

Introduction to Electric & Magnetic Fields

The following videos will take you from vectors to electromagnetic waves. Along the way there are about 50 demonstrations to illustrate many of the concepts. These demonstrations are built from ordinary items, many you might find around your (house, paper clips, batteries, magnets), at a hardware store or on-line. All details of constructing the demonstrations are included. You will also find some anecdotes on the discoveries and the people behind the discoveries.

Week 1

1. Vector Representation & Addition (14:13)

<https://youtu.be/-XSvWOCiHr8>

2 Scalar or Dot Product (6:29)

<https://youtu.be/CvuZNRg9cx8>

3 Vector, or Cross, Product (7:05)

<https://youtu.be/2mANQCZkQEA>

4 Cartesian and Cylindrical Coordinate Systems (15:40)

<https://youtu.be/TORTb-w3pdM>

5 Coordinate Conversion Example (18:52)

<https://youtu.be/z2nSg3Rjeho>

6 Spherical Coordinates (8:06)

<https://youtu.be/JvbmRRowb1o>

7 Differentials (13:27)

<https://youtu.be/GgnfKzmFHmI>

8 Charge, Triboelectric Series, Electrostatic Induction (8:53)

https://youtu.be/y_xPOtN2bvY

9 Voltaic Pile (11:00)

<https://youtu.be/pW4UUOgJX6k>

10 Static charge (4:07)

<https://youtu.be/FIVYAoMreAs>

11 Electrostatic Induction Example Problem 4 Exam 1 Spring 2017 (3:07)

<https://youtu.be/Ni8UCXtpFcc>

12 Franklin's Bells (5:25)

<https://youtu.be/RaKh7ZoLd0M>

Week 2

1 Coulomb's Law (10:43)

<https://youtu.be/QBq3dYeVhFU>

2 Coulomb's Law Example (5:28)

<https://youtu.be/FA2OwdYkt7g>

3 Electric Field Intensity (5:29)

<https://youtu.be/7iiGJPdY2so>

4 Charge Density (7:00)

<https://youtu.be/EkSKzsL0UY0>

5 Electric Field from Charge Distributions (10:50)

<https://youtu.be/o2IrEeHTOME>

6 Rotary Electrostatic Motor (4:30)

<https://youtu.be/9THGyOzMXjo>

7 Faraday and Electric Flux (17:52)

<https://youtu.be/mxcWXLj35b8>

8 Faradays Ice Pail Experiment (7:55)

<https://youtu.be/GNizWxAD-9M>

9 Gauss Law (5:05)

<https://youtu.be/6EMxtP0i7Z4>

10 Where Is Coulomb's Law (5:05)

<https://youtu.be/6M0hyRx154o>

11 Electric Flux Example (4:58)

<https://youtu.be/7fRzkRKJVqE>

12 Electric Field of an Infinite Line of Charge Using Gauss Law (8:55)

<https://youtu.be/MIJcC9F0xWE>

13 Gauss' Law Example Infinitely Long Cylinder of Charge (8:56)

<https://youtu.be/a8dAQj4ZCOM>

14 Electric Field from an Infinite Plane of Charge (5:46)

<https://youtu.be/am1NCdbNAPw>

15 Gauss' Law Example Infinite Rectangular Charge Distribution (8:24)

<https://youtu.be/4JMUwoZWEKY>

16 Van de Graaff generator (14:10)

<https://youtu.be/9EiHz5zRRYI>

17 Electric Flux Density of a Sphere of Charge (5:21)

<https://youtu.be/7mvAu8RHBeI>

Week 3

1 Divergence and Gauss' Law Part 1 (7:17)

<https://youtu.be/u6-hHDAzpgs>

2 Divergence and Gauss' Law Part 2 (15:18)

<https://youtu.be/K0pl6Ch0i0I>

3 Energy and Potential (7:22)

<https://youtu.be/Q02Y6435gkw>

4 Kelvin Electrostatic Generator (9:54)

<https://youtu.be/Y7MJbZTjKyo>

5 Potential of a Point Charge (10:31)

<https://youtu.be/WZ6o5bxM7BM>

6 Potential and Point Charge (4:15)

