

Karya Matematika
itu sebenarnya apa?

Aditya Firman Ihsan

$$\frac{d}{dx} e^x = e^x$$

Sedikit Perjalanan...

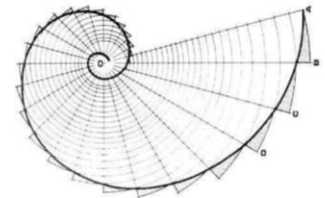
S1 - > Teori Koding (Aljabar, Kombinatorik)

S2 -> Analisis Non Linear (Analisis)

S3 -> PDP dan Perturbasi (Analisis, Terapan)

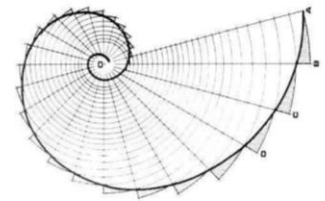
PPMS -> Pemodelan Jaringan Migas (Numerik, Terapan)

Tel-U -> Data Sains dan Deep Learning (Numerik, Statistik)

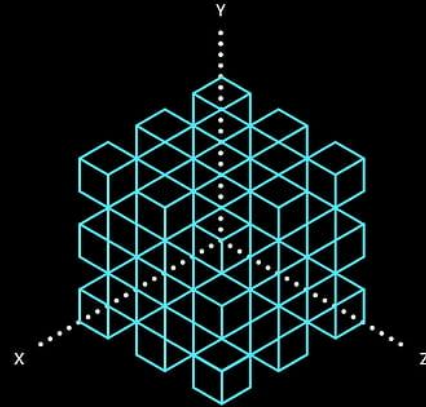


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Mungkin lebih tepat bertanya dulu ...



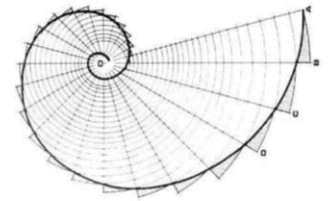
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



Apa sebenarnya matematika?

$$\forall x \forall y [\forall z (z \in x \Leftrightarrow z \in y) \Rightarrow x = y].$$

$$\forall u \forall v (\exists w (x \times w = u \times v) \rightarrow (\exists w (x \times w = u) \vee \exists w (x \times w = v))) \wedge x \neq 0 \wedge x \neq 1$$



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Yuk berhitung!



1



2



3

+



1



2

=



1



2



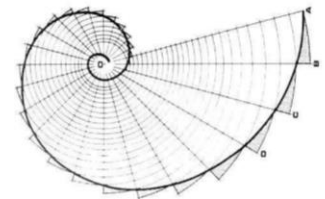
3



4

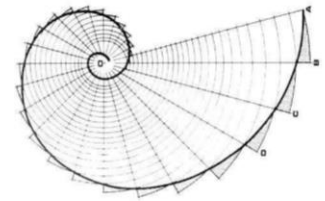
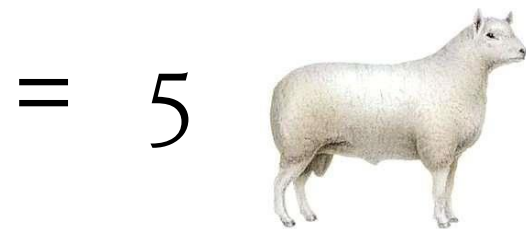
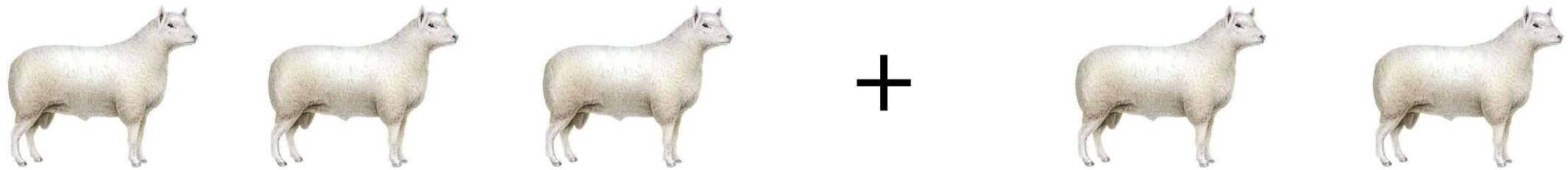


5



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Yuk berhitung!



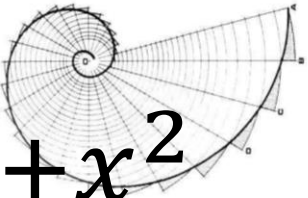
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Yuk berhitung!

$$3 \text{ domba} + 2 \text{ domba} = 5 \text{ domba}$$

$$3 \text{ juta} + 2 \text{ juta} = 5 \text{ juta}$$

$$3 x + 2 x = 5 x$$

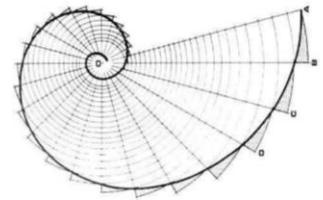
$$3 e^{\pi+x^2} + 2 e^{\pi+x^2} = 5 e^{\pi+x^2}$$


$\phi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$

Yuk berhitung!

$$5x + 2y = 50$$

$$2x + y = 10$$



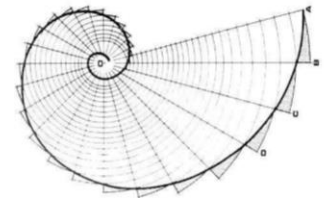
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Yuk berhitung!

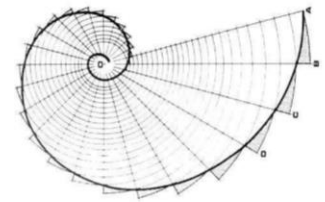
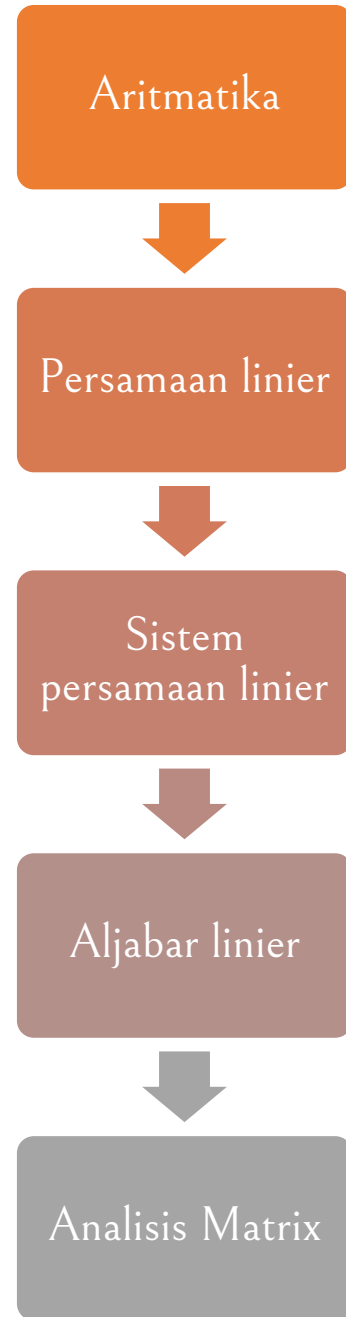
$$\begin{pmatrix} 5 & 2 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 50 \\ 10 \end{pmatrix}$$

$$A x = b$$

Pelajari karakter A secara umum, maka masalah serupa akan dapat lebih mudah diselesaikan

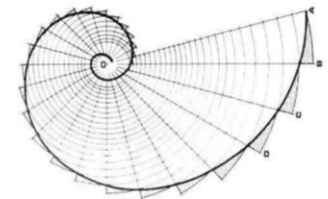
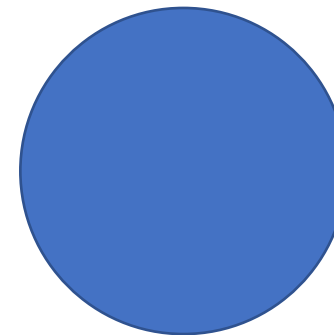
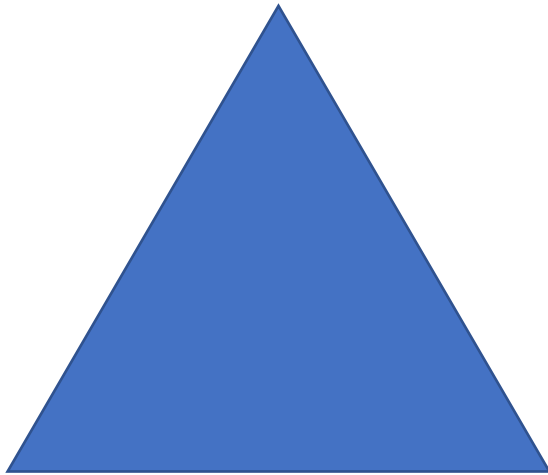


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



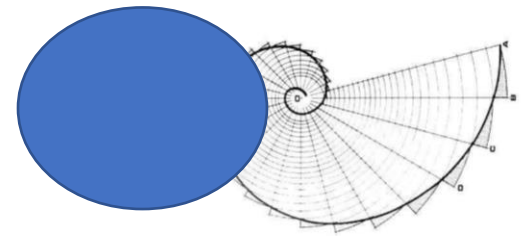
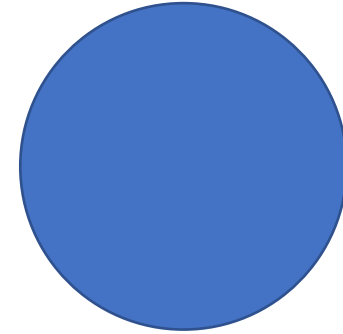
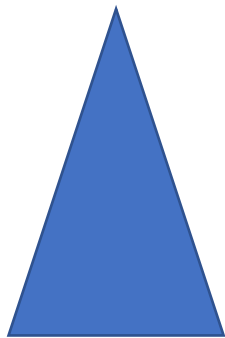
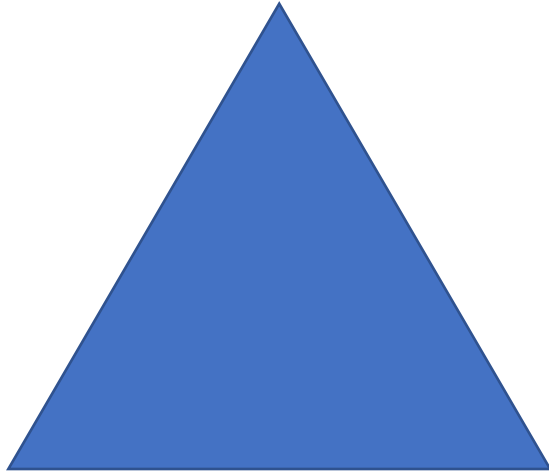
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Yuk menggambar!



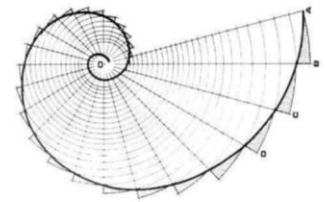
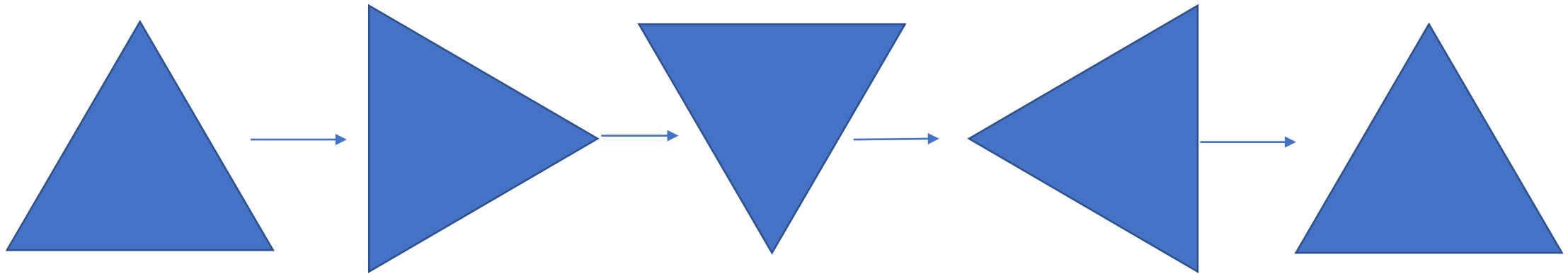
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Yuk menggambar!



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Yuk menggambar!



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Yuk menggambar!

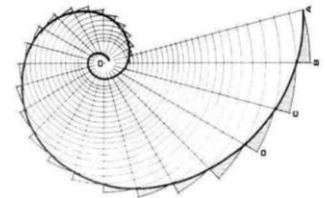
$$R_{\frac{\pi}{2}} \circ R_{\frac{\pi}{2}} = R_{\pi}$$

$$R_{\pi} \circ R_{\pi} = I$$

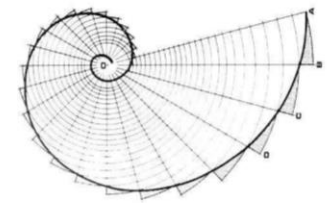
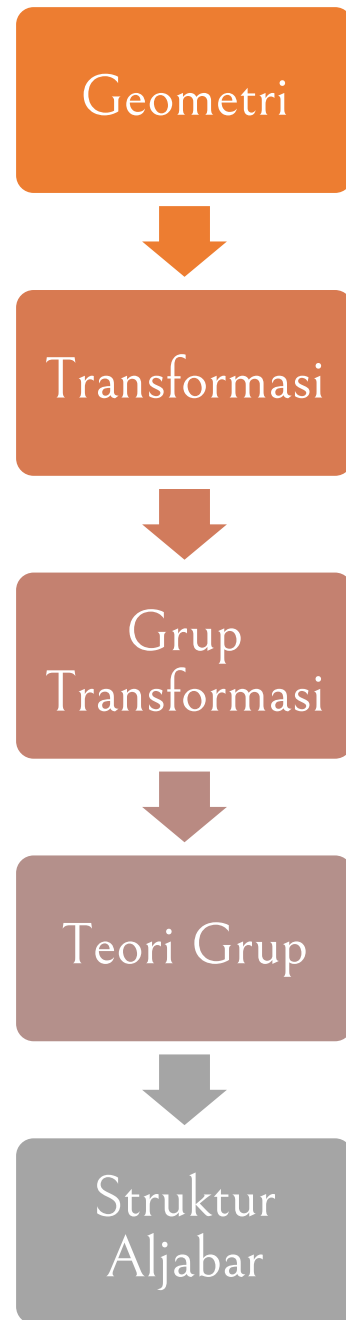
$$R_{\frac{\pi}{2}} \circ R_{-\frac{\pi}{2}} = I$$

