The force between two long, current carrying wires

Consider two long, parallel wires, placed a distance L apart. Suppose they carry currents I_1 and I_2 respectively. Each current produces a magnetic field that is "felt" by the other and thus exert a force on each other.

The force exerted on wire 2 is given by

$$F_2 = B_1 I_2 \ell_2$$

where B_1 is the field at wire 2 due to wire 1 and ℓ_2 is the length of wire 2. But

$$B_1 = k\frac{I_1}{L}$$ then

$$F_2 = \frac{kI_1 I_2 \ell_2}{L}$$ similarly $$F_1 = \frac{kI_1 I_2 \ell_1}{L}$$

If $\ell_1 = \ell_2$

$$F = \frac{kI_1 I_2 \ell}{L}$$

$$\frac{F}{\ell} = \frac{kI_1 I_2}{L}$$

$$I_1 = I_2 = 1A$$

$$\frac{F}{\ell} = \frac{(2 \times 10^{-7}) \times 1 \times 1}{1} = 2 \times 10^{-7}\, Nm^{-1}$$

Ampere

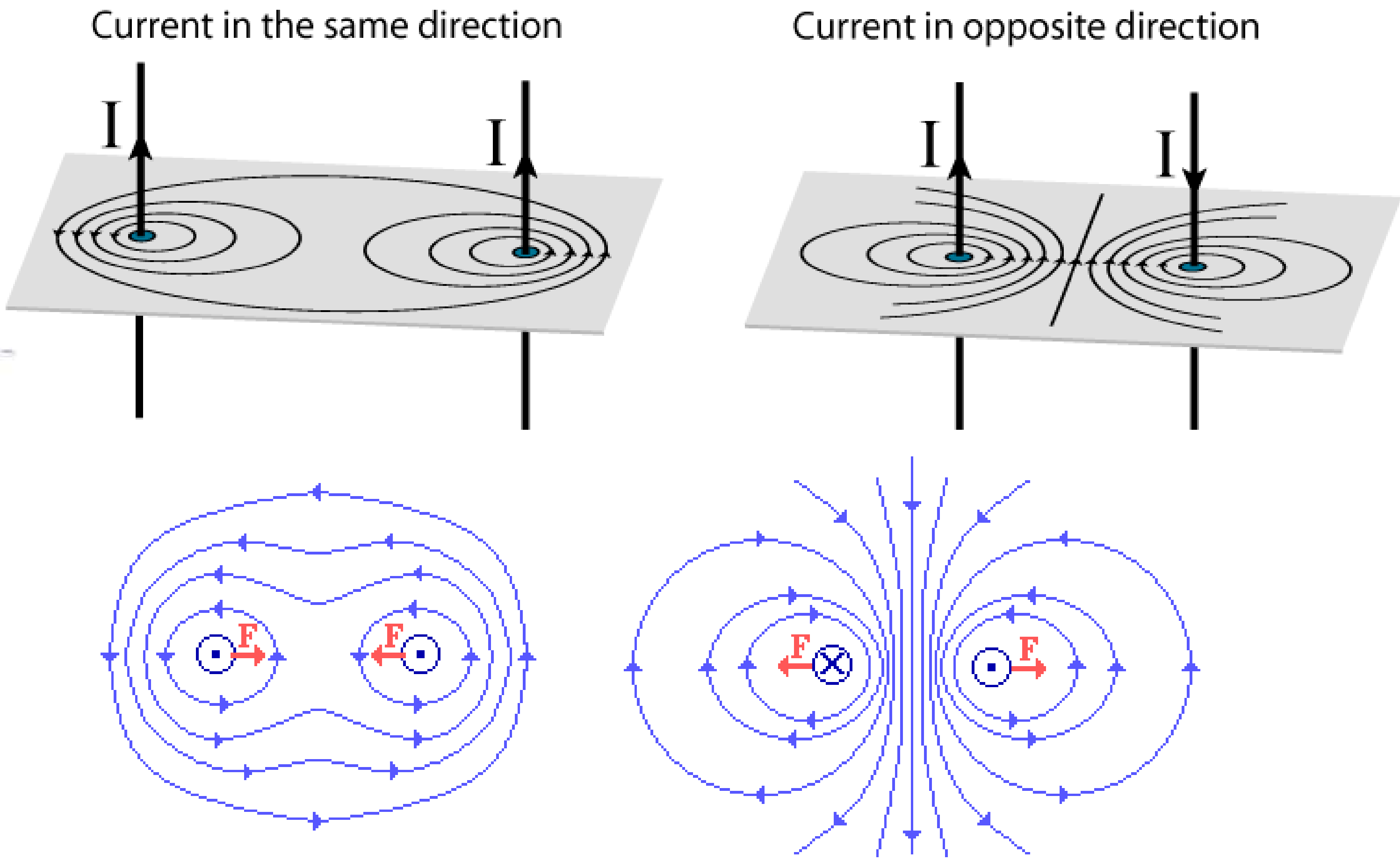
1 ampere is defined as that current flowing in each of two long, parallel wires 1m apart, which results in a force of $2 \times 10^{-7} N$ per metre length of each conductor.

