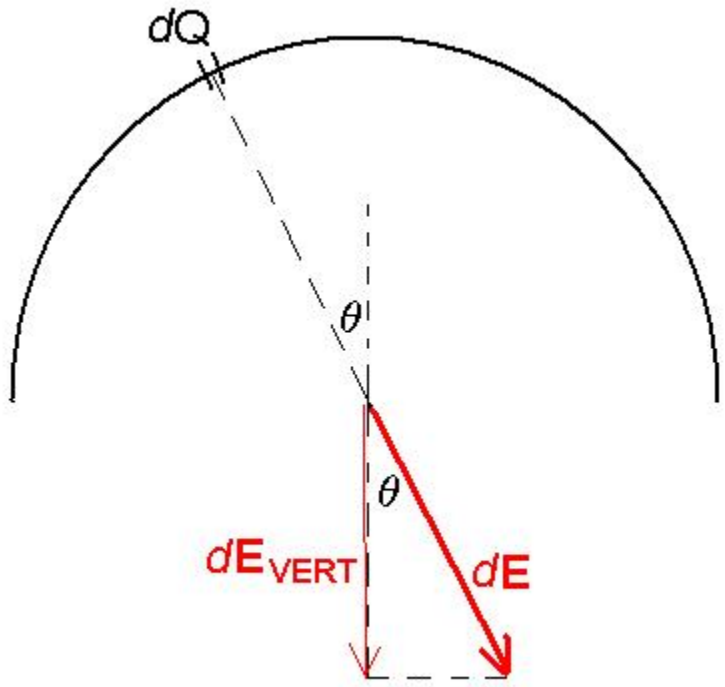
1–4)

Consider a small charge $dQ$ that we can treat as a point charge. The field contribution at Point P will be
$dE = k_e\, dQ\, R^{-2}$.




Now, there will be another small charge located symmetrically from this one whose E contribution will cancel in the horizontal direction, but will add in the vertical direction. So, we will only worry about the vertical component of the field $dE$ from $dQ$:
$dE_{VERT} = k_e\, dQ\, R^{-2}\cos\theta$

We have to integrate to add up all of the contributions, but we have two variables here. We need to clean it up first.

The charge $dQ$ subtends a small angle $d\theta$. Since the charge is evenly distributed along the arc, we can make a proportion:

$$dQ/Q = d\theta/\pi\ .$$

$dQ = Q\, d\theta\, /\pi$.

Let's substitute and do it:

$$E_{VERT} = \int \frac{k_e \cos\theta\, dQ}{R^2} = \int \frac{k_e \cos\theta Q\, d\theta}{R^2 \pi} =$$

$$\frac{k_e Q}{R^2 \pi} \int_{-\pi/2}^{+\pi/2} cos\theta \; d\theta = \frac{k_e Q}{R^2 \pi} sin\theta \Big|_{-\pi/2}^{+\pi/2} = \frac{k_e Q}{R^2 \pi} (1 - {}^{-}1) \; = \; \frac{2k_e Q}{R^2 \pi}$$