<https://youtu.be/OxuU5N2moIE>

7 Potential of a Conducting Sphere (7:16)

<https://youtu.be/2hgoFLcljw>

8 Curvature and Charge Density (8:25)

<https://youtu.be/VTkGMKAeNIA>

9 Potential Field When Point Charge is not at the Origin (5:48)

<https://youtu.be/wJHjvFI9YNw>

10 Potential with Point Charge not at the Origin (3:06)

<https://youtu.be/RXPlb2ZOQKM>

11 Potential from a Line Charge Density (2:57)

<https://youtu.be/jcB7fFIalus>

12 Energy in a Collection of Point Charges (12:40)

https://youtu.be/1OZ2BT_IOqY

13 Gradient and Finding the Potential Field (12:12)

<https://youtu.be/BinFKuZ9UVc>

Week 4

1 Current (11:04)

<https://youtu.be/7llhywQ3yVE>

2 Current and Current Density (6:32)

<https://youtu.be/DzdJyDRr-WY>

3 Drift Velocity Problem (2:44)

<https://youtu.be/oZtHMuRXDEM>

4 Resistance Equation (2:24)

<https://youtu.be/2VmL7bUUqxs>

5 Current from Current Density (6:02)

https://youtu.be/IT0_tos4w14

6 Current from Current Density Example (4:02)

<https://youtu.be/UsqDRwJeNW8>

7. Electric Dipoles, Bound Charge, & Polarization (8:32)

<https://youtu.be/249afo7ThpM>

8. Electric Potential Field And Electric Field Intensity Of An Electric Dipole (3:20)

<https://youtu.be/VtO1-CDQk-s>

9 Electric Dipoles and the Polarization Field (21:01)

https://youtu.be/i6A_pH0ZmW0

10. Absolute and Relative Permittivities (3:05)

<https://youtu.be/eZTrQB6fHqg>

11 Demonstration of the Dipole Nature of Water (2:38)

<https://youtu.be/6FtVZKjcdlo>

12 Charge Density Dielectric Problem (9:50)

<https://youtu.be/7dcUECcotm8>

13 Charge Density Dielectric Problem (4:22)

<https://youtu.be/hPrWm6nflgs>

14 Electrical Boundary Conditions (8:41)

<https://youtu.be/Bf7impeK0JU>

15 Electrical Boundary Condition Problem (5:20)

<https://youtu.be/2aTPGFBBMdc>

Week 5

1 Poisson's and LaPlace's Equations (8:20)

<https://youtu.be/9cuEwv9VUsI>

2 Poisson's Equation Example 1 (4:56)

<https://youtu.be/c-9kAbTLRt4>

3 Poisson Equation Example 2 (10:06)

<https://youtu.be/glqtzC1WnNI>

4 Charge Density from Electric Flux Density (5:40)

<https://youtu.be/Qc21LRi9bp4>

5 Capacitance (12:47)

https://youtu.be/efKNVWS_Ixc

6. How Much Charge is There on a Van de Graaf Generator (10:58)

<https://youtu.be/zEJi71aknqQ>

7 Leiden Jar Capacitor (11:06)

<https://youtu.be/Lh6YATitN9k>

8 Capacitor and Fringing Fields (3:08)

<https://youtu.be/ixe7wUmJGdc>

9 Capacitor with Parallel Dielectrics (9:17)

<https://youtu.be/oa9q55PH0-s>

10 Capacitor with Series Dielectrics (6:14)

<https://youtu.be/kk4Kod3xaVs>

11 Capacitor with Free Charge in the Dielectric (5:26)

<https://youtu.be/cNdFuBKMPiA>

12 Spherical Capacitor Problem (9:21)

<https://www.youtube.com/watch?v=fWhMcSweDGE>

13 Method of Images (8:16)

<https://youtu.be/-AYHbjDf9sM>

Week 6

1 Energy Stored on a Capacitor (8:03)

<https://youtu.be/YblJ3eFWyqk>

2 Capacitor Example with Dielectric Added (4:22)

https://youtu.be/t-0iBuB_5P8

3 Capacitor Example with Battery Attached (4:19)

https://youtu.be/5CM1NNC_kUM

4 Capacitor Example with Battery Removed (4:10)

