Electromagnet Pull Force across an Air Gap

Gap flux density and pull force of a DC electromagnet or relay on its armature from turns, current, gap, pole area and the core path, by Maxwell's pull formula.

Method: Maxwell's pull formula with a series magnetic circuit

Input parameters

Unit system: SI

Parameter	Value	Unit
Number of turns	800.00	
Coil current	1.5000	A
Air gap at each pole	0.50000	mm
Pole face area (each)	4.0000	cm²
Number of gaps in the flux path (1 or 2)	2.0000	
Iron path length (core and armature)	200.00	mm
Relative permeability of the iron	2,000.0	

Calculated results

Parameter	Value	Unit
Flux density in the gap	1.3709	T
Magnetic pressure on the pole face	747.75	kPa
Total pull force	598.20	N
Coil inductance at this gap	292.45	mH

Notes for this case

• Maxwell's pull F = B²A/(2μ₀) per pole, with the iron path of the same section as the poles and no fringing or leakage; the force rises steeply as the gap closes.

Formula and method

$$B_g = \frac{\mu_0 N I}{n_p g + l_c/\mu_r}, \quad F = n_p \frac{B_g^2 A}{2\mu_0}$$

Variables

N	Number of turns	-
I	Coil current	A
g	Air gap at each pole	m
A	Pole face area (each)	m²
n_p	Number of gaps in the flux path (1 or 2)	-
l_c	Iron path length (core and armature)	m
μ_r	Relative permeability of the iron	-
B_g	Flux density in the gap	T
$B^2/2\mu_0$	Magnetic pressure on the pole face	Pa
F	Total pull force	N
L	Coil inductance at this gap	H

Method and standards

Magnetic pull from field energy (Maxwell stress).

Assumptions and limits

- Uniform gap field, no fringing or leakage, linear iron.

References

Maxwell's pull formula with a series magnetic circuit

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/circuits/electromagnet-pull-force

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.