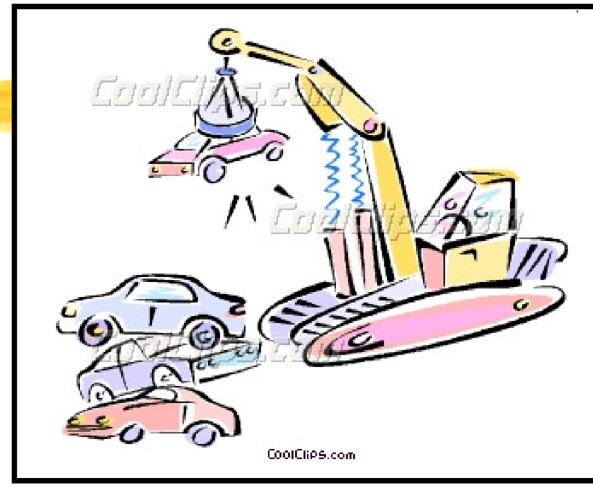
Magnetic Energy Storage & Magnetic Crane



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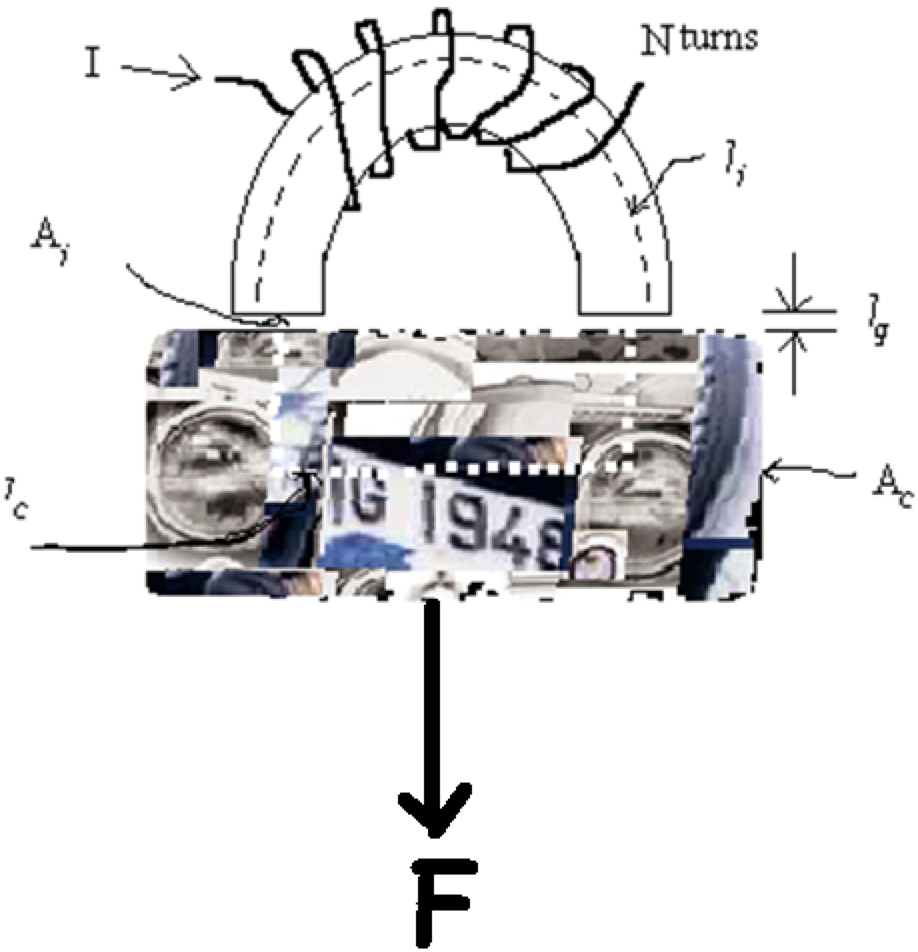
www.mwftr.com/VIPatHUteams.html

