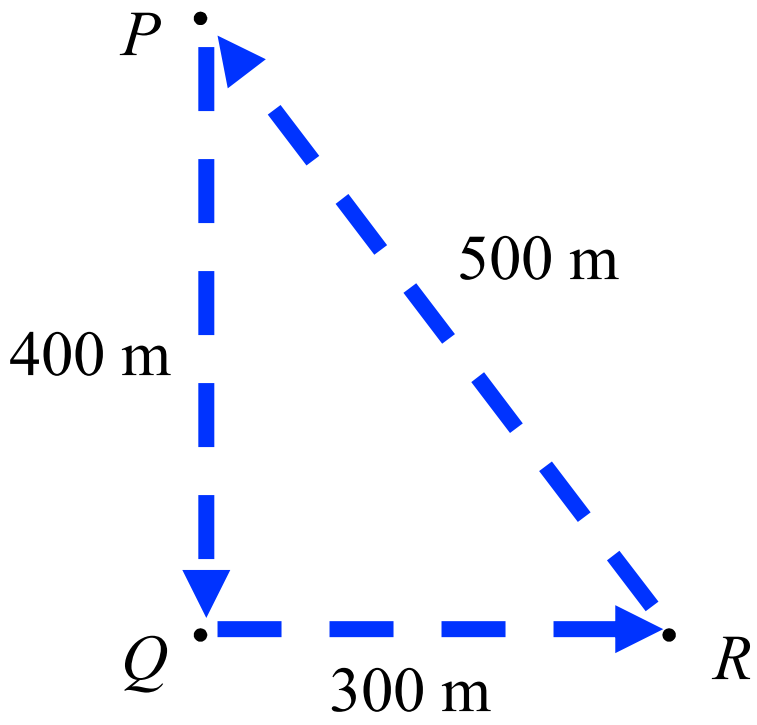
Q3.1

A bicyclist starts at point *P* and travels around a triangular path that takes her through points *Q* and *R* before returning to point *P*. What is the magnitude of her net displacement for the entire round trip?



A. 100 m

B. 200 m

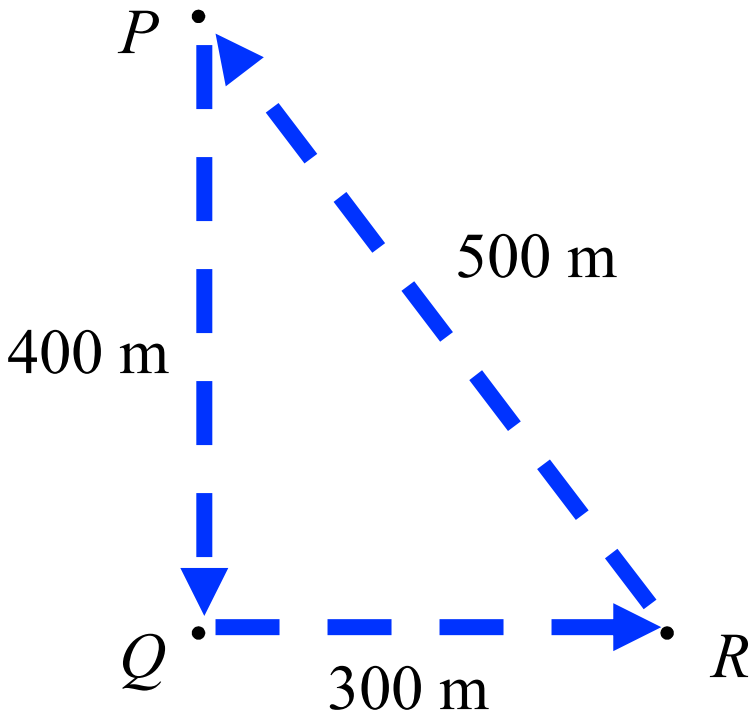
C. 600 m

D. 1200 m

E. zero

A3.1

A bicyclist starts at point P and travels around a triangular path that takes her through points Q and R before returning to point P. What is the magnitude of her net displacement for the entire round trip?



A. 100 m

B. 200 m

C. 600 m

D. 1200 m

✔ E. zero

Q3.2

In which of these situations would the *average* velocity vector over an interval be equal to the *instantaneous* velocity at the *end* of the interval?

A. a body moving along a curved path at constant speed
B. a body moving along a curved path and speeding up
C. a body moving along a straight line at constant speed
D. a body moving along a straight line and speeding up
E. more than one of these

A3.2

In which of these situations would the *average* velocity vector over an interval be equal to the *instantaneous* velocity at the *end* of the interval?

A. a body moving along a curved path at constant speed

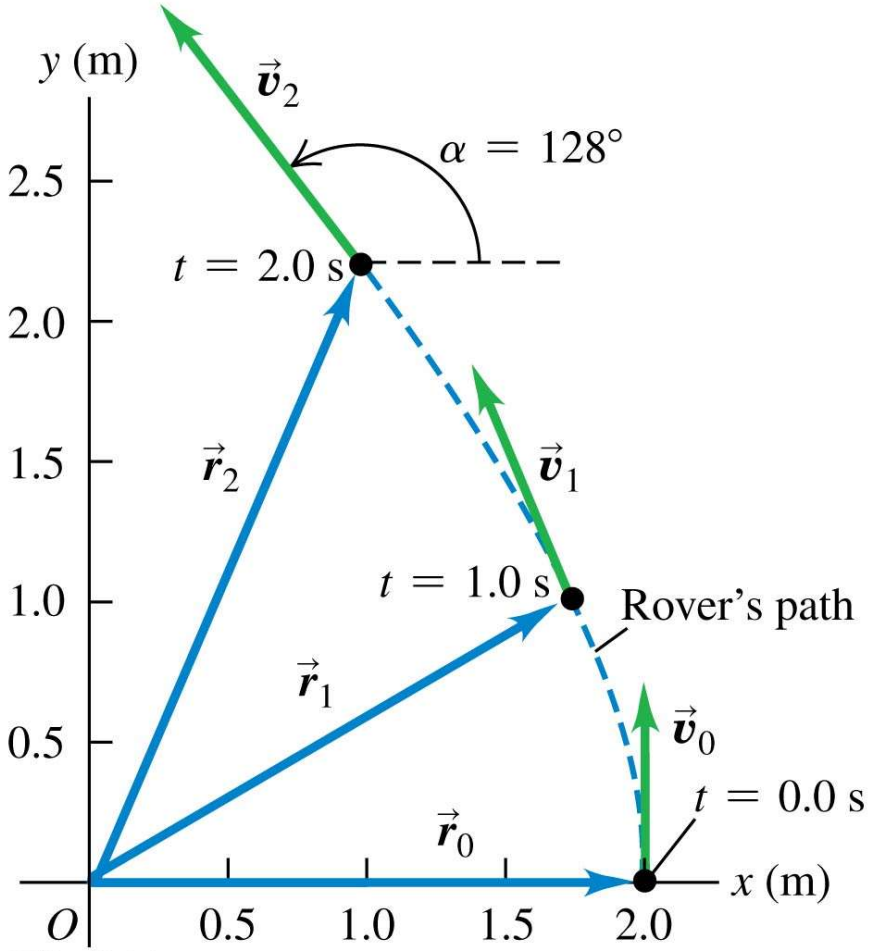
B. a body moving along a curved path and speeding up

