**GOAL & MOTIVATION**

- To design and comprehend the governing physics behind a coil gun.
- Understand why coil guns have not seen widespread use in real-world applications.
- Present a viable alternative to traditional nail guns.

**DESIGN OVERVIEW**

- 3 stages of coils for greater projectile acceleration.
- High voltage capacitors (400V) are charged by a boost converter circuit used to provide the necessary amount of current to propel the projectile.
- A microcontroller is used with a photosensor to provide a feedback loop to activate/deactivate each stage as the projectile passes through them.

**HOW DOES IT WORK?**

- A large pulse of current is used to energize each solenoid (coils of wire wrapped closely together).
- The Biot–Savart Law guarantees the generation of a magnetic field due to the presence of electrical current; a tight packing of these coils allows for a uniform distribution of the field along the coil’s axis and a non-uniform distribution at the face.
- Differential axial field is given by:
  
  \[
  dH_x = \frac{1}{4\pi} \left( \frac{A\cos\theta \sin\theta - A\sin\theta \cos\theta}{(A\cos\theta \sin\theta)^2 + (A\sin\theta \cos\theta)^2} \right) \]

  Plotted in Figure 2

- The Lorentz force in a solenoid is given by:
  
  \[
  F_{\text{pol}} = \frac{1}{\mu_0} \left( 2B_x \frac{\partial B_x}{\partial z} + 2B_y \frac{\partial B_y}{\partial z} \right) I \]

  which tells us that the force exerted per unit volume on a slug at the center of the coil is strongest at the face and is basically zero at the center.

- The projectile will go into the coil and will have the tendency to stay inside of it due to the induced magnetic field.

- To ensure the projectile moves forward inside the barrel, each stage has to be “turned off” as soon as the tip of projectile reaches the magnetic center of the coil.

- The ferromagnetic projectile has to have a certain weight and size to maximize muzzle velocity.

**RESULTS**

- Booster Converter requires approximately 30 seconds to charge up the capacitor to ~390 V with a 12 V input.
- Each solenoid is comprised of 480 turns (8 layers with 60 turns each) made out of 20 AWG copper wire.
- Coil Gun is capable of firing projectiles at a speed of ~100 m/s at full charge.
- Final prototype cost: $125.13, weights ~15 lbs.

**FUTURE WORK**

- Make it a completely handheld device.
- Design a fully semi-automatic model, decrease the time between shots.
- Design a model that can work with nails of different sizes.

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**RESUL TS**

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**NAIL GUN COMPARISON**

- Currently two types of nail gun in the market: pneumatic and electric nail guns.
- Pneumatic gun uses compressed air to push the hammer that drives the nail. It requires an air compressor.
- Electric nail gun uses an electric motor to perform a similar action, but they are relatively weaker given the same price.
- Electromagnetic nail guns establish a middle ground between two models. It combines the high power of pneumatic models and the mobility of electric models.
- Potentially cheaper and lighter than pneumatic gun/compressor combo.
- More powerful than electric models marked at the same price.

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