Fictitious Forces

Reminder:

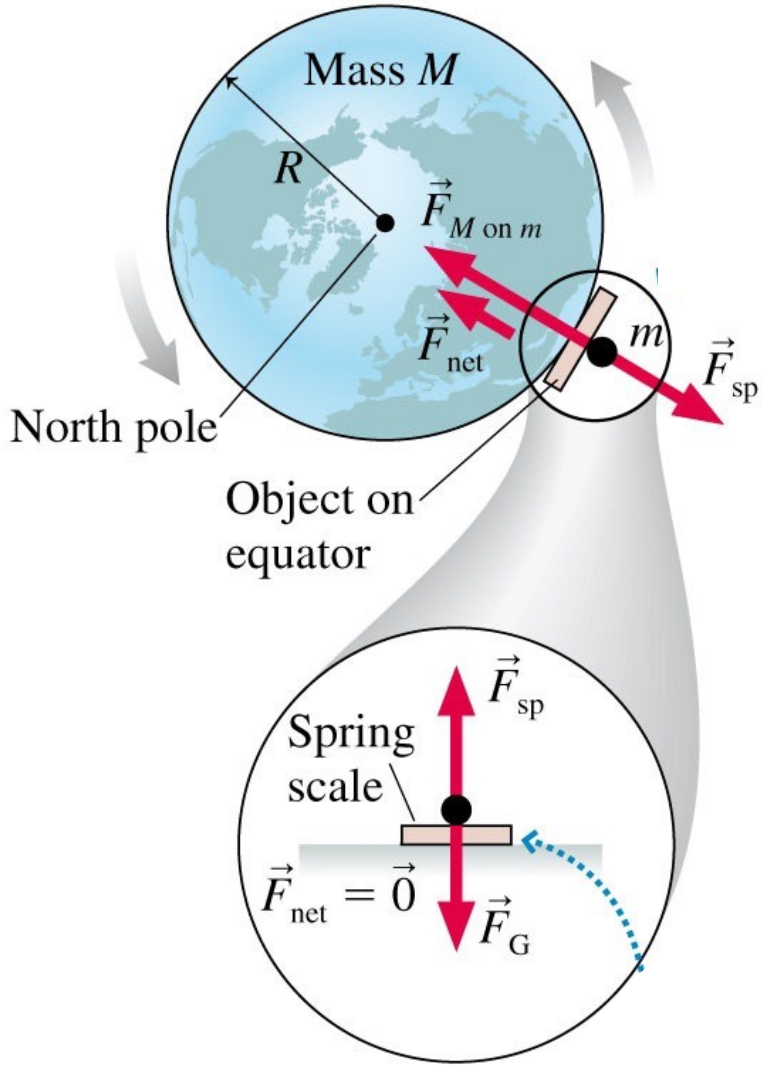
What is the difference between an inertial reference frame and a non-inertial one?

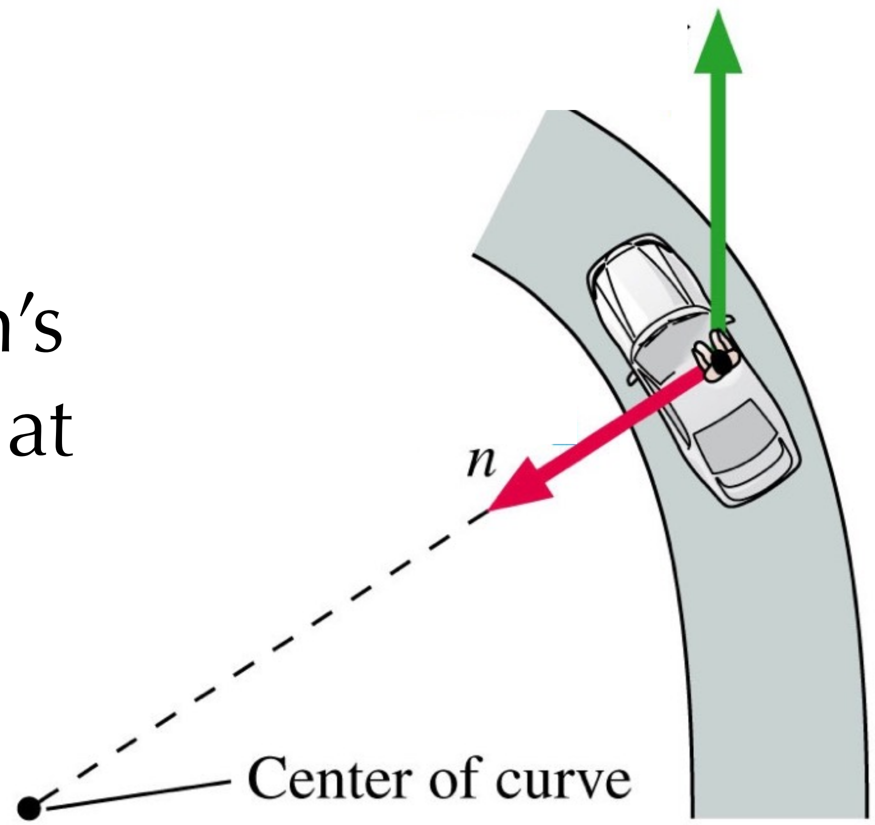
Which reference frame is non-inertial?