C. a body moving along a straight line at constant speed

D. a body moving along a straight line and speeding up

E. more than one of these

Q3.3



This illustration shows the path of a robotic vehicle, or rover. What is the direction of the rover's average acceleration vector for the time interval from $t = 0.0$ s to $t = 2.0$ s?

A. up and to the left

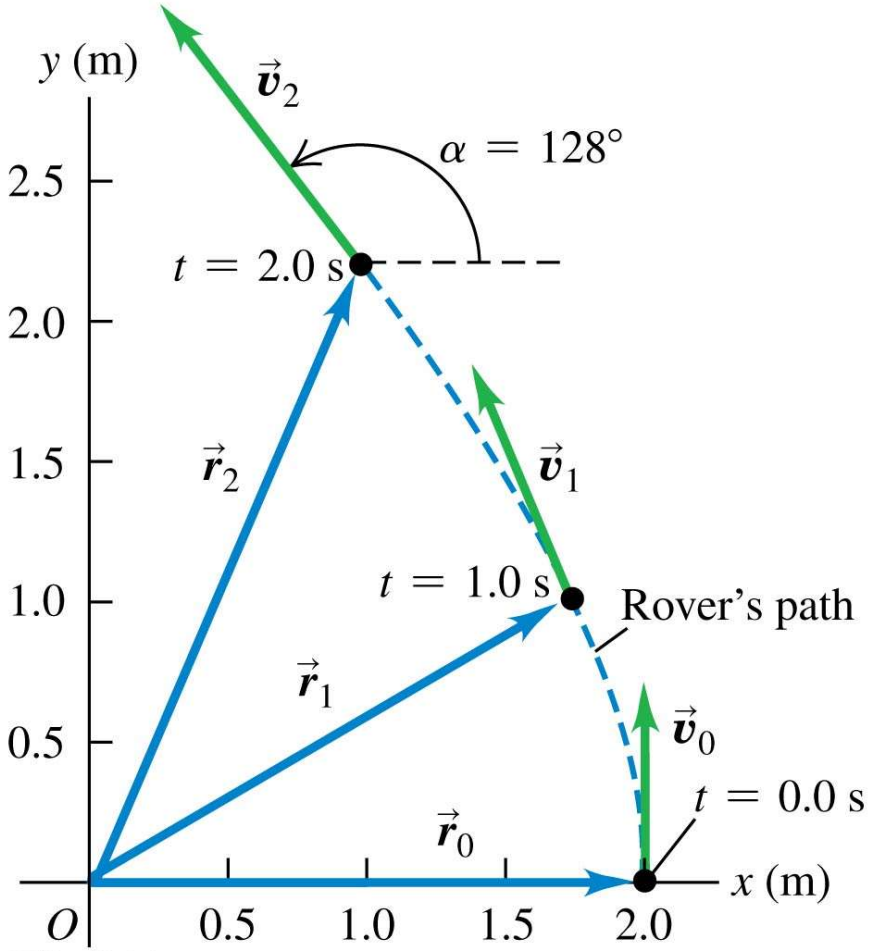
B. up and to the right

C. down and to the left

D. down and to the right

E. none of the above

A3.3



This illustration shows the path of a robotic vehicle, or rover. What is the direction of the rover's average acceleration vector for the time interval from $t = 0.0$ s to $t = 2.0$ s?

A. up and to the left

B. up and to the right

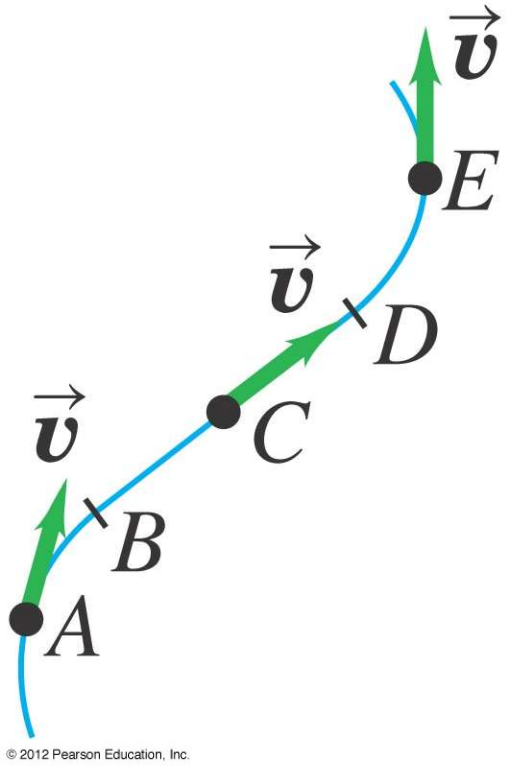
C. down and to the left

D. down and to the right

E. none of the above

Q3.4

The motion diagram shows an object moving along a curved path at constant speed. At which of the points *A, C,* and *E* does the object have *zero* acceleration?



