You can draw here

GET READY: Go here and make sure you see the “Are you Ready” Sli.do Q
Canvas -> Course Content -> Lecture (under Week 4 - Chapter 4)

Physics 111 - Lecture 4

October 1, 2020

Do not draw in/on this box!

You can draw here

You can draw here

Reminders/Announcements

- Bonus Test 1 starts today from 6PM - Saturday at 6 PM
    - (might be slightly delayed)
- For questions about grading Test 1, contact Tutorial TA on Piazza (be patient)
- Homework05 and Homework06 has been released if you want to work on it in advance
- Will post a Piazza message about some feedback I've received - up for discussion

Reminders/Announcements

	Homework (due Wed 6 pm)	Test/Bonus Test (Thurs 6pm - Sat 6pm)	Learning Log (Fri 6pm)
Week 1	-	-	-
Week 2	HW01 - Intro to Mastering Physics **(not for marks)**	Test 0 **(not for marks)**	Learning Log 1 **(yes for marks!)**
Week 3	HW02 - Chapter 2 HW03 - Chapter 3	Test 1 (on Chapters 2 & 3)	Learning Log 2
Week 4 (this week!)	HW04 - Chapter 4	Bonus Test 1	Learning Log 3
Week 5			

Summary of comments from Homework 4 (Chapter 4)

Taking a step back this week…😕

Students Completed

79 / 321

- Relative motion: annoying but okay.
- Circular motion is straight forward.
- **ω** and **α** : angular velocity and angular acceleration
- Getting lost in formulas…
- What **IS** angular velocity?
- Direction of pendulum acceleration (!!!)

Summary of comments from Homework 4 (Chapter 4)

- Relative motion: annoying but okay.
- Circular motion is straight forward
- ω and α : angular velocity and angular acceleration
- Getting lost in formulas
- What **IS** angular velocity?
- Direction of pendulum acceleration (!!!)

“Quote of the week” QOTW

“The tilted axis questions had me sweating; I would say that I found those the most confusing.”

Why do we need angular velocity?

Why do we need angular velocity?

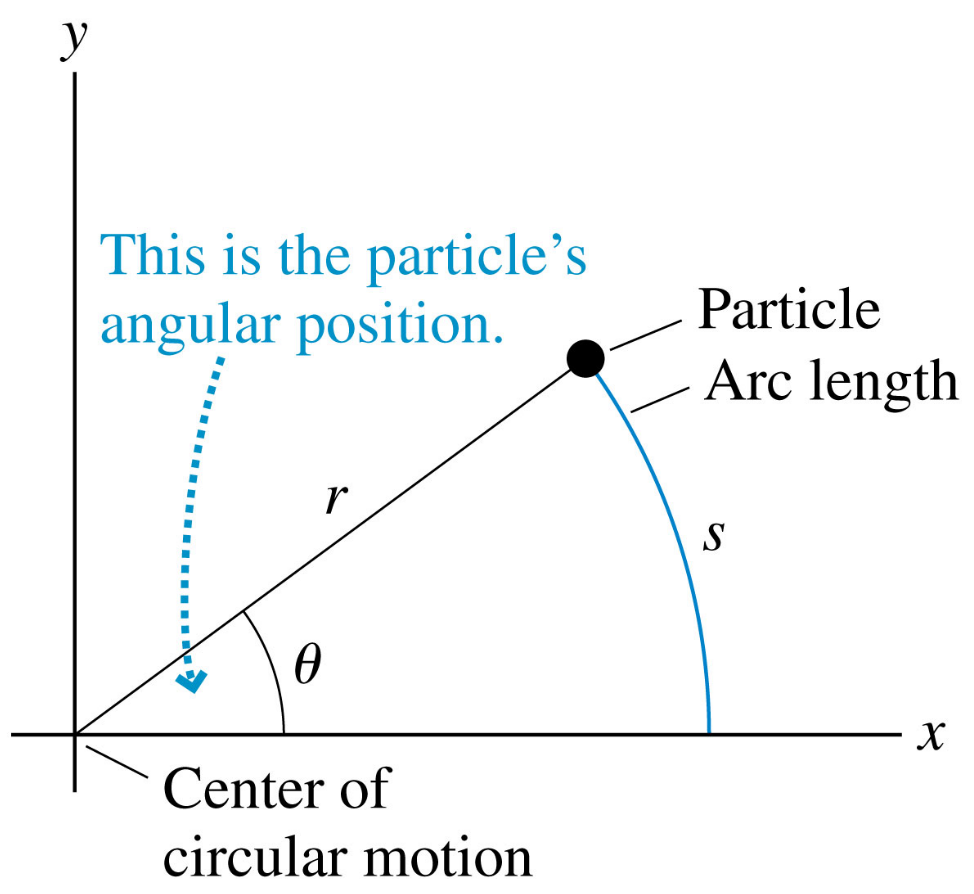
Angular Position

- Consider a particle at a distance r from the origin, at an angle θ from the positive x-axis.
- The angle may be measured in degrees, revolutions (rev) or **radians** (rad), that are related by:

$$1 \text{ rev} = 360^{\circ} = 2\pi \text{ rad}$$

- If the angle is measured in radians, then there is a simple relation between θ and the **arc length** s that the particle travels along the edge of a circle of radius r:

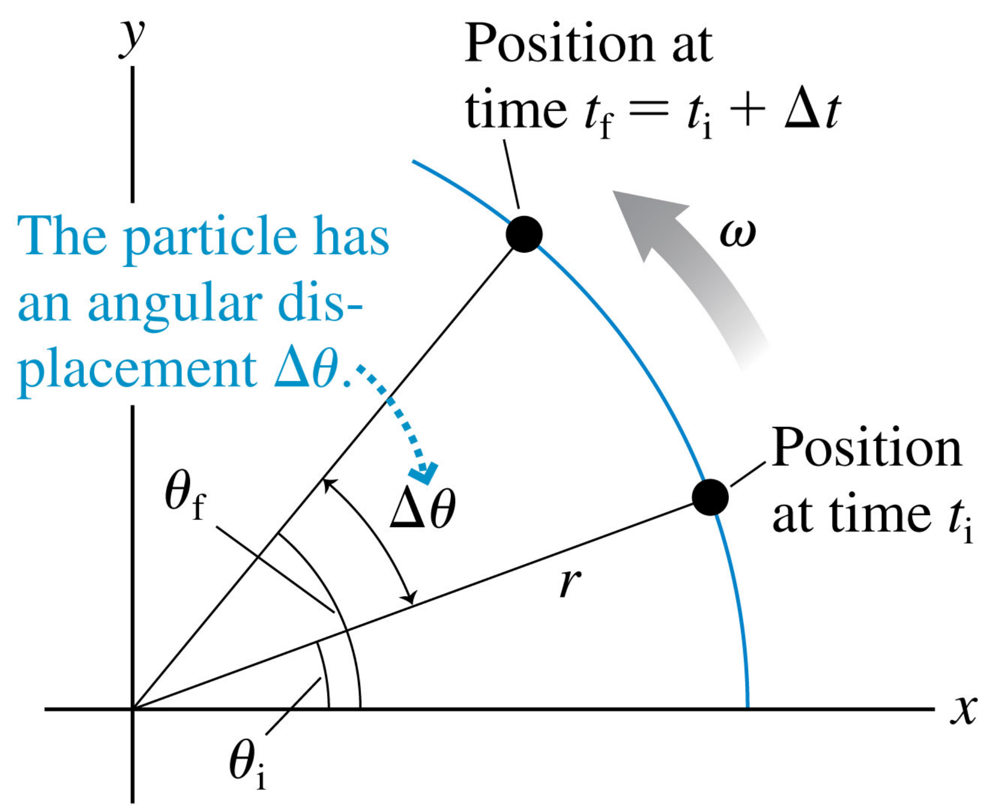
$$s = r\theta \qquad (\text{with } \theta \text{ in rad})$$



Angular Velocity

- A particle on a circular path moves through an **angular displacement** $\Delta\theta = \theta_f - \theta_i$ in a time interval $\Delta t = t_f - t_i$.
- In analogy with linear motion, we define

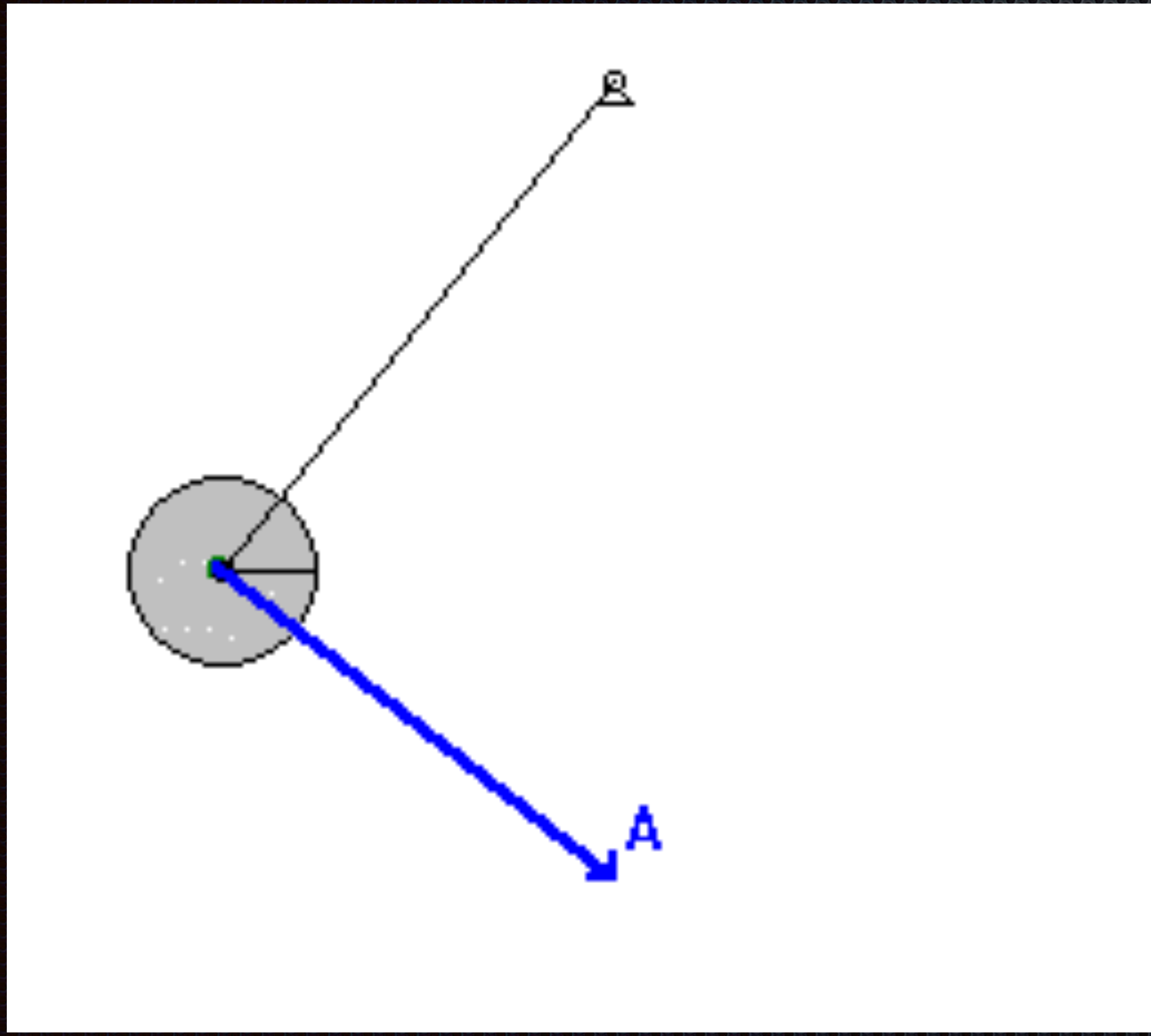
$$\text{average angular velocity} \equiv \frac{\Delta\theta}{\Delta t}$$

