

Themed: 08-02

ΔB makes I & vice-versa, loops, Lenz's law, induction, Faraday's law, generators/motors, transformers

ΔB makes I & vice-versa

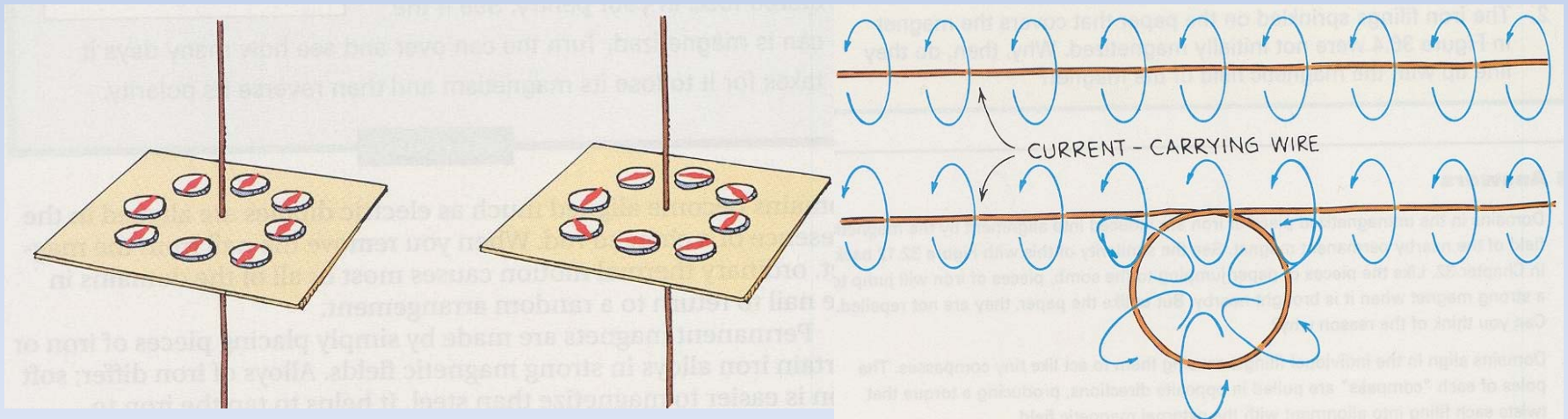
- Moving charge (a “changing electric field, I for example) creates magnetic field
- Changing magnetic field makes charges move (creates voltage)

IT WORKS BOTH WAYS!!!

Isn't symmetry a beautiful thing?

