

所別：太空科學研究所碩士班 一般生 科目：電磁學

1. (a) Derive Laplace's equation from Gauss's law for electric fields in a linear medium. (10 points)  
(b) Determine the potential distribution and the electric field intensity in a capacitor by solving Laplace's equation. The capacitor is formed by two parallel metal plates with a separation of  $d$ . The potential of the upper plate is  $V_0$  and the lower plate is grounded. (5 points)
2. Total charge,  $Q$ , is uniformly distributed over a sphere volume of radius  $a$ . Determine the electric field intensity (8 points) and the potential distribution (10 points) everywhere in space. Also determine the electric energy stored in the system. (7 points)
3. (a) Explain the underlying principle of the operation of an electric motor. (5 points)  
(b) Explain how a transformer works by using Electromagnetics. (5 points)  
(c) State the principle of Electromagnetics behind the operation of an electric generator. (5 points)  
(d) Which Maxwell's equation leads to a discovery of electromagnetic fields propagating in free space with the speed of light? (5 points)  
(e) What are the effects of electric fields and magnetic fields on a charged particle? (5 points)
4. The relative permeability and the magnetic flux density in a finitely conducting magnetic region bounded by a plane  $y \leq 0$  are 10 and  $\vec{B} = 3\vec{a}_x + 4\vec{a}_y - 6\vec{a}_z$  T, respectively. If the other region is characterized by free space, compute  
(a) the  $\vec{H}$  field in both regions, (5 points)  
(b) the magnetization vector in the magnetic region, (5 points)  
(c) and the  $\vec{B}$  field in free space. (5 points)
5. (a) What is the definition of the magnetic flux passing through an open surface  $s$ ? (5 points)  
(b) If  $\vec{B} = -B\vec{a}_z$ , compute the magnetic flux passing through a hemisphere of radius  $R$  centered at the origin and bounded by the plane  $z = 0$ , by integrating over the area of the disc in the  $xy$  plane. (5 points)  
(c) Verify the result in (b) by integrating over the surface of the hemisphere. (10 points)