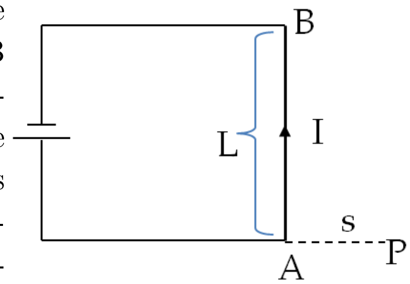
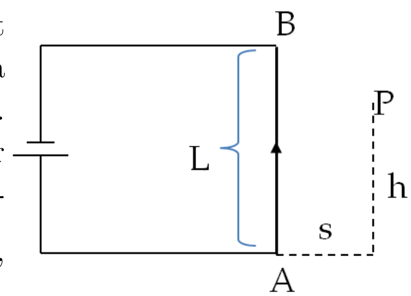
8.5 EXERCISES

Biot-Savart Law

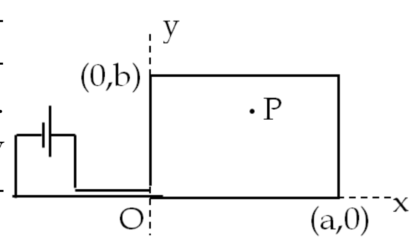
Ex 8.5.1. Find the magnetic field at point P a distance s from the end of a straight wire section AB of length L in a circuit carrying a steady current I. (Ignore the contribution of other parts of the circuit.) Ans: Magnitude: $\frac{\mu_0 I}{4\pi}\frac{L}{\sqrt{s^2+L^2}}$, Direction: into-the-page.



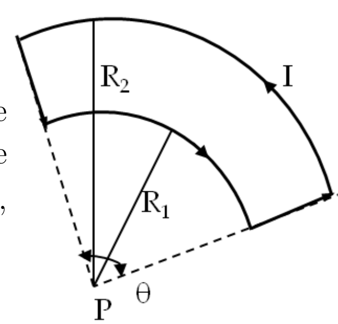
Ex 8.5.2. Find magnetic field at an arbitrary point P by a straight wire section AB of length L in a circuit carrying a steady current I. (Ignore the contribution of other parts of the circuit.) Ans: Magnitude: $\frac{\mu_0 I}{4\pi}\left[\frac{L-h}{\sqrt{s^2+(L-h)^2}}+\frac{h}{\sqrt{s^2+h^2}}\right]$, Direction: into-the-page.



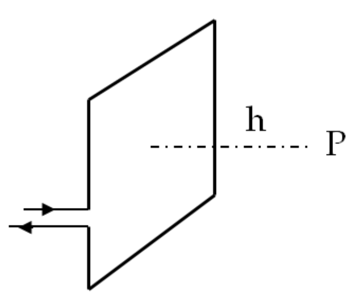
Ex 8.5.3. An electric circuit contains a rectangular wire of dimensions $a \times b$ carrying a current I. Find magnetic field at an arbitrary point P by the current in the rectangular wire in the area enclosed.



Ex 8.5.4. Find the magnetic field at the center of the arcs by the current in wire shown. Ans: Magnitude: $\frac{\mu_0 I\theta}{4\pi}\left|\frac{1}{R_1}-\frac{1}{R_2}\right|$, Direction: into-the-page.

