
1.6726231000E-27	<massa proton			
1.6749300000E-27	<massa neutron			
3.3444946327E-27	<kernmassa deuterium			
5.0082177560E-27	<kernmassa tritium			
5.0171177327E-27	>massa deuterium+proton			
8.8999766897E-30	>massaverlies			
7.9989001405E-13	>energie voor straling, bindingsenergie en k			
1.2071861540E+21	>frq (gamma begint bij 1e20)			



- Deuterium+proton → tritium+photon
- Bij het naderen: neg arbeid (afstoting), daarna pos arbeid (sterke wisselwerking), samen pos arbeid
- Diameter proton is 0.84e-15 (femtometer)
- Einstein Telescope 1e-22
- He-4 is 2p+2n
- He-3 is 2p+1n

Intensity of all stars (Newton)

$$dV = 4\pi r^2 dr$$

$$dA = sd \cdot dV$$

$$dI = dA \cdot I_0 / r^2 = 4\pi \cdot I_0 \cdot sd \cdot dr$$

$$I = 4\pi \cdot I_0 \cdot sd \int_0^{\infty} dr = \infty$$

- dV =volume of spherical shell at distance r
- $A=nr_stars$
- $sd=nr_stars/vol$ (*assumed constant*)
- I =star intensity $\sim 1/r^2$
- The number of stars increases with r^2 , intensity decreases with $r^2 \rightarrow$ total intensity per layer is independent of r , each layer adds a constant amount of intensity

U5

Slide 104

U5

G>light intensity distance--> $1/r^2$

Same for free field sound intensity (Beranek p93)

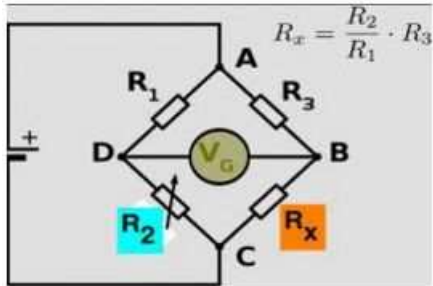
Free field SPL is $1/r$ (Ber p92)

Near field SPL is ??? (wavelengths not in phase)

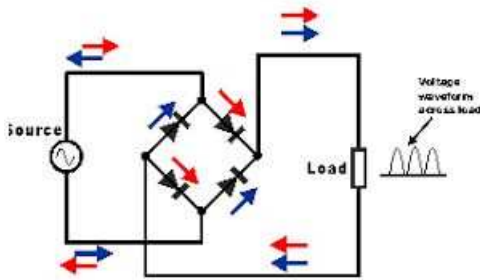
User, 1/18/2020

Wheatstone bridge

Bridge rectifier



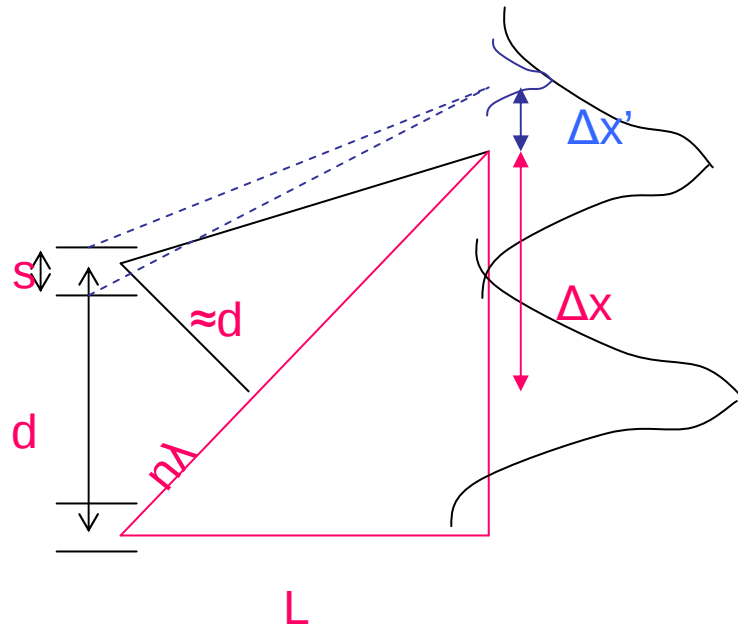
$$R_x \cdot R_1 = R_2 \cdot R_3$$



Velocity sound, mach, air

- Air at 300K, thermal velocity
 - Mean kin en = $3(kT/2)$
 - Kin en = $mv^2/2$
 - $m=1.67e-27*28$ (for N_2 atom nr 7)
 - $m=1.67e-27*32$ (for O_2 atom nr 8)
 - $v=515$ m/s (1854 km/h)(supersonic)
- Mach
 - Bernoulli: $p_0 = \rho v^2/2 \rightarrow v=406$ m/s (1460 km/h)
- Sound 343 m/s (1235 km/h)

Double slit



$$\frac{\lambda}{d} = \frac{\Delta x}{L}$$

$$\lambda = 500 \times 10^{-9}, d = 0.001, L = 1 \rightarrow \Delta x = 0.0005$$

$$\frac{\lambda}{s} = \frac{\Delta x'}{L}$$

Space travel

$$E = \frac{1}{2} m \cdot v^2$$

$$P = \dot{E} = m \cdot v \cdot \dot{v} = m \cdot t \cdot a^2 = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \cdot t \cdot a^2$$

[illegible]

0.34 m

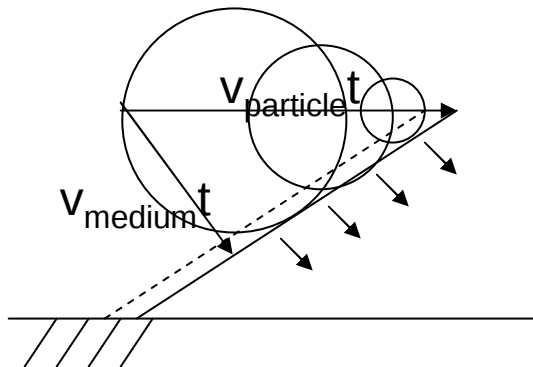
- Sound:
 - 1 ms for travel
 - 1000 Hz wavelength
- Photon
 - About 1 ns for travel (1M faster than sound)

Uit het Niets

	Heelal	Geld	Mens	Firma
Actief	Materie	Papiergeld		
Passief	Gravitatie	Kapitaal, reserves, winsten, goud	Evenbeeld God	
Regelaar		Rente		
Verliesmechanisme	Entropie	Niet-terugbetaalde schuld	Zonde	
	Inflatie	Inflatie		
Eindproduct	Informatie	Waarde		

Sonic boom etc vs wave vel

- Coherent front
- Tsjererkov: Deeltjes die sneller bewegen dan fasesnelheid van het licht in dit medium
 - Het medium is bv. water
 - Electron is het "vliegtuig"
 - Foton is het geluid
 - Boom is de Tsjererkov lichtflits (weerom de vraag: is het eenmalig of continu, en hoort mijn buurman mijn boom of een nieuwe boom)
- Boot die sneller beweegt dan de golfsnelheid in water???
- Vliegtuig dat sneller beweegt dan de geluidssnelheid in lucht
 - Continuous unrolling carpet of booms (bevestigd in krant 24jun23), effect deminishes if plane has high altitude
 - Rocket has vertical cone, is 10 km high as it starts
 - Both front (+) and back (-) 50-500 Pa → N-wave double boom)
 - 1000 km/h is 280 m/s. Critical speed is 1225 km/h or 340 m/s (=sound velocity)
 - Bernouilli: dynamic pressure front= atm pressure back (De Bock p 159) (at front there is no pressure because particles can not bounce back)
 - Thermal velocity air particles at 20 C
- Australian bullwhip
- Neutrino's in ice (Askaryan effect, ANITA balloon)



$$v = \sqrt{\frac{200000}{1.21}} = 400$$

$$v = \sqrt{\frac{k_B \cdot T}{m_{particle}}} = 464$$

Phase > group velocity

Wiki > Voortplantingssnelheid, Boeckaert p341

$$u = \int_{-\infty}^{\infty} A \exp[i(\omega t - kx)]$$

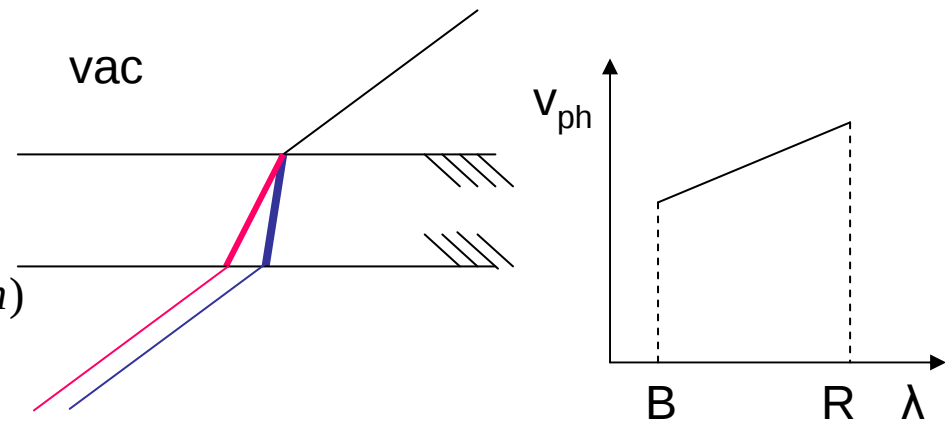
$$v = \frac{\omega}{k} = \frac{x}{t} \text{ (medium velocity)}$$

$$v_{ph} = \frac{\omega'}{k'} \text{ (dominant freq in spectrum)}$$

$$v_g = \frac{\partial \omega}{\partial k}$$

$$v_g = v_{ph} - \lambda \frac{dv_{ph}}{d\lambda}$$

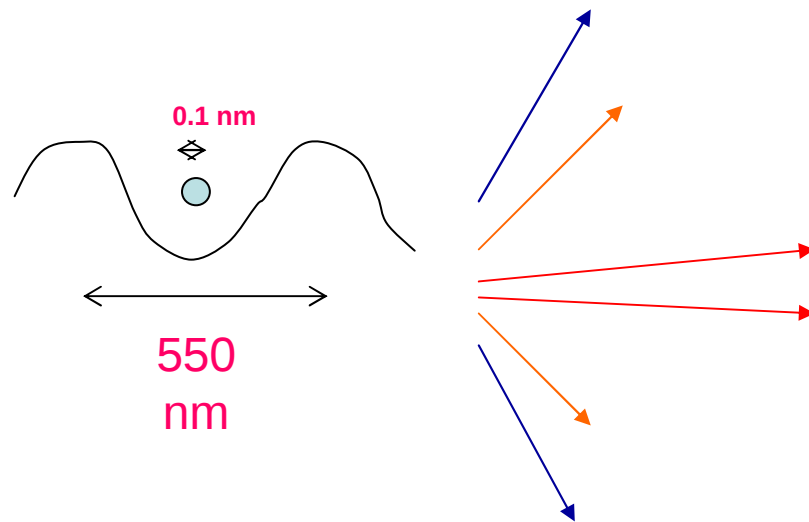
Nog toevoegen: group delay,
fase snelheid = medium vel?



ROGGBIV dispersion $v(\lambda)$, R
at the outside, R evening
color, biggest wavelength
and phase vel

$$\frac{\sin \vartheta_1}{\sin \vartheta_2} = n = \frac{c_{ph}}{v_{ph}} = \sqrt{\epsilon_r \mu_r}$$

Rayleigh scattering



Waarom is de hemel blauw?

Rayleigh scattering on molecules $\sim \text{freq}^4 \sim \text{dist}^{-2} \sim \text{diam}^6$

Als het witte zonlicht invalt op de minuscule lichtdeeltjes van onze dampkring, wordt dat licht in zekere mate verstrooid in alle richtingen. Die verstrooiing van het licht is afhankelijk van de golflengte. Licht van een kleinere golflengte wordt beter verstrooid dan licht van een langere golflengte. En blauw heeft een kleinere golflengte dan bijvoorbeeld groen of rood. "Het blauwe licht wordt dus het best verstrooid, rood het minst van allemaal", aldus Deboosere. "Het resultaat: de hemel kleurt hemelsblauw." Net daarom zien we het witte zonlicht op aarde ook als geel. "Het blauw is verstrooid, het witte zonlicht is dus een beetje van zijn kleur kwijtgeraakt. En wit min blauw is gelijk aan geel." Om het met de woorden van Will Tura te zingen: "Blauw, zo hemelsblauw, in gouden zonneschijn"

Op Mars is de "lucht" (voornamelijk CO₂ op 6360 Pa) ijler en dus minder verstrooiing van het blauw → bruine lucht.

Rode zon 's morgens en 's avonds: zonlicht legt grotere afstand af, dus nog meer verstrooiing van blauw (wiki)

- Dit geldt ook voor lange geluidsgoven door de bladeren

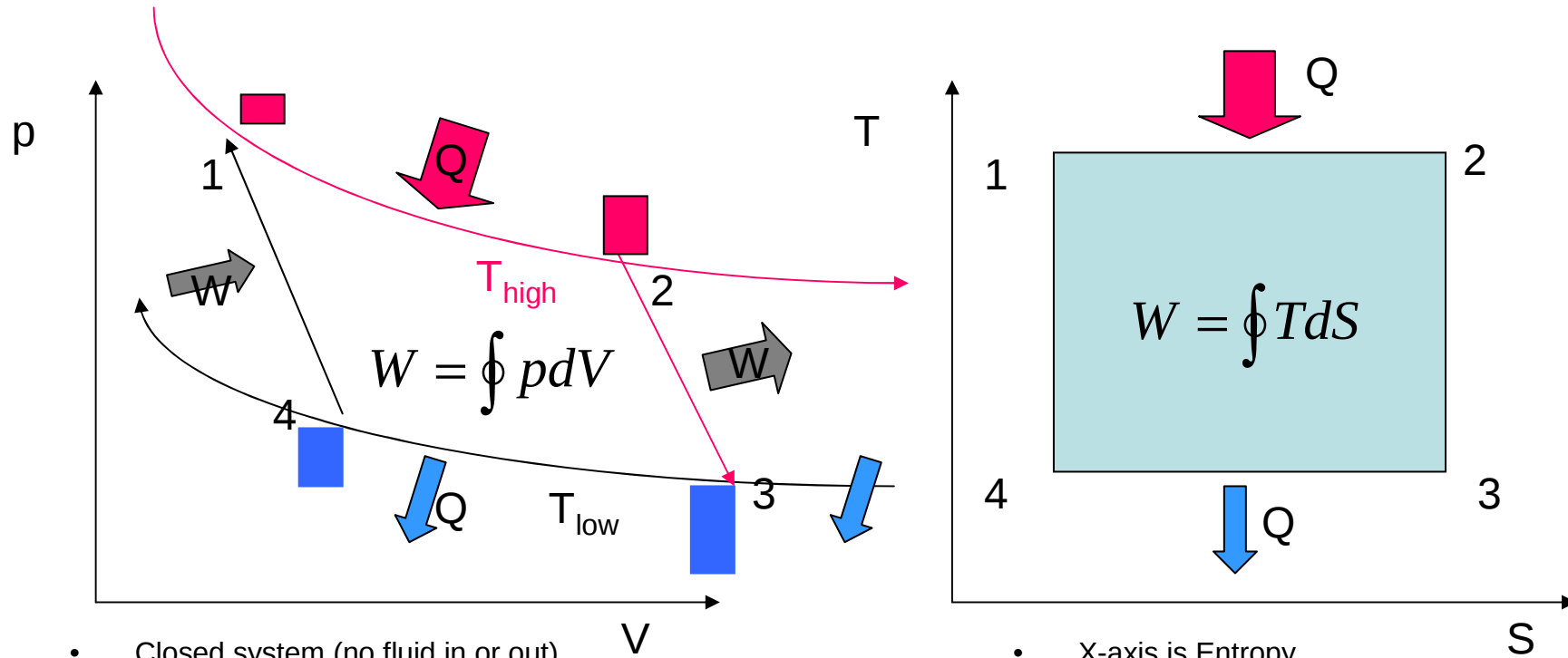
Thermodynamics

Entropy [J/K]= Energy inflation

- Zeroth law:
 - T is state (or intensity, not dependent on mass) variable
 - or thermal equilibrium between systems is transitive
 - “you must play the game”
- First law: conservation of energy
 - “You cannot win”
$$\delta Q = \delta W + dU \quad (U = \text{internal energy})(1st \text{ law})$$
- Second:
 - S is also state variable
 - direction of energy, 2 systems with different T or p have propensity to average in proportion to their mass producing work
 - “you can’t break even” (quite spelen)
$$\oint dS = \oint \frac{dq_{rev}}{T} \leq 0 \quad (0 \text{ is reversible})(Clausius inequality) \quad \left[\frac{J}{K}\right]$$

$$\dot{S} \geq 0 \quad (2nd \text{ law})$$
- Third
 - Entropy at T=0 is infinite
 - “you can’t quit”
- Big Bang entropy ≈ 0

