



## MAGNETIC FIELDS Magnetism and the Earth's Magnetic Field

A magnetic field is a region of space in which magnets and magnetic materials feel forces. The only magnetic materials are iron, steel, nickel, and cobalt. We represent magnetic fields by drawing magnetic field lines.

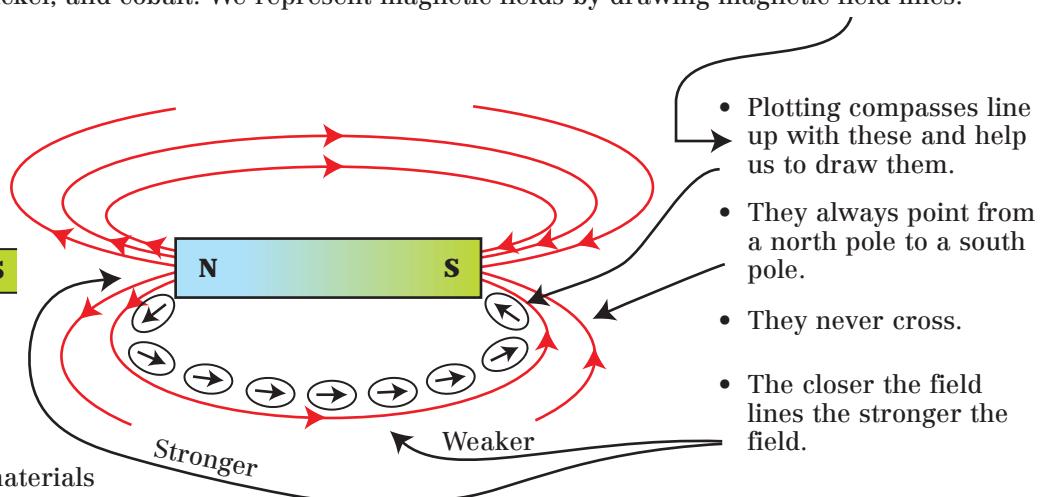
Like poles repel



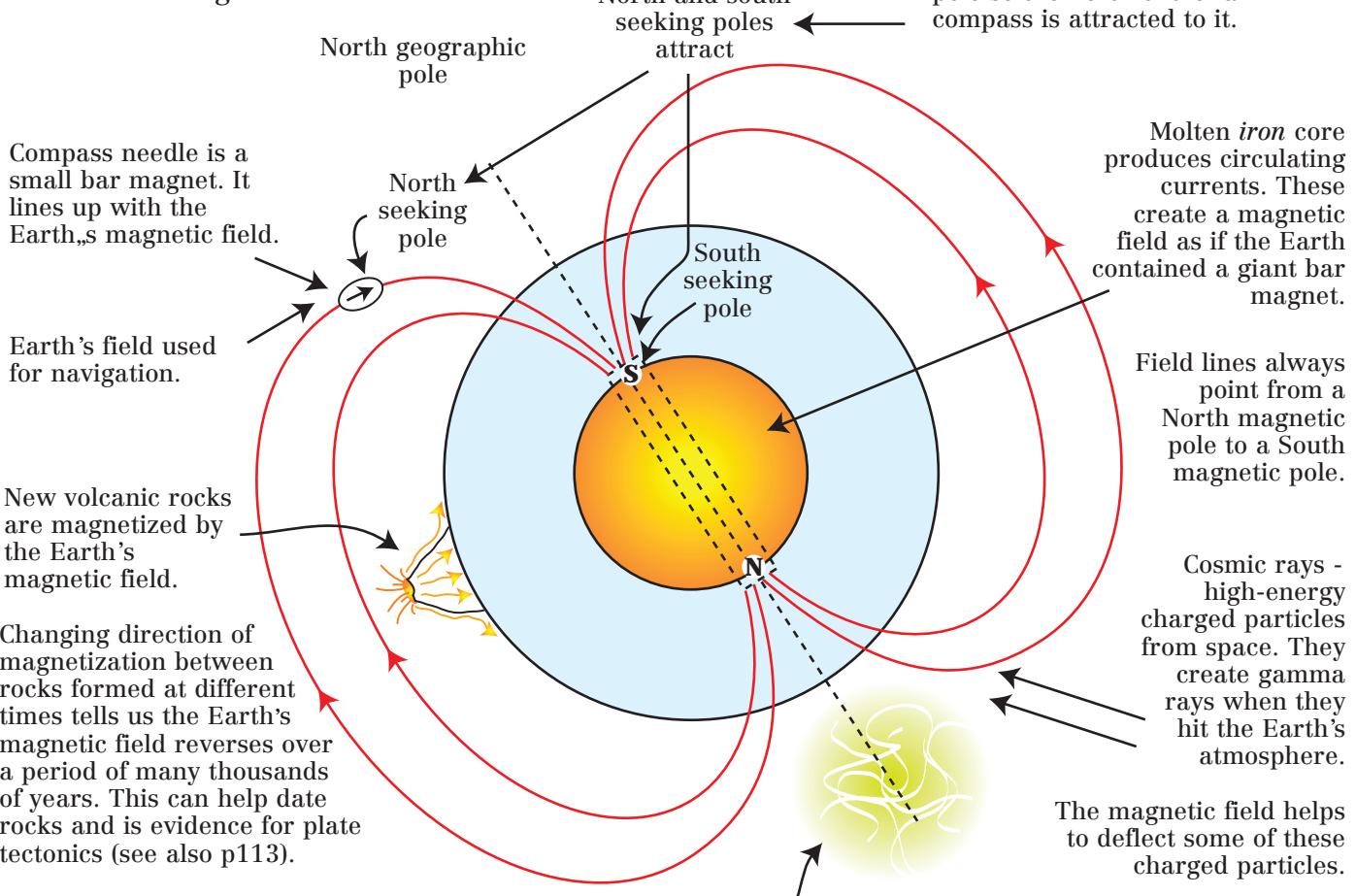
Unlike poles attract



Un-magnetized magnetic materials are attracted to either pole.



### The Earth's magnetic field



The Earth's magnetic field interacts with charged particles from the Sun. They are channelled to the poles where they interact with molecules in the atmosphere making them glow. This is the aurora.

### Questions

- What is a magnetic field? Make a list of three properties of magnetic field lines.
- Make a list of the four magnetic materials. How could you test an unknown material to discover whether it is one of the four in the list?
- Using a magnet how would you tell if a piece of steel was magnetized or un-magnetized?
- If the Earth's magnetic field were to disappear, it would be very bad news for our health. Explain why. (You might need to look at p69.)
- Why might a magnetic compass not work very well close to the North or South Pole?

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Actually	<p><i>adverb</i></p> <p><b>1.</b> [sentence adverb] <i>spoken</i> used to add new information to what you have just said, to give your opinion, or to start a new conversation: <i>I've known Barbara for years. Since we were babies, actually.</i> <i>Actually, on second thoughts, I don't think I want to go out tonight.</i></p> <p><b>2.</b> used to emphasize the real or exact truth of a situation, rather than what people may think: <i>What time are you actually leaving?</i> <i>Labor costs have actually fallen.</i> <i>'Disappointed?' 'No, actually I'm rather glad.'</i></p>	عملا ، در حقیقت
Bar	<p><i>noun [countable]</i> a small block of solid material that is longer than it is wide: <i>a chocolate bar</i> <i>a candy bar</i></p>	میله ، مفتول
Channel	<p><i>verb (past tense and past participle channelled, present participle channelling British English, channelled, channeling American English) [transitive]</i> to control and direct something such as money or energy towards a particular purpose <b>SYN</b> <b>direct</b> <i>Most of his energy was channelled into writing and lecturing.</i> <i>Profits are channelled to conservation groups.</i></p>	تعویض یا تغییر مسیر انجام کاری یا چیزی
Charged	<p><i>adjective</i> having an amount of electricity <i>charged particles</i> <i>Is this phone fully charged?</i></p>	دارای بار
Circulate	<p><i>Verb [intransitive and transitive]</i> to move around within a system, or to make something do this: <i>Swimming helps to get the blood circulating through the muscles.</i> <i>Ceiling fans circulated warm air around the room.</i></p>	به گردش درآوردن ، منتشر شدن
Compass	<p><i>noun [countable]</i></p> <p><b>1.</b> an instrument that shows directions and has a needle that always points north: a map and compass</p> <p><b>2.</b> [countable] (also <b>compasses</b>) a V-shaped instrument with one sharp point and a pen or pencil at the other end, used for drawing circles or measuring distances on maps</p>	پرگار ، قطب نما
Core	<p><i>noun [countable]</i> the centre of a planet <i>The earth's core is a hot, molten mix of iron and nickel.</i></p>	هسته
Cosmic	<p><i>adjective</i> relating to space or the universe</p>	کیهانی
Create	<p><i>verb [transitive]</i> to make something exist that did not exist before: <i>Some people believe the universe was created by a big explosion.</i> <i>Her behaviour is creating a lot of problems.</i> <i>The new factory is expected to create more than 400 new jobs.</i></p>	خلق شدن ، آفریدن ، ایجاد کردن
Cross	<p>[intransitive and transitive] if two or more roads, lines, etc cross, or if one crosses another, they go across each other: <i>The by-pass crosses Wilton Lane shortly after a roundabout.</i></p>	قطع کردن ، عبور کردن

