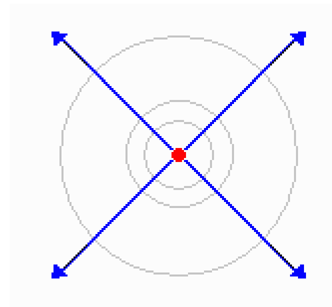
DAY 5

Summary of Topics Covered in Today's Lecture

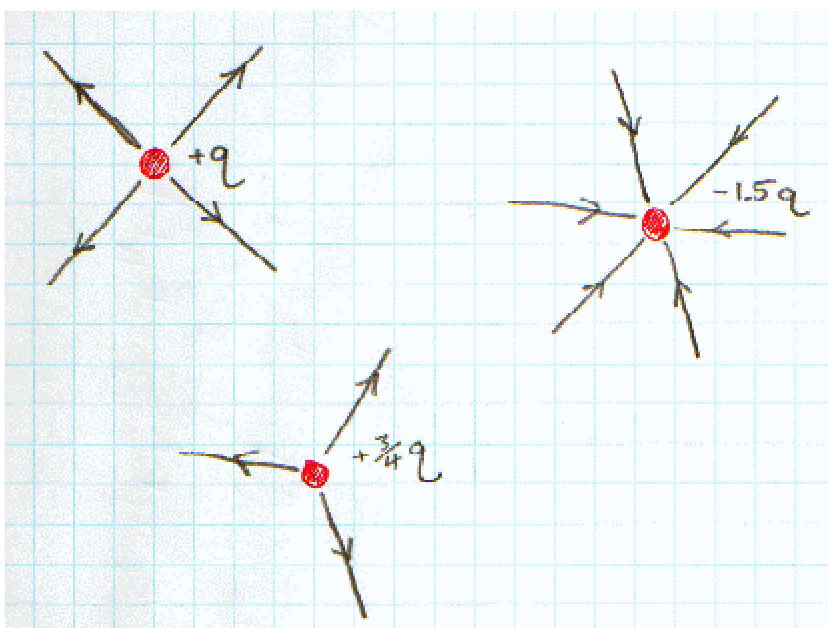
More on Field Lines

Concentric equipotential surfaces indicate that positive charges are the point of origination of electric field lines. Negative charges are the point of termination of electric field lines. Gravitational field lines terminate at masses. Field lines can also originate or terminate at infinity.



Field lines and equipotential surfaces for a positive point charge.

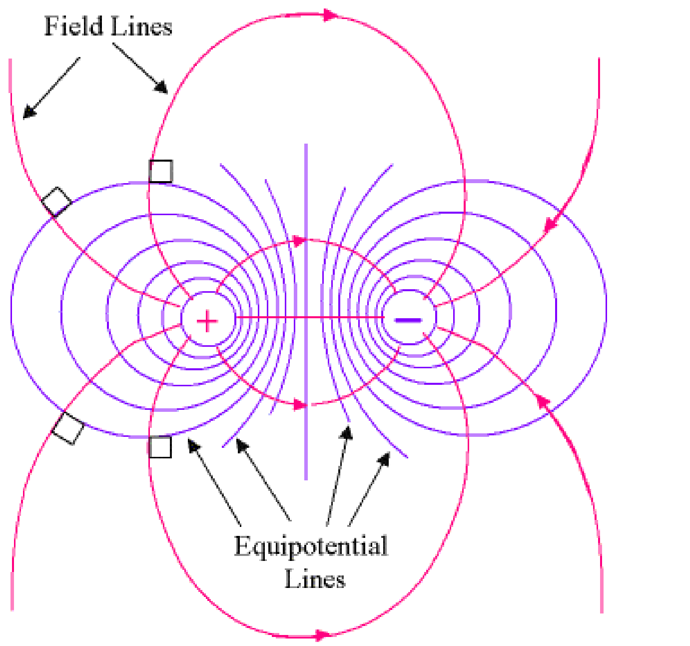
Because numbers of field lines represent field strength, and field strength is proportional to charge or mass, the number of field lines should be proportional to the charge or mass present in any field line diagram.



