Chapter 1

Test 1.1: Point Charge

The electric field **E** at a distance R from a *negative* electric charge:

(a) Decreases in magnitude as $1/R^2$ and points away from the charge.
(b) Decreases in magnitude as $1/R$ and points away from the charge.
(c) Decreases in magnitude as $1/R^2$ and points towards the charge.
(d) Decreases in magnitude as $1/R$ and points towards the charge.

Test 1.2: Electric Force

The electric force acting on a charge at a distance R from another charge of the same polarity:

(a) Is attractive and varies as $1/R$.
(b) Is repulsive and varies as $1/R^2$.
(c) Is repulsive and varies as $1/R$.
(d) Is attractive and varies as $1/R^2$.

Test 1.3: Steady Current

A steady current I:

(a) Induces an electric field, but not a magnetic field.
(b) Induces a magnetic field, but not an electric field.
(c) Induces neither an electric field nor a magnetic field.
(d) Induces both an electric field and a magnetic field.

Test 1.4: Electric and Magnetic Fields

Electric fields are induced by electric charges and magnetic fields are induced by electric currents. Only one of the following four statements is true. Which one?

(a) Electric and magnetic fields are always independent of one another because they are induced by different sources.
(b) Electric and magnetic fields are always coupled, even when electric charges are stationary.
(c) Electric and magnetic fields are always coupled, even when electric charges are moving at a constant velocity.

(d) Electric and magnetic fields are coupled under time-varying conditions.

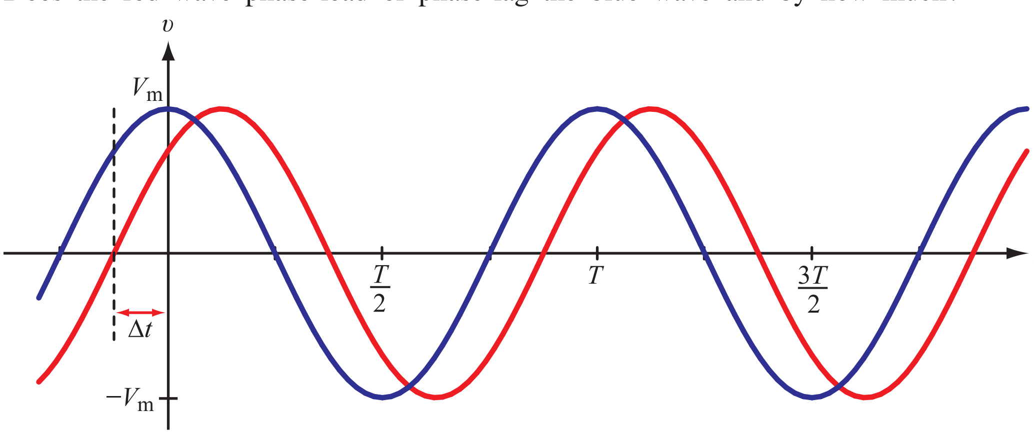
Test 1.5: Acoustic Wave

A 2.8 kHz acoustic wave travels in water at a speed of 1.4 km/s. What is the wave's wavelength?

(a) $\lambda = 0.1$ m
(b) $\lambda = 0.25$ m
(c) $\lambda = 0.5$ m
(d) $\lambda = 2$ m

Test 1.6: Lead/Lag

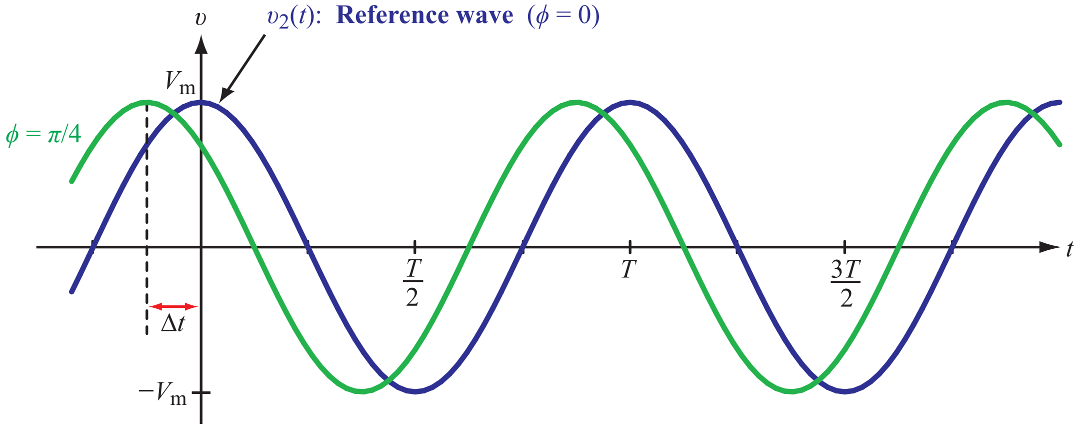
Does the red wave phase-lead or phase-lag the blue wave and by how much?



(a) Leads by 45°
(b) Leads by 90°
(c) Lags by 45°
(d) Lags by 90°

Test 1.7: Time Shift

If $\phi = \pi/4$ and $T = 16$ s, what is Δt?