<b>Deflect</b>	<p><b>verb [intransitive and transitive]</b> if someone or something deflects something that is moving, or if it deflects, it turns in a different direction: <i>armor can deflect bullets</i> <i>Goalkeeper deflected the ball with his hands.</i></p>	منکسر کردن ، منحرف کردن
<b>Evidence</b>	<p><b>noun [uncountable]</b> facts or signs that show clearly that something exists or is true <b>evidence of</b> <i>At present we have no evidence of life on other planets.</i> <b>evidence for</b> <i>There is no evidence for these claims.</i> <b>evidence that</b> <i>Do you have evidence that this treatment works?</i></p>	شاهد ، دلیل ، گواه ، مدرک
<b>Field</b>	<p><b>noun [countable]</b> the area in which a natural force is felt or has an effect <i>the Earth's magnetic field</i></p>	میدان
<b>Giant</b>	<p><b>adjective [only before noun]</b> extremely big, and much bigger than other things of the same type: <i>a giant electronics company</i></p>	غول پیکر ، عظیم
<b>Interact</b>	<p><b>verb [intransitive]</b> if one thing interacts with another, or if they interact, they affect each other <i>The immune system interacts with both the nervous system and the hormone</i></p>	متقابلا عمل کردن
<b>Iron</b>	<p><b>[uncountable]</b> a common hard metal that is used to make steel, is magnetic, and is found in very small quantities in food and blood. It is a chemical element: symbol Fe: <i>the iron and steel industry</i> <i>a driveway with large iron gates</i> <i>iron ore (=rock that contains iron)</i> <i>the absorption of iron from food ? wrought iron, cast iron</i></p>	فلز آهن ، آهنی
<b>Line up</b>	<p><b>phrasal verb</b> if people line up, or if you line them up, they stand in a row or line, or you make them do this: <i>Line up, everybody!</i></p>	به خط شدن
<b>Magnetic</b>	<p><b>Adjective</b> concerning or produced by magnetism: <i>magnetic forces</i></p>	مغناطیسی ، آهن ریابی
<b>Magnetism</b>	<p><b>noun [uncountable]</b> the physical force that makes two metal objects pull towards each other or push each other apart</p>	خاصیت مغناطیسی ، آهن ریابی
<b>Molten</b>	<p><b>adjective [usually before noun]</b> molten metal or rock has been made into a liquid by being heated to a very high temperature: <i>molten iron</i></p>	گداخته ، ذوب شده
<b>Navigation</b>	<p><b>noun [uncountable]</b> the science or job of planning which way you need to go when you are travelling from one place to another: <i>compasses and other instruments of navigation</i></p>	دریانوردی ، ناوبری
<b>Needle</b>	<p><b>noun [countable]</b> <b>1. SEWING</b> a small thin piece of steel, with a point at one end and a hole in the other, used for sewing <i>a needle and thread, a knitting needle</i></p>	سوزن خیاطی ، عقربه

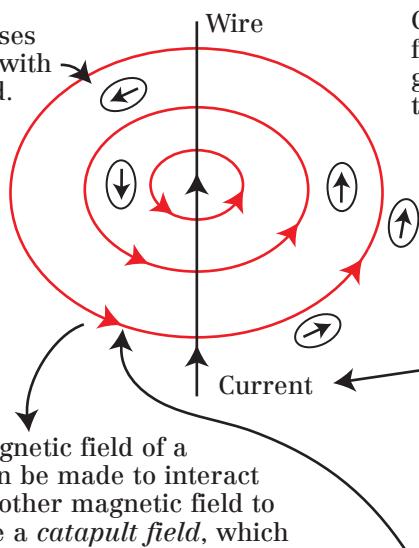
	<b>2. POINTER</b> a long thin piece of metal on a scientific instrument that moves backwards and forwards and points to numbers or directions: <i>a compass needle</i>	
<b>Particle</b>	<b>noun</b> [countable] a very small piece of something: <i>dust particles</i> <i>tiny particles of soil</i>	ریزه، ذره
<b>Plate Tectonics</b>	<b>noun</b> [uncountable] <i>technical</i> the study of the forming and movement of the large sheets of rock that form the surface of the Earth	زمین ساخت صفحه ای یا تکتونیک صفحه ای
<b>Plot</b>	<b>verb</b> [transitive] make (a curve) by marking out a number of points on a graph. <i>a cooling curve is plotted and the freezing point determined</i>	رسم کردن، شکل گشیدن
<b>Pole</b>	<b>noun</b> [countable] one of two points at the ends of a magnet where its power is the strongest	قطب
<b>Property</b>	<b>noun</b> (plural <b>properties</b> ) the thing or things that someone owns <i>the chemical properties of a substance</i>	خاصیت، صفت خاص
<b>Ray</b>	<b>noun</b> [countable] a straight narrow beam of light from the sun or moon: <i>The room darkened as a cloud hid the sun's rays.</i>	شعاع، پرتو، اشعه تابشی
<b>Repel</b>	<b>[intransitive and transitive]</b> if two things repel each other, they push each other away with an electrical force <b>OPP attract</b> : <i>Two positive charges repel each other.</i>	دفع کردن، رد کردن
<b>Represent</b>	<b>verb</b> [transitive] to officially speak or take action for another person or group of people: <i>Mr Kobayashi was chosen to represent the company at the conference.</i>	نمایندگی داشتن، نمایش دادن
<b>Reverse</b>	<b>verb</b> [transitive] to change the direction, order, position, result, etc. of something to its opposite: <i>The runners reversed their direction on the track.</i> <i>There is no way to reverse the aging process.</i> <i>Can anything reverse the trend toward higher prices?</i>	معکوس کردن، برگشت
<b>Seek</b>	<b>Verb</b> to move naturally towards something or into a particular position: <i>Water seeks its own level.</i>	جستجو کردن، جوییدن، طلبیدن
<b>Steel</b>	<b>noun</b> [uncountable] strong metal that can be shaped easily, consisting of iron and carbon: <i>a steel bridge</i> <i>stainless steel (=steel that does not change colour) knives</i>	پولادین، فولاد
<b>Volcanic</b>	<b>Adjective</b> relating to or caused by a volcano: <i>black volcanic sand</i>	آتشفشاری
<b>Volcano</b>	<b>noun</b> (plural <b>volcanoes</b> or <b>volcanos</b> ) [countable] a mountain with a large hole at the top, through which lava (=very hot liquid rock) is sometimes forced out	کوه آتشفشار



## MAGNETIC FIELDS Electromagnetism and The Motor Effect

A current carrying wire produces a magnetic field around it.

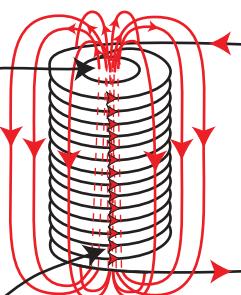
Plotting compasses line up with the field.



The magnetic field of a wire can be made to interact with another magnetic field to produce a *catapult field*, which exerts a force on the wire.

Circular field lines (getting further apart as the field gets weaker further from the wire).

A coil (or solenoid) produces a magnetic field through and around it.



### Right Hand Grip Rule

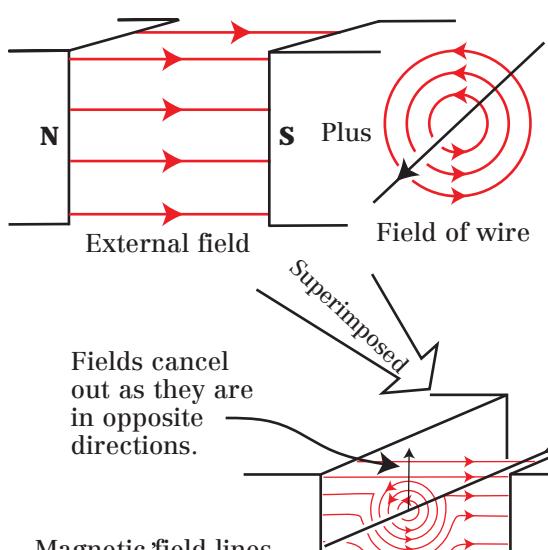
Thumb points in the direction of current

Fingers curl in direction of field lines

Field inside coil

Current around the coil

The more turns on the coil, a bigger current and adding a soft iron core all strengthen the magnetic field.