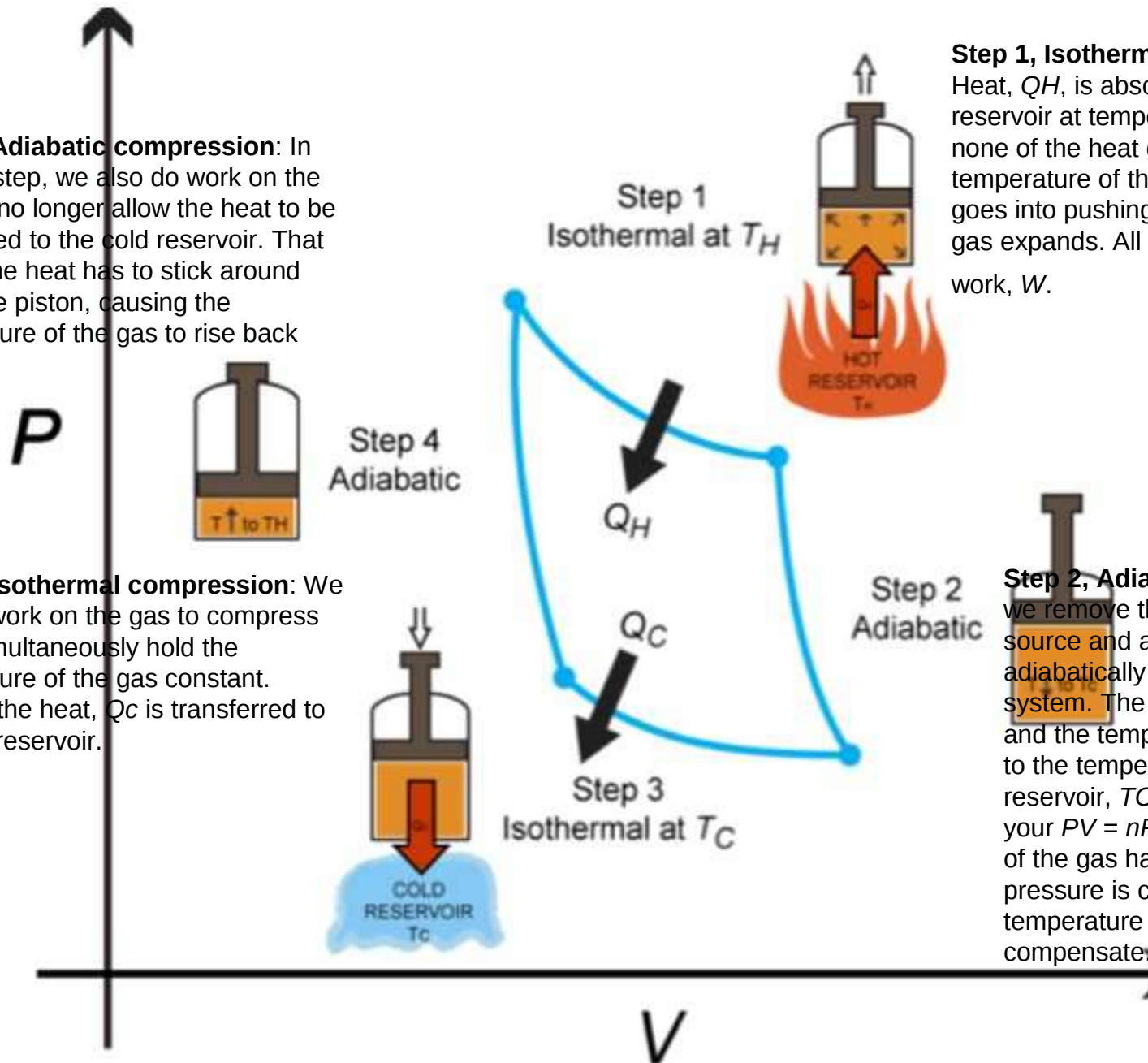
Steam engine-Carnot cycle



- Closed system (no fluid in or out)
- Start at 1
- Horizontal is isotherm (hyperbolic law Boyle-Mariotte)
- Vertical is adiabatic (isotherm=constant entropy)
- Steam Efficiency = $1 - T_{K_{low}}/T_{K_{high}} = 0.3$ ($177 \rightarrow 27$ C)
- Compressor and heat pump are reversed Carnot
 - Start at $3 > 2 > 1 > 4$, all flows reversed, throttling left, compressor right

Step 4, Adiabatic compression: In the last step, we also do work on the gas, but no longer allow the heat to be transferred to the cold reservoir. That means the heat has to stick around inside the piston, causing the temperature of the gas to rise back to T_H .

Step 3, Isothermal compression: We now do work on the gas to compress it but simultaneously hold the temperature of the gas constant. Instead, the heat, Q_C , is transferred to the cold reservoir.



Step 1, Isothermal Expansion:

Heat, Q_H , is absorbed from the hot reservoir at temperature T_H . Because none of the heat goes into changing the temperature of the gas, all of the heat goes into pushing the piston up as the gas expands. All of Q_H is turned into work, W .

Step 2, Adiabatic Expansion: Now we remove the hot reservoir heat source and allow the gas to expand adiabatically with no heat added to the system. The gas continues to expand, and the temperature of the gas drops to the temperature of the cold reservoir, T_C . Remember your $PV = nRT$ training; if the volume of the gas has expanded, and the pressure is constant, then the temperature has to drop to compensate.

Wind turbine

Lagrange La Moindre Action

- Multipliers ??? Nog te doen
- Eq of motion U11
 - Springs k_1 and k_2 , block m and J in Z
 - Generalized coordinates x and φ

$$T = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} I \dot{\varphi}^2 \Rightarrow \frac{\partial T}{\partial \dot{x}}, \frac{\partial T}{\partial \dot{\varphi}}, \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{x}} \right), \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{\varphi}} \right)$$

$$U = \frac{1}{2} (k_1 x_1^2 + k_2 x_2^2) = \frac{1}{2} (k_1 (x - a_1 \varphi)^2 + k_2 (x + a_2 \varphi)^2) \Rightarrow \frac{\partial U}{\partial x}, \frac{\partial U}{\partial \varphi}$$

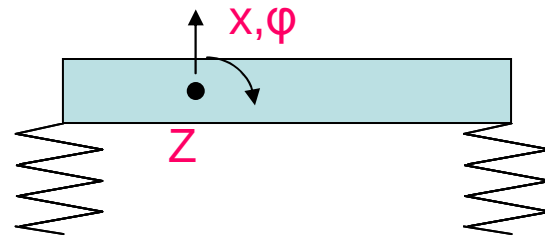
$$m\ddot{x} + kx = f = 0 \text{ [N, 0 for eigenfrq]}$$

$$\Rightarrow \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{x}} \right) + \frac{\partial U}{\partial x} = 0$$

$$\Rightarrow \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{\varphi}} \right) + \frac{\partial U}{\partial \varphi} = 0$$

multiply by $-s^2$ for frq domain gives eigenfrqs

- Lagrangian = kin – pot en
- When are you on top of mountain
- Variation principle see wiki kettinglijn, nog te doen



Slide 118

U11

Zie map tools-TD-basicmeshlib>Koster

User, 7/7/2020

Glass temper

Newton-Planck-Einstein-de Broglie-Schrödinger

$$\frac{1}{2m} p^2 + V = E$$

$$\Psi = e^{i(kx - \omega t)} \quad (k = 2\pi / \lambda = \omega / c \quad \omega = 2\pi \cdot f) \quad [\Psi] = [-]$$

k =circular wavelength ω =circular frq

$$\frac{\partial^2 \Psi}{\partial x^2} = -k^2 \Psi \quad \frac{\partial \Psi}{\partial t} = -i\omega \Psi$$

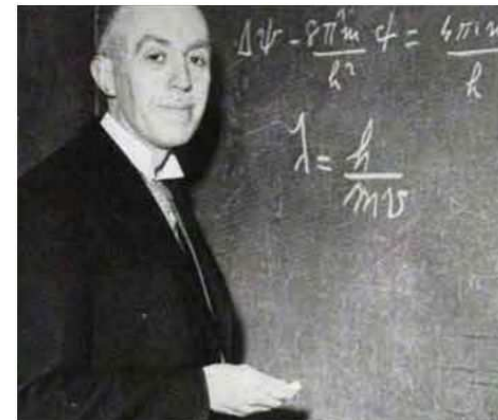
$$E_q = \hbar \cdot \omega = m \cdot c^2 = p \cdot c \quad (\hbar = 1.05 \cdot 10^{-34} \text{ [Nms]}) \Rightarrow p = \hbar \frac{\omega}{c} = \hbar \cdot k \text{ (Broglie) ("pishoek")}$$

$$\frac{1}{2m} p^2 \Psi + V \Psi = E \Psi \quad [J]$$

$$\frac{1}{2m} \hbar^2 \underline{k^2} \Psi + V \Psi = \hbar \underline{\omega} \Psi$$

$$-\frac{\hbar^2}{2m} \frac{\partial^2 \Psi}{\partial x^2} + V \Psi = -\frac{\hbar}{i} \frac{\partial \Psi}{\partial t}$$

$$H \Psi = i \hbar \dot{\Psi} \quad [\text{grafschrijf Schrödinger in Dublin}]$$



QM Time dependent Schrödinger

Start met $E = \hbar\omega$, $\omega \sim 1$ maal differentieren naar t en $-i$ compenseren

Zie ook Boeckeaert Golfmechanica p33

Note : $[\hbar] = Js$ $[\frac{\hbar}{m}] = \frac{m^2}{s} \text{ (Diffus)}$

$$\left(-\frac{\hbar^2}{2m_{rel}} \nabla^2 + V \right) \Psi = \frac{\hbar}{-i} \frac{\partial}{\partial t} \Psi$$

$$\frac{\hbar}{2im} \nabla \cdot (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*) + \frac{\partial}{\partial t} (\Psi^*, \Psi) = 0 \Rightarrow \text{continuity} \quad eq \quad p33 b$$

$$\frac{\hbar}{2im} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*) = \text{prob dens current} \quad \left[\frac{1}{s} \right]$$

$$\text{for } \Psi = Ae^{ikx} e^{-i\omega t} \quad s = \frac{\hbar k}{m} |A|^2$$

$$\text{for } \Psi = (Ae^{ikx} + Be^{-ikx}) e^{-i\omega t} \quad s = \frac{\hbar k}{2m} (|A|^2 - |B|^2)$$

Change of probability density = probability density current

QM Schroedinger (Olaf Verbeke)

Start met $p^2/2m$, vul in $p=\hbar k$, $k \sim 2$ maal differentieren naar x en -1 compenseren

$$\text{Energy photon} = p_{rel}c = h\nu \Rightarrow p_{rel} = \frac{h}{\lambda} = \hbar k \quad (h\nu = mc^2 \text{ does not work } m = \frac{0}{0})$$

$$\frac{1}{2m} p^2 + \frac{k}{2} x^2 = E \quad (\text{CM total energy harmonic oscillator, Bouck 24b})$$

$$\text{Multiply by } \Psi = \exp(ikx) = \exp(i \frac{p_{rel}}{\hbar} x)$$

$$\frac{\partial \Psi}{\partial x} = \Psi \cdot i \frac{p_{rel}}{\hbar}$$

$$\frac{\partial^2 \Psi}{\partial x^2} = \frac{\partial \Psi}{\partial x} \cdot i \frac{p_{rel}}{\hbar} = -\Psi \frac{p_{rel}^2}{\hbar^2} \frac{2m_{rel}}{2m_{rel}} \Rightarrow -\frac{\hbar^2}{2m_{rel}} \frac{\partial^2 \Psi}{\partial x^2} = \frac{p_{rel}^2}{2m_{rel}} \Psi$$

$$\left(-\frac{\hbar^2}{2m_{rel}} \nabla^2 + \frac{k}{2} x^2 \right) \Psi_n = E_n \Psi \quad (\text{QM total energy})$$

Psi kan een in de ruimte geconcentreerd golfpakketje zijn

QM Wave equation

$$\frac{\partial}{\partial x} \rightarrow ik \quad \frac{\partial}{\partial t} \rightarrow -i\omega$$

$$p = \hbar k \quad E = \hbar \omega$$

$$p = \frac{\hbar}{i} \frac{\partial}{\partial x} \quad E = \frac{\hbar}{-i} \frac{\partial}{\partial t}$$

$$\frac{1}{2m} p^2 = -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2}$$

Relativistic energy

$$m_{rel}^2 = m_{rest}^2 \gamma^2 \text{ with } \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \geq 1$$

$$(1 - \frac{v^2}{c^2}) m_{rel}^2 c^4 = m_{rest}^2 c^4$$

$$m_{rel}^2 c^4 - v^2 m_{rel}^2 c^2 = m_{rest}^2 c^4$$

$$m_{rel}^2 c^4 = p_{rel}^2 c^2 + m_{rest}^2 c^4 \quad (/ G > \text{photon mass})$$

$$\text{low } v : m_{rel} c^2 = m_{rest} c^2$$

$$\text{photon} : m_{rel} c^2 = p_{rel} c$$

QM operators

- Is measurement if applied to vector
- Represented by matrix
- Solve matrix product for eigenvalue (subtract from diagonal elements)
- Eigenvalue is result of measurement on vector
- Eigenfunctions are normal

$$\text{Expect value of } A = \frac{(\Psi, A\Psi)}{(\Psi, \Psi)} = \frac{\iiint \Psi^* A\Psi \, dx dy dz}{\iiint \Psi^* \Psi \, dx dy dz}$$

$$\text{Position meas : } x \cdot \Psi = \xi \Psi \Rightarrow \xi \text{ is eigenvalue of } \Psi = \delta(x - \xi)$$

$$\text{Momentum meas : } \frac{\hbar}{i} \frac{\partial}{\partial x} \Psi = p_x \Psi \Rightarrow p_x \text{ is eigenvalue of } \Psi = e^{i(\frac{p_x}{\hbar}x)}$$

$$\text{Energy meas : } -\frac{\hbar}{i} \frac{\partial}{\partial t} \Psi = E \Psi \Rightarrow E \text{ is eigenvalue of } \Psi = e^{-i(\frac{E}{\hbar}t)}$$

