# Chapter 30

1

Sources of the magnetic field



1

# Lecture 02

2

Magnetic Force Between Two Parallel Conductors

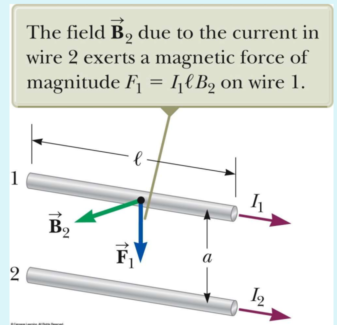


2

## Magnetic Force Between Two Parallel Conductors

3

- Two parallel wires each carry a steady current.
- The field $\vec{B}_2$ due to the current in wire 2 exerts a force on wire 1 of magnitude $F_1 = I_1 \ell B_2$.






3

## Magnetic Force Between Two Parallel Conductors

4

- Substituting the equation for the magnetic field ($B_2$) gives

$$F_1 = \frac{\mu_\circ I_1 I_2}{2\pi a} \ell$$

  - Parallel conductors carrying currents in the same direction attract each other.
  - Parallel conductors carrying current in opposite directions repel each other.



4

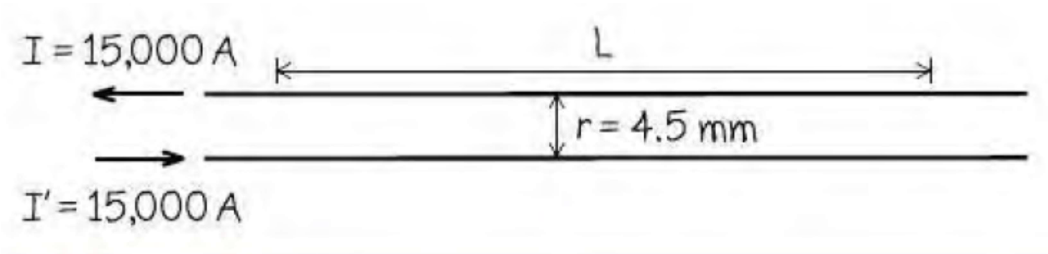
# Forces between parallel wires

Monday, 5 April, 2021 22:10

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

- [ ] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [ ] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [x] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [ ] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

Two straight, parallel, superconducting wires $4.5\ mm$ apart carry equal currents of $15000\ A$ in opposite directions. What force, per unit length, does each wire exert on the other?




$$\frac{F}{L} = \frac{\mu_o I_1 I_2}{2\pi r} = \frac{4\pi \times 10^{-7} \times 15000^2}{2\pi \times 4.5 \times 10^{-3}} = 1 \times 10^4\ N/m$$

# Magnetic force between currents

Thursday, 4 February, 2021 16:47


Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

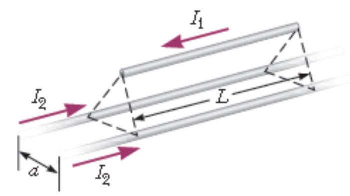
R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.

J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.

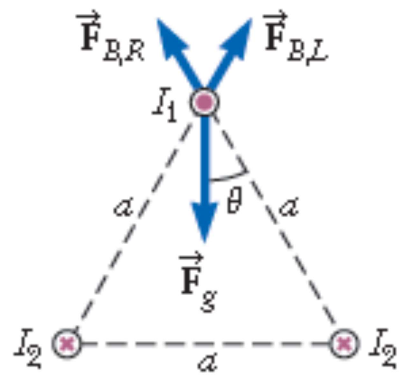
H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.

H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.


Two infinitely long, parallel wires are lying on the ground a distance $a = 1.00\ cm$ apart as shown. A third wire, of length $L = 10.0\ m$ and mass $400\ g$, carries a current of $I_1 = 100\ A$ and is levitated above the first two wires, at a horizontal position midway between them. The infinitely long wires carry equal currents $I_2$ in the same direction, but in the direction opposite that in the levitated wire. What current must the infinitely long wires carry so that the three wires form an equilateral triangle?




SOLUTION




Because the current in the short wire is opposite those in the long wires, the short wire is repelled from both of the others.

Figure 30.8b shows the desired situation with the three wires forming an equilateral triangle.

Because the levitated wire is subject to forces but does not accelerate, it is modeled as a particle in equilibrium.

The horizontal components of the magnetic forces on the levitated wire cancel. The vertical components are both positive and add together. Choose the *z* axis to be upward through the top wire in Figure 30.8b and in the plane of the page.

Find the total magnetic force in the upward direction on the levitated wire:

$$\vec{F}_B = 2\left(\frac{\mu_0 I_1 I_2}{2\pi a}\ell\right)\cos\theta\,\hat{K} = \frac{\mu_0 I_1 I_2}{\pi a}\ell\cos\theta\,\hat{k}$$

Find the gravitational force on the levitated wire:

$$\vec{F}_g = -mg\hat{k}$$

Apply the particle in equilibrium model by adding the forces and setting the net force equal to zero:

$$\sum \vec{F} = \vec{F}_B + \vec{F}_g = \frac{\mu_0 I_1 I_2}{\pi a}\ell\cos\theta\,\hat{k} - mg\hat{k} = 0$$

Solve for the current in the wires on the ground:

$$I_2 = \frac{mg\pi a}{\mu_0 I_1 \ell\cos\theta}$$

Substitute numerical values:

$$I_2 = \frac{(0.400kg)(9.80m/s^2)\pi(0.0100m)}{(4\pi \times 10^{-7}T \cdot m/A)(100A)(10.0m)\cos 3\,0.0°}$$

$$= 113A$$