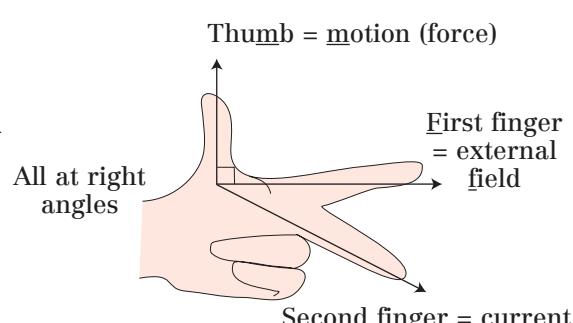
Magnetic field lines try to get as short as possible by pushing the wire out of the field and removing the distortion.

Fields cancel out as they are in opposite directions.

Fields reinforce each other as they are in the same direction.

Wire pushed up and out of magnetic field.

The directions of the external field, current, and the resulting force (and hence motion of the wire) are remembered by Fleming's Left Hand Rule.



Reversing either current or field will reverse direction of the force.

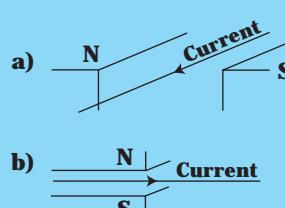
If the current is parallel to the external magnetic field the two magnetic fields are at right angles to each other and cannot interact so no force is produced.

Size of the force can be increased by:

- Using a larger current
- Using a stronger external field

### Questions

1. In what ways are the fields around a bar magnet and around a long coil (solenoid) similar and in what ways are they different?
2. What would happen to the direction of the magnetic field lines around a wire, or through a coil, if the current direction reverses?
3. Make a list of five uses for an electromagnet and suggest why electromagnets are often more useful than permanent magnets.
4. What happens to the direction of the force on a current carrying wire if both the field and current directions are reversed?
5. Copy the diagrams (right) and add an arrow to show the direction of the force on the wire.



Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Apart	adverb, adjective if you keep things apart, you keep them separate from each other: I try to keep my work and private life as far apart as possible. (phrasal verb)	سوا ، مجزا
Cancel out	cancel something out (of a factor or circumstance) neutralize or negate the force or effect of (another) the electric fields may cancel each other out	حذف کردن ، ملغی کردن ، باطل کردن
Catapult	noun [countable] 1. a large weapon used in former times to throw heavy stones, iron balls etc. 2. British English a small stick in the shape of a Y with a thin rubber band fastened over the two ends, used by children to throw stones SYN slingshot American English	فلاخن ، هر جسمی که دارای خاصیت فتری بوده و برای پرتاب اجسام به کار میرود ، منجنیق
Circular	adjective shaped like a circle: a circular table noun [countable] 1. a continuous series of circular rings into which something such as wire or rope has been wound or twisted <i>coil of</i> a coil of rope 2. a wire or a metal tube in a continuous circular shape that produces light or heat when electricity is passed through it: the coil in a light bulb	دایره‌ای شکل ، گرد ، دایره‌ای ، مدور
Coil	verb [intransitive and transitive] to form a twisted or curved shape, or to make something do this: Mary was busy curling her hair.	بوبین ، حلقه ، کویل
Curl	noun [countable] a flow of electricity through a wire: an electrical current, alternating current, direct current	حلقه شدن ، پیچیدن
Current	verb [intransitive and transitive] to change the appearance, sound, or shape of something so that it is strange or unclear: Tall buildings can distort radio signals.	جريان
Distort	conjunction <i>either ... or</i> used to begin a list of two or more possibilities: She's the kind of person you either love or hate.	انحراف ، اعوجاج ، اغتشاش
Either ... or	adjective OUTSIDE PART relating to the outside of something or of a person's body OPP internal: the external appearance of the building	هر یک از دو تا
External	noun [countable] the area in which a natural force is felt or has an effect the Earth's magnetic field	بیرونی ، خارجی
Field	adverb formal [sentence adverb] for this reason: The cost of transport is a major expense for an industry. Hence factory location is an important consideration.	میدان
Hence	verb [transitive] if one thing interacts with another, or if they interact, they affect each other The immune system interacts with both the nervous system and the hormone	از این جهت ، پس ، بنابر این
Interact	M	متقابلانه عمل کردن

Parallel	<p>adjective 1. two lines, paths etc. that are parallel to each other are the same distance apart along their whole length: Lines AB and CD are parallel.</p> <p><b>parallel to</b> She was travelling parallel to her previous route.</p> <p><b>parallel with</b> The railway is parallel with the canal.</p> <p>verb [transitive] to make, write etc. something to be bought, used, or enjoyed by people</p> <p>The factory produces an incredible 100 cars per hour. How did you manage to produce a meal so quickly?</p>	همسو، موازی
Produce	<p>verb [transitive] to make, write etc. something to be bought, used, or enjoyed by people</p> <p>The factory produces an incredible 100 cars per hour. How did you manage to produce a meal so quickly?</p>	ساختن، تولید کردن
Reinforce	<p>verb [transitive] to make something stronger: The pockets on my jeans are reinforced with double stitching.</p>	مستحکم کردن، تقویت کردن، محکم کردن
Reverse	<p>verb [transitive] to change the direction, order, position, result, etc. of something to its opposite: The runners reversed their direction on the track.</p> <p>Can anything reverse the trend toward higher prices?</p> <p>noun [countable]</p>	معکوس کردن، برگشتن
Right Angle	<p>1. an angle of 90°, like the angles at the corners of a square 2. <b>at right angles (to something)</b> if two things are at right angles, they make a 90° angle where they touch: Hold the brush at right angles to the surface.</p>	زاویه قائم
Right Hand Grip Rule	<p>Fleming's right-hand rule (for generators) shows the direction of induced current when a conductor moves in a magnetic field. It can be used to determine the direction of current in a generator's windings.</p>	قاعده دست راست
Solenoid	<p>noun [countable] a coil of wire usually in cylindrical form that when carrying a current acts like a magnet so that a movable core is drawn into the coil when a current flows and that is used especially as a switch or control for a mechanical device (as a valve)</p>	سولنؤید، بوبین، سیم پیچی به شکل استوانه برای ایجاد میدان مغناطیسی
Superimpose	<p>verb [transitive] to combine two systems, ideas, opinions etc. so that one influences the other</p> <p><b>superimpose something on/onto something</b> Eastern themes superimposed onto Western architecture</p> <p>noun [countable]</p>	روی چیزی قرار گرفتن، اضافه شدن بر
Thumb	<p>the part of your hand that is shaped like a thick short finger and helps you to hold things: a baby sucking its thumb</p> <p>She held the coin carefully between finger and thumb.</p>	شست (دست یا پا)
Turn	<p>noun [countable] a single round (as of rope passed about an object or of wire wound on a core)</p>	دور (در سیم پیچ)
Wire	<p>noun [countable] a piece of metal like this, used for carrying electrical currents or signals: a telephone wire</p>	سیم، مفتول



Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Alternatively	adverb [sentence adverb] as another option or possibility alternatively, you may telephone us direct if you wish noun [countable]	متناوباً ، به طریق دیگر
Coil	a wire or a metal tube in a continuous circular shape that produces light or heat when electricity is passed through it: the coil in a light bulb	بوبین ، حلقة ، کویل
Consider	verb [intransitive and transitive] to think about something carefully, especially before making a choice or decision <b>consider whether (to do something)</b> We are considering whether to change our advice to tourists. <b>consider where/how/why etc..</b> , We're still considering where to move to.	رسیدگی کردن ، ملاحظه کردن
Conventional	adjective [only before noun] a conventional method, product, practice etc has been used for a long time and is considered the usual type: Internet connections through conventional phone lines are fairly slow. Bake for 20 minutes in a conventional oven; 8 in a microwave.	متداول ، متعارف ، قراردادی ، مرسوم
Cross Section	noun [countable] a surface or shape exposed by making a straight cut through something, especially at right angles to an axis	سطح مقطع
Current	noun [countable] a flow of electricity through a wire: an electrical current, alternating current, direct current	جريان
Expose	verb [transitive] to present to view; exhibit; display: The storekeeper exposed his wares.	درعرض گذاشتن ، نمایش دادن
Field	noun [countable] the area in which a natural force is felt or has an effect the Earth's magnetic field	میدان
Induce	verb [transitive] 1. <b>formal</b> to persuade someone to do something, especially something that does not seem wise <b>induce somebody to do something</b> Nothing would induce me to vote for him again. 2. <b>formal</b> to cause a particular physical condition: Patients with eating disorders may use drugs to induce vomiting.	القا ، وادرار کردن
Interact	verb [transitive] if one thing interacts with another, or if they interact, they affect each other The immune system interacts with both the nervous system and the hormone	متقابل عمل کردن
Motion	[uncountable] the process of moving or the way that someone or something moves the motion of the planets Newton's first law of motion	جنیش ، تکان ، حرکت ، جنب و جوش
Parallel	adjective two lines, paths etc. that are parallel to each other are the same distance apart along their whole length: Lines AB and CD are parallel. <b>parallel to</b> She was travelling parallel to her previous route. <b>parallel with</b> The railway is parallel with the canal.	همسو ، موازی

