12. Electric Field

Electric Field vs Gravitational Field	Electric		Gravitational	
Force (Vector)	$F_E = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$	• Attractive or repulsive	$F_G = -G\frac{m_1m_2}{r^2}$	• Always attractive
Field Strength (Vector)	$E = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r^2}$	• Points away from *positive* charge	$g = -G\frac{m_1}{r^2}$	• Points towards *mass*
Potential Energy (Scalar)	$U_E = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r}$	• Positive or negative, depends on product Q_1Q_2	$U_G = -G\frac{m_1m_2}{r}$	• Always negative
Potential (Scalar)	$V = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r}$	• Positive or negative, depends on charge Q_1	$\phi = -G\frac{m_1}{r}$	• Always negative
Relationship	$F_E = -\frac{dU_E}{dr}$	$E = -\frac{dV}{dr}$	$F_G = -\frac{dU_G}{dr}$	$g = -\frac{d\phi}{dr}$

Definitions

Electric field strength: The electric field strength at a point in an electric field is defined as the force per unit charge acting on a small positive test charge at that point.

Uniform: Uniform means that every point in the field region has the same (not constant) field strength.

Electric potential: The electric potential at a point in an electric field is the work done by an external force in moving a unit positive charge from infinity to that point without a change in kinetic energy.

Questions

1. A and B are 2 identical conducting sphere, each carrying a charge +Q and are placed in a vacuum with their centres distance d apart as shown. Explain why the force F between them is **not** given by the expression F=Q^2/4piεd^2

Ans: The positive charges in each sphere will be repelled such that the charges are concentrated on the outer sides of both spheres. Since they are no longer uniformly distributed, there is no longer spherical symmetry and hence the formula cannot be used.

2. The electric field near the Earth's surface is large, explain why you do not experience an electric shock when you stand upright.

Ans: The number of free electrons in the atmosphere is very small. Thus, although there is a large potential difference between the head and feet, this potential difference is not able to deliver sufficient current through the body. Therefore, an electric shock is not experienced.

3. A student claims that the mass of the particle is… Using the formula q/m, explain why his answer is not valid.

Ans: Using the formula, the charge is 45.651e. This is not valid as charge is quantised in integer multiples of e.