The definition of the ampere in turns allows us to define the coulomb.

Coulomb

One coulomb is the quantity of electric charge that passes a given point in a conductor in one second when the current is one ampere.

Direction of a force between two long, current carrying wires



Same direction

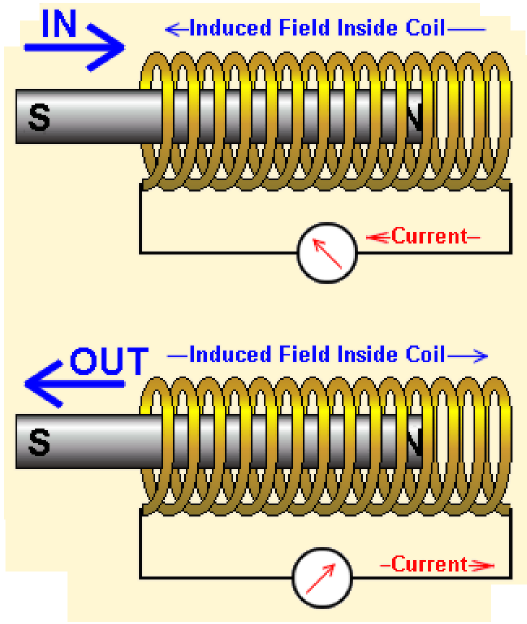
Opposite direction

Electromagnetism

We have discussed two ways in which electricity and magnetism are related.
(a) An electric current produces a magnetic field, and
(b) A magnetic field exerts a force on an electric current.

Can magnetic field produces current

Yes



$$\frac{V_s}{V_p} = \frac{n_s}{n_p}$$

$$\frac{n_s}{n_p} = n$$

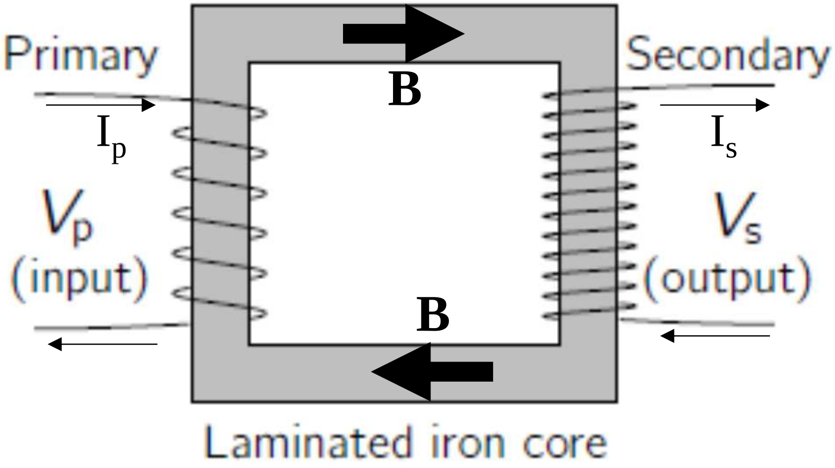
$n > 0$ step-up
$n < 0$ step-down

n is a turn ratio

$$\frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{n_s}{n_p} = n$$

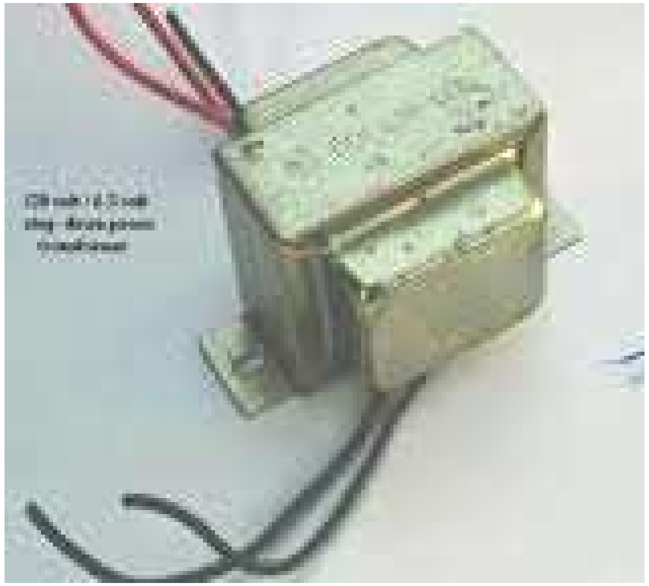
Examples

Electric windmill



Transformer

Examples of transformers



Example

Example 3.2: A step-down transformer

A transformer reduces 240 V ac to 9 V ac to operate a cd player. The secondary coil contains 30 turns and the cd player draws 400mA. Calculate

(a) the number of turns in the primary coil,

(b) the power transformed and

(c) the current in the primary coil.

Tutorials

73. Determine the magnetic field midway between two long, straight wires 10 cm apart if one carries 10 A and the other 8.0 A and these currents are
(a) in the same direction, and
(b) in opposite directions.

78. A transformer changes 12 V to 18 000 V and there are 6000 turns in the secondary. How many turns are there in the primary?

79. A transformer has 145 turns in the primary and 55 in the secondary. What kind of transformer is this, and by what factor does it change the voltage?