⋮

Grup Rotasi: $\{R_{\frac{\pi}{2}}, R_{-\frac{\pi}{2}}, R_{\pi}, I\}$



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



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Geometri



Transformasi



Grup Transformasi



Teori Grup



Struktur Aljabar

Aritmatika



Persamaan linier



Sistem persamaan linier



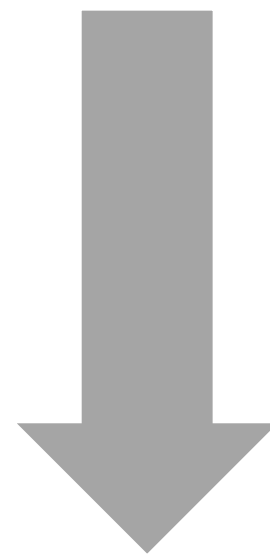
Aljabar linier



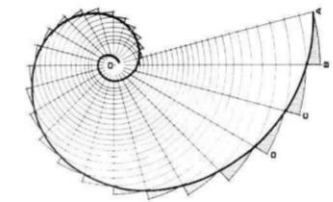
Analisis Matrix



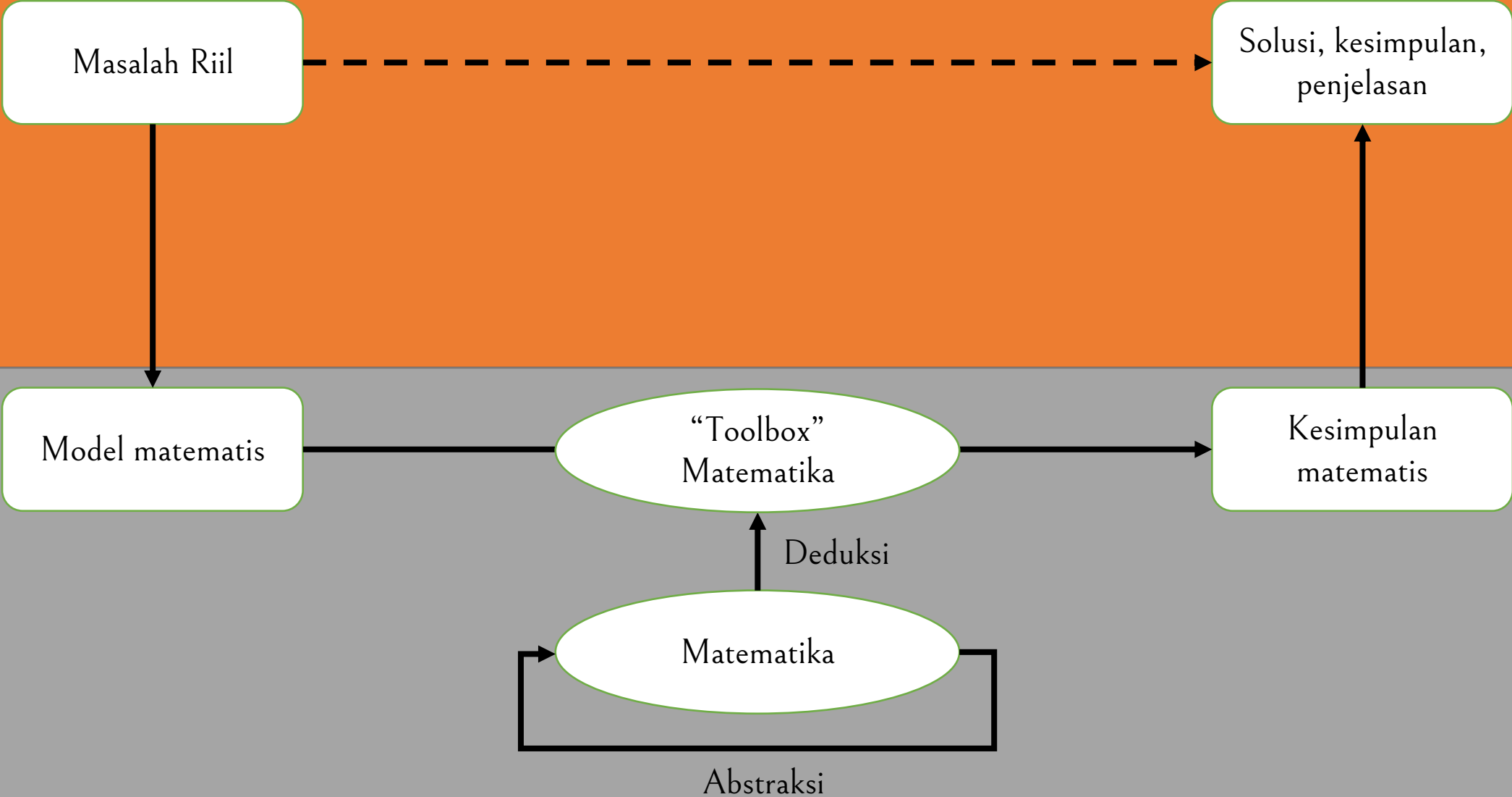
Deduksi



Abstraksi

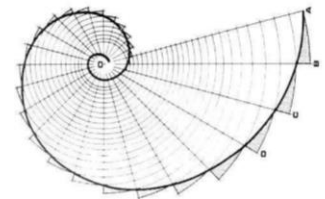


$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$



Menggali Matematika

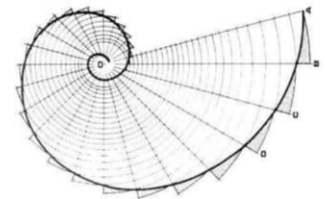
Matematika: Abstraksi + Deduksi



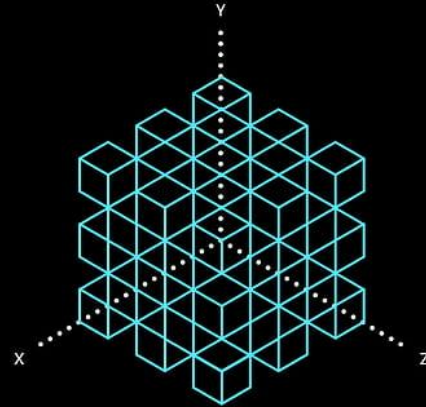
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Menggali Matematika

Kita coba telusuri yuk!



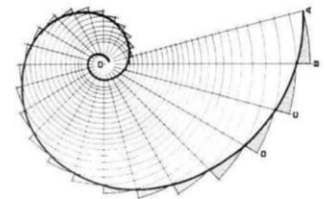
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



Menghayati keutuhan matematika

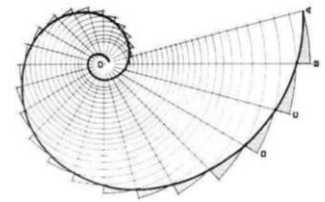
Paling dasar, sekelompok hal di dunia ini
terkadang butuh dienumerasi

Jadilah bilangan bulat



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

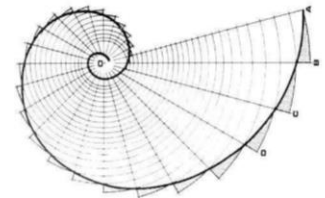
Bilangan Bulat



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Kelompok-kelompok hal ini terkadang bergabung
dan terpisah

Jadilah operasi penjumlahan, pengurangan, perkalian, dan pembagian

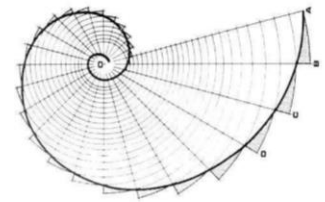


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Bilangan
Bulat



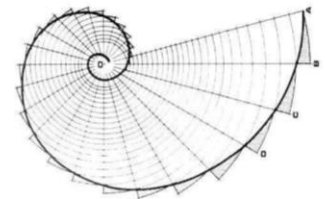
Aritmatika



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Tidak semua enumerasi bisa terbagi.
Di sisi lain, beberapa hal kontinu juga perlu diukur

Jadilah bilangan rasional (dan riil)

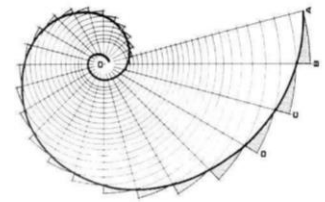


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Bilangan
Riil



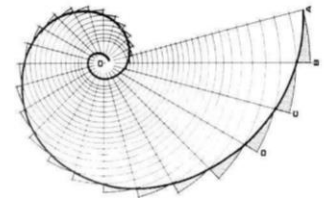
Aritmatika



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Beberapa perhitungan melibatkan nilai-nilai yang belum diketahui, sehingga dibuat aturan dasar penggunaan variabel

Jadilah aljabar



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

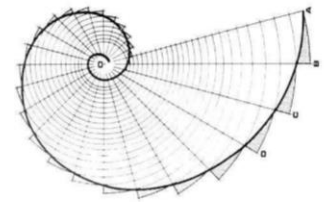
Bilangan Riil



Aritmatika



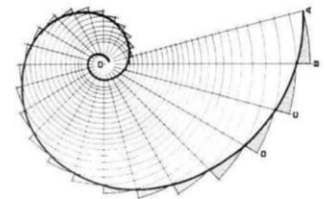
Aljabar



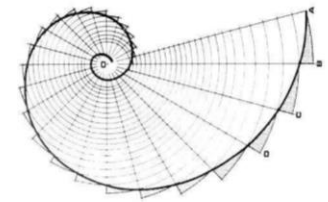
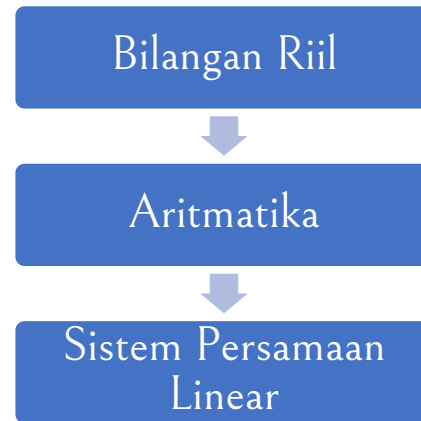
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Beberapa perhitungan aljabar memiliki banyak informasi yang saling berkaitan

Jadilah system persamaan linear



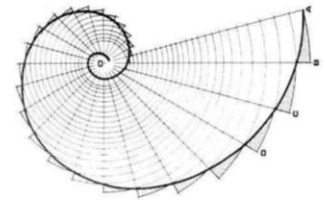
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Sementara itu, manusia butuh memahami bentuk-bentuk untuk bisa mencipta dan membangun

Jadilah konsep geometri dasar



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Bilangan Riil

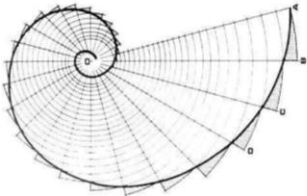


Aritmatika



Sistem Persamaan
Linear

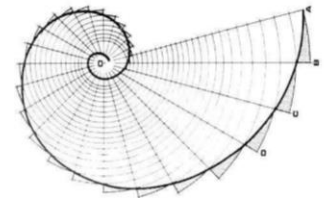
Geometri Euklid



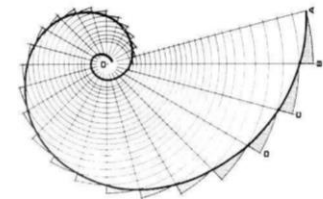
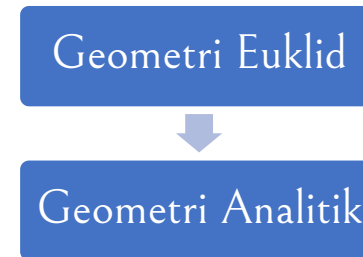
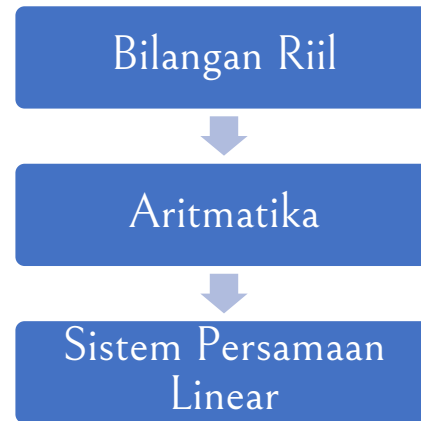
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Manusia mulai berusaha memanipulasi gerak

Jadilah geometri kartesius dan konsep vektor



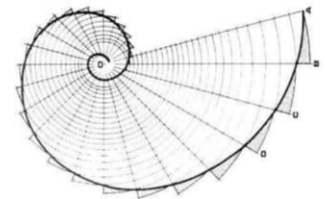
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$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Sifat-sifat vektor diformalisasi untuk memudahkan perluasan aplikasi

Jadilah konsep ruang vektor



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Bilangan Riil



Aritmatika



Sistem Persamaan Linear

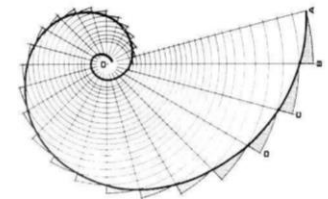
Geometri Euklid



Geometri Analitik



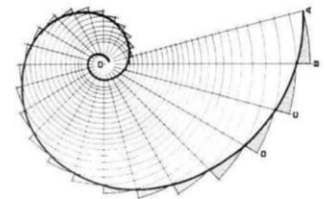
Ruang Vektor



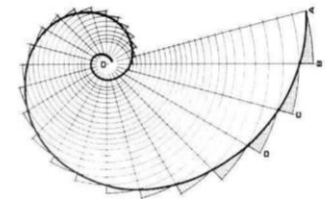
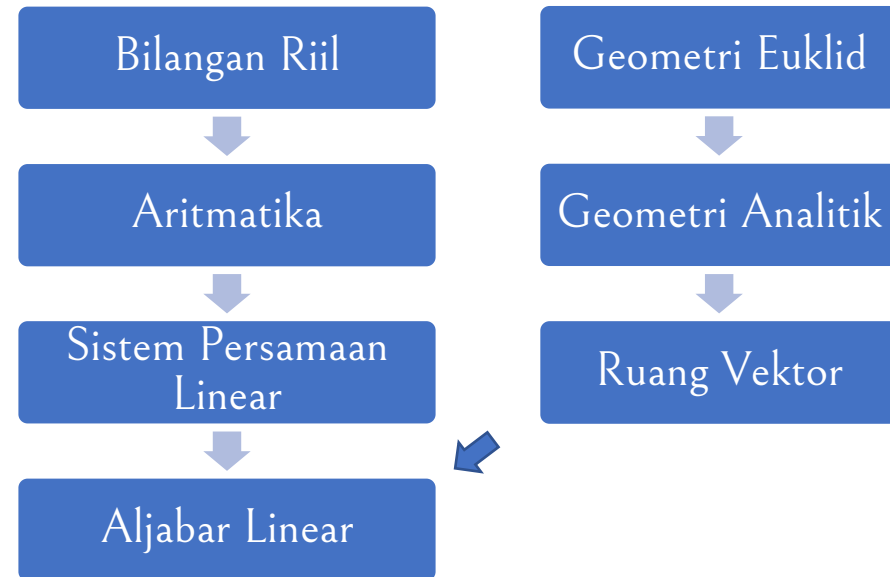
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Konsep ruang vektor ternyata dapat diperluas untuk menyelesaikan SPL

