**Dropping Magnet Challenge, part 1:**

Drop a disk magnet through a copper tube and observe its behavior. (Please do not drop the magnet on the floor.)

1. Describe qualitatively the mechanism that slows down the falling magnet. Describe how the phenomena depend on the orientation of the magnet relative to the axis of the tube.
2. Identify the physical quantities in the setup that are relevant for the phenomena (geometric, electric, magnetic…). Include a sketch describing all relevant quantities.

When done with these 2 questions, ask one of the instructors or a TF to discuss your answers and get the remaining portion of the challenge.
Dropping Magnet Challenge, part 2:

3. Assume the disk magnet is generating a magnetic field with components along $z$: $B_z(r, z-z_m)$ and along $r$: $B_r(r, z-z_m)$. We will use cylindrical coordinates. Here $z_m(t)$ is the vertical position of the disk magnet. Write down the flux through a horizontal loop of radius $R$ at position $z$ generated by the magnet in terms of its magnetic field.

4. Write down the EMF around the loop. Do not try to solve any of the integrals. How does this EMF depend on the velocity $\frac{dz_m}{dt}$ of the disk magnet?
5. By considering the flux through a Gaussian cylinder of radius $R_0$, and infinitesimal height $dz$, derive a relationship between the radial and vertical components of $\vec{B}$. Do not assume that $B_z(r, z - z_m)$ is independent of $r$.

6. Using the relation in 5, write the induced EMF using $B_z(R_0, z - z_m)$ only. Why is this substitution convenient for measuring/calculating the induced EMF?
7. Consider a current loop formed by a slice of tube of height $dz$ at position $z$. Given that the resistivity of copper is $\rho$ (whose value can either be measured or looked up online), write an expression for the induced current $dI$ around the loop.

8. The disk magnet exerts a force $d\vec{F}$ on the current $dl$ at position $z$. Write down the expression for $dF_z$ (vertical component of the force only).
9. Write down the expression for the integrated force on the disk magnet, assuming the tube is infinitely long.

10. Write down the net force acting on the disk magnet, including gravity, and write down the equations of motion. Write down an expression for the velocity of the disk magnet in steady state (i.e. terminal velocity).
11. What quantities should you measure in order to determine the velocity of the magnet using the derived expressions?
   a. Measure these quantities.
   b. Measure the velocity of the disk magnet.

12. HW: Using MATLAB compute the velocity based on the expression from 10 and the quantities you measured. Compare your results.