Centrifugal Force?

Which reference frame is non-inertial?

What does the person's motion look like in that frame?

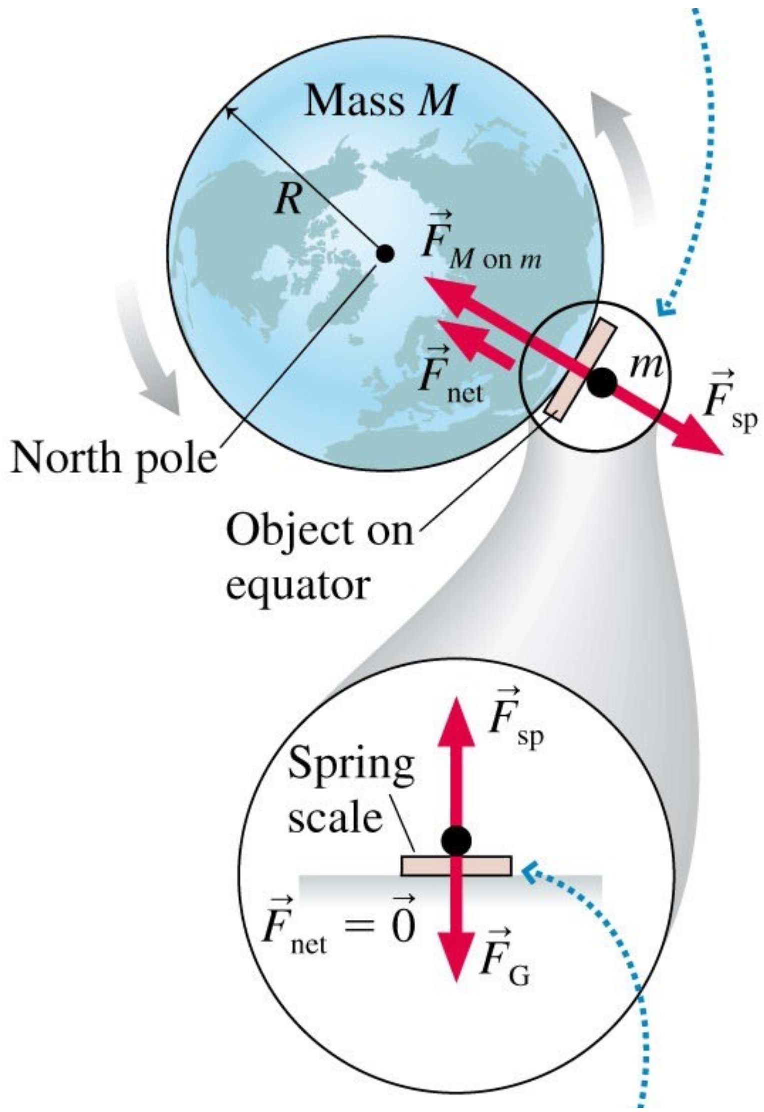




Coriolis force movie

Gravity on a rotating Earth

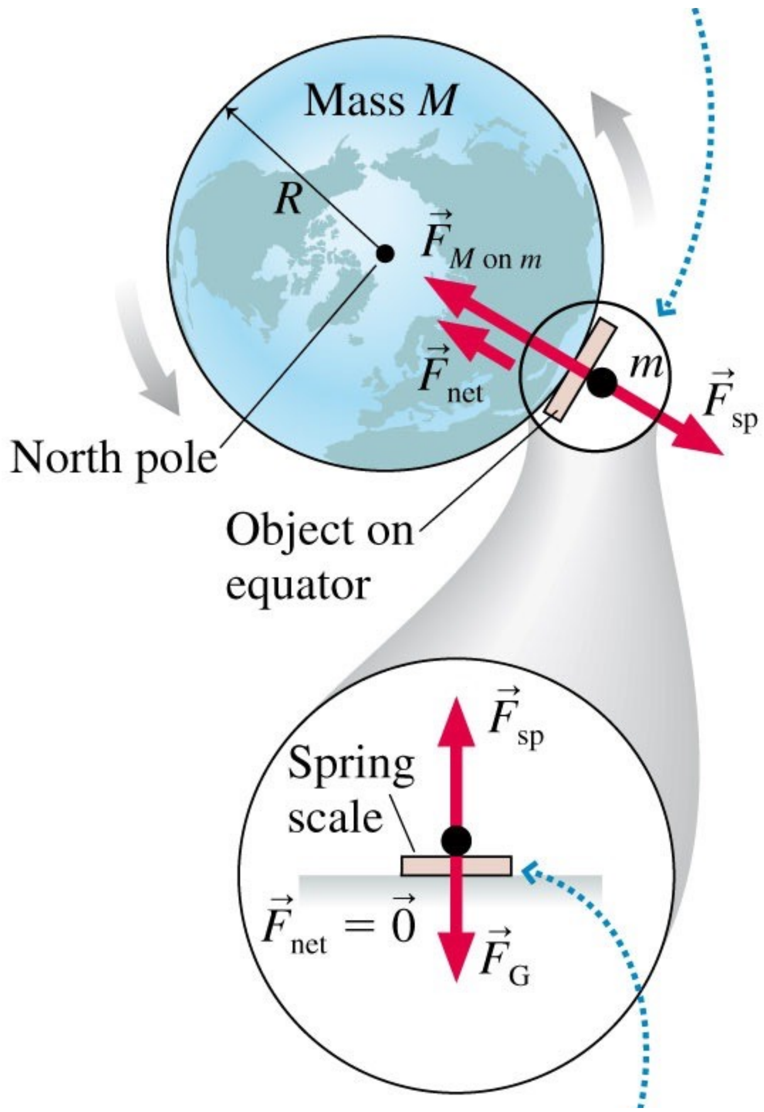