(a) $\Delta t = 2$ s
(b) $\Delta t = 4$ s
(c) $\Delta t = 6$ s
(d) $\Delta t = 8$ s

Test 1.8: Traveling Wave

The height profile of a water wave created by a wave generator is given by

$$y(x) = 3e^{-0.4x}\cos(4\pi x) \text{ meters},$$

where $x = 0$ is the location of the generator. At what distance is the amplitude of the wave reduced to 0.6 m?

(a) 4 m
(b) 1.2 m
(c) 0.6 m
(d) 2 m

Test 1.9: Traveling Wave

The height profile of a water wave created by a wave generator is given by

$$y(x) = 4e^{-0.4x}\cos(4\pi x) \text{ meters},$$

where $x = 0$ is the location of the generator. At what distance is the amplitude of the wave reduced to 0.8 m?

(a) 4 m

(b) 1.2 m
(c) 0.6 m
(d) 2 m

Test 1.10: EM Spectrum

The visible part of the EM spectrum covers the wavelength range:

(a) 1–4 mm
(b) 0.4–4 μm
(c) 0.4–0.7 μm
(d) 0.1–0.4 μm

Test 1.11: Mobile Phone Bands

Most mobile-phone communication channels operate in:

(a) the VHF band
(b) the HF and VHF bands
(c) the UHF and SHF bands
(d) the EHF band

Test 1.12: Complex Numbers

Given that $\mathbf{V}_1 = 6 - j8$ and $\mathbf{V}_2 = 3 + j4$, what is $\mathbf{V}_1/\mathbf{V}_2$?

(a) $\mathbf{V}_1/\mathbf{V}_2 = 4\underline{/-53^\circ}$
(b) $\mathbf{V}_1/\mathbf{V}_2 = 4\underline{/53^\circ}$
(c) $\mathbf{V}_1/\mathbf{V}_2 = 2\underline{/106^\circ}$
(d) $\mathbf{V}_1/\mathbf{V}_2 = 2\underline{/-106^\circ}$

Test 1.13: Complex Numbers

Given that $\mathbf{V}_1 = 6 - j8$ and $\mathbf{V}_2 = 3 + j4$, what is $\mathbf{V}_1\mathbf{V}_2^*$?

(a) $\mathbf{V}_1\mathbf{V}_2^* = 50\underline{/0^\circ}$
(b) $\mathbf{V}_1\mathbf{V}_2^* = 25\underline{/0^\circ}$
(c) $\mathbf{V}_1\mathbf{V}_2^* = 50\underline{/-106^\circ}$
(d) $\mathbf{V}_1\mathbf{V}_2^* = 25\underline{/106^\circ}$

Test 1.14: Complex Numbers

Given that $\mathbf{V}_1 = 6 - j8$ and $\mathbf{V}_2 = 3 + j4$, what is $\mathbf{V}_1\mathbf{V}_2$?

(a) $\mathbf{V}_1\mathbf{V}_2 = 50\underline{/0^\circ}$
(b) $\mathbf{V}_1\mathbf{V}_2 = 25\underline{/0^\circ}$
(c) $\mathbf{V}_1\mathbf{V}_2 = 50\underline{/-106^\circ}$
(d) $\mathbf{V}_1\mathbf{V}_2 = 25\underline{/106^\circ}$

Test 1.15: Complex Algebra

Given $\mathbf{z} = 2\underline{/-0.5}$ rad, determine $\ln \mathbf{z}$.

(a) $\ln \mathbf{z} = -j0.345$
(b) $\ln \mathbf{z} = 0.69 - j0.5$
(c) $\ln \mathbf{z} = 2 - j1$
(d) $\ln \mathbf{z} = 0.69 - j2$

Test 1.16: Phasors

The phasor equivalent of the time function $\upsilon(t) = 10\sin(\omega t + 45^\circ)$ is:

(a) $\widetilde{V} = 10e^{-j45^\circ}$
(b) $\widetilde{V} = 10e^{j45^\circ}$
(c) $\widetilde{V} = 10e^{-j135^\circ}$
(d) $\widetilde{V} = 10e^{j135^\circ}$

Test 1.17: Phasors

The phasor equivalent of the time function $\upsilon(t) = -4\cos(\omega t - 30^\circ)$ is:

(a) $\widetilde{V} = 4e^{-j150^\circ}$
(b) $\widetilde{V} = 4e^{j150^\circ}$
(c) $\widetilde{V} = -4e^{j30^\circ}$
(d) $\widetilde{V} = -4e^{j150^\circ}$

Test 1.18: Phasors

For an ac voltage at an angular frequency ω, the instantaneous time function corresponding to the phasor $\widetilde{V} = -5e^{j30^\circ}$ is:

(a) $\upsilon(t) = 5\cos(\omega t + 150^\circ)$
(b) $\upsilon(t) = 5\cos(\omega t - 30^\circ)$

(c) $\upsilon(t) = 5\cos(\omega t - 150^\circ)$
(d) $\upsilon(t) = -5\cos(\omega t + 60^\circ)$

Test 1.19: Phasors

For an ac voltage at an angular frequency $\omega = 377$ rad/s, the instantaneous time function corresponding to the phasor $\widetilde{V} = 3e^{-j30^\circ}$ is:

(a) $\upsilon(t) = 3\cos(377t + 30^\circ)$
(b) $\upsilon(t) = 3\cos(377t + 150^\circ)$
(c) $\upsilon(t) = -3\cos(377t - 30^\circ)$
(d) $\upsilon(t) = -3\sin(377t - 120^\circ)$

Test 1.20: Traveling Wave

The height profile of a water wave created by a wave generator is given by

$$y(x) = 6e^{-0.2x}\cos(8\pi x) \text{ meters.}$$

What is the wavelength of the wave?

