120 minutes. Closed book. You will not need a calculator.

Write your answers in an exam book. Please be sure to put your name on the front of the book! Show your work, explain your reasoning, and please box your final answers.

There are three problems with point values indicated. The total points value is 50.

Good luck.

After you have completed the exam, write and sign the honor pledge on the front of the exam book:
"I pledge my honor that I have not violated the Honor Code during this examination."

[20 points] A dielectric cylinder with relative dielectric constant ϵ_r and radius R is placed in a uniform external electric field of strength E_0. The symmetry axis of the cylinder is perpendicular to the external elctric field. Find the potential everywhere in space and find the electric field inside the cylinder.

You may recall that by solving Laplace's equations in cylindrical coordinates using separation of variables, one finds:

$$V(r,\phi) = (a_0 + b_0 \ln r)(c_0 + d_0\phi) + \sum_k \left[\left(a_k r^k + \frac{b_k}{r^k} \right) \cos k\phi + \left(c_k r^k + \frac{d_k}{r^k} \right) \sin k\phi \right].$$

[15 points] A thin disk of radius R carries a uniformly distributed charge Q and spins about its center with $\vec{\omega}$ perpendicular to the plane of the disk. What are the vector potential and magnetic field at $r >> R$ in the plane of the disk? Be sure to give magnitude and direction. [Hint: There are a number of ways to solve this problem. If you encounter a difficult integral, you may consider expanding the integrand before integrating.]

[15 points] A perfect dipole $\mathbf{p}$ is situated a distance z above an infinite grounded conducting plane. The dipole makes an angle θ with the perpendicular to the plane. Find the torque on $\mathbf{p}$. If the dipole is free to rotate, in what orientation will it come to rest?