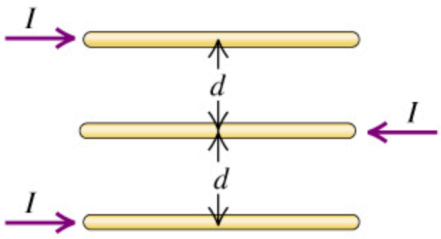
Exercise 28.28 - Enhanced - with Feedback

Three parallel wires each carry current I in the directions shown in (Figure 1). The separation between adjacent wires is d.

Figure

1 of 1



Review | Constants

Part A

Calculate the magnitude of the net magnetic force per unit length on the top wire.

Express your answer in terms of I, d, and magnetic constant μ_0.

Submit Request Answer

Part B

What is its direction?

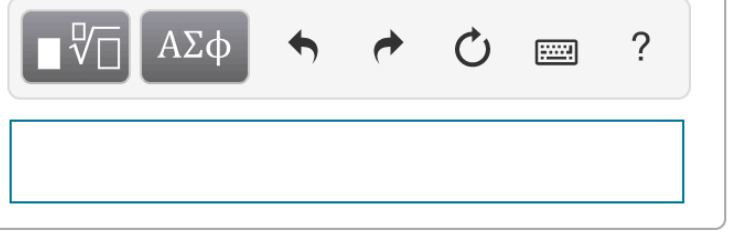
- Upward
- Downward
- The force is zero

Submit Request Answer

Part C

Calculate the magnitude of the net magnetic force per unit length on the middle wire.

Express your answer in terms of I, d, and magnetic constant μ_0.



Submit Request Answer

Part D

What is its direction?

- Upward
- Downward
- The force is zero

Submit Request Answer

Part E

Calculate the magnitude of the net magnetic force per unit length on the bottom wire.

Express your answer in terms of I, d, and magnetic constant μ_0.

Submit Request Answer

Part F

What is its direction?

- Upward
- Downward
- The force is zero

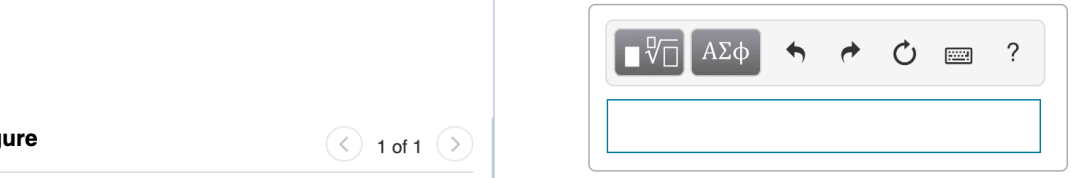
Submit Request Answer

Review | Constants

Part A

Calculate the magnitude of the magnetic field at point *P* due to the current in the semicircular section of wire shown in the figure (Figure 1). (*Hint:* Does the current in the long, straight section of the wire produce any field at *P*?)

Express your answer in terms of the variables I, R, and magnetic constant μ_0.



Submit Request Answer

Part B

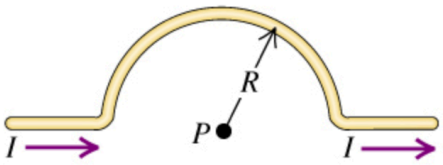
Find the direction of the magnetic field at point *P*.

- into the page
- out of the page

Submit Request Answer

Figure

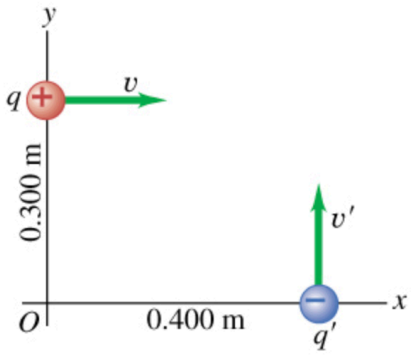
1 of 1



Problem 28.49

A pair of point charges, q = +8.50 μC and q' = -5.00 μC , are moving as shown in the figure (Figure 1) with speeds $v = 9.00\times10^4$ m/s and $v' = 6.50\times10^4$ m/s . The charges are at the locations shown in the figure.

Figure 1 of 1



Review | Constants

Part A

What is the magnitude of the magnetic field produced at the origin?