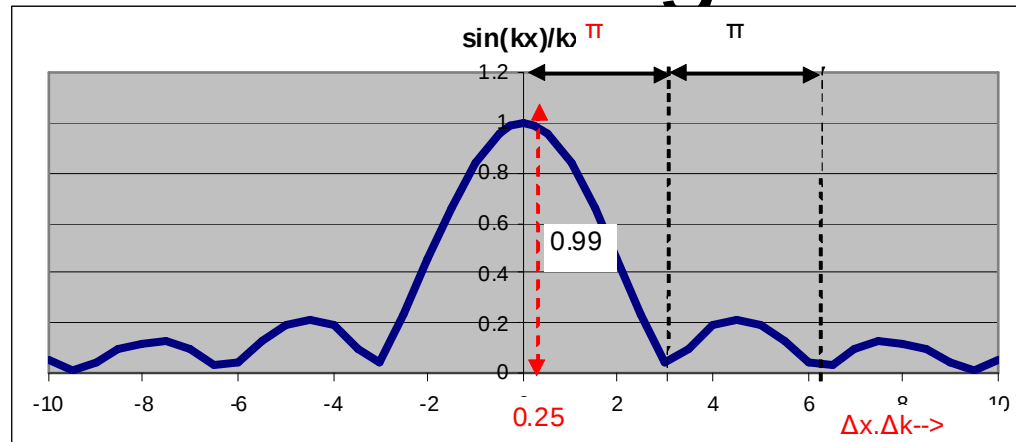
The C14 (Carbon) dating

- Zou normaal al lang moeten verdwenen zijn op aarde, ook uit steenkool
- Wordt gevormd uit N₂ en kosmische straling (neemt toe) en opgenomen in het lichaam via fotosynthese
- Calibratie d.m.v. Jaarringen tot meer dan 10000 jaar
- Halveringstijd 5736 jaar
- Comparison of degrading C14 to degrading C12
- Actual limit is 50000 y
- Alternative: Uranium>Thorium(>radium>lood)
- Ouderdom aarde-zonnestelsel uit isotopische loodsamenstelling van gesteenten en meteorieten geven hetzelfde resultaat
- Radiactiviteit houdt de aarde warm

The atmosphere warming-up

1 mol lucht bevat A (Avogadro 6.0×10^{23}) moleculen met 3 VG. De energie inhoud is $(3/2)A \cdot k \cdot T$					
Hiervan zijn p (400 ppm) moleculen CO ₂ met 5 extra VG. De extra energieinhoud is $(5/2) \cdot p \cdot A \cdot k \cdot T$					
De energieinhoudstoename is $5 \cdot p / 3 = 0.00066$					
De toename van de temperatuur is $300 \cdot$ het voorgaande of 0.2K					

Fourier-Heisenberg-sinc=sinx/x



Source [Sincardinalis.xls](#)

Accurate measurement must be within 0.99
dx.dk is then within 0.25+/-
spread is 1/2

Spread of $\Delta x \cdot \Delta k$:

Math: $\Delta x \cdot \Delta k = 2\pi$

FFT: $\Delta T \cdot \Delta \omega = 2\pi$ or $\Delta f = 1/\Delta T$

QM: $\Delta x \cdot \Delta p = h$

If spread $\geq 1/2$: $\Delta x \cdot \Delta p \geq \hbar/2$ (H)

$$\text{Number of tops} \leq \frac{\Delta x}{\lambda}$$

Take differential both sides and mult by 2π

$$2\pi \leq x \cdot \Delta \left(\frac{2\pi}{\lambda} \right) = \Delta x \cdot \Delta k$$

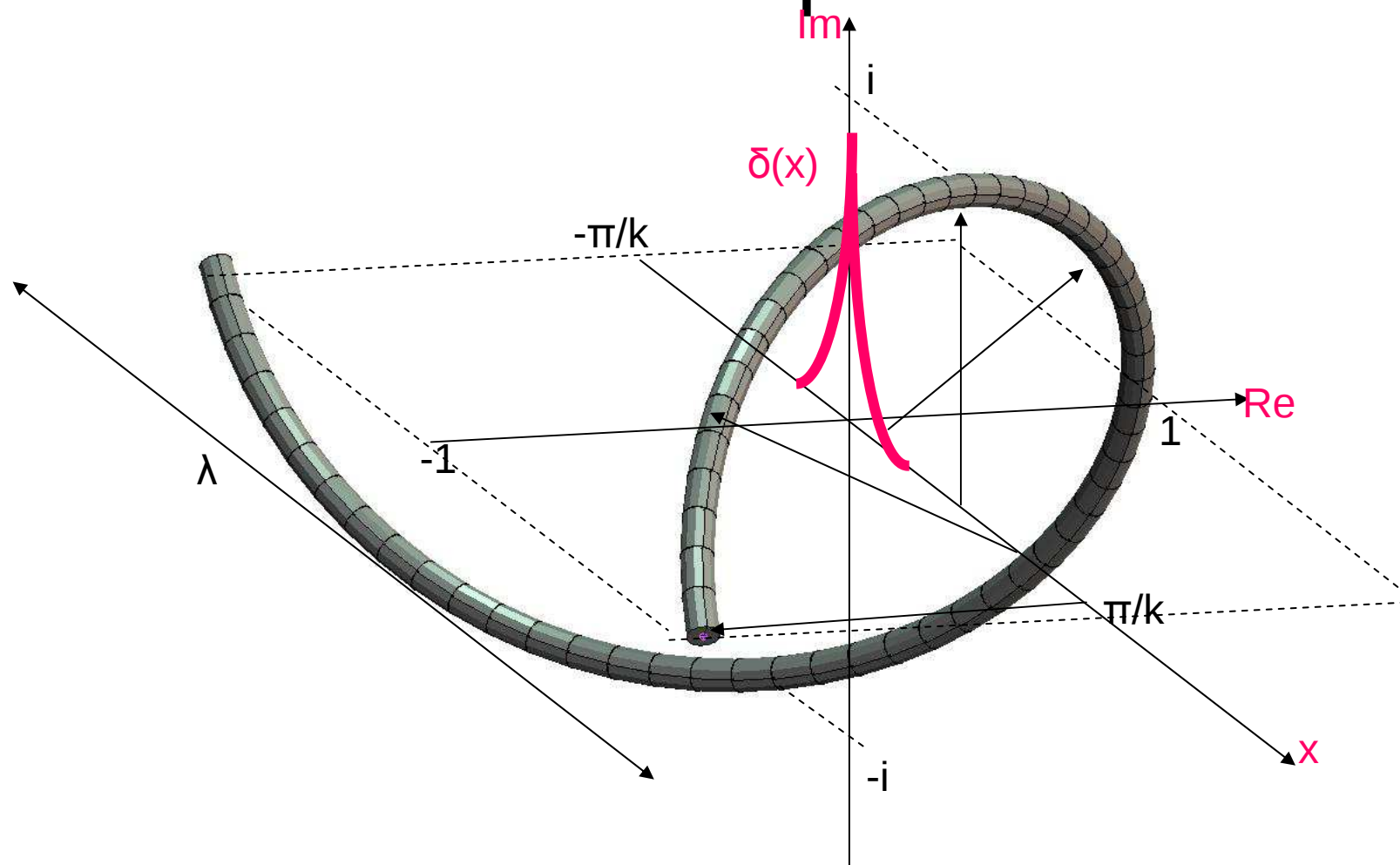
For QM substitute k by $\frac{p}{\hbar}$

$$\Delta x \cdot \Delta p \geq h$$

Fourier transform

Math	$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left(\int_{-\infty}^{\infty} f(x) e^{-ikx} dx \right) e^{ikx} dk$	Truncation interval= Δx $\Delta x \cdot \Delta k \approx 2\pi$ $k = \frac{2\pi}{\text{periodlength}}$	Symmetry properties see Recipes423	Truncation=convolu tion with $\sin x/x$ $k = \text{nr of "tops" in } \Delta x$ $k = \Delta x/\lambda$
CM	$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left(\int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt \right) e^{i\omega t} d\omega$	Truncation interval= Δt $\Delta t \cdot \Delta \omega \approx 2\pi$	$x \rightarrow t$ $k \rightarrow \omega$	
QM	$\Psi(x,0) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left(\int_{-\infty}^{\infty} \Psi(x,0) e^{-ikx} dx \right) e^{ikx} dk$	Truncation interval= Δx $k = \frac{2\pi}{\lambda} = \frac{2\pi}{h/p_x} = \frac{p_x}{\hbar}$ $\Delta x \cdot \Delta p_x \approx h$	$x \rightarrow x$ $k \rightarrow \frac{p_x}{\hbar} \rightarrow$ $\frac{1}{i} \frac{\partial}{\partial x} \text{ or } \frac{1}{-i} \frac{\partial}{\partial t}$	$\omega = 2\pi\nu \frac{h}{h} = \frac{E}{\hbar}$
IM	$x(n) = \frac{1}{N} \sum_{m=0}^{N-1} \left(\sum_{n=0}^{N-1} x(n) e^{-j\frac{2\pi}{N}mn} \right) e^{j\frac{2\pi}{N}mn}$	Truncation interval= T $T \cdot \Delta \omega \approx 2\pi$ $\Delta t \cdot f_s \approx 1$	$x \rightarrow \sqrt{\frac{2\pi}{N}} n$ $k \rightarrow \sqrt{\frac{2\pi}{N}} m$	Discretisation $\rightarrow$ peri odicity Truncation $\rightarrow$ leakag e

Fourier spinor e^{ikx}



$k = nr$ of turns in π [1/m]

Fourier integral

Volgt uit kleinste kwadraat benadering van $f(t)$ met spinor weegfunctie

$$w_k = \frac{1}{\sqrt{2\pi}} e^{ikx} \text{ spinor weight function orthogonal normalized } \int_{-\pi}^{\pi} w_k^*(x) \cdot w_l(x) dx = \delta_{kl}$$

$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left(\int_{-\infty}^{\infty} f(x) e^{-ikx} dx \right) e^{ikx} dk$$

Toegepast op delta functie

$$\delta(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left(\int_{-\infty}^{\infty} \delta(x) e^{-ikx} dx \right) e^{ikx} dk = \frac{1}{2\pi} \int_{-\infty}^{\infty} (1) e^{ikx} dk$$

Goedel-Heisenberg

The end of rationality:

- Heisenberg uncertainty (indeterminacy)
- Gödel incompleteness

Reason: human information is between

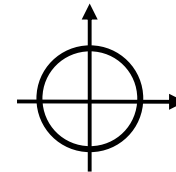
- Finiteness of universe
- Finiteness of continuity

Spinor, complex i mixed with j

Rayleigh-Huyghens integral for 2 elements with acceleration a and a' and with j convention. Switching acoustic spinor to i convention: set
Zelfde d met versch fase en versch d met zelfde fase-->im factor heeft geen invloed

[illegible]

- $kx - \omega t$ of $\omega t - kx$ lopende golf, leiden beide tot $v = \lambda \cdot f$ of $x = v \cdot t$
- Conventie (1): $i(kx - \omega t) = i kx + j \omega t =$
 - Bouckaert lopende golf (p248)
 - Bouckaert Wisk Nat electrotechniek p150 $i < \rightarrow j$
 - Ad vd Enden Fourier (p38) $\rightarrow -i \omega t$
 - Recipes FFT wsl $-i \omega t$ (zie EPSI hieronder)
 - QM $\rightarrow i(kx - \omega t)$
 - Bij constante x draait de fasehoek in de negatieve zin (clock-wise)
- Conventie (2): $i(\omega t - kx)$
 - Ansys en MARC $\rightarrow +i \omega t$
 - URAY $\rightarrow -i k d$ (Kaizer gebruikte $-j k d$)
 - Skudrzyk $\rightarrow -j k r = -i k r$ (p18 zijn $j = i$, en 496)
 - Bouckaert Fourier (p7) $\rightarrow -i k x$
 - Recipes Fourier (p423) $\rightarrow +i \omega t$
 - Kaizer (p43)
 - Elektrische netwerken $\rightarrow +i \omega t$
 - EPSI (mijn netwerkformules zijn conventie (2), echter ik moest $j = -i$ zetten om Recipes FFT te kunnen gebruiken)
- Omkeren van de fasehoek doe je door het imaginair deel om te keren (de tijd wordt dan omgekeerd)
 - Gebruik $i = (0, 1)$ voor cw en $j = (0, -1)$ voor ccw
 - Complexe vogelpik: om gemakkelijk complexe getallen te begrijpen
- Combineren FEM (+ $i \omega t$) met Rayleigh van Kaizer: $e^{i \omega t} e^{-j k x} = e^{i \omega t} e^{i k x}$ Corrigeren door dit te vermenigvuldigen met $e^{-i 2 k x}$

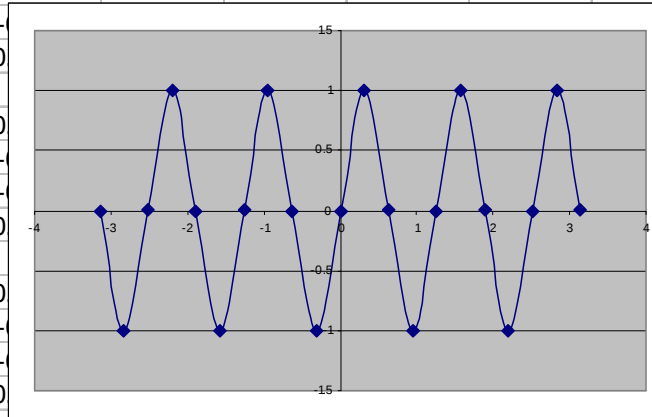


Kaizer

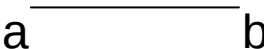
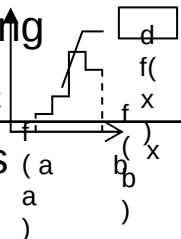
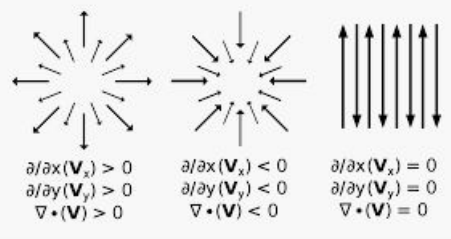
[illegible]

Spinor orthogonality

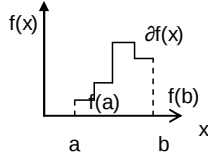
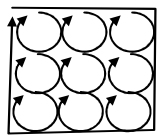
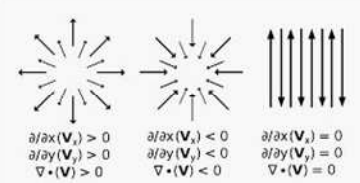
Cfr Bouckaert Golfmechanica p6 orthogonaliteit spinor (voor indexen k en l om geen verwarring te hebben met im getal i)									
Nota: bij sommige waarden van k of l is de berekening niet juist, bv. k=0 en l=100 (voor k=0 zou het resultaat steeds nul moeten zijn)									
Rechts staat enkel sin(kx), men ziet dat k=aantal perioden binnen het interval 2pi of k=2pi/periodelengte									
5 < k									
1 < l									
3.141593 < pi									
	x	exp(-ikx)	exp(ikx)	improduct	imreal	imaginary	cum sum r	cum sum im	sin(kx)
-1	-3.14159	-1+6.1257i	-1-1.2251i	1-4.90059i	1	-4.9E-16	0	0	-6.1E-16
-0.9	-2.82743	5.5131680i	-0.951056i	0.3090169	0.309017	-0.95106	0.097081	-0.29878	-1
-0.8	-2.51327	1-4.90059i	-0.809016i	-0.809016	-0.80902	-0.58779	-0.15708	-0.48344	4.9E-16
-0.7	-2.19911	-4.288019i	-0.587785i	-0.809016	-				1
-0.6	-1.88496	-1+3.6754i	-0.309016i	0.3090169	0				-3.7E-16
-0.5	-1.5708	3.0628711i	6.1257422i	1-2.45029i					-1
-0.4	-1.25664	1-2.45029i	0.3090169	0.3090169	0				2.45E-16
-0.3	-0.94248	-1.837722i	0.5877852i	-0.809016i	-				1
-0.2	-0.62832	-1+1.2251i	0.8090169i	-0.809016i	-				-1.2E-16
-0.1	-0.31416	6.1257422i	0.9510565i	0.3090169	0				-1
0	0	1	1	1					0
0.1	0.314159	6.1257422i	0.9510565i	0.3090169	0				1
0.2	0.628319	-1-1.2251i	0.8090169i	-0.809016i	-				1.23E-16
0.3	0.942478	-1.837722i	0.5877852i	-0.809016i	-				-1
0.4	1.256637	1+2.45029i	0.3090169i	0.3090169	0				-2.5E-16
0.5	1.570796	3.0628711i	6.1257422i	1+2.45029i	1	2.45E-16	0	7.7E-17	1
0.6	1.884956	-1-3.6754i	-0.309016i	0.3090169	0.309017	-0.95106	0.097081	-0.29878	3.68E-16
0.7	2.199115	-4.288019i	-0.587785i	-0.809016i	-0.80902	-0.58779	-0.15708	-0.48344	-1
0.8	2.513274	1+4.90059i	-0.809016i	-0.809016i	-0.80902	0.587785	-0.41124	-0.29878	-4.9E-16
0.9	2.827433	5.5131680i	-0.951056i	0.3090169	0.309017	0.951057	-0.31416	0	1
1	3.141593	-1-6.1257i	-1+1.2251i	1+4.90059i	1	4.9E-16	0	1.54E-16	6.13E-16