(a) $\lambda = 0.2$ m
(b) $\lambda = 0.25$ m
(c) $\lambda = 0.4$ m
(d) $\lambda = 4$ m

Chapter 3

Test 3.1: Commutative Vector Operations

For two vectors **A** and **B**, which one of the following statements is true?

(a) $\mathbf{A} \cdot \mathbf{B}$ is commutative, as is $\mathbf{A} \times \mathbf{B}$.
(b) $\mathbf{A} \cdot \mathbf{B}$ is commutative, but $\mathbf{A} \times \mathbf{B}$ is not.
(c) $\mathbf{A} \cdot \mathbf{B}$ is not commutative, but $\mathbf{A} \times \mathbf{B}$ is.
(d) Neither $\mathbf{A} \cdot \mathbf{B}$ nor $\mathbf{A} \times \mathbf{B}$ is commutative.

Test 3.2: Cross Product

For the vector operation $\mathbf{C} = \mathbf{A} \times \mathbf{B}$, which one of the following statements is true?

(a) The direction of **C** lies in the plane containing **A** and **B** and obeys the right-hand rule.
(b) The direction of **C** lies in the plane containing **A** and **B** and obeys the left-hand rule.
(c) The direction of **C** is orthogonal to the plane containing **A** and **B** and obeys the right-hand rule.
(d) The direction of **C** is orthogonal to the plane containing **A** and **B** and obeys the left-hand rule.

Test 3.3: Meaningful Products

Only one of the following four statements is a meaningful product. Which one?

(a) $\mathbf{A} \cdot (\mathbf{B} \cdot \mathbf{C})$
(b) $\mathbf{A} \times (\mathbf{B} \cdot \mathbf{C})$
(c) $\mathbf{A}(\mathbf{B} \times \mathbf{C})$
(d) $\mathbf{A}(\mathbf{B} \cdot \mathbf{C})$

Test 3.4: Differential Length

Of the following four definitions for the differential length $d\mathbf{l}$ in cylindrical coordinates, only one is correct. Which one?

(a) $d\mathbf{l} = \hat{\mathbf{r}}\, r\, dr + \hat{\boldsymbol{\phi}}\, r\, d\phi + \hat{\mathbf{z}}\, dz$
(b) $d\mathbf{l} = \hat{\mathbf{r}}\, dr + \hat{\boldsymbol{\phi}}\, d\phi + \hat{\mathbf{z}}\, dz$

(c) $d\mathbf{l} = \hat{\mathbf{r}}\,dr + \hat{\boldsymbol{\phi}}\,r\,d\phi + \hat{\mathbf{z}}\,dz$
(d) $d\mathbf{l} = \hat{\mathbf{r}}\,dr + \hat{\boldsymbol{\phi}}\,r\,d\phi + \hat{\mathbf{z}}\,r\,dz$

Test 3.5: Angle between Vectors

Given vectors $\mathbf{A} = \hat{\mathbf{x}}3 - \hat{\mathbf{z}}4$ and $\mathbf{B} = \hat{\mathbf{z}}2$, what is the angle θ_{AB} between them?

(a) $\theta_{AB} = 36.87^\circ$
(b) $\theta_{AB} = 143.13^\circ$
(c) $\theta_{AB} = -36.87^\circ$
(d) $\theta_{AB} = -143.13^\circ$

Test 3.6: Gradient and Curl Operators

Only one of the following four statements is valid. Which one?

(a) The gradient can operate on only scalar fields while the curl can operate on only vector fields.
(b) Both the gradient and the curl can operate on scalar fields.
(c) Both the gradient and the curl can operate on vector fields.
(d) The gradient can operate on only vector fields while the curl can operate on only scalar fields.

Test 3.7: Directional Derivative

For the scalar function $V = x^2y - 2z^2$, determine its directional derivative along the $\hat{\mathbf{z}}$ direction and then evaluate it at $P = (1, 2, 3)$.

(a) $\left(\frac{dV}{dl}\right)\Big|_{(1,2,3)} = 8$
(b) $\left(\frac{dV}{dl}\right)\Big|_{(1,2,3)} = -2$
(c) $\left(\frac{dV}{dl}\right)\Big|_{(1,2,3)} = 2$
(d) $\left(\frac{dV}{dl}\right)\Big|_{(1,2,3)} = -12$

Test 3.8: Directional Derivative

For the scalar function $V = 5e^{-2r}\sin\phi$, determine its directional derivative along the $\hat{\boldsymbol{\phi}}$ direction and then evaluate it at $P = (0.5, \pi/4, 2)$.