Are we in an inertial reference frame right now?



Gravity on a rotating Earth

Are we in an inertial reference frame right now?

$$7.3 \times 10^{-5} \text{ rads/sec}$$

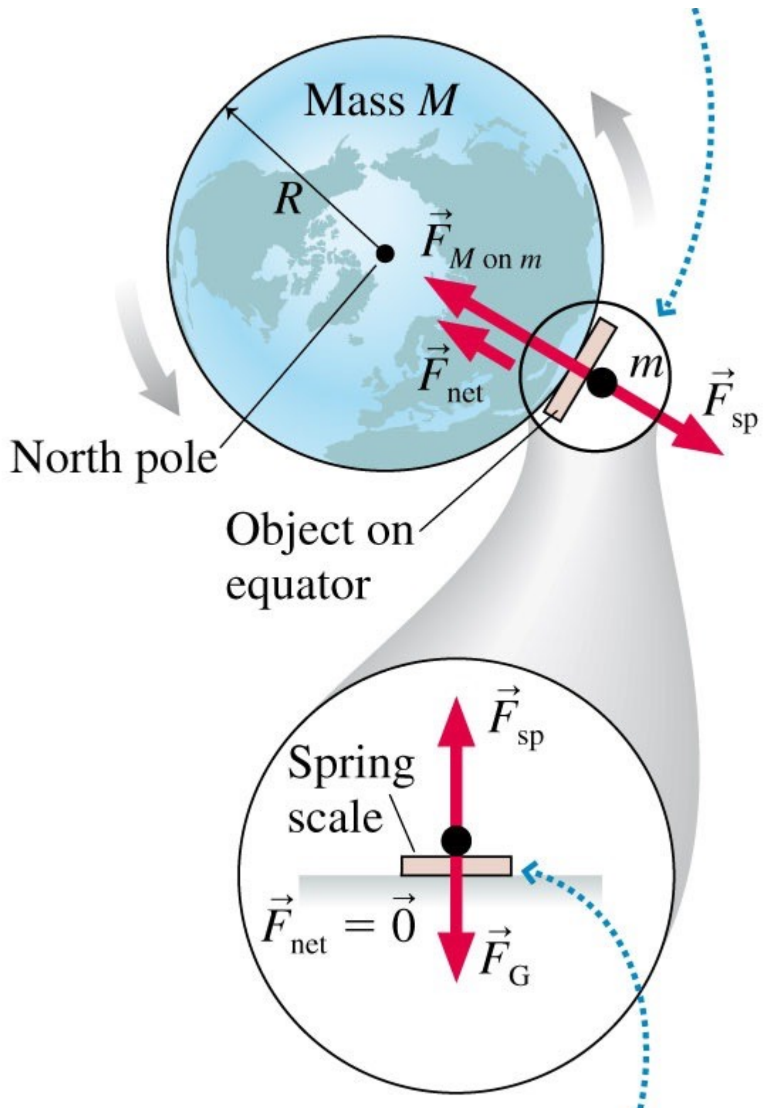


Gravity on a rotating Earth

Are we in an inertial reference frame right now?

