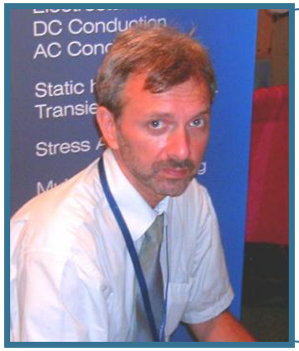
Inductance calculation with QuickField



Vladimir Podnos,
Director of Marketing and Support,
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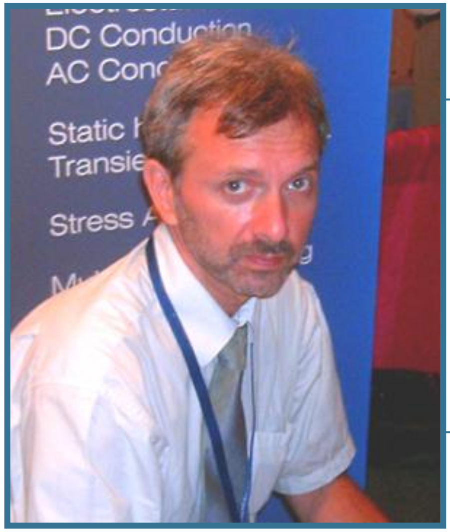
Magnetic analysis with QuickField



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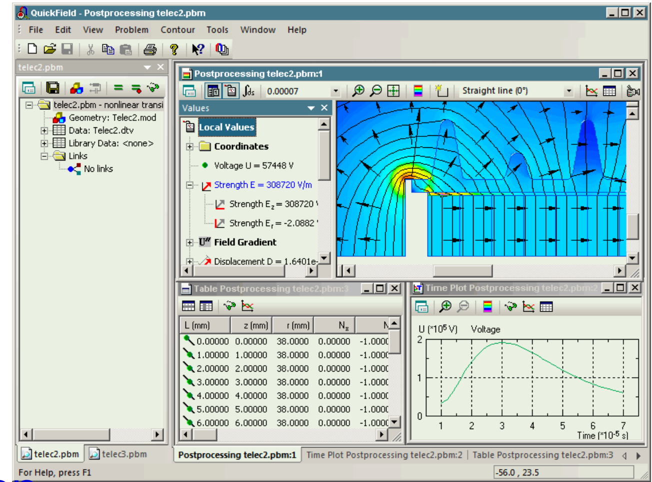
QuickField Analysis Options