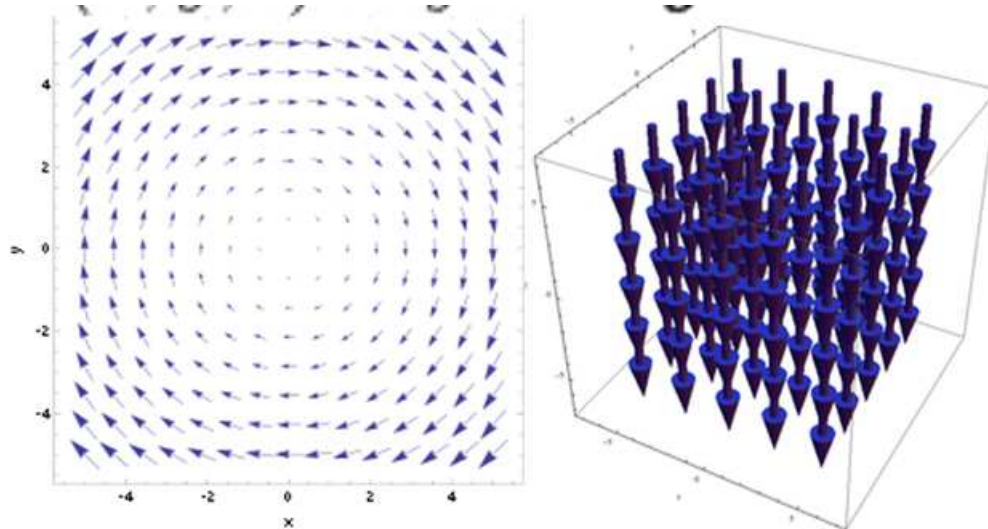
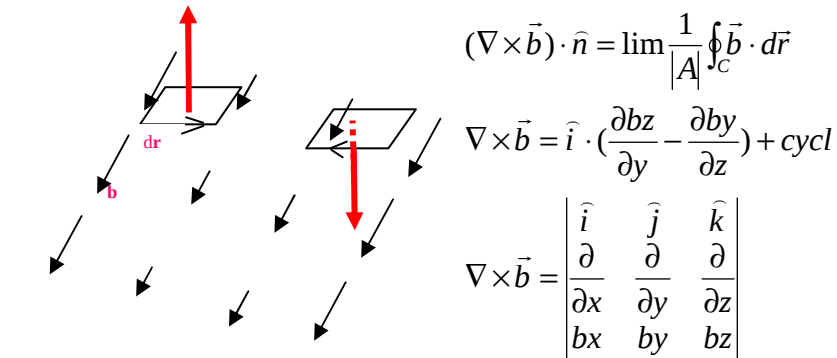
Integral

	Flux		
$\int_a^b \frac{\partial f(x)}{\partial x} dx = \int_a^b \partial f(x)$	$f(b) - f(a)$		De Moivre Gradientstelling The stairs 
$\iint_S \nabla \times \vec{a} \cdot d\vec{S}$	$\oint_C \vec{a} \cdot d\vec{s}$		Kelvin-Stokes The vortex
$\iiint_V \nabla \cdot \vec{a} \cdot dV$	$\iint_S \vec{a} \cdot d\vec{S}$		Gauss-Green-Ostrogradsky Divergentiestelling "Divergence" 

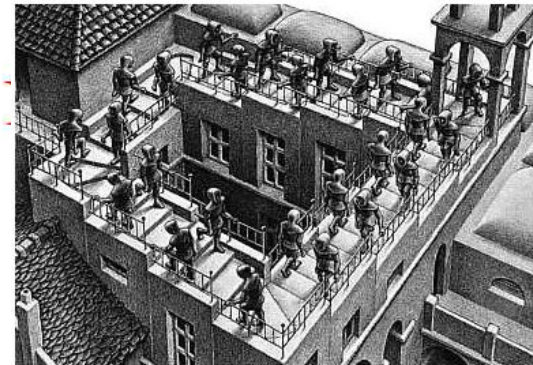
Integral 2

Name	Formula left	Formula right	Pic
De Moivre	$\int_a^b \frac{\partial f(x)}{\partial x} dx = \int_a^b \partial f(x)$	$f(b) - f(a)$	 Add all steps or take 1 giant step = Newton "flux"
Stokes	$\iint_S \nabla \times \vec{a} \cdot d\vec{S}$	$\oint_C \vec{a} \cdot d\vec{s}$	 Add only external paths, internal cancel
Gauss-Green-Ostrogradsky	$\iiint_V \nabla \cdot \vec{a} \cdot dV$	$\iint_S \vec{a} \cdot d\vec{S}$	 Divergence = "outgoingness" Note: S must contain some source or sink, otherwise it is zero because (wiki)
Adding 1 "normal" dimension requires 1 extra derivative			
Holography	Illumination beam - reference beam	Hologram (add reference beam to go back)	
(De)Correlation			
DSP			
Er zijn extra onzichtbare kolommen			

Rotation (kolk)



- Zie wiki curl mathematics
- Path (=contour) lies in the plane of the vectors
- unity vector (blue) refers to direction of path (screwdriver's rule)
- all b vectors equal $\rightarrow \text{curl}=0$
- left curl: pos inner product dominates, if you reverse contour dir, neg inner product dominates, but unity vector is also reversed, hence direction of red vector does not depend on path direction. Draai kurketrekker van grote naar kleine b , dan is het altijd goed
- $\text{div rot } b = 0$ intuitive 2D: div is dot product of 2 perp vectors
- $\text{rot grad } b = 0$ Intuitive: lemmings, no Escher stair, no perpetuum mobile, block on frictionless surface will not slide to lower around without spinning



Gauss Green Stokes Newton Leibniz

All scalars. Left is flux, right is divergence

Influx (Newton, out – in) = accumulation

S = scalar, V = vector, ∇ = vector

$$\iint \vec{V} \cdot d\vec{S} = \iiint (\nabla \cdot \vec{V}) dV$$

Gauss gravity law : $\vec{V} \rightarrow \vec{g}$

$$\iint \vec{g} \cdot d\vec{S} = \iiint (\nabla \cdot \vec{g}) dV = 4\pi GM \quad (M = \text{mass enclosed}) \left[\frac{Nm^2}{kg} = \frac{m^3}{s^2} \right]$$

$$\Rightarrow g(r < R) = \frac{4\pi G \rho}{3} r \quad (\text{spring!}) \quad g(r \geq R) = G \frac{M}{r^2}$$

Coulomb charge law : $\vec{V} \rightarrow \vec{D}$ (displ. current) or E (Electric field)

$$\iint \vec{D} \cdot d\vec{S} = \iiint (\nabla \cdot \vec{D}) dV = \iiint \sigma \cdot dV (= \text{FREE charges enclosed}) [Q]$$

$$\iint \vec{E} \cdot d\vec{S} = \iiint (\nabla \cdot \vec{E}) dV = \iiint \sigma \cdot dV (= \text{ALL charges enclosed}) ???$$

Kelvin – Stokes generalization : only outer curls add, internal curls cancel :

$$\oint \vec{V} \cdot d\vec{r} = \iint (\nabla \times \vec{V}) \cdot d\vec{S}$$

Is generalization of Fundamental Theorem of calculus $F(b) - F(a) = \int_a^b \frac{\partial F}{\partial x} dx$

• Divergence Theorem (Lagrange Green Gauss Ostrogradski conservation, continuity)

• Note : div maakt van vector een scalar, gradient maakt van een scalar een vector

• Gauss: gravitatie wet wordt niet bewezen, het is een wet (de inclusiewet)

• Newton gebruikte het (correcte) woord "flux"

Vector

$$\vec{a} \bullet \vec{b} = ax \cdot bx + ay \cdot by = a \cdot b \cdot \cos() \quad \text{dot or in product}$$

$$\vec{a} \times \vec{b} = \hat{i} \cdot (ay \cdot bz - az \cdot by) + \text{cycl} \quad |\vec{a} \times \vec{b}| = a \cdot b \cdot \sin() \quad \text{cross or out product}$$

$$(\nabla \times \vec{b}) \cdot \hat{n} = \lim_{|A| \rightarrow 0} \frac{1}{|A|} \oint_C \vec{b} \cdot d\vec{r} = \nabla \times \vec{b} = \hat{i} \cdot \left(\frac{\partial}{\partial y} bz - \frac{\partial}{\partial z} by \right) + \text{cycl} \quad C \text{ is inplane}$$



$$\text{div} \vec{V} = \nabla \cdot \vec{V} = \frac{\partial V_x}{\partial x} + \text{cycl}$$

$$\text{grad} S = \nabla S = \hat{i} \frac{\partial S}{\partial x} + \text{cycl}$$

Gradient:

- Points in the direction of the highest slope (magn=slope)
- Perpendicular on altitude contour line
- Independent of CS

Laplace (De Bock 171) → Hoop stress

(Independent of Ymod)

$$p = ST \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$$

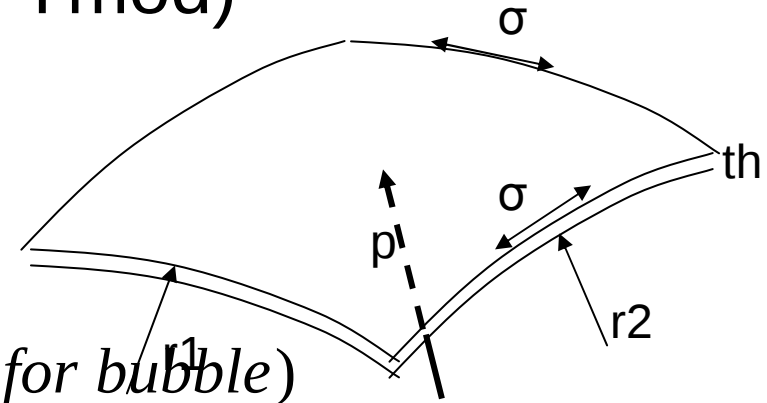
$$p = ST \frac{2}{r} \text{ (for sphere)}; p = ST \frac{4}{r} \text{ (for bubble)}$$

(ST surface _ tension = $f / l = f \cdot th / S \Rightarrow \sigma \cdot th$ for shell)

(ST caused by (em) Vanderwaals forces)

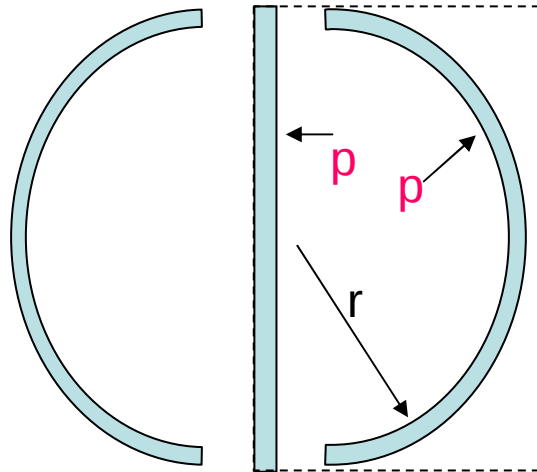
$$\frac{p}{\sigma} = th \left(\frac{1}{r_1} + \frac{1}{r_2} \right) [-] \text{ (mnemo : } p < \sigma \text{)}$$

$$\frac{p}{\sigma} = th \frac{2}{r} \text{ (for spherical vessel)}$$

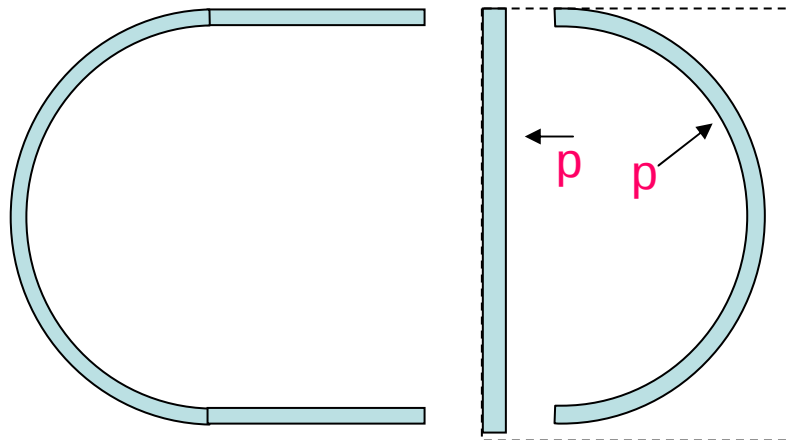


Pressure vessel

(“Why does a sausage always burst axially”
Least effort for most understanding)



Action=reaction



Cylinder 1 m depth, consider square

$$\sigma_h \cdot th \cdot 2 = p \cdot 2r \cdot 1$$

$$\frac{\sigma_h}{p} = \frac{r}{th}$$

Sphere :

$$\sigma_h \cdot th \cdot 2\pi r = p \cdot \pi r^2 \Rightarrow \frac{\sigma_h}{p} = \frac{1}{2} \frac{r}{th}$$

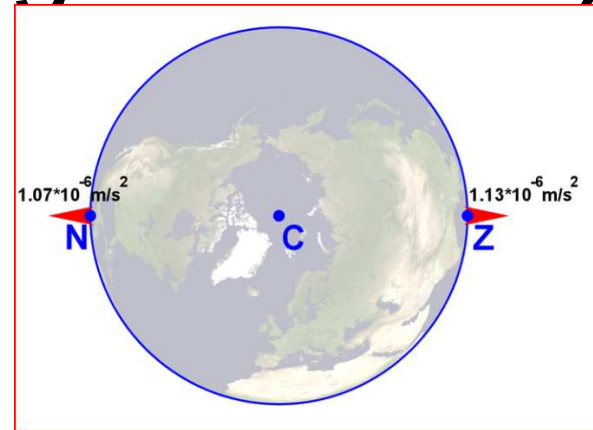
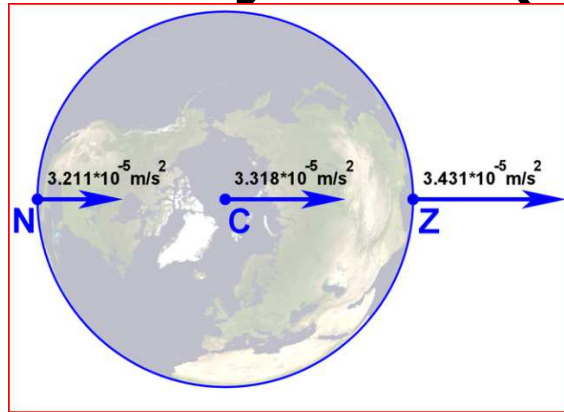
Note: To open the Magdeburg (Maagdenburg) 1654 hemispheres
(diam=0.5 m, the force = $p \cdot (\text{equatorial surface}) = 20000 \text{ N}$)

