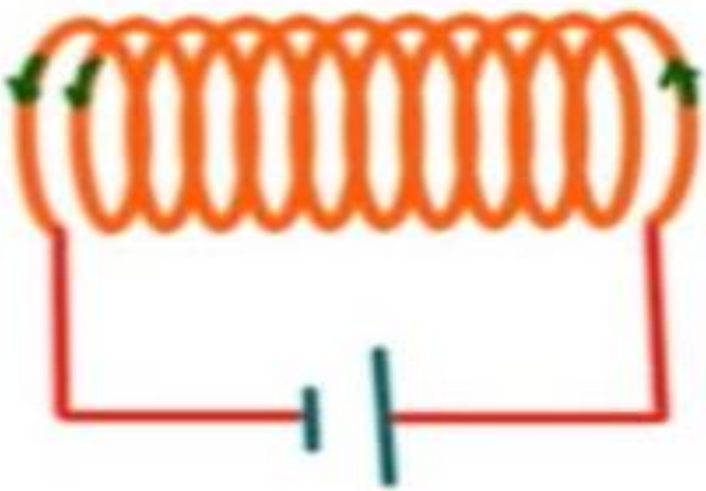
Magnetic field of solenoid and toroid

Applied Physics

PH-122

Solenoid

Solenoid



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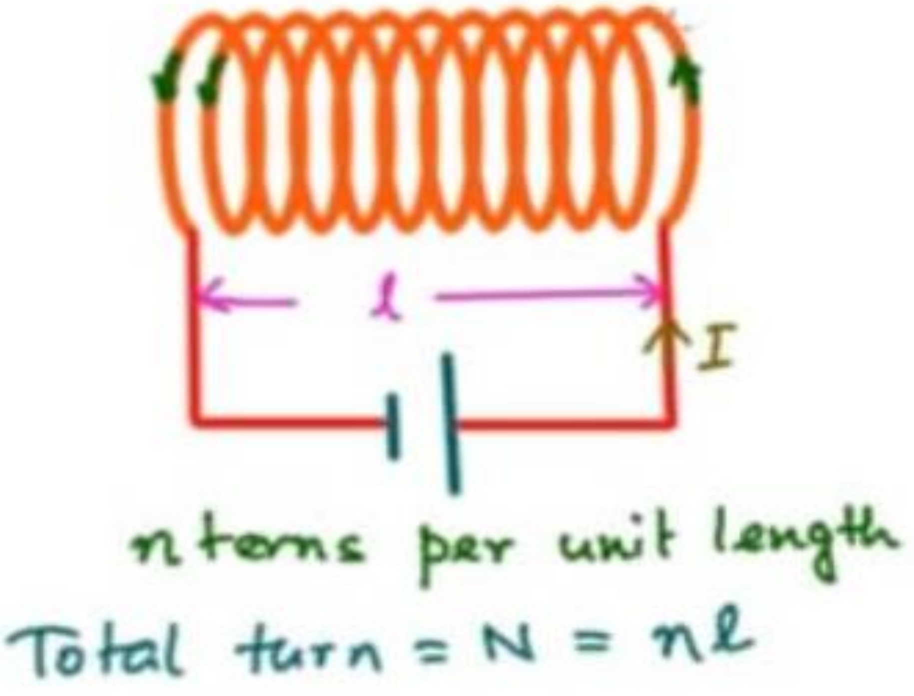
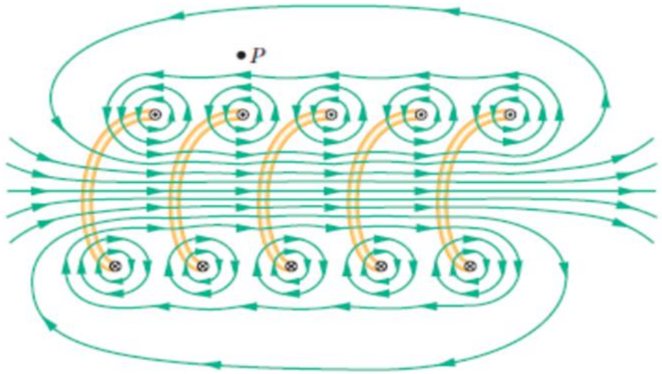


Magnetic Field by solenoid



A vertical cross section through the central axis of a "stretched-out" solenoid. The back portions of five turns are shown, as are the magnetic field lines due to a current through the solenoid. Each turn produces circular magnetic field lines near itself. Near the solenoid's axis, the field lines combine into a net magnetic field that is directed along the axis. The closely spaced field lines there indicate a strong magnetic field. Outside the solenoid the field lines are widely spaced; the field there is very weak.