Magnetic Suite

- AC Magnetics
- Transient + DC Magnetics
  - DC Magnetics

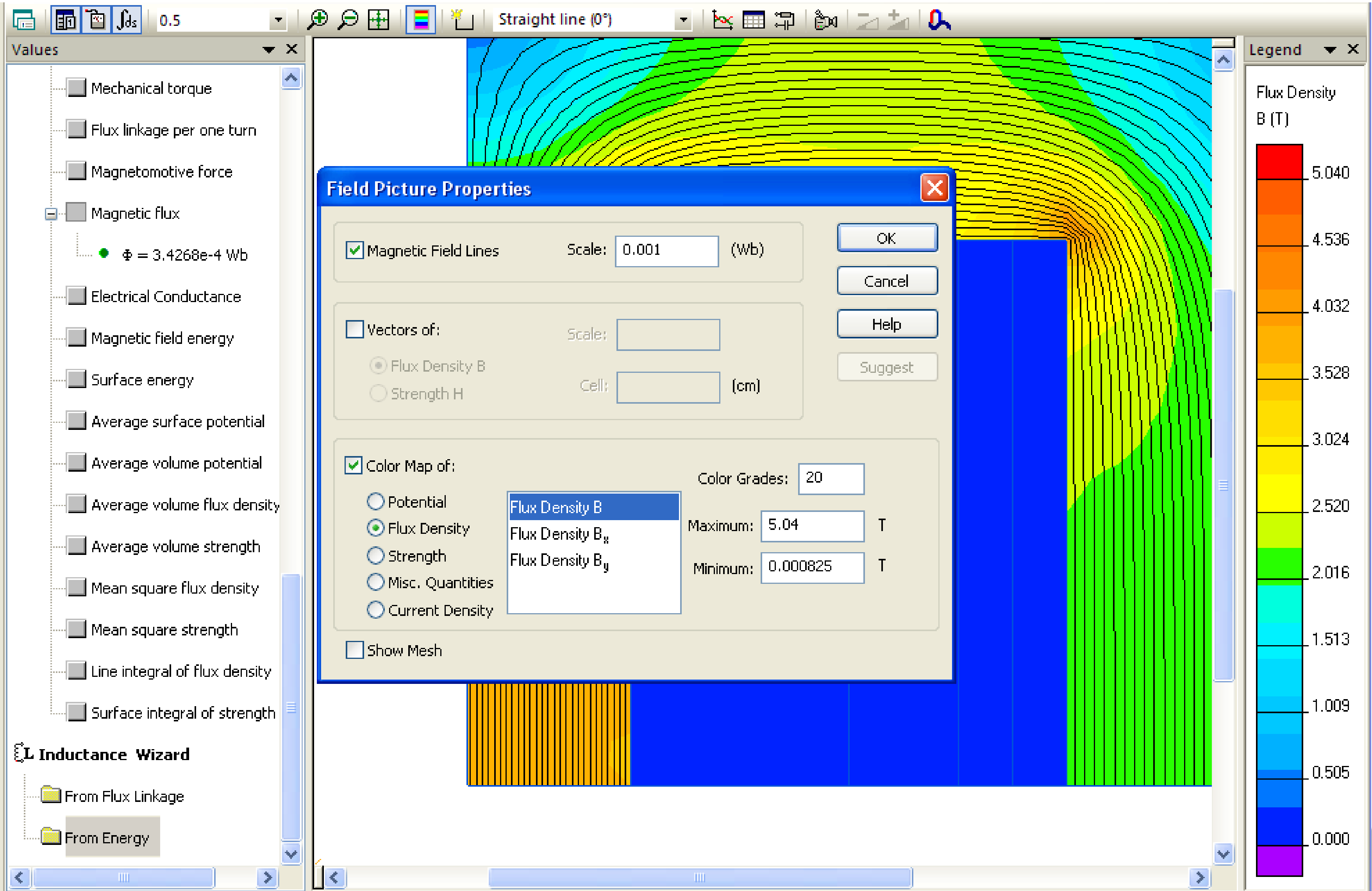
Electric Suite

- AC conduction + Electrostatics & DC conduction
- Transient Electric + Electrostatics & DC conduction
- Electrostatics & DC conduction