$$7.3 \times 10^{-5} \text{ rads/sec}$$

$$6.37 \times 10^{6} \text{ m}$$



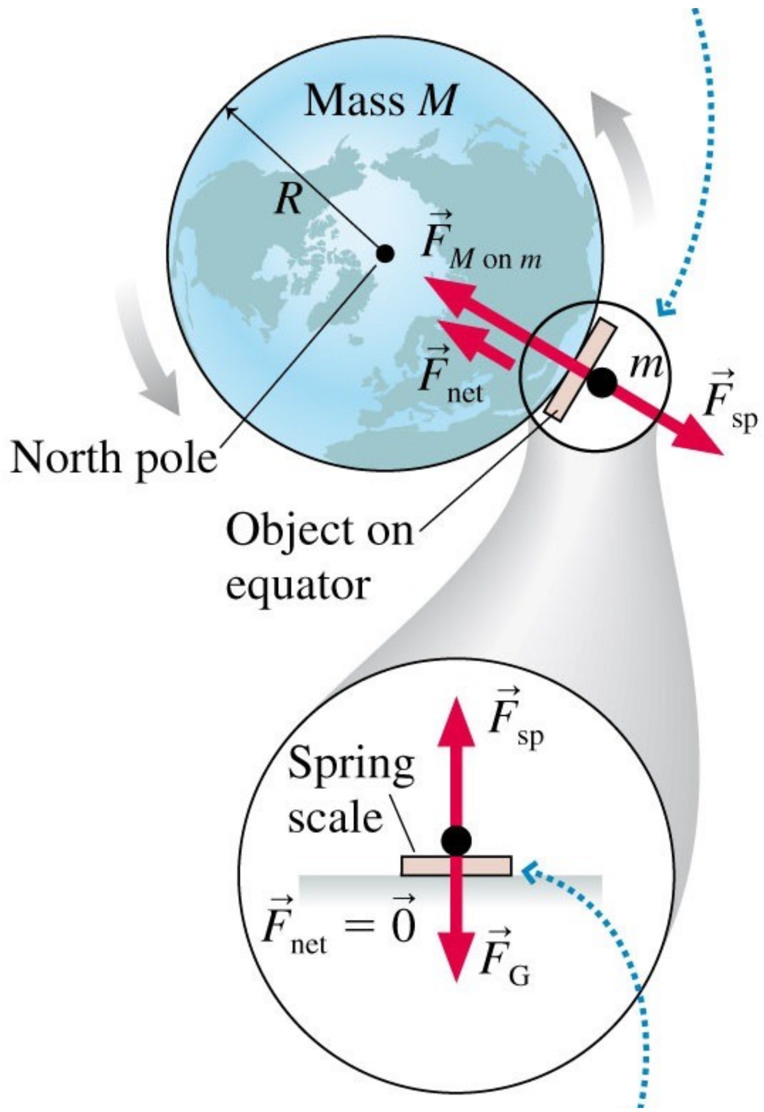
Gravity on a rotating Earth

Are we in an inertial reference frame right now?