Express your answer in teslas.

B = T

Submit Request Answer

Part B

What is the direction of the magnetic field produced at the origin?

- in $+x$−direction
- in $+y$−direction
- out of the page
- into the page

Part C

What is the magnitude of the magnetic force that q' exerts on q?

Express your answer in newtons.

$F =$ N

Submit Request Answer

Part D

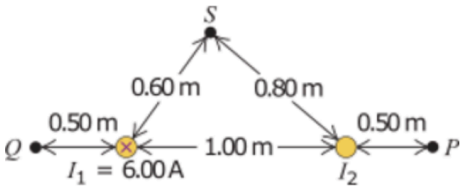
What is the direction of the magnetic force that q' exerts on q?

- into the page
- in $+y-$direction
- in $+x-$direction
- out of the page

Problem 28.59

Two long, straight, parallel wires are 1.00 m apart (Figure 1). The wire on the left carries a current I_1 of 6.00 A into the plane of the paper.

Figure 1 of 1



Review | Constants

Part A

What must the magnitude of the current I_2 be for the net field at point P to be zero?

Express your answer with the appropriate units.

I_2 = Value Units

Submit Request Answer

Part B

What must the direction of the current I_2 be for the net field at point P to be zero?

- out of the page
- into the page

Part C

Then what is the magnitude of the net field at Q?

Express your answer with the appropriate units.

B = Value | Units

Submit | Request Answer

Part D

What is its direction?

- upward
- downward

Submit | Request Answer

Part E

Then what is the magnitude of the net field at S?

Express your answer with the appropriate units.

$B =$ *Value* *Units*

Submit Request Answer

Problem 28.63

A long, straight, solid cylinder, oriented with its axis in the *z*-direction, carries a current whose current density is $\vec{J}$. The current density, although symmetrical about the cylinder axis, is not constant and varies according to the relationship

$$\vec{J} = \left(\frac{b}{r}\right) e^{(r-a)/\delta}\hat{k} \quad \text{for } r \leq a$$

$$= 0 \quad \text{for } r \geq a$$

where the radius of the cylinder is $a = 5.00\ \text{cm}$, r is the radial distance from the cylinder axis, b is a constant equal to $600\ \text{A/m}$, and δ is a constant equal to $2.50\ \text{cm}$.

Review | Constants

Part A

Let I_0 be the total current passing through the entire cross section of the wire.

Express your answer in terms of the variables b, δ, and a.

$I_0 =$

Submit Request Answer

Part B

Evaluate your expression to obtain a numerical value for I_0.

Express your answer in amperes.

$I_0 =$ A

Part C

Using Ampere's law, derive an expression for the magnetic field $\vec{B}$ in the region $r \geq a$. Express your answer in terms of I_0

Express your answer in terms of the variables I_0, r, and magnetic constant μ_0.

$B =$

Submit Request Answer

Part D

Obtain an expression for the current I contained in a circular cross section of radius $r \leq a$ and centered at the cylinder axis.

Express your answer in terms of the variables I_0, r, δ, a, and magnetic constant μ_0.

$I =$

Part E

Using Ampere's law, derive an expression for the magnetic field $\vec{B}$ in the region $r \leq a$.

Express your answer in terms of the variables I_0, r, δ, a, and magnetic constant μ_0.

$$B = \frac{\mu_0 I_0}{2\pi r}\left(\frac{e^{\frac{r-a}{\delta}} - e^{-\frac{a}{\delta}}}{1 - e^{-\frac{a}{\delta}}}\right)$$

Submit | Previous Answers

✔ Correct

Part F

Evaluate the magnitude of the magnetic field at $r = \delta$.

Express your answer in teslas.

$B =$ [ ] T

Part G

Evaluate the magnitude of the magnetic field at $r = a$.

Express your answer in teslas.

$B =$ T

Submit | Previous Answers | Request Answer

✖ **Incorrect; Try Again**

Part H

Evaluate the magnitude of the magnetic field at $r = 2a$.

Express your answer in teslas.

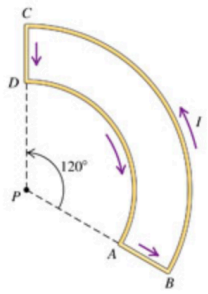
$B =$ T

Problem 28.64 - Enhanced - with Feedback

In the wire shown in (Figure 1) segment BC is an arc of a circle with radius 30.0 cm, and point P is at the center of curvature of the arc. Segment DA is an arc of a circle with radius 20.0 cm, and point P is at its center of curvature. Segments CD and AB are straight lines of length 10.0 cm each.

