An Uncertainly Scientific Railgun

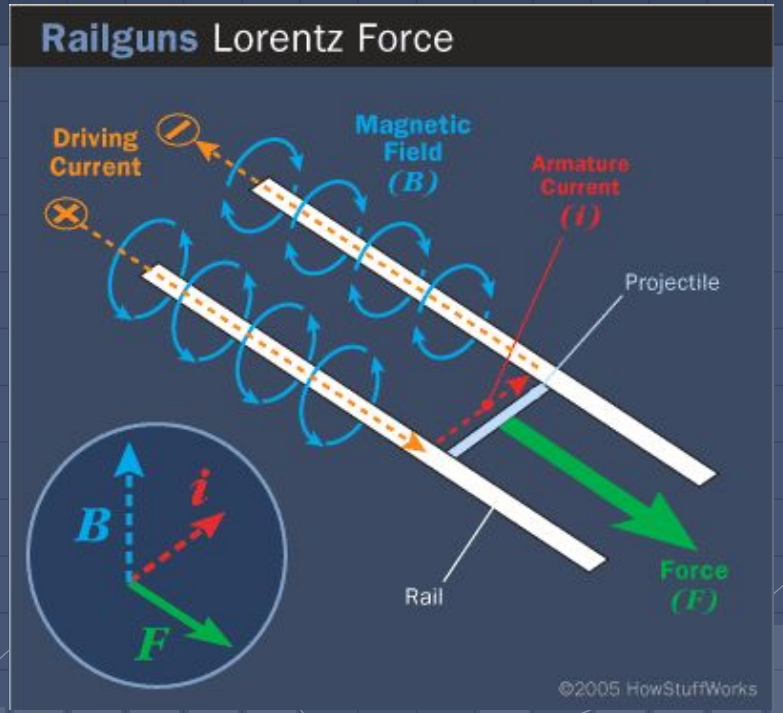
A Nicholas Kocurek Project

Railgun Theory

Currents circulate through rails

Net magnetic field is up

Lorentz force accelerates the projectile (but also the rails)



Misaka's Railgun

Theory ✔

Firepower ✔

currents. For the Railgun to work, the driving current goes through the positive side, through the projectile (coin) and comes back through the negative side, using the Lorentz Force with the addition of Fleming's left-hand rule. The arcade coin acts as the projectile, which is propelled towards the target using the electromagnetic force.[24] The third-ranked Level 5 is able to fire a metal projectile at three times the speed of sound by utilizing a great amount of electricity, supposedly somewhere in the region of 2,250,000 amperes, or about 1,000,000 volts, 1/10th of her power.[25]

Properties of Arcade Coin (Projectile)

Zinc Alloy

Diameter: 25mm, Thickness: ~2mm

Mass: ~5g

Zinc Properties:

MP: 419.53 °C

ρ = 59.0 nΩ·m (at 20 °C)

c = .390 J/g°C

$\alpha = 36 \times 10^{-4}\ °C^{-1}$

k = 113 W/mK

Mechanics of Railgun

$B = 2\mu_0 I/2\pi R$

$= 4x10^{-7}$ Tm/A (2.25x10^6 A) / (.025 / 2 m)

$= 72$ T

$F = IL \times B$

$= 2.25x10^6$ A (.025 m) (72 T)

$= 4.05x10^6$ N

$F = d\rho/dt \qquad dm/dt = 0$

$Ft = m\Delta v$

$t = m\Delta v/F$

$= .005$ kg(1030 m/s)/(4.05x10^6) N

$= \mathbf{1.2716x10^{-6}\ s}$

Thermodynamics of Projectile

$P = I^2R$

$P = I^2R\,(1 + \alpha(T-20\,^\circ C))$

$P = dT/dt\ cm \qquad (T < 1000K)$

$dT/dt = I^2R/cm\,(1 + \alpha(T-20\,^\circ C))$

$\int dt = cm/I^2R \int (dT/(1 + \alpha(T-20\,^\circ C))$

$R = \rho l/A$

$t = cm/I^2R\alpha\ \ln|1+\alpha T-20\alpha|$

$I^2R\alpha t/cm = \ln|1+\alpha T-20\alpha|$

$e^{I*IR\alpha t/cm} = 1 + \alpha T - 20\alpha$

$(e^{I*IR\alpha t/cm} - 1)/\alpha = T - 20$

$T = (e^{I*I\rho l\alpha t/Acm} - 1)/\alpha + 20$

$T = 309.6124\,^\circ C$

Less than 419.53 °C MP

Internal Force

$B = \mu_0 I / 2\pi R$

$= 4 \times 10^{-7}$ Tm/A $(2.25 \times 10^6$ A) / (.025 m) (2)

$=$ **18 T**

$F = IL \times B$

$= 2.25 \times 10^6$ A (.864 m) (18 T)

$=$ **3.50×10^7 N**

References

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