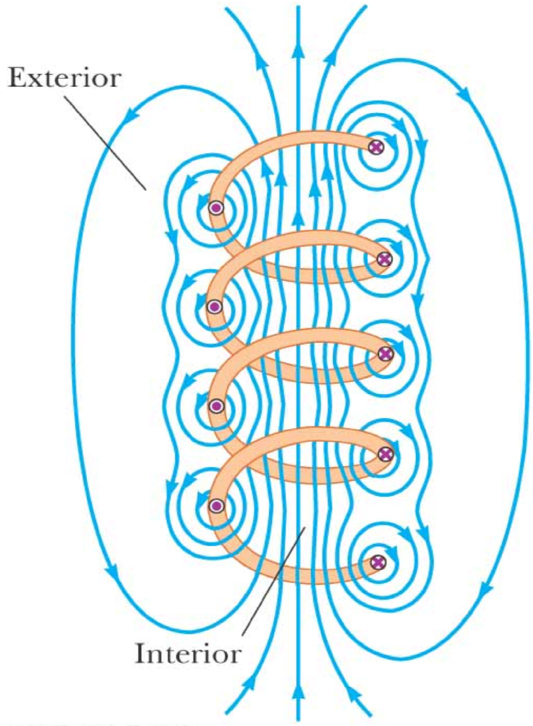
30.4 The magnetic field of a solenoid

A solenoid is a long wire wound in the form of a helix. With this configuration, a reasonably uniform magnetic field can be produced in the space surrounded by the turns of wire—which we shall call the *interior of the solenoid—when the solenoid* carries a current.

The field lines in the interior are nearly parallel to one another, are uniformly distributed, and are close together, indicating that the field in this space is uniform and strong.

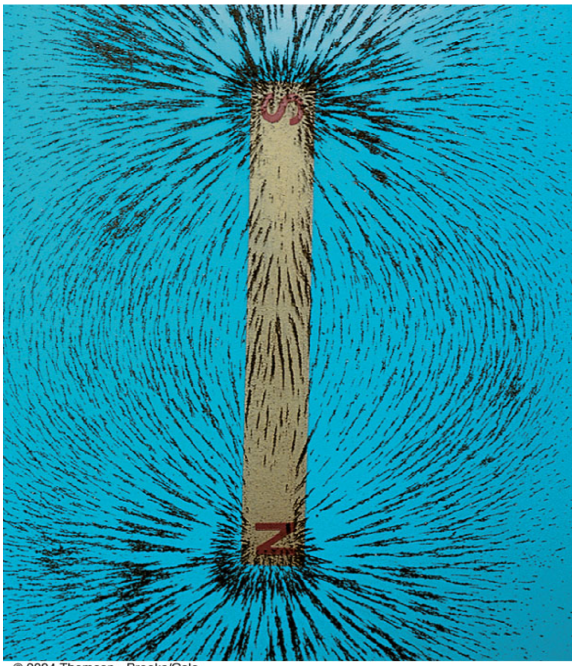
The field lines between current elements on two adjacent turns tend to cancel each other because the field vectors from the two elements are in opposite directions.

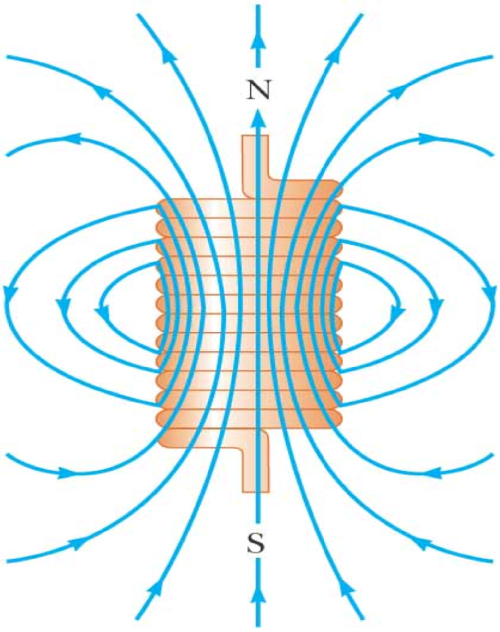


The field at exterior points such as *P is weak because* the field due to current elements on the right-hand portion of a turn tends to cancel the field due to current elements on the left-hand portion.

❖ **Magnetic field lines for a tightly wound solenoid of finite length, carrying a steady current**

The field at exterior points such as *P is weak because* the field due to current elements on the right-hand portion of a turn tends to cancel the field due to current elements on the left-hand portion.