A. point *A* only

B. point *C* only

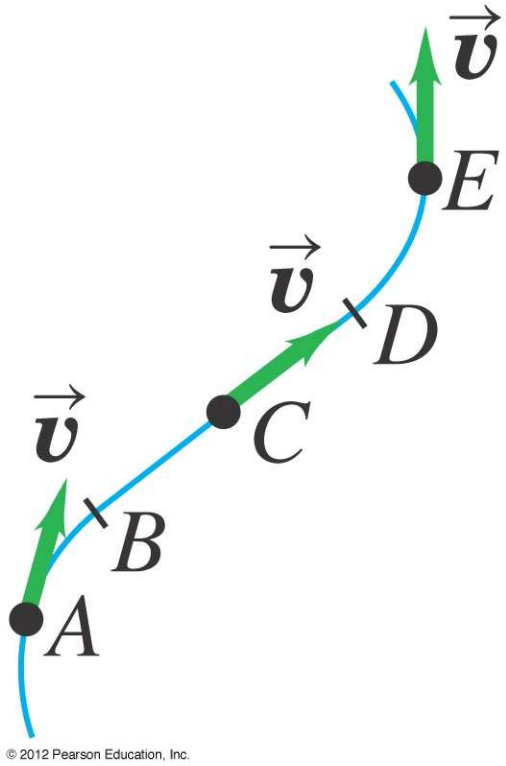
C. point *E* only

D. points *A* and *C* only

E. points *A, C,* and *E*

A3.4

The motion diagram shows an object moving along a curved path at constant speed. At which of the points *A, C,* and *E* does the object have *zero* acceleration?



A. point *A* only

✔ B. point *C* only

C. point *E* only

D. points *A* and *C* only

E. points *A, C,* and *E*

Q3.5

If a cyclist is going around a curve at constant speed, is he accelerating? If so, what is the direction of his acceleration?

A. No, he is not accelerating.

B. Yes, he is accelerating in the direction of his motion.

C. Yes, he is accelerating toward the inside of the curve.

D. Yes, he is accelerating toward the outside of the curve.

E. Yes, he is accelerating in some other direction.

A3.5

If a cyclist is going around a curve at constant speed, is he accelerating? If so, what is the direction of his acceleration?

A. No, he is not accelerating.

B. Yes, he is accelerating in the direction of his motion.

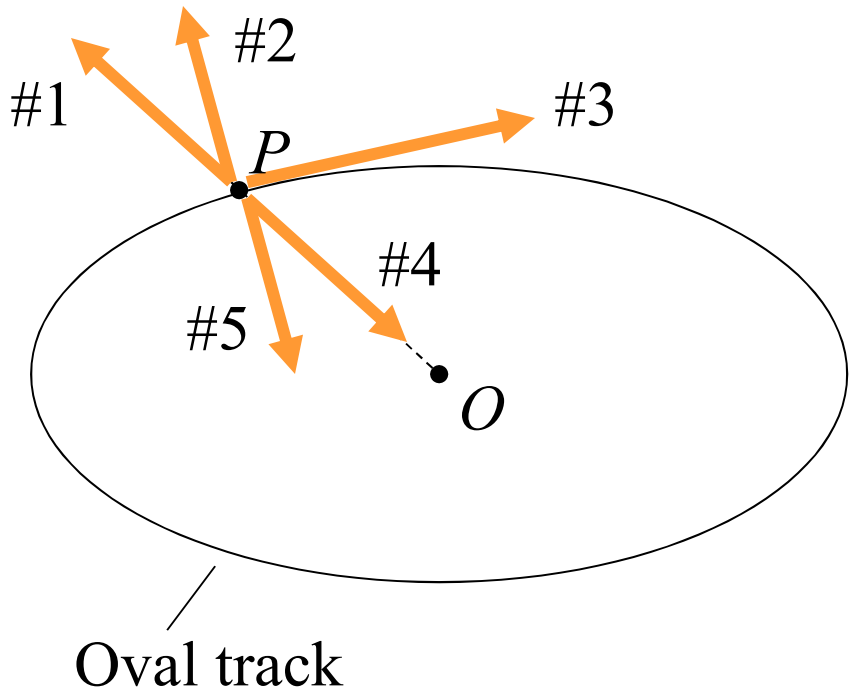
C. Yes, he is accelerating toward the inside of the curve.

D. Yes, he is accelerating toward the outside of the curve.

E. Yes, he is accelerating in some other direction.

Q3.6

An object moves at a constant speed in a clockwise direction around an oval track. The geometrical center of the track is at point *O*. When the object is at point *P*, which arrow shows the direction of the object's acceleration vector?



A. #1 (directly away from *O*)

B. #2 (perpendicular to the track)

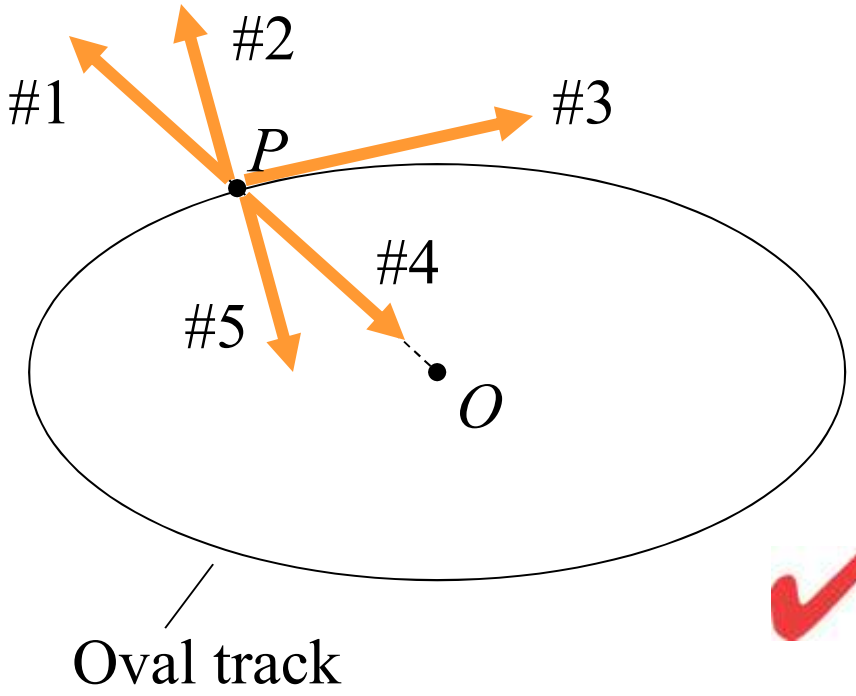
C. #3 (in the direction of motion)

D. #4 (directly toward *O*)

E. #5 (perpendicular to the track)

A3.6

An object moves at a constant speed in a clockwise direction around an oval track. The geometrical center of the track is at point *O*. When the object is at point *P*, which arrow shows the direction of the object's acceleration vector?