<https://youtu.be/-38-uaueHMc>

5 Introduction to Magnetic Fields (2:12)

https://youtu.be/_h5rgbt14hc

6 Magnetic Field of a Coil (12:44)

<https://youtu.be/bq6lhafucE>

7 Force Between Current Carrying Coils (3:16)

https://youtu.be/FLWgm_j0XZc

8 Styrofoam Cup Loudspeaker (4:04)

<https://youtu.be/6Slmr99o5wI>

9 Magnetic Field of a Bar Magnet (1:25)

<https://youtu.be/QaZ0h76X6d0>

10 Magnetic Field from a Current Carrying Coil (1:20)

<https://youtu.be/s-qHfqYAvaw>

11 Magnetic Field of a Wire (1:26)

<https://youtu.be/caHXwJbkbQU>

12 Ampere's Force Law and the Biot-Savart Law (8:07)

https://youtu.be/I4oXcqd5z_E

13 H-field of an Infinite Line of Current using the Biot-Savart Law (4:00)

https://youtu.be/zM_qC5Q8EOw

14 Force on a Current Carrying Wire in a Magnetic Field (4:47)

<https://youtu.be/b93eL6HwABU>

15 Current Balance (4:22)

<https://youtu.be/S0YXJe13MxE>

Week 7

1 Ampere's Circuital Law (17:56)

https://youtu.be/R7v8i8bW_js

2 Magnetic Field of a Current Carrying Wire (2:46)

<https://youtu.be/Rw7IKosT01E>

3 Surface Current Density (1:30)

<https://youtu.be/Thrx0i2hxjg>

4 Magnetic Field Intensity from an Infinite Current Sheet (9:44)

<https://youtu.be/rlsJISorvUc>

5 Ampere's Circuital Law Example (2:31)

<https://youtu.be/ssuv4xYUve4>

6 Magnetic Field Intensity from a Current Flowing in the Axial Direction on the Surface of a Cylinder (13:22)

https://youtu.be/q_zODnbNVp8

7 Curl Part 1 (4:21)

<https://youtu.be/6F1GNvksR0E>

8 Curl Part 2 (10:37)

<https://youtu.be/7iwpsN9f508>

Week 8

1 Force on Moving Charge in a B field (9:41)

<https://youtu.be/ompJcDSAx7A>

2 Force on moving charge in magnetic field (3:13)

<https://youtu.be/HvG4ik-TFS8>

3 Measuring Earth's Magnetic Field (9:19)

<https://youtu.be/8Nz6MwK6lV4>

4 Mass Spectrometry (4:48)

<https://youtu.be/whkdhJ3OQ8I>

5 Linear Motor (2:10)

<https://youtu.be/ge-eD1C8Uxk>

6 Hall Effect (8:41)

<https://youtu.be/6mNCr5GUECs>

7 Faraday's Motor (1:21)

<https://youtu.be/leYqp0oDPBs>

8 Faraday Like Motor (2:26)

<https://youtu.be/sseL9rdN-u8>

9 DC Motors (13:50)

<https://youtu.be/IMP-8ctzgAY>

10 Simple Motor with a Permanent Magnet (3:36)

<https://youtu.be/PO0m0xFcyS0>

11 Simple Motor with an Electromagnet (3:43)

<https://youtu.be/Yw8ru6TR2JQ>

12. Synchronous Motors (11:08)

<https://youtu.be/a49sIEpSoeg>

Week 9

1 Magnetization (16:10)

<https://youtu.be/U0DyxMR5X0Q>

2 Linear Electric Motor (9:08)

<https://youtu.be/CZbXaNWGAkM>

3 Diamagnetism & Paramagnetism (9:34)

<https://youtu.be/lBHx9jzjkWQ>

4 Demonstrations of Diamagnetism and Paramagnetism (6:12)

<https://youtu.be/2RRX8xmLR8E>

5 Ferromagnetism (16:47)

<https://youtu.be/HDUgCEVC7DQ>

6 Magnetizing, and demagnetizing, paper clips (0:45)

<https://youtu.be/P0Mr1a2aIW0>

7 Further Discussion of B, H, & M (5:02)

<https://youtu.be/XfthOKIMkxE>

Week 10

1 Magnetic Boundary Conditions (7:01)

<https://youtu.be/3IKF8dXUtMk>

2 Magnetic Boundary Example (6:34)

https://youtu.be/G4sk8Li8_WQ

3 Inductance (7:30)

<https://youtu.be/McRwGS0fj6o>

4 Inductance of a Coil (2:37)