Jadilah aljabar linear



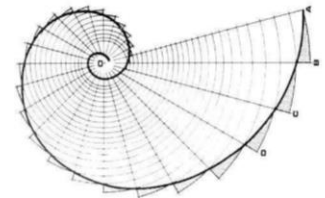
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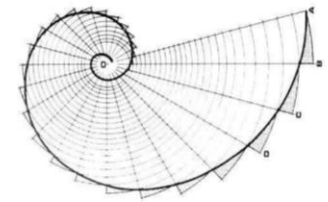
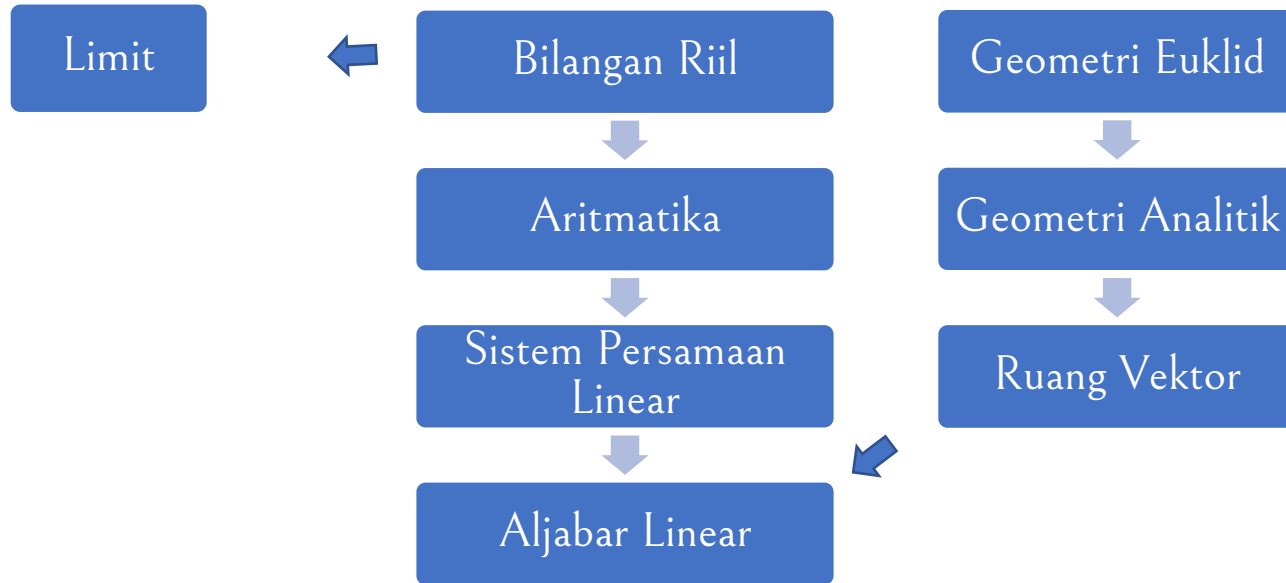
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Dunia ini selalu bergerak dan berubah, maka
pemahaman akan konsep kontinu

Jadilah konsep limit



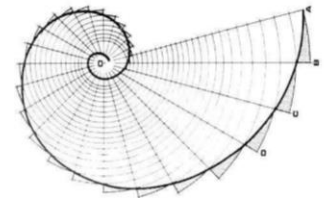
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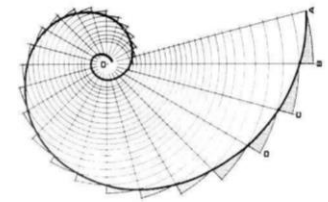
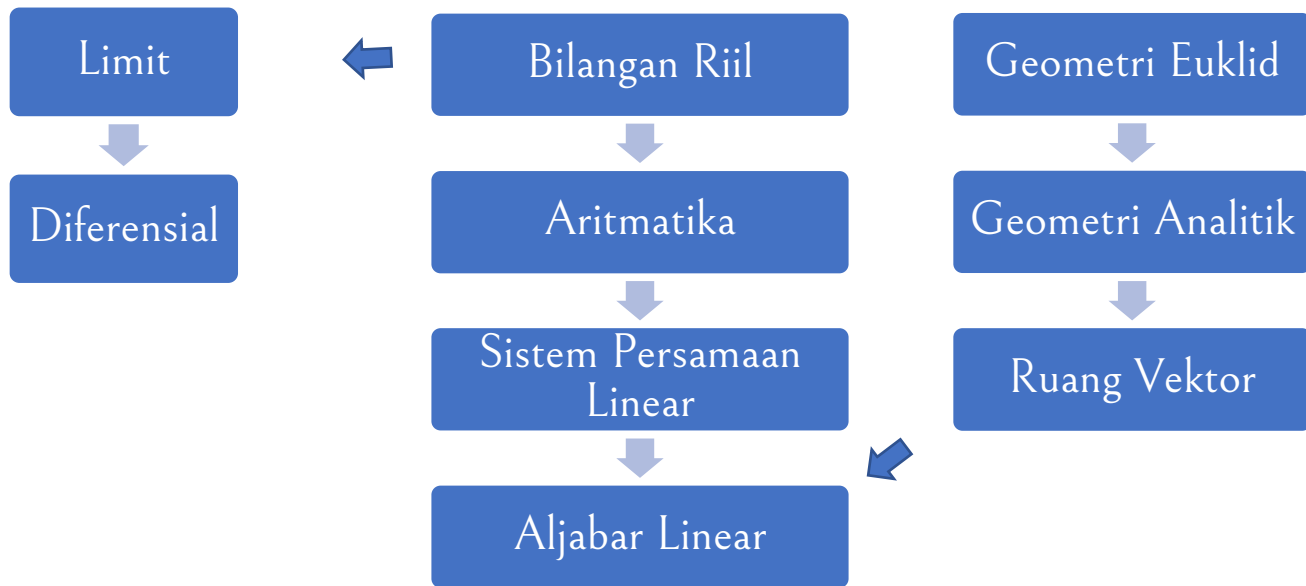
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Konsep mekanika disempurnakan seiring fisika berkembang

Dan dengan itu juga berkembang konsep turunan



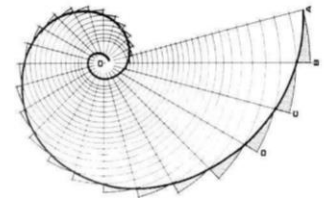
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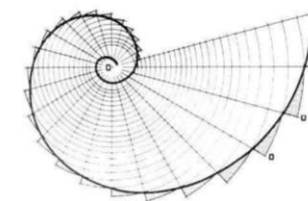
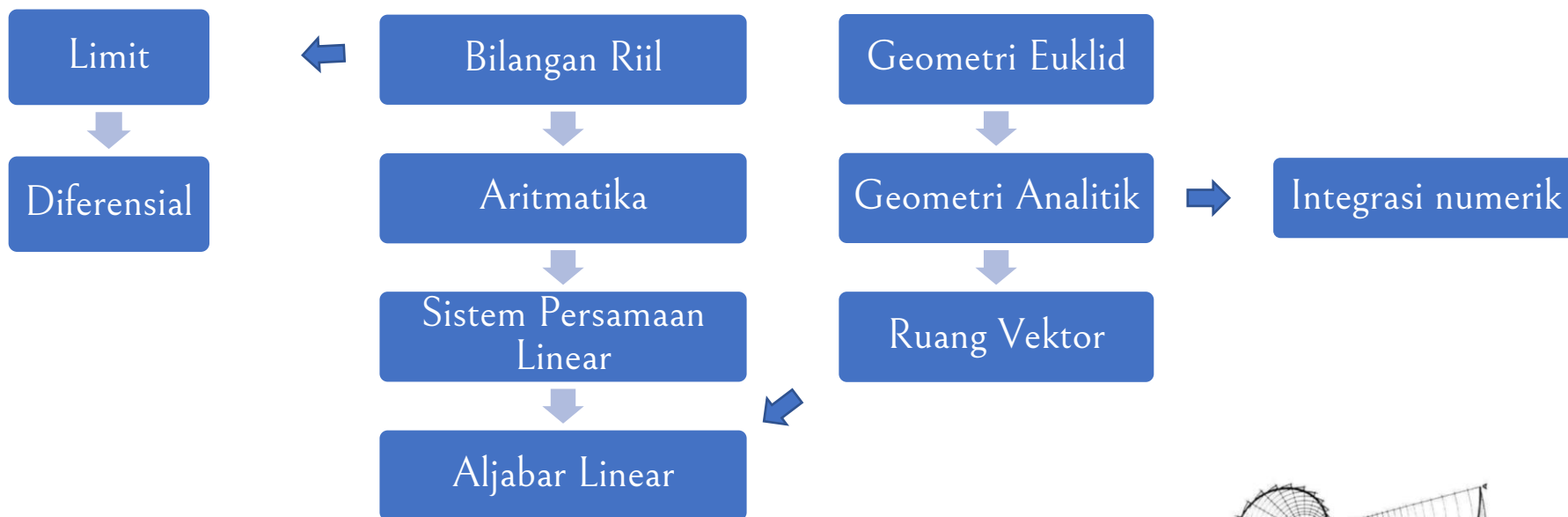
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Di tempat lain, beberapa bentuk geometri tidak berbentuk sehingga sukar dihitung luas/volumenya

Jadilah metode-metode integrasi numerik



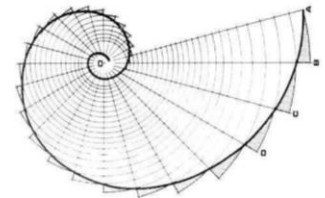
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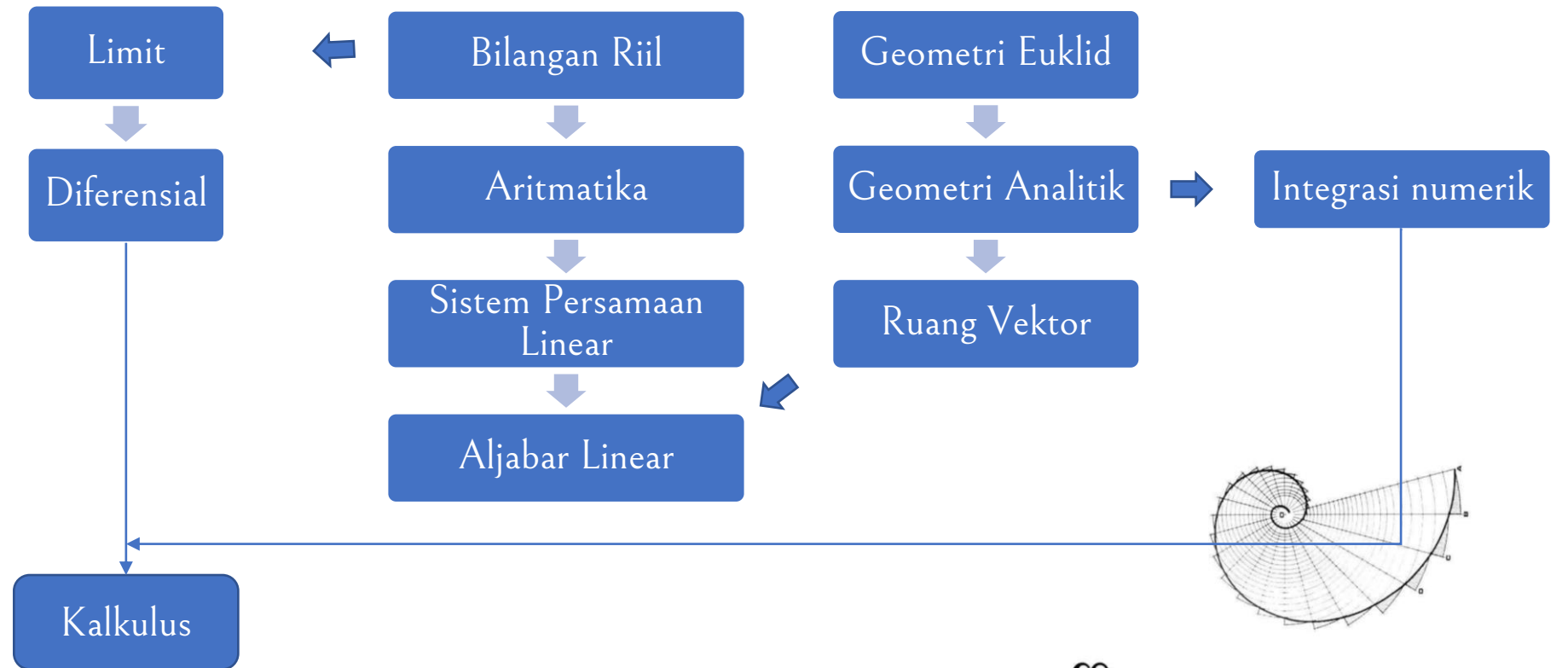
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Ternyata, salah satu integrasi numerik, yakni jumlah Riemann, terkait dengan konsep anti-turunan

Jadilah kalkulus



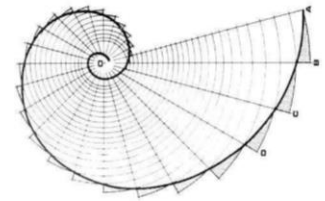
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Sementara itu, kembali ke...

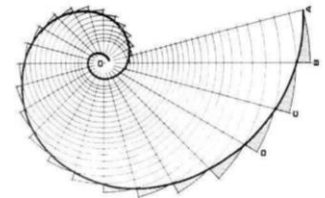
Bilangan Bulat



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Beberapa orang cukup tertarik dengan bilangan bulat, dan menemukan banyak sifat khusus

Jadilah teori bilangan

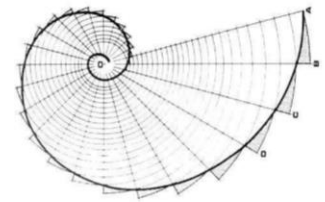


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Bilangan Bulat



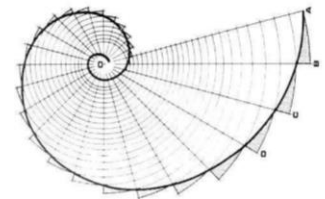
Teori Bilangan



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Teori bilangan berkembang dan menyusun struktur-struktur baru.