$$7.3 \times 10^{-5} \text{ rads/sec}$$

$$6.37 \times 10^{6} \text{ m}$$

$$g = g_{\text{earth}} - \omega^2 R$$



Gravity on a rotating Earth

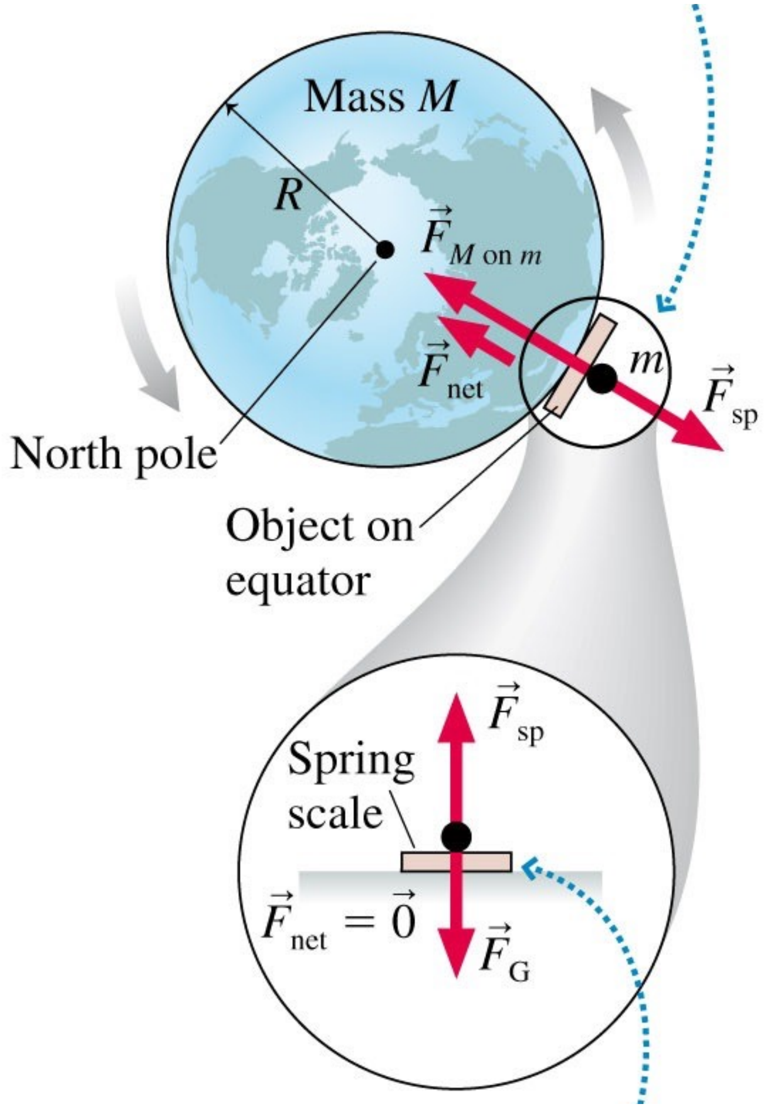
Are we in an inertial reference frame right now?