Oct 31, 2016

Magnetic Energy Storage



Pulling force by magnetic Energy stored in magnetic field

$F = (B^2/u_0)*A$

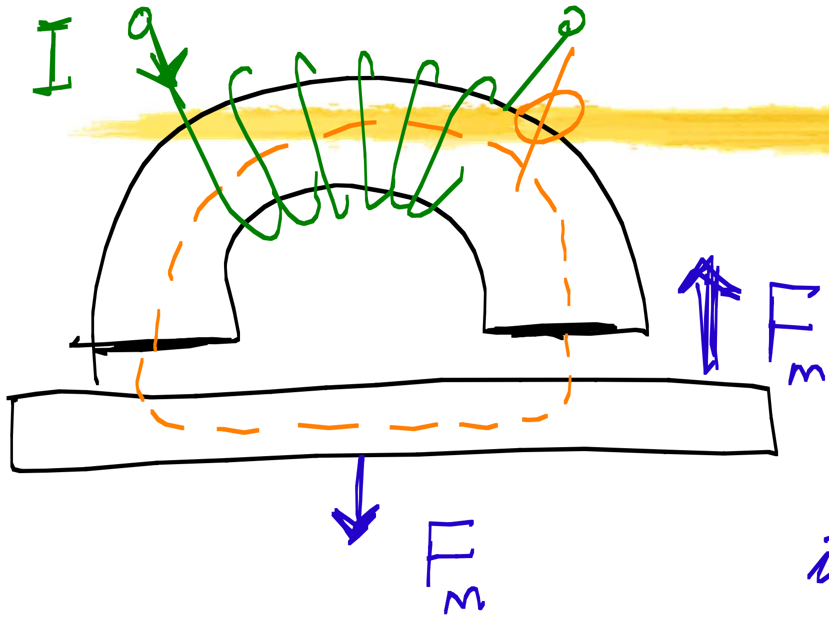
$F = mg$

$N = kg* m /s^2$

½ Newton is close to 500g, which is close to 1 lb.

- $G = 9.8\ m/s^2$

Magnetic System & Lifting Force



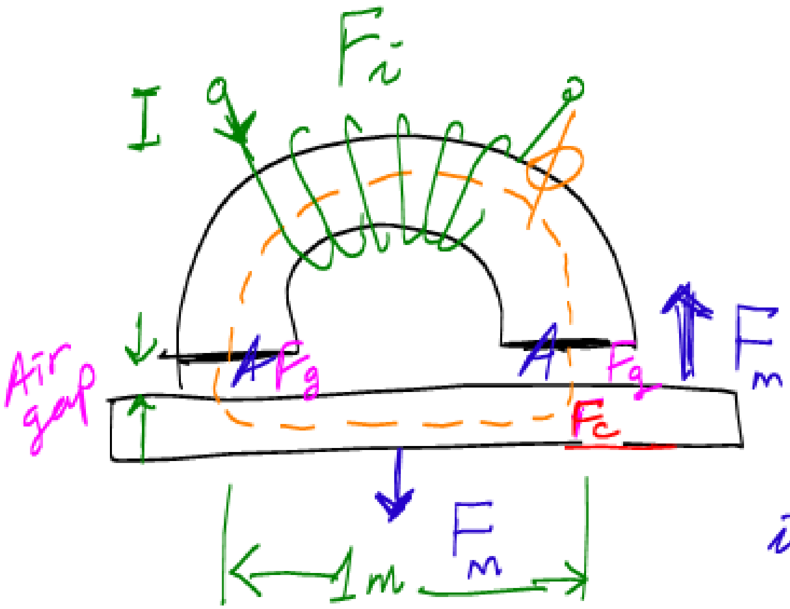
F_m (pulling force in Newton)

$$F_m = \left(\frac{B^2}{\mu_0}\right) A \,,\qquad B = \mu H = \frac{\phi}{A}$$

Intensity (→ H)

density (→ B)

Magnetic System



F_m (pulling force in Newton)

F_i : mmf generated by coil * Turn (NI)

$A = 0.1\,m^2$ $\left\{ \begin{array}{l} l_g = 5\,mm \\ l_c = 1\,m \end{array} \right\}$