A. #1 (directly away from *O*)

B. #2 (perpendicular to the track)

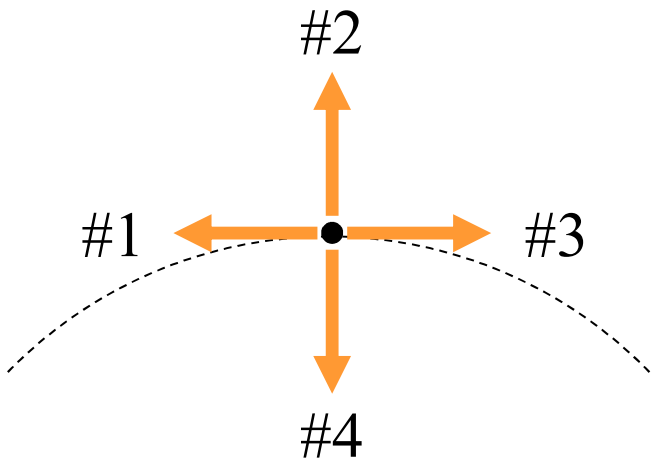
C. #3 (in the direction of motion)

D. #4 (directly toward *O*)

✔ E. #5 (perpendicular to the track)

Q3.7

A sled travels over the crest of a snow-covered hill. The sled slows down as it climbs up the left-hand side of the hill and gains speed as it descends on the right-hand side. Which of the vectors in the figure correctly shows the direction of the sled's acceleration at the crest?



A. #1 (to the left)

B. #2 (straight up)

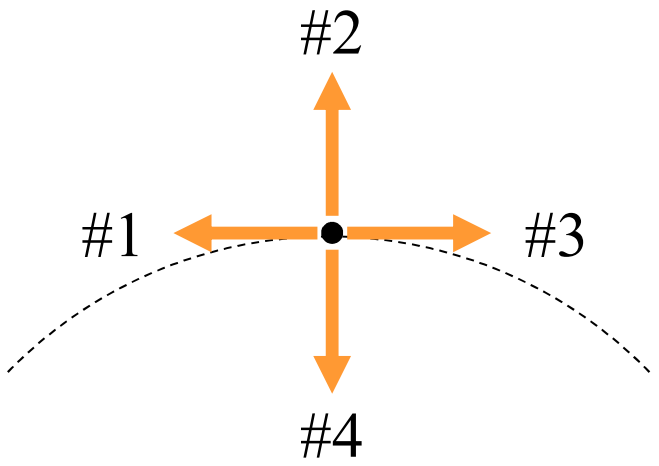
C. #3 (to the right)

D. #4 (straight down)

E. none of these

A3.7

A sled travels over the crest of a snow-covered hill. The sled slows down as it climbs up the left-hand side of the hill and gains speed as it descends on the right-hand side. Which of the vectors in the figure correctly shows the direction of the sled's acceleration at the crest?



A. #1 (to the left)

B. #2 (straight up)

C. #3 (to the right)

✔ D. #4 (straight down)

E. none of these

Q3.8

A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration as it moves from left to right through point *Q* (the low point of the motion)?

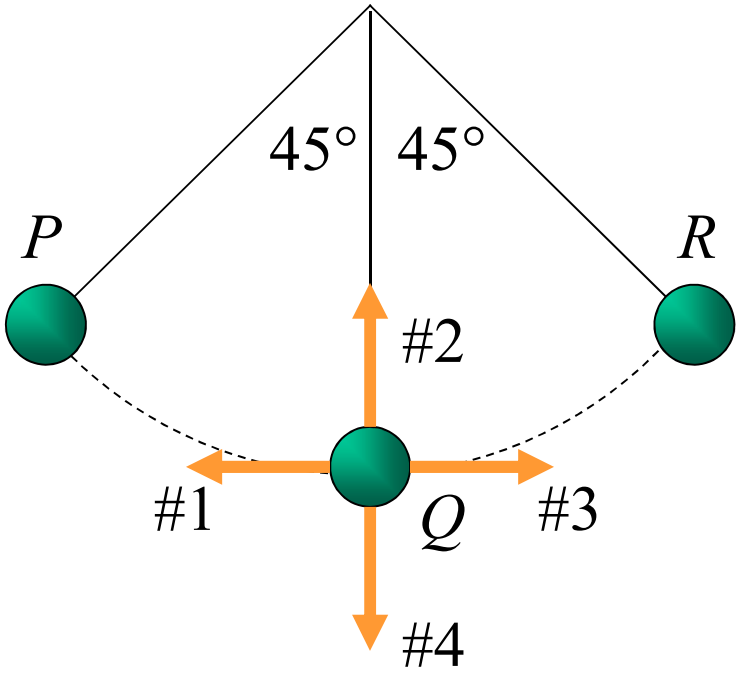
A. #1 (to the left)

B. #2 (straight up)

C. #3 (to the right)

D. #4 (straight down)

E. misleading question—the acceleration is zero at *Q*



A3.8

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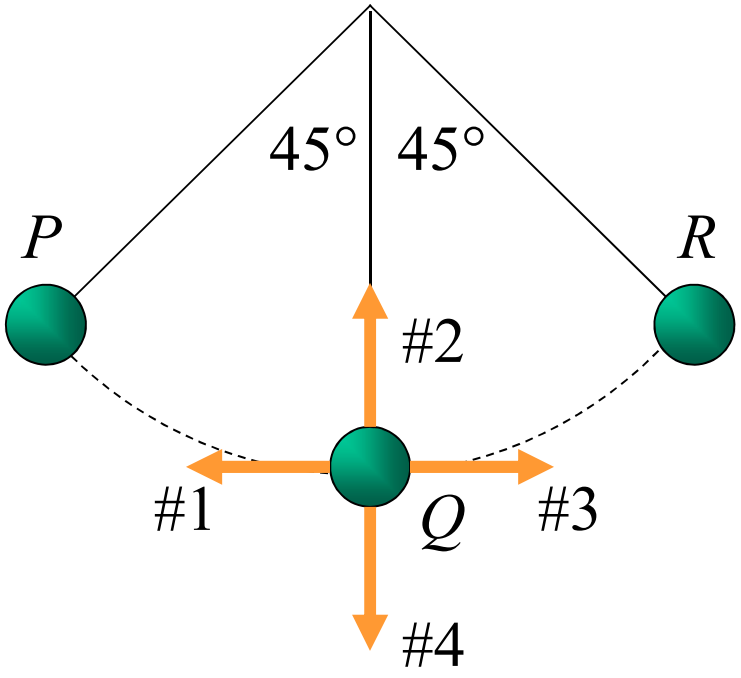
A. #1 (to the left)

✔ B. #2 (straight up)

C. #3 (to the right)

D. #4 (straight down)

E. misleading question—the acceleration is zero at *Q*



Q3.9

A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration at *P* (the far left point of the motion)?