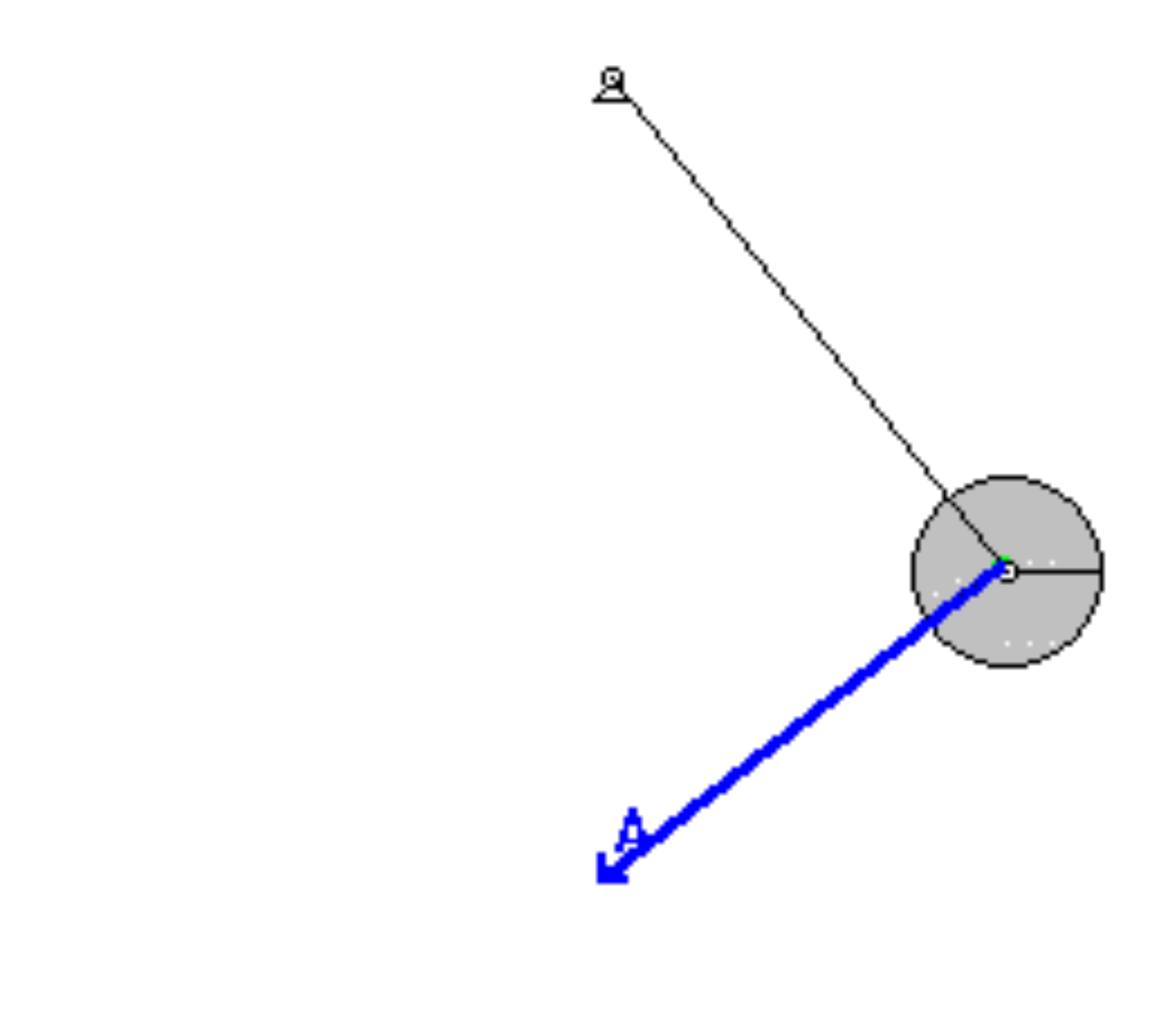


- As the time interval Δt becomes very small, we arrive at the definition of instantaneous **angular velocity:**

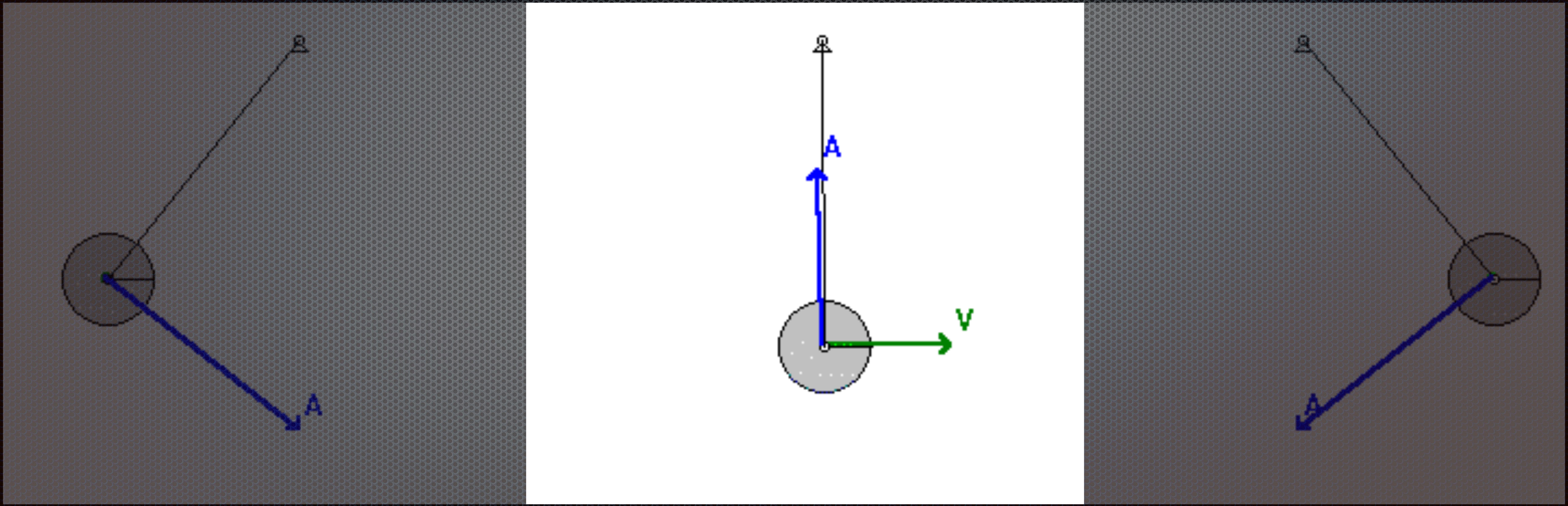
$$\omega \equiv \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t} = \frac{d\theta}{dt} \qquad \text{(angular velocity)}$$

Direction of Pendulum Acceleration





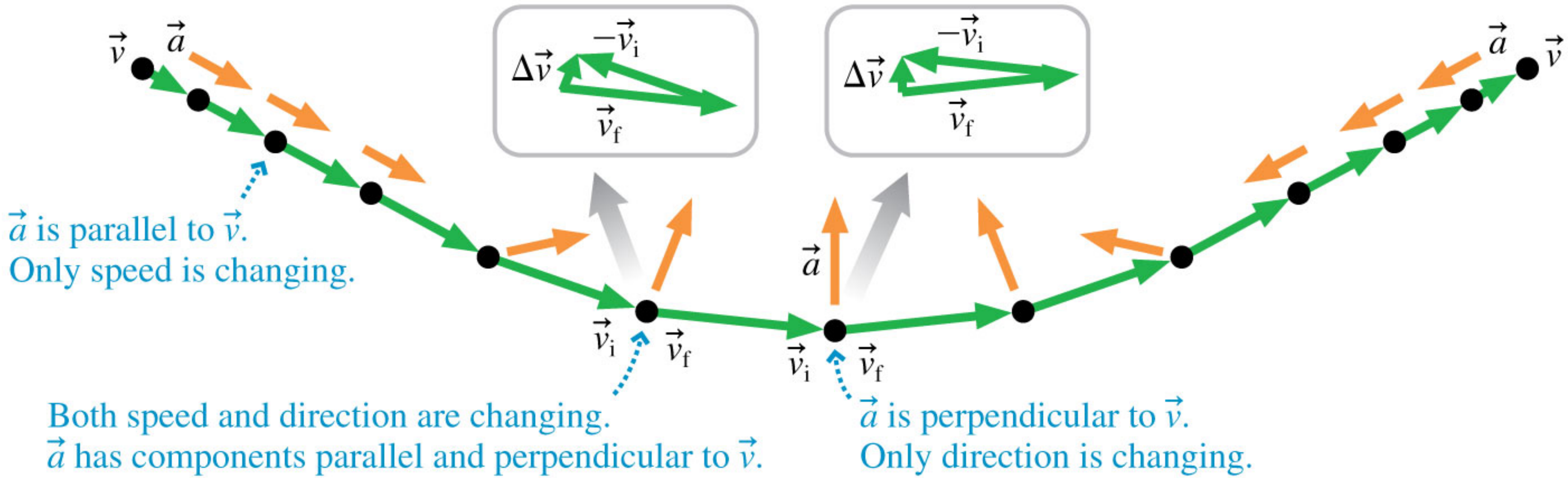
Direction of Pendulum Acceleration



Direction of Pendulum Acceleration

EXAMPLE 4.2 Through the valley

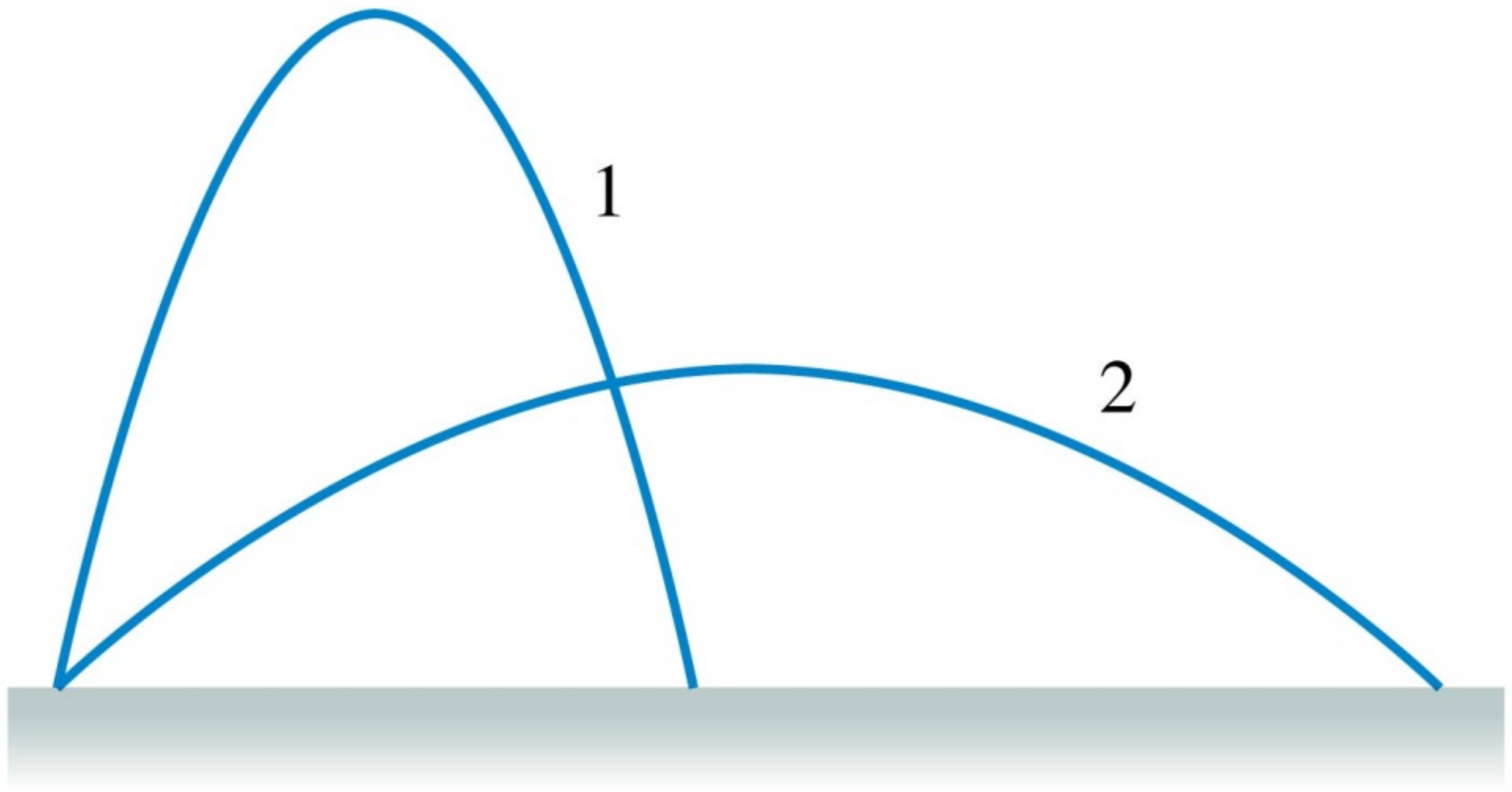
VISUALIZE FIGURE 4.4 is the motion diagram. Where the particle moves along a *straight line,* it speeds up if $\vec{a}$ and $\vec{v}$ point in the same direction and slows down if $\vec{a}$ and $\vec{v}$ point in opposite directions. This important idea was the basis for the one-dimensional kinematics we developed in Chapter 2. When the direction of $\vec{v}$ changes, as it does when the ball goes through the valley, we need to use vector subtraction to find the direction of $\Delta\vec{v}$ and thus of $\vec{a}$. The procedure is shown at two points in the motion diagram.