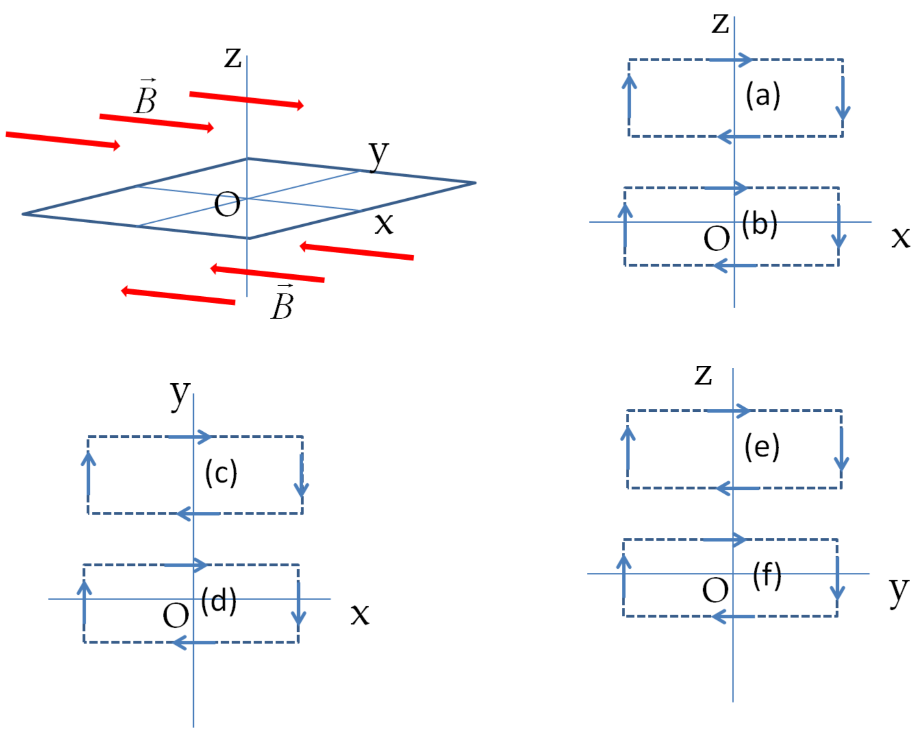


Ex 8.5.5. Find magnetic field a point P a height h above the center of a square loop of side a carrying a current I. Ans: Magnitude: $\frac{\mu_0 I a^2}{2\pi}\frac{1}{(h^2+a^2/4)\sqrt{h^2+a^2/2}}$, Direction: into-the-page.



Circulation of Magnetic Field

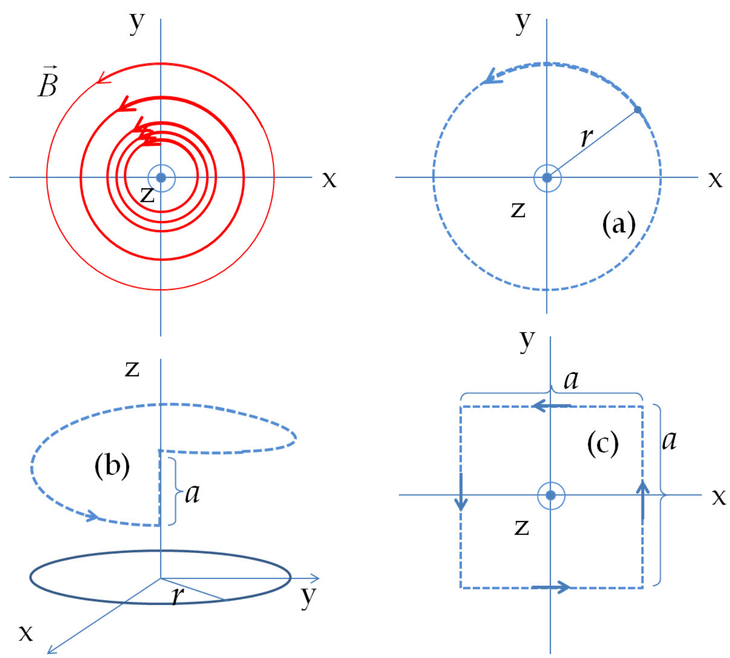
Ex 8.5.6. A magnetic field is uniform with magnitude B_0 above $z = 0$ plane and points towards the positive x-axis and uniform with with same magnitude B_0 below $z = 0$ axis but points towards the negative x-axis as shown in the figure. Find the circulation of the magnetic field for the closed loops (a)-(f). Note the loops have been drawn in different planes.



Ex 8.5.7. A non-uniform magnetic field exists in a region of space such that the magnitude of the field varies with distance r from the z-axis as

$$B = \frac{\alpha}{r},$$

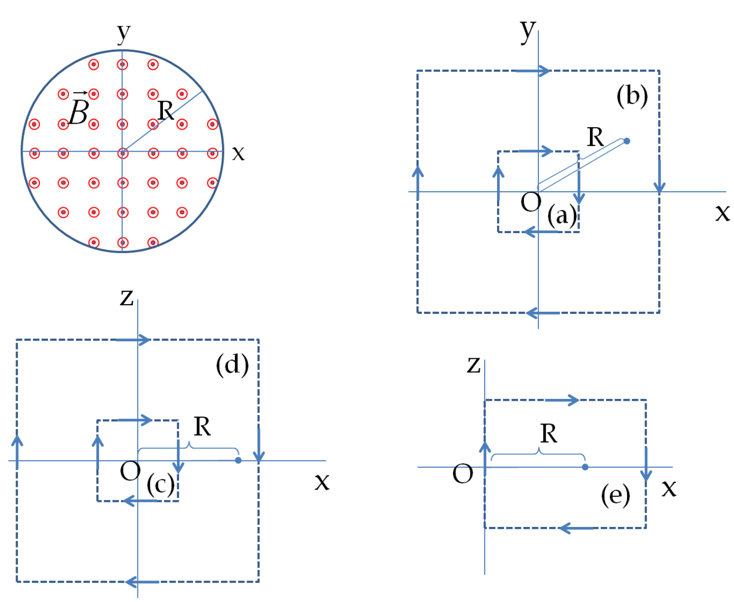
where α is a constant, and the direction of the field in the xy-plane is shown in figure below. Find the circulation of the magnetic field for the closed loops (a)-(c). Loop (b) is a three-dimensional loop in the shape of a helix which has a circular projection of radius r on the xy-plane as indicated in the figure.