One horse traction force is about 1000 N

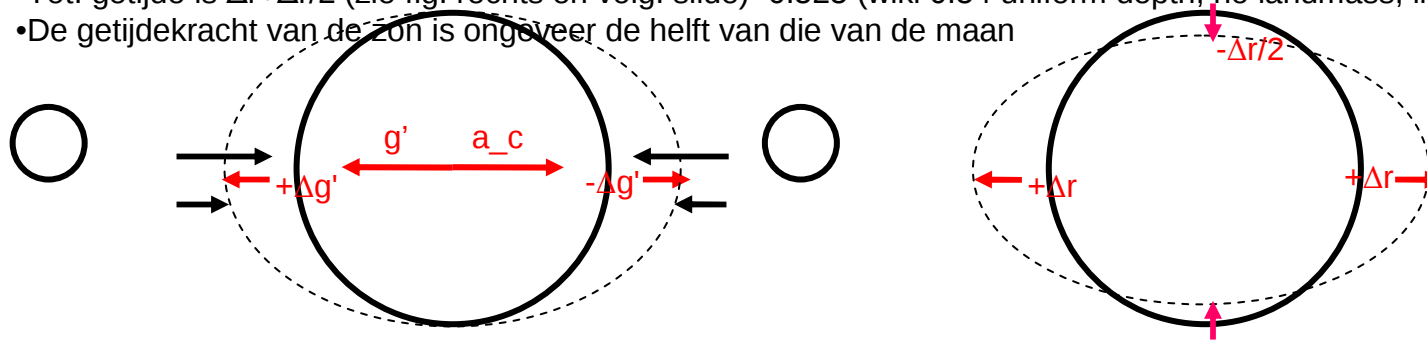
$$\sigma_{ax} \cdot th \cdot 2\pi r = p \cdot \pi r^2$$

$$\frac{\sigma_{ax}}{p} = \frac{1}{2} \frac{r}{th}$$

Getijden ($\Delta g/g = 1.12 \cdot 10^{-7}$)



- (m' is maanmassa, r straal aarde = $6371 \cdot 10^3 \text{ m}$, R afstand aarde-maan = $3.8 \cdot 10^8 \text{ m}$)
- Er is gravitatieversnelling g' (afh afstand) en centripetale versnelling a_c (CONSTANT over de aarde)
- We maken even abstractie van de aardversnelling g
- $a_c = g'$ in het centrum van de aarde
- Een punt op aardopp ondervindt een extra versnelling $\Delta g' = g' - a_c$
- Aan de maankant is er surplus aan maangravitatie = $Gm'/(R-r)^2 - Gm'/R^2 = 2Gm'r/R^3$ (ong $1.1 \cdot 10^{-6} \text{ m/s}^2$)
- Aan de andere kant is er tekort aan maangravitatie = $Gm'/(R+r)^2 - Gm'/R^2 = -2Gm'r/R^3$
- Aan beide kanten wordt g kleiner, dus het water komt OMHOOG
- $\Delta r/r = 0.5 \Delta g/g \rightarrow \Delta r = 0.35 \text{ [m]}$
- Tot. getijde is $\Delta r + \Delta r/2$ (zie fig. rechts en volg. slide) = 0.525 (wiki 0.54 uniform depth, no landmass, in-step rotation)
- De getijdekracht van de zon is ongeveer de helft van die van de maan



Getijden ($\Delta r/r = 1.12 \cdot 10^{-7}/2$)

In de richting van de maan

$$f = G \frac{mM}{r^2} \text{ (at surface earth)}$$

$$f' = G \frac{mM}{(r + \Delta r)^2} \text{ (at tide top)}$$

$$\frac{f}{f'} \approx 1 + 2 \frac{\Delta r}{r} = \frac{g}{g - \Delta g}$$

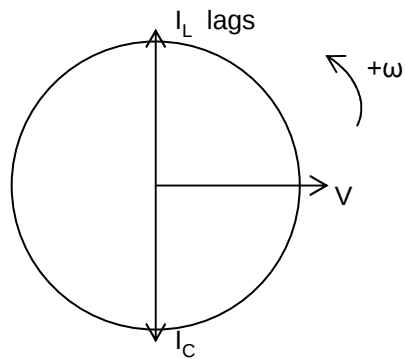
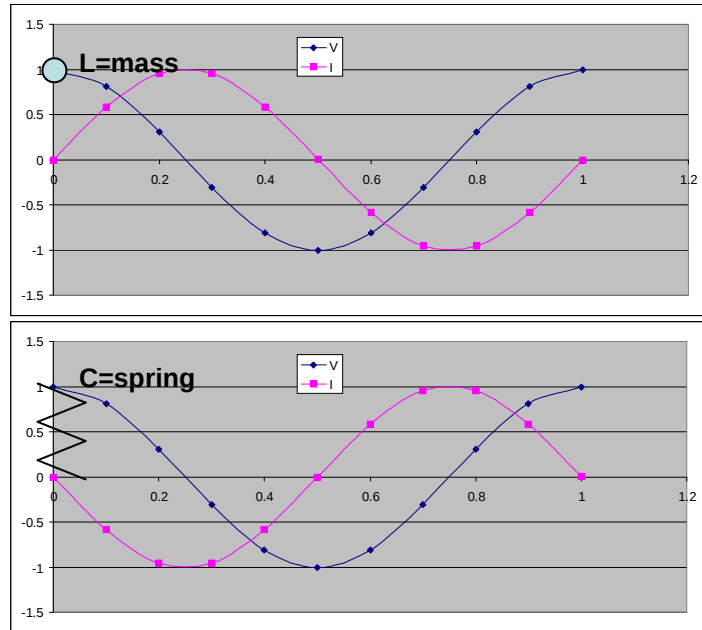
$$\frac{\Delta r}{r} = 0.5 \frac{\Delta g}{g} \text{ (= longitudinal strain)}$$

In de andere richting gelijkheid
van volume

$$\frac{4}{3} \pi (r + \Delta r)(r - x)^2 = \frac{4}{3} \pi r^3 \Rightarrow x = \frac{\Delta r}{2}$$

Reactance

Analogies Hughes p 341 and 345



$$V = -L \cdot dI_L / dt$$

$$Ve^{j\omega t} = -L \cdot dI_L / dt$$

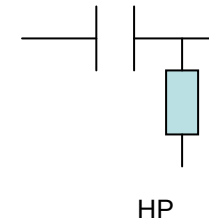
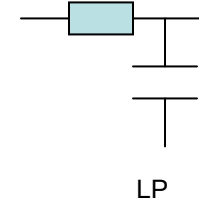
$$-\frac{V}{L} \int e^{j\omega t} dt = I_L$$

$$i \frac{Ve^{j\omega t}}{\omega L} = I_L \Rightarrow I \text{ lags } V$$

or

$$I_L = \frac{V}{Z_L} = \frac{V}{j\omega L} = I_L \frac{V}{\omega L} \Rightarrow I \text{ lags } V$$

$$\tau = R \frac{1}{L} \quad \omega_c = \frac{1}{R} L \quad \left(\frac{1}{\sqrt{2}} \right)$$



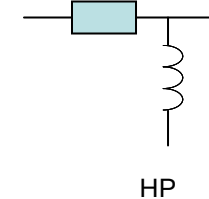
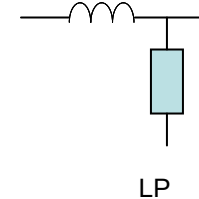
$$I_C = C \cdot dV / dt$$

$$= C \frac{d}{dt} Ve^{j\omega t} = j\omega C Ve^{j\omega t} \Rightarrow I \text{ leads } V$$

or

$$I_C = \frac{V}{Z_C} = V \cdot j\omega C = j \cdot V \omega C \Rightarrow I \text{ leads } V$$

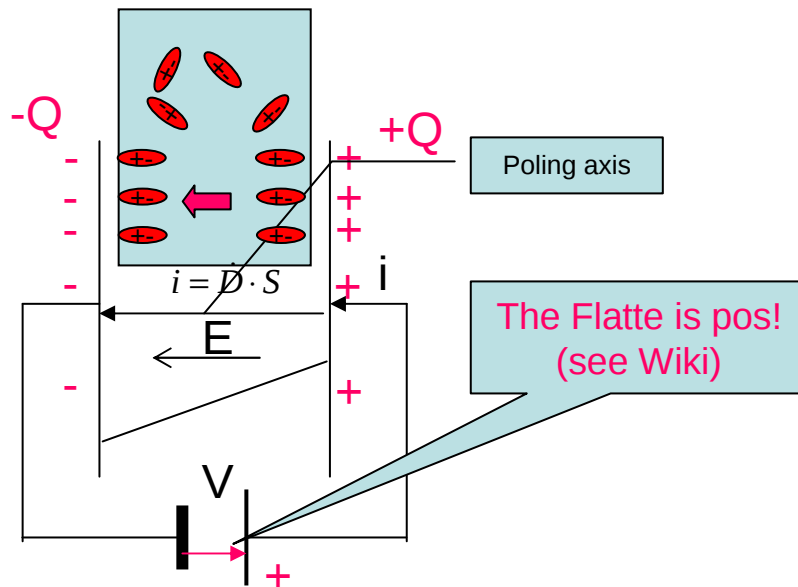
$$\tau = R \cdot C \quad \omega_c = \frac{1}{RC} \quad \left(\frac{1}{\sqrt{2}} \right)$$



$$LC \quad \tau = \text{none} \quad \omega_c = \frac{1}{\sqrt{LC}}$$

Capacitor displacement field

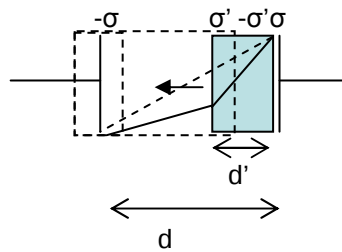
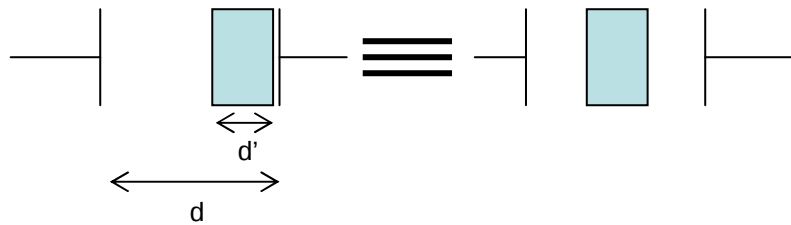
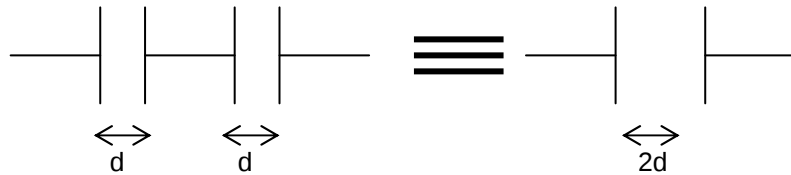
G>wiki capacitor



- Force is $Q \cdot E$ (Gravitation field analogy, $m \rightarrow Q$)
- $C = Q/V = \epsilon S/d$ [$F = As/V$]
- $[E] = V/m$
- $[QV] = [Nm] = [J]$
- Within dielectric $\rightarrow$ charge separation of indiv. atoms
- Increases of charge and capacity.
 - $D = \epsilon E$ [Q/m^2]
 - $i = dQ/dt$
- If the dielectric is piezoelectric
 - The poling direction is opposite to the poling voltage
 - The stretching is in the poling direction
 - γ_{mod} and permittivity are smallest in the poling direction

Capacitor

Ashish Atota physicsgallery.com



$$C = \frac{\epsilon_0 \cdot S}{d - d'(1 - 1/\epsilon_r)}$$

2 times Gauss with D :

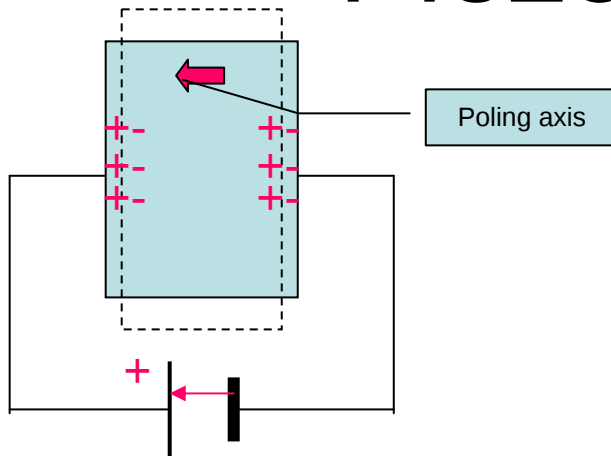
$$-D = -\sigma$$

$$-D' = -\sigma$$

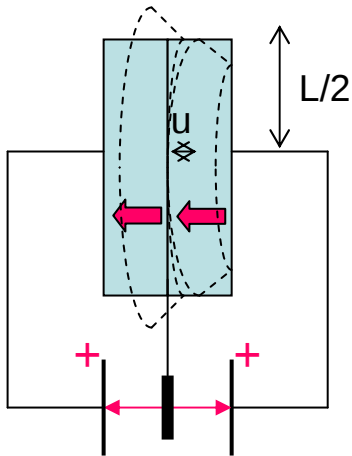
$$\rightarrow D = D' \text{ or } E = \epsilon_r E'$$

2 times Gauss with E :

Piezoelectricity



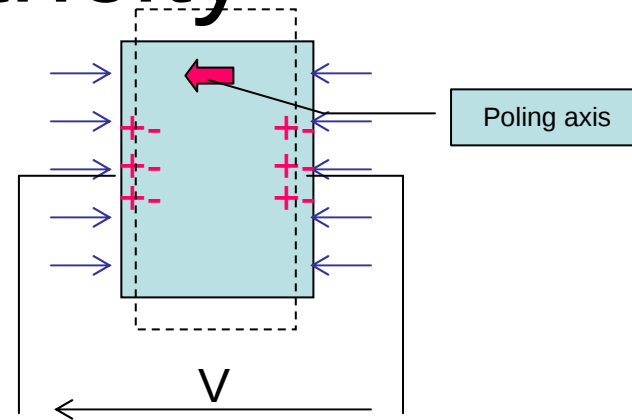
- External voltage in the poling direction: + and – attraction in dipoles is increased → dipoles compressed
- See Philips booklet p6 fig 2.2.d
- Bimorph magnification M: see below



$$u = \frac{f(L/2)^3}{3EI} = \frac{f \cdot L^3}{24EI}$$

$$\varepsilon \cdot l = \frac{m \cdot th}{2I} \frac{L}{E} = \frac{f \cdot L^2 \cdot th}{4EI}$$

$$M = \frac{u}{\varepsilon \cdot L} = \frac{L}{6 \cdot th} \quad [= \frac{25}{6 \cdot 0.2} = 20.8]$$



- External compression: dipoles compressed → + and – attraction in dipoles is increased
- See booklet p6 fig 2.2.c
- Canonic equations: see below