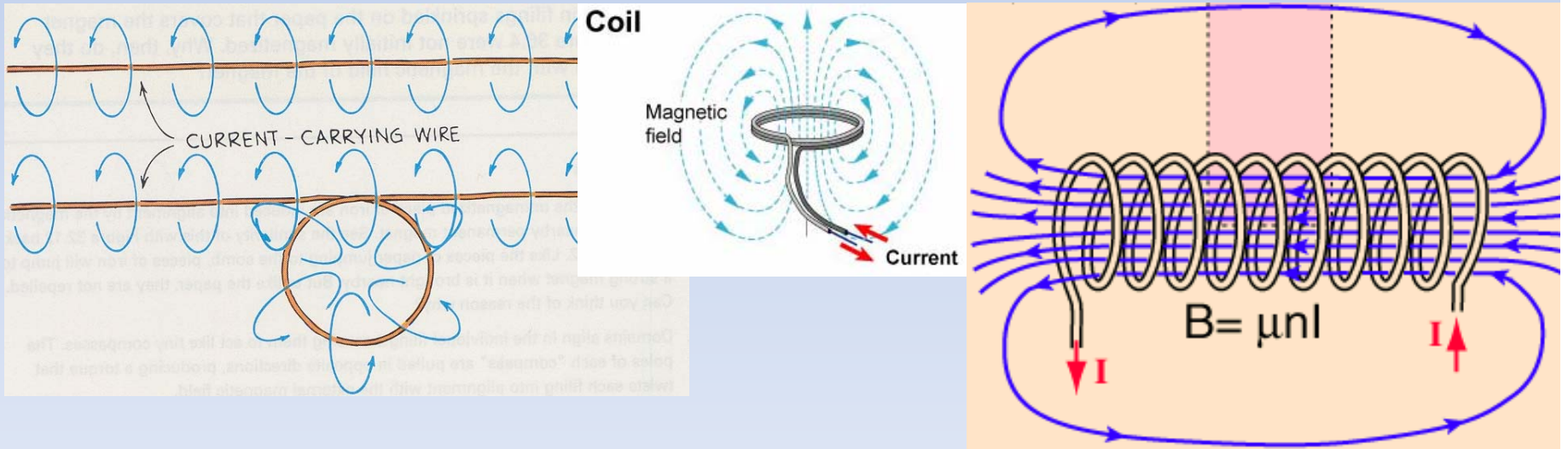
Loops - Making strong magnetic field

- We can't make individual electrons spin, like ferromagnetic materials, but we can make current
- Current is charge in motion, so it makes a magnetic field (remember right hand rule!)
- Reversing direction of current reverses poles



