A ball of mass $m = 2\,kg$ is located at $\langle 24, -12, 6\rangle m$ at time $t = 14.9s$. At this time, it is traveling with a velocity $\langle -1, 4, 3\rangle m/s$. It experiences a net force $\vec{F}_{net} = \langle 2, 1.6, -1\rangle N$. What is the new position at $t = 15.0s$?

Solution: Update momentum:

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t = m\vec{v}_i + \vec{F}_{net}(t_f - t_i)$$
$$= (2kg)\langle -1, 4, 3\rangle m/s + \langle 2, 1.6, -1\rangle N\,(15.0 - 14.9)s$$
$$= \langle -1.8, 8.16, 5.9\rangle kg\cdot m/s$$

-0% (perfect)

Net force constant, use mathematical definition of $\vec{v}_{avg}$

$$\vec{v}_{avg} = \frac{1}{2}(\vec{v}_i + \vec{v}_f) = \frac{1}{2}\left(\vec{v}_i + \frac{\vec{p}_f}{m}\right)$$
$$= \frac{1}{2}\left(\langle -1, 4, 3\rangle m/s + \frac{1}{2kg}\langle -1.8, 8.16, 5.9\rangle kg\cdot m/s\right)$$
$$= \langle -0.95, 4.04, 2.975\rangle m/s$$

Update position:

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \vec{r}_i + \vec{v}_{avg}(t_f - t_i)$$
$$= \langle 24, -12, 6\rangle m + \langle -0.95, 4.04, 2.975\rangle m/s\,(15.0 - 14.9)s$$
$$= \langle 23.905, -11.596, 6.298\rangle m$$

$\vec{r}_f = \langle 23.91, -11.60, 6.30\rangle m$

Analytic with error:

-30%

Update momentum:

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t = m\vec{v}_i + \vec{F}_{net}\Delta t$$
$$= 2\cdot\langle -1, 4, 3\rangle + \langle 2, 1.6, -1\rangle(15.0 - \cancel{14.8}\ 14.9)$$
$$= \langle -1.6, 8.32, 5.8\rangle$$

-10% clerical

-20% Didn't average velocity

Update position

$$\vec{r}_f = \vec{r}_i + \frac{\vec{p}_0}{m}\Delta t$$
$$= \langle 24, -12, 6\rangle + \frac{\langle -1.6, 8.32, 5.8\rangle}{2}(15.0 - 14.8)$$
$$= \langle 23.84, -11.168, 6.58\rangle m$$

$\vec{r}_f = \langle 23.84, -11.17, 6.58\rangle m$

Numeric with error:

-80%

Update momentum

$$\vec{p}_f = \langle -1, 4, 3\rangle + \langle 2, 1.6, -1\rangle(0.2)$$
$$= \langle -0.6, 4.32, 2.8\rangle$$

Update position

$$\vec{r}_f = \langle 24, -12, 6\rangle + \frac{\langle -0.6, 4.32, 2.8\rangle}{2}\,0.2$$
$$= \langle 23.9, -11.5, 6.3\rangle$$

$\vec{r}_f = \langle 23.9, -11.5, 6.3\rangle$

Errors: No units in final answer
Incorrect calculation of Δt (clerical)
Didn't multiply initial velocity by mass to get momentum (minor)
Didn't average velocity (minor)