wk.13.field_lines_equipotential

Fields and Force
Potential and energy
equipotential lines
Newton's Law of Universal Gravity
G = 6.67 x 10^{-11} N•kg^2/m^2
Inverse Square Law

Notes

• In the past we have dealt with the acceleration due to gravity *g* at or near the surface of a planet. Usually that planet is earth and g= 9.8 m/s^2

• Any mass exerts a gravitational field and thus a gravitational force on another mass. The force one mass exerts on another mass is equal to the force that the other mass exerts on it and is pointed in the opposite direction.

• Newton assumed that the mass of an object operated from the center of mass of the object. However, he had to develop calculus in order to demonstrate this.

• Just like the thickness of a balloon decreases by a factor of r^2 as the balloon is filled up to a radius of "r," a field drops off as the function of the square of its inverse radius. This is called the **Inverse Square Law**

• Newton knew that the gravitational force was proportional to both the masses of the two attractive bodies and inversely proportional to the square of the inverses of the distance between them

$$Force_{gravity} \propto \frac{Mm}{r^2}$$

The constant of proportionality was determined to be equal to 6.67 x 10^{-11} N•m^2/kg^2 or **G** so

$$Force_{gravity} = G\frac{Mm}{r^2}$$

This is often written as

$$Force_{gravity} = G\frac{m_1 m_2}{r^2}$$

Both masses must be in kilograms and r must be in meters. If so, the force will come out in newtons.

Example: How much force does one 50 kg. person exert on another 50 kg person if they are standing 1.0 meter apart from each other. Compare this to the force one person feels from the earth.

solution: $Force_{gravity} = 6.67N\frac{m^2}{kg^2}\frac{(50kg)(50kg)}{(1m)^2} =$ *1.67 x* 10^{-7} *N*

The earth exerts a force of 50kg•9.8 m/s^2 *or 490 N. So the ration of these forces is*

$$\frac{490}{1.67e-7} = 2.9e9$$

In other words, the force you exert on another person a meter from you is far less than the force that the earth exerts on either two of you.

Field Lines

Field lines are a imaginary construction that aids in the understanding of fields. A field line either begins or ends on the object and radiates out from it much like pins radiate out of a pin cushion.

Equipotential lines and surfaces.

Equipotential lines are lines where, if an object were placed on that line and moved about the line to any other location, it would still have the same energy. The elevation lines on a contour map are examples of equipotential lines

Equipotential lines and surfaces are always normal (or perpendicular) to field lines

Electric fields and forces

An electric field behaves in a very similar fashion to a gravitational field. It obeys the inverse square law and is proportional to the magnitude of the charge that creates it.

$$E = k\frac{q}{r^2}$$

Where E is the electric field in newtons/coulomb
q is the magnitude of the charge in coulombs
r is the distance in meters

k is the coulomb constant which is equal to 9 x 10^9 N•m^2/C^2

The force between two charges separated by a distance "r" is

$$F_{electric} = k\frac{q_1 q_2}{r^2}$$

If one charge is negative and one is positive, the resulting negative sign will simply indicate the direction of the force.

The potential due to one charge is equal to

$$P = k\frac{q}{r}$$

This is measured in volts and is often given the symbol (uppercase) V

The potential energy of one charge placed within the <u>potential</u> of another charge is equal to

` **Vq**

or

$$Energy = k\frac{q_1 q_2}{r}$$

The table below compares electric fields and potentials to gravitational fields and potentials

	field	force	potential	energy
gravitational	$G\frac{m}{r^2}$ vector	$G\frac{m_1 m_2}{r^2}$ vector	$G\frac{m}{r}$ scalar	$G\frac{m_1 m_2}{r}$ scalar
electric	$k\frac{q}{r^2}$ vector	$k\frac{q_1 q_2}{r^2}$ vector	$k\frac{q}{r}$ scalar	$k\frac{q_1 q_2}{r}$ scalar