Jadilah konsep lapangan (hingga)



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

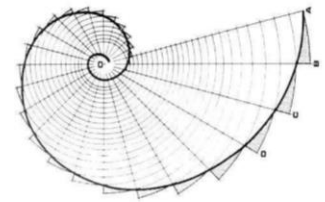
Bilangan Bulat



Teori Bilangan



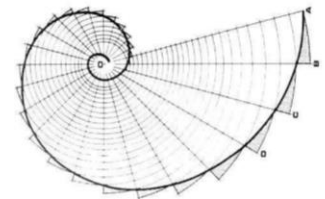
Lapangan hingga



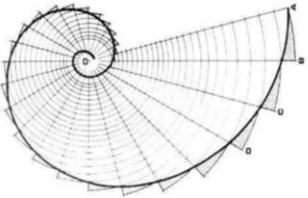
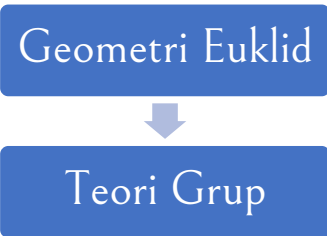
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Sementara ternyata geometri euklid sendiri punya banyak sifat transformasi yang dapat diperumum

Jadilah teori grup



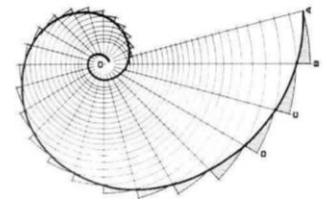
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



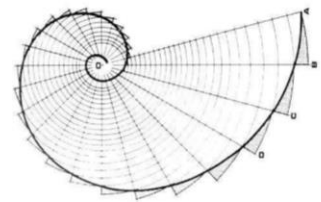
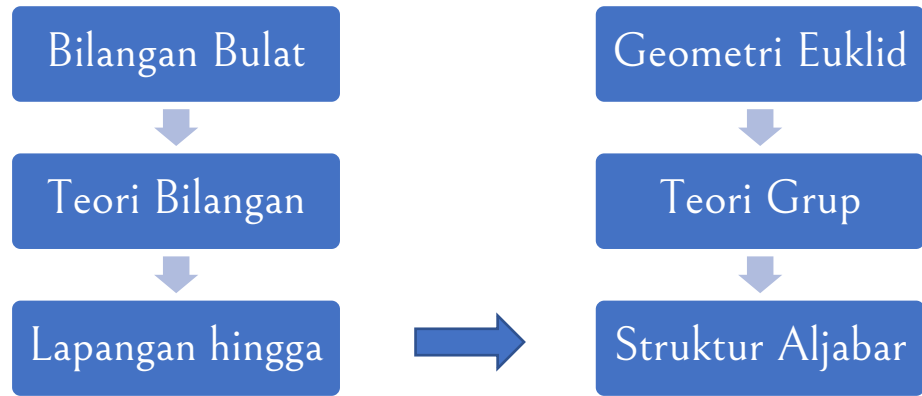
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Teori grup dan konsep lapangan diperluas dan dikaitkan

Jadilah aljabar modern (struktur aljabar)



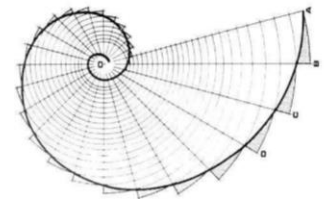
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



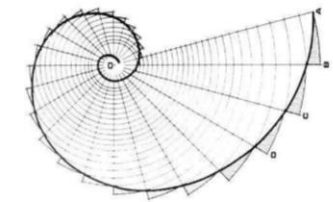
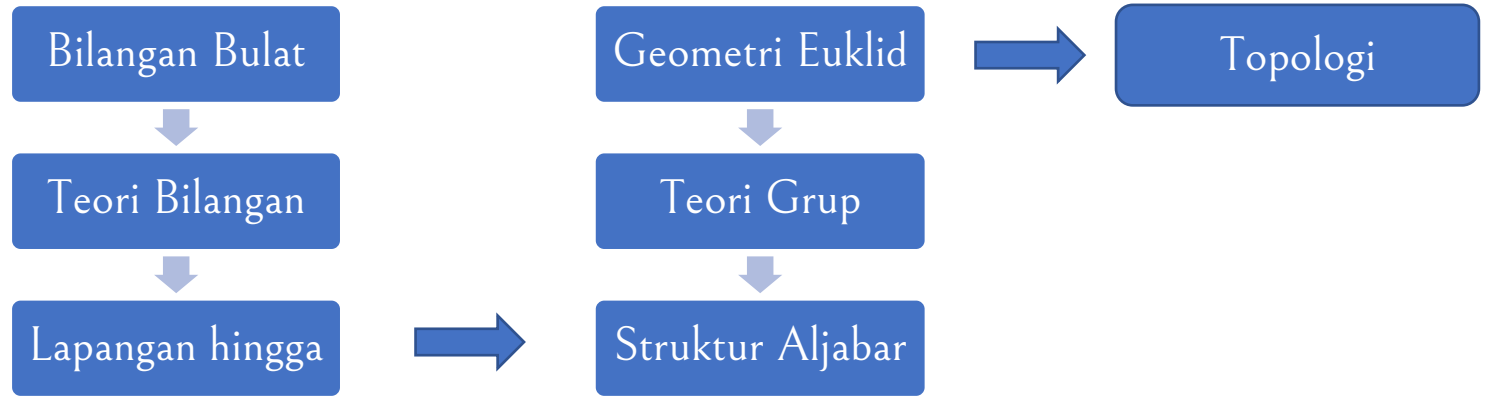
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Konsep geometri diperluas lagi menjadi konsep ruang yang lebih umum, dimana hanya melihat titik-titik dalam himpunan

Jadilah topologi



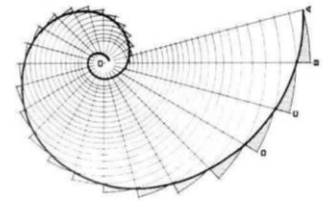
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



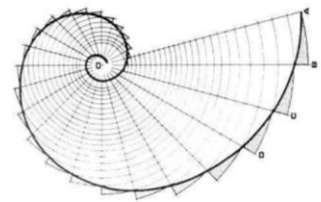
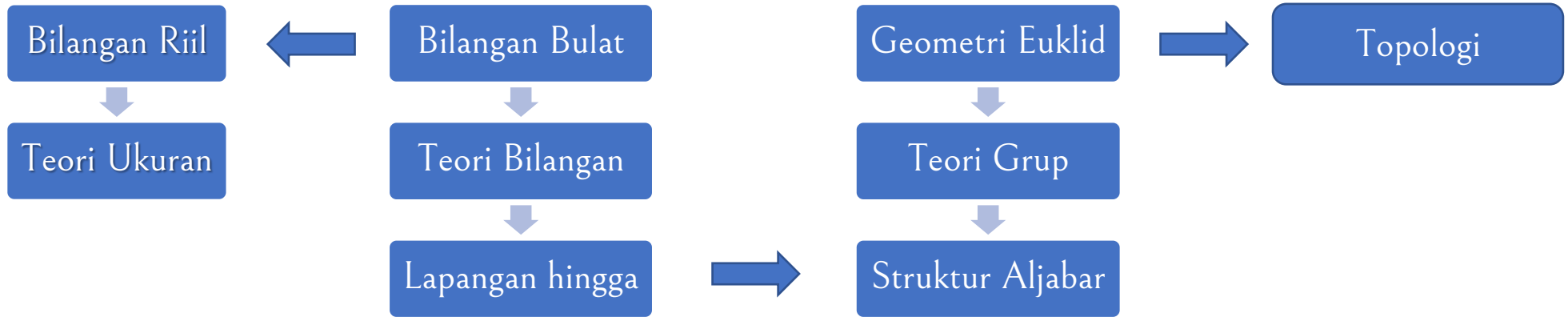
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Di bilangan riil sendiri, konsep fungsi diperluas
dan juga dengan itu perangkat kalkulusnya

Jadilah teori ukuran dan integral Lebesgue



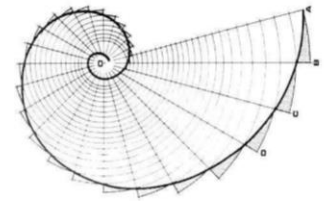
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



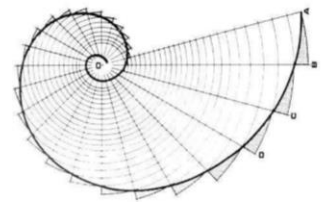
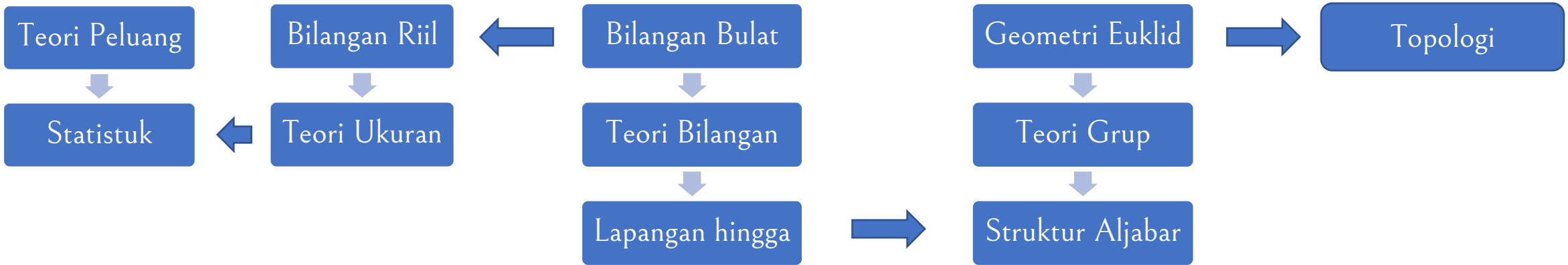
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Teori ukuran digunakan sebagai basis untuk teori peluang

Jadilah statistik

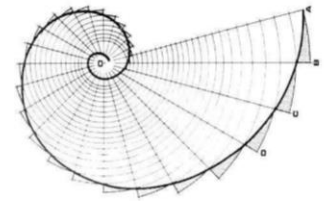


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

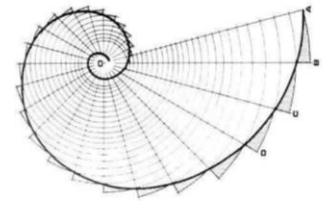
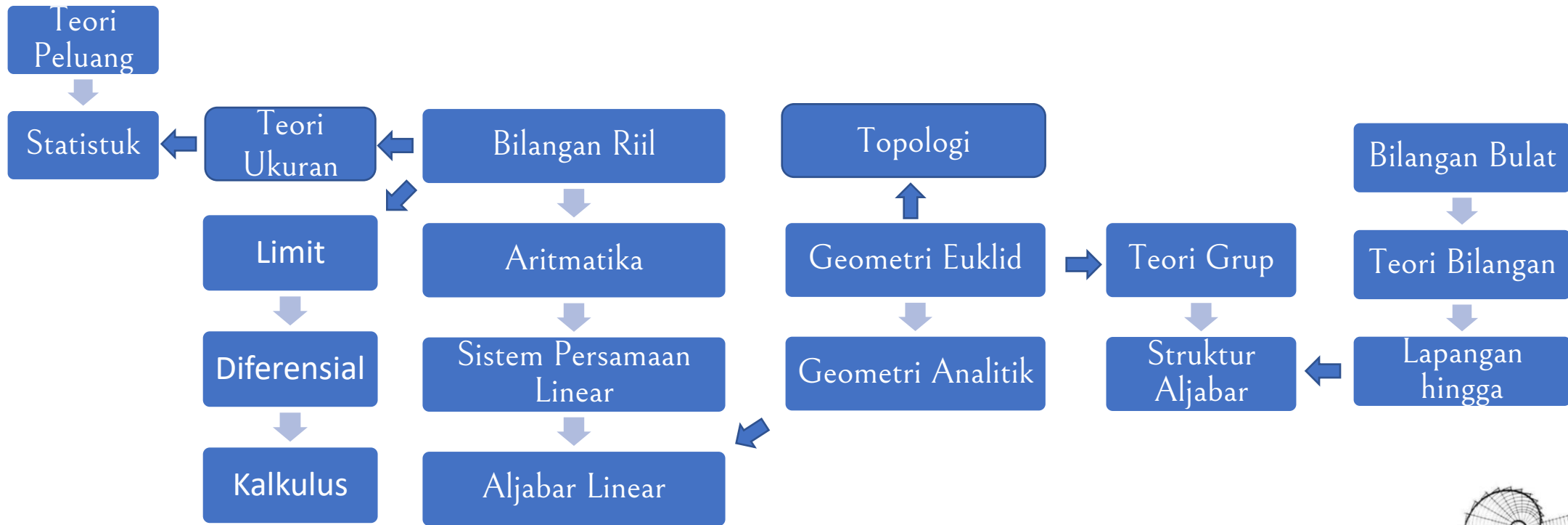