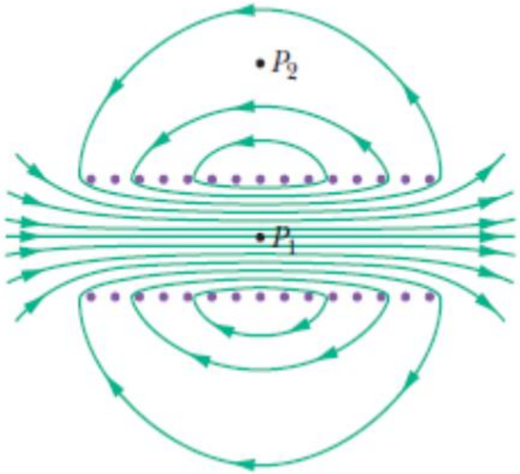
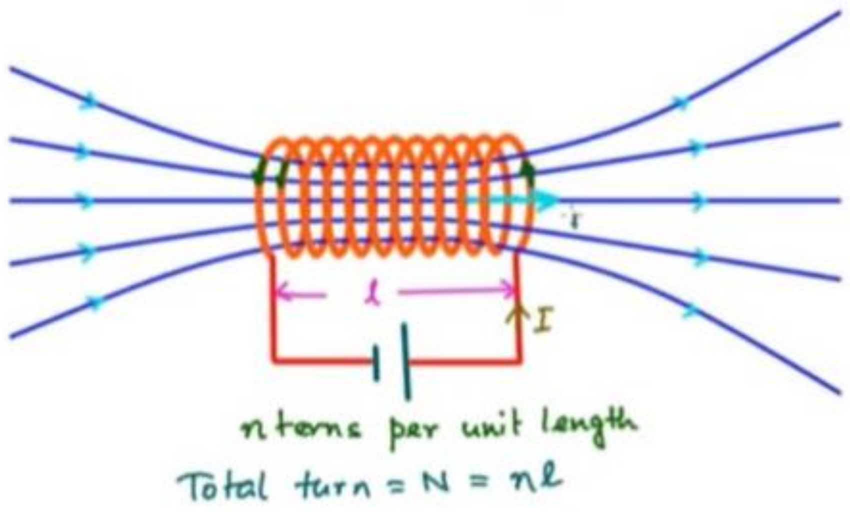


Figure Magnetic field lines for a real solenoid of finite length. The field is strong and uniform at interior points such as P_1 but relatively weak at external points such as P_2.

Amperes Law



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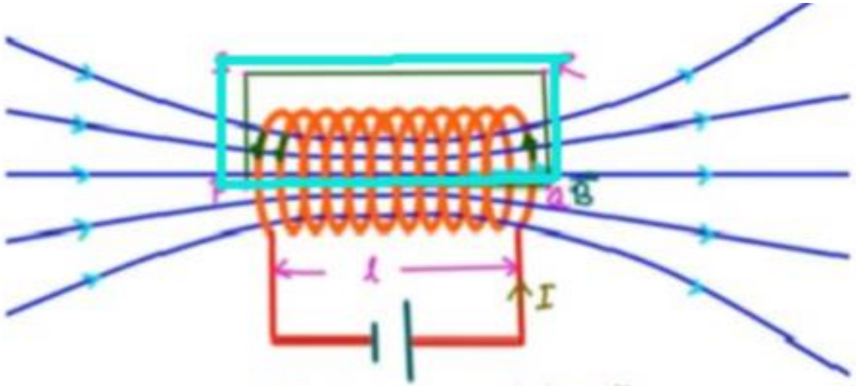