MARC notation (map93)

stress based

$$\sigma = L^E : \varepsilon - e \cdot E \quad [N/m^2]$$

$$D = e^T : \varepsilon + \zeta \cdot E \quad [C/m^2]$$

$$e = L : d = \text{piezo const}$$

$$\zeta = \text{permittivity}$$

See Marc104 8.1–8

Philips notation

Strain based

$$\varepsilon_1 = d_{31} \cdot E_3 + \frac{1}{Y_1^E} \sigma_1 \quad [-]$$

$$D_3 = \zeta_{33}^{\sigma} \cdot E_3 + d_{31} \cdot \sigma_1 \quad [C/m^2]$$

$$\begin{bmatrix} \varepsilon_1 \\ D_3 \end{bmatrix} = \begin{bmatrix} d_{31} & \frac{1}{Y_1^E} \\ \zeta_{33}^{\sigma} & d_{31} \end{bmatrix} \begin{bmatrix} E_3 \\ \sigma_1 \end{bmatrix}$$

$$d_{31} = \text{piezo const} \quad [C/N]$$

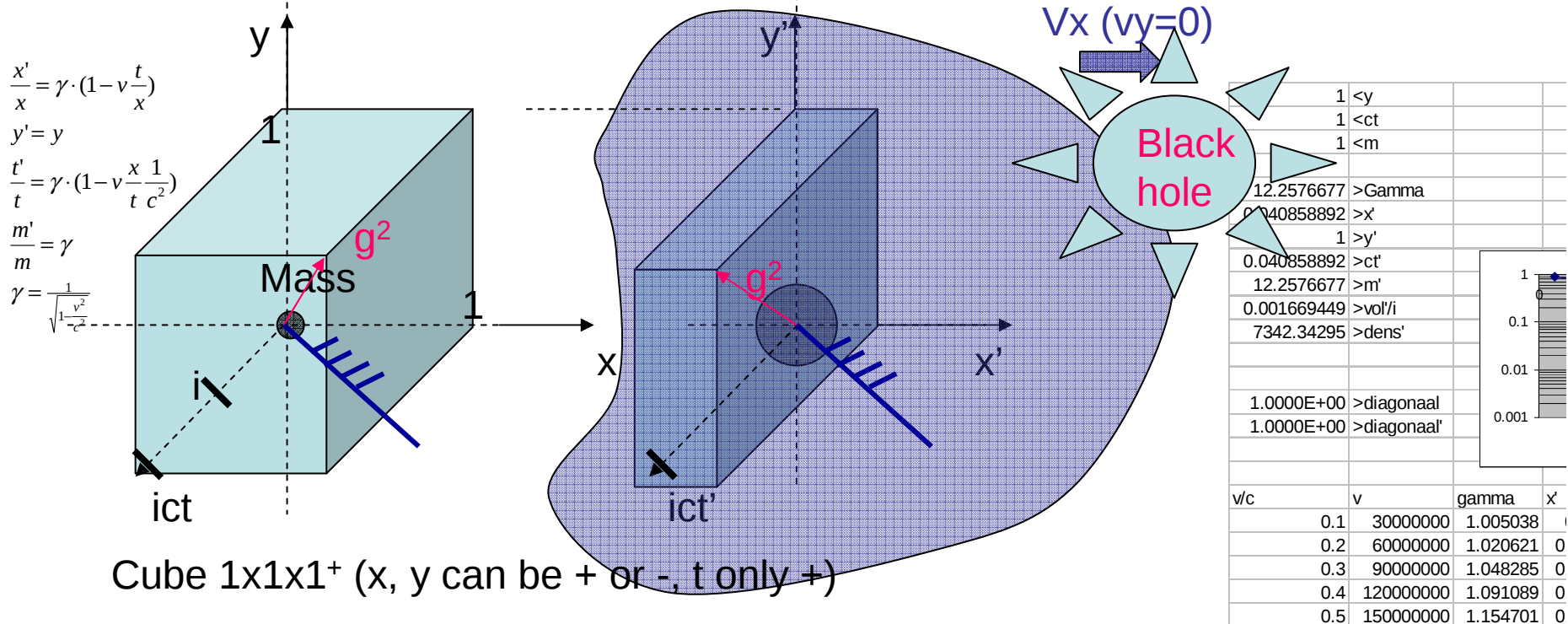
$$\zeta = \text{permittivity} \quad [C/V/m]$$

$$\varphi = d_{31} \cdot Y_1^E \quad [N/V]$$

$$\kappa^2 = \frac{d_{31}^2}{\frac{\zeta_{33}^{\sigma}}{Y_1^E}} = \text{coupling factor} [-]$$

See Franssen L : \piezo \

Relativistic mechanics



Cube 1x1x1⁺ (x, y can be + or -, t only +)

g is space-time and is imaginary ($x^2 + y^2 - c^2 t^2 < 0$)

Blue line is the worldcone, hatched region is not observable

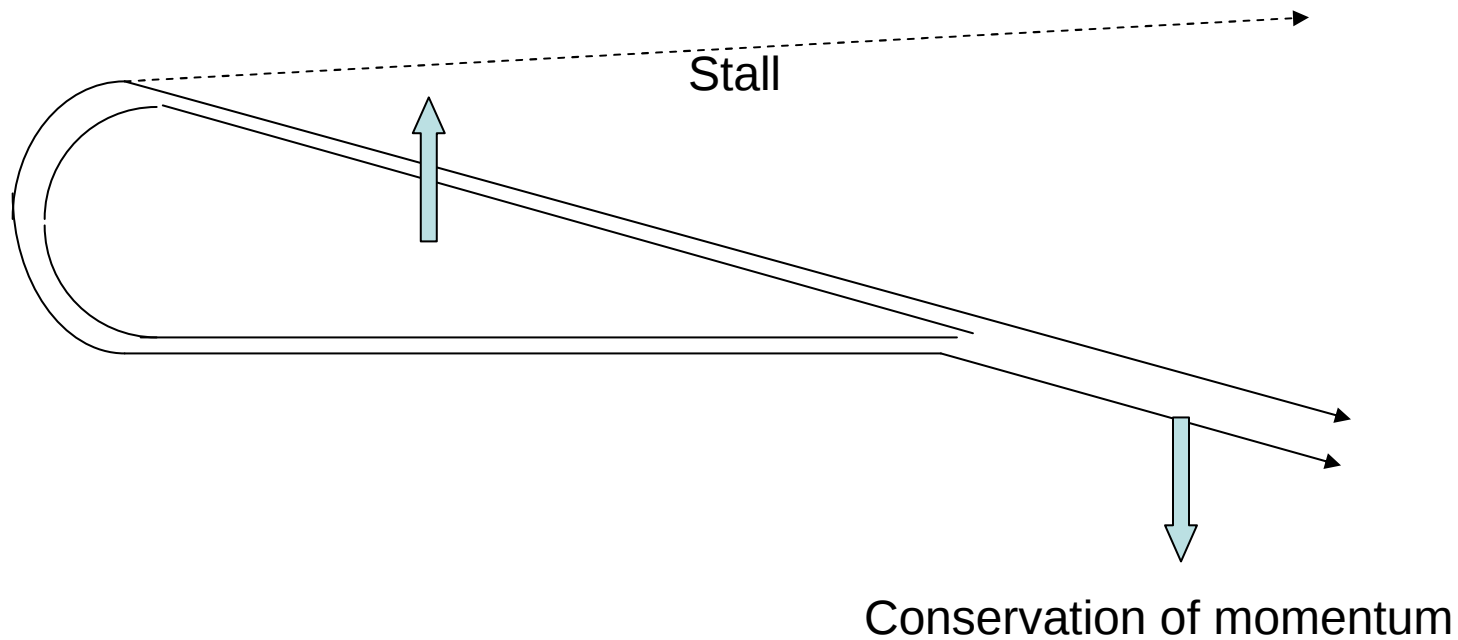
Inertial CS =

- no acceleration nor rotation (no ext force, 1st law Newton)
- Free particle straight line

Volume NOT constant

Tijd loopt TRAGER voor waarnemers die met hoge snelheid reizen (denk aan meereizen met een foton dat 300000 km moet afleggen voor er 1 s is verlopen) en/of in groter gravitatieveld

Bernoulli lift



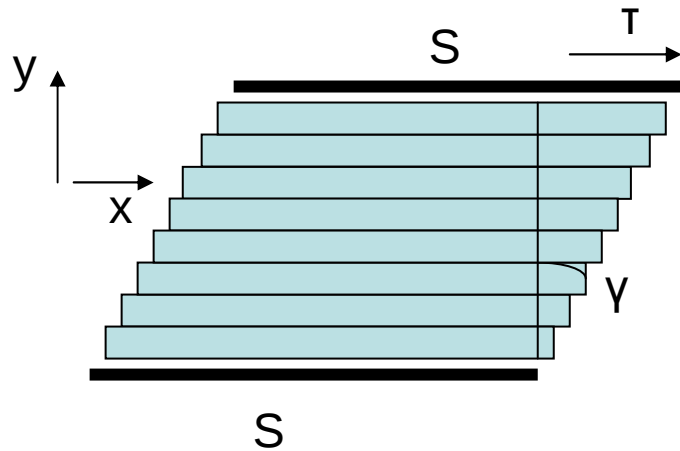
Nog eens berekenen wat de opwaartse kracht is op een vliegtuig

Boeing 747 startsnelheid 290 km/h

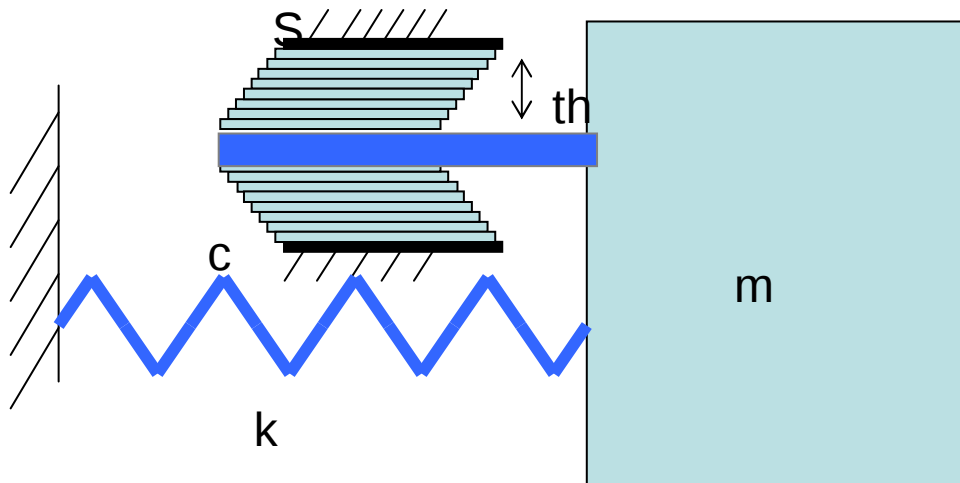
Solid (Hookean) vs fluid (Newtonian)

Struct	$f=ku$	$\sigma=E\varepsilon$	$dJ/dV=$ $E \varepsilon^2$
Fluid	$f=cv$	$\tau=\eta d\gamma/dt$	$dW/dV=$ $3 \eta (d\gamma/dt)^2$

Newtonian fluid and mkc



$$c = dvis \cdot S / th [Ns / m]$$

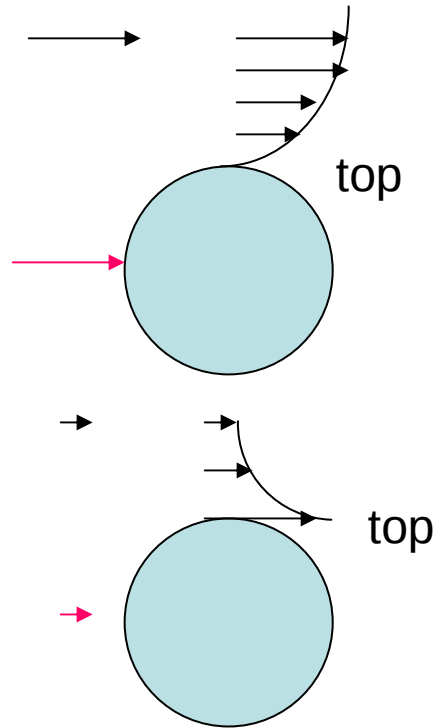


Reynolds number

Reynolds = thrustforce / dragforce

$$= \rho \cdot v^2 S / (c \cdot v) = \rho \cdot v \cdot y / \mu$$

Hydrodynamics



- Newton (incompressible, viscous e.g. water) flow
 - $v=0$ at surface (no slip BC)
 - Note: continuity is OK
- Inviscid or potential flow, solution of Euler eq. (Dirichlet)
 - v is highest at top of object (continuity)
 - Pressure at top is lower than at thrust line (red arrow)
 - (Rayleigh) free disc: because of shifted thrust lines the disc remains perpendicular on flow
 - no net drag (d'Alembert's paradox, De Bock p156)

$$thrust = \frac{1}{2} \rho v_{stow}^2 + p_0$$

$$f_x = c_x \cdot (\text{dynamic pressure})$$

$$c_x = \text{drag coef}$$

• Real fluid

- Viscous Prandtl layer at surface $th = \sqrt{\frac{6\eta L}{\rho v_{stow}}}$
- Ideal outside
- At high v , Prandtl layer loses contact → von Karman vortices

Fluids

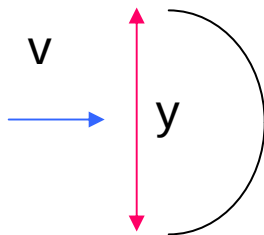
- Fully developed flow → parabolic velocity distribution
- Ideal: no interaction between molecules
- Incompressible: density constant
- Newtonian flows like water—its stress versus rate of strain curve is linear and passes through the origin. The constant of proportionality is known as the viscosity. In common terms, this means the fluid continues to flow, regardless of the forces acting on it. For example, water is Newtonian, because it continues to exemplify fluid properties no matter how fast it is stirred or mixed.
- Contrast this with a non-Newtonian fluid, in which stirring can leave
 - a "hole" behind (that gradually fills up over time - this behaviour is seen in materials such as pudding, starch in water (oobleck knv), or, to a less rigorous extent, sand), or
 - cause the fluid to become thinner [shear thinning or pseudoplastic < shear thickening or dilatant], the drop in viscosity causing it to flow more (this is seen in non-drip paints, which brush on easily but become more viscous when on walls).
 - Some of the other materials, such as emulsions and slurries and some visco-elastic materials (eg. blood, some polymers), have more complicated non-Newtonian stress-strain behaviours. These materials include *sticky liquids* such as latex, honey, and lubricants which are studied in the sub-discipline of rheology.

Hydrodynamics

$$Re = \frac{v \cdot y}{\text{visc_kin}} = \frac{v \cdot y}{15e-6} \text{ SI for air}$$

- Reynolds number is dyn/drag pressure
- y is purely convention!
- v is mean velocity
- $Re > 3000$??? start of turbulence

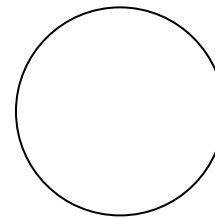
Cx values



1.11



0.35

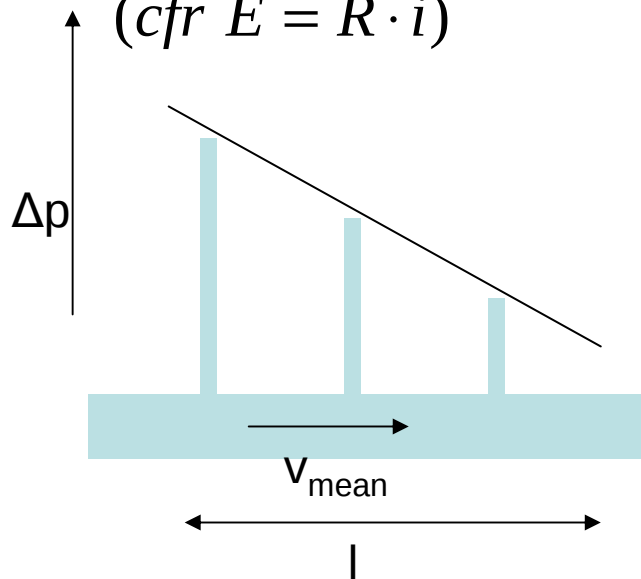


0.3

Hydrodynamics

$$\Delta p = \frac{8\eta}{\pi} \cdot \frac{l \cdot v_{vol}}{r^4}$$

(cfr $E = R \cdot i$)



$$Z_m = \frac{\Delta f}{v_{mean}} = 8\pi\eta l \left[\frac{Ns}{m} \right]$$

$$Z_a = \frac{Z_m}{S} = \frac{\Delta p}{v v_{mean}} = \frac{8\eta l}{\pi r^4} \left[\frac{Ns}{m^5} \right]$$