Loops - Add a loop, add more B

- Looping a current-carrying wire concentrates the magnetic field (B) in the loop's center
- Stacking loops adds more B
- More current is also more B
- Add a ferromagnetic nail in the core (center) and you got an electromagnet!

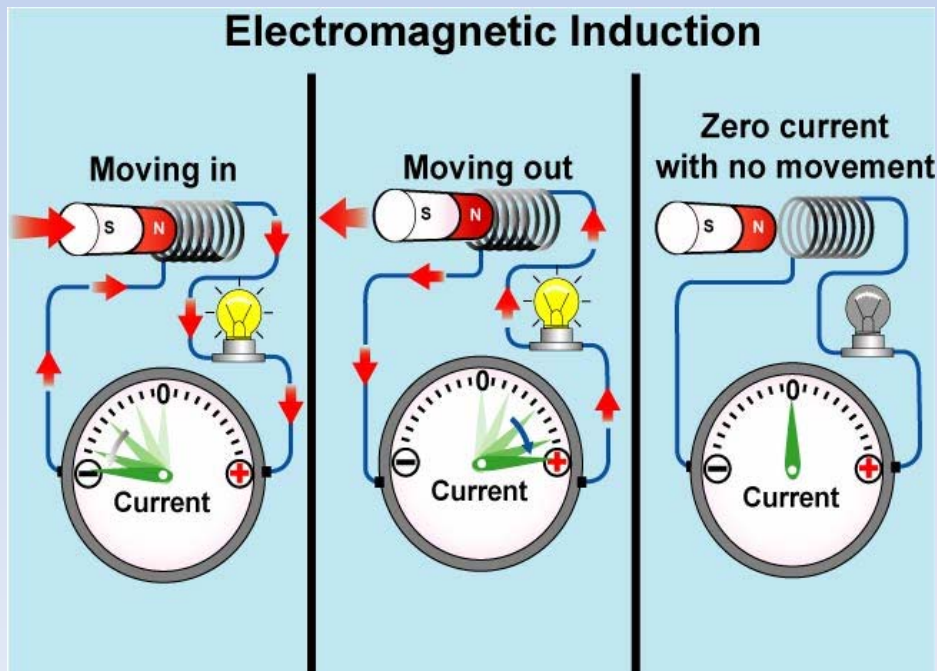
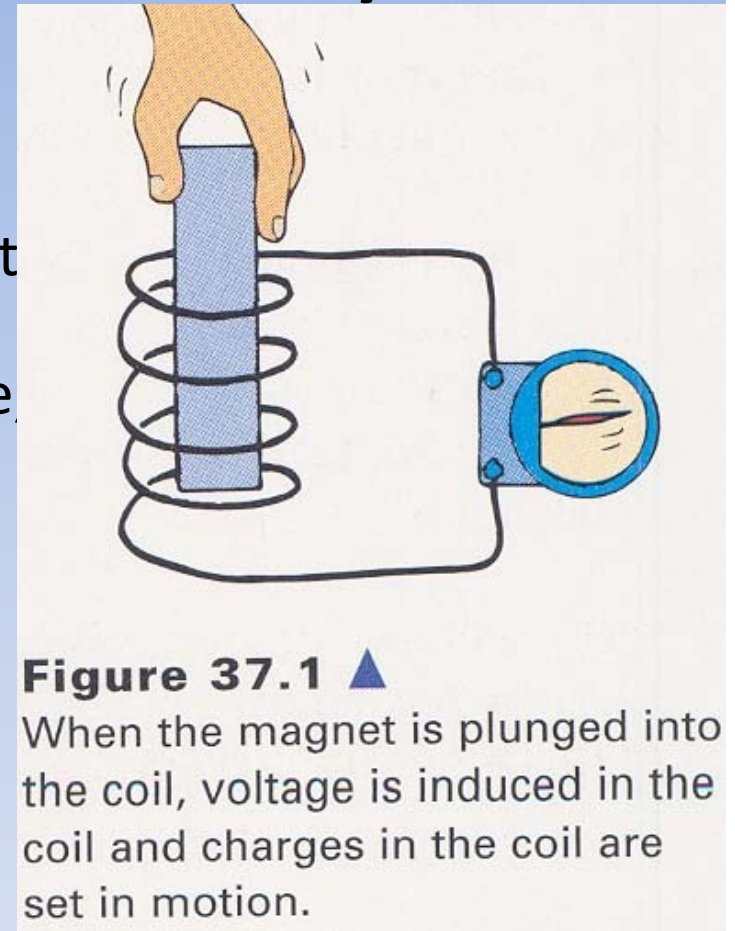