$$7.3 \times 10^{-5} \text{ rads/sec}$$

$$6.37 \times 10^{6} \text{ m}$$

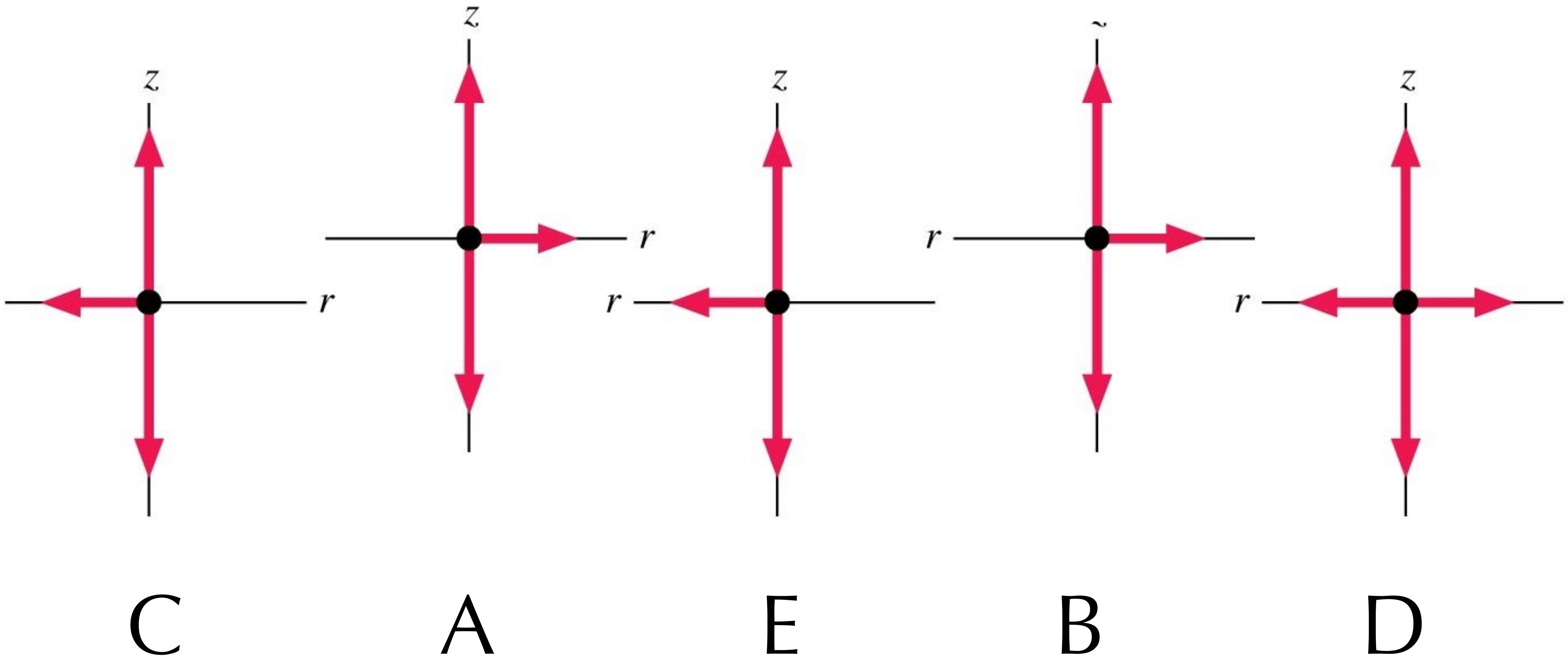
$$g = g_{\text{earth}} - \omega^2 R$$

0.034



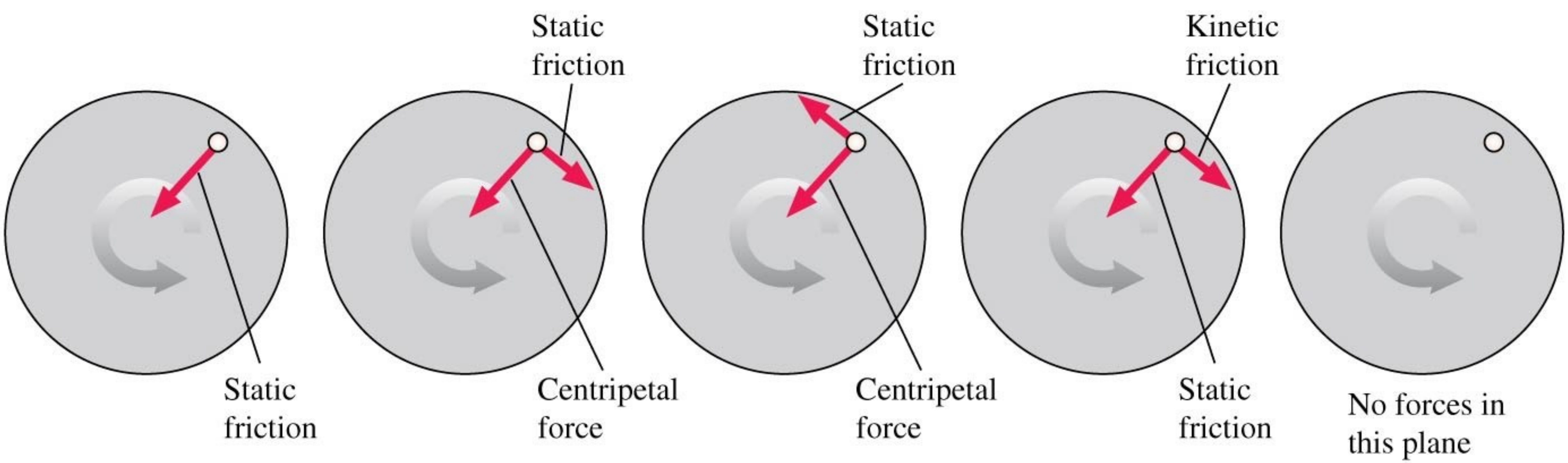
Question #1

A coin sits on a turntable as the table steadily rotates ccw. The free-body diagrams below show the coin from behind, moving away from you. Which is the correct diagram?