n turns per unit length

Total turn = N = nl

$$\oint_{PQRSP} \vec{B}\cdot d\vec{l} = \mu_0 (n l I)$$

Continued

$$\oint_{PQRSP} \vec{B}\cdot d\vec{l} = \mu_0 (n l I) \quad \ldots\ldots (1)$$

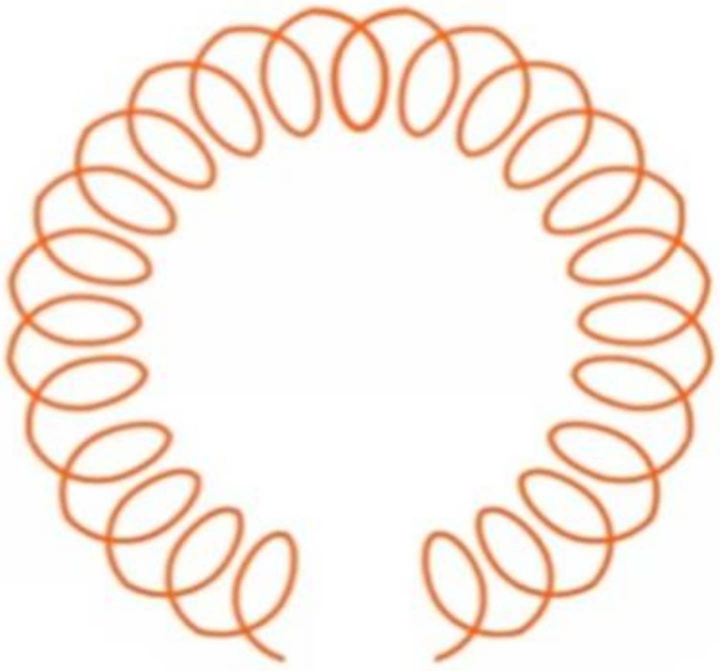
$$\oint_{PQRSP} \vec{B}\cdot d\vec{l} = \int_P^Q \vec{B}\cdot d\vec{l} + \int_Q^R \vec{B}\cdot d\vec{l} + \int_R^S \vec{B}\cdot dl + \int_S^P \vec{B}\cdot d\vec{l}$$

$$= \int_P^Q \vec{B}\cdot d\vec{l} + 0 + 0 + 0 = \int_P^Q \vec{B}\cdot d\vec{l}$$

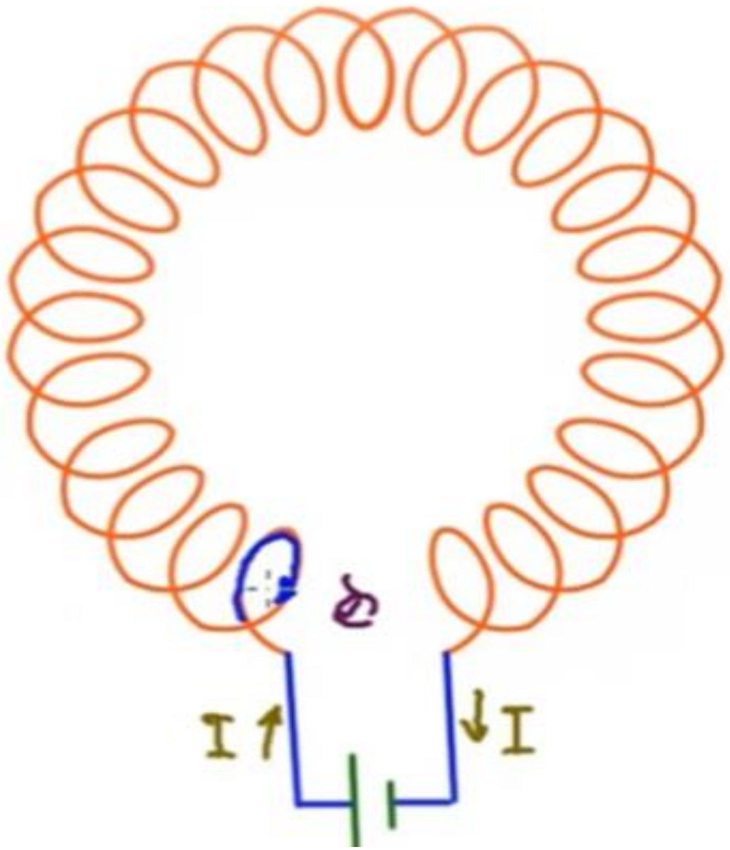
$$= \int_P^Q B\, dl \cos 0^\circ = \int_P^Q B\, dl = B \int_P^Q dl = B l$$

