1. Simply take an amount of charge -Q off of one sphere and add it to the other; leaving the first sphere with a net charge of +Q. Then solve for the Q necessary to produce the indicated force: 
\[ Q = \sqrt{\frac{F \cdot e^2}{k}} = \sqrt{\frac{(1 \times 10^3 N)(1m)^2}{(9 \times 10^9 Nm^2C^{-2})}} \]
\[ \approx 3.3 \times 10^{-4} C. \] Finally, divide the charge by the charge per electron to obtain the number of electrons: 
\[ N = \frac{Q}{e} = 3.3 \times 10^{-4} C/(1.6 \times 10^{-19} C/e) = 2.1 \times 10^5 \text{ e's}. \]

2. Let \( d \) be the distance between the +3q and the +q charges and let \( x \) be the distance from the +3q charge to the bead at its equilibrium point (i.e. zero electric field). Then \( d-x \) is the distance from the bead to the +q charge.

At equilibrium we have \( \frac{3q}{x^2} - \frac{q}{(d-x)^2} = 0 \) or \( \frac{\sqrt{3}}{x} = \frac{1}{d-x} \). Solving for \( x \) gives
\[ x = \frac{\sqrt{3}}{1+\sqrt{3}} d. \]

3. a) By symmetry, guess that the point of zero electric field is the center of the triangle. Check: with the base charges at \((0,0)\) and \((a,0)\), the location of the charge at the top of the triangle is \((a \cos \frac{\pi}{3}, a \sin \frac{\pi}{3}) = \left( \frac{a}{2}, \frac{a\sqrt{3}}{2} \right) \). Let \( d \) be the distance of the triangle center from a corner. The location of the triangle center is then \((d \cos \frac{\pi}{6}, d \sin \frac{\pi}{6}) = \left( \frac{d\sqrt{3}}{2}, \frac{d}{2} \right) \). But \( \frac{d\sqrt{3}}{2} = \frac{a}{2} \) since the center is equidistant from the corners, so \( d = \frac{a}{\sqrt{3}} \). In terms of \( a \), the location of the triangle center is \( \left( \frac{a}{2}, \frac{a}{2\sqrt{3}} \right) \). The electric field is \( \vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 \)
\[ = \left( \frac{kQ}{a^2} \cos \frac{\pi}{6}, \frac{kQ}{a^2} \sin \frac{\pi}{6} \right) + \left( \frac{-kQ}{a^2} \cos \frac{\pi}{6}, \frac{kQ}{a^2} \sin \frac{\pi}{6} \right) + \left( 0, -\frac{kQ}{a^2} \right) = \left( 0, \frac{kQ\sqrt{3}}{a^2} \right) \].

b) The electric field at point P (top of the triangle) is \( \left( \frac{kQ}{a^2} \cos \frac{\pi}{3}, \frac{kQ}{a^2} \sin \frac{\pi}{3} \right) + \left( -\frac{kQ}{a^2} \cos \frac{\pi}{3}, \frac{kQ}{a^2} \sin \frac{\pi}{3} \right) = (0, 2 \frac{kQ}{a^2} \sin \frac{\pi}{3}) \)

4. Let \((x_0, y_0)\) be the coordinates of charge \( Q \) and \((x, y)\) be the coordinates of an arbitrary point \( P \) on the xy plane. The points \( P, Q, \) and \( R = (x, y_0) \) are corners of a right triangle with \( QR \) as the hypotenuse, \( QR \) as the side adjacent, and \( RP \) as the side opposite. Also let \( r = \sqrt{(x-x_0)^2 + (y-y_0)^2} \) be the length of the hypotenuse. Then the electric field at \( P \) is \( \vec{E} = \frac{kQ}{r^2} \left( \cos \theta \, \hat{i} + \sin \theta \, \hat{j} \right) \)
But \( \cos \theta = \frac{x-x_0}{r} = \frac{x-x_0}{\sqrt{(x-x_0)^2 + (y-y_0)^2}} \) and \( \sin \theta = \frac{y-y_0}{\sqrt{(x-x_0)^2 + (y-y_0)^2}} \), therefore
\[ \vec{E} = \frac{kQ(x-x_0)}{((x-x_0)^2 + (y-y_0)^2)^{3/2}} \hat{i} + \frac{kQ(y-y_0)}{((x-x_0)^2 + (y-y_0)^2)^{3/2}} \hat{j}. \]
5. The problem should read "at a distant point along the x axis." Choosing an 
\( x >> 2a \), the electric field in the x direction is 
\[ \frac{kq}{x^2} \left( (1 - \frac{a}{x})^{-2} - (1 + \frac{a}{x})^{-2} \right) \approx \frac{kq}{x^2} \left( 1 + \frac{2a}{x} - 1 - \frac{2a}{x} \right) = \frac{4kqa}{x^3} \] 
using the binomial approximation.