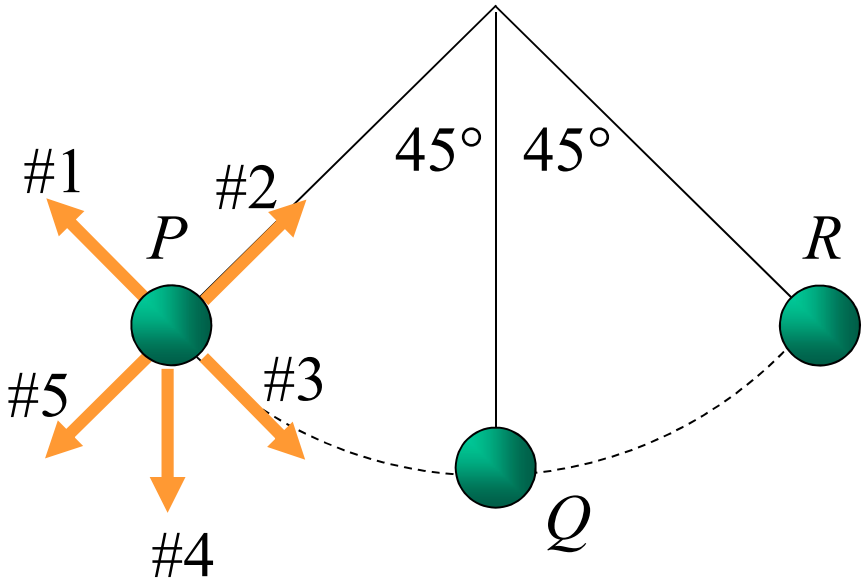
A. #1 (up and to the left)

B. #2 (up and to the right)

C. #3 (down and to the right)

D. #4 (straight down)

E. #5 (down and to the left)



A3.9

A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration at *P* (the far left point of the motion)?

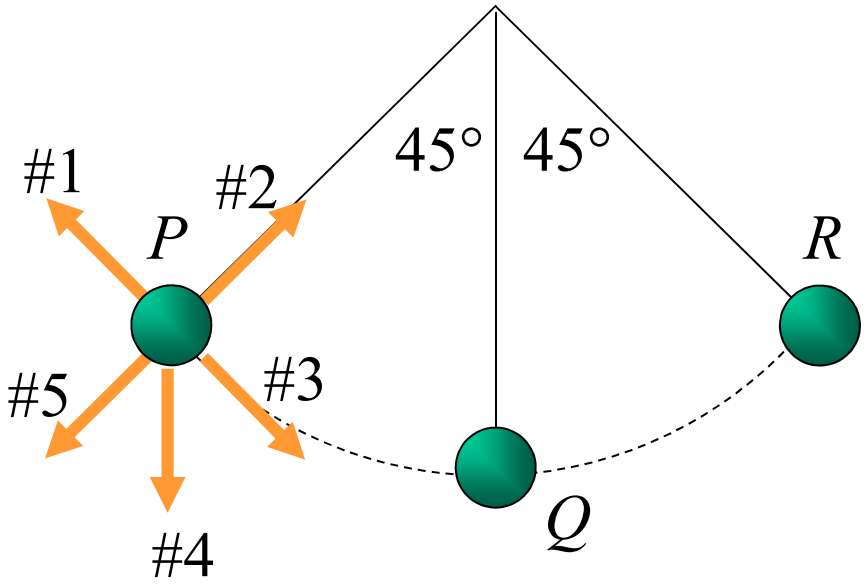
A. #1 (up and to the left)

B. #2 (up and to the right)

C. #3 (down and to the right)

D. #4 (straight down)

E. #5 (down and to the left)



Q3.10

The velocity and acceleration of an object at a certain instant are

$$\vec{v} = (3.0\ \text{m/s})\,\hat{j}$$

$$\vec{a} = (0.5\ \text{m/s}^2)\,\hat{i} - (0.2\ \text{m/s}^2)\,\hat{j}$$

At this instant, the object is

A. speeding up and following a curved path.

B. speeding up and moving in a straight line.

C. slowing down and following a curved path.

D. slowing down and moving in a straight line.

E. none of these.

A3.10

The velocity and acceleration of an object at a certain instant are

$$\vec{v} = (3.0\ \text{m/s})\,\hat{j}$$

$$\vec{a} = (0.5\ \text{m/s}^2)\,\hat{i} - (0.2\ \text{m/s}^2)\,\hat{j}$$

At this instant, the object is

A. speeding up and following a curved path.

B. speeding up and moving in a straight line.

✔ C. slowing down and following a curved path.

D. slowing down and moving in a straight line.

E. none of these.

Q3.11

The velocity and acceleration of an object at a certain instant are

$$\vec{v} = \left(2.0\ \text{m/s}^2\right)\hat{i} + \left(3.0\ \text{m/s}\right)\hat{j}$$

$$\vec{a} = \left(0.5\ \text{m/s}^2\right)\hat{i} - \left(0.2\ \text{m/s}^2\right)\hat{j}$$

At this instant, the object is

A. speeding up and following a curved path.

B. speeding up and moving in a straight line.

C. slowing down and following a curved path.

D. slowing down and moving in a straight line.

E. none of these.

A3.11

The velocity and acceleration of an object at a certain instant are

$$\vec{v} = \left(2.0\ \text{m/s}^2\right)\hat{i} + \left(3.0\ \text{m/s}\right)\hat{j}$$

$$\vec{a} = \left(0.5\ \text{m/s}^2\right)\hat{i} - \left(0.2\ \text{m/s}^2\right)\hat{j}$$

At this instant, the object is

A. speeding up and following a curved path.

B. speeding up and moving in a straight line.

C. slowing down and following a curved path.

D. slowing down and moving in a straight line.

E. none of these.

Q3.12

You drop a ball from rest and simultaneously shoot a second, identical ball horizontally from the same height as the first ball. If there is no air resistance, which ball hits the ground first?

A. The dropped ball hits first.

B. The ball shot horizontally hits first.

C. They both hit at the same time.

D. Answer depends on the speed with which the second ball is shot.

E. Answer depends on the speed with which the second ball is shot *and* the masses of the balls.

A3.12

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E. Answer depends on the speed with which the second ball is shot *and* the masses of the balls.