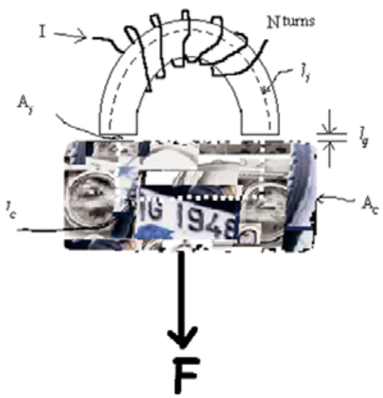
$$F_m = \left(\frac{B^2}{\mu_0}\right) A_g, \quad B = \mu H = \frac{\phi}{A_g}$$

Intensity (H)

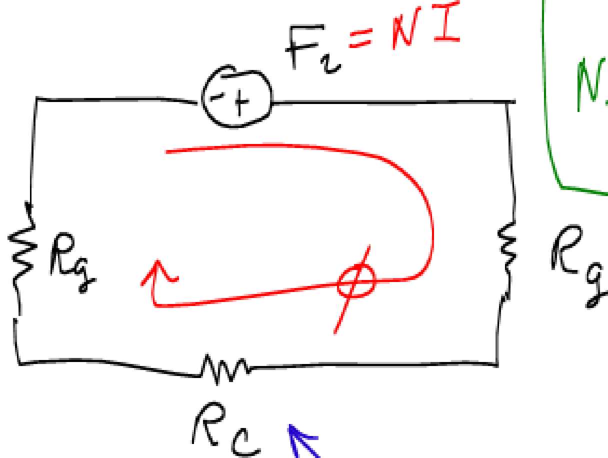
density (B)

$$\left(\frac{\text{let } A_g = A_c = A}{= 0.1\,m^2}\right)$$

Magnetic Circuit



Equivalent Circuit



μ_0

$\mu = 250\mu_0$, $l_c = 1M$

$$NI = F_i = \phi\left(\frac{2\cdot l_g}{\mu_0 A_g} + \frac{l_c}{250\mu_0 A_c}\right)$$

$l_g = 5mm$

Let $A = 0.1m^2 = A_g = A_c$

R : Reluctance

$$= \frac{l}{\mu A}$$

$\mu_0 = 1.257 \times 10^{-6}$ [H/m]

permeability

Magnetic Circuit

$$NI = \boxed{\mathcal{F}_i = \phi\left(\frac{2\cdot l_g}{\mu_0 A_g} + \frac{l_c}{250\mu_0 A_c}\right)}$$

Let (If) $A = A_g = A_c$

$$= \phi\left(\frac{500 \times 5\times 10^{-3} + 1}{\mu_0 A \cdot 250}\right) = \phi\left(\frac{3.5}{250\cdot\mu_0 A}\right)$$

$$\longrightarrow \phi = \frac{\mu_0 A N I}{1.4\times 10^{-2}} \longrightarrow B = \frac{\phi}{A_g} = \frac{\mu_0 N I}{1.4\times 10^{-2}}$$

Relationship between mmf and lifting force

1000 turns

$$F_m = \frac{B^2 A_g}{\mu_0} = \frac{\left(\frac{\mu_0 N I}{1.4\times10^{-2}}\right)^2 A_g}{\mu_0} = \frac{1.257\times10^{3}\times I^2}{1.96}$$

$$\rightarrow I^2 = \frac{F_m}{641.32}$$

If $F_m = 15000$ Newton

$I = 4.83$ [A]