6. Assume that the line charge density is positive. Then the direction of the electric 
field at the origin is \( \hat{i} \). The magnitude of this field is 
\[ \int_{x_0}^{\infty} \frac{kqd}{x^2} \, dx = \int_{x_0}^{\infty} \frac{k\lambda dx}{x^2} = k\lambda \left( \frac{1}{x} \bigg|_{\infty}^{x_0} \right) \]
\[ = \frac{k\lambda}{x_0} \]

7. By symmetry, the direction of the electric field will be horizontally towards the 
semicircle since the object is negatively charged. Let \( O \) represent the origin 
of a coordinate system, as well as the origin of a semicircle, and let \( r \) be the 
distance from \( O \) to the semicircle. Let the \( y \) axis pass through \( O \) and connect 
the ends of the rod, and let \( \theta \) be the angle between the positive \( y \) axis and the 
line connecting \( O \) and an element of charge \( dq \) on the semicircle. Then the 
electric field at \( O \) due to \( dq \) is 
\[ \frac{kqd}{r^2} (-\sin \theta \hat{i} + \cos \theta \hat{j}) \] 
Now \( dq = \lambda ds = \lambda rd\theta \). To find \( E \) we integrate counterclockwise starting at the top of the semicircle, so 
\( \theta : 0 \rightarrow \pi \). Then 
\[ E = \int_0^\pi \frac{k\lambda r d\theta}{r^2} (-\sin \theta \hat{i} + \cos \theta \hat{j}) = \frac{k\lambda}{r} (\cos \theta \big|_0^\pi \hat{i} + \sin \theta \big|_0^\pi \hat{j}) \]
\[ = -2 \frac{k\lambda}{r} \hat{i} \] 
We’ve already taken care of the direction of the field due to the 
negative charge, so we just have \( \lambda = 7.5 \times 10^{-6} \text{C} \div 1.4 \times 10^{-2} \text{m} = 5.4 \times 10^{-4} \text{C/m} \) 
and \( r = 1.4 \times 10^{-2} \text{m} \div \pi = 4.5 \times 10^{-3} \text{m} \). Thus 
\[ E = -2.16 \times 10^9 \text{N/C} \hat{i} \]

8. a) The electric field at point \( P \) due to each element of length \( dx \) is 
\( dE = \frac{kqd}{(x^2 + y^2)^{3/2}} \), and is directed along the line joining the length element to \( P \). By 
symmetry, \( E_x = \int dE_x = 0 \). Also we have \( E_y = \int dE_y = \int dE \cos \theta = \int \frac{k\lambda dy}{(x^2 + y^2)^{3/2}} \)
since \( \cos \theta = \frac{y}{\sqrt{x^2 + y^2}} \). Again by symmetry, \( E_y = 2 \int_0^{\frac{\pi}{2}} \left( \int_0^{\frac{\pi}{2}} \frac{k\lambda dy}{(x^2 + y^2)^{3/2}} \right) \)

b) For a line of infinite length, \( \theta \rightarrow \frac{\pi}{2} \) and \( E_y = \frac{2k\lambda}{\sqrt{\pi}} \).

9. For cylinder A, \( Q = \sigma A = (15.0 \text{nC/m}^2)(2\pi \times 2.50 \times 10^{-2} \text{m} \times 6.00 \times 10^{-2} \text{m} + 
2 \times \pi \times (2.50 \times 10^{-2})^2) = 2.00 \times 10^{-10} \text{C} \) or \( 0.200 \text{nC} \). For cylinder B, \( Q = \rho V = 
500 \times 10^{-9} \text{C/m}^3 \times \pi \times (2.50 \times 10^{-2} \text{m})^2 \times 6.00 \times 10^{-2} \text{m} = 1.88 \times 10^{-11} \text{C} \).

10. To stop a moving electron, the applied electric field must point in the same 
direction as the velocity of the electron. The work done in stopping the 
electron is \( W = \Delta K = qEd = K \), so \( E = \frac{K}{qd} \).