Ex 8.5.8. A magnetic field exists in a region of space such that the magnitude of the field varies with distance r from the z-axis as

$$B = \begin{cases} B_0 & r < R \\ 0 & r > R \end{cases}$$

where B_0 is a constant, and the direction of the non-zero field is towards the positive z-axis as shown in the figure below. Find the circulation of the magnetic field for the closed loops (a)-(e). Note the loops have been drawn in different planes.



Ampere's Law

Ex 8.5.9. Find the circulation of magnetic field in terms of currents for the loops shows with dashed lines in various figures using the statement of Ampere's law.

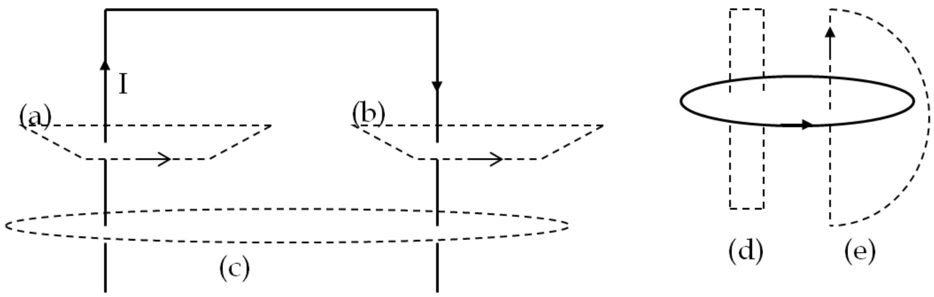


Figure 8.33: Exercise **??**

Ex 8.5.10. Circulation of magnetic field around a loop that encloses many wires is found to be zero. Can you conclude that current is zero in the wires? Explain.

Ex 8.5.11. On a flat plate there is a uniform surface current density of 200 A/cm. Determine the magnetic field (both magnitude and direction) 0.5 cm from the surface. For the direction, draw out the surface current and the point at which you have determined the direction of magnetic field. Ans: Magnitude: 12.6 mT, Direction: use RHR.

Ex 8.5.12. You need a uniform magnetic field of magnitude 2.5 T over a large flat copper surface. Determine the surface current density required. Draw a figure to illustrate the directions of the current and the magnetic field. Ans: Magnitude of surface current density: 4×10^6 A/m.

Ex 8.5.13. A long wire carries a steady current of 30 amps. Find the magnitude and direction of magnetic field 2 cm from the wire. Ans: 300 μT in the clockwise as you look from behind the current.

Ex 8.5.14. A current in a straight co-axial cable runs in a thin wire at the center and returns at the surface conductor, a cylindrical shell of radius 0.5 cm. For a current of 3 A, determine the magnetic field at a point 0.2 cm from the center and at a point 0.7 cm from the center. Ans: 3 mT in the clockwise as you look from behind the current.

Ex 8.5.15. A straight wire at the center of a long solenoid carries 20 A current. The solenoid has 100 turns per cm and carries 2 A current. Find the magnetic field inside the solenoid at a point 3 mm from the center, which is outside the thin wire. Assume infinitely long solenoid. Ans: 12.7 mT, direction 84° counter-clockwise from the positive x-axis towards the positive z-axis.

Ex 8.5.16. A long solenoid with 50 turns per cm is set parallel to a wide plate that carries a surface current of 15 A/cm. A current of 1 A flows in the solenoid such that the solenoid produces magnetic field in the same direction as the direction of flow of the surface current. Find magnetic field at a point inside the solenoid. Ans: 1.13 mT, 56.4° from the axis of the solenoid.