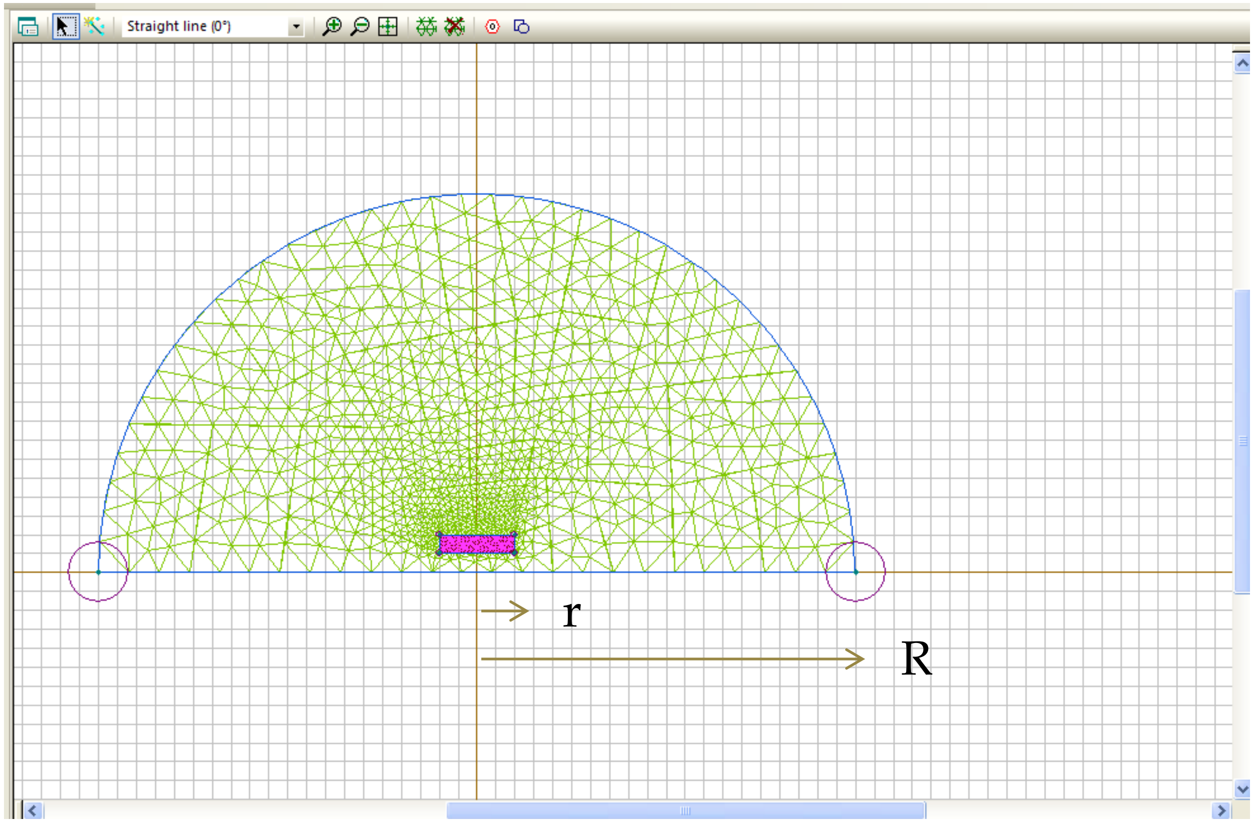
Thermostructural

- Stress Analysis
- Transient Heat transfer
  - Steady State Heat transfer

Magnetic analysis

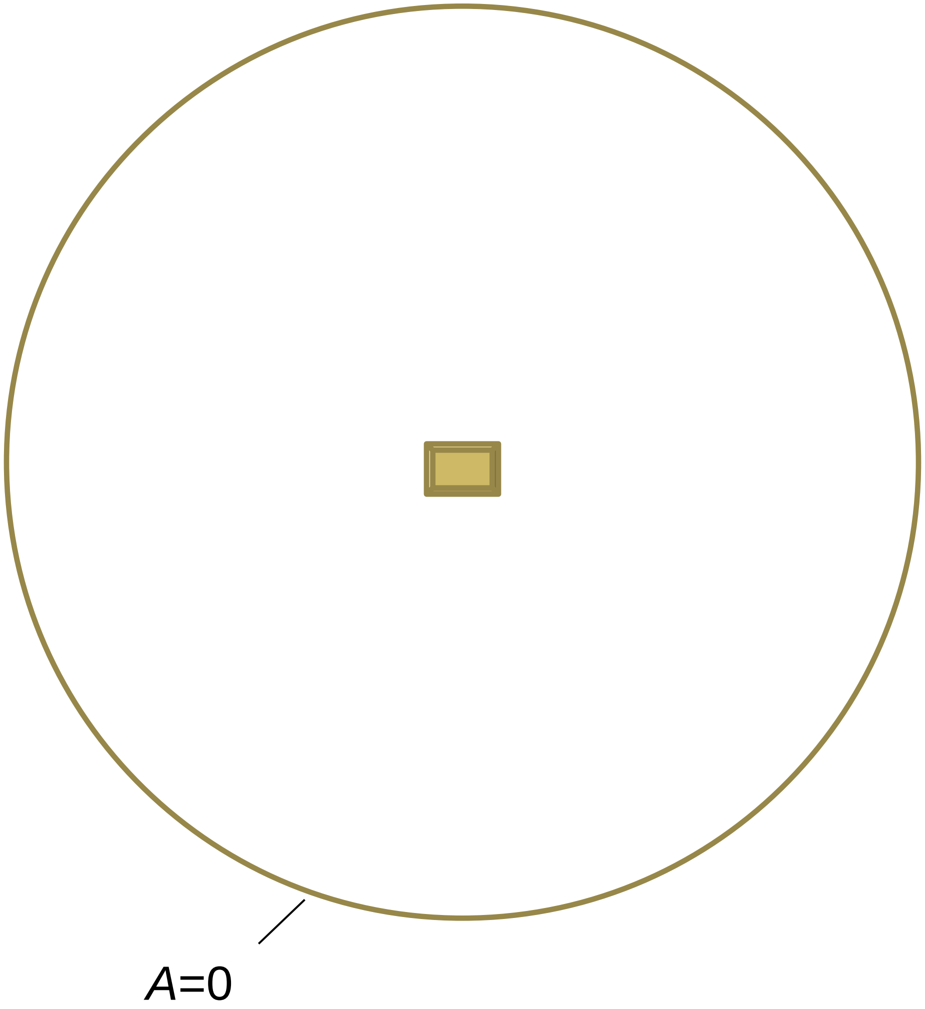


