

An Object Accelerating on a Ramp

Learning Goal:

Understand that the acceleration vector is in the direction of the change of the velocity vector.

In one dimensional (straight line) motion, acceleration is accompanied by a change in speed, and the acceleration is always parallel (or antiparallel) to the velocity.

When motion can occur in two dimensions (e.g. is confined to a tabletop but can lie anywhere in the x-y plane), the definition of acceleration is

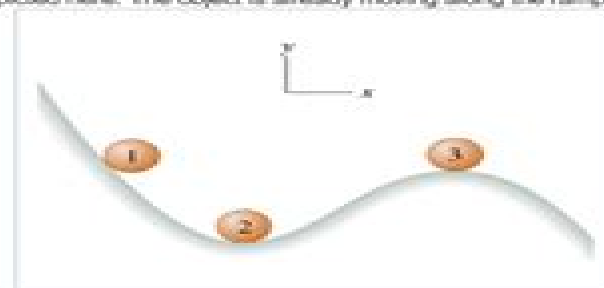
$$\vec{a}(t) = \frac{\vec{v}(t + \Delta t) - \vec{v}(t)}{\Delta t} \text{ in the limit } \Delta t \rightarrow 0.$$

In picturing this vector derivative you can think of the derivative of a vector as an instantaneous quantity by thinking of the velocity of the tip of the arrow as the vector changes in time. Alternatively, you can (for small Δt) approximate the acceleration as

$$\vec{a}(t) \approx \frac{\vec{v}(t + \Delta t) - \vec{v}(t)}{\Delta t}.$$

Obviously the difference between $\vec{v}(t + \Delta t)$ and $\vec{v}(t)$ is another vector that can lie in any direction. If it is longer but in the same direction, $\vec{a}(t)$ will be parallel to $\vec{v}(t)$. On the other hand, if $\vec{v}(t + \Delta t)$ has the same magnitude as $\vec{v}(t)$ but is in a slightly different direction, then $\vec{a}(t)$ will be perpendicular to \vec{v} . In general, $\vec{v}(t + \Delta t)$ can differ from $\vec{v}(t)$ in both magnitude and direction, hence $\vec{a}(t)$ can have any direction relative to $\vec{v}(t)$.

This problem contains several examples of this. Consider an object sliding on a frictionless ramp as depicted here. The object is already moving along the ramp toward position 2 when it is at position 1. The following questions concern the direction of the object's acceleration vector, \vec{a} . In this problem, you should find the direction of the acceleration vector by drawing the velocity vector at two points near to the position you are asked about. Note that since the object moves along the track, its velocity vector at a point will be tangent to the track at that point. The acceleration vector will point in the same direction as the vector difference of the two velocities. (This is a result of the equation $\vec{a}(t) \approx (\vec{v}(t + \Delta t) - \vec{v}(t))/\Delta t$ given above.)



Part A

Which direction best approximates the direction of \vec{a} when the object is at position 1?

Hint 1. Consider the change in velocity

At this point, the object's velocity vector is not changing direction; rather, it is increasing in magnitude. Therefore, the object's acceleration is nearly parallel to its velocity.

ANSWER:

- ☐ straight up
- ☐ downward to the left
- ☒ downward to the right
- ☐ straight down

Correct

Mastering Physics Answers Chapter 5

D Keegan



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