$$B l = \mu_0 (n l I) \Rightarrow B = \mu_0 n I$$

Toroid



Toroid



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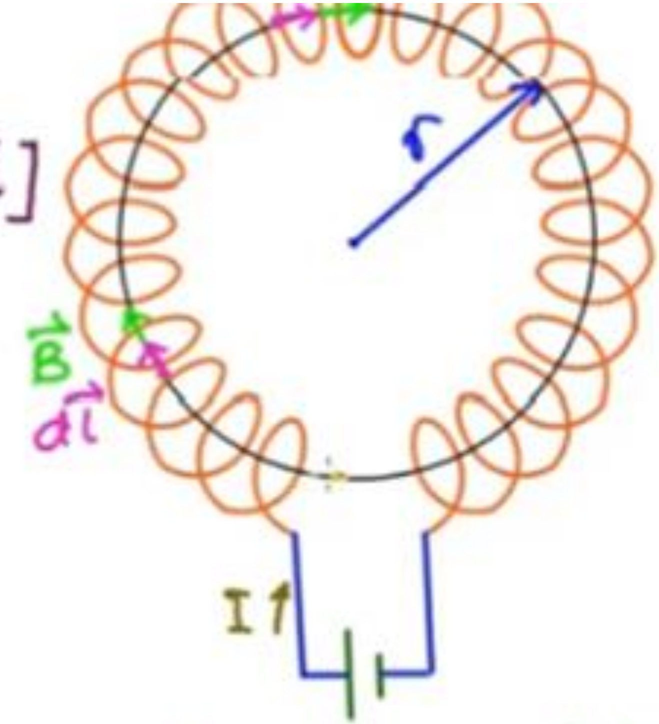
$$\oint \vec{B}\cdot\vec{dl} = \oint B\,dl\cos\theta \quad [\theta = \text{angle between } \vec{B} \text{ and } \vec{dl}]$$

$$= \oint B\,dl$$

$$= B\oint dl$$



n turns per unit length

Total turns $= n(2\pi r)$

Continued

$$\oint \vec{B}\cdot\vec{dl} = \oint B\,dl\cos\theta \quad [\theta = \text{angle between } \vec{B} \text{ and } \vec{dl}]$$

$$= \oint B\,dl$$

$$= B\oint dl$$

$$= B\,.\,2\pi r$$

Continued

- Ampere's law

$$\oint B \,.\, dl = \mu_o I N$$

- By comparing equation

$$B.\, 2\pi r = \mu_o I N$$
$$B = \mu o N I / 2\pi \text{ R}$$

Problem

- A solenoid has length L=1.23 m and inner diameter is 3.55cm and it carries current of i=5.57amp and it can consist of 5 layers packed each with 850 turns along length L. what is magnetic field?

Problem

- Compute the magnetic field of a long straight wire that has a circular loop with a radius of 0.05m. 2amp is the reading of the current flowing through this closed loop..

Problem:

- A closely wound solenoid is 1 m long and has 5 layers and each winding have 500 turns. If the average diameter o solenoid is 3cm and each carries a current of 4 amperes. Find the magnetic field?

Problem

- A solenoid of length $\frac{\pi}{2}$m long has a two layers of winding of 500 turn each of turn have radius 5cm. What is magnetic field when current is 5 ampere?

Problem

- A surveyor is using magnetic compass 6.1m below the power line in which there is a steady current 100A.what is magnetic field at the site of compass due to power line? will this interference seriously done with compass reading? The horizontal magnitude of earths magnetic field at the site $20\mu T$

Summary

- Magnetic field of solenoid

$$B = \mu_o n i$$

- Magnetic Field of toroid

$$B = \mu_o n i / 2\pi r$$

If you have any questions regarding this lecture, please ask in the live session

Thank you