Chapter 4
Clicker Questions

L4.Q1 - QuickCheck 4.4

Projectiles 1 and 2 are launched over level ground with the same speed but at different angles. Which hits the ground first? Ignore air resistance.



A. Projectile 1 hits first.

B. Projectile 2 hits first.

C. They hit at the same time.

D. There's not enough information to tell.

L4.Q1 - QuickCheck 4.4

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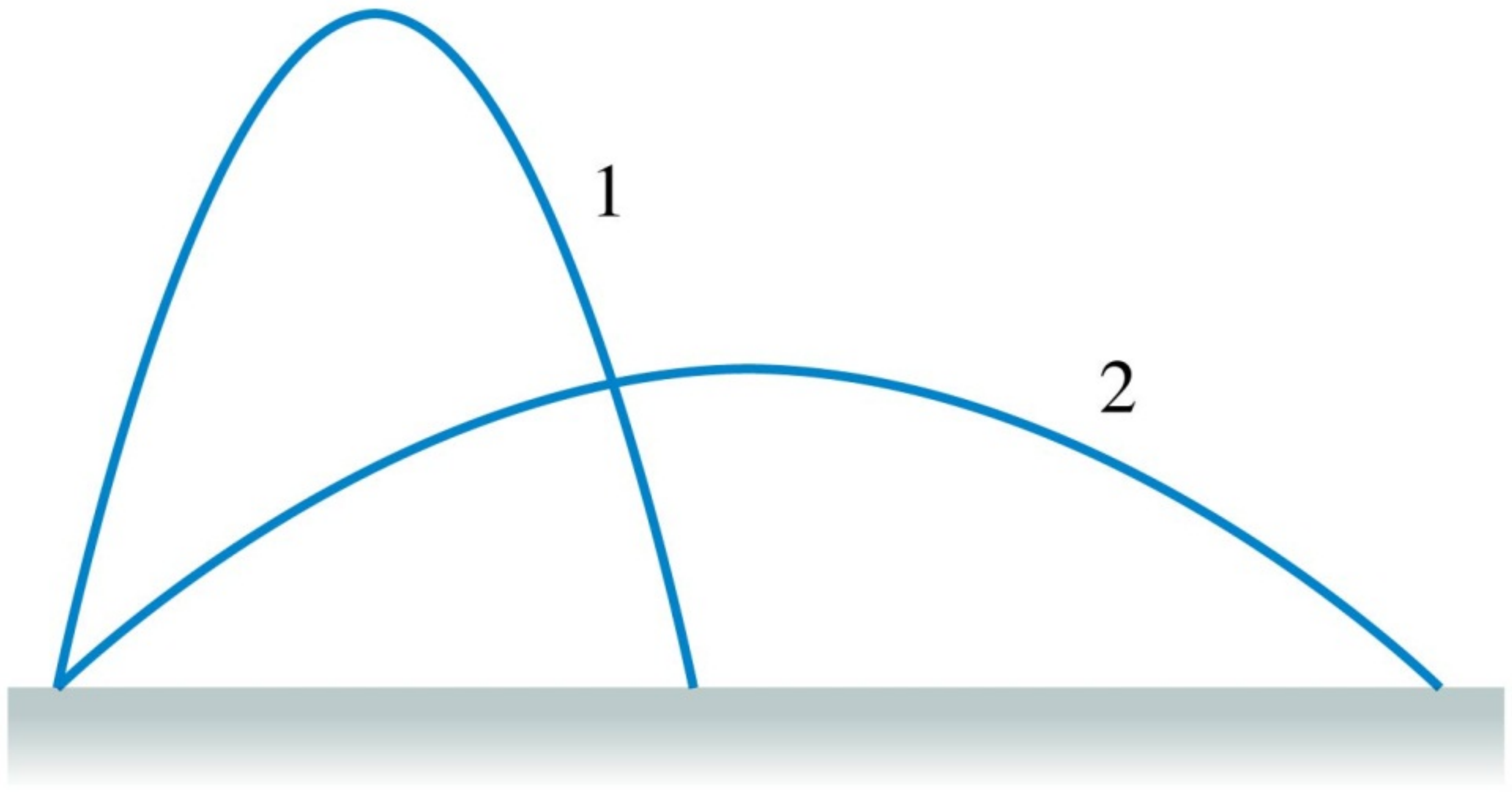


A. Projectile 1 hits first.

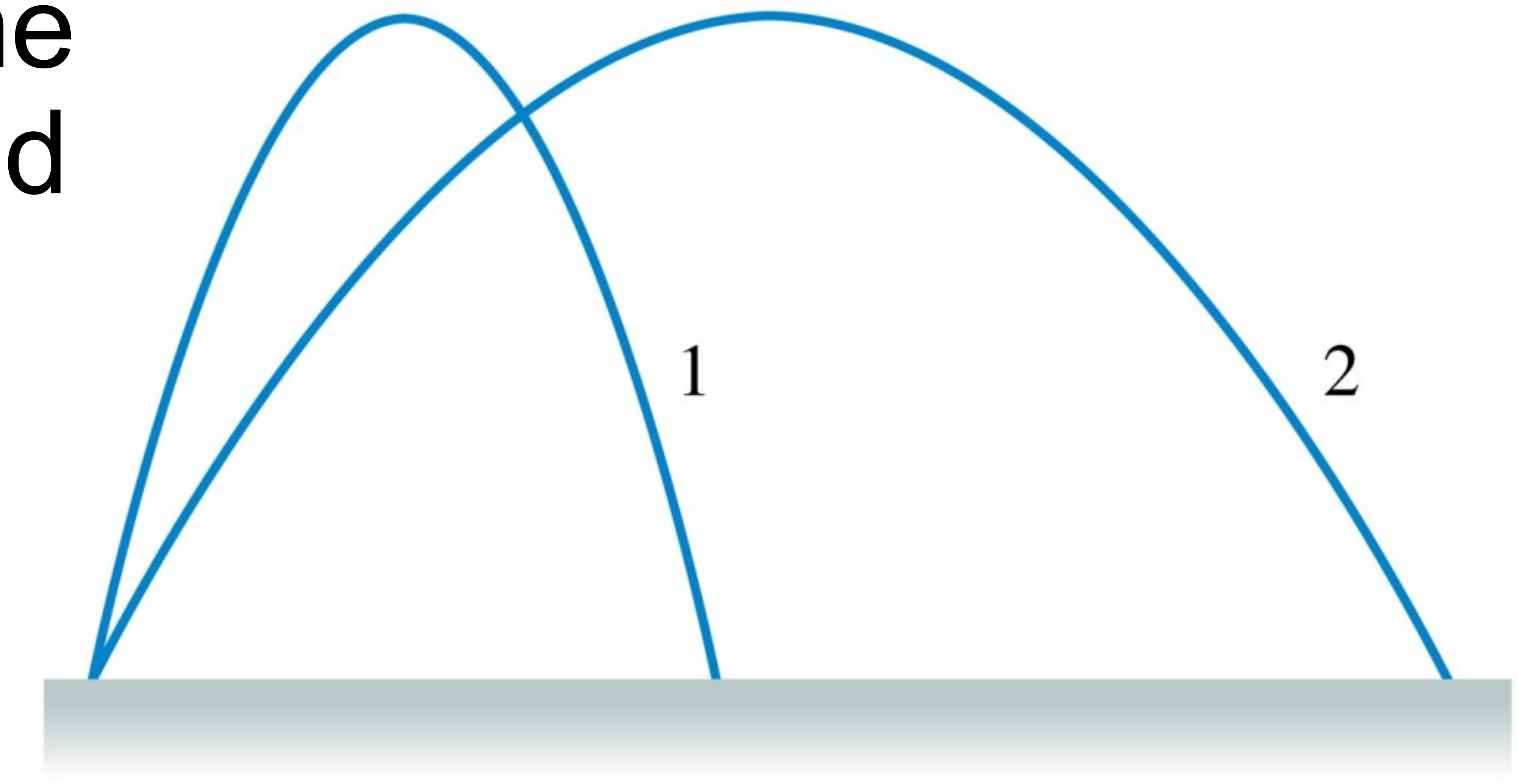
B. Projectile 2 hits first.

C. They hit at the same time.

D. There's not enough information to tell.

L4.Q2 - QuickCheck 4.5

Projectiles 1 and 2 are launched over level ground with different speeds. Both reach the same height. Which hits the ground first? Ignore air resistance.



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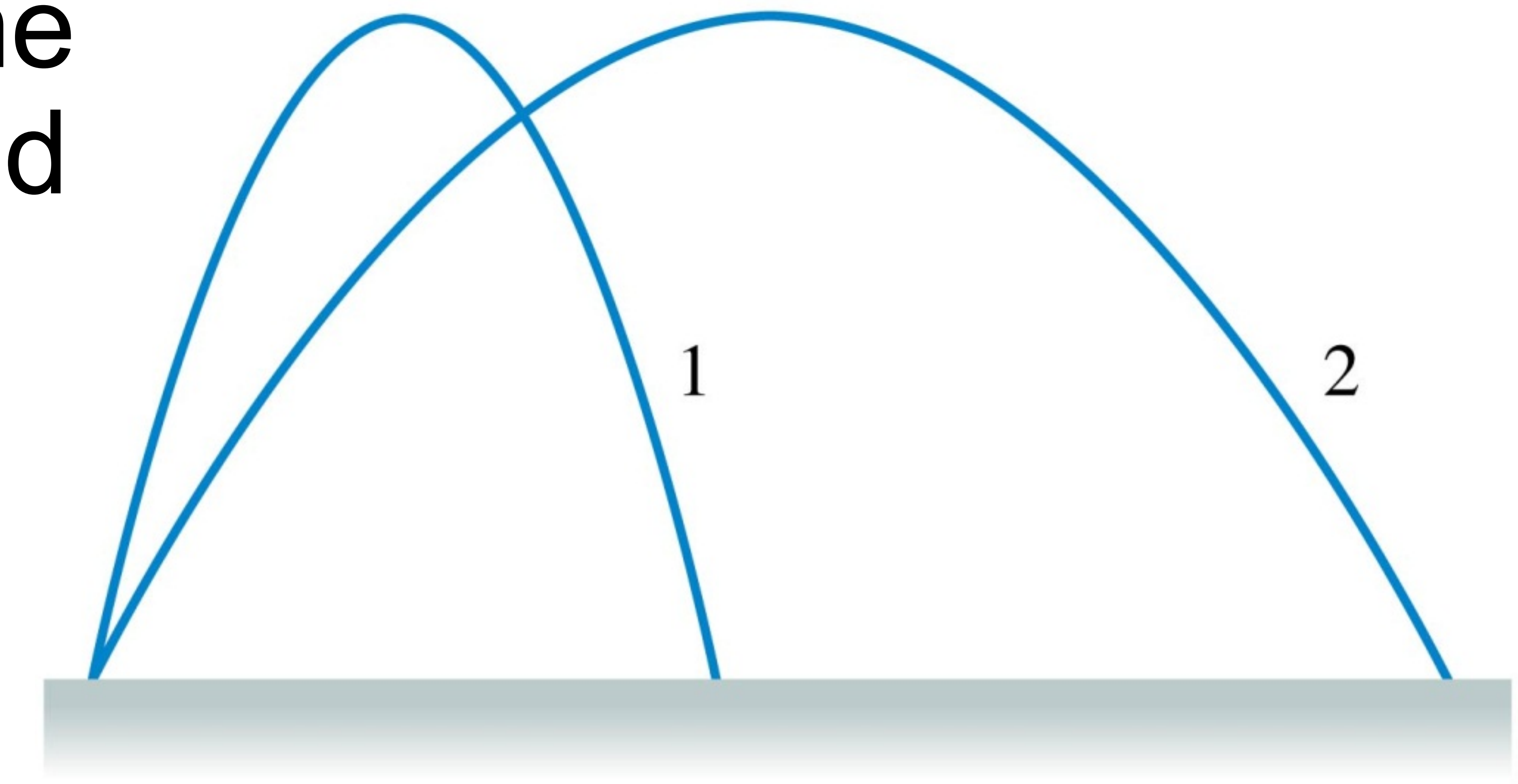

