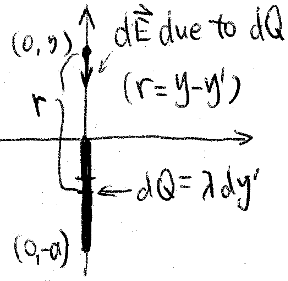
Yellow

5. (15 pts) A negative charge ($Q < 0$) is uniformly distributed from $(0, -a)$ to the origin $(0, 0)$. Compute E_y at $(0, y)$ for $y > 0$.



$|d\vec{E}| = \frac{k\,dQ}{r^2} = \frac{k\lambda\,dy'}{r^2}$

Use $dr = d(y - y') = 0 - dy' = -dy'$.

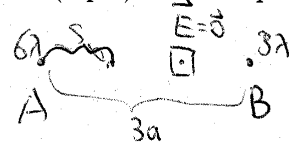
Then $|d\vec{E}| = \frac{k\lambda(-dr)}{r^2}$ ← [Sign OK since $dr < 0$ on going from $y' = -a$ to $y' = 0$]

$dE_y = -|d\vec{E}| = \frac{k\lambda dr}{r^2}$

$$E_y = +k\lambda\int_{y+a}^{y}\frac{dr}{r^2} = -k\lambda\int_{y}^{y+a}\frac{dr}{r^2} = -k\lambda\left(\frac{1}{y} - \frac{1}{y+a}\right).$$

6. Two uniform line charges are normal to the page. A, with charge density 6λ, passes through the origin. To its right, B, with charge density 3λ, passes through $(3a, 0)$.

a. (8 pts) Find the position $(s, 0)$ where the electric field is zero.



At $(s, 0)$. $|\vec{E}_A| = |\vec{E}_B|$. so

$\frac{2k(6\lambda)}{s} = \frac{2k(3\lambda)}{3a - s}$, so $2(3a - s) = s$,

or $6a = 3s$. so $\boxed{s = 2a}$

b. (7 pts) If λ is represented by two field lines, find the angle between the field lines near A; near B; as viewed from far away from both A and B.

For A alone, $6\lambda \times 2 = 12$ lines. so $\frac{360°}{12} = 30°$.

For B alone, $3\lambda \times 2 = 6$ lines. $\frac{360°}{6} = 60°$.

For combination, $12 + 6 = 18$ lines. $\frac{360°}{18} = 20°$.

c. (10 pts) Sketch the field lines for this geometry. Take one field line from A to go directly to the left, and take one field line from B to go directly to the right.