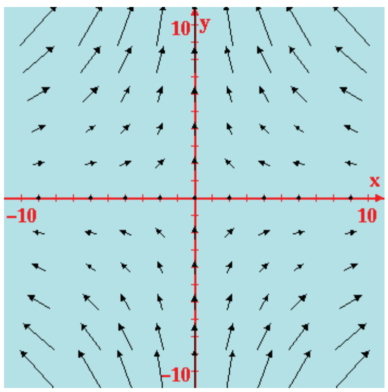
(a) $\left(\frac{dV}{dl}\right)\Big|_{(0.5,\pi/4,2)} = 2.6$
(b) $\left(\frac{dV}{dl}\right)\Big|_{(0.5,\pi/4,2)} = 1.3$

(c) $\left(\frac{dV}{dl}\right)\Big|_{(0.5,\pi/4,2)} = -2.6$

(d) $\left(\frac{dV}{dl}\right)\Big|_{(0.5,\pi/4,2)} = 0.3$

Test 3.9: Divergence

Given vector $\mathbf{A} = -\hat{\mathbf{x}}\,2xy + \hat{\mathbf{y}}\,2y^2$, determine the divergence $\nabla \cdot \mathbf{A}$ at $P = (1,2)$.



(a) $(\nabla \cdot \mathbf{A})|_{(1,2)} = 0$

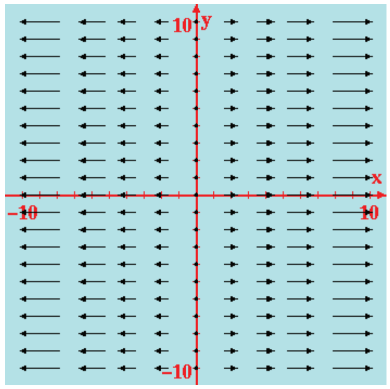
(b) $(\nabla \cdot \mathbf{A})|_{(1,2)} = 2$

(c) $(\nabla \cdot \mathbf{A})|_{(1,2)} = 4$

(d) $(\nabla \cdot \mathbf{A})|_{(1,2)} = -2$

Test 3.10: Flux Out of a Cube

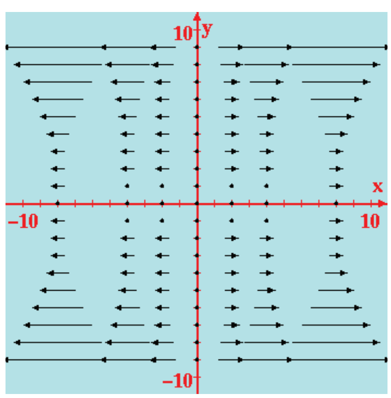
Given a vector field $\mathbf{A} = \hat{\mathbf{x}}\,x$, determine the amount of flux flowing out of a cube centered at the origin with its sides extending between -10 and $+10$ along x, y, and z.



(a) $\oint_S \mathbf{A} \cdot d\mathbf{s} = -2000$
(b) $\oint_S \mathbf{A} \cdot d\mathbf{s} = 0$
(c) $\oint_S \mathbf{A} \cdot d\mathbf{s} = 4000$
(d) $\oint_S \mathbf{A} \cdot d\mathbf{s} = 8000$

Test 3.11: Flux Out of a Cube

Given a vector field $\mathbf{A} = \hat{\mathbf{x}}\, xy^2$, determine the amount of flux flowing out of a cube centered at the origin with its sides extending between -10 and $+10$ along x, y, and z.



(a) $\oint \mathbf{A} \cdot d\mathbf{s} = -2000$
(b) $\oint \mathbf{A} \cdot d\mathbf{s} = \frac{8}{3} \times 10^5$
(c) $\oint \mathbf{A} \cdot d\mathbf{s} = \frac{4}{3} \times 10^5$
(d) $\oint \mathbf{A} \cdot d\mathbf{s} = -2000$

Test 3.12: Conservation Vector

A vector field $\mathbf{A}$ is aisd to be conservative if:

(a) $\nabla \cdot \mathbf{A} = 0$
(b) $\nabla \times \mathbf{A} = 0$
(c) $\nabla \cdot \mathbf{A} = 0$ and $\nabla \times \mathbf{A} = 0$
(d) None of the above

Test 3.13: Divergence

At a given point is space, the divergence of a vector field $\mathbf{E}$ is negative; that is, $\nabla \cdot \mathbf{E} < 0$. This means that the small volume surrounding that point in space is equivalent to:

(a) A sink of field lines.
(b) A source of field lines.
(c) Neither a sink nor a source.
(d) A sink or a source.