External boundary

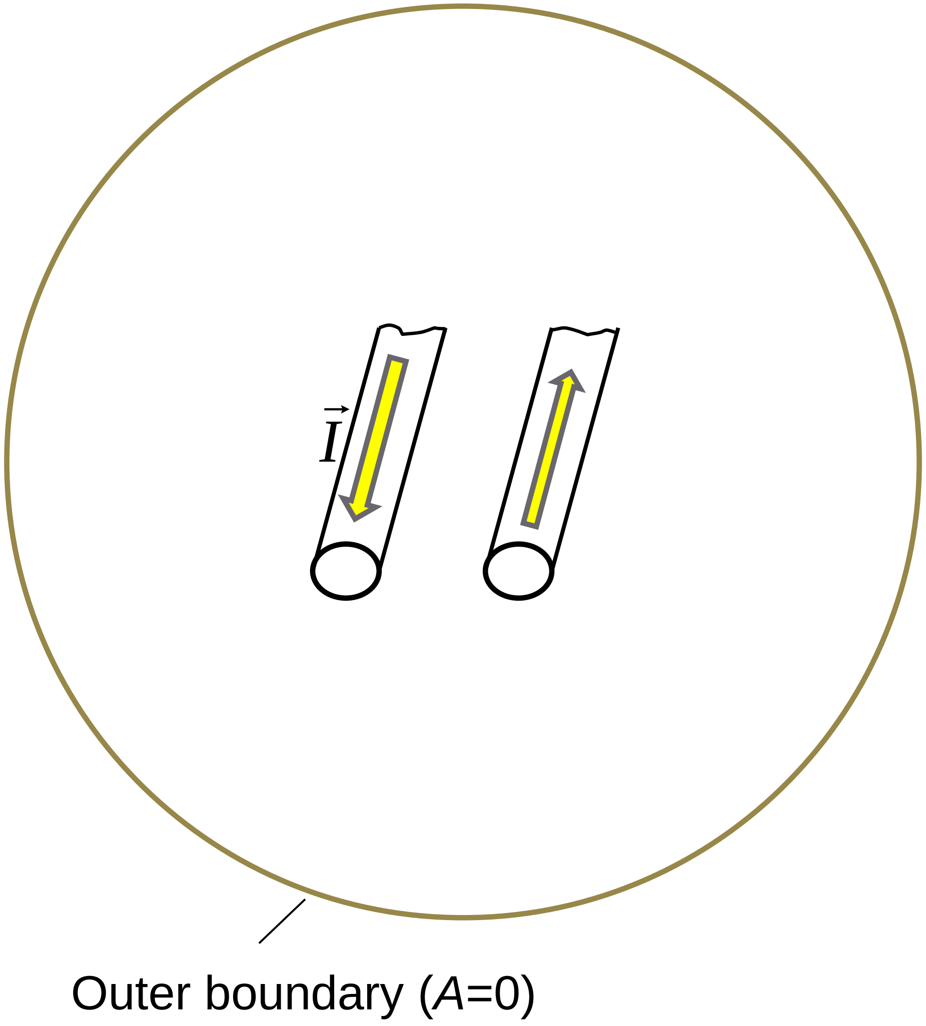


R > 10*r

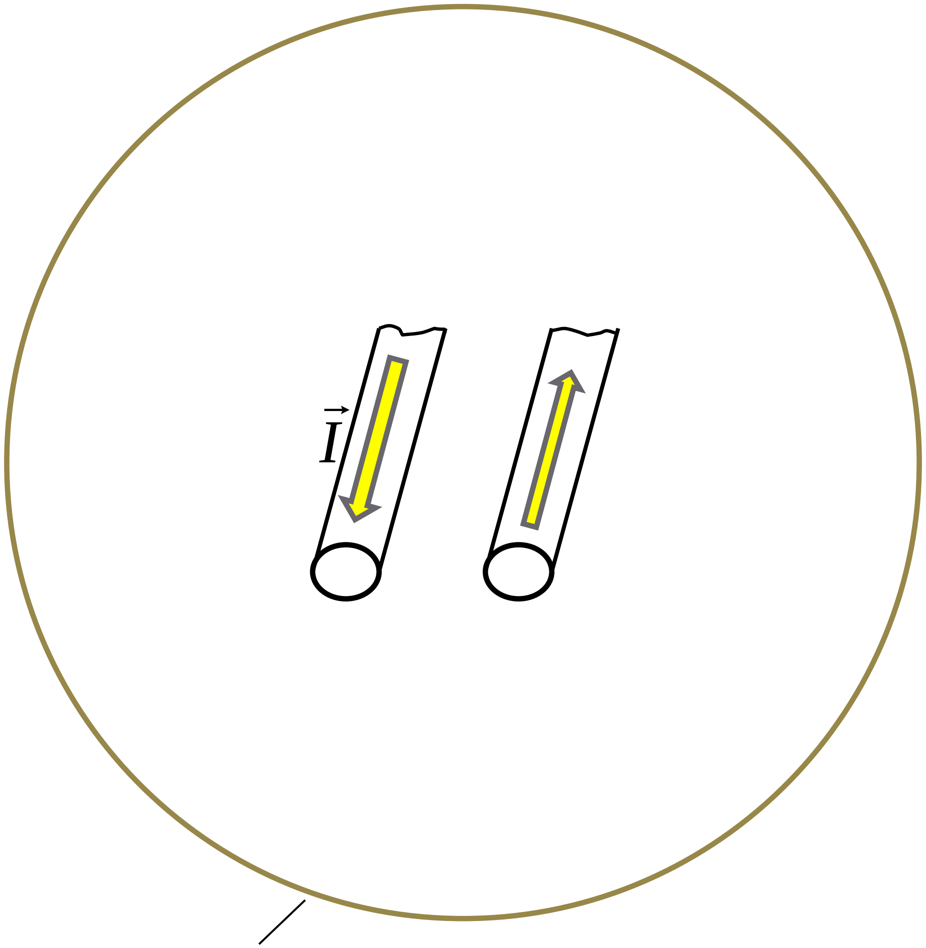
Calibration



Direct and reverse currents



Inductance in QuickField



Outer boundary (A=0)

Inductance $L = \Phi / I$,

Φ – flux

I - current

Magnetic field energy

$W = L * I^2 / 2$

Inductance calculation with QuickField

Alexander Lyubimtsev
Support Engineer, Tera Analysis Ltd.