A. Projectile 1 hits first.

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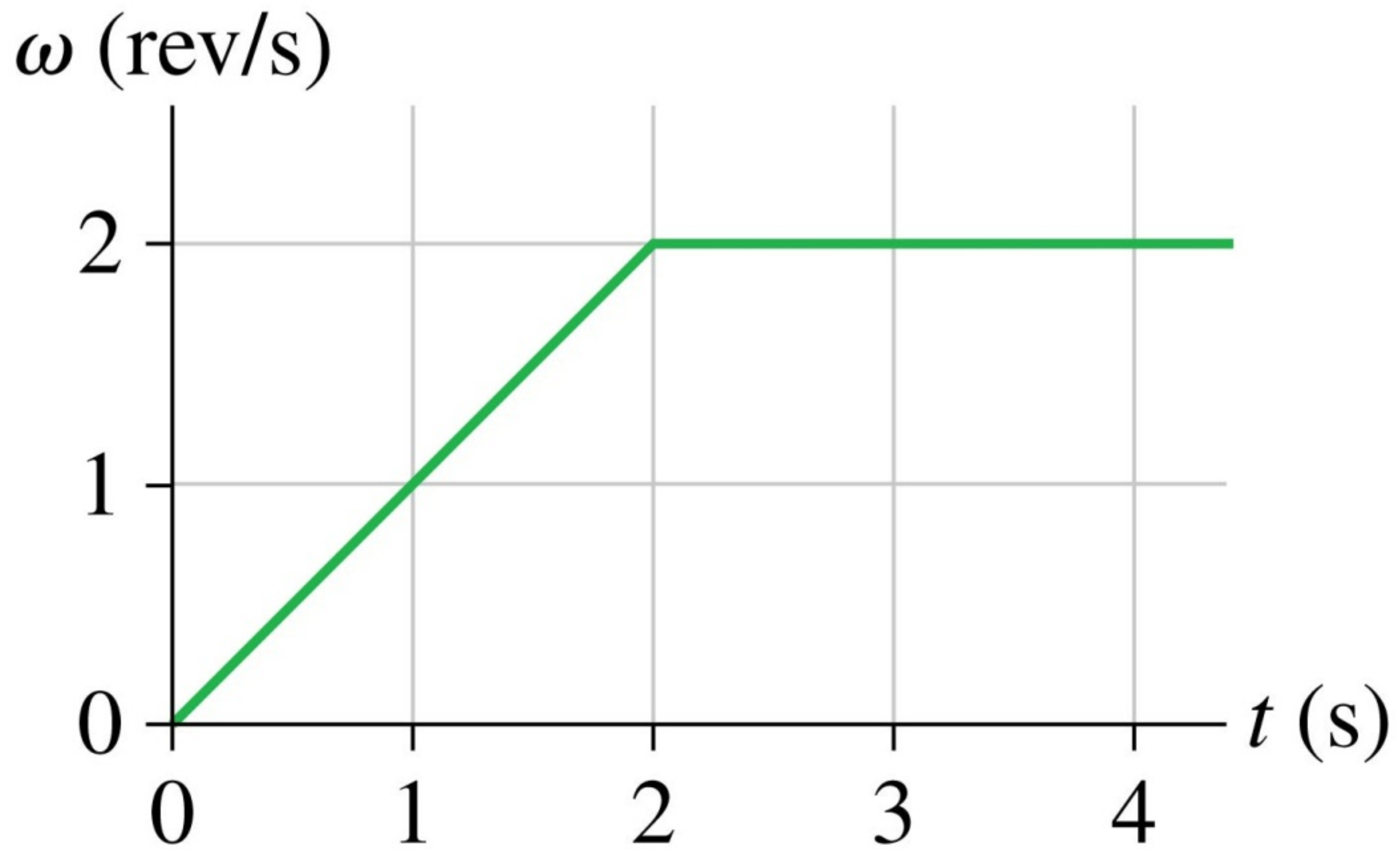
L4.Q3 - QuickCheck 4.7

This is the angular velocity graph of a wheel. How many revolutions does the wheel make in the first 4 s?



A. 1

B. 2

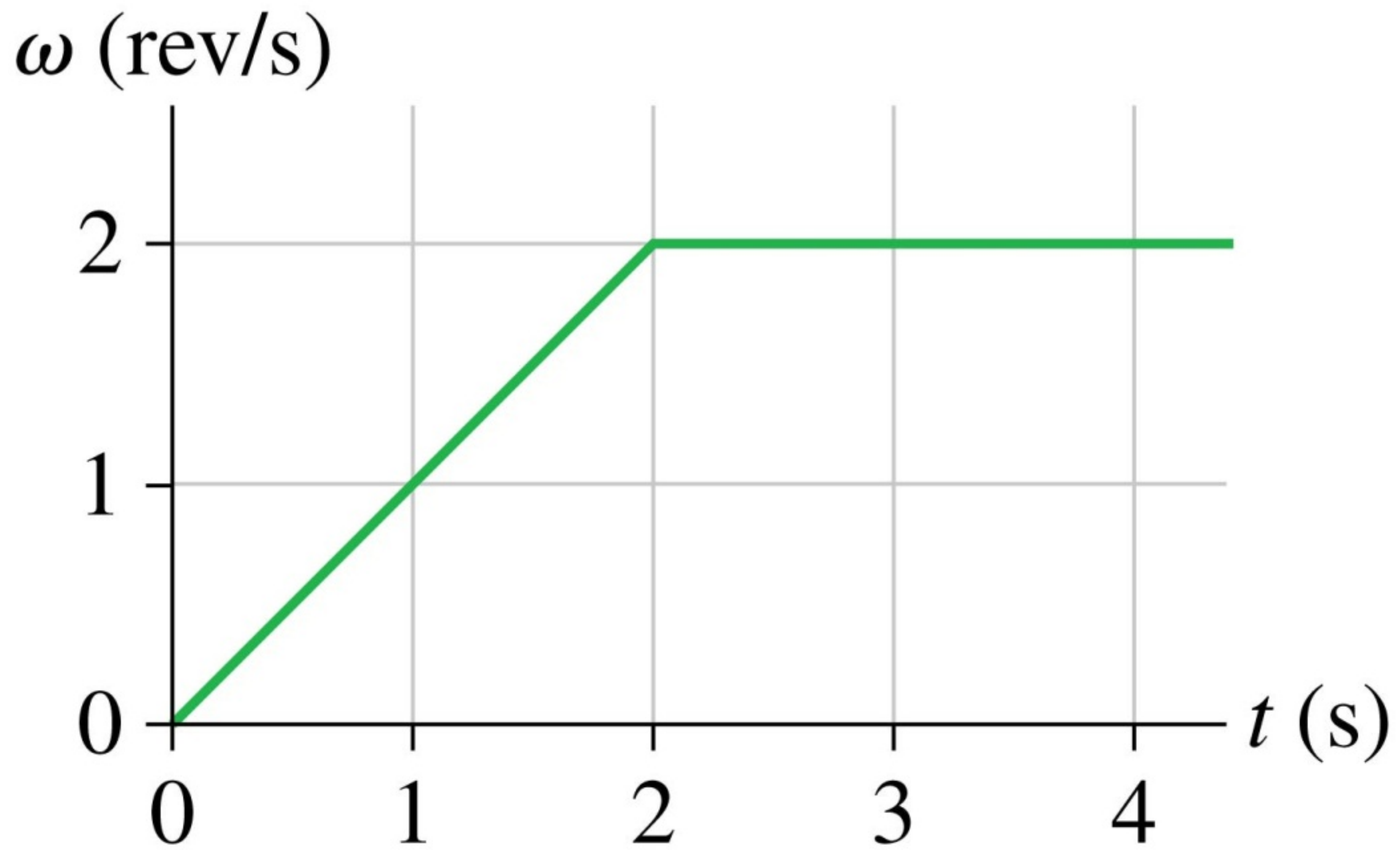
C. 4

D. 6

E. 8

L4.Q3 - QuickCheck 4.7

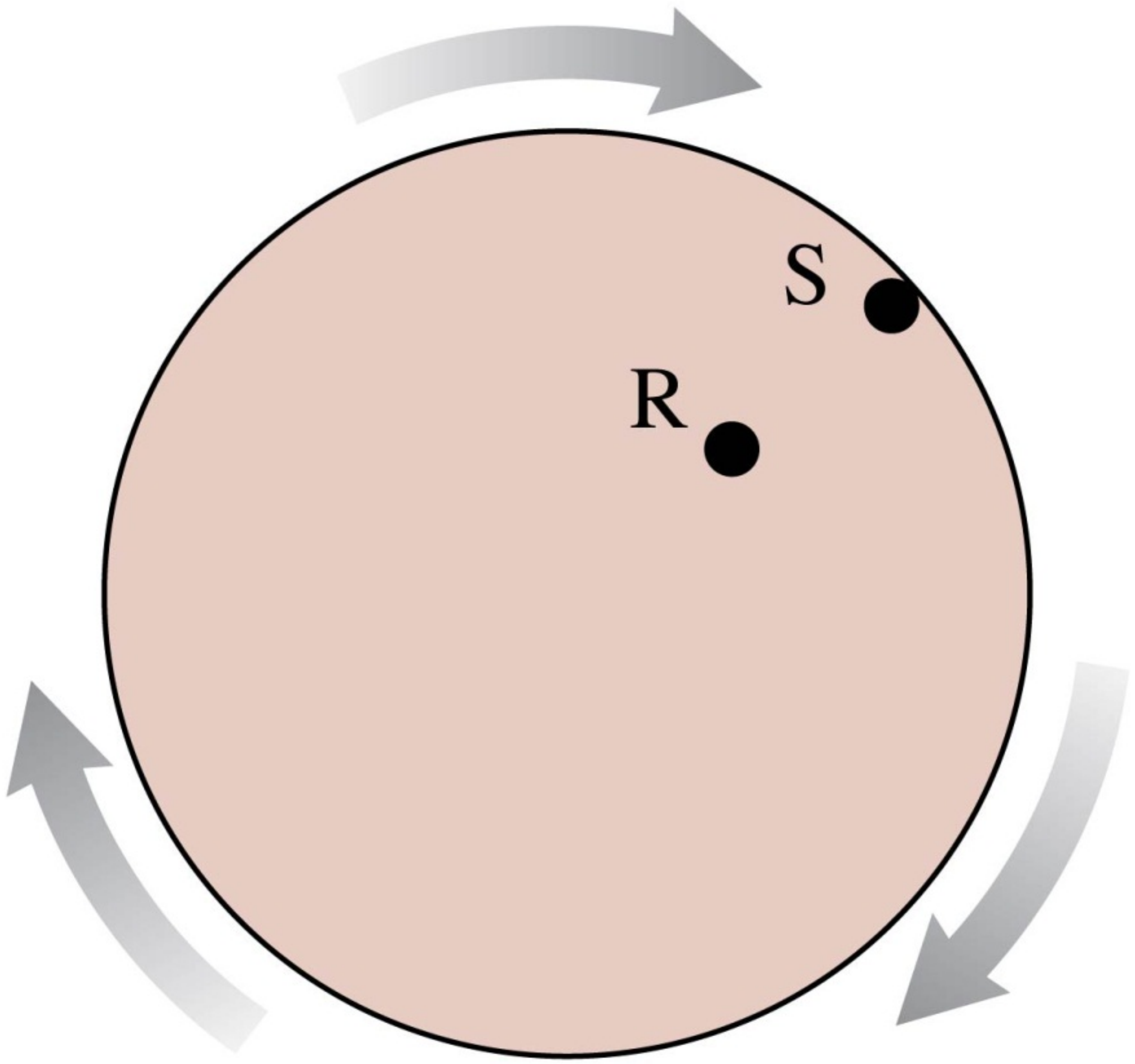
This is the angular velocity graph of a wheel. How many revolutions does the wheel make in the first 4 s?



