Script

**Intro Slide**

Hello everyone. Today I’d like to speak to you about eddy currents and eddy current braking. I will first address the theory behind eddy current braking and then how we will apply the theory to produce a model.

**Slide 1 – Linear Brake Diagram**

Think of a conductive, non-ferrous surface (such as copper or aluminium) moving through a stationary magnetic field, as shown here on the slide. We will assume that the sheet is moving with a constant velocity, v, in a straight line. The magnetic field can be created by either a permanent magnet or an electromagnet. Although, the magnitude of the field can be regulated when using an electromagnet. The magnetic field will induce circular currents in the surface. These are known as eddy currents.

So how do we use these currents to decelerate the surface? In accordance with Faraday’s Law of induction, when the sheet is approaching the magnet, a counter-clockwise flow of electric current is produced. Ampere’s Circuital Law tells us that this will generate a repulsive magnetic field, slowing down the surface’s approach to the magnet. When the sheet moves away from the magnet, a clockwise current is induced which produces an attractive magnetic field that, again, slows down the surface. This is shown in the diagram, this part [RIGHT HAND SIDE] moving away, inducing an attractive magnetic field, and this part [LEFT HAND SIDE] moving towards the magnet, inducing a repulsive field.

The kinetic energy in the system is dissipated as heat generated in the surface due to ohmic heating.

**Slide 2 – Faraday’s Law of Induction and Lenz’s Law**

The force that slows down the surface is described by Faraday’s Law of Induction. This states that the size of the force is proportional to the rate of change of magnetic flux. Lenz’s law states that the force opposes the flux change (thus a minus sign is included in the equation).

*click*

The force is proportional to both velocity and the magnetic field strength. Because of this, eddy current brakes have no holding force; As when the velocity is zero, the force is zero too. In this way, the force acts similar to viscous friction in a liquid. This analogy could help when modelling this system. These relationships also suggest that as the magnetic field strength increases, the force on the surface does too. This will be confirmed in the experiment in the lab and simulated in the model by varying the current through the electromagnet.

**Slide 3 – Disk Brake Diagram**

In the experiment we will use, shown in the Panopto recordings, the surface is not moving through a magnetic field linearly as we have just discussed. Instead, the surface rotates around a central pivot. The question we must ask then is: ‘How does this differ?’. We actually find that the workings of a disk brake are exactly the same. However, the disk brake passes repeatedly through the magnetic field, so it will get hotter and hotter quicker than the linear brake.

**Slide 4 – Laminations**

In a way to control the heating effect, some materials are laminated into sheets and each sheet insulated. This splits the core in many individual circuits and the insulation restricts the flow of the eddy currents between layers. Thus, reducing the amount of heat generated through ohmic heating.

**Slide 5 – Model**

Now that we have an understanding of the workings of eddy current braking, we must apply the theory to create a model. There are two possible models that myself and the computational physicist have decided that we could use.

The first of these is to imagine the metal surface as a whole as described earlier. This would utilise Faraday’s Law to calculate the force on the surface by measuring both the time taken to brake and the magnetic field that the surface passes through.

*click*

The second method would be to treat each charge carrier separately, moving to the right with velocity, v. The magnetic field would exert a sideways force on them, F, equal to **.** As the charge carrier is an electron and therefore negatively charged, the force will act in the opposite direction to that shown in this diagram. The force would be directed towards the rear of the surface (to the left when facing in the direction of motion), and consequently induce clockwise currents to the right and anticlockwise to the left.

**Slide 6 – Problems**

There are obviously still some problems that will need to be solved. The first of these is that the surface is not infinite. There are edges to it and we will need to establish what happens to the eddy currents at these edges.

Furthermore, the surface may not travel in a straight line. However, this is already accounted for in the second modelling method as in the Lorentz equation, velocity is treated as a vector.

**Slide 7 – Aims**

In the coming week, we as a team would like to establish a working model to test hypotheses. We would also like analyse the data in order to make sure the theory is correct and the model is an accurate representation of the actual system.

That’s it for my planned presentation, thanks for listening and I would be happy to take any questions that anyone may have.