Polarity	noun (plural <b>polarities</b> ) [uncountable and countable] <b>technical</b> the state of having either a positive or negative electric charge verb [ <b>transitive</b> ] to make, write etc. something to be bought, used, or enjoyed by people The factory produces an incredible 100 cars per hour. How did you manage to produce a meal so quickly?	قطبیت ، قطبش
Produce	verb [ <b>transitive</b> ] to make something stronger: The pockets on my jeans are reinforced with double stitching.	ساختن ، تولید کردن
Reinforce	verb [ <b>transitive</b> ] to make something stronger: The pockets on my jeans are reinforced with double stitching.	مستحکم کردن ، تقویت کردن ، محکم کردن
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Right Hand Grip Rule	Fleming's right-hand rule (for generators) shows the direction of induced current when a conductor moves in a magnetic field. It can be used to determine the direction of current in a generator's windings.	قاعده دست راست
Solenoid	noun [ <b>countable</b> ] a coil of wire usually in cylindrical form that when carrying a current acts like a magnet so that a movable core is drawn into the coil when a current flows and that is used especially as a switch or control for a mechanical device (as a valve)	سولنؤید ، بوین ، سیم پیچی به شکل استوانه برای ایجاد میدان مغناطیسی
Stationary	adjective standing still instead of moving: How did you manage to drive into a stationary vehicle?	ساکن ، بی حرکت ، بی تغییر ، ایستا
Thumb	noun [ <b>countable</b> ] the part of your hand that is shaped like a thick short finger and helps you to hold things: She held the coin carefully between finger and thumb.	شست (دست یا پا)
Turn	noun [ <b>countable</b> ] a single round (as of rope passed about an object or of wire wound on a core)	دور (در سیم پیچ)
Wire	[ <b>countable</b> ] a piece of metal like this, used for carrying electrical currents or signals: a telephone wire	سیم ، مفتول



# THE SUPPLY AND USE OF ELECTRICAL ENERGY

## Electricity Generation – Electromagnetic Induction

Moving an electrical conductor through a magnetic field produces a potential difference across the conductor. This is called *electromagnetic induction*.

If the conductor forms part of a complete circuit, the potential difference will drive a current through it.

Induced current - the wire in the field behaves like an electric cell in the circuit.

Direction of the magnetic field, current, and motion must all be at right angles.

Second finger - current

Thumb - motion



First finger - magnetic field

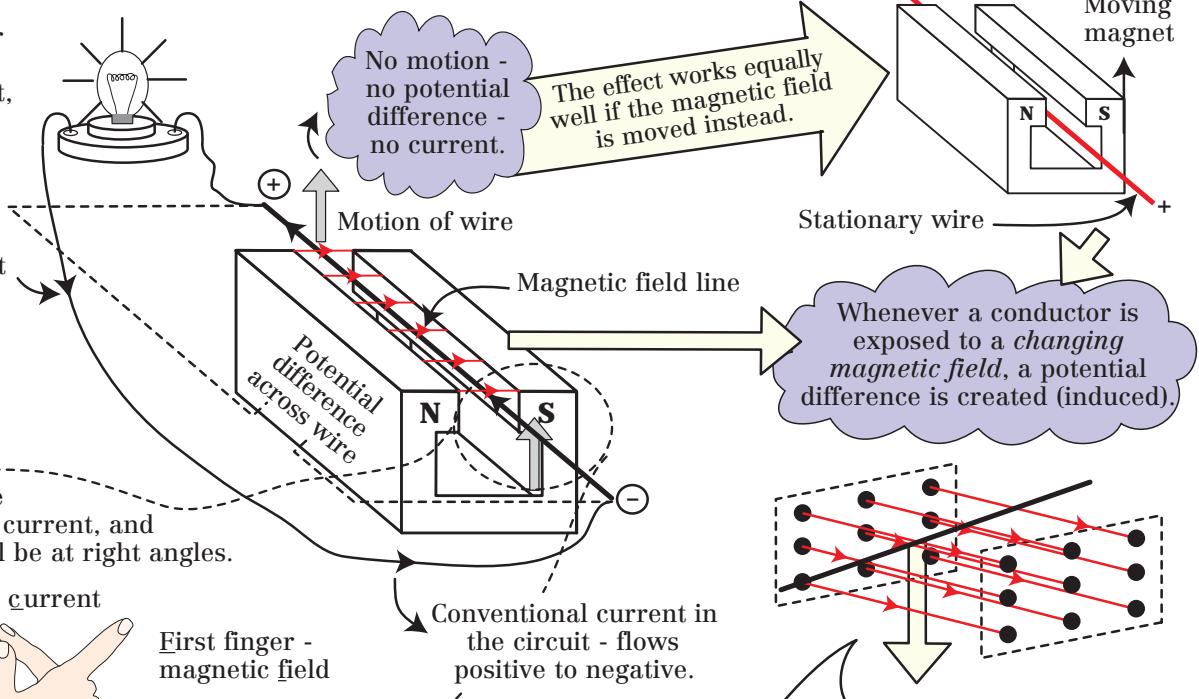
The *Right Hand Rule* relates the field, current, and motion. (compare with the Left Hand Rule on p59).

Induced potential difference (and current) increased by:

- Using more coils.
- Moving the magnet faster.
- Using a stronger magnet.
- Using a coil with a larger cross sectional area.

Conventional current flows if the coil terminals are connected.

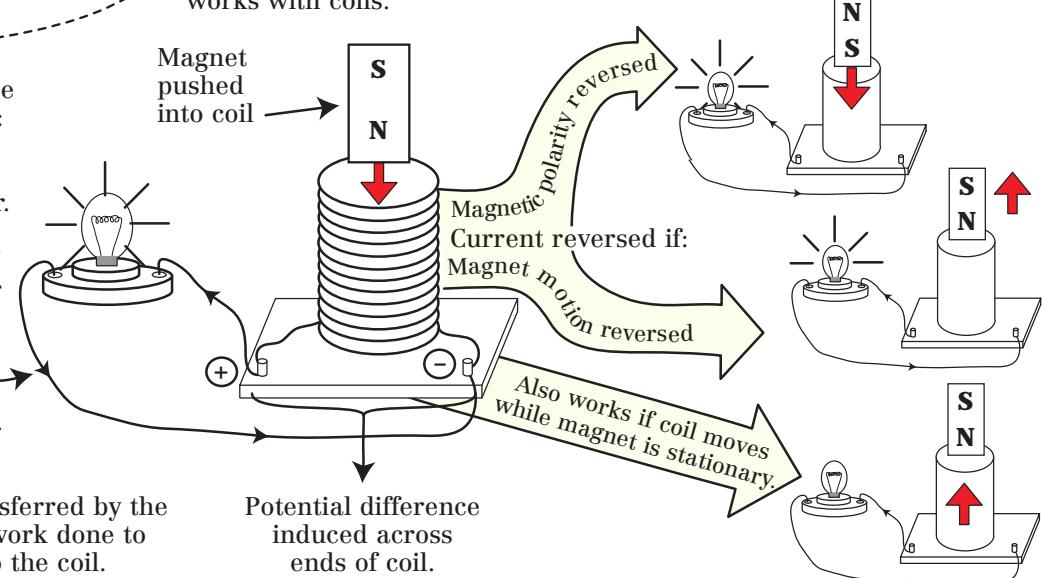
The electrical energy transferred by the circuit comes from the work done to push the magnet into the coil.



Conventional current in the circuit - flows positive to negative.

Alternatively consider the rate the conductor is cutting through lines of magnetic force. The faster it cuts, the greater the potential difference induced.

Induction also works with coils.