- Leon's pipe formula (De Bock 178)
- η is dvis! Dim= Ns/m^2 and NOT c from mkc system
- v is zero at outer radius and max in center (for viscous laminar flow)

$$v_{mean} = \frac{v_{vol}}{\pi \cdot r^2} \quad [m / s]$$

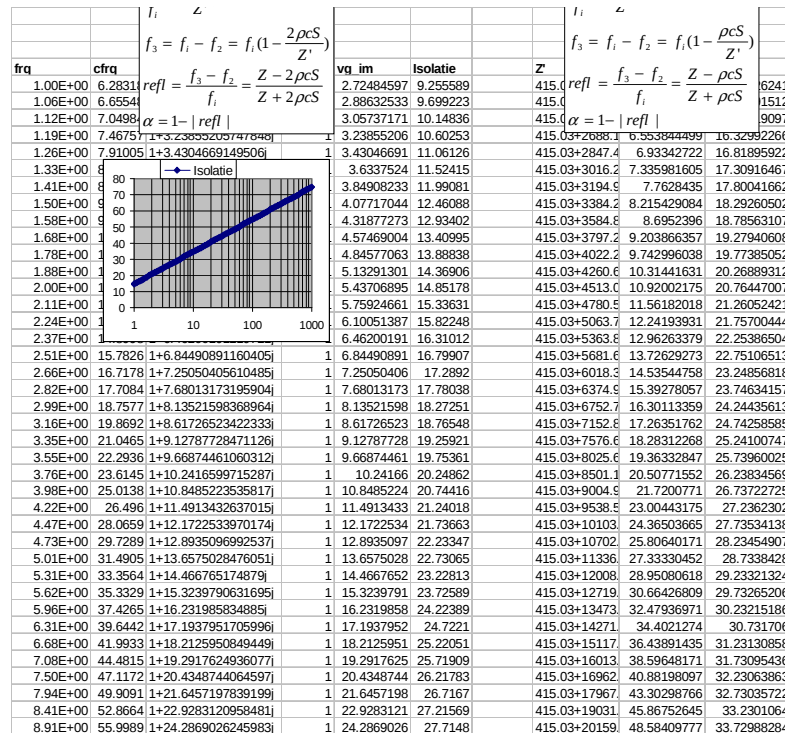
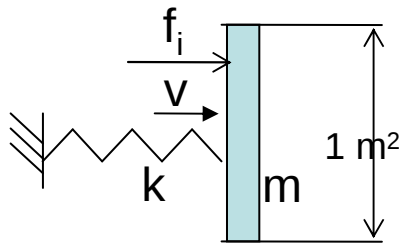
- Poiseuille in impedance forms (Z_m independent of r)
- Better name for Z_a is Z_{fl}
- Correction for compressible fluids: divide Z_m and Z_a by $(p_i + p_o)/2/p_o$ (Wiki)

Conjugate heat transfer

- A **conjugate heat transfer** (CHT) problem is one that solves for both the fluid flow field and the temperature field inside a **solid**. [in STAR-CD, for conductive heat transfer, the flow calculation is suppressed]
- For over 15 years, the FLOTHERM solver has specifically addressed electronics cooling applications. The solver, based on a cartesian gridding system results in the most accurate results possible and the fastest solution time per grid cell. Massive disparity in geometric length scales are resolved using the unique 'localized-grid' technique which allows for integrally matched, nested, non-conformal grid interfaces between different parts of the solution domain. The **conjugate nature of heat transfer** within electronic systems is concurrently solved using a preconditioned conjugate residual solver together with a flexible cycle multi-grid solution technique. Pragmatic, unique and accurate solution termination criteria produce useful results in engineering, not academic, time scales.

Wall acoustic isolation R-mass law

(Lichtveld p16T uses Newton's mass law)



See



Microsoft

R=reduction=1/transmission

The incident force f_i drives the wall (mass and spring) and the 2 room radiation resistances, f_2 drives only 2 plane sound waves: one reflected in room 1 and one transmitted to room 2

$$R = \frac{f_i}{f_2} = \frac{j\omega m + \frac{k}{j\omega} + 2\rho cS}{2\rho cS} = 1 + \frac{j\omega m}{2\rho cS} - j\frac{k/\omega}{2\rho cS}$$

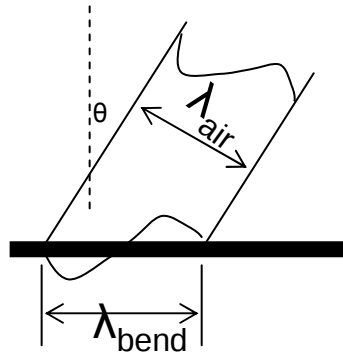
$$\text{spring controlled : } R = 1 - j\frac{k}{\omega \cdot 2\rho cS} \Rightarrow R = 20\log || = 10\log \left(1 + \left(\frac{k}{\omega \cdot 2\rho cS} \right)^2 \right)$$

$$\text{mass controlled : } R = 1 + j\frac{\omega m}{2\rho cS} \Rightarrow R = 20\log || = 10\log \left(1 + \left(\frac{\omega m}{2\rho cS} \right)^2 \right) \quad (6\text{dB/oct})$$

Or (right, my method): f_i drives the wall and left sound field, f_2 drives right field. If m is very large, only left sound field is active (**Note: 2 disappears in denominator**)

Random incidence: - 5 dB

Coincidence/flanking (Lichtveld 19)



$$\lambda_B = \frac{\lambda_{air}}{\sin \vartheta}$$

- Occurs when strike velocity of air waves ($c_0/\sin\theta$) equals bending wave velocity $\rightarrow$ Loss of wall reduction

$$c_B = \sqrt[4]{\frac{E \cdot th^2 \omega^2}{12 \cdot dens}} \approx 1.34 \sqrt{c_L \cdot th \cdot frq}$$

$$c_L = \sqrt{\frac{E}{dens(1 - pr^2)}}$$

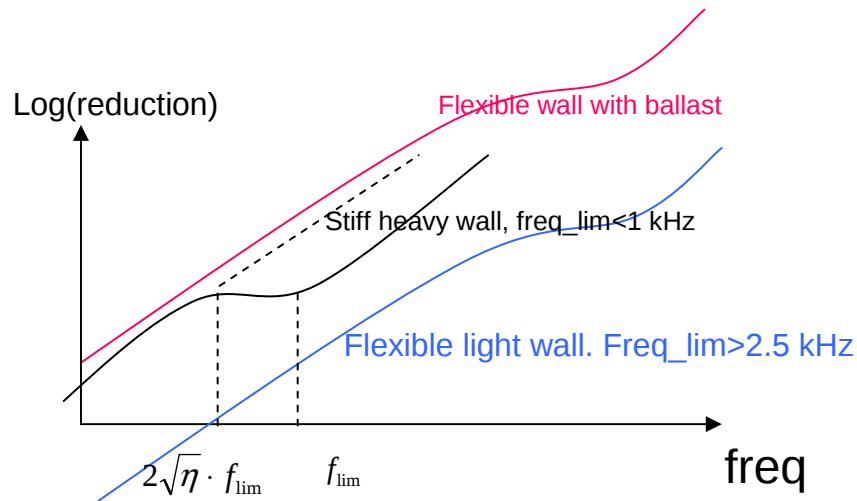
$$f_{lim} = \frac{64000}{c_L \cdot th}$$

$$f_{coin} = f_{lim} \frac{1}{\sin^2 \vartheta}$$

$$f_{lim} th = \frac{c^2}{c_L}$$

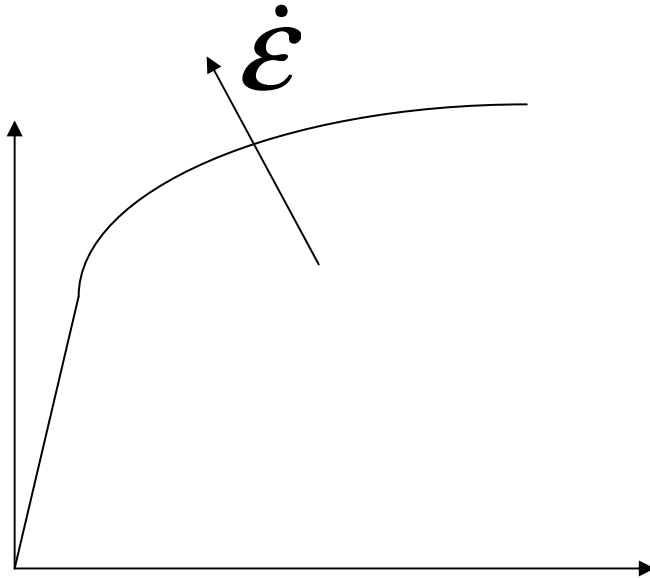
$$f_{lim} m = \frac{c^2}{c_L} dens$$

$$10 \log \left(1 + \left(\frac{\omega m}{2 \rho c} \right)^2 \right) - 5dB \text{ (random incidence)}$$



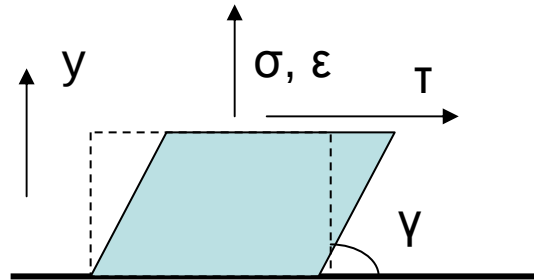
	$f_{lim} th$
Steel, glass, concrete	10
Masonry	20
Board wood, gypsum board	30
Lead	50
Plastics	90

Plasticity



- Dit is volgens Johnson Cook (zie Contiteves_vva)
- Snap koud vervormen bij hoge reksnelheid dan niet

Solid (Hookean) vs fluid (Newtonian)



$$f = k \cdot u = E \frac{S}{l} u \Leftrightarrow \sigma = E \varepsilon \Leftrightarrow \frac{dJ}{dV} = \sigma \cdot \varepsilon = E \cdot \varepsilon^2 [J / m^3]$$

[Better : $\sigma_{11} = E \varepsilon_{11} + \nu(\sigma_{22} + \sigma_{33})$] (Timoshenko p8)

$$\tau = G \gamma = 2(1 + \nu) E \cdot \gamma$$

Trick to switch from solid
to fluid (Troussart):

traction $\rightarrow$ shear

$u \rightarrow du/dt$

$\varepsilon \rightarrow dy/dt$

$\sigma \rightarrow \tau$

$E \rightarrow \eta$

$J \rightarrow W/3$

$$f = c \cdot v \Leftrightarrow \tau = \eta \dot{\gamma} \Leftrightarrow \frac{dW}{dV} = 3 \cdot \tau \cdot \dot{\gamma} = 3 \cdot \eta \cdot \dot{\gamma}^2 [W / m^3]$$

cfr : divide by S and $v = \Delta v$: $\tau = \frac{c \cdot th}{S} \frac{dv}{th} = \eta \dot{\gamma}$

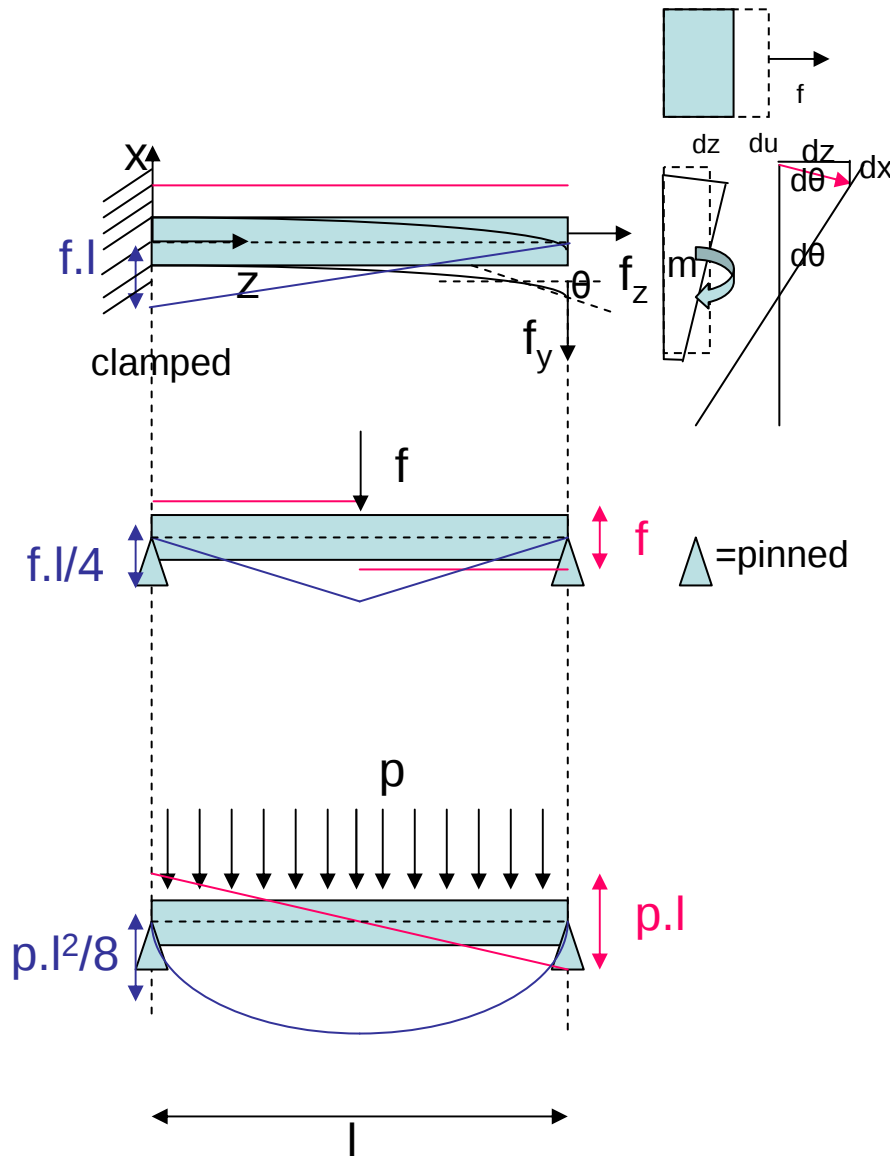
(with $\frac{c \cdot th}{S} = \eta$ and $\frac{dv}{th} = \frac{d}{dy} \frac{du}{dt} = \frac{d}{dt} \left(\frac{du}{dy} \right) = \dot{\gamma}$)

$$[\eta = dvis] = Ns / m^2$$

$$[c = \eta \cdot th / S] = Ns / m$$

Beam

(De Bock p106, Morley p96, Bouckaert p11 → verder nog bekijken 4^{de} afgeleide)



$$f_z = k \cdot u = \frac{ES}{l} u = ES \frac{du}{dz}$$

$$m_y = \dots = EI_{yy} \frac{d\theta}{dz} = EI_{yy} \frac{d^2 x}{dz^2}$$

$$m_z = G(I_{xx} + I_{yy}) \cdot \frac{u_{xx}}{l}$$

$$\left. \begin{array}{l} f \rightarrow m \\ k \rightarrow EI_{yy} \text{ (bending stiffness)} \\ u \rightarrow \theta \\ \frac{d^2 x}{dz^2} = \frac{d\theta}{dz} = \frac{1}{R} \end{array} \right\}$$

$$\text{Bending stiffness} = EI = \frac{E \cdot th^3 \cdot b}{12} \text{ (rect. beam)}$$

$$\text{deflection at free end} = \frac{f \cdot l^3}{3EI}$$

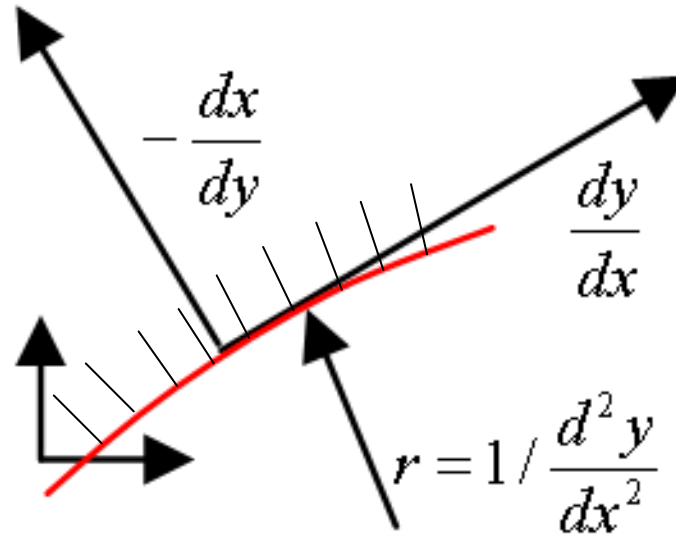
$$\text{stiffness at free end} = \frac{3EI}{l^3}$$

$$\text{stress at outer fiber} = \frac{1}{2} \frac{m \cdot th}{I}$$

$$\text{bending energy} = \frac{1}{2} \frac{m^2}{EI}$$

- MARC axes used
- Red=shearing force fy
- Blue=bending moment m (relevé des moments fléchissants)
 - Is zero at pinning
- Misunderstandings
 - Bernoulli beam has NO shearing
 - The wedge has no parallel-shape
 - De Bock uses 2 vertical axes (z and y)
 - Use y as global, yL as local (only for calculation section moment)
 - See also p111 torsion (klopt met boven voor cilinder)
 - Central force: think of
 - 2 beams centrally clamped with length l/2
 - f/2 reaction force at both ends
 - Bouckaert starts with constant m load
 - Moment is converted to shearing force