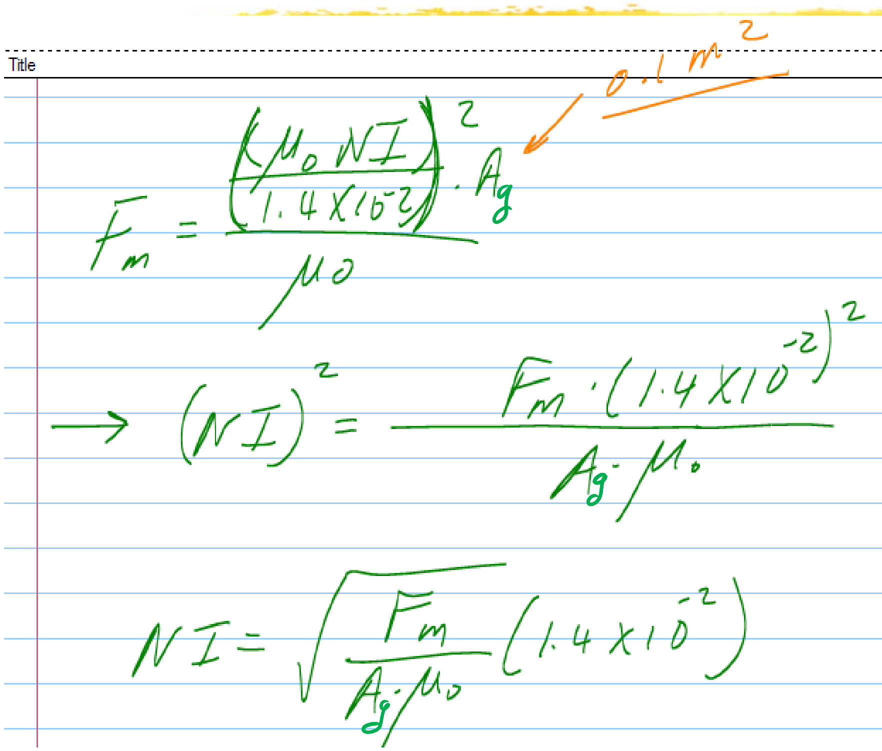
Essex Magnet Wire 22 AWG Gauge Enameled Copper Wire - 10 LBS

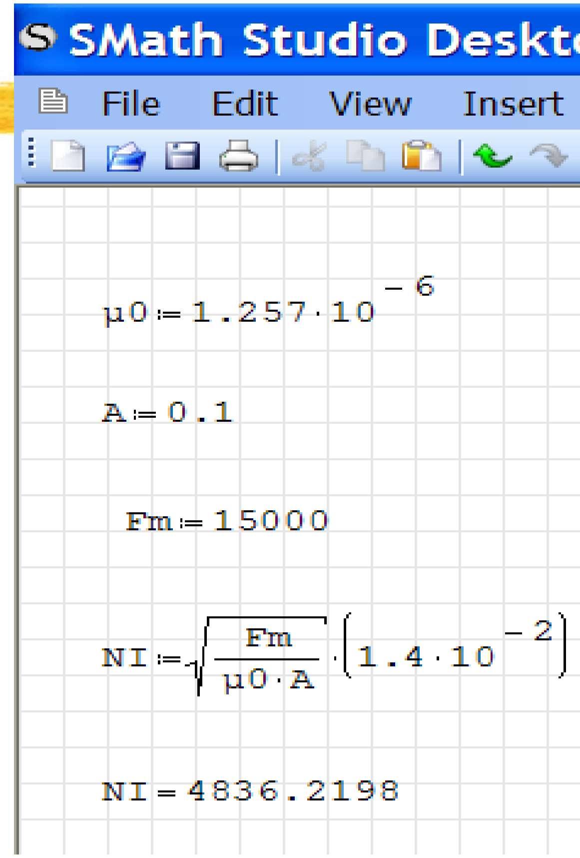
Magnet Wire, Neodymium Magnets, Wind Generator and Rotor Blades. Applied Magnets (www.magnet4less.com), Top Quality, Lowest Price !!!

