Flipping Physics Lecture Notes:
Continuous Charge Distributions
http://www.flippingphysics.com/continuous-charge-distributions.html

Continuous Charge Distribution: A charge that is not a point charge. In other words, a charge which has shape and continuous charge distributed throughout the object.

In order to find the electric field which exists around a continuous charge distribution, we can use Coulomb's Law and the equation definition of an electric field. We consider the charged object to be made up of an infinite number of infinitesimally small point charges dq and add up the infinite number of electric fields via superposition. It's an integral.

$$\vec{F}_e = k\frac{(q_1)(q_2)}{r^2}\hat{r} \;\;\&\;\; \vec{E} = \frac{\vec{F}_e}{q} \Rightarrow \vec{E}_{\text{point charge}} = k\frac{\frac{(q)(Q)}{r^2}}{q}\hat{r} = \frac{kQ}{r^2}\hat{r}$$

$$\Rightarrow d\vec{E} = \frac{k\,(\mathrm{d}q)}{r^2}\hat{r} \Rightarrow \int d\vec{E} = \int \frac{k\,(\mathrm{d}q)}{r^2}\hat{r} \Rightarrow \vec{E}_{\text{continuous charge distribution}} = k\int \frac{\mathrm{d}q}{r^2}\hat{r}$$

Realize that, for AP Physics C: Electricity and Magnetism, students are only expected to be able to use this equation to determine electric fields around continuous charge distributions with high symmetry. The specific examples students are responsible for are:

- An infinitely long, uniformly charged wire or cylinder at a distance from its central axis
- A thin ring of charge at a location along the axis of the ring
- A semicircular arc or part of a semicircular arc at its center
- A finite wire or line of charges at a distance that is collinear with the line of charge or at a location along its perpendicular bisector.

Quick review of charge densities:

linear charge density, $\lambda = \frac{Q}{L}$ in $\frac{C}{m}$ & surface charge density, $\sigma = \frac{Q}{A}$ in $\frac{C}{m^2}$

& volumetric charge density, $\rho = \frac{Q}{V}$ in $\frac{C}{m^3}$