https://youtu.be/omLQG5jVI_Y

5 Inductance Twin Lead Antenna Wire (4:44)

<https://youtu.be/56mdQRsxi0g>

6 Inductance of a Coaxial Cable (4:20)

<https://youtu.be/4bIEWOc9cts>

Week 11

1 Electromagnetic Induction (2:03)

<https://youtu.be/AxIg-9uoLHM>

2 Electromagnetic Induction and Faraday's Law (5:31)

<https://youtu.be/KUihEkvabpo>

3 Further Demonstrations of EM Induction (5:38)

<https://youtu.be/JGgHe2oiaMg>

4 Faraday's & Lenz's Laws (7:01)

<https://youtu.be/-Dk-kA1iGM4>

5 Lenz Law (2:41)

<https://youtu.be/pMfNuP1Wozw>

6 Faraday Flashlight (3:03)

<https://youtu.be/fiyaYII7ROA>

7 Faraday's Law, Inductance, & Energy (12:16)

<https://youtu.be/ZfSd-jSJuk4>

8 Faraday's Law Example 1 (Electromagnetic Induction) (10:00)

<https://youtu.be/O52qfOnJ97A>

9 Faraday's Law Example 2 (Electromagnetic Induction) (4:07)

<https://youtu.be/lw54vo7yZpc>

10 Faraday's Law Example 3 (Electromagnetic Induction) (7:50)

https://youtu.be/_6UaU9Ze2KI

11 Faraday's Law Example 4 (Electromagnetic Induction) (6:16)

<https://youtu.be/sAsxEBkaty8>

Week 12

1 Transformers (28:00)

<https://youtu.be/mRQqqSxBRSs>

2 Linear Generator (3:17)

<https://youtu.be/KuJZmWtFsG8>

3 AC Generator (6:22)

<https://youtu.be/dSZKHUwtCEQ>

4 AC Generator (4:32)

<https://youtu.be/O5n6ubrbK5A>

5 Eddy Currents & Magnetic Braking (5:32)

<https://youtu.be/H310MWSWxF0>

6 Eddy Currents and Magnetic Braking of a Pendulum (4:43)

<https://youtu.be/MglUIiBy2lQ>

7 Investigation of Electromagnetic Induction (Lenz's & Faraday's Laws)

<https://youtu.be/wlNWfO4SW9I>

8 Displacement Current & Maxwell's Equations (10:30)

<https://youtu.be/Kh6NbIDS4ac>

Week 13

1 Waves (14:39)

<https://youtu.be/K82qtc7XDaE>

2 Uniform Plane Waves (16:15)

<https://youtu.be/MAMdOnmhrjs>

3 Speed of Light (1:42)

<https://youtu.be/TxL8lJDBp1E>

4 Hertz (2:22)

<https://youtu.be/f3IbL1F8VOw>

5 Ruhmkorff, Spark, or Ignition Coil (10:57)

<https://youtu.be/iVbNGJX88gc>

6 Speed of Light in SiO₂ (1:35)

<https://youtu.be/f3Acdi3G0YI>

Week 14

1 Power Flow in a TEM (4:21)

<https://youtu.be/ba5xHkLb9MA>

2 TEM Wave Problem (6:31)

<https://youtu.be/qLzmpyiUD18>

3 Phasor Review (9:35)

<https://youtu.be/e6S5BA27vMk>

4 Plane Waves in Lossy Material (8:14)

<https://youtu.be/Ogbbiuas3xo>

5 Plane Waves in Good Conductors (11:32)

<https://youtu.be/oUUEEcbmtcQ>

6 Example TEM In Lossy Material (2:17)

<https://youtu.be/81cOeb4h2OU>

Photoelectric Effect and Wave particle Duality of EMWs (8:50)

https://youtu.be/_kOZpu6OJs0

Youngs Double Slit Experiment (9:28)

<https://youtu.be/wVZny2KFB1Y>

Using a Tesla Coil to Launch and a Loop Antenna to Detect an Electromagnetic Wave (16:59)

<https://youtu.be/ysDgCtjvPcQ>

Color Vision (10:56)

<https://youtu.be/lCeK6IDLHIA>

Week 15

1 Power Flow associated with Conductors (4:53)

<https://youtu.be/B5UV4uob9Wk>

2 Reflection of Plane Waves Part 1 (6:16)

<https://youtu.be/AY7Q8uTvaTs>

3 Reflection of Plane Waves Part 2 (7:05)

<https://youtu.be/ldMTHTWtovo>

4 Reflection of plane wave Part 3 (11:49)

<https://youtu.be/eCLL3yCJh8c>