Lenz's Law

- Change the magnetic field in a loop that's part of a circuit and current will flow to create (induce) a magnetic field to oppose that change
- Simpler: Nature likes the magnetic field the way it is, don't change it!
- Everything electrical you ever owned and pretty much all the technology you love is based on this!

Induction: because it works both ways

- Change the magnetic field in the coil and you get electrons to flow, this is an “induced” current
- Strongest magnetic field in the world won't make any current unless it's CHANGING
- Anything that “pushes” electrons is voltage, AKA electromotive force, or EMF



Induction - How to get more current

- Change the magnetic field in the coil = get electrons to flow
- Change it quickly/by a lot = get electrons to flow fast:
 - Move magnet fast
 - Use strong magnet
 - Add more coils

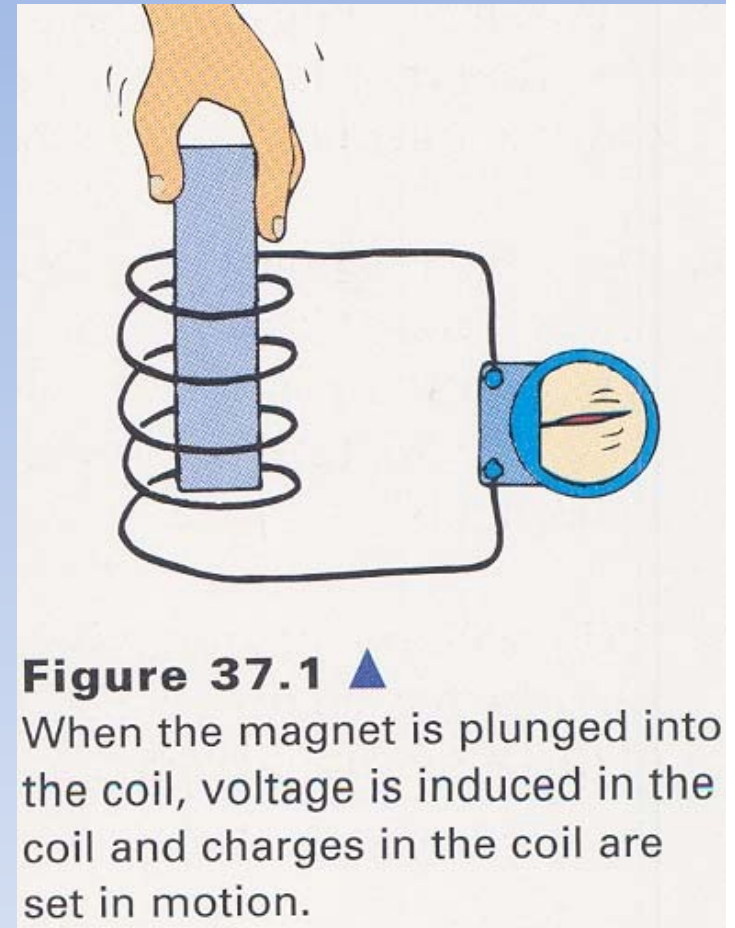
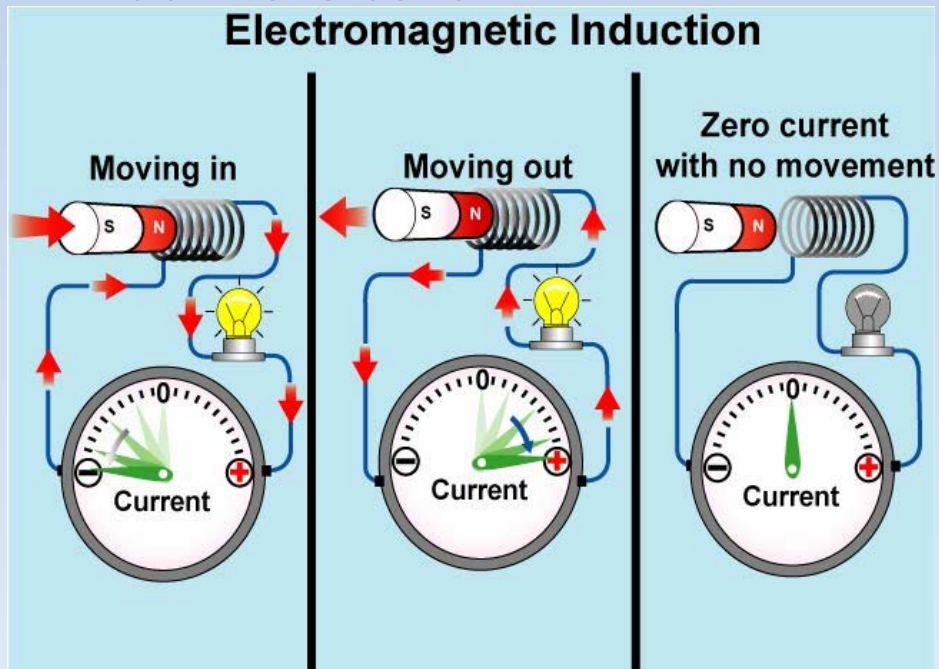


Figure 37.1 ▲
When the magnet is plunged into the coil, voltage is induced in the coil and charges in the coil are set in motion.



Faraday's law

(Themed: Concepts only)

- Law says: Voltage (in a circuit coil) is induced by a CHANGING magnetic field

$$N \Delta(BA)$$

- $\varepsilon = \frac{\quad}{\Delta t}$ easy if you use correct units!
 - ε is induced voltage caused by changing magnetic field,
 - N is the number of loops,
 - B is the strength of the magnetic field,
 - A is the area (in square METERS, of course!): A is important for rotating coils (motors, generators)
- Your book goes over this and has practice problems I will assign later (plug and chug)
- Understand the concept and this is easy
- See how a generator uses this!

http://www.walter-fendt.de/ph14e/generator_e.htm

Themed Only - Generators and motors

- Know they are opposites in function, but work on same principle
 - Generators take mechanical energy and output current (electrical energy)
 - Motors take current and output mechanical energy
- Lenz's law predicts this
 - Since nature opposes change, you have to input mechanical work to make a change
 - You turn a crank (or waterfall, etc. turns a paddle wheel) and your mechanical work gets turned into electrical energy