Tangent, normal, curvature

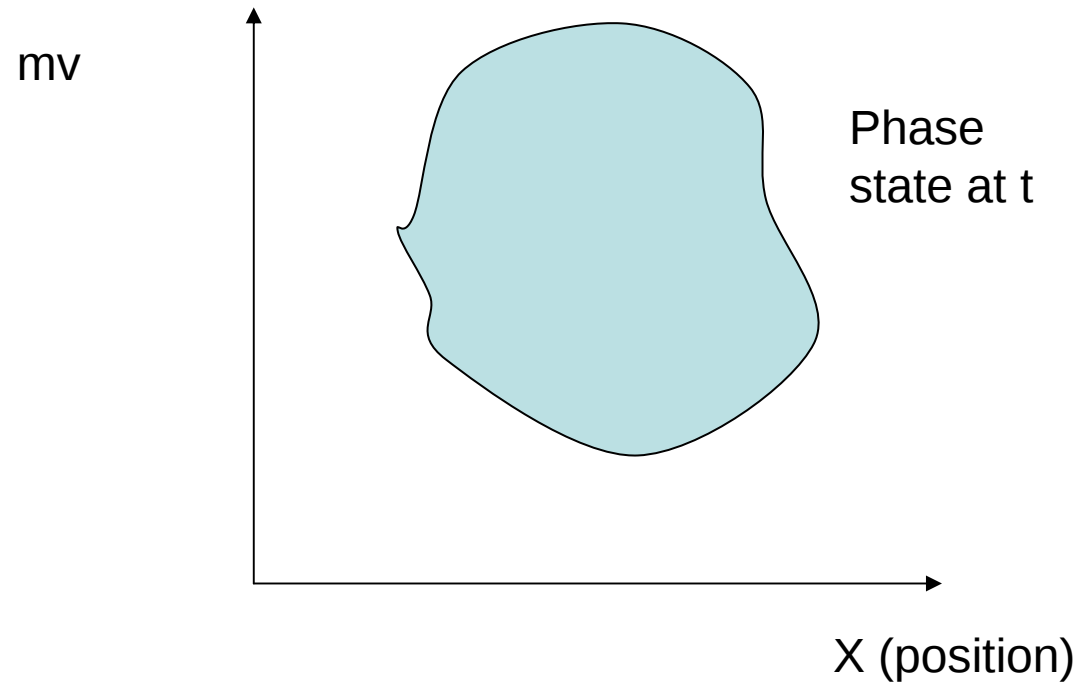


Sphere: tangent plane lies exterior $\rightarrow$ positive curvature, triangle sum $> 180^\circ$

Hyperboloid: tangent plane lies interior $\rightarrow$ negative curvature, triangle sum $< 180^\circ$

Normal: cfr $\tan(\alpha + \pi/2) = -\cot(\alpha) = -1/\tan(\alpha)$

Phase space



Bernoulli equation

$$\frac{1}{2}\rho v^2 + p + g\rho\Delta h = \text{total pressure} [Pa = J / m^3]$$

divide by $g\rho$

$$\frac{v^2}{2g} + \frac{p}{g\rho} + \Delta h = \text{total head} [m]$$

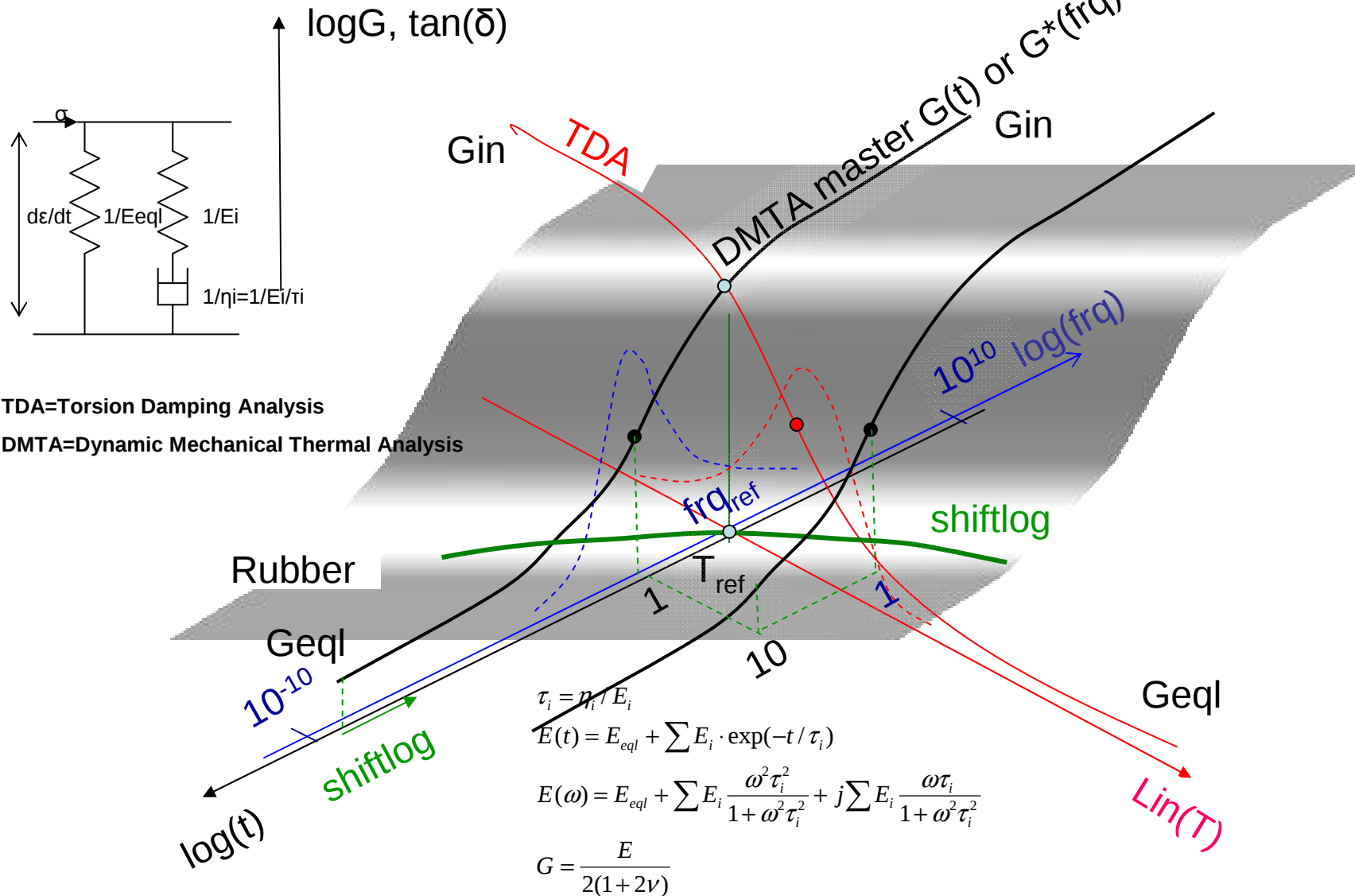
$$\frac{p}{g\rho} + \Delta h = \text{hydr. head} [m]$$

$$D_h = \frac{4A}{P}$$

- De Bock p151
- Const density, no viscosity
- Som dyn.+stat,+ext. drukken constant en is energy per vol [N/m²=J/m³]
- p=hydrostatic pressure
- Third term is potential energy (0 for horizontal flow)
- Head = verval
- D_h Hydraulic diameter
 - A = cross sectional area
 - P = wetted perimeter of the cross-section
 - For circular, D_h=D

Viscoelasticity

[ALL visco-elasticity.ppt](#) (RM open)



The God uncertainty equation

$$\Delta G \bullet \Delta K \geq Z$$

$$\Delta J \bullet \Delta M \geq Z$$

$$\Delta R \bullet \Delta B \geq Z$$

$$\prod_i \Delta X_i \geq Z$$

$$\Delta R \bullet \Delta E \bullet \Delta B \geq Z$$

•Common problem: “God is infinitely good and knowledgeable, so why created He men, who are bad most of the time. He could have foreseen it”

•“Infinite” is a convenience concept invented by humans, very useful in mathematics, not necessarily applicable to God

•G=Goodness

•K=Knowledge

•J=Justice

•M=Mercyfulness

•Z=God constant

•R=Reason

•E=Emotion

•B=Believe or Body

In het begin

- In den beginne schiep God de hemel en de aarde. De aarde was woest en ledig, en de duisternis lag op de vloed, en de Geest Gods zweefde over de wateren
- In den beginne was het Woord en het Woord was bij God, en het Woord was God
- Het toeval (geen oorzaak, geen begintijd) en de onvermijdbaarheid (design?)
 - Het heelal is een onvermijdbaar toeval
 - Accident waiting to happen?

Het evangelie = het goede nieuws?

- Je wordt ongevraagd in het ellendige heelal geworpen en moet de rit uitrijden
 - Je bent zondig geboren
 - Wegwijzers in alle richtingen
 - Je moet hiervoor dankbaar zijn
- Er is een God die je persoonlijk in de gaten houdt en een goed geheugen heeft
- Je weet wat het einde is
 - Aangekomen in Auschwitz ga je wsl naar links moeten, tenzij je op goede voet staat met Dr. Mengele God

De filosofen

- Thales (+ -546)
- Pythagoras (+ -500) harmonie
- Heraklitos (+ -480) alles wordt één op dialectische (via strijd, zie dialectiek) wijze, alles stroomt
- Socrates (+ -399) zelfkennis en -kritiek leidt tot deugdzamer leven, gifbeker
- Democritos (+ -370) Het toeval en de onvermijdelijkheid (Le hasard et la necessite Jacques Monod), de ruimte is oneindig en bestaat uit niets en iets (atomen, zijn eeuwig en bewegen)
 - The catastrophe waiting to happen (Het ongeluk dat te gebeuren staat, er is dus een “vector”, la moindre action (actie, NIET weg), die deze vector aanstuurt)
- Euclides (+ -350 onzeker)
- Plato (+ -347) Ideeën
- Aristoteles (+ -322) peripatetische leraar, Alexander de Grote, Phyllis, inductieve methode, de natuur doet niks vergeefs, alles beweegt, God de onbewogen beweger
- Archimedes (+ -212) (het sg van de kroon was te laag, zie G>archimedes>wiki voor demonstratie met onderdompeling)
- Descartes methodisch twijfelen
- Pascal kiest het zekere, nl geloven in God
- Leibniz Das Ding und etwas (Monaden)
- Kant Das Ding an sich
- Hegel Voor de blijvende Geest gaat niets verloren, het geestelijk dialectisme (dialectiek: redeneervorm die gebruik maakt van tegenstellingen om de waarheid te vinden, het denken en de wereld zich ontwikkelt t.g.v. tegenstellingen)
- Schopenhauer De wereld als wil (levensdrift) en voorstelling???
- Marx Het materialistisch dialectisme (beter is 90 gr of out of the box)
- Bergson (+1941) De duur (La duree) zit in het bewustzijn (>< Einstein tijd staat er los van)
- Kierkegaard vader existentialisme
- Sartre l'Être et le neant (><Robert Salah Dieu ou rien) pas met de dood vorm je karakter, bij leven moet je zelf verantwoorde keuzes maken
- Monod Le hasard et la necessite “l'homme seule dans l'indifference de l'Univers d'ou il a emerge par HASARD. Non plus que son destin, son devoir n'est ecrit nulle part. A lui de choisir entre le Royaume et les tenebres”
- Ik:
 - er is niets → heelal om te onderwerpen (Schopenhauer)
 - Of er is iets → heelal om DNA toe te laten bewustzijns te kloten

- Het Niets > Tijd, ruimte - gravitatie > wiskunde > logica
- Materie, energie, zuinigste weg, evolutie en entropie
- Ruis en interacties > zelfstartende takel
 - Intelligent life
 - Unasked for present, where from, where go
 - Why Good and Bad, is there payday
 - God, Devil or nothing
 - Het Niets > kapitaal – schuld???
 - Waar plaats ik de strijd tussen goed en kwaad?

God heeft het heelal niet geschapen

- Als God, die goed is en voorzienend, het heelal heeft geschapen heeft hij de evolutiewet en de vrije wil ingesteld
- De evolutie wet is de wet van de best aangepaste (minste weerstand = T-V?), en doet de zwakste verdwijnen maar de beste moeten sterven
- De vrije wil leidt ook tot het kwaad

(Artificial) Intelligence (AI)

- The first enabLING
- Hardware
 - Sensors
- Software
 - Adaptive self-learning
- Big data
 - Bifurcate into useful intelligent information
 - Critical mass
 - Attractor
 - Self organizing criticality (SOC, Bak)
- Je pense, donc je suis
- Network
 - Pro-creation

Het leven zin geven, wat is dat?

- Je wordt ongevraagd lichtzinnig in het heelal geworpen (een ongevraagd vergiftigd “geschenk” dat in feite een onoplosbaar “raadsel” is)
 - Life owns you nothing, you owe everything to life?
- Dit heelal is vijandig en vol vragen
- Er zijn enkel tegenstrijdige antwoorden
- Niets is absoluut zeker behalve 1 ding: je moet sterven
- Tussen geboorte en dood moet je proberen gelukkig te zijn en zin te geven aan je leven
 - Wat is “geluk”? Niemand weet het, volgens mij: afwezigheid van ongeluk door de weg van de minste weerstand te volgen, zoals de grondwet van het heelal, de natuurlijke selectie
 - Epictetus (GR slaaf in Rome +130n.Chr.): Dingen in je macht zijn vrij (ongehinderd), de rest is onvrij (zwak, verslavend). Je wordt gelukkig als je het onderscheid kan maken (some things are up to us and some are not)
 - Een goede gezondheid, relatie, job of intellectuele bezigheid, voldoende geld
 - Levensvoldoening als geheel (7-8)
 - Is geen levensdoel
 - Wat is de “zin” van het leven? Volgens Dirk De Wachter: goed doen voor je naaste, volgens mij zoveel mogelijk genieten tussen het in- en uitgangsgaatje van het heelal, anders is het helemaal “waste”, zin hebben IN het leven
 - The purpose of life is to find out who I am [, what are my DOF and limits of my free-choice try-out interaction space], why I’m here and where I go (Harrison) (Ik ben de zin van het leven)

De leugens

- Zelig zijn zij > wij
- Jezus liep op > naast
- Luc19 Zacheus en de talenten (NIET kundes, wel geld, ponden of euro's) > de fiscus waarvan je terugtrekt door Gods genade i.p.v. de fiscusbende die zichzelf en de burgers uitzuigt en –moordt (de evolutiewet toch?)
 - Echter in Mat25 wordt niet over Zacheus gesproken en is het de derde dienaar die wordt gedood, hij is de enige rechtvaardige
 - De derde dienaar is dus Jezus?
 - Besluit: de evangelisten spreken elkaar tegen

Rechts-links

- Rechts: het geluk uitstellen tot de hemel (en God kan dit niet appricieren)
- Links: het geluk nu pakken en ook dat van rechts zonder te bedanken en met schop in gat (door de alomtegenwoordige jaloersheid te bundelen)(en God vindt dat goed)

Monod

- *L'homme sait enfin qu'il est seul dans (seul?)*
- *l'indifference de l'Univers (Le Createur?)*
- *d'ou il a émergé par hasard. (Le “Design”)*
- *Non plus que son destin, son devoir n'est écrit nulle part. (La Bible)*
- *A lui de choisir entre le*
 - *Royaume (“esprit” “le pouvoir” “le bon”) et les*
 - *ténèbres (“vitalisme” “Dieu” “diep geheim” “hushbush” “le mal”)*