Q3.13

An object is dropped from an airplane flying at a constant speed in a straight line at a constant altitude. If there is no air resistance, the falling object will (as seen from the ground)

A. lag behind the airplane, but still move forward.
B. lag behind the airplane and fall straight down.
C. lag behind the airplane and move backward.
D. remain directly under the airplane.
E. move ahead of the airplane.

A3.13

An object is dropped from an airplane flying at a constant speed in a straight line at a constant altitude. If there is no air resistance, the falling object will (as seen from the ground)

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B. lag behind the airplane and fall straight down.

C. lag behind the airplane and move backward.

D. remain directly under the airplane.

E. move ahead of the airplane.

Q3.14

A zookeeper fires a tranquilizer dart directly at a monkey. The monkey lets go of the branch from which he is hanging at the same instant that the dart leaves the gun barrel. The dart reaches a maximum height *P* before striking the monkey. Ignore air resistance.

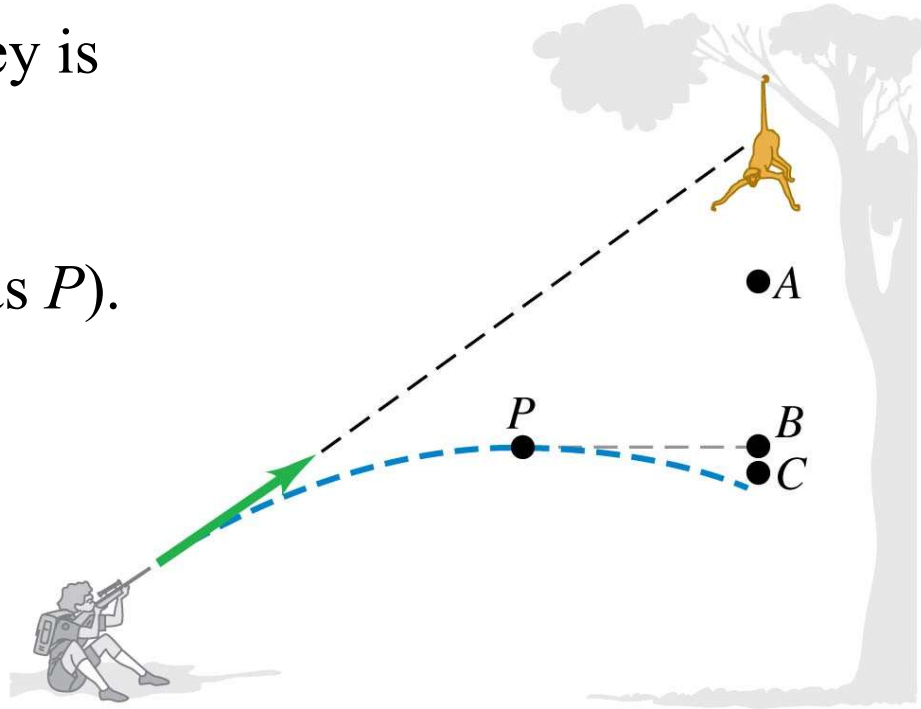
When the dart is at *P*, the monkey is

A. at *A* (higher than *P*).

B. at *B* (at the same height as *P*).

C. at *C* (lower than *P*).

D. at unknown height because not enough information is given to decide.



A3.14

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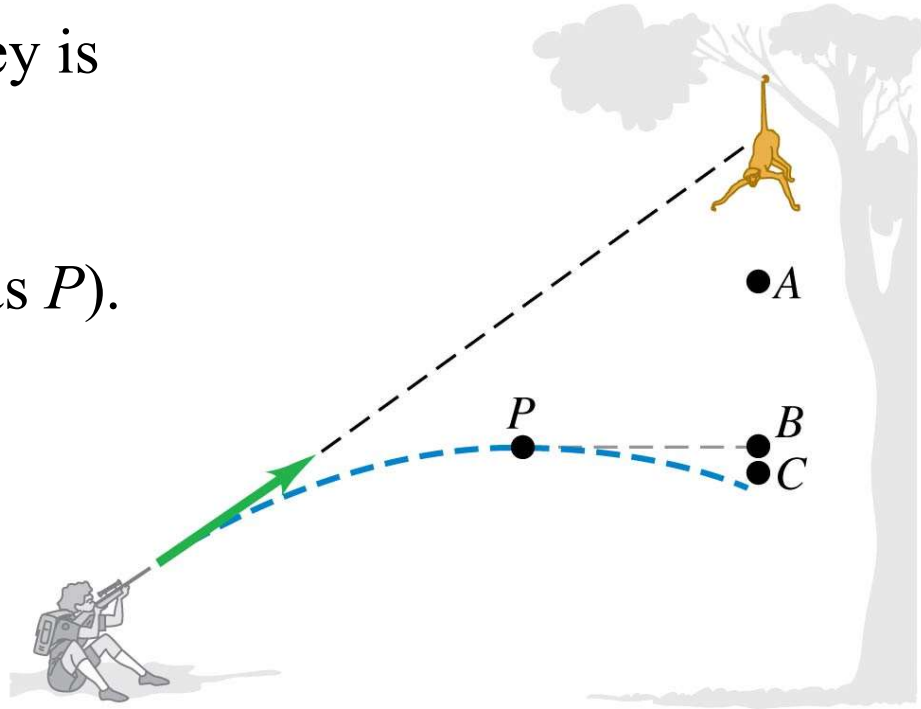

Q3.15

A projectile is launched at a 30° angle above the horizontal. Ignore air resistance. The projectile's acceleration is greatest

A. at a point between the launch point and the high point of the trajectory.

B. at the high point of the trajectory.

C. at a point between the high point of the trajectory and where it hits the ground.

D. misleading question—the acceleration is the same (but nonzero) at all points along the trajectory

E. misleading question—the acceleration is zero at all points along the trajectory

A3.15

A projectile is launched at a 30° angle above the horizontal. Ignore air resistance. The projectile's acceleration is greatest

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C. at a point between the high point of the trajectory and where it hits the ground.

