11. Summary

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Summarize

Big Picture

Motion in the plane or in three-dimensional space can be described by a vector-valued function $\vec{r}\,(t)$. We can do calculus with $\vec{r}\,(t)$ to get insight into the motion's speed and velocity.

Mechanics

Motion given by functions $x\,(t)\,,y\,(t)\,,z\,(t)$ can be packaged into a vector:

$$\vec{r} = \begin{pmatrix} x\,(t) \\ y\,(t) \end{pmatrix} \quad \text{or} \quad \vec{r} = \begin{pmatrix} x\,(t) \\ y\,(t) \\ z\,(t) \end{pmatrix} \tag{6.93}$$

Sometimes, it's helpful to use vector arithmetic to analyze $\vec{r}$. One can also compute speed and velocity using calculus:

- $\vec{v} = \dfrac{d\vec{r}}{dt}$ is the **velocity** vector at a given time t. Its components are the derivatives of the components of $\vec{r}$.
- The **speed**$= |\vec{v}|$ is the magnitude of the velocity vector.
- $\widehat{T} = \frac{\text{velocity}}{\text{speed}}$ is the **unit tangent vector**.

Ask Yourself

Do we have to use vectors to understand parametric curves?

No, the notation of $\vec{r}\,(t)$ can be replaced by the individual functions $x\,(t)\,,y\,(t)\,,z\,(t)$. But there are some advantages to thinking with vectors instead of individual functions. For one, it might be possible to use vector arithmetic to understand the motion described by $\vec{r}$. Furthermore, using three functions $x\,(t)\,,y\,(t)\,,z\,(t)$ can become cumbersome when there are many other variables in the problem already. Using a single letter $\vec{r}$ often makes it easier to stay organized and clarify your thinking.

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Is it possible for velocity to be zero?

Some care must be taken to interpret "zero" correctly. "Zero" could refer to the number 0 or to the vector of all-zeros $\vec{0}$ (the “zero-vector"). But in the context of velocity, we always mean the zero-vector. With this in mind, yes, velocity can be zero.

Intuitively, the velocity is zero means the particle isn't moving. When a car stops at a traffic light, the car's velocity has become zero.

It's not enough for one component of the velocity to be zero. At the peak of its trajectory, a baseball may have $y' = 0$, but the velocity wouldn't be $\vec{0}$ unless x' is also 0.

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Calculator Hide Notes

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