Question #2

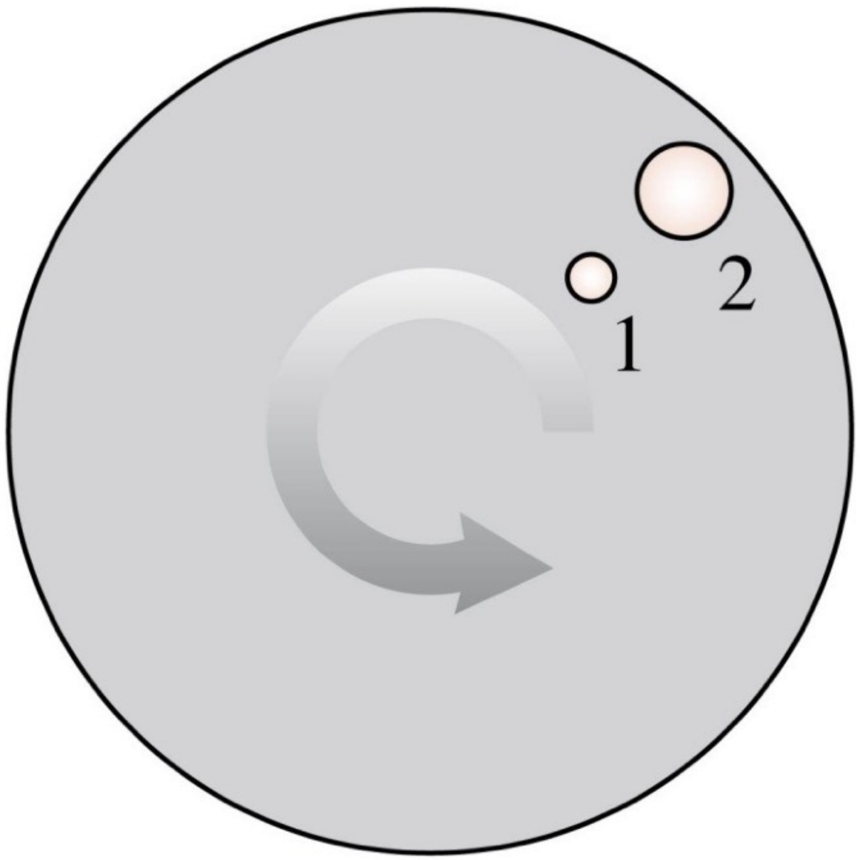
A coin sits on a turntable as the table ***steadily*** rotates ccw. What force or forces act in the plane of the turntable?



A B C D E

Question #3

Two coins are on a turntable that steadily speeds up, starting from rest, with a ccw rotation. Which coin flies off the turntable first?



a. Both coins fly off at the same time.

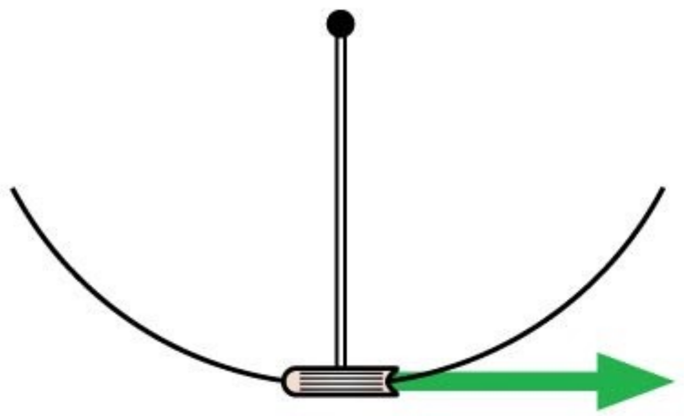
b. Coin 1 flies off first.

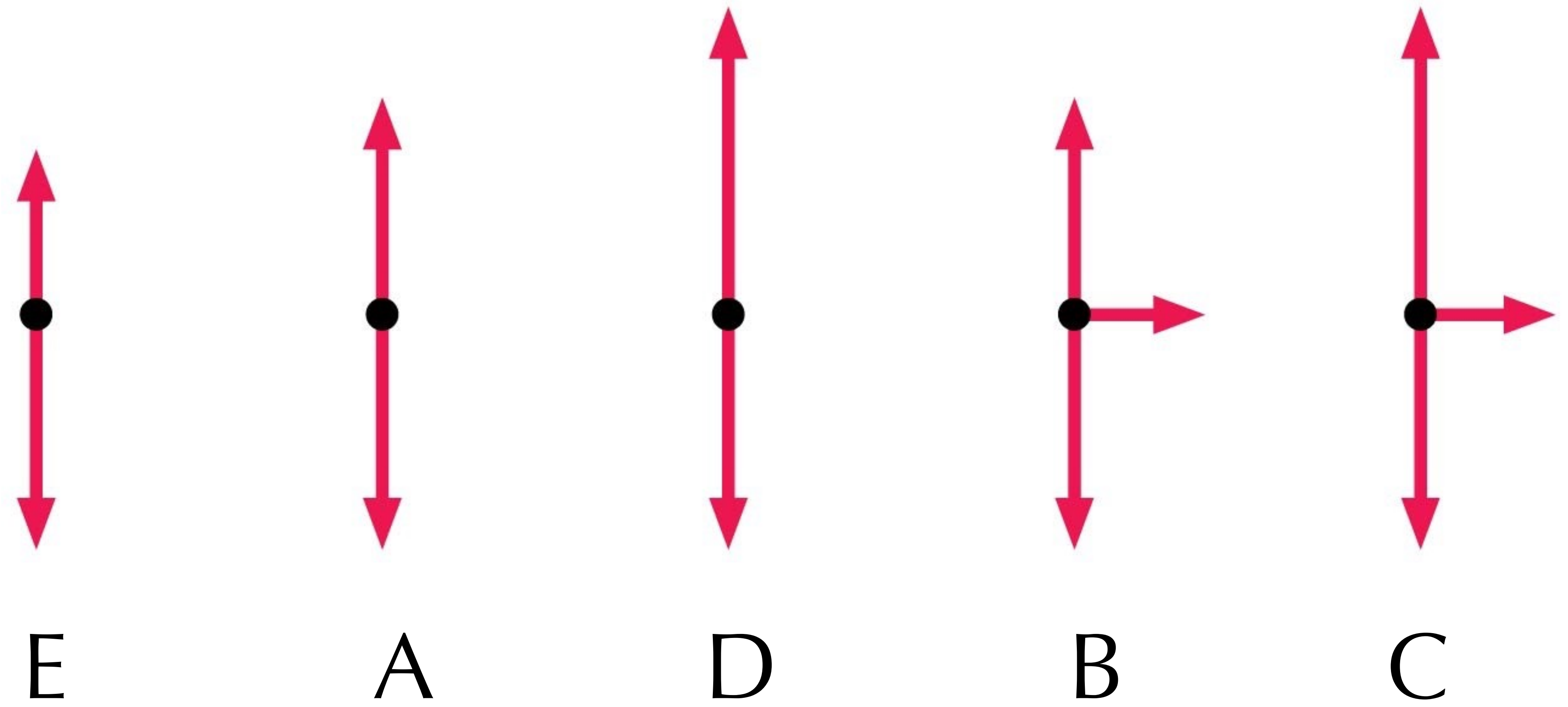
c. Coin 2 flies off first.