D. misleading question—the acceleration is the same (but nonzero) at all points along the trajectory

E. misleading question—the acceleration is zero at all points along the trajectory

Q3.16

You drive a race car around a circular track of radius 100 m at a constant speed of 100 km/h. If you then drive the same car around a different circular track of radius 200 m at a constant speed of 200 km/h, your acceleration will be

A. eight times greater.
B. four times greater.
C. twice as great.
D. the same.
E. half as great.

A3.16

You drive a race car around a circular track of radius 100 m at a constant speed of 100 km/h. If you then drive the same car around a different circular track of radius 200 m at a constant speed of 200 km/h, your acceleration will be

A. eight times greater.

B. four times greater.

C. twice as great.

D. the same.

E. half as great.

Q3.17

A roller coaster car moves around a vertical circle. At the bottom of the circle, the car experiences four times as much radial acceleration as at the top of the circle. Compared to its speed at the top of the circle, the speed of the car at the bottom of the circle is

A. $\sqrt{2}$ times as great.

B. twice as great.

C. $2\sqrt{2}$ times as great.

D. four times as great.

E. 16 times as great.

A3.17

A roller coaster car moves around a vertical circle. At the bottom of the circle, the car experiences four times as much radial acceleration as at the top of the circle. Compared to its speed at the top of the circle, the speed of the car at the bottom of the circle is

A. $\sqrt{2}$ times as great.

B. twice as great.

C. $2\sqrt{2}$ times as great.

D. four times as great.

E. 16 times as great.

Q3.18

The pilot of a light airplane with an airspeed of 200 km/h wants to fly due west. There is a strong wind of 120 km/h blowing from the north. If the pilot points the nose of the airplane north of west so that her ground track is due west, what will be her ground speed?

A. 80 km/h

B. 120 km/h

C. 160 km/h

D. 180 km/h

E. It would be impossible to fly due west in this situation.

A3.18

The pilot of a light airplane with an airspeed of 200 km/h wants to fly due west. There is a strong wind of 120 km/h blowing from the north. If the pilot points the nose of the airplane north of west so that her ground track is due west, what will be her ground speed?

A. 80 km/h

B. 120 km/h

C. 160 km/h

D. 180 km/h

E. It would be impossible to fly due west in this situation.

Q3.19

Suppose the nose of an airplane is pointed due east and the airplane has an airspeed of 150 km/h. Due to the wind, the airplane is moving due north relative to the ground and its speed relative to the ground is 150 km/h. What is the velocity of the air relative to the earth?

A. 150 km/h from southwest to northeast
B. 150 km/h from southeast to northwest
C. 212 km/h from southwest to northeast
D. 212 km/h from southeast to northwest
E. There is no possible wind that would make this airplane move north at 150 km/h.

A3.19

Suppose the nose of an airplane is pointed due east and the airplane has an airspeed of 150 km/h. Due to the wind, the airplane is moving due north relative to the ground and its speed relative to the ground is 150 km/h. What is the velocity of the air relative to the earth?

A. 150 km/h from southwest to northeast

B. 150 km/h from southeast to northwest

C. 212 km/h from southwest to northeast

D. 212 km/h from southeast to northwest

E. There is no possible wind that would make this airplane move north at 150 km/h.

Q-RT3.1

The table below lists the instantaneous velocities of five objects (A, B, C, D, and E) at $t = 0$ and at $t = 10.0$ s. **Rank the objects** in order of the magnitude of their average acceleration during the interval from $t = 0$ to $t = 10.0$ s, from largest to smallest.

Object	Velocity at $t = 0$	Velocity at $t = 10.0$ s
A	3.00 m/s, east	2.00 m/s, east
B	3.00 m/s, east	4.00 m/s, north
C	3.00 m/s, east	5.00 m/s, east
D	3.00 m/s, east	5.00 m/s, west
E	3.00 m/s, east	zero

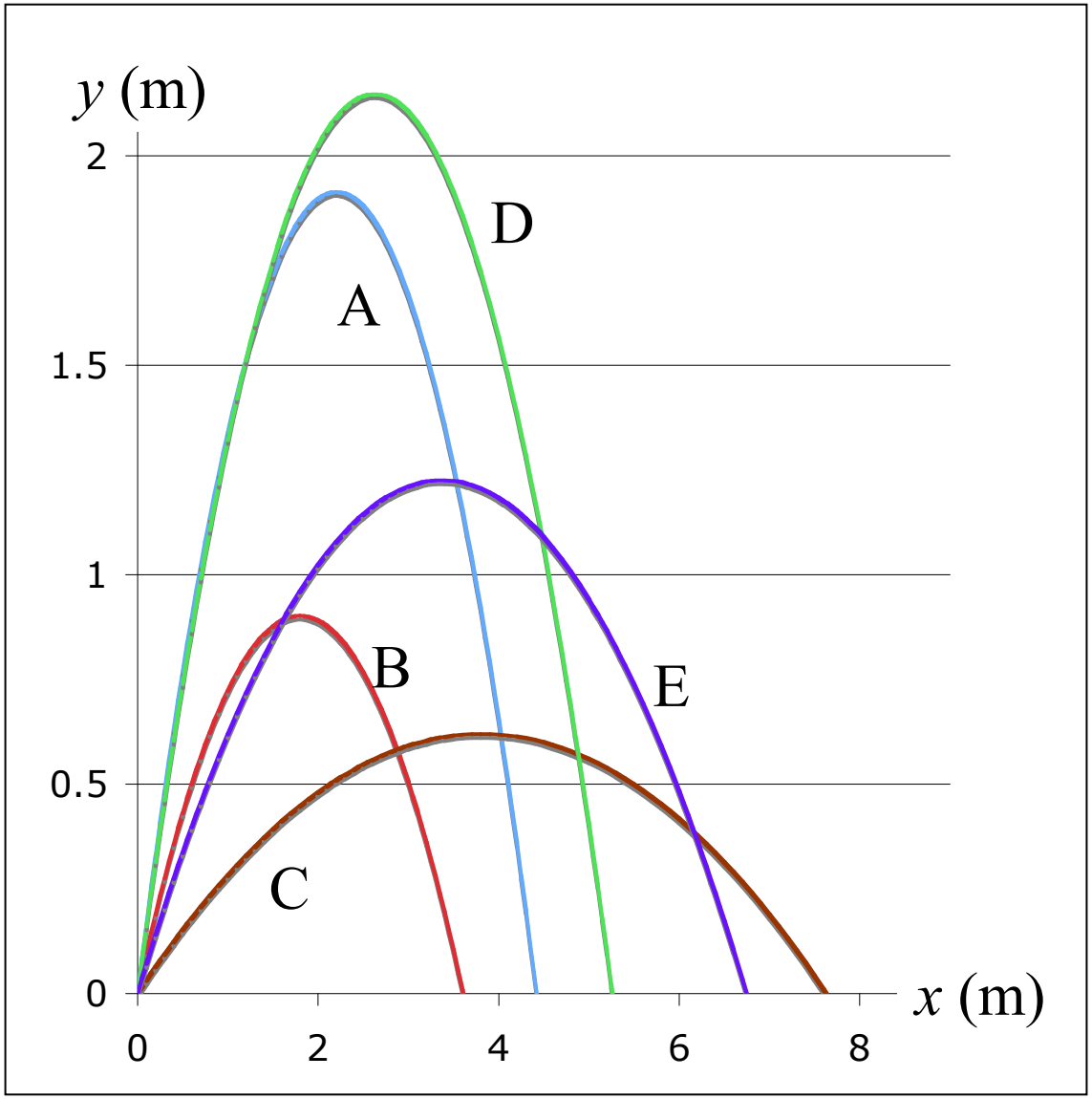
A-RT3.1

The table below lists the instantaneous velocities of five objects (A, B, C, D, and E) at $t = 0$ and at $t = 10.0$ s. **Rank the objects** in order of the magnitude of their average acceleration during the interval from $t = 0$ to $t = 10.0$ s, from largest to smallest.