Themed Only - Generators and motors

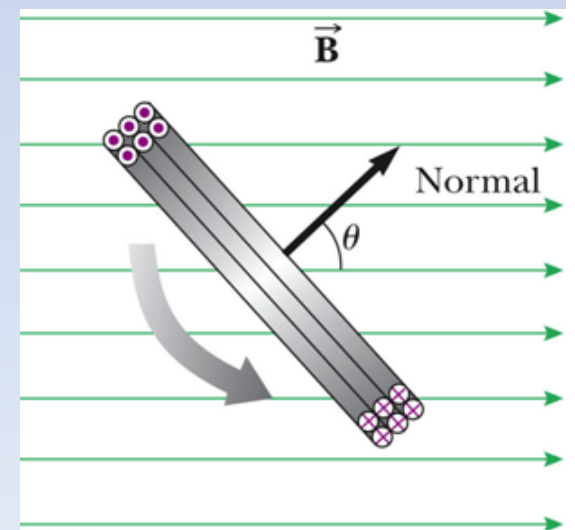
- Key idea to notice from Faraday's law

$$N \Delta(BA)$$

$$\varepsilon = \frac{\quad}{\Delta t} \quad (\text{remember EMF means voltage})$$

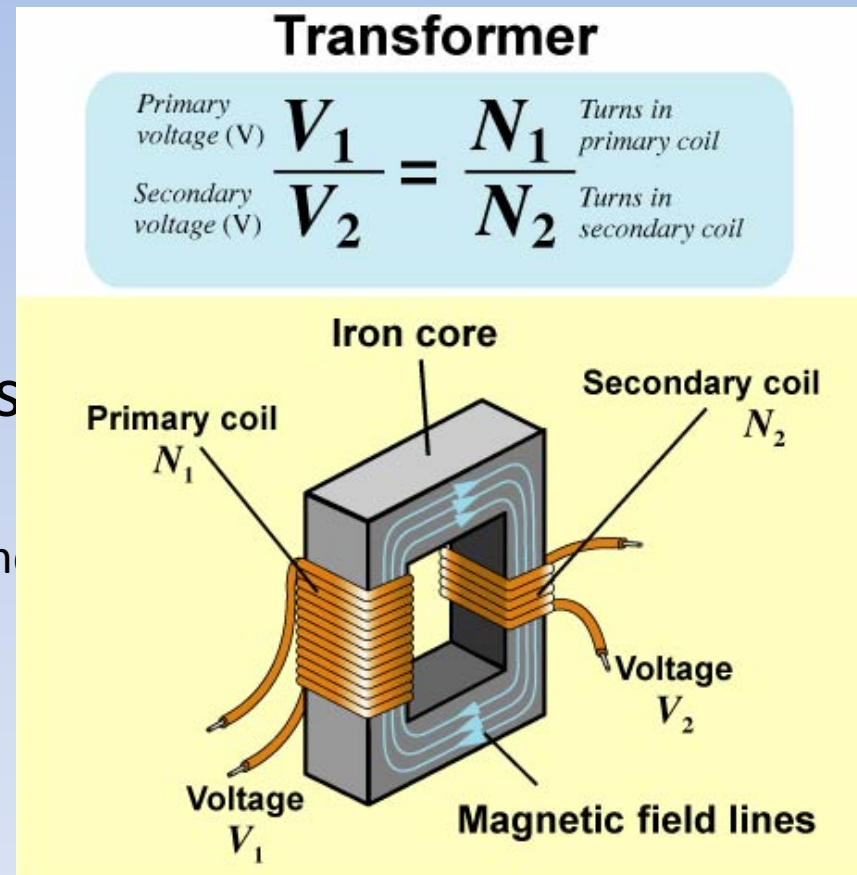
- Notice BA changes, nature rebels & makes current (produces voltage)
- Spinning a loop changes A of BA, AREA
- Changed BA means voila, you force current flow
- See the CCW loop at right?
- See how less B passes through loop?
- Visit generator link and watch it!
- See why motors/generators use magnets?