Figure

1 of 1



Review | Constants

Part A

Calculate the magnitude of the magnetic field at a point P due to a current 12.0 A in the wire.

Express your answer with the appropriate units.

$B =$ *Value* *Units*

Submit Request Answer

Part B

What is the direction of magnetic field?

- out of the page
- into the page

Submit Previous Answers

Correct

Problem 28.65

A long, straight wire with a circular cross section of radius R carries a current I. Assume that the current density is not constant across the cross section of the wire, but rather varies as $J = \alpha r$, where α is a constant.

Review | Constants

Part A

By the requirement that J integrated over the cross section of the wire gives the total current I, calculate the constant α in terms of I and R.

Express your answer in terms of the variables I and R.

$\alpha = \dfrac{3I}{2\pi R^3}$

Submit | Previous Answers

✔ Correct

Part B

Use Ampere's law to calculate the magnetic field $B(r)$ for $r \leq R$. Express your answers in terms of I.

Express your answer in terms of the variables I, R, r, and magnetic constant μ_0.

$B(r) =$

Submit | Request Answer

Part C

Use Ampere's law to calculate the magnetic field $B(r)$ for $r \geq R$. Express your answers in terms of I.

Express your answer in terms of the variables I, r, and magnetic constant μ_0.

$B(r) =$

Submit Request Answer

n 28.67

Complete

A long, straight, solid cylinder, oriented with its axis in the $z-$direction, carries a current whose current density is $\vec{J}$. The current density, although symmetrical about the cylinder axis, is not constant but varies according to the relationship

$$\vec{J} = \frac{2I_0}{\pi a^2}\left[1 - \left(\frac{r}{a}\right)^2\right]\hat{k} \quad \text{for } r \leq a$$
$$= 0 \quad \text{for } r \geq a$$

where a is the radius of the cylinder, r is the radial distance from the cylinder axis, and I_0 is a constant having units of amperes.

Review | Constants

Part A

Using Ampere's law, derive an expression for the magnitude of the magnetic field $\vec{B}$ in the region $r \geq a$.

Express your answer in terms of some or all of the variables I_0, a, r, and magnetic constant μ_0.

$B = \frac{\mu_0 I_0}{2\pi r}$

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Correct

Part B

Obtain an expression for the current I contained in a circular cross section of radius $r \leq a$ and centered at the cylinder axis.

Express your answer in terms of some or all of the variables I_0, a, r, and magnetic constant μ_0.

Part C

Using Ampere's law, derive an expression for the magnitude of the magnetic field $\vec{B}$ in the region $r \leq a$.

Express your answer in terms of some or all of the variables I_0, a, r, and magnetic constant μ_0.

Problem 28.75

A plasma is a gas of ionized (charged) particles. When plasma is in motion, magnetic effects "squeeze" its volume, inducing inward pressure known as a pinch. Consider a cylindrical tube of plasma with radius R and length L moving with velocity $\vec{v}$ along its axis. If there are n ions per unit volume and each ion has charge q, we can determine the pressure felt by the walls of the cylinder.

Review | Constants

Part A

What is the volume charge density ρ in terms of n and q?

$\rho =$

Submit Request Answer

Part B

The thickness of the cylinder "surface" is $n^{-1/3}$. What is the surface charge density σ in terms of n and q?

$\sigma =$

Submit Request Answer

Part C

The current density inside the cylinder is $\vec{J} = \rho\vec{v}$. Use this result along with Ampere's law to determine the magnetic field on the surface of the cylinder. Denote the circumferential unit vector as $\hat{\phi}$.

Express your answer in terms of the variables μ_0, n, q, v, and R.

$\vec{B}$ = $\hat{\phi}$

Submit Request Answer

Part D

The width of a differential strip of surface current is $R\,d\phi$. What is the differential current dI_{surface} that flows along this strip?

Express your answer in terms of the variables n, q, v, R, and $d\phi$.

dI =

Part E

What differential force is felt by this strip due to the magnetic field generated by the volume current?