Object	Velocity at $t = 0$	Velocity at $t = 10.0$ s
A	3.00 m/s, east	2.00 m/s, east
B	3.00 m/s, east	4.00 m/s, north
C	3.00 m/s, east	5.00 m/s, east
D	3.00 m/s, east	5.00 m/s, west
E	3.00 m/s, east	zero

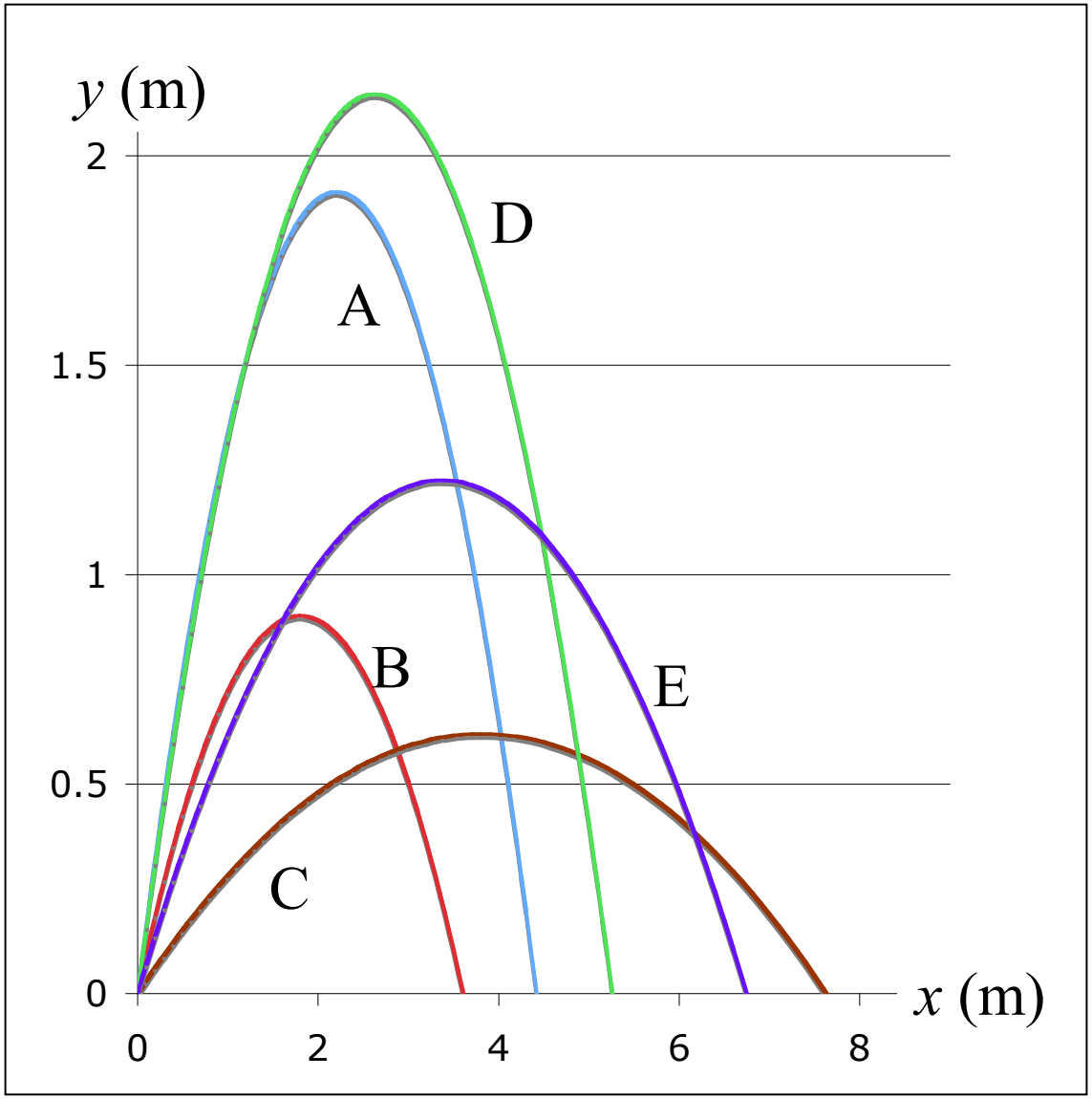
✔ Answer: ACEBD

Q-RT3.2



Five identical objects, A through E, are launched simultaneously from the ground. Air resistance can be ignored. **Rank the objects** in order of when they hit the ground, from first to last.

A-RT3.2



Five identical objects, A through E, are launched simultaneously from the ground. Air resistance can be ignored. **Rank the objects** in order of when they hit the ground, from first to last.

✔ Answer: CBEAD

Q-RT3.3

The table below lists the properties of five objects (A, B, C, D, and E) that each move around a circle at a constant speed. **Rank the objects** in order of the magnitude of their acceleration, from largest to smallest.

Object	Speed	Radius of circle
A	5.00 m/s	5.00 m
B	5.00 m/s	10.0 m
C	5.00 m/s	20.0 m
D	10.0 m/s	5.00 m
E	10.0 m/s	10.0 m

A-RT3.3

The table below lists the properties of five objects (A, B, C, D, and E) that each move around a circle at a constant speed. **Rank the objects** in order of the magnitude of their acceleration, from largest to smallest.

Object	Speed	Radius of circle
A	5.00 m/s	5.00 m
B	5.00 m/s	10.0 m
C	5.00 m/s	20.0 m
D	10.0 m/s	5.00 m
E	10.0 m/s	10.0 m

Answer: DEABC