Test 3.14: Divergence Theorem

For a vector field $\mathbf{A}$ defined over a volume υ bounded by a surface S, the divergence theorem is given by:

(a) $\displaystyle\int_\upsilon \nabla \cdot \mathbf{A}\, d\upsilon = \oint_S (\nabla \times \mathbf{A}) \cdot d\mathbf{s}$
(b) $\displaystyle\oint_S \mathbf{A} \cdot\, d\mathbf{s} = \oint_\upsilon |\mathbf{A}|\, d\upsilon$
(c) $\displaystyle\int_\upsilon \nabla \cdot \mathbf{A}\, d\upsilon = \oint_S \mathbf{A} \cdot d\mathbf{s}$
(d) $\displaystyle\int_S (\nabla \times \mathbf{A}) \cdot d\mathbf{s} = \int |\mathbf{A}|\, d\upsilon$

Test 3.15: Stokes's Theorem

For a vector field $\mathbf{B}$ defined over a surface S bounded by a contour C, Stokes's theorem states:

(a) $\displaystyle\int_S \mathbf{B} \cdot d\mathbf{s} = \oint_C \mathbf{B} \cdot d\boldsymbol{\ell}$
(b) $\displaystyle\int_S \nabla \cdot\, d\mathbf{s} = \oint_C \mathbf{B}\, d\boldsymbol{\ell}$
(c) $\displaystyle\int_S \mathbf{B} \cdot d\mathbf{s} = \oint_C (\nabla \times \mathbf{B}) \cdot d\boldsymbol{\ell}$

(d) $\int_S (\nabla \times \mathbf{B}) \cdot d\mathbf{s} = \oint_C \mathbf{B} \cdot d\boldsymbol{\ell}$

Test 3.16: Divergence

Compute the divergence of the vector field

$$\mathbf{A} = \hat{\mathbf{x}} x^2 y - \hat{\mathbf{y}} x y^2.$$

(a) $\nabla \cdot \mathbf{A} = 2xy$
(b) $\nabla \cdot \mathbf{A} = 4xy$
(c) $\nabla \cdot \mathbf{A} = 0$
(d) $\nabla \cdot \mathbf{A} = x^2 - y^2$

Test 3.17: Divergence

Compute the divergence of the vector field.

$$\mathbf{A} = \hat{\mathbf{r}} \frac{\cos\phi}{r^2} + \hat{\boldsymbol{\phi}} \frac{\sin\phi}{r^2}.$$

(a) $\nabla \cdot \mathbf{A} = 0$
(b) $\nabla \cdot \mathbf{A} = \frac{2\cos\phi}{r^2}$
(c) $\nabla \cdot \mathbf{A} = -\frac{2\cos\phi}{r^2}$
(d) $\nabla \cdot \mathbf{A} = \frac{2\cos\phi}{r^3}$

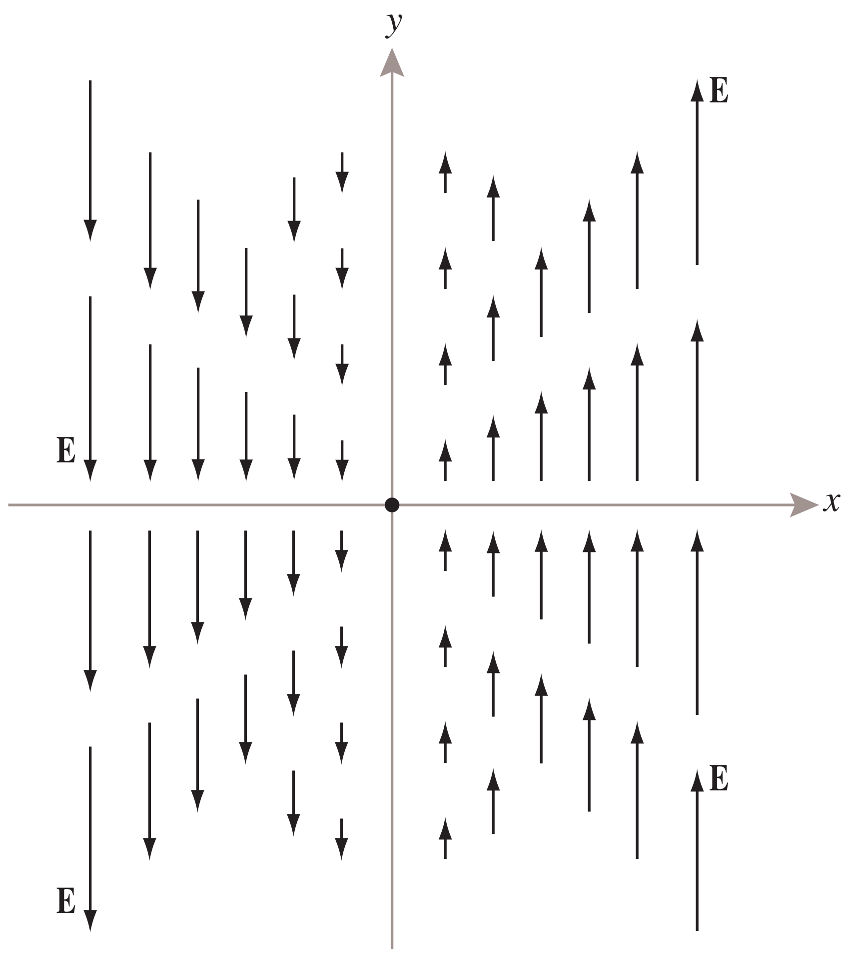
Test 3.18: Laplacian

Compute the Laplacian of the scalar function

$$V = x^2 y + y^2 z + y^2 x.$$

(a) $\nabla^2 V = 0$
(b) $\nabla^2 V = x + z$
(c) $\nabla^2 V = y + z$
(d) $\nabla^2 V = 2(x + y + z)$

