12.1.4 First,

$$\mathbf{r}'(t) = \langle -2\sin 2t, 6\cos 2t\rangle,$$

so

$$\mathbf{r}'(0) = \langle 0, 6\rangle;$$

next,

$$\mathbf{r}''(t) = \langle -4\cos 2t, -12\sin 2t\rangle,$$

so

$$\mathbf{r}''(0) = \langle -4, 0\rangle.$$

For an equation involving only x and y, don't try to solve for t (which is too complicated), but use a trigonometric identity:

$$x = \cos 2t,\ y = 3\sin 2t;$$

$$\cos 2t = x,\ \sin 2t = \frac{y}{3};$$

$$\cos^2 2t = x^2,\ \sin^2 2t = \frac{y^2}{9};$$

$$x^2 + \frac{y^2}{9} = 1.$$

12.2.12 First,

$$\mathbf{r} = \int \langle 180t, 180t - 16t^2\rangle\,\mathrm{d}t = \left\langle 90t^2, 90t^2 - \frac{16}{3}t^3\right\rangle + \mathbf{C};$$

when $t = 0$,

$$\langle 0, 100\rangle = \mathbf{r} = \langle 0, 0\rangle + \mathbf{C},$$

so $\mathbf{C} = \langle 0, 100\rangle$, so

$$\mathbf{r} = \left\langle 90t^2, 90t^2 - \frac{16}{3}t^3 + 100\right\rangle.$$

12.3.1 First

$$\mathbf{v} = \frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t} = \left\langle -2\sin t, 2\cos t, \sqrt{5}\right\rangle;$$

then

$$\|\mathbf{v}\| = \sqrt{4\sin^2 t + 4\cos^2 t + 5} = 3.$$

Thus, the unit tangent vector is

$$\mathbf{T} = \frac{\mathbf{v}}{\|\mathbf{v}\|} = \left\langle -\frac{2}{3}\sin t, \frac{2}{3}\cos t, \frac{1}{3}\sqrt{5}\right\rangle,$$

and the arclength from $t = 0$ to $t = \pi$ is

$$L = \int_0^\pi 3\,\mathrm{d}t = 3\pi.$$