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Fyuh, Let's Summarize

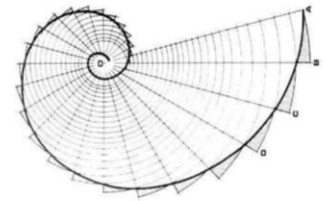


$$\varphi = \frac{1+\sqrt{5}}{2} \simeq 1,618033988749894848204586834365$$

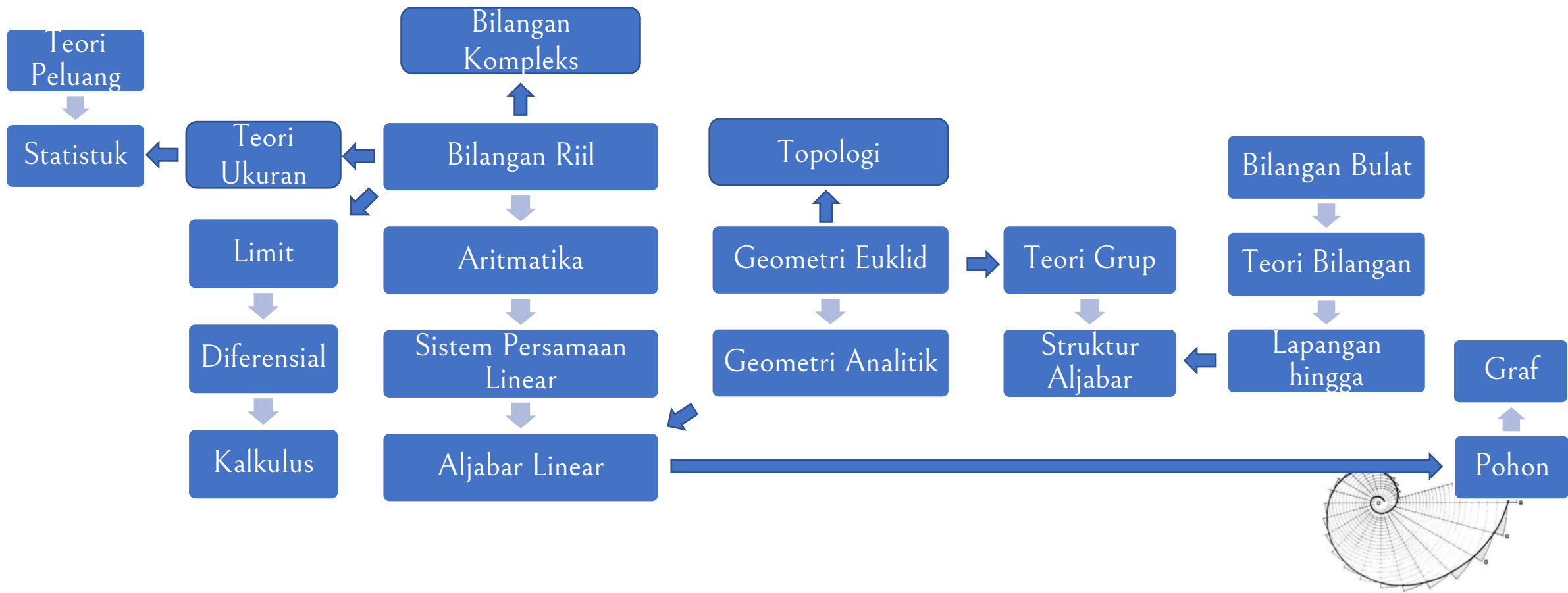


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

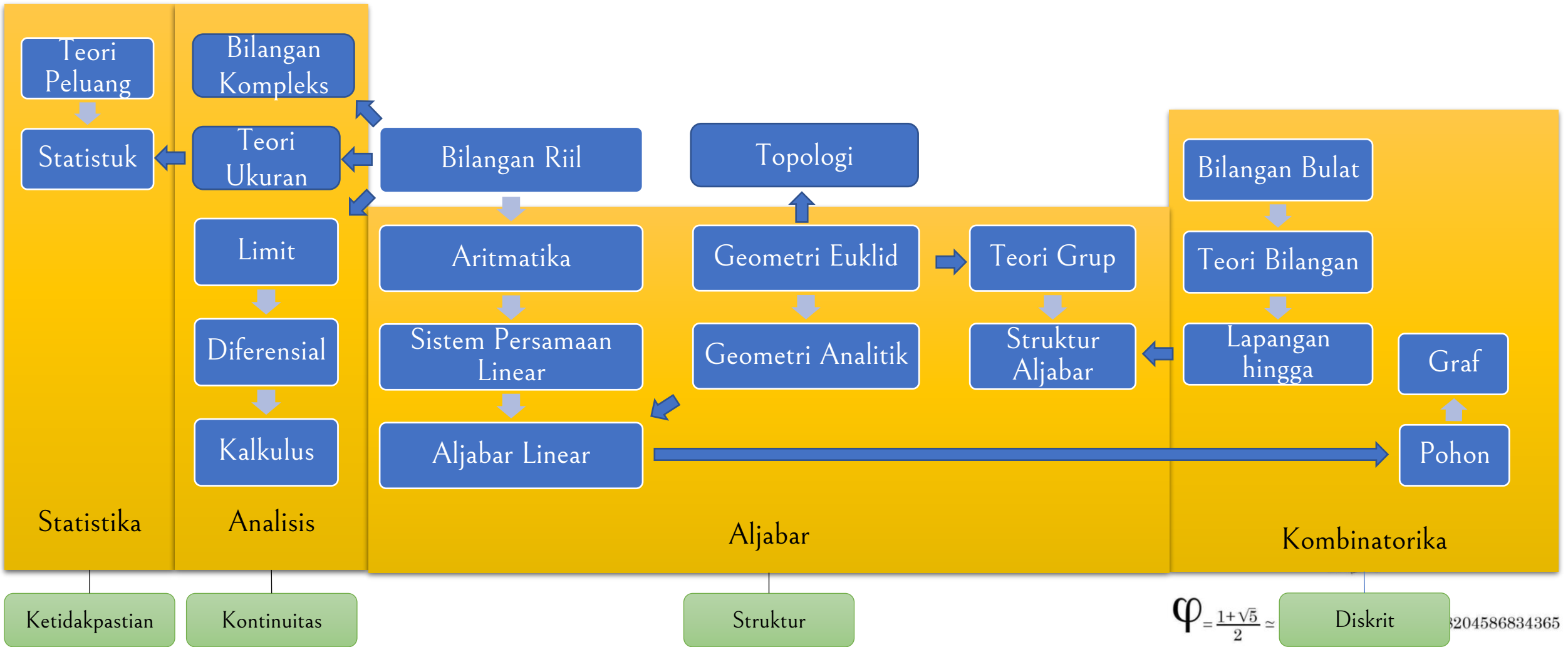
Ups, ada yang terlewat



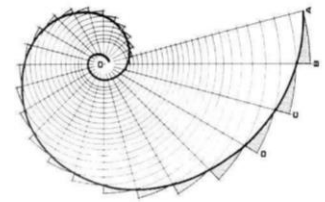
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



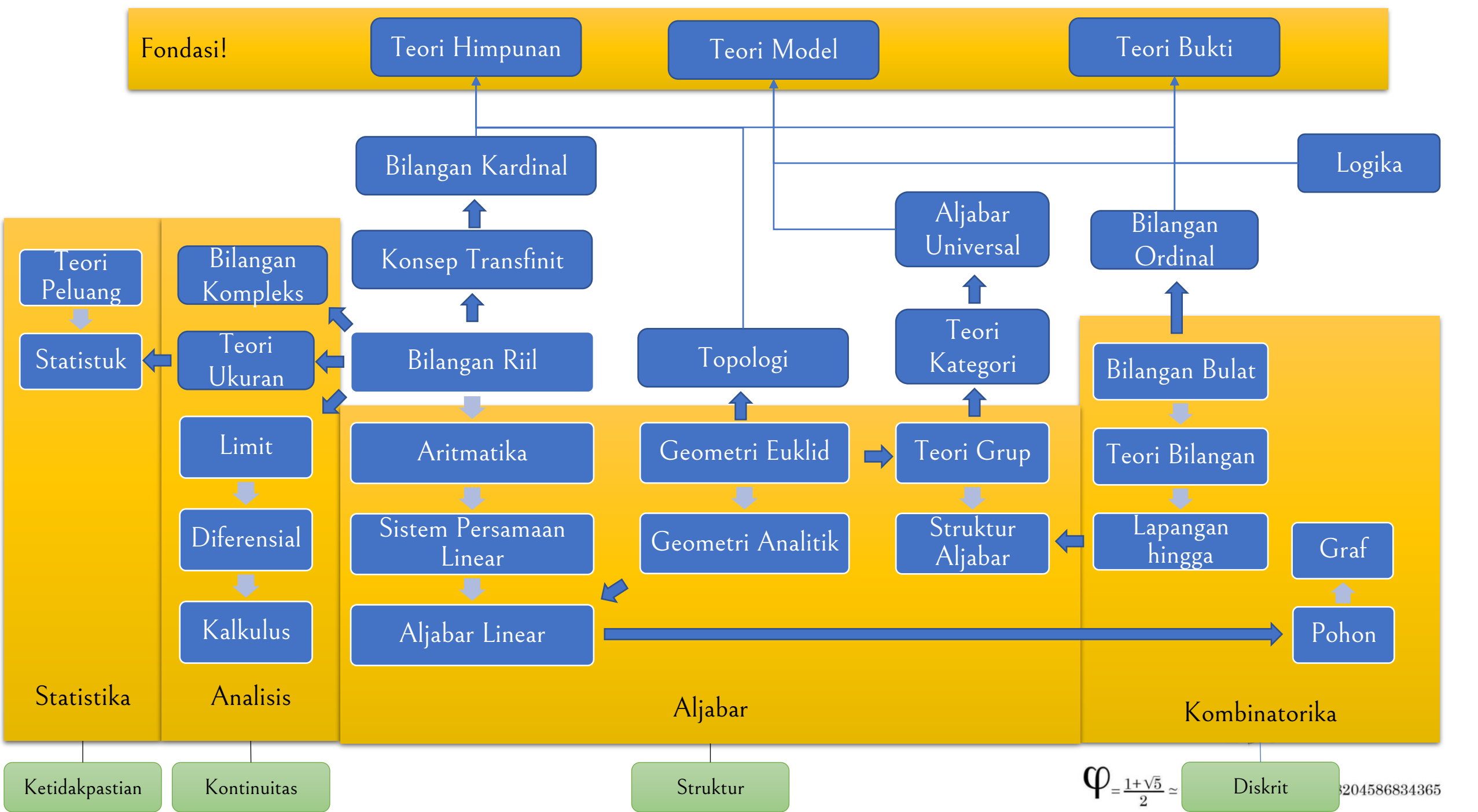
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



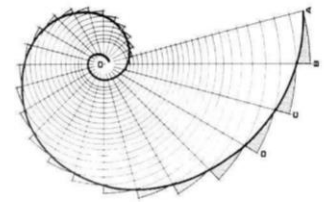
Cukup?



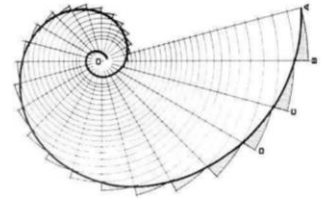
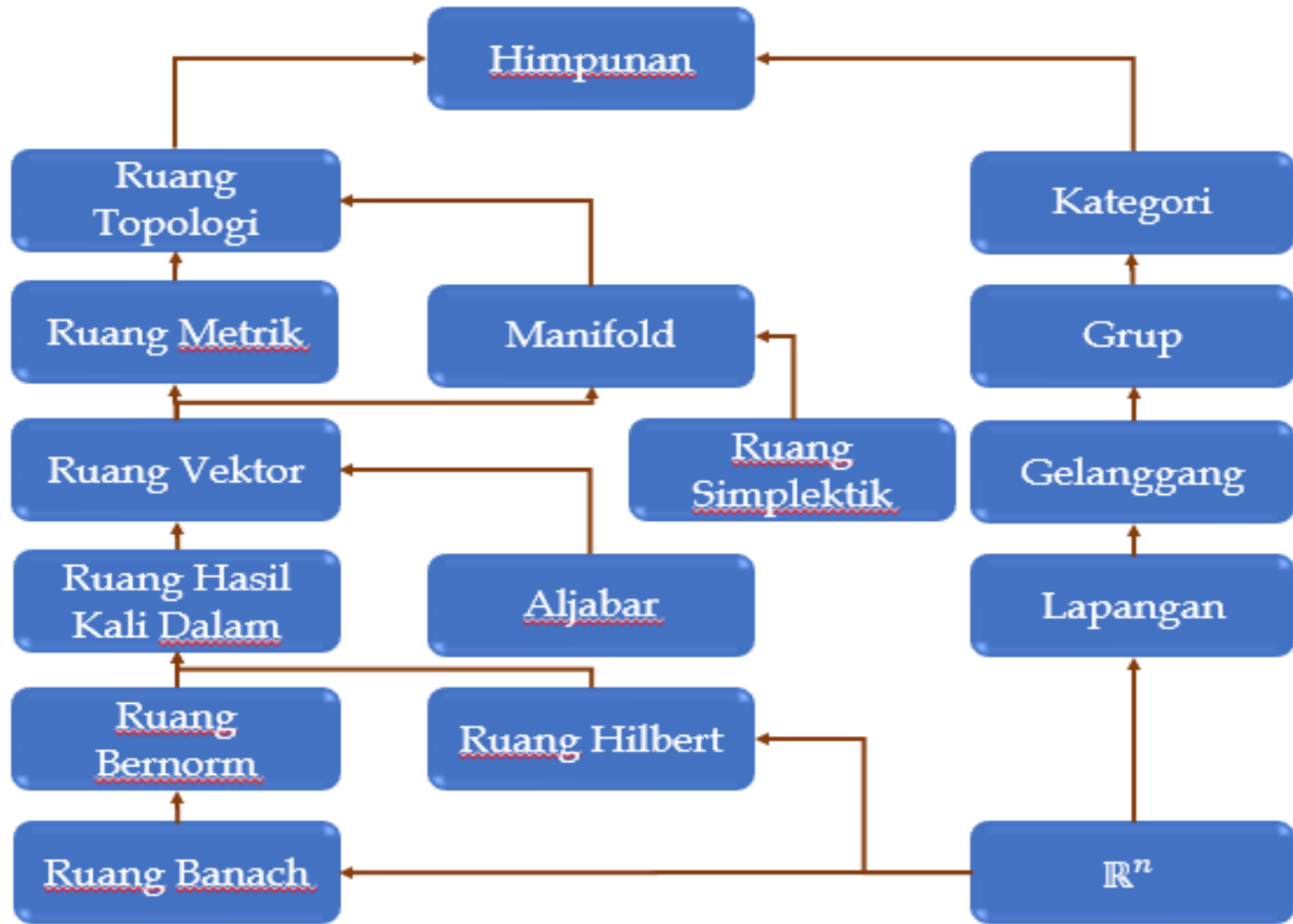
$$\varphi = \frac{1+\sqrt{5}}{2} \simeq 1,618033988749894848204586834365$$



Coba kita zoom in sedikit



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

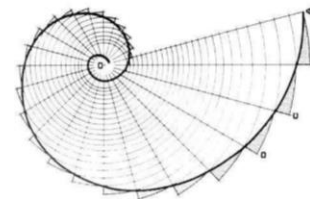


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Group-like structures

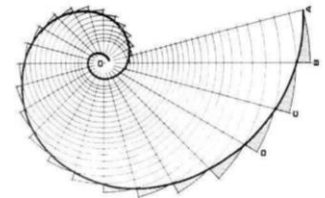
	Totality ^α	Associativity	Identity	Invertibility	Commutativity
Semigroupoid	Unneeded	Required	Unneeded	Unneeded	Unneeded
Small Category	Unneeded	Required	Required	Unneeded	Unneeded
Groupoid	Unneeded	Required	Required	Required	Unneeded
Magma	Required	Unneeded	Unneeded	Unneeded	Unneeded
Quasigroup	Required	Unneeded	Unneeded	Required	Unneeded
Unital Magma	Required	Unneeded	Required	Unneeded	Unneeded
Loop	Required	Unneeded	Required	Required	Unneeded
Semigroup	Required	Required	Unneeded	Unneeded	Unneeded
Inverse Semigroup	Required	Required	Unneeded	Required	Unneeded
Monoid	Required	Required	Required	Unneeded	Unneeded
Commutative monoid	Required	Required	Required	Unneeded	Required
Group	Required	Required	Required	Required	Unneeded
Abelian group	Required	Required	Required	Required	Required

^αClosure, which is used in many sources, is an equivalent axiom to totality, though defined differently.

