1. $dx/dt = 6t^2 + 6t$ and $dy/dt = 2t - 3$.

   (a) length $= \int_{-4}^{2} \sqrt{(6t^2 + 6t)^2 + (2t - 3)^2}\, dt$

   (b) To be vertical, $dx/dt = 0$, which means $t = 0$ or $t = -1$. This gives the two points $(-1, 2)$ and $(0, 6)$.

2. (a) Let $\mathbf{c} = \overrightarrow{BA} = \langle 1, 1, -1\rangle$ and $\mathbf{b} = \overrightarrow{AC} = \langle x - 2, 2, 4\rangle$. Since $\mathbf{b}$ must be perpendicular to $\mathbf{c}$, $\mathbf{b} \cdot \mathbf{c} = 0$. Thus $x = 4$ and so C is $(4, 3, 4)$ and $\mathbf{b} = \langle 2, 2, 4\rangle$.

   (b) Let $\mathbf{a} = \overrightarrow{BC} = \langle 3, 3, 3\rangle$. The cosine is

$$\frac{\mathbf{a} \cdot \mathbf{b}}{|\mathbf{a}|\;|\mathbf{b}|} = \frac{6 + 6 + 12}{\sqrt{4 + 4 + 16}\,\sqrt{9 + 9 + 9}} = \frac{24}{\sqrt{24}\,\sqrt{27}} = \sqrt{\frac{24}{27}} = \frac{2\sqrt{2}}{3}.$$

3. (a) **First plane**: The equation is $\langle 1, 2, 0\rangle \cdot \langle x - 0, y - 0, z - 0\rangle = 0$; that is, $x + 2y = 0$. **Second plane**: Since the line is in the plane, $\langle 1, 1, 0\rangle$ is parallel to the plane. With $t = 0$, we see that $(0, 2, 0)$ is in the plane. (Any other value of t would work.) Since the origin is in the plane, $\langle 0, 2, 0\rangle$ is parallel to the plane. Taking the cross product of the two vectors, we get the normal $\langle 0, 0, 2\rangle$ and the equation of the plane is $2z = 0$ or, equivalently, $z = 0$.

   (b) We have the equations $x + 2y = 0$ and $z = 0$ for the planes. Since both must hold for the intersection, we could take, say, $y = t$. Then $x = -2t$ and $z = 0$. In other words, $\langle x, y, z\rangle = t\langle -2, 1, 0\rangle$. Of course, other answers are also valid, for example, $\langle x, y, z\rangle = t\langle 2, -1, 0\rangle + \langle -4, 2, 0\rangle$.

   Alternatively, we could take the cross product of the two normals to the planes, $\langle 1, 2, 0\rangle$ and $\langle 0, 0, 1\rangle$ to get a vector in the direction of the line. We also need a point on the line. The origin works since the plane passes through the origin.

   Alternatively, we could find two points on the line, P and Q and then the line would be $t\overrightarrow{PQ} + Q$. An obvious point is the origin. We can find another by choosing any nonzero value for x or y; for example, with $x = 12$, $x + 2y = 0$ gives us $y = -6$. Since we have $z = 0$ from the second plane, our point is $(12, -6, 0)$.