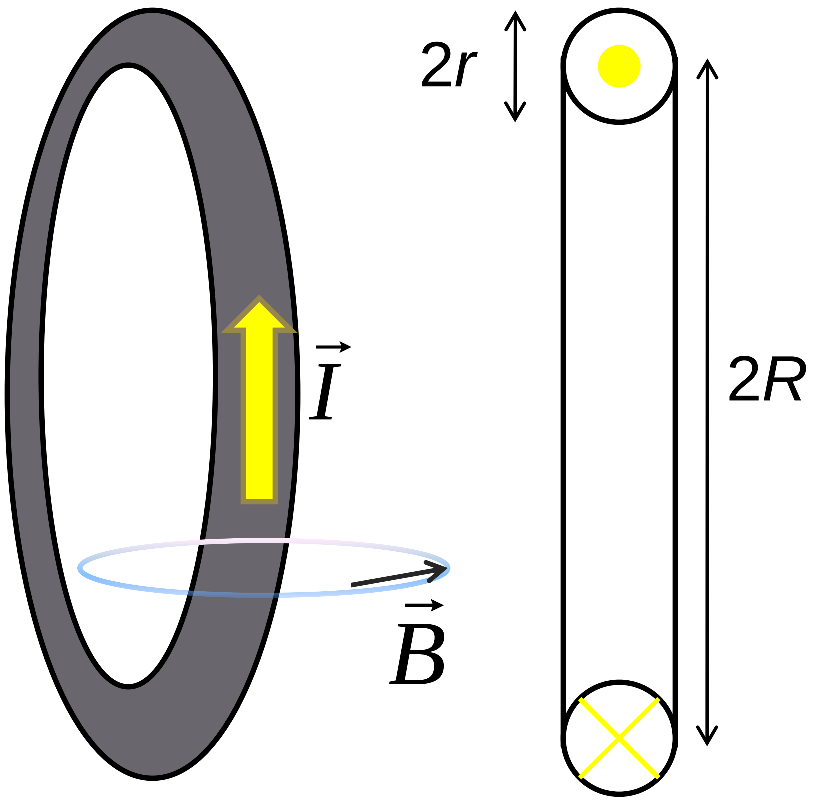
Inductance calculation with QuickField

1. Inductance of a ring, pair of wires, coaxial cable and solenoid;

2. Mutual inductance;

3. Inductance of the transmission line.

Wire ring inductance



Problem specification:

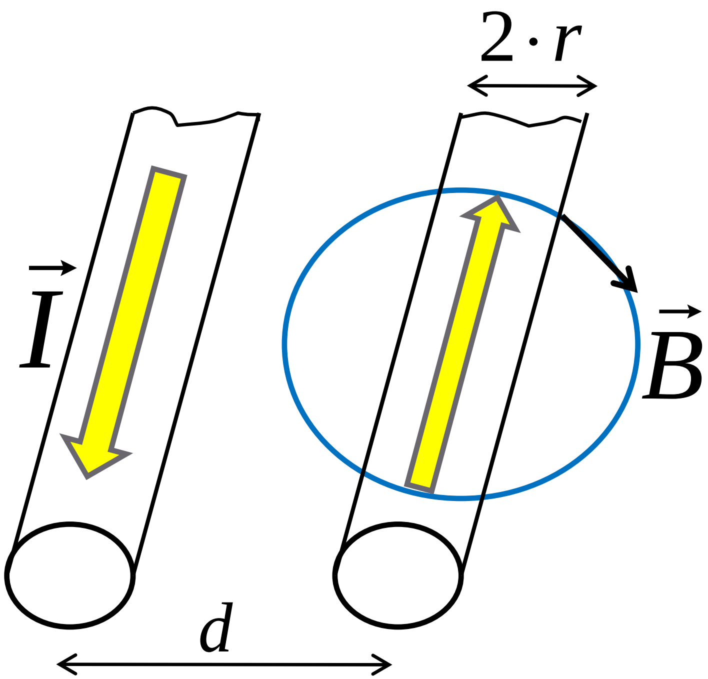
Ring radius R = 100 mm
Wire radius r = 5 mm

Theoretical result:

$$L = \mu_0 R[\ln \frac{8R}{r} - \frac{7}{4}]$$

$$L = 4.179e\text{-}7\ \mathrm{H}$$

Parallel wires inductance



Problem specification:

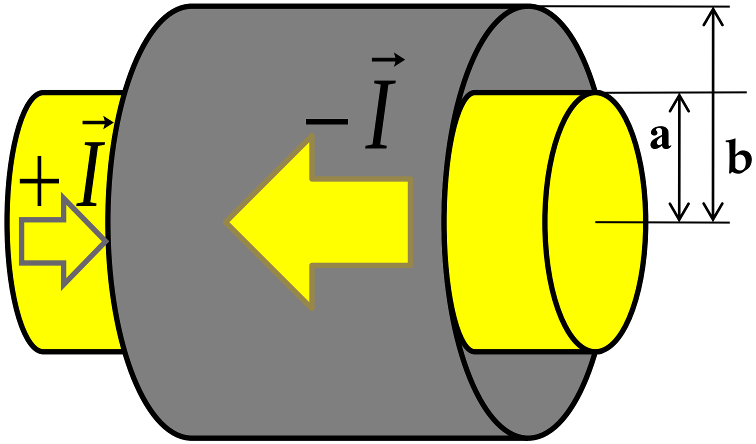
r = 4 mm
d = 500 mm

Theoretical result:

$$L = \frac{\mu_0}{\pi}[\ln(\frac{d}{r}) + \frac{1}{4}]$$

L = 2.031 e-6 H/m

Coaxial cable inductance



Problem specification:

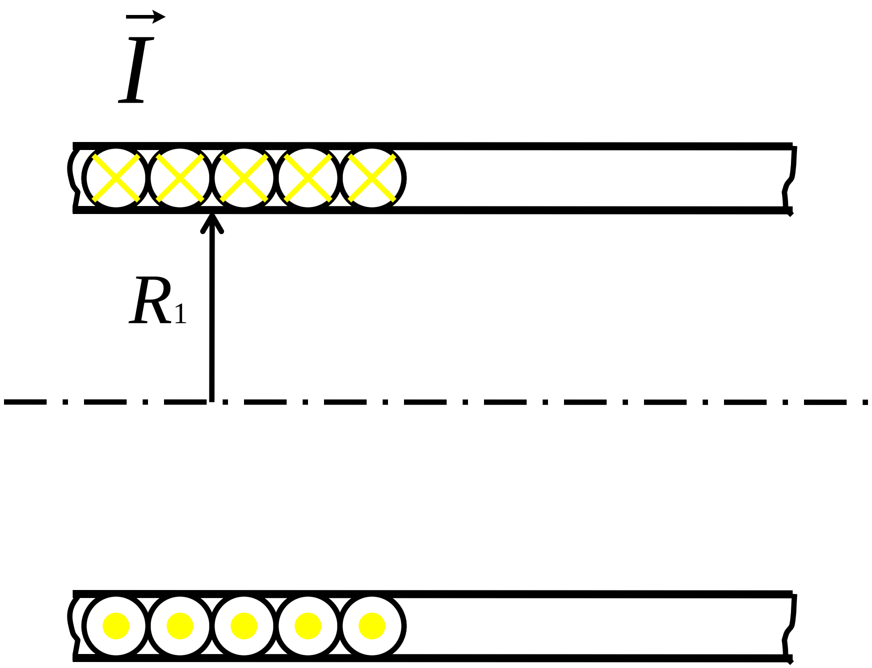
internal radius *a* = 1 mm;
external radius *b* = 4 mm;
current I = 1 A

Theoretical result:

$$L = \frac{\mu_0}{2\pi}[\frac{1}{4} + \ln(\frac{b}{a})] \quad \text{H/m}$$

$$L = 3.272e\text{-}7 \ \text{H/m}$$

Soleniod inductance



Problem specification:

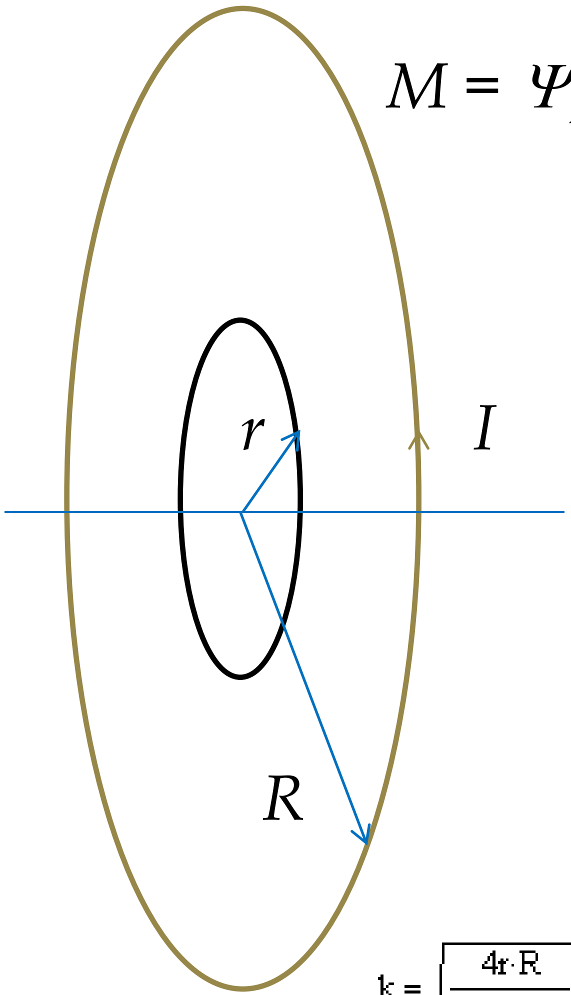
R_1 = 30 mm;
number of turns N = 1000;
length of the solenoid l = 0.5 m