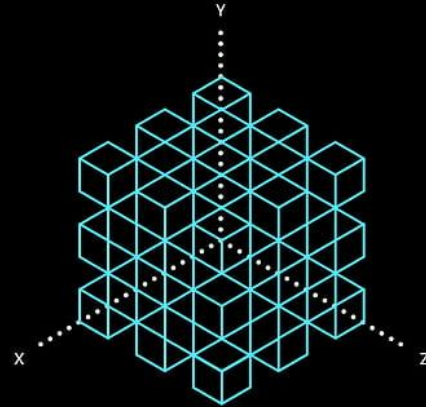


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Proses abstraksi ini dapat dilakukan terus, karena pada dasarnya pohon itu bentuknya seperti ini



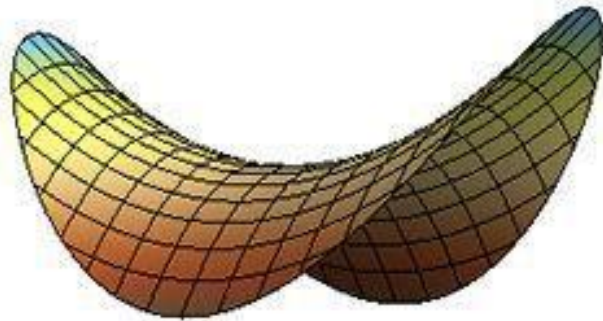
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



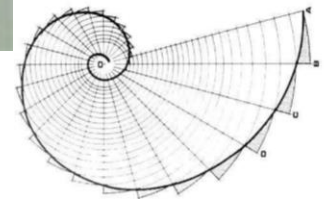
Lah, yang terapan bagaimana?

1. Geometri + Kalkulus = Geometri Diferensial

Desain kurvatur, fisika relativitas, pemodelan membrane, analisis permukaan (computer vision)



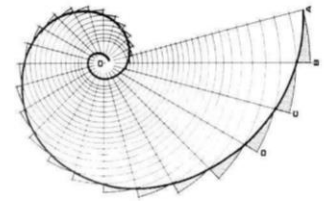
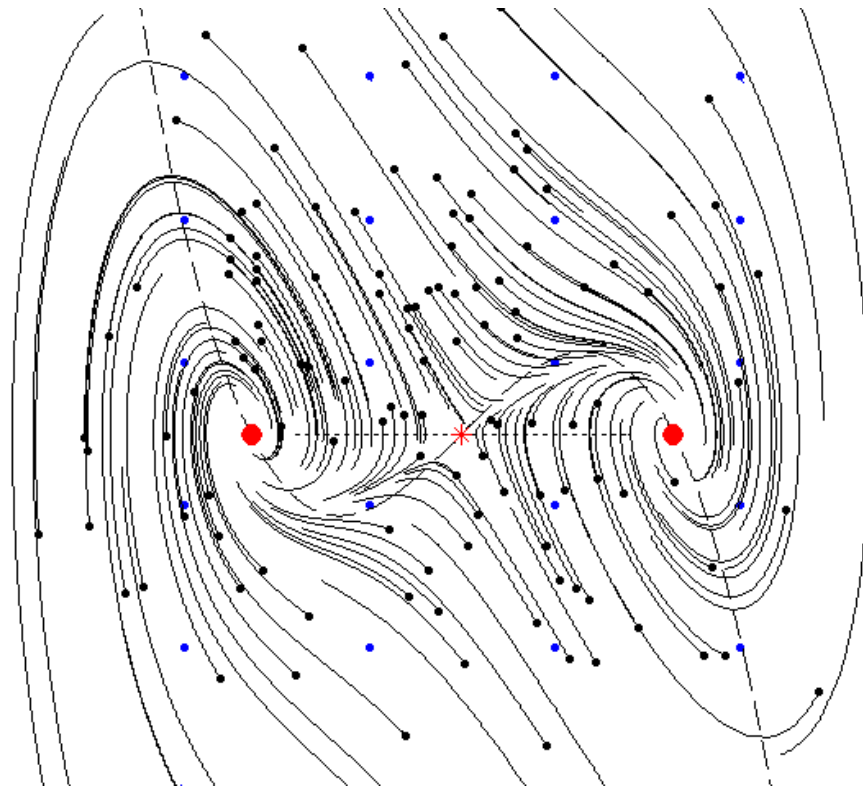
$$z = \frac{x^2}{a^2} - \frac{y^2}{b^2}, \quad \frac{x^2}{a^2} + \frac{y^2}{b^2} < 1$$



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

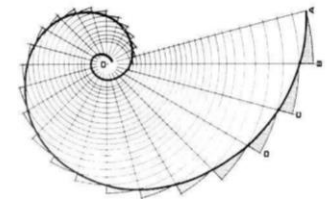
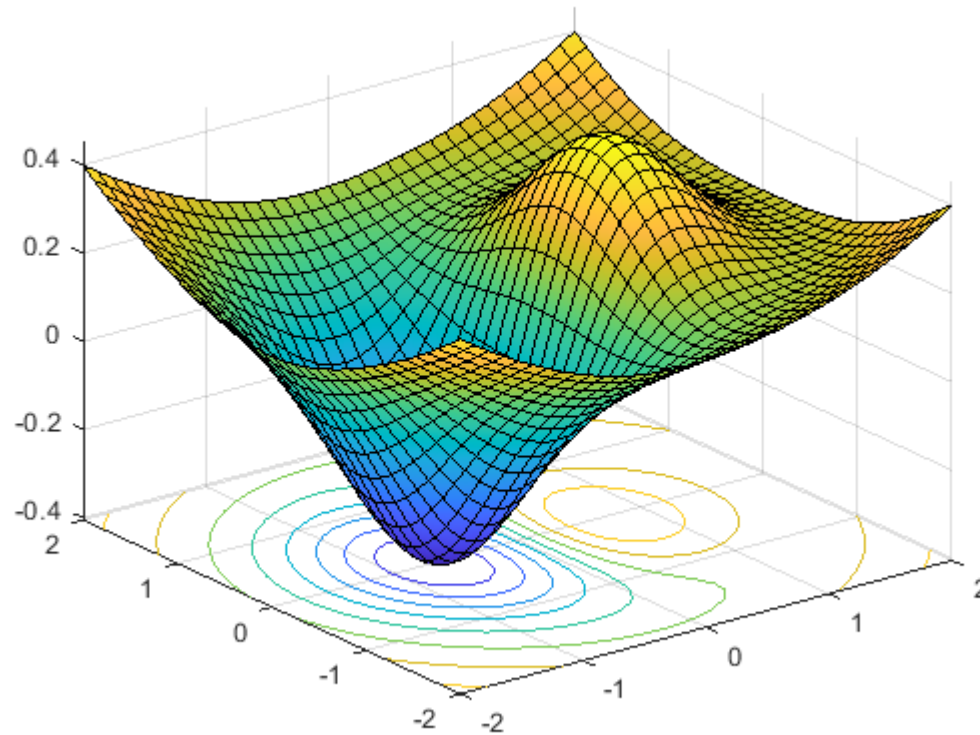
2. Kalkulus + Aljabar Linear = Sistem Dinamik

Analisis perubahan system, dinamika populasi,
biomatematika, epidemiologi, mekanika



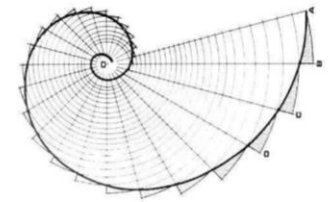
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

3. Kalkulus + Aljabar Linear = Optimisasi Penjadwalan, rekayasa kontrol, decision-making, machine learning, analisis efisiensi



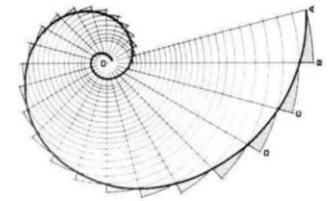
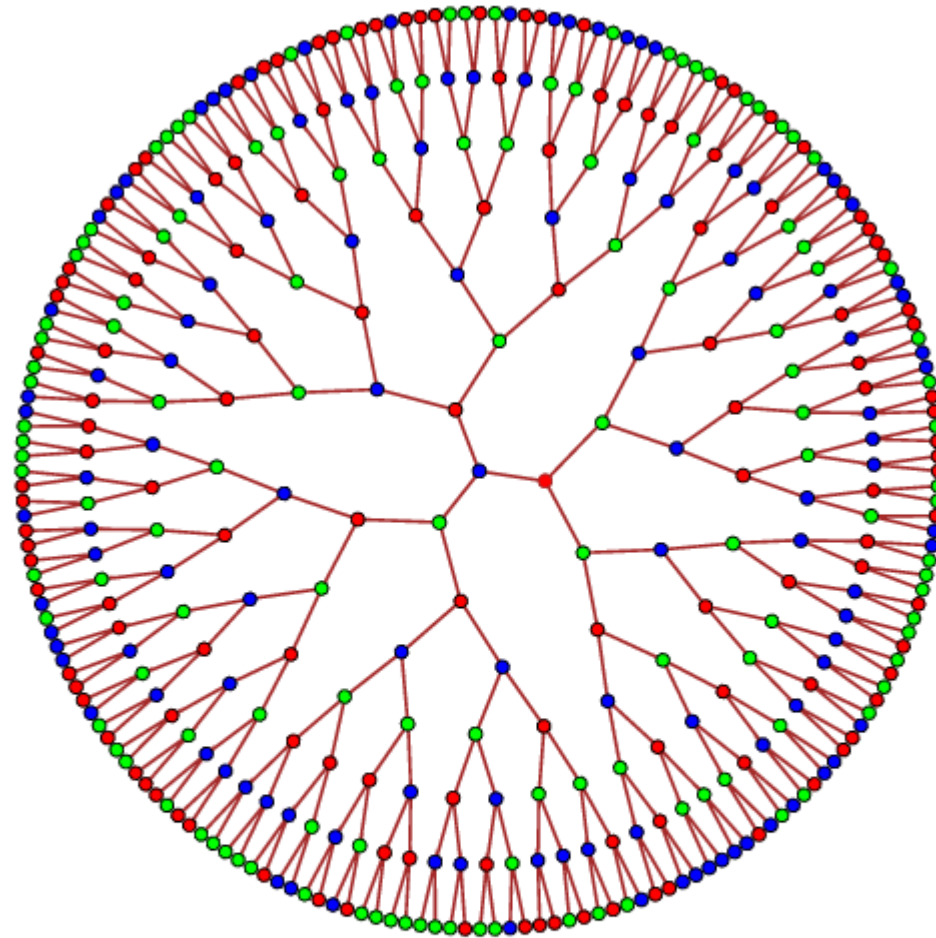
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

4. Teori Bilangan + Struktur Aljabar = Kriptografi, Teori Koding



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

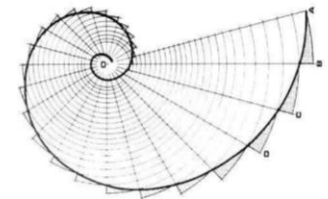
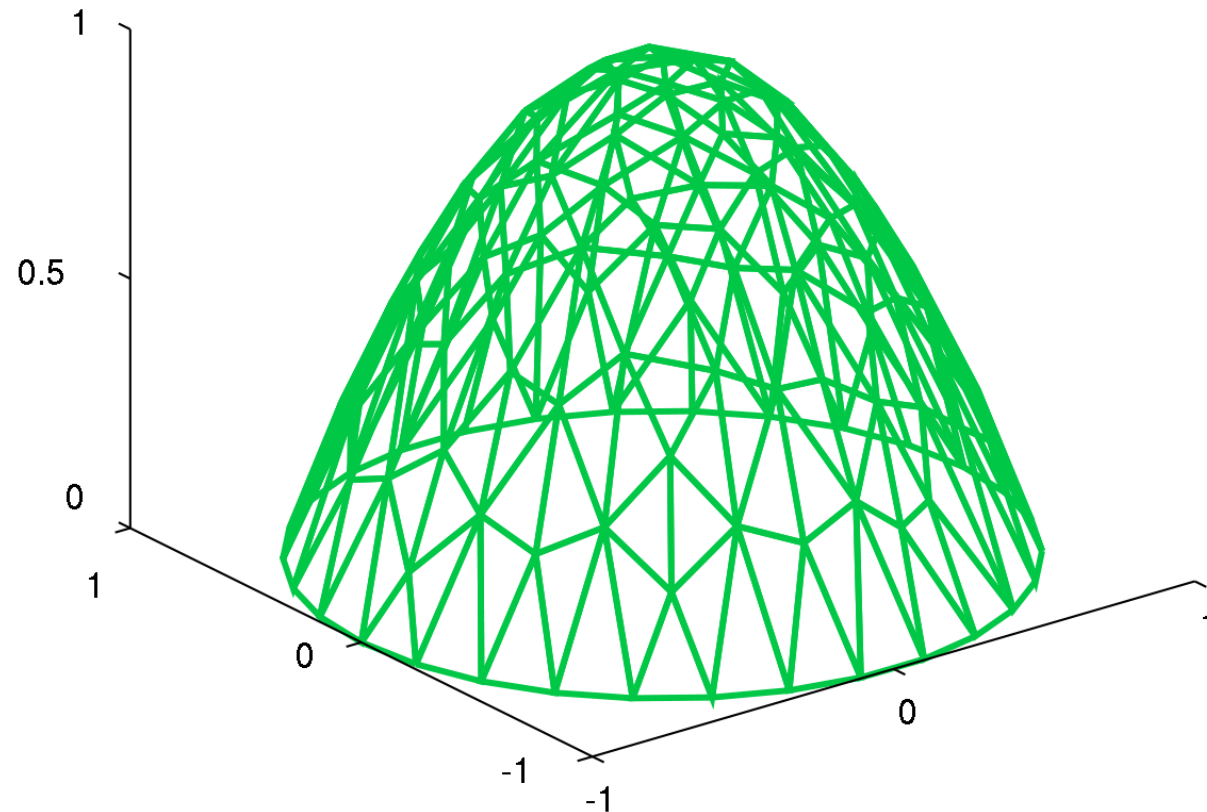
5. Statistika + Aljabar Linier = Proses Stokastik
Teori Resiko, aktuarial, teori antrian, gerak acak,
reinforcement learning