### Questions

1. A wire is moved at right angles to a magnetic field. What would happen to the size of the potential difference across the wire if:
  - a. The wire was moved faster?
  - b. The magnet was moved instead of the wire, but it was moved at the same speed as the wire?
  - c. A weaker magnetic field was used?
  - d. The wire stopped moving?
  - e. Two magnets were used end to end so more wire was in the field?
  - f. The wire moved from a north pole to a south pole along the magnetic field lines?
2. When pushing a magnet into a coil how could you make the size of the induced potential difference bigger (3 ways)? How could you reverse the direction of the potential difference (2 ways)?
3. When generating electricity by induction where does the energy that is converted into electrical energy come from?

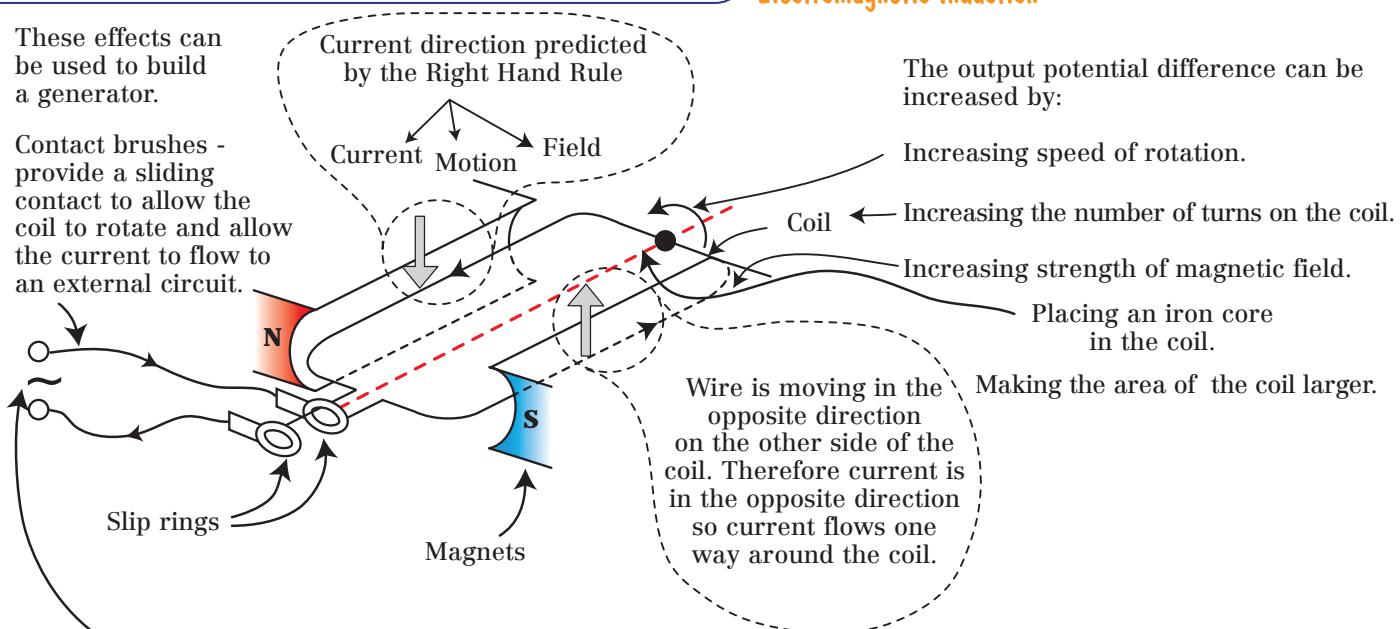


## THE SUPPLY AND USE OF ELECTRICAL ENERGY

### Electricity Generation – Electromagnetic Induction

These effects can be used to build a generator.

Contact brushes - provide a sliding contact to allow the coil to rotate and allow the current to flow to an external circuit.



Output is alternating as the current reverses once every half revolution.

The output potential difference can be increased by:

Increasing speed of rotation.

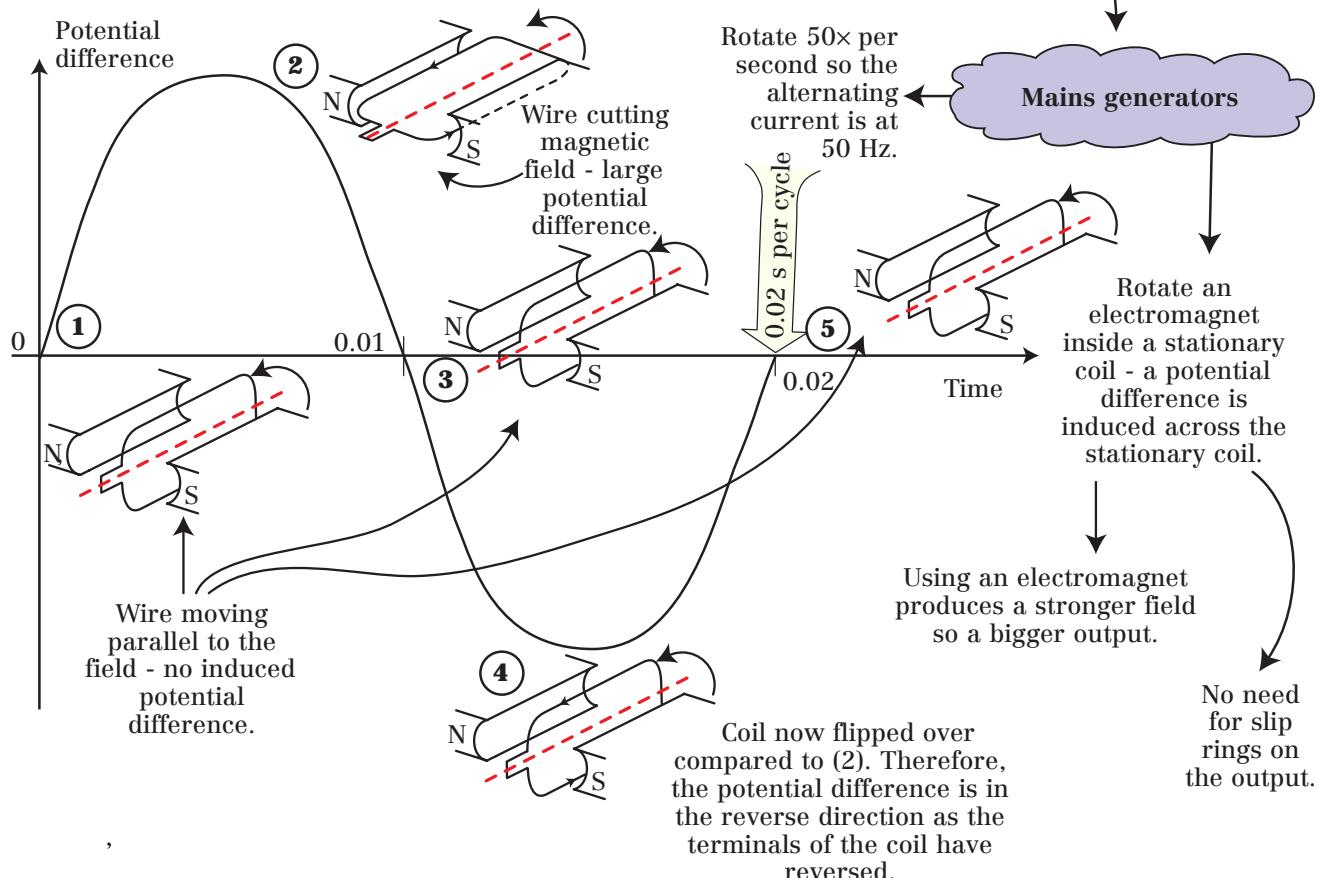
Increasing the number of turns on the coil.

Increasing strength of magnetic field.

Placing an iron core in the coil.

Making the area of the coil larger.

Generators for mains electricity work in a similar way - the output is alternating current.



#### Questions (continued)

4. List five ways the output of an alternating current generator can be increased.
5. The mains electricity in the UK alternates through 50 complete cycles per second. What does this tell us about the rate of rotation of the generators in power stations in the UK?
6. Suggest two differences between the simple generator shown above and the generators used to generate mains electricity.
7. Why is the potential difference produced by a generator zero twice every revolution?
8. Draw a labelled diagram of an alternating current generator and use it to explain why the current it produces is alternating.