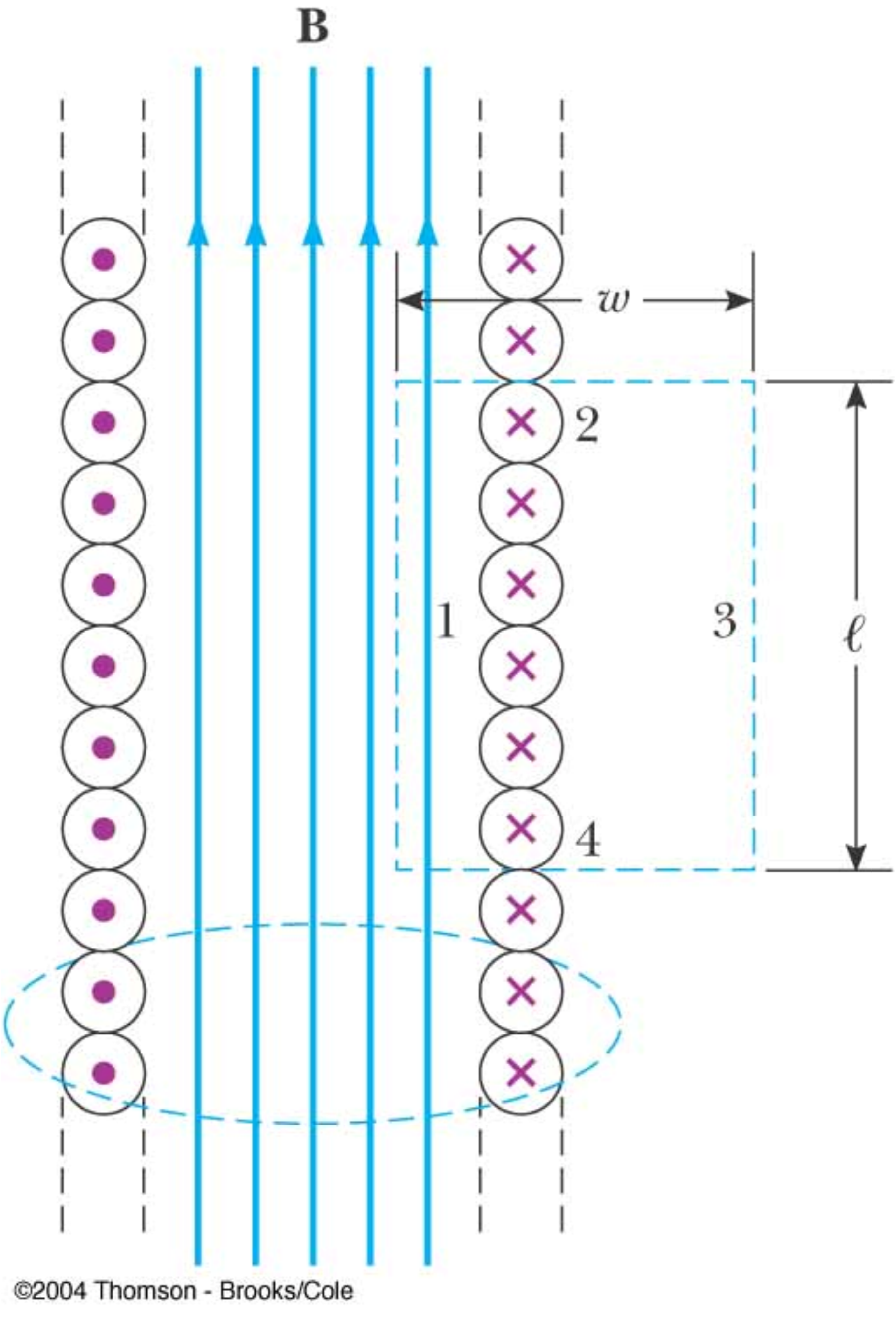




(a)

The magnetic field pattern of a bar magnet, displayed with small iron filings on a sheet of paper.

An *ideal solenoid is approached* when the turns are closely spaced and the length is much greater than the radius of the turns. In this case, the external field is zero, and the interior field is uniform over a great volume.


B
w
2
1
3
ℓ
4

Because the solenoid is ideal, B in the interior space is uniform and parallel to the axis, and B in the exterior space is zero.

Consider the rectangular path of length and width w shown in Figure…. We can apply Ampère's law to this path by evaluating the integral of **B.*ds*** over each side of the rectangle.

$$\oint \vec{B}.d\vec{s} = \int_{path1} \vec{B}.d\vec{s} = B \int_{path\ 1} ds = Bl \qquad 30.8$$

If N is the number of turns in the length l, the total current through the rectangle is NI. Therefore, we can write 30.8 as following,

$$\oint \vec{B}.d\vec{s} = Bl = \mu_0 I \qquad 30.9$$

So,

$$B = \mu_0 \frac{N}{l} I = \mu_0 nl \qquad 30.10$$

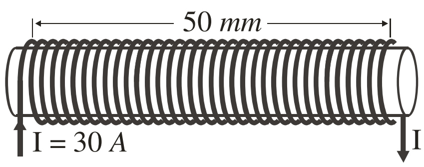
Where n is the number of turns per unit length.

س٢٥- يمر تيار $1\ A$ في ملف سلنويد طوله متر يحوي ١٠٠٠ لفة له مساحة مقطع $16\ cm^2$. شدة المجال المغناطيسي داخله تساوي:

Q25- A solenoid of 1 *m* length has 1000 *turns* and a cross section area of 16 cm^2. What is the magnetic field inside the solenoid if the current through the coil is 1 *A*?

A) 1.256×10^{-3} B) 10^{-4} C) 7.85×10^{-5} D) 1.57×10^{-4}

س٢٢- إذا كان عدد اللفات الكلية للملف (Solenoid) N = 34 *turns* فإن شدة المجال المغناطيسي داخله تساوي:



A) 0.052 B) 0.026 C) 0.072 D) 0.036