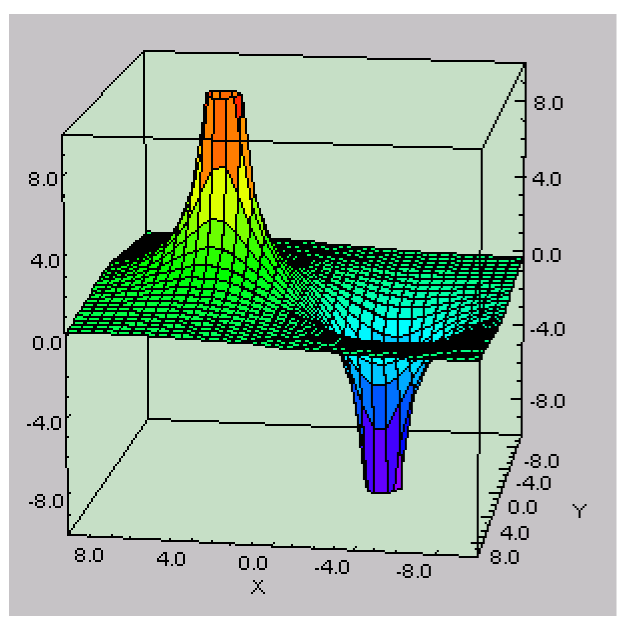
Summary – Field Lines and Equipotential Surfaces Rules (so far)

- Field lines and equipotential surfaces are always perpendicular.
- More densely pack field lines indicate a stronger field; less densely pack field lines indicate a weaker field.
- Field lines always indicate the direction of the field at the location of the line.
- **E**-field lines originate on positive charges (or at infinity); **E**-field lines terminate on negative charges (or at infinity); **g**-field lines terminate on masses and originate at infinity.

Following these rules you can determine the basic look of the field and potential around even fairly complex systems, just by drawing. For example, at right are the field lines and equipotential surfaces for two charges, one positive and one negative, both equal in magnitude (this configuration, which is what you would get with, say, a proton and an electron, is called an *electric dipole*). The field lines are perpendicular to the equipotential surfaces. The field lines originate and terminate on charges or at infinity. Since the charges are equal in magnitude they each have the same number of field lines approaching them. A plot of the potential of an electric dipole is also shown at right.



http://www.pstcc.edu/departments/natural_behavioral_sciences/



Some Applications involving Gravity -- Orbits and Escape Velocity

In gravitational fields, potential is always considered to be negative because

$$U_g = -Gm/r$$

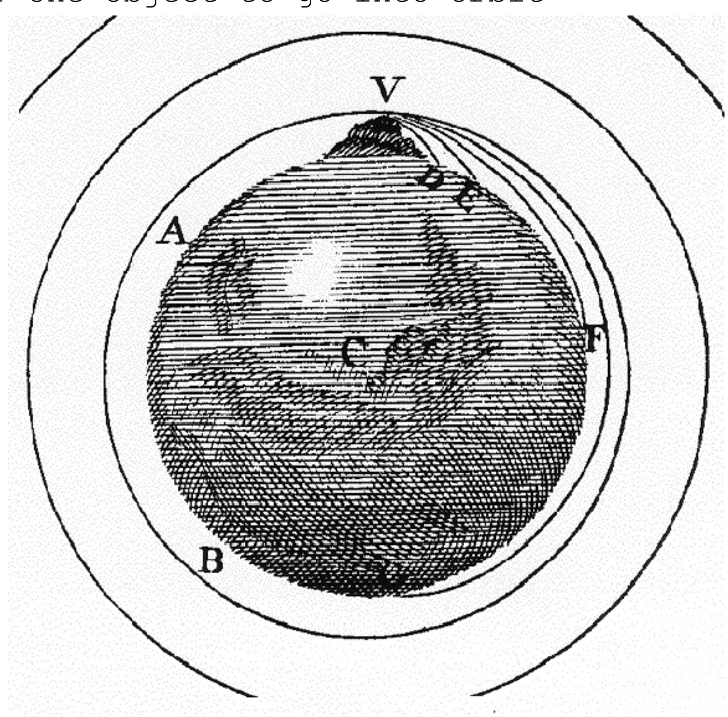
If there is mass present, the only location in space that has zero potential is a point an infinite distance from the mass, at $r = \infty$.