A. 1
B. 2
C. 4
D. $\boxed{6}$
E. 8

L4.Q4A - QuickCheck 4.12

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's angular velocity is ______ that of Rasheed.



A. half

B. the same as

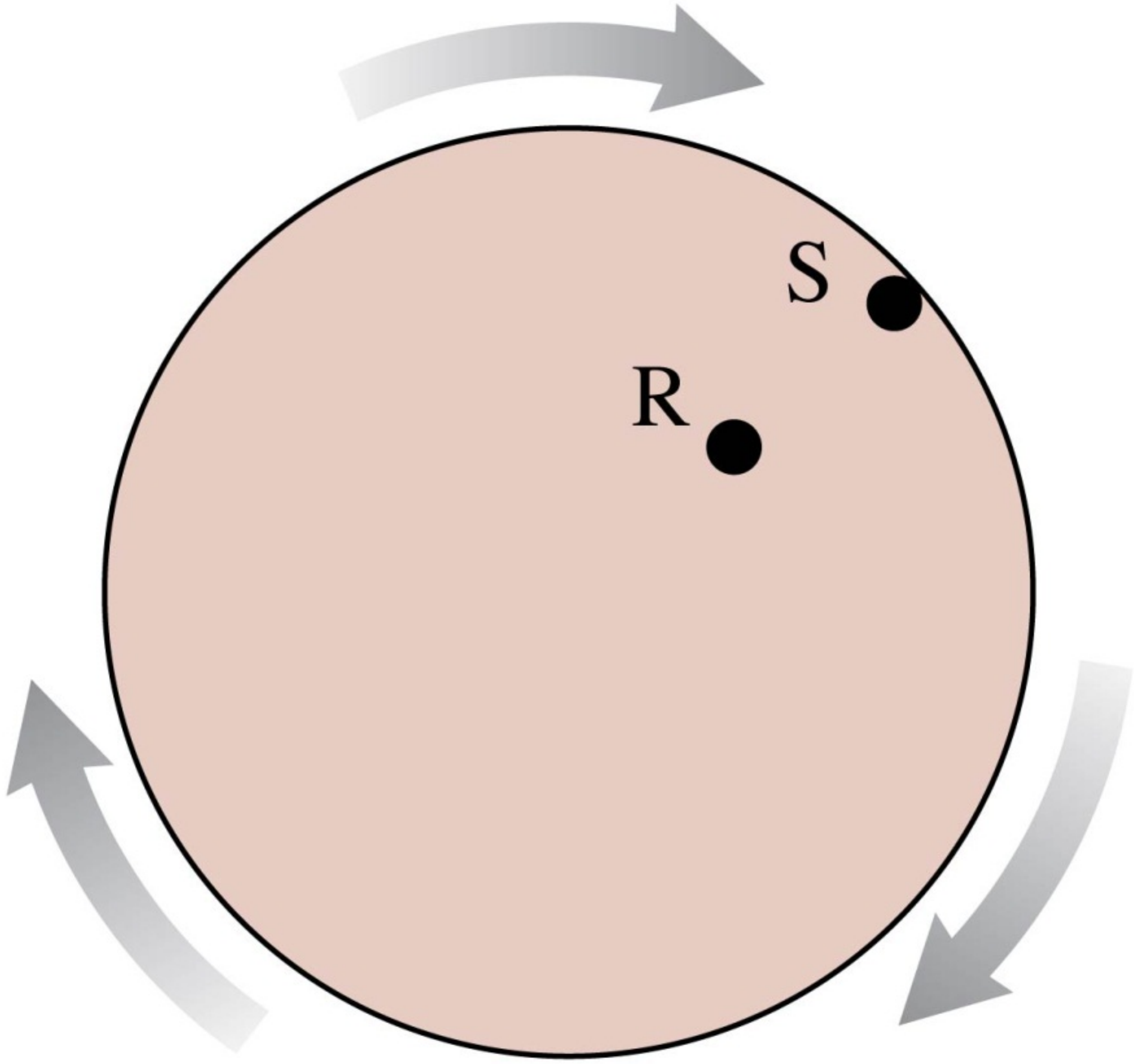
C. twice

D. four times

E. We can't say without knowing their radii.

L4.Q4B - QuickCheck 4.13

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's speed is _______ that of Rasheed.



A. half

B. the same as

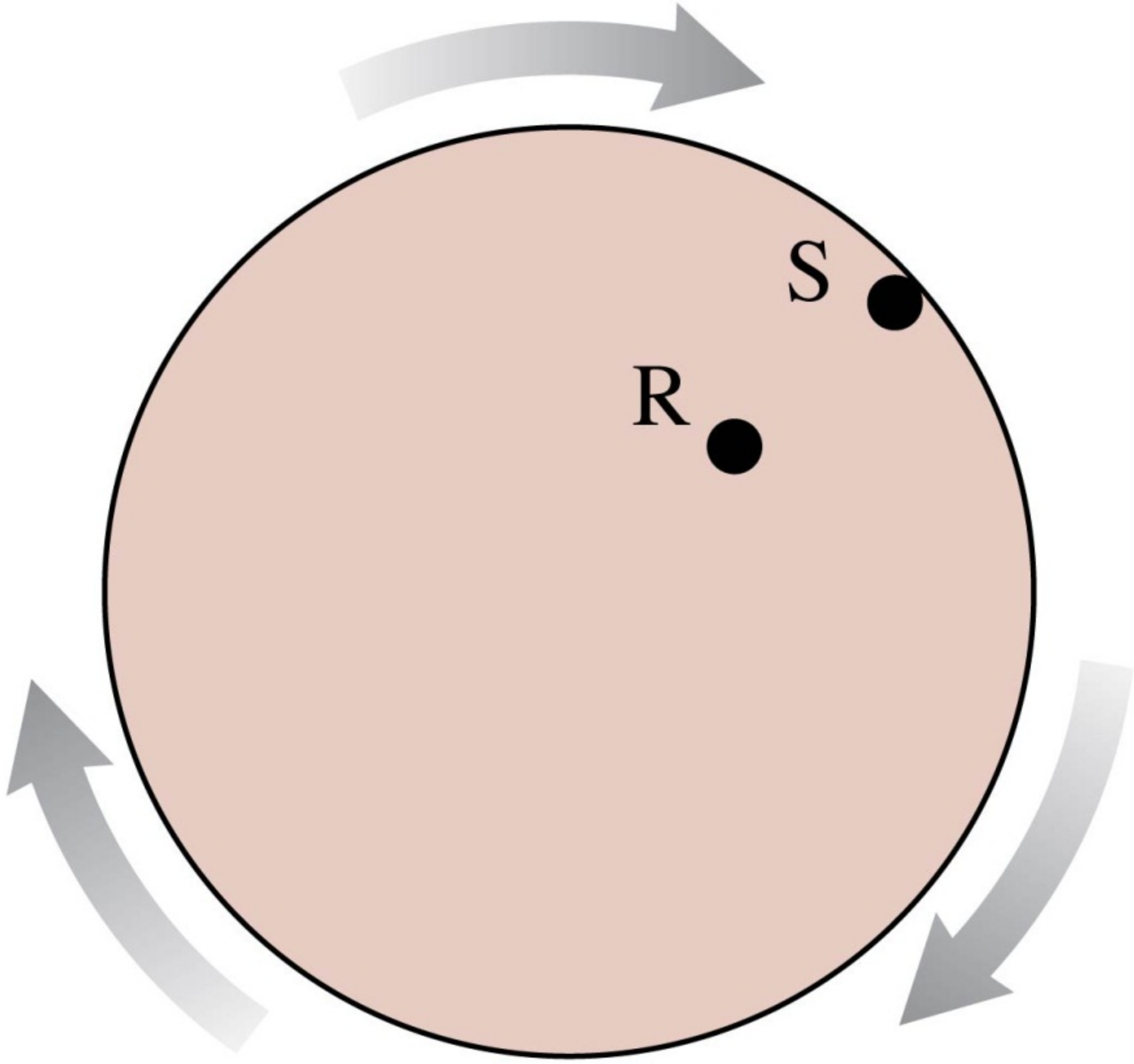
C. twice

D. four times

E. We can't say without knowing their radii.

L4.Q4C - QuickCheck 4.14

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's acceleration is ______ that of Rasheed.