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Area</b>	<p><b>noun [countable]</b> the amount of space that a flat surface or shape covers</p> <p><b>area of</b> <i>an area of 2,000 square miles</i></p> <p><b>a formula to calculate the area of a circle</b></p>	سطح ، مساحت
<b>Brush</b>	<p><b>noun [countable]</b> an object that you use for cleaning, painting, making your hair tidy etc, made with a lot of hairs, bristles, or thin pieces of plastic, fastened to a handle</p> <p><i>hairbrush, nailbrush, paintbrush, toothbrush</i></p>	برس ، زغال
<b>Current</b>	<p><b>noun [countable]</b> a flow of electricity through a wire:</p> <p><i>an electrical current, alternating current, direct current</i></p>	جریان
<b>Effect</b>	<p><b>noun</b> <b>[uncountable and countable]</b> a change that is caused by an event, action etc</p> <p><b>effect on</b> <i>My parents' divorce had a big effect on me.</i></p> <p><b>effect of</b> <i>the harmful effects of modern farming practices</i></p> <p><i>the long-term effects of the drug</i></p>	اثر ، نتیجه
<b>External</b>	<p><b>adjective</b> <b>OUTSIDE PART</b> relating to the outside of something or of a person's body <b>OPP internal:</b></p> <p><i>the external appearance of the building</i></p>	بیرونی ، خارجی
<b>Flip</b>	<p><b>verb (past tense and past participle <b>flipped</b>, present participle <b>flipping</b>)</b> <b>[intransitive, transitive always + adverb/preposition]</b> to move something with a quick sudden movement so that it is in a different position: <i>She flipped the lid of the box open and looked inside.</i></p> <p><b>flip over</b> <i>He flipped the paper over and started writing on the back.</i></p>	برگشتن ، معکوس شدن
<b>Induce</b>	<p><b>verb [transitive]</b></p> <p><b>1. formal</b> to persuade someone to do something, especially something that does not seem wise</p> <p><b>induce somebody to do something</b> <i>Nothing would induce me to vote for him again.</i></p> <p><b>2. formal</b> to cause a particular physical condition: <i>Patients with eating disorders may use drugs to induce vomiting.</i></p>	القا ، وادار کردن
<b>Mains</b>	<p><b>noun</b></p> <p><b>1. [countable]</b> a large pipe or wire carrying the public supply of water, electricity, or gas: <i>The report found that many of Yorkshire's water mains needed replacing.</i></p> <p><b>a burst gas main</b></p> <p><b>2. British English</b></p> <p>a) <b>the mains</b> the place on a wall where you can connect something to a supply of electricity: <i>You can run the torch off batteries or plug it into the mains.</i></p> <p><b>at the mains</b> <i>Make sure that the television is turned off at the mains.</i></p> <p>b) <b>mains gas/water/electricity</b> gas, water, or electricity supplied to a building through a pipe or wire: <i>The heater will run off mains gas or bottled gas.</i></p>	خط اصلی برق ، گاز و آب

<b>Parallel</b>	<p><i>adjective</i>          two lines, paths etc. that are parallel to each other are the same distance apart along their whole length:  <i>Lines AB and CD are parallel.</i></p> <p><b>parallel to</b>  <i>She was travelling parallel to her previous route.</i></p> <p><b>parallel with</b>  <i>The railway is parallel with the canal.</i></p>	همسو، موازی
<b>Revolutions</b>	<p><i>noun [countable]</i> one complete circular spinning movement, made by something such as a wheel attached to a central point ?</p> <p><b>revolve:</b>  <i>a speed of 100 revolutions per minute</i></p>	یک دوره کامل، دوران کامل
<b>Right Hand Grip Rule</b>	<p><b>Fleming's right-hand rule</b> (for generators) shows the direction of induced current when a conductor moves in a magnetic field. It can be used to determine the direction of current in a generator's windings.</p>	قاعده دست راست
<b>Rotate</b>	<p><i>verb</i></p> <p><b>1. [intransitive and transitive]</b> to turn with a circular movement around a central point, or to make something do this <b>SYN revolve, spin:</b>  <i>The Earth rotates on its axis once every 24 hours.</i>  <i>Rotate the pan halfway through the baking time.</i></p> <p><b>2. [intransitive and transitive]</b> if a job rotates, or if people rotate jobs, they each do a particular job for a particular period of time:  <i>The chairmanship of the committee rotates annually.</i>  <i>Employers may rotate duties to give staff wider experience.</i></p>	چرخیدن، برمحور خود گردیدن، دوران کردن
<b>Suggest</b>	<p><i>verb [transitive]</i>          to make someone think that a particular thing is true <b>SYN indicate:</b></p> <p><b>suggest (that)</b>  <i>Opinion polls suggest that only 10% of the population trust the government.</i></p> <p><b>evidence/results/data/studies etc suggest(s) that</b>  <i>The evidence suggests that single fathers are more likely to work than single mothers.</i></p>	اشاره کردن بر، اظهار کردن
<b>Turn</b>	<p><i>noun [countable]</i>          a single round (as of rope passed about an object or of wire wound on a core)</p>	دور (در سیم پیچ)
<b>Twice</b>	<p><i>adverb, predeterminer</i>          two times:  <i>He was questioned by police twice yesterday.</i>  <b>twice a day/week/year etc</b> (=two times in the same day, week etc)  <i>Letters were delivered twice a week only.</i>  <i>None of our dinner menus are exactly the same twice over.</i></p>	دو بار، دو دفعه، دو مرتبه
<b>Wire</b>	<p><i>[countable]</i> a piece of metal like this, used for carrying electrical currents or signals:  <i>a telephone wire</i></p>	سیم، مفتول

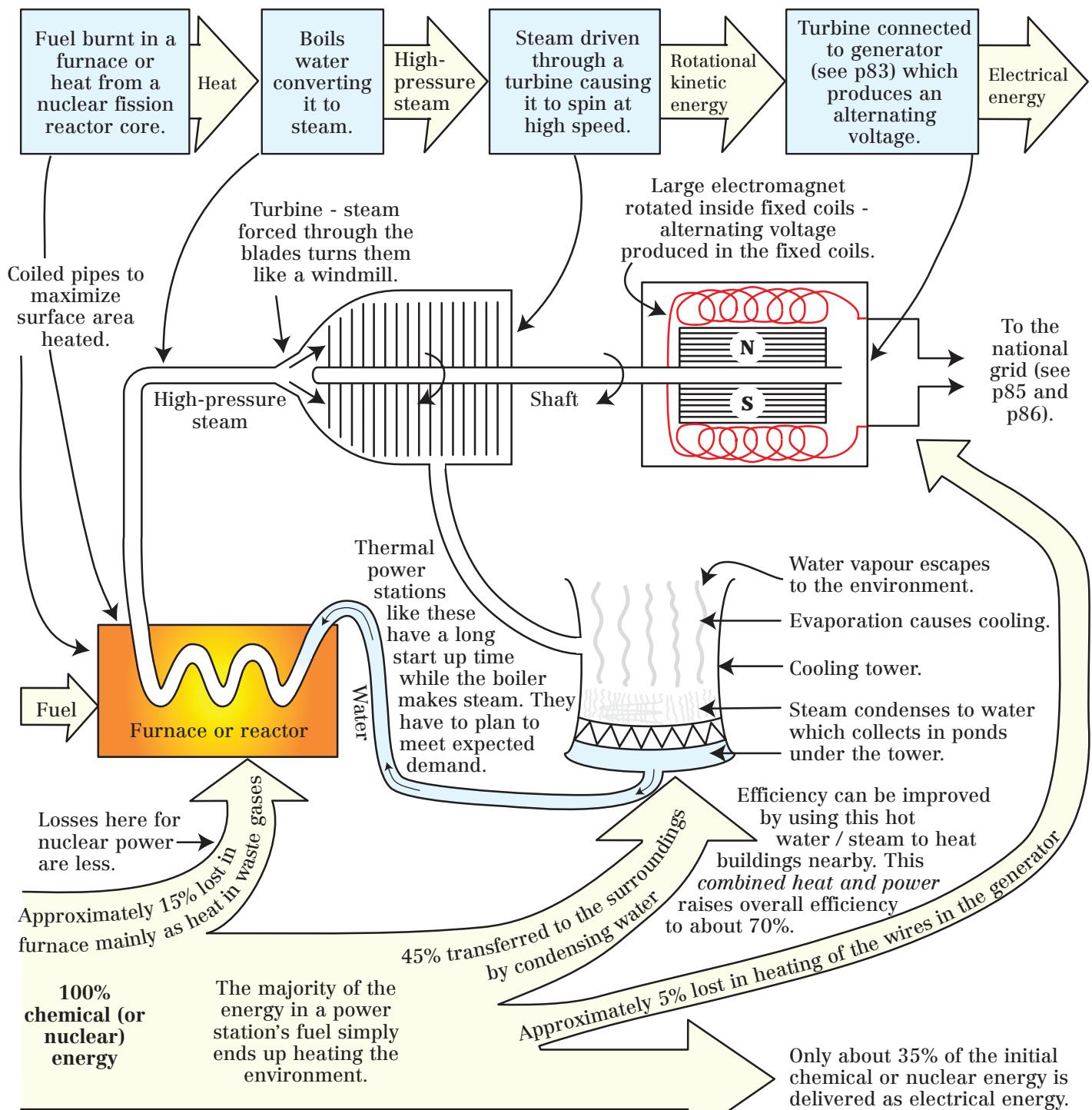


# THE SUPPLY AND USE OF ELECTRICAL ENERGY

## How Power Stations Work

Electricity is very useful energy source because it is easy to distribute and control. However, it is a *secondary energy source* because another primary energy source has to be used to generate it. In conventional power stations, that energy source is either fossil fuels (coal, oil, or natural gas) or nuclear energy stored in uranium or plutonium (see p77 and p111). Increasingly renewable energy resources (see p88 and p89) are also being used.