AWG

21	0.0285	0.723	35.1	13.8	0.810	0.410	42.00	12.80	—	—
22	0.0253	0.644	39.5	15.5	0.642	0.326	52.96	16.14	7	5
23	0.0226	0.573	44.3	17.4	0.509	0.258	66.79	20.36	—	—
24	0.0201	0.511	49.7	19.6	0.404	0.205	84.22	25.67	3.5	2.1

Relationship between (*N and I*) and lifting force





⌘ **If N and I are two variables?**

Summary for Energy Storage and Magnetic Crane

(1) Magnetic Circuit

① μ

② Area

③ Force Required to levitate

(2) Find ϕ from Magnetic Circuit

(3) Convert ϕ to B

(4) Use $F_m = \frac{B^2 A}{\mu_0}$ Relationship

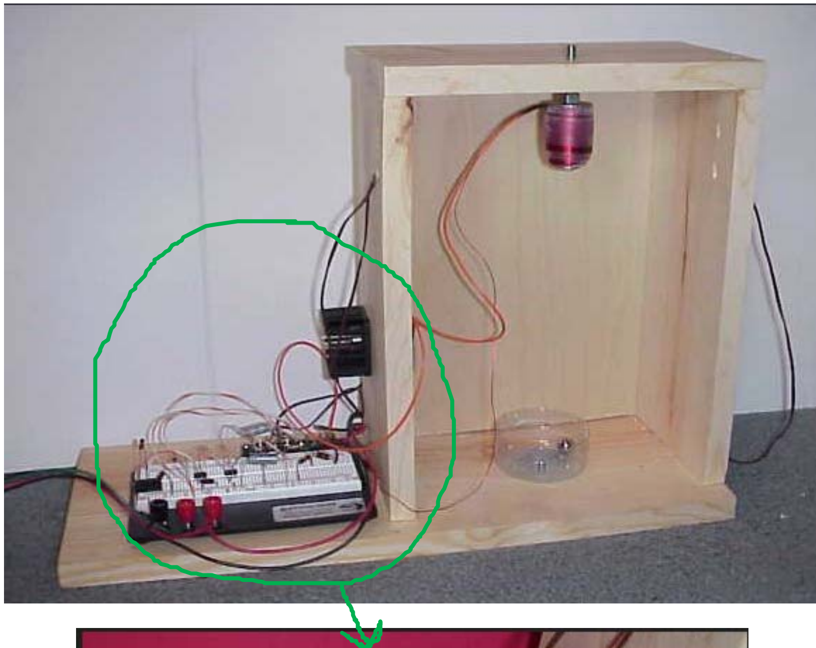
Design Issues

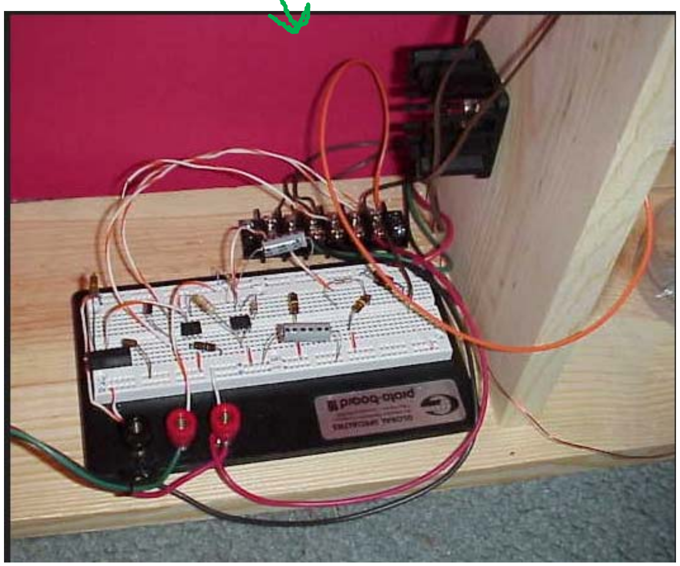
- A) permeability of the core and the object--- the material perspective
- B) the mean paths of air gap, core, and object --- the shape or geometry perspective
- C) number of turns of the coil --- the geometry and coil wire gauge perspective
- D) the weight of the object to lift up