A. half

B. the same as

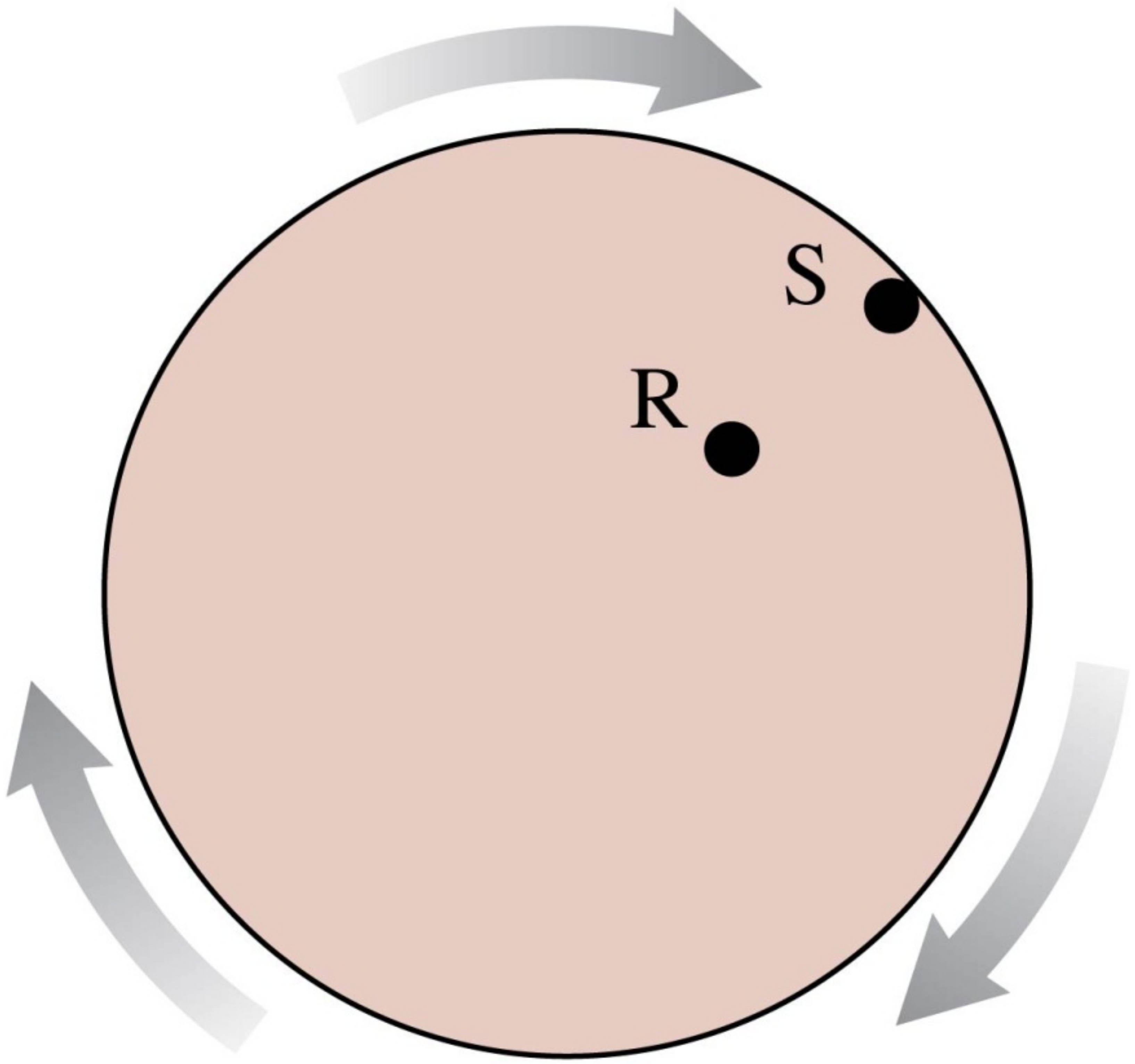
C. twice

D. four times

E. We can't say without knowing their radii.

L4.Q4A - QuickCheck 4.12

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's angular velocity is ______ that of Rasheed.



A. half

B. the same as

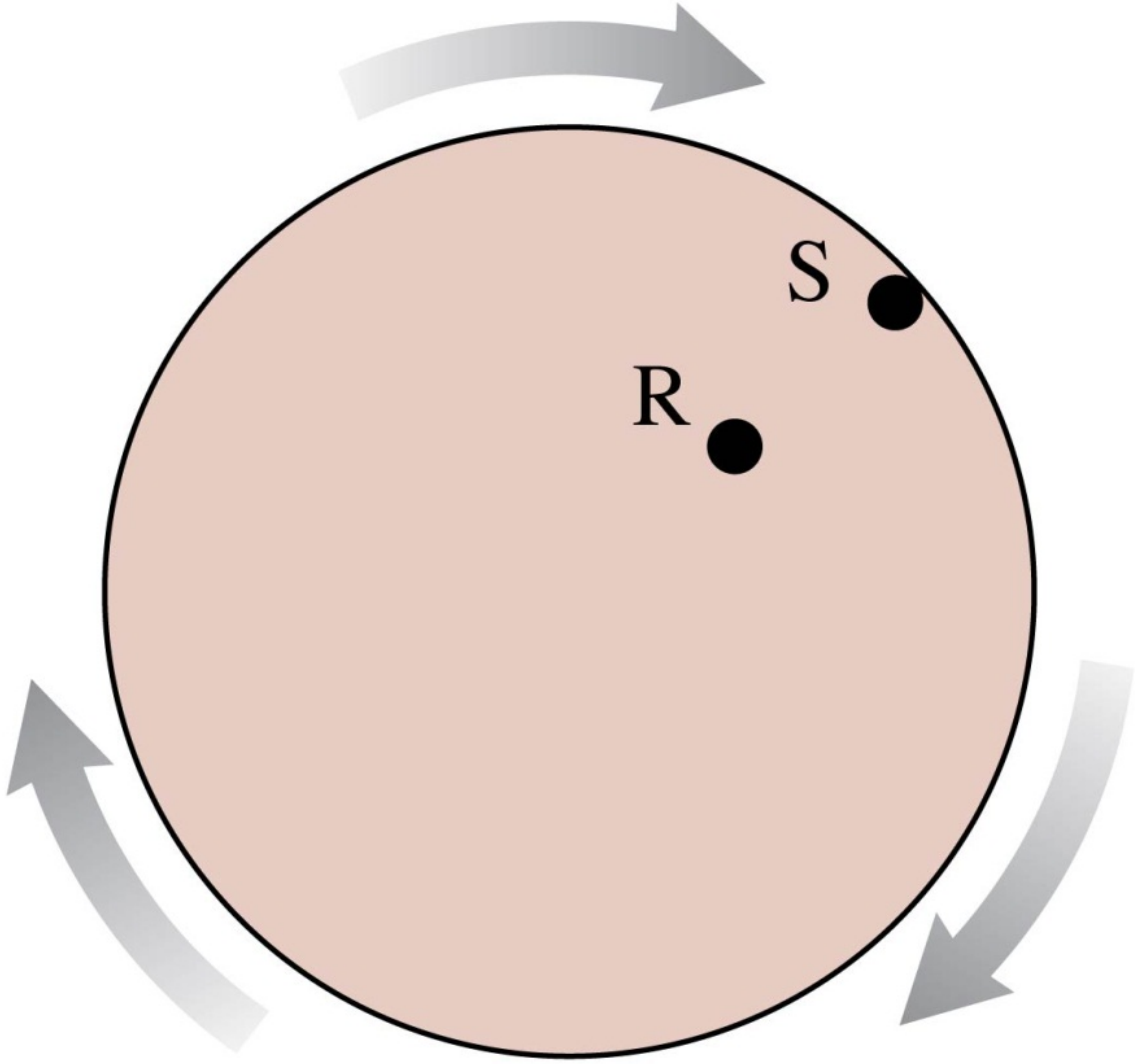
C. twice

D. four times

E. We can't say without knowing their radii.

L4.Q4B - QuickCheck 4.13

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's speed is _______ that of Rasheed.



A. half

B. the same as

C. twice

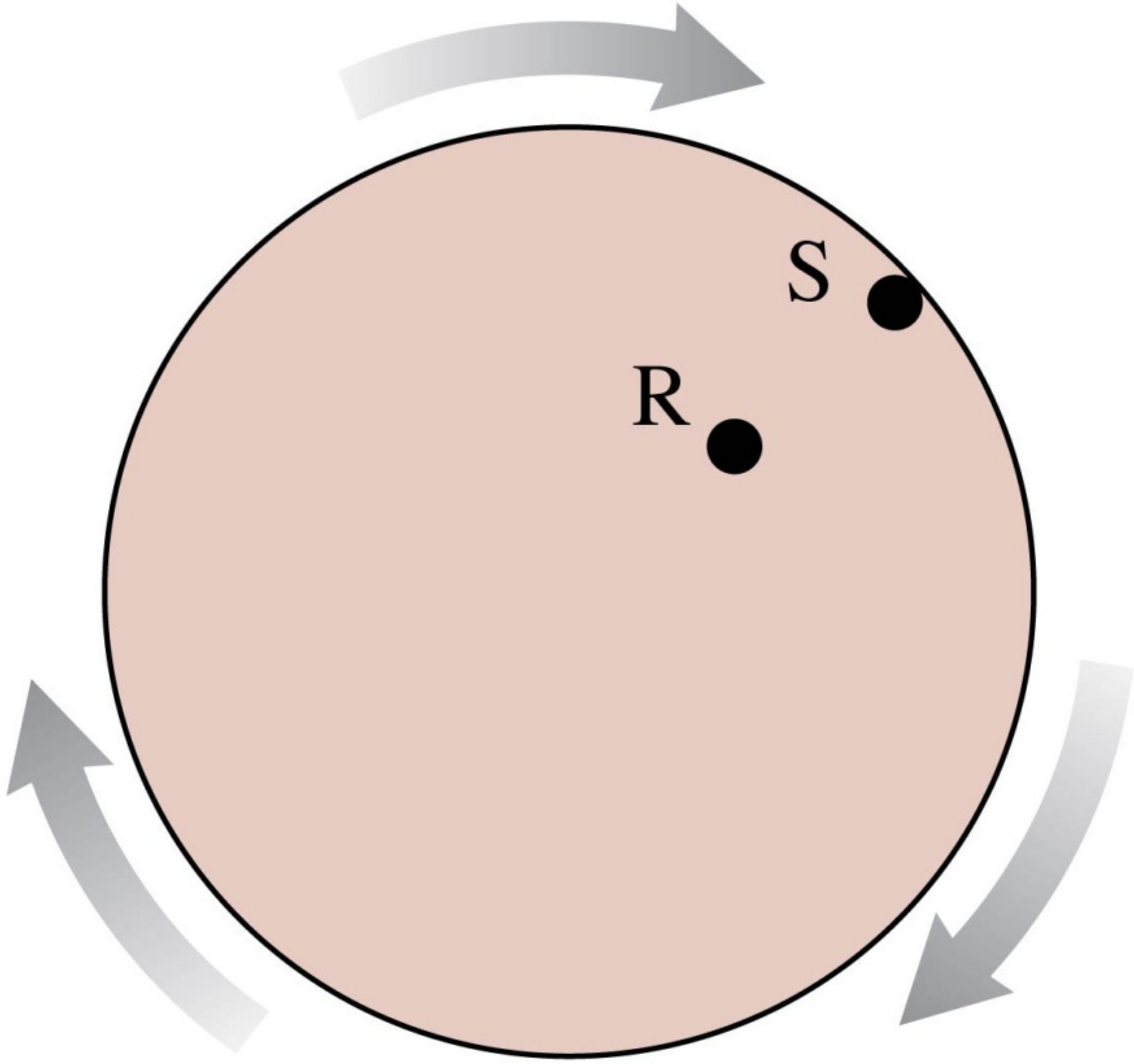
$v = \omega r$

D. four times

E. We can't say without knowing their radii.

L4.Q4C - QuickCheck 4.14

Rasheed and Sofia are riding a merry-go-round that is spinning steadily. Sofia is twice as far from the axis as is Rasheed. Sofia's acceleration is _______ that of Rasheed.



