Calculus Needed for AP Physics C
Electricity and Magnetism

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Correlated to 2024 CED

Unit	Skill	Equations	CED ref.
Unit 8 Electric Charges, Fields, and Gauss's Law	Integrate to find electric field of • an infinite wire or cylinder at a distance from central axis • thin ring along the axis, an arc or semicircle at its center • a finite wire or line charge at a point collinear or along its perpendicular bisector	$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r^2}\hat{r}$	p. 35 8.4.A.1
Unit 8 Electric Charges, Fields, and Gauss's Law	calculate electric flux by integration	$\Phi_E = \int \vec{E} \cdot d\vec{A}$	p. 36 8.5.A.3
Unit 8 Electric Charges, Fields, and Gauss's Law	work with Gauss's Law for spherical, cylindrical, planar symmetries	$\Phi_E = \frac{q_{enc}}{\varepsilon_0}$ $\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$ $Q_{total} = \int \rho(\vec{r})dV$	p. 37 8.6.A.1-8.6.A.5
Unit 8 Electric Charges, Fields, and Gauss's Law	qualitatively apply Maxwell's first equation	$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$	p. 38 8.6.A.6
Unit 9 Electric Potential	use calculus to find electric potential by integration of • infinite wire or cylinder at distance from central axis • thin ring along the axis • an arc at the center • a finite wire or line charge at collinear point or along perpendicular bisector	$V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r}$	p. 45 9.2.A.2
Unit 9 Electric Potential	relate electric field to the spatial rate of change of the electric potential	$\Delta V = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{r}$ $E_x = -\frac{dV}{dx}$	p. 46 9.2.B.1 9.2.B.2

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Unit 10 **Conductors and Capacitors**	apply Gauss's Law to calculate the electric field inside a capacitor: • parallel-plate • spherical • cylindrical	$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$ $E = \frac{Q}{\varepsilon_0 A}$	p. 59 10.3.A.3.i-ii
Unit 11 **Electric Circuits**	apply calculus definition of current	$I = \frac{dQ}{dt}$ $I = \int \vec{J} \cdot d\vec{A}$ Derived equation: $I_{tot} = \int \vec{J}(r) \cdot d\vec{A}$	p. 67-68 11.1.A.1 11.1.A.2 11.1.A.3
Unit 11 **Electric Circuits**	integrate to find the resistance of a resistor whose resistivity varies	$R = \int \frac{\rho(\ell) d\ell}{A}.$	p. 71 11.3.A.2.iii
Unit 11 **Electric Circuits**	derive expressions for RC circuits, work with functions or graphs for RC circuits	Derived equation: $\mathcal{E} = \frac{dq}{dt} R + \frac{q}{C}$ $\tau = R_{eq} C_{eq}.$	p. 80 11.8.B.1 11.8.B.2.i-iii 11.8.B.3-i-vii
Unit 12 **Magnetic Fields and Electromagnetism**	recognize that Maxwell's second equation "Gauss's law for magnetism" implies no net flux from a magnetic field through a closed surface	$\oint \vec{B} \cdot d\vec{A} = 0$	p. 88 12.1.A.3.i
Unit 12 **Magnetic Fields and Electromagnetism**	work with the Biot-Savart Law, straight current segments and circular loops	$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I(d\vec{\ell} \times \vec{r})}{r^2}$ Derived equation: $B_{\text{center of loop}} = \frac{\mu_0 I}{2R}$	p. 93 12.3.A.1 12.3.A.3
Unit 12 **Magnetic Fields and Electromagnetism**	work with the calculus definition of magnetic force	$\vec{F}_M = \int I(d\vec{\ell} \times \vec{B})$	p. 94 12.3.B.1
Unit 12 **Magnetic Fields and Electromagnetism**	work with Ampere's Law (Maxwell's third equation) for long straight wires, slabs, solenoids, cylindrical conductors	$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$ Derived equation: $B_{wire} = \frac{\mu_0}{2\pi} \frac{I}{r}$ Derived equation: $B_{sol} = \mu_0 n I$	p. 95 12.4.A.1-3
Unit 12 **Magnetic Fields and Electromagnetism**	apply the idea that a changing electric field creates a magnetic field; Maxwell's fourth equation (qualitative only)	$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$	p. 96 12.4.A.4
Unit 13 **Electromagnetic Induction**	work with magnetic flux	$\Phi_B = \int \vec{B} \cdot d\vec{A}$	p. 103 13.1.A.2

Unit	Skill	Equations	CED ref.
Unit 13 Electromagnetic Induction	apply Faraday's Law as a differential equation	$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d(\vec{B}\cdot\vec{A})}{dt}$	p. 104 13.2.A.1
Unit 13 Electromagnetic Induction	apply a conceptual understanding of Maxwell's equations and their relationship to electromagnetic waves	$\mathcal{E} = \oint \vec{E} \bullet d\vec{\ell} = -\frac{d\Phi_B}{dt}$ $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$	p.105 13.2.A.3 13.2.A.4
Unit 13 Electromagnetic Induction	integrate to find the force exerted by an external magnetic field on the induced moving charges in a conductive loop	$\vec{F}_B = \int I\left(d\vec{\ell} \times \vec{B}\right)$	p. 106 13.3.A.1
Unit 13 Electromagnetic Induction	relate induced emf to inductance and the rate of change of current	$\varepsilon_i = -L\frac{dI}{dt}$	p. 108 13.4.A.3
Unit 13 Electromagnetic Induction	apply Kirchhoff's laws with a 1st order differential equation that describes the potential in an LR circuit, integrate to solve	*Derived equation:* $\mathcal{E} = IR + L\frac{dI}{dt}$ $\tau = \frac{L}{R_{eq}}$	p.109 13.5.A.2, 13.5.A.3.i-iii
Unit 13 Electromagnetic Induction	apply Kirchhoff's laws with a 2nd order differential equation that describes the current in an LC circuit, deduce the solution from the differential equation (do not solve)	*Derived equation:* $\frac{d^2q}{dt^2} = -\frac{1}{LC}q$ *Derived equation:* $\omega = \frac{1}{\sqrt{LC}}$	13.6.A.2 13.6.A.3