Problem 1 (20 Points)

1. State the Helmoltz theorem in one sentence, and Lorentz equation. (2 Points)
2. State Maxwell's equations in the differential form, and name the laws that the equations state. (8 points)
3. Derive the integral form of Maxwell's equations showing where the divergence theorem and Stokes theorem are used. (10 points)

Problem 2 (15 Points)

1. Derive the formula for divergence in two dimensions. (5 Points)
2. Derive the formula for the z-component of curl. (5 points)
3. From gradient, curl, and divergence state the two equations that show two different ways that one operator applied to another gives zero as the output. (5 points)

Problem 3 (20 Points) Starting from Maxwell's equations

1. Derive the equation for conservation of charge, (5 Points)
2. Derive Poisson's equation for the electric potential in a static electro-magnetic field, and (10 Points)
3. Derive the vector Poisson's equation for the magnetic potential in a static electro-magnetic field. (10 Points)

Problem 4 (15 Points)

1. Derive Coulomb's law from Gauss' law. (5 Points)
2. Derive Biot from the magnetic potential formula (two step derivation). (5 points)
3. Derive the electromagnetic wave equation for electric or magnetic field in a charge and current free medium. (5 points)