http://www.walter-fendt.de/ph14e/generator_e.htm



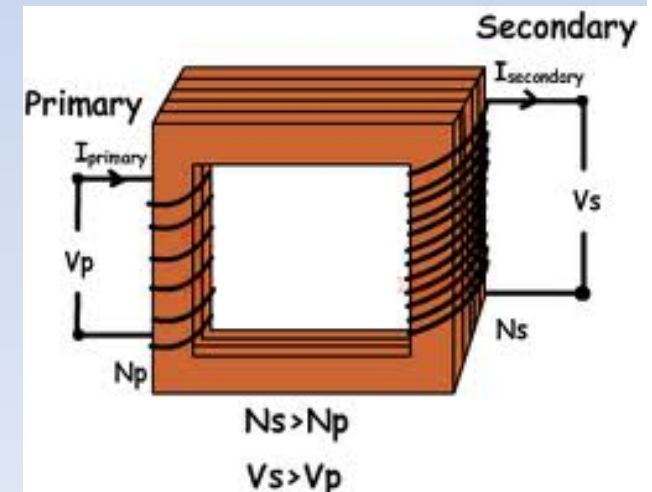
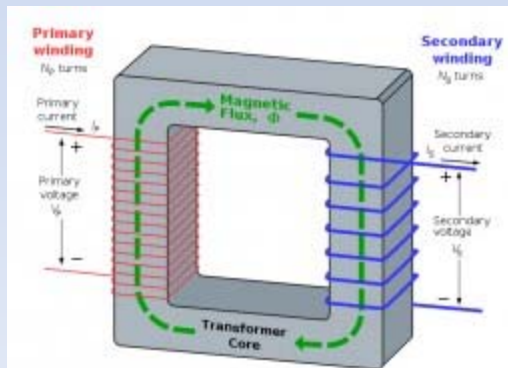
Transformer: use induction/AC to change voltage

- AC is alternating current
- Direction of current reverses 60x each second
- Iron core is a magnet
- Core magnetic polarity reverses 60x (N/S poles flip)
- Changing magnetic field in 2ⁿ coil makes current flow
- Different # of coils means different current (voltage)
- The only equation you need!



Transformer practice problems

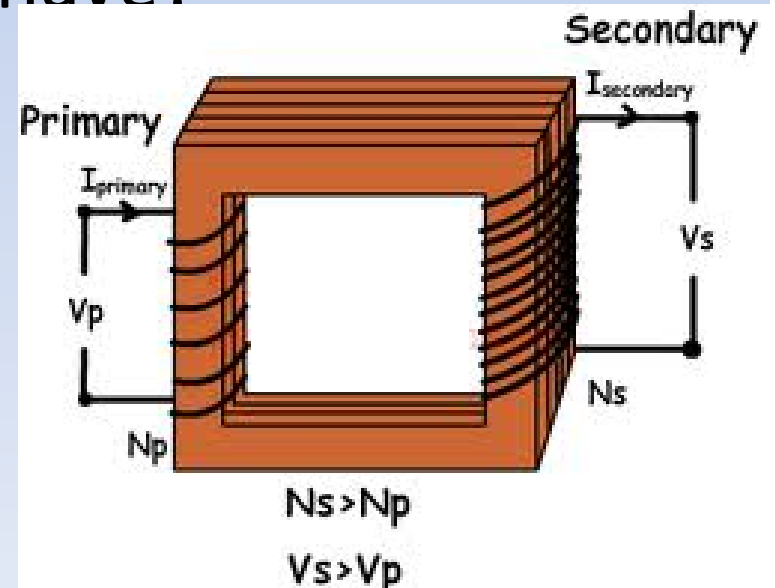
- $N_1/V_1 = N_2/V_2$
- In order to transmit electrical energy over long distances, power companies must increase voltage. If the primary coil has 30 loops and input voltage is 3,000 V and output voltage is 400,000 volts, how many loops are present in the transformer's secondary coil?
- (4000)