Using calculus (see PHY 232 example problem from previous day) we show that while the potential of a point object is of the form $1/r$, the field is of the form $1/r^2$. Likewise, the gravitational field for a massive object like a planet is

$$\mathbf{g} = Gm/r^2$$

directed toward the planet. This is also zero only at $r = \infty$.

Isaac Newton said that since gravity always pulls objects toward themselves, it is possible for one object to go into orbit around another. An object orbiting the Earth is constantly "falling" toward the Earth – it's just that the Earth is curved so it never hits the surface! Be sure to check out the animated version of this diagram.



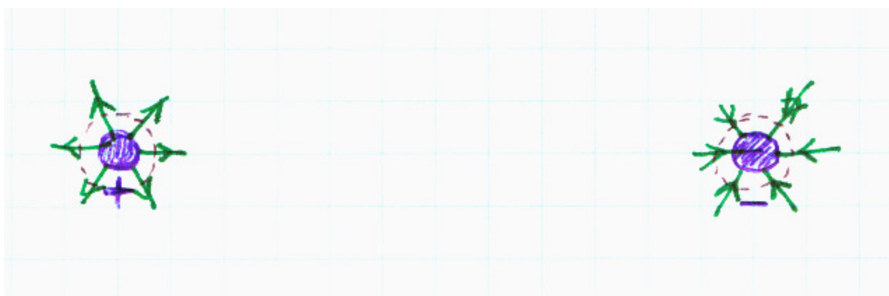
Example Problem #1

Sketch the field lines and equipotential surfaces of an electric dipole for yourself.

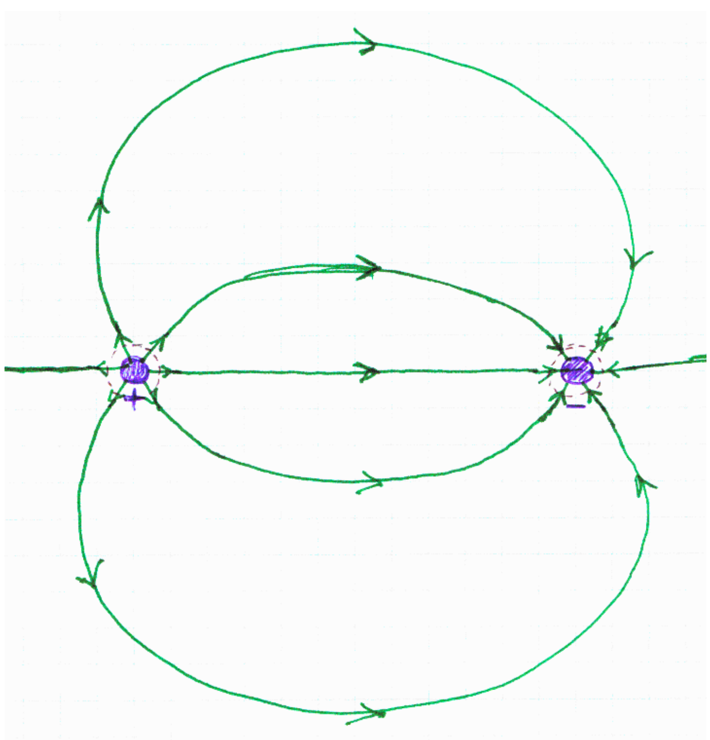
Solution:

First I draw my equal but opposite charges.

