# Slide 1 - Intro

Hello, today I’ll be speaking to you about the work I’ve been doing on my group T-02’s simulation.

# Slide 2 - Structure

For this presentation I’ll first talk briefly about the derivation of the theory the simulation is based on, and the sources it originates from. Then we’ll move onto how I developed the model, including overarching principles applied when writing the code. Finally, I’ll talk about what the model predicts, ways to test them and what’s next based on the successes and failings of the model.

# Slide 3 – Theory

The derivation for the theory behind this model comes primarily from a paper published by the American Association of Physics Teachers named “Magnetic braking: Simple theory and experiment” by H. D. Wiederick, N. Gauthier, D. A. Campbell, and P. Rochon. A full reference is provided at the end.

The aim of the derivation is to reduce the complexity of the physics of eddy-current braking for the early undergraduates. It avoids solving Maxwell’s equations in time-dependent scenarios by making some careful approximations and building a model based on an analogous concepts more in line with the physics they will have encountered by that point in a degree.

# Slide 4 – Derivation 1

Take small strip with thickness delta centred around the shadow of the poles of the electromagnet. Poles have dimensions of width w length l

In the absence of other forces, strip would move freely between the poles when no current is flowing in the electromagnet.

When current flows a magnetic field is created and if poles are close together… assume uniform field… with a size of B0 in the k direction.

Ohm + Lorentz 🡪 current density in terms of sigma, etc.

If

# Slide 5 – Derivation 2

By expressing the resistance of the unshaded region of the strip as **R** we can solve for the induced current, giving the current in terms of a constant alpha, the conductivity, the magnitude of the applied magnetic field, the cross-sectional length, the thickness, and magnitude of the strip velocity. Alpha relates to the ratio of the external to the internal resistance and can be found either by measurement of a piece of the same type of metal with the same dimensions of the strip, or as the authors did through a much more complex calculation involving conformal transformation techniques. The latter inappropriate given the context of the experiment using 1st & 2nd year undergraduate physics. Finally, we arrive at our expression for the drag force by integrating the cross product of the current density and magnetic field.

# Slide 6 – Derivation 3

We now link the braking force to the rotational motion of the disc. The force causing a rotational acceleration can be expressed in terms of the moment of inertia **k** and the angular acceleration. In our case, this is equal to the sum of the torques due to air resistance and the applied magnetic field. The air drag is assumed to be viscous and hence linearly proportional to the angular velocity. Similarly, the angular velocity of the strip, **omega**, can be found with the distance from the axis of rotation to the centre of the strip. Integrating this differential equation gives our expression for the dependence of the angular velocity with time, where **omega\_0** is the initial velocity, and **tau** is described by the following equation. **Tau\_0** is the time constant due to air resistance and **m** is as follows.

x

l

w

L

y

ω