Test 3.19: Arrow Representation



The arrow representation shown in the figure corresponds to the function:

(a) $\mathbf{E} = \hat{\mathbf{x}}y$
(b) $\mathbf{E} = \hat{\mathbf{y}}x$
(c) $\mathbf{E} = -\hat{\mathbf{x}}y$
(d) $\mathbf{E} = -\hat{\mathbf{y}}x$

Test 4.1: Static Conditions

In electromagnetics, under "static conditions" means that **E** and **H** in a given region of space do not vary with time, which is due to:

(a) all electrons being stationary (not moving).
(b) the charge density ρ_v within every elemental volume $\Delta\upsilon$ is constant with time and the current density **J** crossing the surface of $\Delta\upsilon$ is zero.
(c) both ρ_v and **J** are constant with time.
(d) $\rho_v = 0$ and $\mathbf{J} = 0$.

Test 4.2: Static and Dynamic Conditions

When computing electric and magnetic fields in a given region of space, under what circumstances do we have to consider both fields simultaneously?

(a) Never; we always should be able to compute **E** independently of **H**, and vice versa.
(b) We have to consider **E** and **H** simultaneously if they point in the same direction.
(c) Under static conditions.
(d) Under dynamic conditions.

Test 4.3: Electric Charge

Consider 2 circular disks of electric charge:

Disk 1: $\rho_{s_1} = \rho_0 r$ (linear variation with r)

Disk 2: $\rho_{s_2} = \rho_0 r^2$ (quadratic variation with r)

Both disks have a radius of 1 m and $\rho_0 =$ constant. What is the ratio of the total amount of charge Q_1 on disk 1 to Q_2 on disk 2?

(a) $\frac{3}{4}$
(b) $\frac{4}{3}$
(c) 2
(d) $\frac{1}{2}$

Test 4.4: Electric Charge

Consider 2 circular disks of electric charge:

Disk 1: $\rho_{s_1} = \rho_0 r$ with radius $a_1 = 1$ m

Disk 2: $\rho_{s_2} = \rho_0 r^2$ with radius $a_2 =$ unknown.

Here, $\rho_0 =$ constant. What should the value of a_2 be so that the two disks have the same amount of total charge?

(a) $a_2 = 1.075$
(b) $a_2 = 0.75$
(c) $a_2 = 0.79$
(d) $a_2 = 1.33$

Test 4.5: Electric Charge

Find the total charge contained in a cylindrical volume defined by $r \leq 3$ m and $0 \leq z \leq 2$ m if $\rho_v = 20rz$ (mC/m^3).

(a) $Q = 0.4$ Coulomb
(b) $Q = 0.8$ Coulomb
(c) $Q = 1.13$ Coulomb
(d) $Q = 2.26$ Coulomb

Test 4.6: Electric Charge

If the line charge density is given by $\rho_l = 12y^2$ (mC/m), find the total charge distributed on the y axis from $y = -5$ to $y = 5$.

(a) $Q = 4$ C
(b) $Q = 1$ C
(c) $Q = 0.2$ C
(d) $Q = 2$ C

Test 4.7: Electric Charge

The charge density across the surface of a circular disk is given by

$$\rho_s = 2e^{-r} \text{ (C/m)},$$

where r is the radial distance from the center of the disk. The disk radius is 3 m. What is the total charge on the disk?

(a) $Q = 5.03$ C

(b) $Q = 10.06$ C
(c) $Q = 22.32$ C
(d) $Q = 0.51$ C

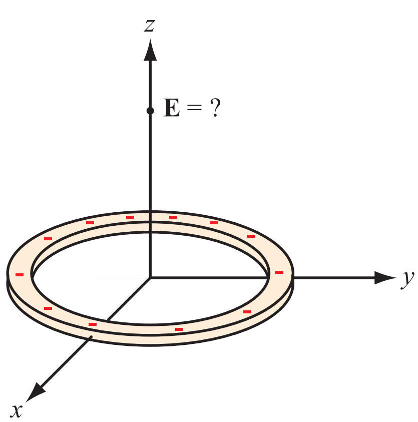
Test 4.8: Electric Current

If the current density is given by $\mathbf{J} = \hat{\mathbf{z}}3xz$, what is the total current flowing through a square with corners at $(0,0,0)$, $(2,0,0)$, $(2,0,2)$, and $(0,0,2)$?