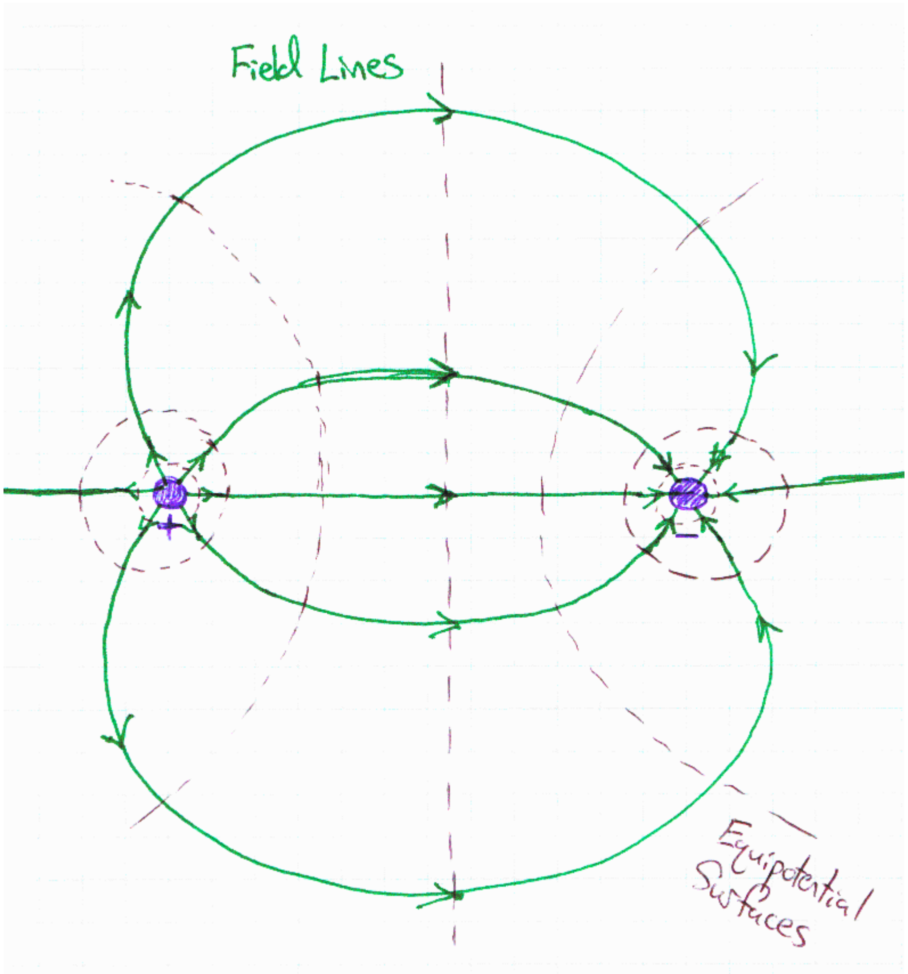
Now, at least close to each charge I expect to find a nice, symmetrical, circular equipotential surface surrounding it. Perhaps further out the surfaces might get more complex, but close in should be circles. Also, I need field lines leaving the positive charge and terminating on the negative charge. Finally, since both charges are the same magnitude, I have the same number of field lines at each,



OK, now I'm going to connect these together in a nice, smooth fashion – no weird moves, no kinks in the lines…



Lastly, I add in the rest of the equipotential surfaces. Where the field lines are packed more densely (like near the charges), I know the field is stronger, the potential gradient is steeper, and so the equipotential surfaces should be closer together. So I put the equipotential surfaces a little closer together in those regions. Also, every equipotential surface must be perpendicular to every field line. Following that line of reasoning, and again making sure I have no weird moves or kinks in my drawing, I get this:



Example Problem #2

Sketch the equipotential surfaces and electric field lines for a positive and negative charge configuration similar to a dipole, except that the positive charge is twice the magnitude of the negative charge.

Solution:

I start this just like the last one. However, since the positive charge is twice the magnitude of the negative charge, I need to have twice the field lines at it.

Now I'll finish the job just like I did with the dipole. However, this time only half of the lines that originate on the positive charge will terminate on the negative charge. The other half terminate at infinity.