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

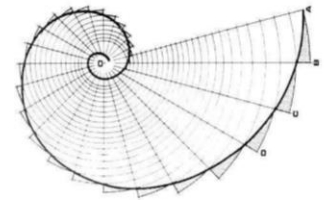
6. Statistika + Kalkulus + MatDiskrit = Analisis Numerik

Regresi, Interpolasi, Persamaan Beda, Integrasi numerik



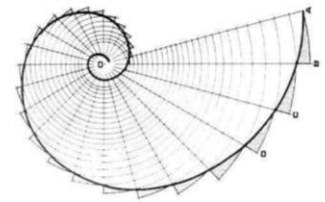
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

7. Graf + Topologi + Statistik = Teori Jaringan Social Network Analysis, Computer Network, dll



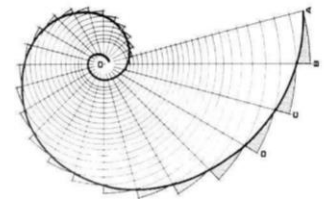
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Dan.. Masih banyak lagi

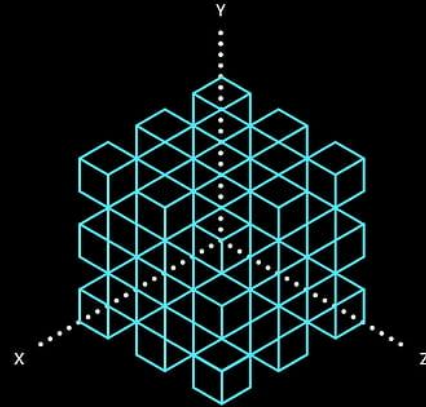


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

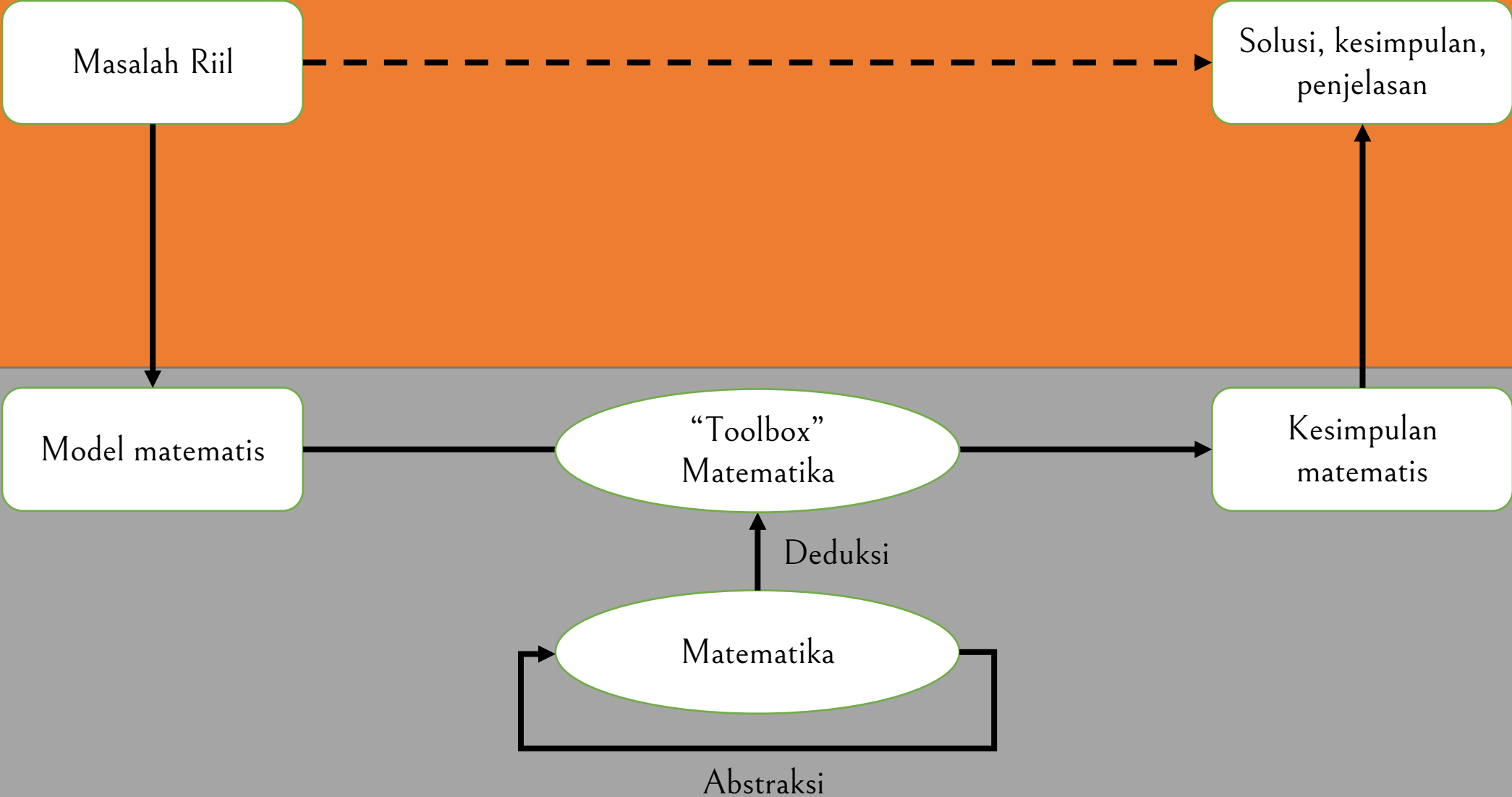
Matematika terapan adalah penggunaan toolbox yang sudah tersedia



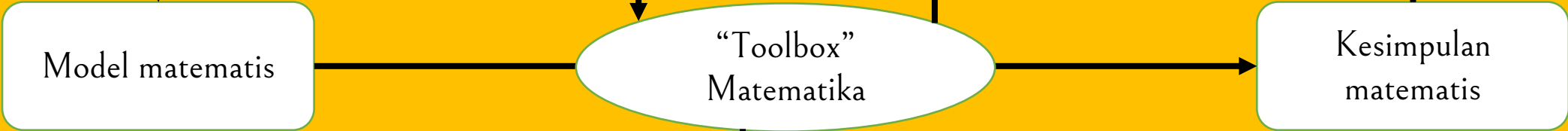
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



Teori vs Terapan?



Dunia nyata

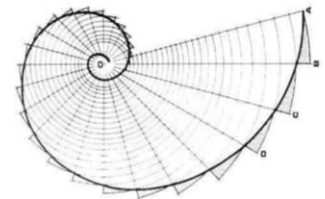


Matematika Terapan + Teknik



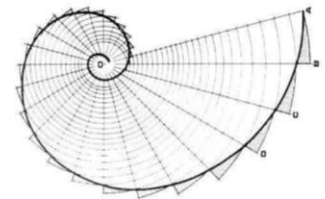
Matematika Murni

Apa yang bisa dipakai matematikawan terapan, adalah akumulasi apa yang dikembangkan di dunia murni

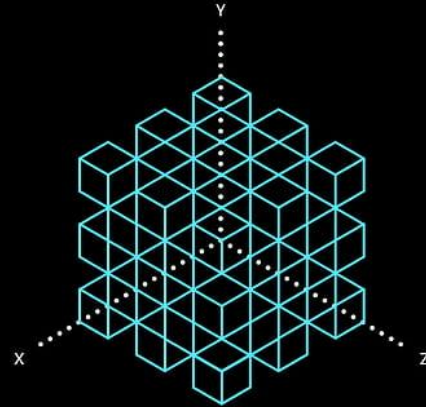


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Namun juga, sebagian teknik dan metode di matematika terapan justru berkembang di ilmu lain (terutama fisika)



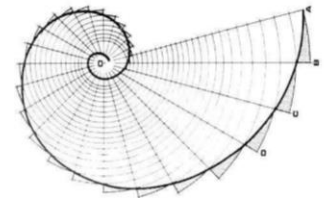
$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



Bagaimana cara memilihnya?

1. Memahami peta utuh

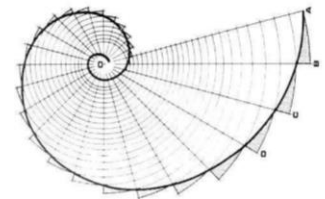
Gagal melihat keseluruhan,
akan gagal menentukan arah perjalanan,
atau terasingkan di tengah kerumitan



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

2. Memahami *sense* dari setiap perkembangan

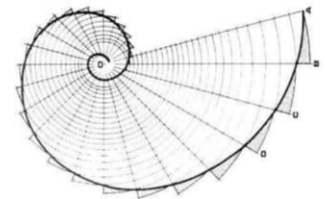
Bukan bertanya untuk apa, tapi kenapa ada yang mau mengembangkannya itu



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

3. Haus Mencari Tahu

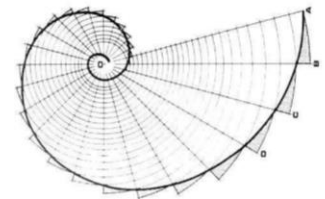
Baca bukan karena ada mata kuliahnya atau
karena mau tugas akhir / tesis



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

4. Berangkat dari Kesenangan

Matematika berkembang selayaknya dua hal, yakni berkembangnya kedokteran dan berkembangnya industri game. Yang pertama, karena dibutuhkan, yang kedua, karena itu menyenangkan.

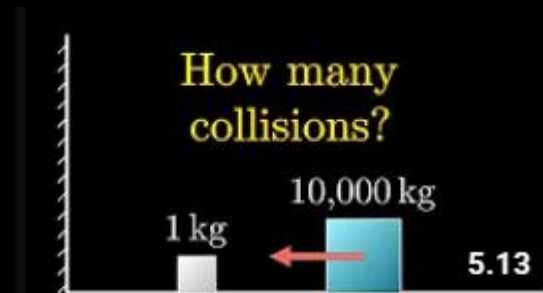


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



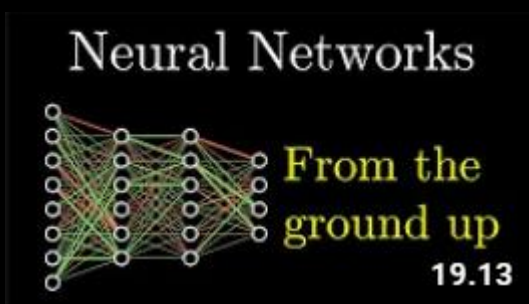
But what is the Fourier Transform? A visual...

3Blue1Brown ✓



The most unexpected answer to a counting puzzle

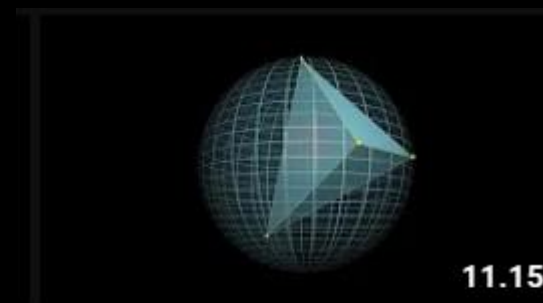
3Blue1Brown ✓



3BLUE1BROWN SERIES S3 · E1

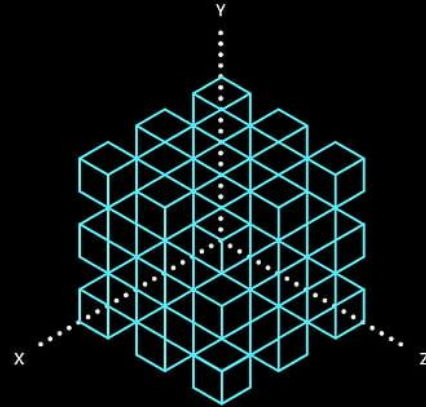
Jadi, apa itu Neural Network? | Deep Learning, bab 1

