The exam consists of three problems. Please show all work and give explanations for all answers since the reasoning behind your answer is as important than the final answer itself.

1. (30 points)

(a) A solenoid produces a circular region of magnetic field into the page as shown. The magnetic field strength decreases with time. Sketch the electric field which is produced by this time varying magnetic field.

(b) What is the net electric field flux through a cylindrical closed surface enclosing and centered on the solenoid above. Why? Assume that the solenoid has infinite extent in the out-of-plane direction.

(c) Consider three current loops (a) and (b) as shown. Loop (a) is held fixed but loop (b) is free to move by rotating or translating. First indicate the direction of the magnetic field produced by loop (a) at the location of the loop (b) and then describe the motion of the loop (b). Justify your answers.
2. (30 points) Consider three infinite sheets of current with current per unit length $-\lambda/2$, $\lambda$ and $-\lambda/2$ as shown.

(a) Sketch the magnetic field lines for this configuration.

(b) Calculate the magnetic field everywhere. Sketch $B$ as a function of the distance perpendicular to the sheet.

(c) For $\lambda = 10 \text{A/cm}$, calculate the maximum value of $B$.

3. (40 points) Consider a square wire loop with sides of length $L$, mass $m$ and resistance $R$. The loop is placed on a horizontal frictionless surface. A bar magnetic which produces a square region of magnetic flux sweeps across the loop with a constant velocity $v$ as shown. The magnetic field $B$ is in a direction perpendicular to the plane of the loop. In all of the questions below you can assume that the velocity $v$ of the bar magnetic greatly exceeds the velocity of the loop.

(a) In which direction will the current flow in the loop as the region of magnetic field crosses into the loop, while it is entirely in the loop and as it leaves the loop?

(b) Calculate the current $I$ flowing in the loop as the magnetic field cuts across the wire forming the loop.

(c) What is the direction of the force acting on the loop as the magnetic field enters the loop? Leaves the loop? Calculate the forces. Describe the motion of the loop in response to these forces.

(d) Calculate the velocity of the loop after the magnetic field is interior to the loop. After the magnetic field has again crossed out of the loop.