A. half

B. the same as

C. $\boxed{\text{twice}}$

D. four times

E. We can't say without knowing their radii.

Centripetal acceleration $a = \dfrac{v^2}{r} = \omega^2 r$

Chapter 4
Important Concepts

Important Concepts

Kinematics in two dimensions

If $\vec{a}$ is constant, then the x- and y-components of motion are independent of each other.

$$x_f = x_i + v_{ix}\,\Delta t + \tfrac{1}{2}a_x(\Delta t)^2$$

$$y_f = y_i + v_{iy}\,\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$v_{fx} = v_{ix} + a_x\,\Delta t$$

$$v_{fy} = v_{iy} + a_y\,\Delta t$$

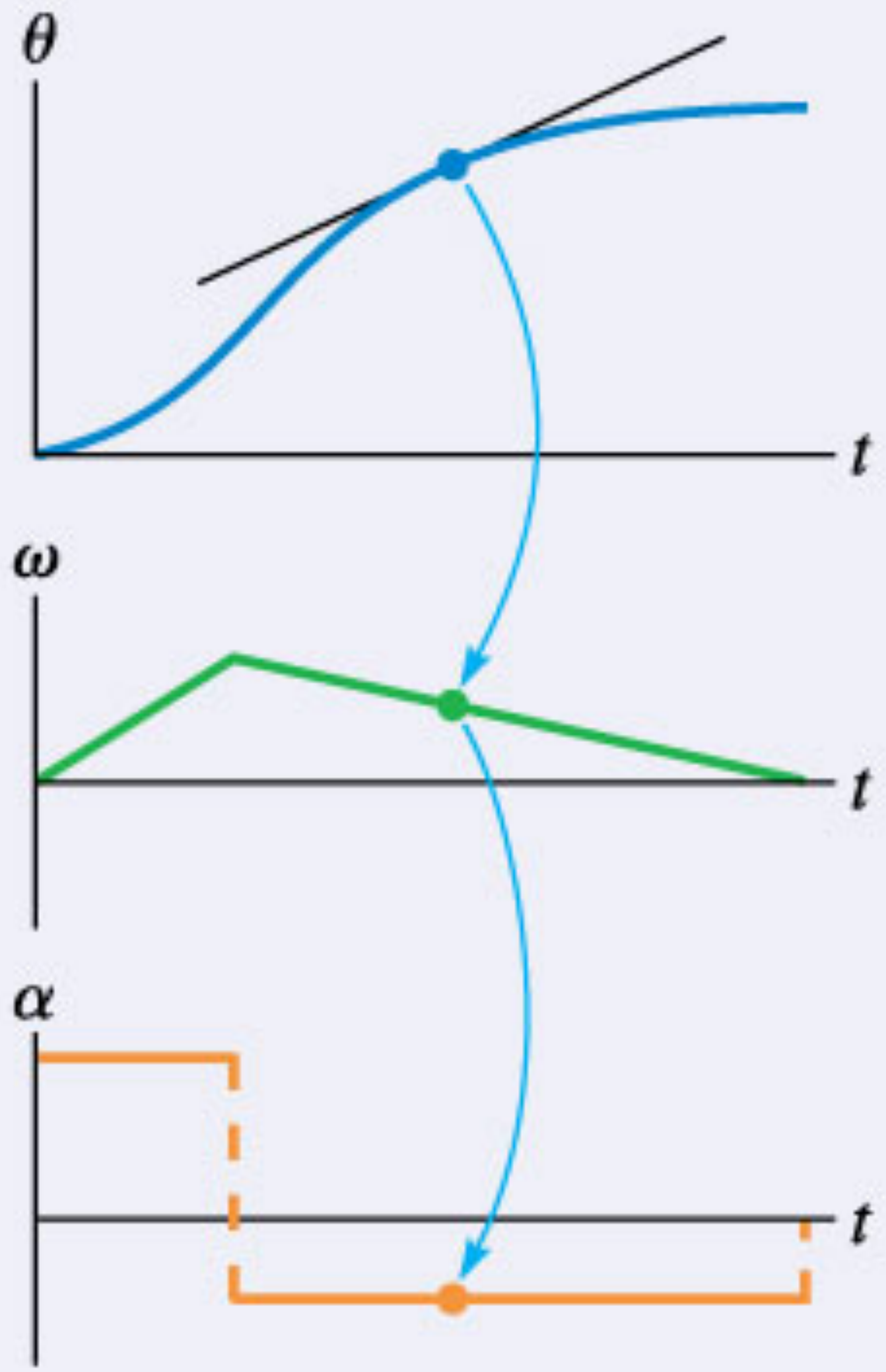
Important Concepts

Circular motion kinematics

Circular motion graphs and kinematics are analogous to linear motion with constant acceleration.

Angle, angular velocity, and angular acceleration are related graphically.

- The angular velocity is the slope of the angular position graph.
- The angular acceleration is the slope of the angular velocity graph.



Important Concepts

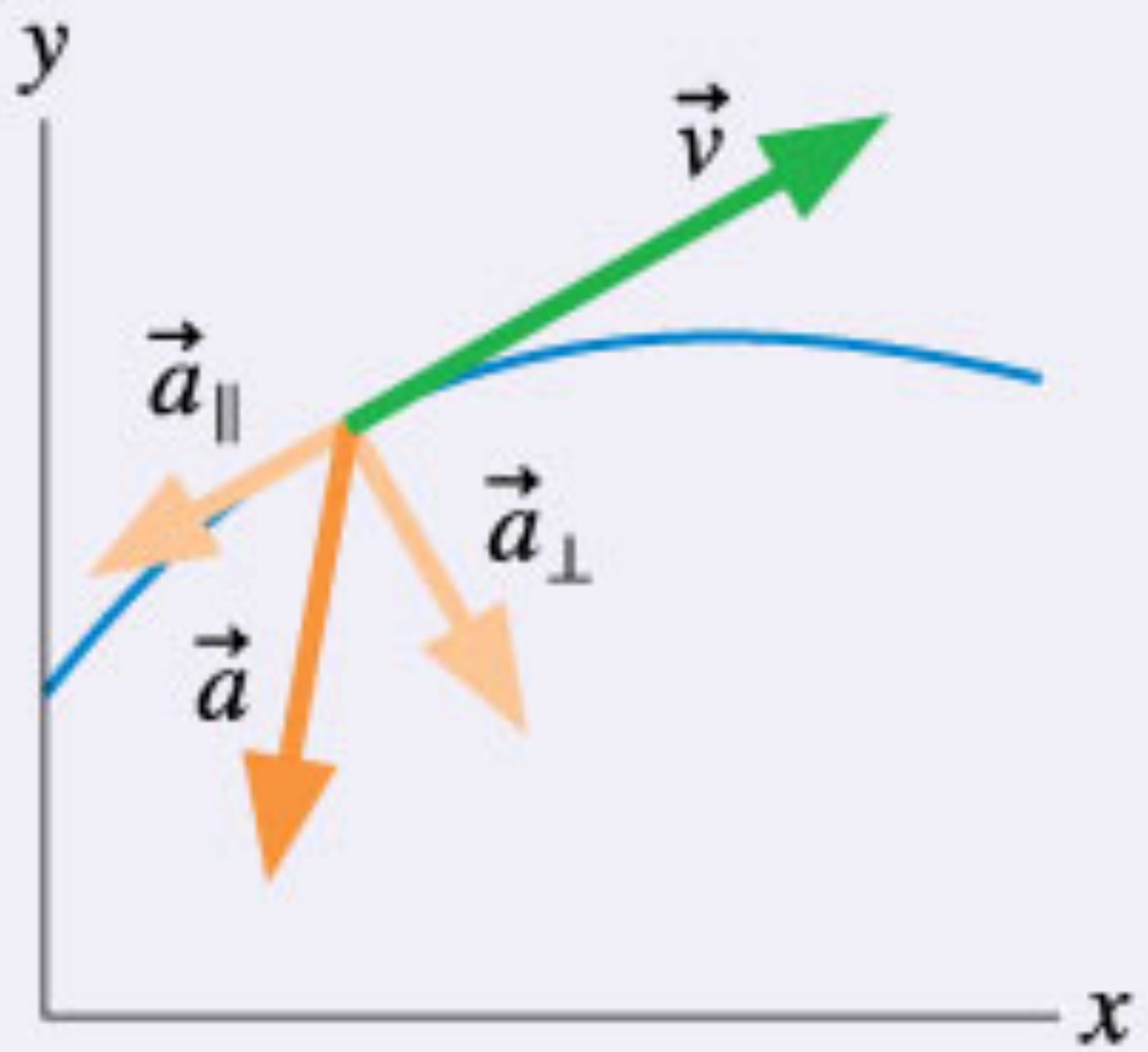
The **instantaneous velocity**

$$\vec{v} = d\vec{r}/dt$$

is a vector tangent to the trajectory.

The **instantaneous acceleration** is

$$\vec{a} = d\vec{v}/dt$$



$\vec{a}_{\parallel}$, the component of $\vec{a}$ parallel to $\vec{v}$, is responsible for change of *speed*. $\vec{a}_{\perp}$, the component of $\vec{a}$ perpendicular to $\vec{v}$, is responsible for change of *direction*.

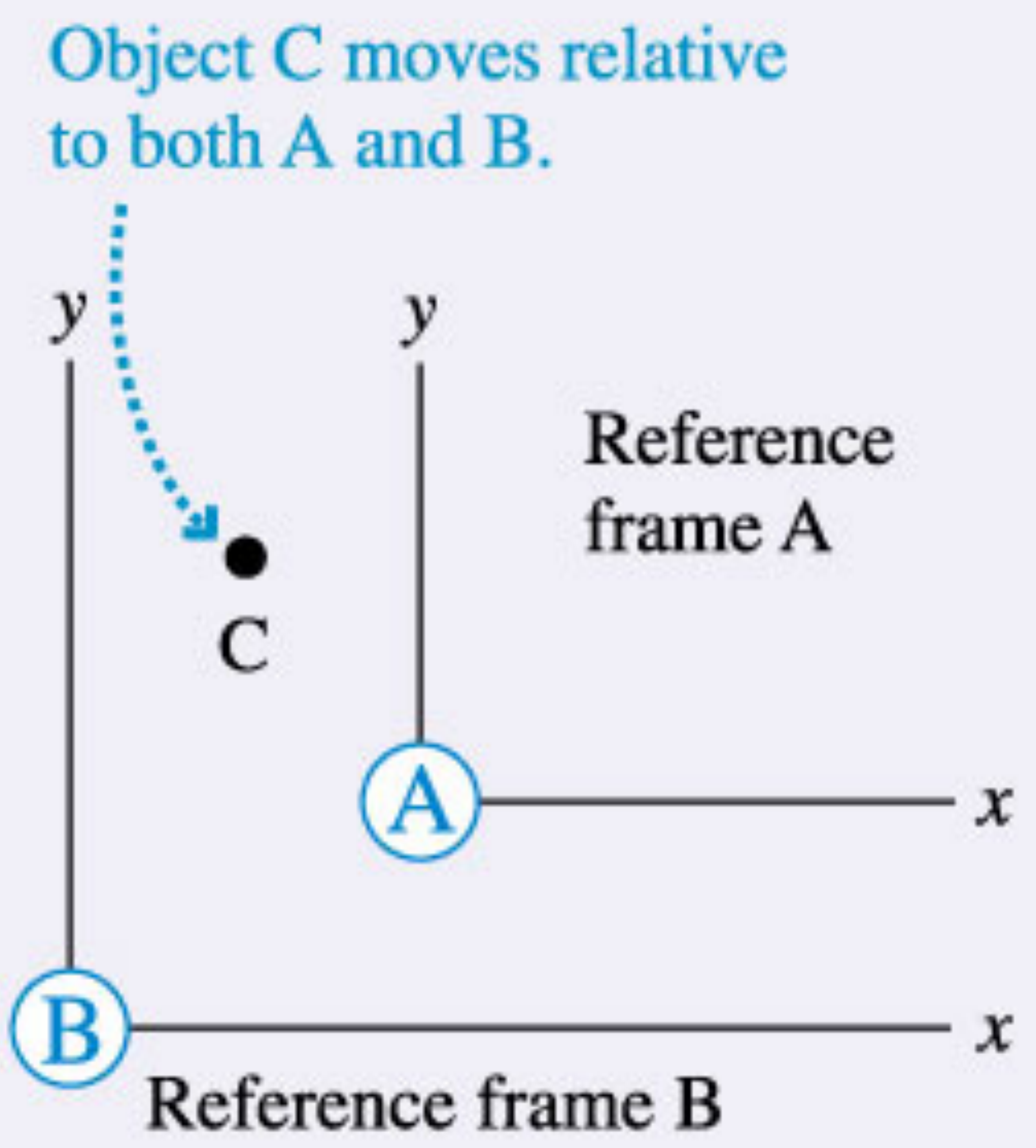
Important Concepts

Relative Motion

If object C moves relative to reference frame A with velocity $\vec{v}_{CA}$, then it moves relative to a different reference frame B with velocity

$$\vec{v}_{CB} = \vec{v}_{CA} + \vec{v}_{AB}$$

where $\vec{v}_{AB}$ is the velocity of A relative to B. This is the Galilean transformation of velocity.



Important Concepts

Uniform Circular Motion

Angular velocity $\omega = d\theta/dt$.

