Conceptual Electronics Videos

This series of 24 videos manages to start from scratch and work its way up to Electromagnetism pretty much without math. One thing they could have improved though is the labelling. So while you watch the videos, keep in mind that:

- Red particles are positive charges
- Blue particles are negative charges
- Purple arrows are electric fields
- Green arrows are magnetic fields.

I would probably also skip the second video, which I found a bit long and abstract. Here's a quick summary of it:

- [4:00] Magnetic fields exerts a force on moving charged particles because a moving charged particle creates curly magnetic field around it (Ampere's Law) so the particle behaves like a magnet. This is the principle behind old Cathode Ray Tube TVs: send electrons flying toward a screen that can image them, and adjust their deflection using a magnetic field.
- [4:16] A charged particle moving in a loop creates a magnetic field (Ampere's Law) which is the same for a spinning electric charge, which is the what permanent magnets are made of. Notice how the magnetic field lines form closed loops (Gauss' Law of Magnetism).
- [5:20] Magnetic fields can be created by a current through a wire (first part of Ampere's Law), which is how electric motors function.
- [7:08] Electric fields can be created by a magnetic field which is changing in time (Faraday's Law of Induction), which is how alternators function.
- [10:15] Magnetic fields can also be created by a changing electric field (second part of ampere's law). Together with the other three laws, these can lead to a feed back loop where a changing magnetic field creates a changing electric field, which creates a changing magnetic field, and so on. This is how electromagnetic waves are created.

In mathematical terms, there are four equations (known as Maxwell's Equations) that explain all the electromagnetic phenomena we observe:

Name	Math	Description	Pictures
Gauss' Law	\$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}\$$	An electric charge, \$\rho\$, creates an electric field, \$\vec{E}\$, that points away from the charge and "disperses" to infinity	
Gauss' Law of Magnetism	\$$\vec{\nabla} \cdot \vec{B} = 0\$$	A magnetic field, \$\vec{B}\$, can not "disperse" to infinity the way an electric field can. Instead, magnetic field lines loop onto themselves. In other words: "magnetic charges" don't exist the way electric charges do.	
Faraday's Law of Induction	\$$\vec{\nabla} \times <fc #9400d3>\vec{E}</fc> = -\frac{\partial \vec{B}}{\partial t}\$$	A changing magnetic field, \$\vec{B}\$, creates a "curly" electric field, \$\vec{E}\$ and vice-versa.	
Ampere's Law	\$$\vec{\nabla} \times \vec{B} = \mu_0 \Big(\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \Big)\$$	An electric current, \$\vec{J}\$, and/or a changing electric field, \$\vec{E}\$, creates a "curly" magnetic field, \$\vec{B}\$	