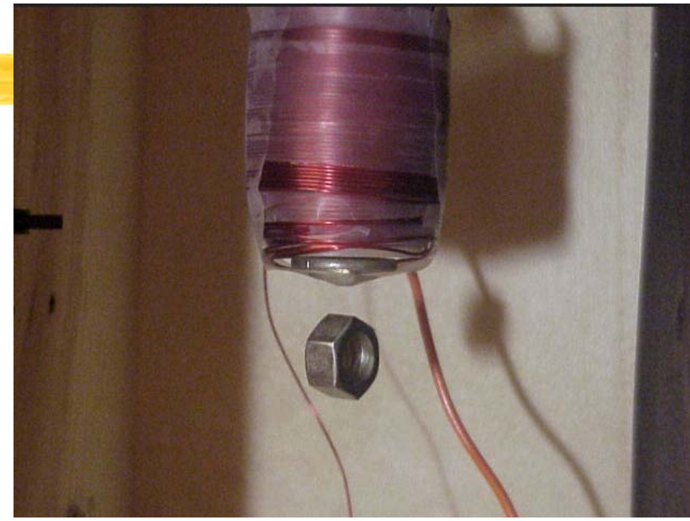
Example

Barry's Magnetic Levitation

www.coilgun.info/levitation/home.htm



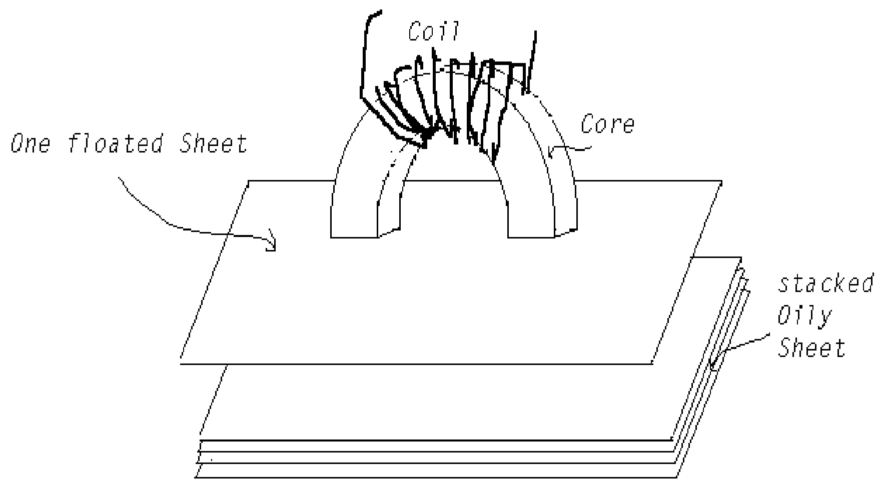




Design Problem for Team Seismolator

- **1. Design** a magnetic crane which floats one sheet of **1200 x 2400 x 0.5 mm** steel-sheets stacked by
  - Modeling of an equivalent Circuit
  - Determination of the material characteristic of the steel-sheet
  - Selection of core material and permeability
  - Determination of Area of the core
  - Consideration of Insulated Wire (and American Wire Gauge) for coil
    - Maximum Current – Ampacity
  - Geometry of the Core after Number of Turn is found after calculation
  - A lot of trade-off between core material, core geometry, coil size, and the number of coil turns
  - Inclusion of the air-gap: 1 mm

- **2 Teams & 2 Designs**
  - **Design Evaluation**
  - **Final Design**



American Wire Gauge

https://en.wikipedia.org/wiki/American_wire_gauge

American wire gauge

From Wikipedia, the free encyclopedia

"AWG" redirects here. For other uses, see AWG (disambiguation).