3Blue1Brown ✓



The hardest problem on the hardest test

3Blue1Brown ✓



Di balik karya Matematika

Dunia nyata

Masyarakat

Sains +
Teknik

Sistem / Produk /
Teknologi /
Kebijakan

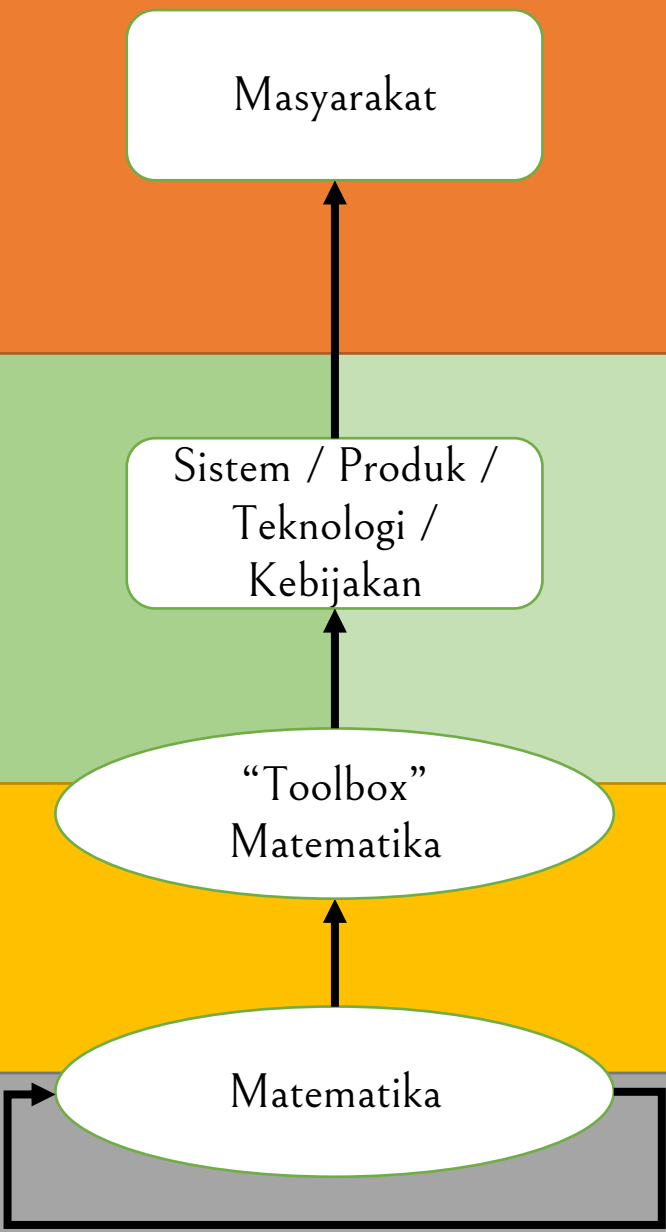
Sosial
Humaniora

“Toolbox”
Matematika

Matematika Terapan

Matematika

Matematika Murni



Dunia Awam

Masyarakat

Pasar / Pemerintah

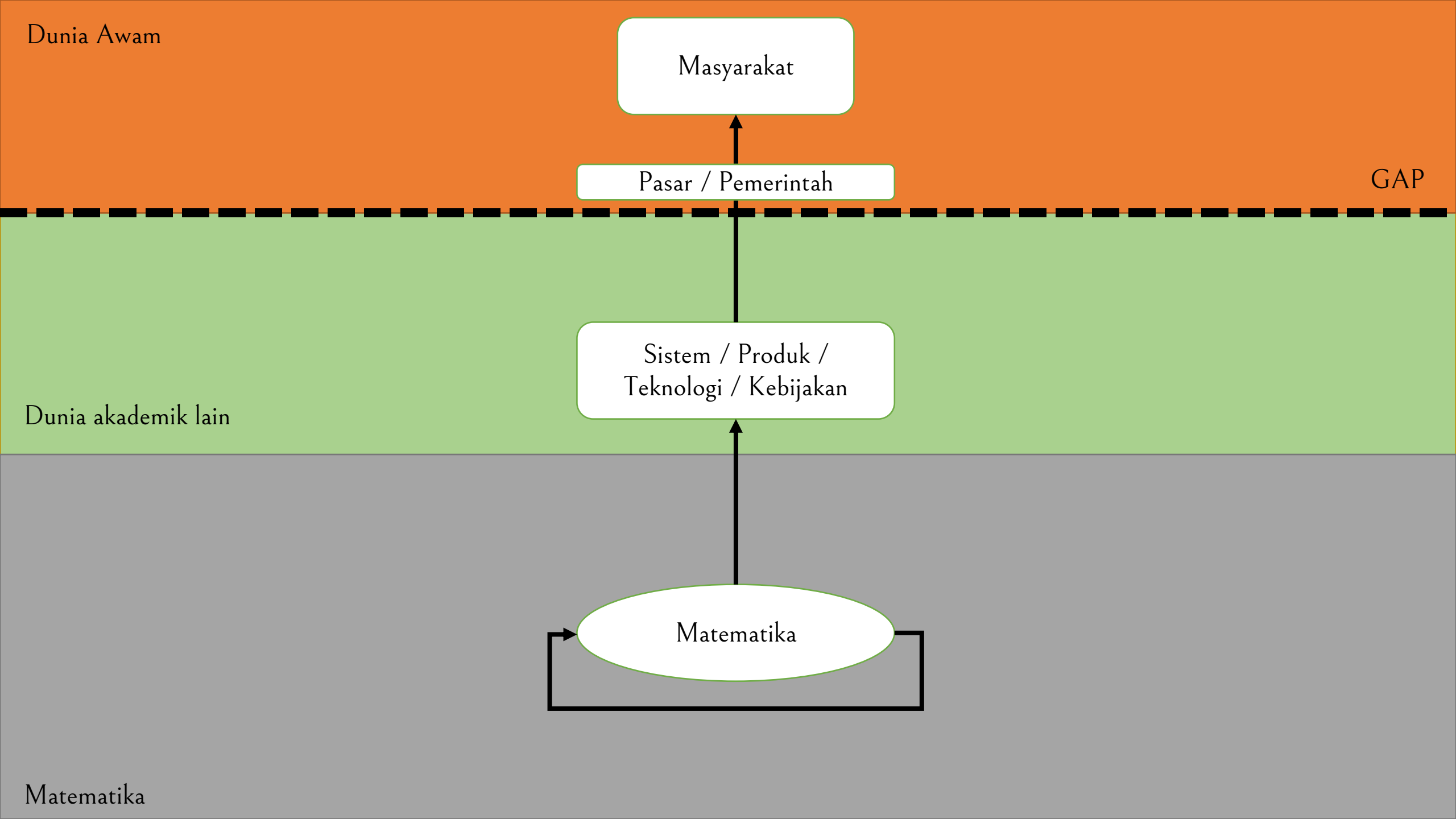
GAP

Dunia akademik lain

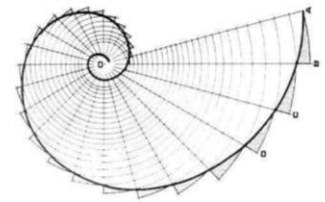
Sistem / Produk /
Teknologi / Kebijakan

Matematika

Matematika



Haruskah dengan cara seperti itu?



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

Dunia Awam

Masyarakat

Pasar / Pemerintah

Sistem / Produk /
Teknologi / Kebijakan

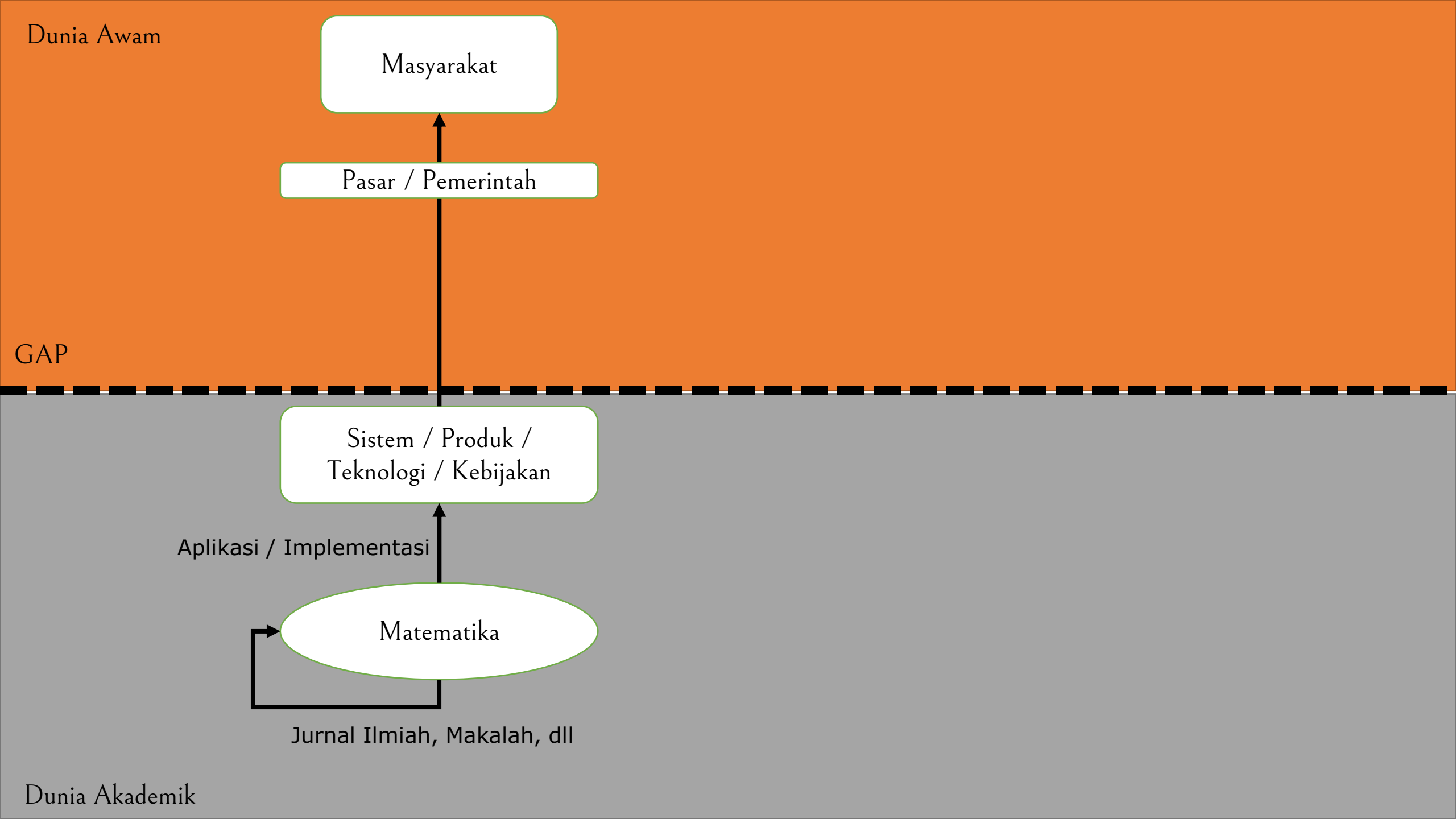
Aplikasi / Implementasi

Matematika

Jurnal Ilmiah, Makalah, dll

GAP

Dunia Akademik



Dunia Awam

Masyarakat

Pasar / Pemerintah

Sistem / Produk /
Teknologi / Kebijakan

Aplikasi / Implementasi

Matematika

Jurnal Ilmiah, Makalah, dll

Pengajaran

Latihan Soal Tes
CPNS, TPA, dll

Buku Cinta /
Nikah / Jodoh

Tips & Trick

Novel

Tutorial

Motivasi

Buku teks

Jurnal

dll

Perbukuan

GAP

Dunia Akademik

Dunia Awam

Masyarakat

Pasar / Pemerintah

Tips & Trick

Cinta / Nikah

Latihan tes

Novel

Motivasi

3Blue1Brown

Numberphile

StandUpMath

dll

Media (Youtube, dll)

Sistem / Produk /
Teknologi / Kebijakan

Pengajaran /
Pendidikan

Buku teks

Jurnal

dll

Perbukuan

Aplikasi / Implementasi

Matematika

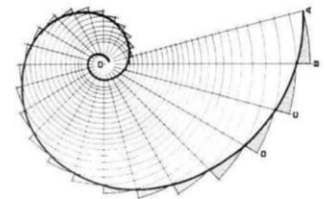
Jurnal Ilmiah, Makalah, dll

GAP

Dunia Akademik

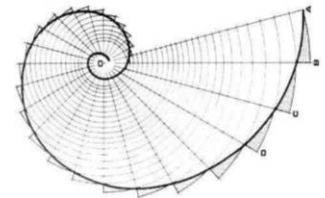
Selama matematikawan sibuk dengan dunianya sendiri,
akan selalu dibutuhkan puluhan tahun hingga ilmu itu
sampai ke masyarakat

Sedangkan manfaat ilmu matematika di masyarakat
bukan hanya dari produknya, tapi dari kemampuan
berpikirkannya

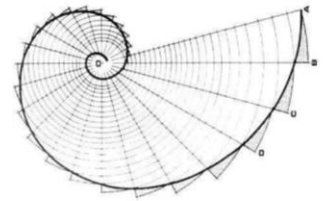
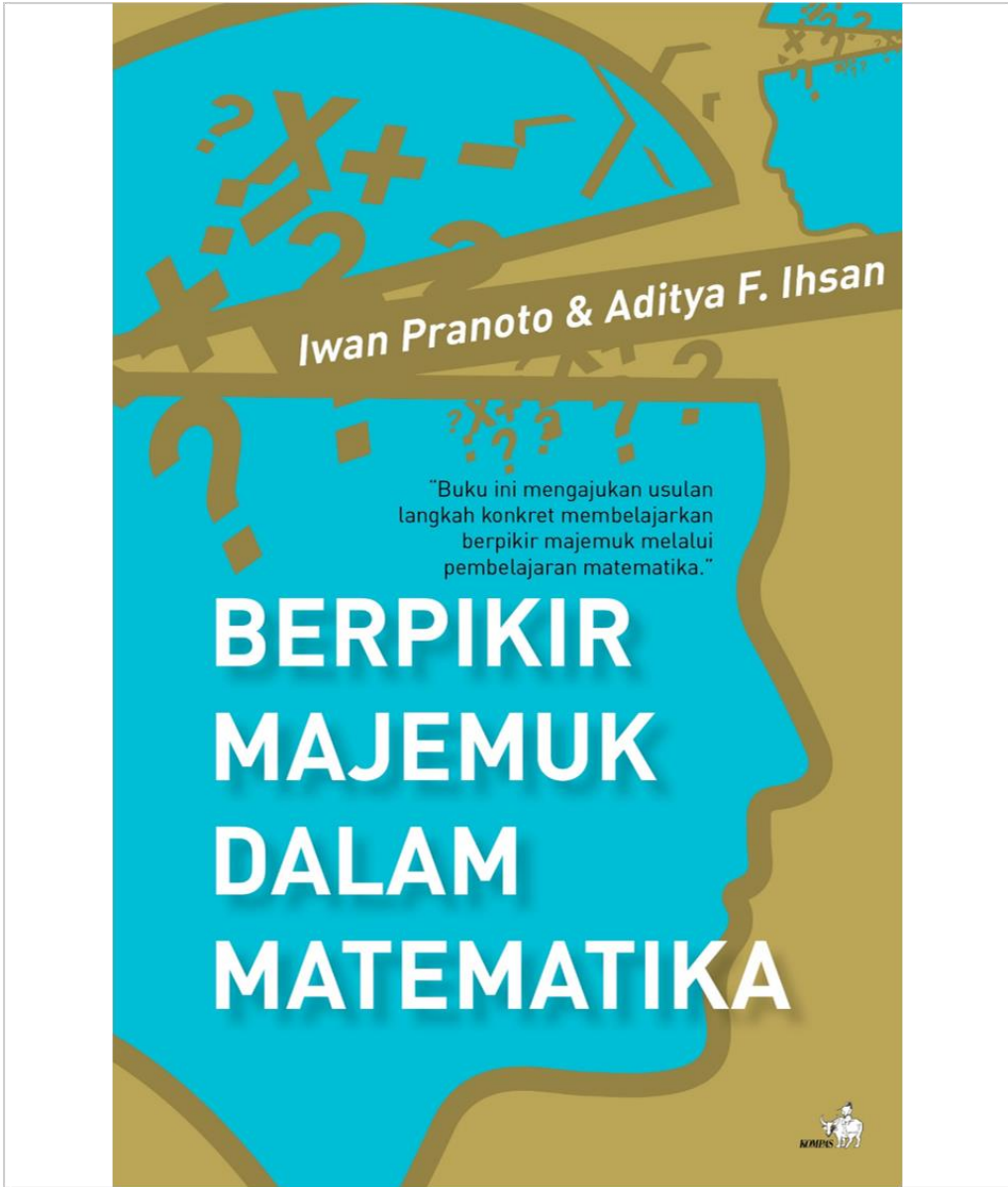


$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$

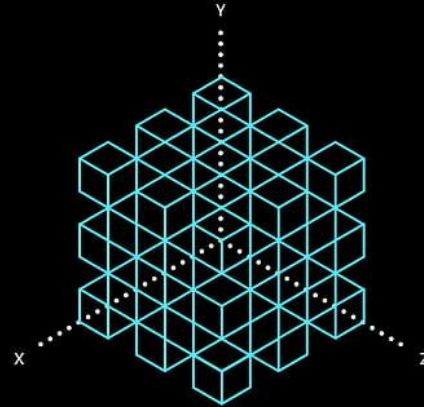
It is clear that the chief end of mathematical study
must be to make the students think.
— John Wesley Young



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1,618033988749894848204586834365$$



“The intention of mathematics teaching is to promote the learning of mathematics”