Here we focus on conventional power stations.



Power stations are situated in the country to reduce pollution in towns. They are often close to rivers or the sea for their cooling water supply.

### Questions

1. Name energy sources used to generate electricity in thermal power stations.
2. Draw an energy flow diagram for a coal-fired power station. Start with chemical energy in the coal and end with electrical energy produced.
3. What is combined heat and power?
4. Why are thermal power stations built near rivers or the sea?
5. What is the typical efficiency of conversion of chemical energy to electricity in a thermal power station? To what form of energy is most of the chemical energy converted?

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
<b>Boil</b>	<p><b>verb [intransitive and transitive]</b> when a liquid boils, or when you boil it, it becomes hot enough to turn into gas</p> <p><b>boil at</b> <i>The solution boiled at 57.4°C.</i></p> <p><b>Put the spaghetti into plenty of boiling salted water.</b></p> <p><b>We were advised to boil the water before drinking it.</b></p>	جوشاندن ، به جوش آمدن
<b>Condense</b>	<p><b>verb [intransitive and transitive]</b> if a gas condenses, or is condensed, it becomes a liquid:</p> <p><b>condense into</b> <i>The gaseous metal is cooled and condenses into liquid zinc.</i></p>	هم چگال کردن ، متراکم کردن
<b>Demand</b>	<p><b>noun [singular, uncountable]</b> the need or desire that people have for particular goods and services:</p> <p><i>Production is increasing faster than demand.</i></p> <p><b>demand for</b> <i>the demand for new housing</i></p>	تفاضل
<b>Distribute</b>	<p><b>verb [transitive]</b></p> <p><b>1.</b> to share things among a group of people, especially in a planned way <b>SYN give out</b></p> <p><b>distribute something among/to somebody</b> <i>Clothes and blankets have been distributed among the refugees.</i></p> <p><b>2.</b> to supply goods to shops and companies so that they can sell them:</p> <p><i>Milk is distributed to the local shops by Herald's Dairies.</i></p>	بخش کردن ، تقسیم کردن ، توزیع کردن
<b>Efficiency</b>	<p><b>noun [uncountable]</b> the quality of doing something well and effectively, without wasting time, money, or energy <b>OPP inefficient</b></p> <p><b>efficiency of</b> <i>the efficiency of the train service</i></p> <p><i>considerable advancements in energy efficiency</i></p>	بازده ، بهره وری ، راندمان
<b>Evaporate</b>	<p><b>verb [intransitive and transitive]</b> if a liquid evaporates, or if heat evaporates it, it changes into a gas:</p> <p><i>Most of the water had evaporated.</i></p> <p><i>The sun evaporates moisture on the leaves.</i></p>	تبخیر شدن ، تبخیر کردن ، تبدیل به بخار کردن
<b>Fission</b>	<p><b>noun [uncountable] technical</b> participle of <i>findere</i> '<b>to split</b>'</p> <p>the process of splitting an atom to produce large amounts of energy or an explosion <b>OPP fusion</b></p>	شکافت
<b>Furnace</b>	<p><b>noun [countable]</b></p> <p><b>1.</b> a large container for a very hot fire, used to produce power, heat, or liquid metal</p> <p><b>2.</b> a piece of equipment used to heat a building</p>	کوره ، نور
<b>Pollution</b>	<p><b>noun [uncountable]</b> the process of making air, water, soil etc dangerously dirty and not suitable for people to use, or the state of being dangerously dirty:</p> <p><i>California's tough anti-pollution laws</i></p> <p><b>air/water/soil pollution</b></p> <p><i>air pollution from traffic fumes</i></p> <p><b>pollution prevention/standards/control</b></p> <p><i>The costs of pollution control must be considered.</i></p>	آلودگی

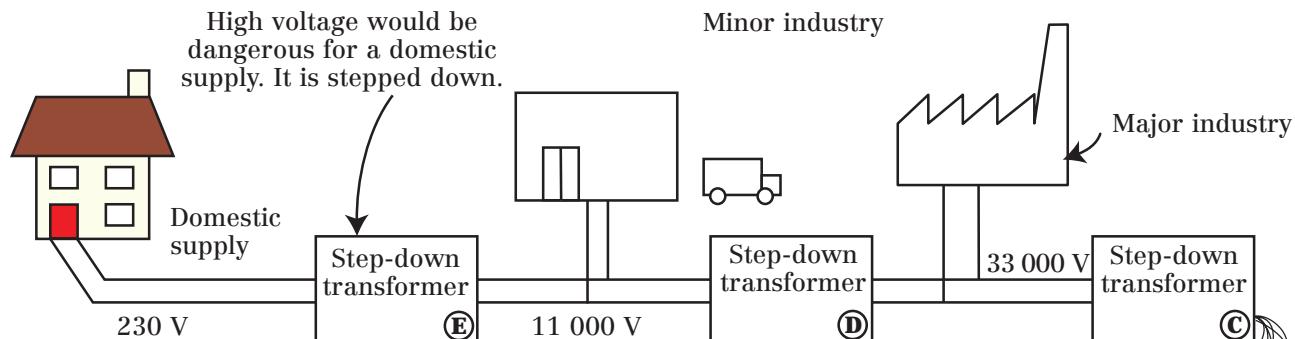
<b>Pond</b>	<p><b>noun [countable]</b> a small area of fresh water that is smaller than a lake, that is either natural or artificially made</p>	تالاب ، مخزن
<b>Primary</b>	<p><b>adjective [usually before noun]</b> most important <b>SYN main:</b> <i>Our primary concern is to provide the refugees with food and health care.</i> <i>Many of the villagers rely on fishing as their primary source of income.</i> <b>primary purpose/aim/objective</b> <i>Their primary objective is to make money.</i> <i>Personal safety is of primary importance.</i></p>	اولیہ ، ابتدائی
<b>Renewable</b>	<p><b>adjective [usually before noun]</b> able to be replaced by natural processes or good management and never used up : renewable energy replaces itself naturally, or is easily replaced because there is a large supply of it: <i>renewable energy such as solar power</i> <i>an industry based on renewable resources</i></p>	تجددی شدندی
<b>Secondary</b>	<p><b>adjective</b> not as important or urgent as something else : <i>a secondary coil or winding in an electrical transformer</i></p>	ثانویہ
<b>Source</b>	<p><b>noun [countable]</b> a thing, place, activity etc that you get something from: They get their money from various sources. <b>source of</b> <i>Beans are a very good source of protein.</i> <i>For me, music is a great source of enjoyment.</i></p>	منبع ، منشاء
<b>Spin</b>	<p><b>verb (past tense and past participle spun , present participle spinning)</b> <b>[intransitive and transitive]</b> to turn around and around very quickly, or to make something do this: <i>The plane's propellers were spinning.</i> <b>spin (something/somebody) around</b> <i>She grabbed Norm's arm and spun him around to face her.</i></p>	چرخیدن، چرخش
<b>Steam</b>	<p><b>noun [uncountable]</b> the hot mist that water produces when it is boiled: <i>Steam rose from the hot tub.</i></p>	بخار
<b>Surroundings</b>	<p><b>noun [plural]</b> the objects, buildings, natural things etc that are around a person or thing at a particular time <b>sb's surroundings</b> <i>He switched on the light and examined his surroundings.</i></p>	محیط
<b>Windmill</b>	<p><b>noun [countable]</b> <b>1.</b> a building or structure with parts that turn around in the wind, used for producing electrical power or crushing grain <b>2. British English</b> a toy consisting of a stick with curved pieces of plastic at the end that turn around when they are blown <b>SYN pinwheel American English</b></p>	آسیاب بادی ، ہر چیزی شبیہ آسیاب بادی



# THE SUPPLY AND USE OF ELECTRICAL ENERGY

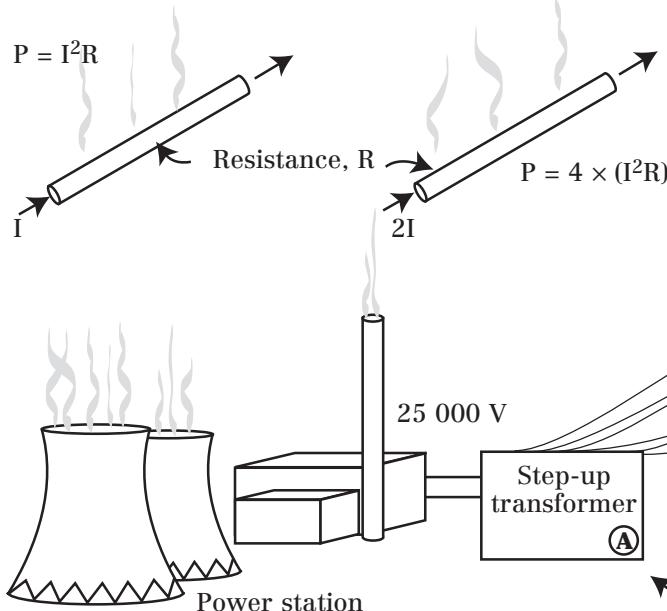
## The National Grid

Electricity is supplied from power stations to consumers by a 'national grid' of interconnected cables and transformers. They allow energy to be sent where it is needed anywhere in the country, and diverted around any faults that develop.