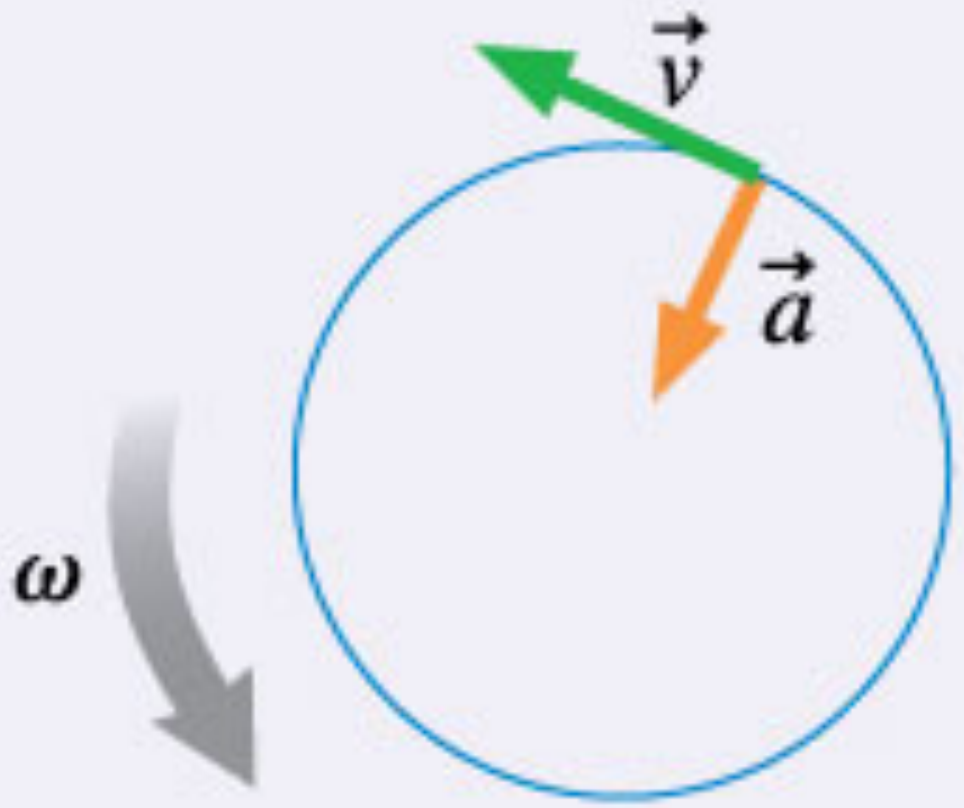
v_t and ω are constant:

$$v_t = \omega r$$

The centripetal acceleration points toward the center of the circle:

$$a = \frac{v^2}{r} = \omega^2 r$$

It changes the particle's direction but not its speed.

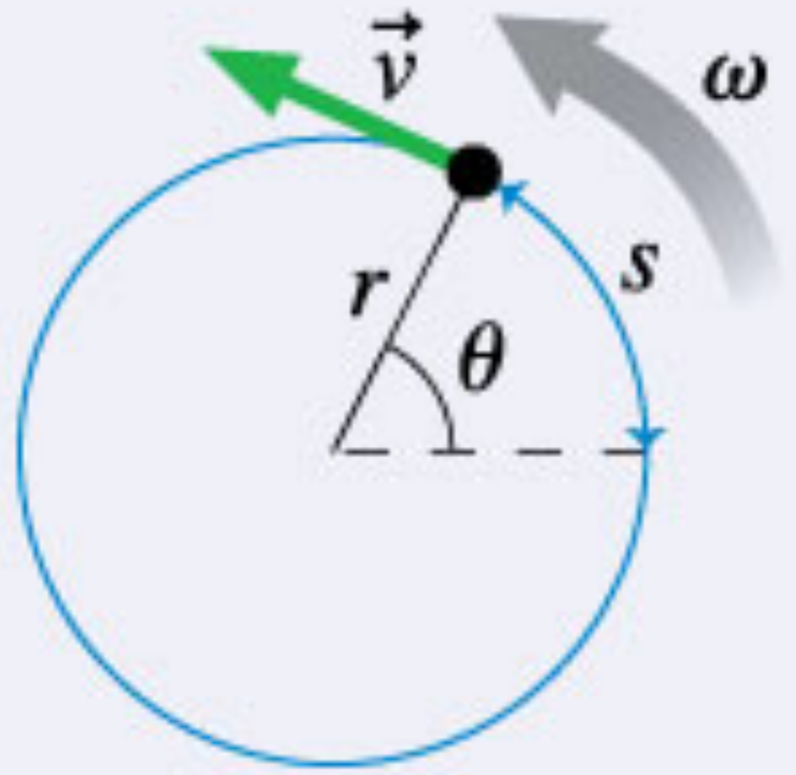


Important Concepts

Circular motion kinematics

Period $T = \dfrac{2\pi r}{v} = \dfrac{2\pi}{\omega}$

Angular position $\theta = \dfrac{s}{r}$



Constant angular acceleration

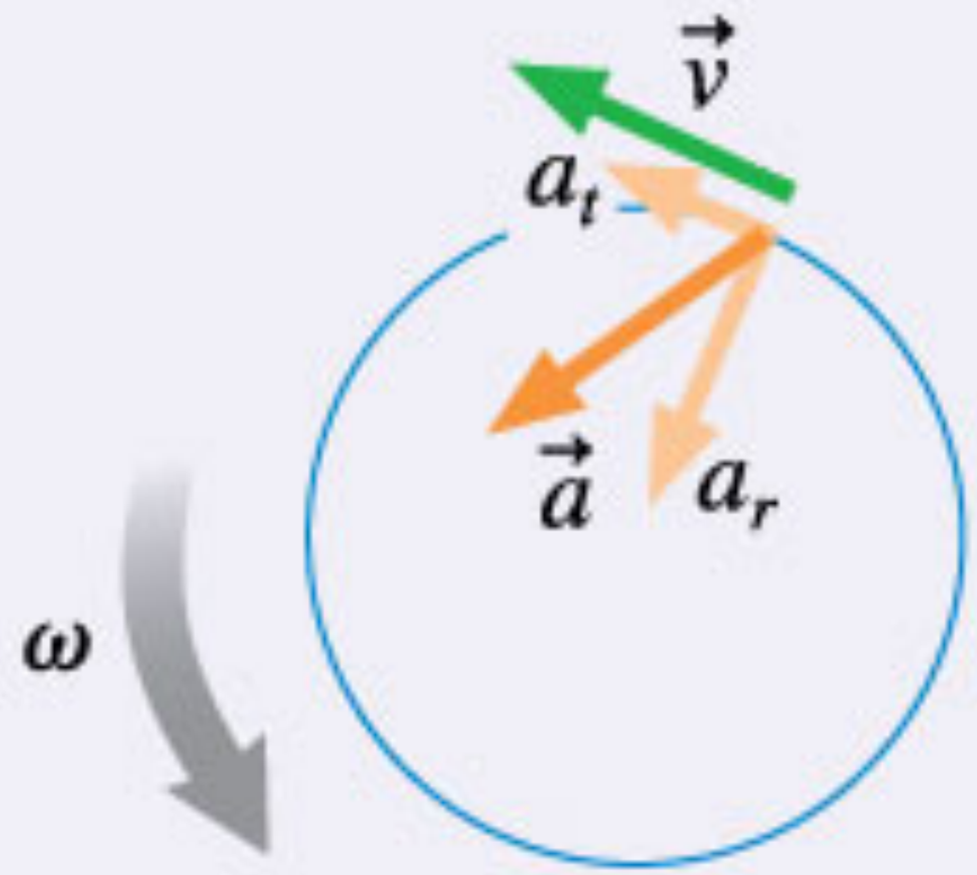
$$\omega_f = \omega_i + \alpha\,\Delta t$$
$$\theta_f = \theta_i + \omega_i\,\Delta t + \tfrac{1}{2}\alpha(\Delta t)^2$$
$$\omega_f^2 = \omega_i^2 + 2\alpha\,\Delta\theta$$

Important Concepts

Nonuniform Circular Motion

Angular acceleration $\alpha = d\omega/dt$.
The radial acceleration

$$a_r = \frac{v^2}{r} = \omega^2 r$$



changes the particle's direction. The tangential component

$$a_t = \alpha r$$

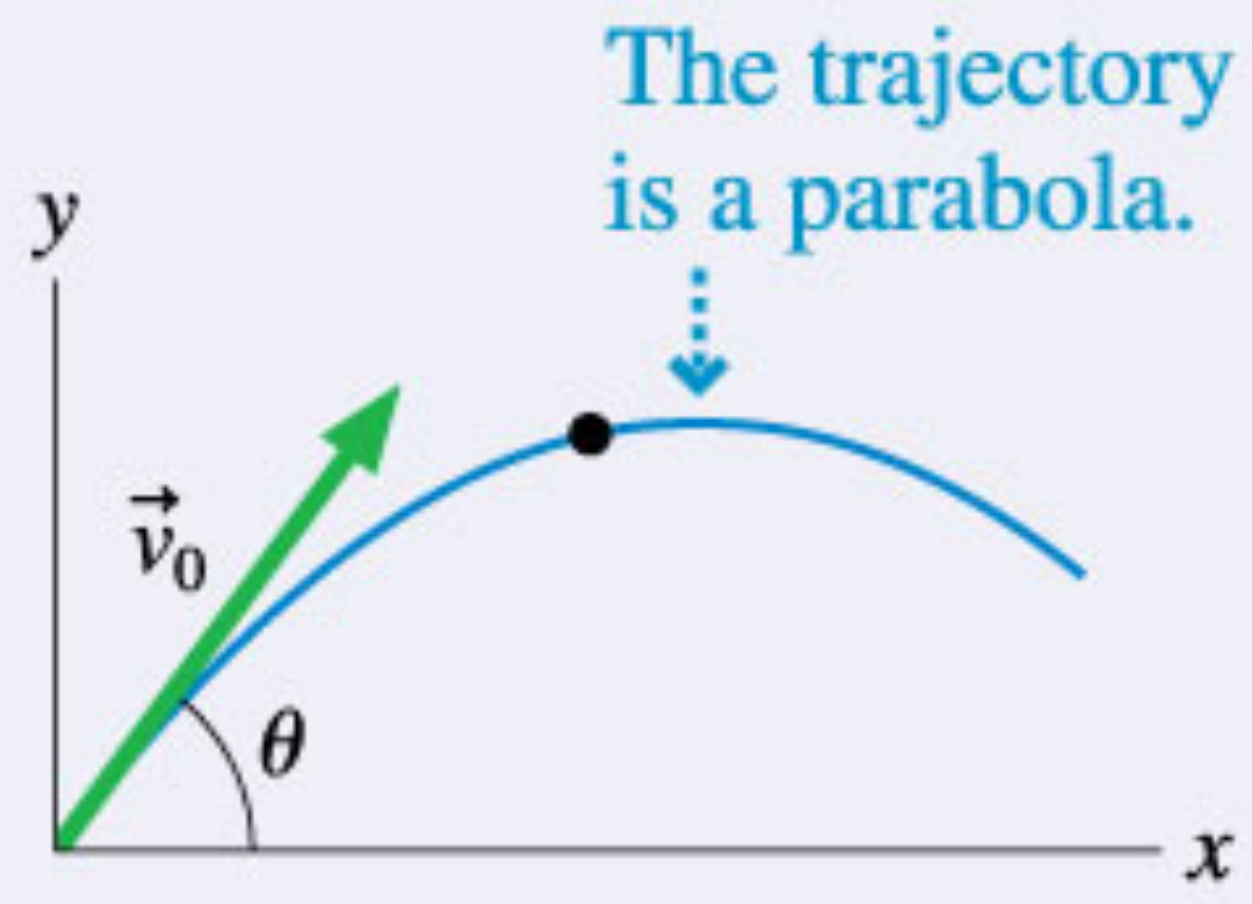
changes the particle's speed.

Important Concepts

Projectile motion is motion under the influence of only gravity.

MODEL Model as a particle launched with speed v_0 at angle θ.

VISUALIZE Use coordinates with the x-axis horizontal and the y-axis vertical.



SOLVE The horizontal motion is uniform with $v_x = v_0 \cos\theta$. The vertical motion is free fall with $a_y = -g$. The x and y kinematic equations have the *same* value for Δt.