(a) $I = 0$
(b) $I = 4$ A
(c) $I = 2$ A
(d) $I = 16$ A

Test 4.9: Electric Field

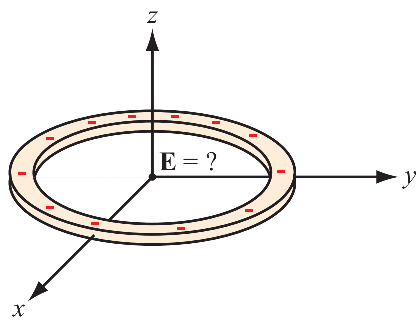
The ring of charge shown in the figure is situated in the x–y plane and carries a uniform line charge density $\rho_\ell = -2$ (C/m). What is the direction of the induced electric field at a point along the upper part of the z axis?



(a) $\mathbf{E} = 0$ everywhere along z axis.
(b) $\mathbf{E}$ direction is undefined.
(c) $\mathbf{E}$ direction along $-\hat{\mathbf{z}}$.
(d) $\mathbf{E}$ direction along $+\hat{\mathbf{z}}$.

Test 4.10: Electric Field

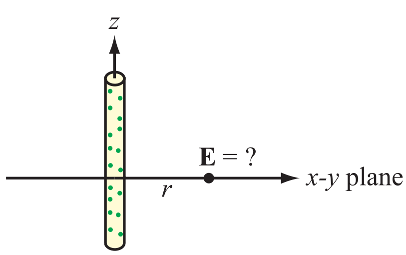
The ring of charge shown in the figure is situated in the x–y plane and carries a uniform line charge density $\rho_\ell = -2$ (C/m). What is the direction of $\mathbf{E}$ at the origin?



(a) Along $-\hat{\mathbf{z}}$
(b) Irrelevant, because $\mathbf{E} = 0$ at the origin
(c) Along $+\hat{\mathbf{z}}$
(d) Along $\hat{\mathbf{r}}$, the radial direction away from the origin.

Test 4.11: Electric Field

For a very long wire coincident with the z axis and containing electrons, what is the direction of $\mathbf{E}$ at a distance r from the wire?



(a) Along $\hat{\mathbf{r}}$
(b) Along $+\hat{\mathbf{z}}$
(c) Along $-\hat{\mathbf{z}}$
(d) Along $-\hat{\mathbf{r}}$

Test 4.12: Electric Potential

Only one of the following four statements is totally correct. Which one?

(a) *Electric potential difference* and *voltage difference* are fundamentally the same quantity.
(b) Electric potential difference applies to charges, whereas voltage applies to circuits, so they are totally different.
(c) Electric potential difference becomes equivalent to voltage, but only if the charges are stationary.
(d) None of the above three statements is correct.

Test 4.13: Electric Flux Density

In a given region of space, the electric flux density is given by $\mathbf{D} = \hat{\mathbf{x}}xz^2$. What is the corresponding volume charge density at $(0,0,2)$?

(a) $\rho_{\rm v} = 0$
(b) $\rho_{\rm v} = -2$ (C/m^3)
(c) $\rho_{\rm v} = 4$ (C/m^3)
(d) $\rho_{\rm v} = 6$ (C/m^3)

Test 4.14: Electric Flux Density

The electric flux density inside a dielectric sphere of radius $a = 2$ m and centered at the origin is given by

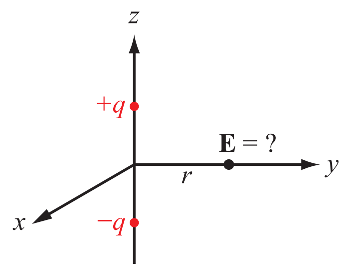
$$\mathbf{D} = \hat{\mathbf{R}}5R^2 \quad (\text{C/m}^2).$$

What is the volume charge density at $r = a$?

(a) $\rho_{\rm v} = 150$ (C/m^3)
(b) $\rho_{\rm v} = 40$ (C/m^3)
(c) $\rho_{\rm v} = 15$ (C/m^3)
(d) $\rho_{\rm v} = 60$ (C/m^3)

Test 4.15: Electric Field

For the electric dipole shown in the figure, what is the direction of $\mathbf{E}$ at a distance r from the midpoint of the dipole?



(a) Along $+\hat{\mathbf{z}}$
(b) Along $\hat{\mathbf{y}}$
(c) Along $-\hat{\mathbf{z}}$
(d) Along $\hat{\mathbf{x}}$

Test 4.16: Electrical Conductivity

Copper is a good conductor and mica is a good insulator. The conductivity of copper relative to that of mica is on the order of:

(a) 10^{23}
(b) 10^{6}
(c) 100
(d) 10

Test 4.17: Piezoresistor

How does a *piezoresistor* function as a sensor?

(a) It is used to measure temperature.
(b) Its resistance depends on the current flowing through it.
(c) It functions like a fuse.
(d) Its resistance changes if it gets stretched or compressed.