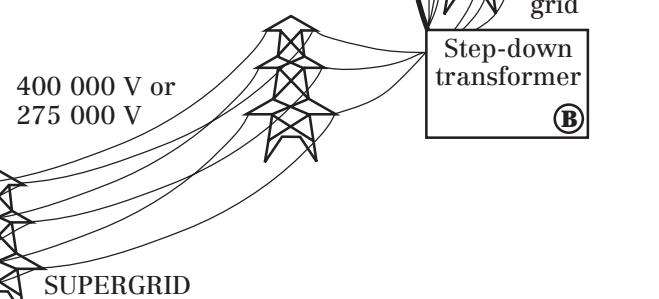


Remember: electrical power =  $(\text{current})^2 \times \text{resistance}$

Wires get hot when electricity passes through them.  
Doubling the current, quadruples the energy lost to heat.



Sometimes cables are buried to avoid spoiling the landscape, or if there is no land for the pylons. They get hotter and are less efficient. They are also harder to maintain.



Remember: electrical power = current  $\times$  voltage

If a transformer is 100% efficient then  
 $\text{Power in} = V_p I_p = \text{power out} = V_s I_s$

Increasing the potential difference (voltage) across the power lines reduces the current flowing.

This means less energy is lost heating up the power lines.

Good for the environment.

Lower cost to distribute electricity.

Some people worry that living near high voltage cables might make them ill.

There is no conclusive evidence either way.

As transformers are essential to the national grid and they only work with alternating current this is a key reason for generating and distributing electricity as alternating current.

### Questions

- Suggest two reasons for a 'national grid' to supply electricity, rather than each town having its own power station.
- Assuming the super-grid power lines operate at 400 000 V, calculate the ratio  $N_p:N_s$  for each of the transformers in the diagram above.
- Why do we use very high voltages to distribute electricity when a lower voltage would be a lot safer?
- Step-down transformer B (above) has an output of 300 A at 132 000 V, what is the current flowing into it assuming the input voltage is 400 000 V and it is 100% efficient?
- Explain (using a formula) the statement, 'Doubling the current in a wire, quadruples the energy loss from it as heat'.
- Draw up a table of advantages and disadvantages of underground vs. overground cables.

Word	Definition (Longman Dictionary of Contemporary English, 5 <sup>th</sup> Edition)	Farsi Equivalent
Avoid	<p><b>verb [transitive]</b> to prevent something bad from happening: <i>Road safety is taught to young children to avoid road accidents.</i> <b>It is important to take measures to avoid the risk of fire.</b> <b>avoid doing something</b> <i>The refugees left to avoid getting bombed.</i> <i>Alan narrowly avoided an accident.</i></p>	دوري کردن از ، احتراز کردن ، اجتناب کردن
Conclusive (Evidence)	<p><b>adjective</b> showing that something is definitely true <b>OPP inconclusive</b> <b>conclusive proof/evidence/findings etc</b> <i>The investigation failed to provide any conclusive evidence.</i></p>	(دليل) قاطع ، (مدرك) قاطع
Consumer	<p><b>noun [countable]</b> someone who buys and uses products and services <b>consumption, producer:</b> <i>Consumers will soon be paying higher airfares.</i> <i>It will offer a wider choice of goods for the consumer (=consumers in general).</i> <i>Consumer demand led to higher imports of manufactured goods.</i> <i>Consumer spending was down by 0.1% last month.</i> <i>sources of consumer advice</i></p>	صرف کننده
Divert	<p><b>verb [transitive]</b> to change the direction in which something travels <b>divert a river/footpath/road etc</b> <i>Canals divert water from the Truckee River into the lake.</i> <i>The high street is closed and traffic is being diverted.</i></p>	منحرف شدن ، منحرف کردن
Double	<p><b>verb [intransitive and transitive]</b> to become twice as big or twice as much, or to make something twice as big or twice as much <b>double in size/number/value etc</b> <i>Within two years the company had doubled in size.</i> <b>double the size/number/amount etc (of something)</b> <i>A promise was given to double the number of police on duty.</i></p>	دو برابر شدن ، دوبرابر کردن
Fault	<p><b>noun [countable]</b> a) something that is wrong with a machine, system, design etc, which prevents it from working properly: <i>a design fault</i> <b>fault in</b> <i>It sounds as if there's a fault in one of the loudspeakers.</i> b) something that is wrong with something, which could be improved <b>SYN flaw:</b> <i>For all its faults (=in spite of its faults) we love this city.</i> c) a mistake in the way that something was made, which spoils its appearance <i>The sweater had a fault in it and I had to take it back.</i></p>	خطا ، اشتباه

<b>Interconnect</b>	<p><b>verb</b> [<i>intransitive and transitive</i>]          if two systems, places etc are interconnected, or if they interconnect, they are joined together:  <i>a series of interconnected lakes</i>  <i>interconnecting rooms</i>  <i>Our operating system can now interconnect with other networks.</i></p>	با یکدیگر اتصال دادن ، به هم پیوستن ، به هم وصل کردن
<b>Landscape</b>	<p><b>noun</b>  <b>1.</b> [<i>countable</i>] an area of countryside or land of a particular type, used especially when talking about its appearance:  <i>the beauty of the New England landscape</i>  <b>rural/industrial/urban etc landscape</b>  <b>2.</b> [<i>countable</i>] a picture showing an area of countryside or land:  <i>English landscape artists</i></p>	دورنمای ، چشم انداز ، منظوره طبیعی
<b>Maintain</b>	<p><b>verb</b> [<i>transitive</i>]          to make something continue in the same way or at the same standard as before:  <i>A lot depends on building and maintaining a good relationship with your customers.</i>  <i>The hotel prides itself on maintaining high standards.</i>  <i>How can we maintain control of spending?</i></p>	نگهداری ، برقرار داشتن ، حفظ کردن
<b>National Grid</b>	<p><b>noun</b>          a system of special wires that take electricity from power stations (=places where electricity is made) to all parts of a country</p>	سیستم انتقال نیروی برق (معادل توانیر)
<b>Power</b>	<p><b>noun</b> [<i>uncountable</i>]          the rate at which energy is used, or the ability to produce energy:  <i>The ship was only slightly damaged in the collision and was able to sail into port under its own power.</i>  <i>The power rating of my amplifier is forty watts per channel.</i></p>	توان ، قدرت
<b>Pylon</b>	<p><b>noun</b> [<i>countable</i>]  <b>1.</b> a tall metal structure that supports wires carrying electricity  <b>2. American English</b> one of a set of plastic cones placed on a road to control traffic and protect people working there</p>	شاه تیر ، دکل برق
<b>Spoil</b>	<p><b>verb</b> (<i>past tense and past participle spoiled or spoilt British English</i>)  <b>[transitive]</b>          to have a bad effect on something so that it is no longer attractive, enjoyable, useful etc <b>SYN ruin</b>:  <i>The whole park is spoiled by litter.</i>  <i>We didn't let the incident spoil our day.</i>  <i>I don't want to spoil your fun.</i>  <i>Why do you always have to spoil everything?</i>  <b>spoil/ruin your appetite</b> at <i>appetite</i></p>	از بین بردن ، غارت کردن ، ضایع کردن
<b>Step-down Transformer</b>	<p><b>noun</b> [<i>countable</i>]          A step down transformer has more turns of wire on the primary coil and less turns of wire on the secondary coil. This makes a smaller induced voltage in the secondary coil. Compare this with a <b>step up transformer</b>.</p>	ترانسفورماتور کاهنده