Express your answer in terms of the variables μ_0, n, q, v, L, R, and $d\phi$.

$$dF = \frac{1}{2}\mu_0 n^{\frac{5}{3}} q^2 v^2 R^2 L d\phi$$

Submit | Previous Answers

✔ Correct

Part F

Integrate to determine the total force on the walls of the cylinder.

Express your answer in terms of the variables μ_0, n, q, v, L, and R.

$F =$

Submit | Request Answer

Part G

Divide the total force by the wall area to obtain the pressure.

Express your answer in terms of the variables μ_0, n, q, v, L, and R.

$p = \frac{1}{2}\mu_0 n^{\frac{5}{3}} q^2 v^2 R$

Submit Previous Answers

✔ **Correct**

Part H

If a plasma cylinder with radius 2.0 cm has a charge density of $8.0 \times 10^{16}\ \mathrm{ions/cm^3}$, where each ion has a charge of $e = 1.6 \times 10^{-19}\ \mathrm{C}$ and is moving axially with a speed of 20.0 $\mathrm{m/s}$, what is its pinch pressure?

Express your answer to two significant figures and include the appropriate units.

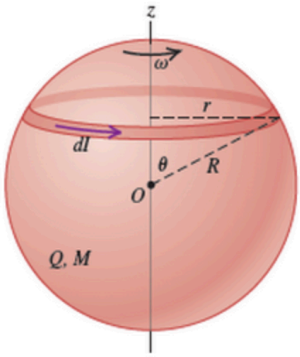
$p =$ *Value* *Units*

Challenge Problem 28.77

When a rigid charge distribution with charge Q and mass M rotates about an axis, its magnetic moment $\vec{\mu}$ is linearly proportional to its angular momentum $\vec{L}$, with $\vec{\mu} = \gamma\vec{L}$. The constant of proportionality γ is called the gyromagnetic ratio of the object. We can write $\gamma = g(Q/2M)$, where g is a dimensionless number called the g-factor of the object. Consider a spherical shell with mass M and uniformly distributed charge Q centered on the origin O and rotating about the z-axis with angular speed ω. (Figure 1)

Figure

1 of 2



Review | Constants

Part A

A thin slice with latitude θ measured with respect to the positive z-axis describes a current loop with width $R\,d\theta$ and radius $r = R\sin\theta$, as shown in (Figure 2). What is the differential current dI carried by this loop ?

Express your answer in terms of the variables Q, ω, R, θ, and $d\theta$, if needed.

$$dI = \frac{Q\omega\sin(\theta)d\theta}{4\pi}$$

Submit | Previous Answers

✔ Correct

Part B

The differential magnetic moment contributed by that slice is $d\mu = A\,dI$ where $A = \pi r^2$ is the area enclosed by the loop.

Express your answer in terms of the variables Q, ω, R, θ, and $d\theta$, if needed.

$$d\mu = \frac{1}{4}Q\omega R^2(\sin\theta)^3 d\theta$$

Submit | Previous Answers

Part C

Integrate over θ to determine the magnetic moment $\vec{\mu}$.

Express your answer in terms of the variables Q, ω, and R, if needed.

$\mu = \frac{1}{3}Q\omega R^2$

Submit Previous Answers

✔ Correct

Part D

What is the magnitude of the angular momentum $\vec{L}$?

Express your answer in terms of the variables Q, ω, R, and M, if needed.

Part E

Determine the gyromagnetic ratio γ.

Express your answer in terms of the variables Q, ω, R, and M, if needed.

$\gamma = \dfrac{Q}{2M}$

Submit Previous Answers

Correct

Part F

What is the g-factor for a spherical shell?

Express your answer as an integer.

Challenge Problem 28.80

Complete

A wide, long, insulating belt has a uniform positive charge per unit area σ on its upper surface. Rollers at each end move the belt to the right at a constant speed v.

Review | Constants

Part A

Calculate the magnitude of the magnetic field produced by the moving belt at a point just above its surface. (*Hint:* At points near the surface and far from its edges or ends, the moving belt can be considered to be an infinite current sheet.)

Express your answer in terms of the variables v, σ, and magnetic constant μ_0.

$B = \frac{1}{2}\mu_0 \sigma v$

Submit | Previous Answers

Correct

Part B

What is its direction?

- (•) out of the page
- ( ) into the page