Transformer practice problems

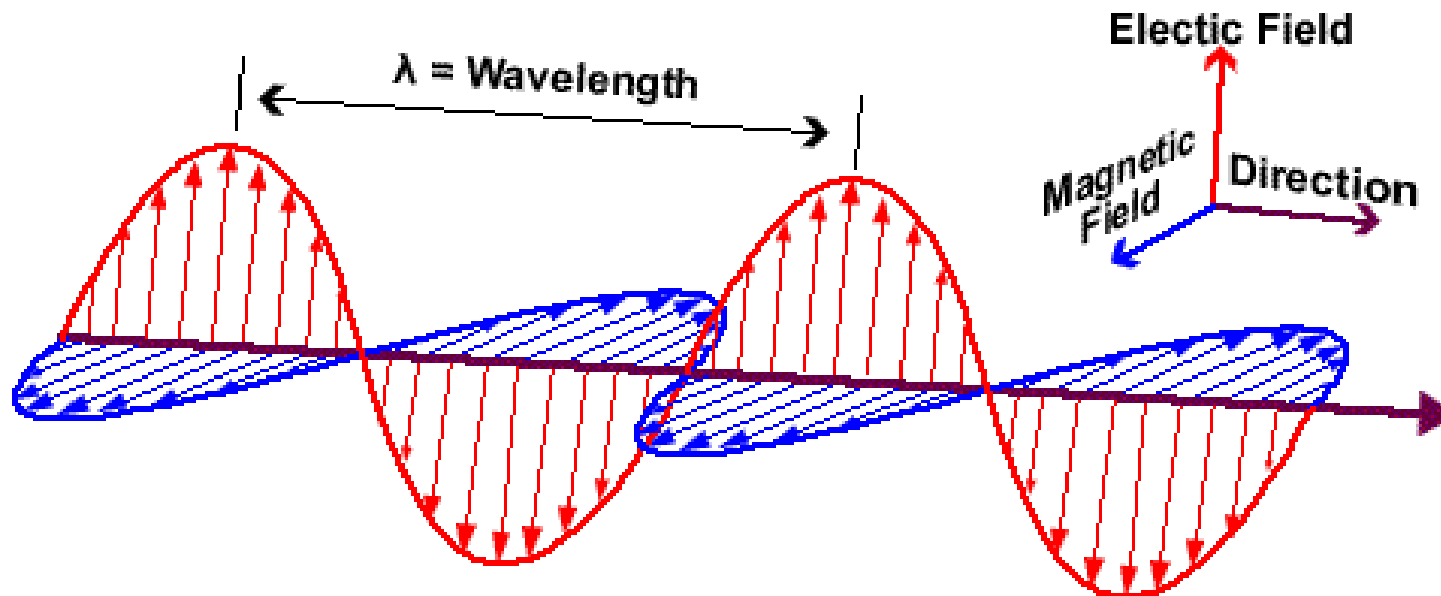
- $N_1/V_1 = N_2/V_2$
- My Toshiba laptop requires 15 V. If I plug it into an outlet with 120 V and assuming the secondary coil has 60 loops, then how many loops does the primary coil have?

- (480)



Themed only - What light really is

- Say a lot of energy causes an electron to vibrate, like you get iron red hot
- The vibrating electric field is a changing electric field, which induces a magnetic field
- The magnetic field is changes and created (induces) a changing electric field
- If this light wave is the lowest frequency we can see, our red cones are stimulated and we see it's red hot!



Themed only - What light really is

- Light is merely changing electric fields inducing changing magnetic fields, etc.
- Any vibrating electrically charged particle can make it, but electrons are usually handy
- Remember when we said you'd have to understand magnetism to understand electromagnetic radiation? See why?