Test 4.18: Voltage Breakdown

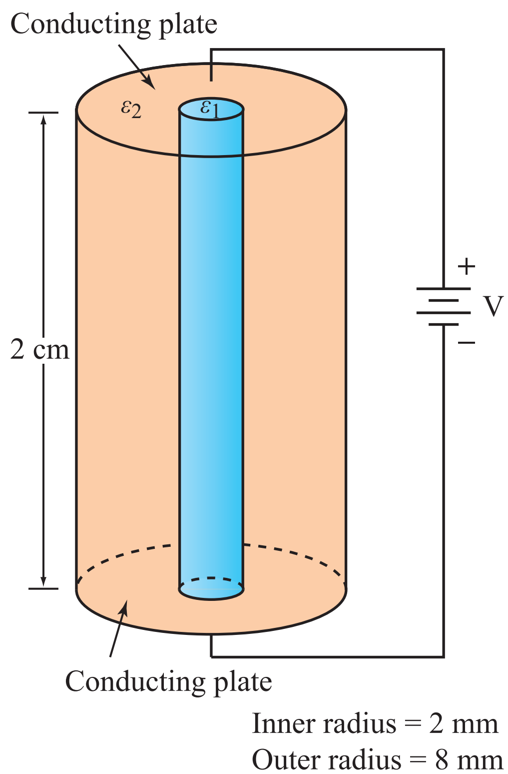
The dielectric strength of air is around 3 MV/m. When cloud-to-ground lightening occurs between a cloud whose base is 600 m above the ground, the corresponding breakdown voltage between the cloud and the ground is

(a) $V = 5$ kV
(b) $V = 1.8$ GV

(c) 2 kV
(d) 30 kV

Test 4.19: Capacitance

The structure shown in the figure consists of two concentric cylindrical shells, with the inner cylinder composed of a dielectric material with $\varepsilon_1 = 8\varepsilon_0$ and surrounded by a material with $\varepsilon_2 = 2\varepsilon_0$. The structure has conducting plates covering the top and bottom ends. What is the capacitance of the structure?



(a) $C = 12\varepsilon_0$ mF
(b) $C = 24\pi\varepsilon_0$ mF
(c) $C = 7.2\varepsilon_0$ mF
(d) $C = 7.6\pi\varepsilon_0$ mF

Test 4.20: Supercapacitor

Select the only totally correct statement.

(a) A supercapacitor can store more energy per unit weight than a traditional capacitor, but its charge and discharge rates are slower.
(b) A supercapacitor has faster charge and discharge rates than a traditional capacitor.
(c) A supercapacitor has the same charge and discharge rates as a traditional capacitor, but it can store more energy per unit weight.
(d) A supercapacitor can store more energy per unit weight than a traditional capacitor and also has faster charge and discharge rates.

Test 4.21: Supercapacitor

Select the only totally correct statement.

(a) A supercapacitor can charge and discharge faster than a battery as well as store more energy.
(b) A supercapacitor can charge and discharge faster than a battery but it can store only a fraction of the energy that an equal-weight battery can.
(c) A supercapacitor can store more energy per unit weight than a battery, but its charge and discharge rates are slower.
(d) A supercapacitor cannot charge and discharge as fast as a battery nor store as much energy as an equal-weight battery can.

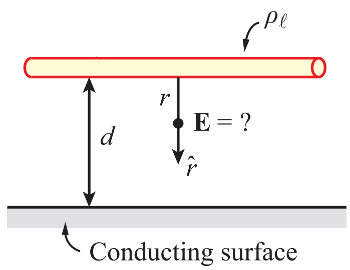
Test 4.22: Humidity Sensor

A capacitive sensor measures the change in voltage in an ac bridge circuit due to a change in the capacitance. In a capacitive humidity sensor, the change in capacitance is due to:

(a) change in conductivity of the electrodes due to humidity.
(b) change in separation between electrodes as the substrate expands because of humidity.
(c) change in the permittivity of the substrate as a function of humidity.
(d) change in the conductivity of the substrate as a function of humidity.

Test 4.23: Image Method

Consider the infinitely long line of charge, with charge density ρ_ℓ, positioned parallel to a perfectly conducting flat surface at a distance d. Using the result of Example 4-6 and the image method, obtain an expression for the electric field $\mathbf{E}$ at a distance r from the line of charge.



(a) $\mathbf{E}\dfrac{\hat{\mathbf{r}}\rho_\ell}{\pi\varepsilon_0 r}$

(b) $\mathbf{E}\dfrac{\hat{\mathbf{r}}\rho_\ell}{2\pi\varepsilon_0}\left[\dfrac{1}{r} - \dfrac{1}{2d-r}\right]$

(c) $\mathbf{E}\dfrac{\hat{\mathbf{r}}\rho_\ell}{2\pi\varepsilon_0}\left[\dfrac{1}{r} + \dfrac{1}{2d-r}\right]$

(d) $\mathbf{E}\dfrac{\hat{\mathbf{r}}2\rho_\ell}{\pi\varepsilon_0 r}$

Test 4.24: Electrical Energy

A micro–parallel-plate capacitor has square plates, each at 2 cm on the side, and separated by 1 mm. The material between the plates is mica with a permittivity $\varepsilon = 6\varepsilon_0$ and a dielectric strength of 200 MV/m. What is the maximum amount of electrical energy that can be stored in the capacitor before dielectric breakdown occurs?

(a) $W_e = 2.25$ J
(b) $W_e = 2.25$ nJ
(c) $W_e = 4.25\ \mu$J
(d) $W_e = 0.425$ J