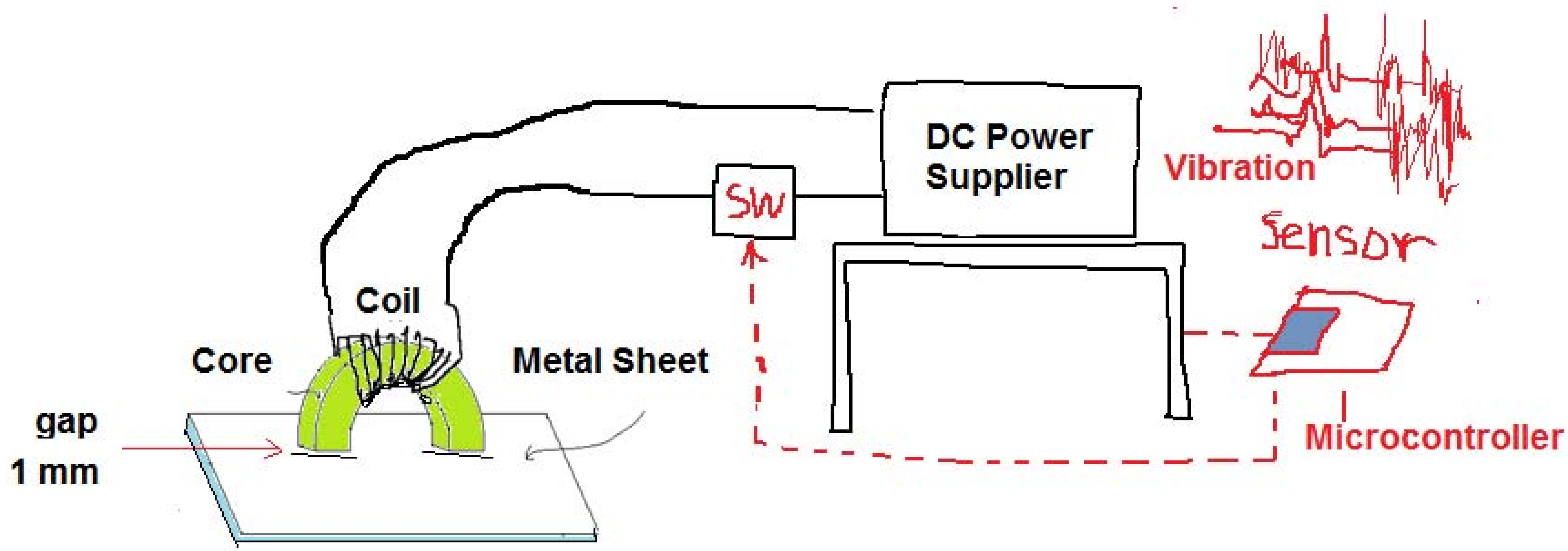
American wire gauge (**AWG**), also known as the **Brown & Sharpe wire gauge**, is a standardized wire gauge system used since 1857 predominantly in North America for the diameters of round, solid, nonferrous, electrically conducting wire. Dimensions of the wires are given in ASTM standard B 258.[1] The cross-sectional area of each gauge is an important factor for determining its current-carrying capacity.

Magnet Wire 17 AWG Gauge Enameled Copper 200C 1lb 158ft Magnetic Coil Winding

AWG gauge	Conductor Diameter Inches	Conductor Diameter mm	Ohms per 1000 ft.	Ohms per km	Maximum amps for chassis wiring	Maximum amps for power transmission	Maximum frequency for 100% skin depth for solid conductor copper	Breaking force Soft Annealed Cu 37000 PSI
17	0.0453	1.15062	5.064	16.60992	19	2.9	13 k Hz	59 lbs
18	0.0403	1.02362	6.385	20.9428	16	2.3	17 kHz	47 lbs
19	0.0359	0.91186	8.051	26.40728	14	1.8	21 kHz	37 lbs
20	0.032	0.8128	10.15	33.292	11	1.5	27 kHz	29 lbs
21	0.0285	0.7239	12.8	41.984	9	1.2	33 kHz	23 lbs
22	0.0253	0.64516	16.14	52.9392				
23	0.0226	0.57404	20.36	66.7808				
24	0.0201	0.51054	25.67	84.1976				
25	0.0179	0.45466	32.37	106.173				
26	0.0159	0.40386	40.81	133.856				
27	0.0142	0.36068	51.47	168.821				
28	0.0126	0.32004	64.9	212.872				

Design Problem for Team Seismolator

⌘ **2. Prototype Implementation**: a magnetic isolator for floating one sheet of 1200 x 2400 x 0.5 mm steel-sheets.



Next Step

- **Implementation**: a magnetic isolator for floating An object of 1 lb weight