Theoretical result:

$$L = N^2 \cdot \mu_0 A / l$$

$$L = 7.1061 \text{ mH}$$

Mutual inductance



$$M = \Psi_2 / I_1$$

Problem specification:

R = 0.3 m, r = 0.2 m

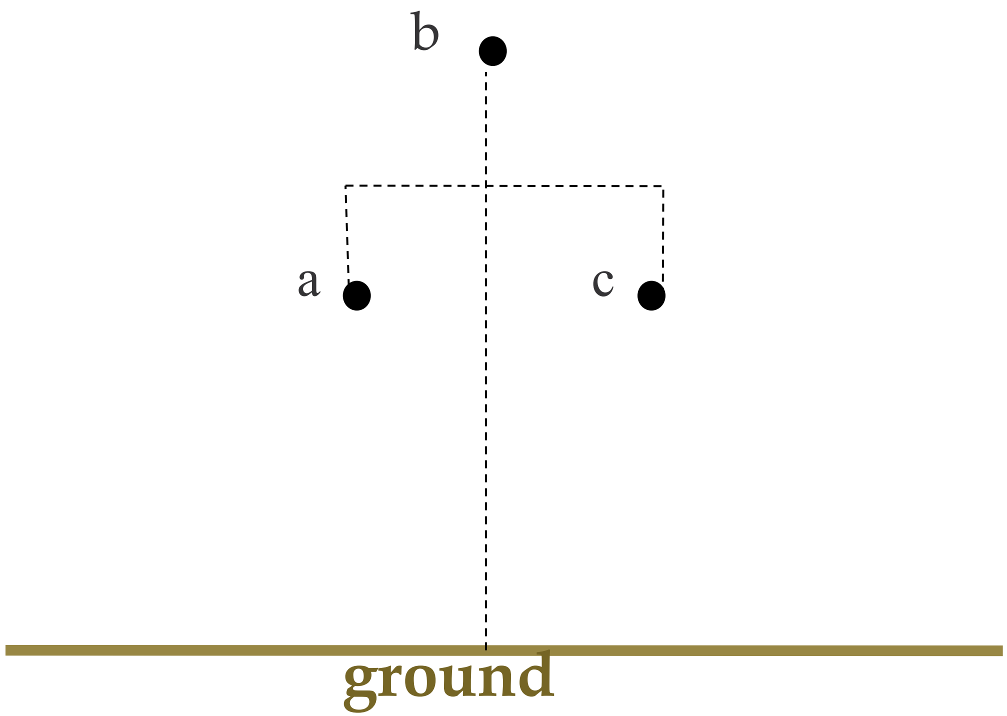
Theoretical result:

$$M = \mu_0 \sqrt{Rr} \cdot \left[\left(\frac{2}{k} - k \right) \cdot K - \frac{2}{k} \cdot E \right]$$

$M = 3.254e\text{-}7$ H

$$k = \sqrt{\frac{4r \cdot R}{(R+r)^2}} \qquad K = \int_0^{\frac{\pi}{2}} \frac{1}{\sqrt{1 - k^2 \cdot \sin(\alpha)^2}} \, d\alpha \qquad E = \int_0^{\frac{\pi}{2}} \sqrt{1 - k \cdot \sin(\alpha)^2} \, d\alpha$$

Transmission line inductance



Partial inductance matrix

	a	b	c
a	L_{aa}	M_{ab}	M_{ac}
b	M_{ba}	L_{bb}	M_{bc}
c	M_{ca}	M_{cb}	L_{cc}

Flux linkage $$\Phi_a = L_{aa} \cdot I_a + M_{ab} \cdot I_b + M_{ac} \cdot I_c$$

L-matrix calculation

Conductor counter initialization k=1

Zero current assignment to all conductors but k (i_k=1A).

Setting up and solving of the QuickField problem .

Get the flux linkage and calculate the inductance.

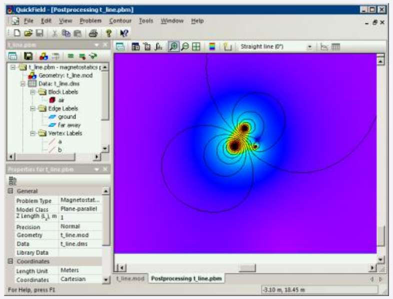
Is k-conductor the last?

No
k=k+1

Yes

Exit

QuickField



Excel