d. We can't say without knowing their masses.

Question #4

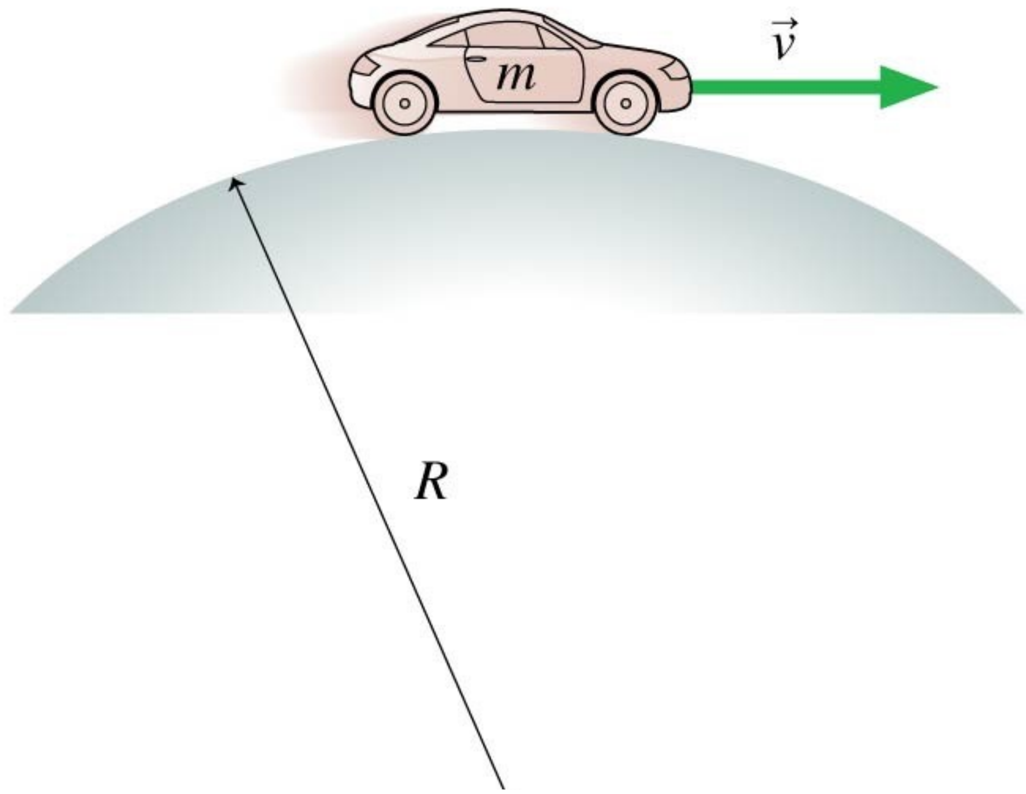
A physics textbook swings back and forth as a pendulum. Which is the correct free-body diagram when the book is at the bottom and moving to the right?

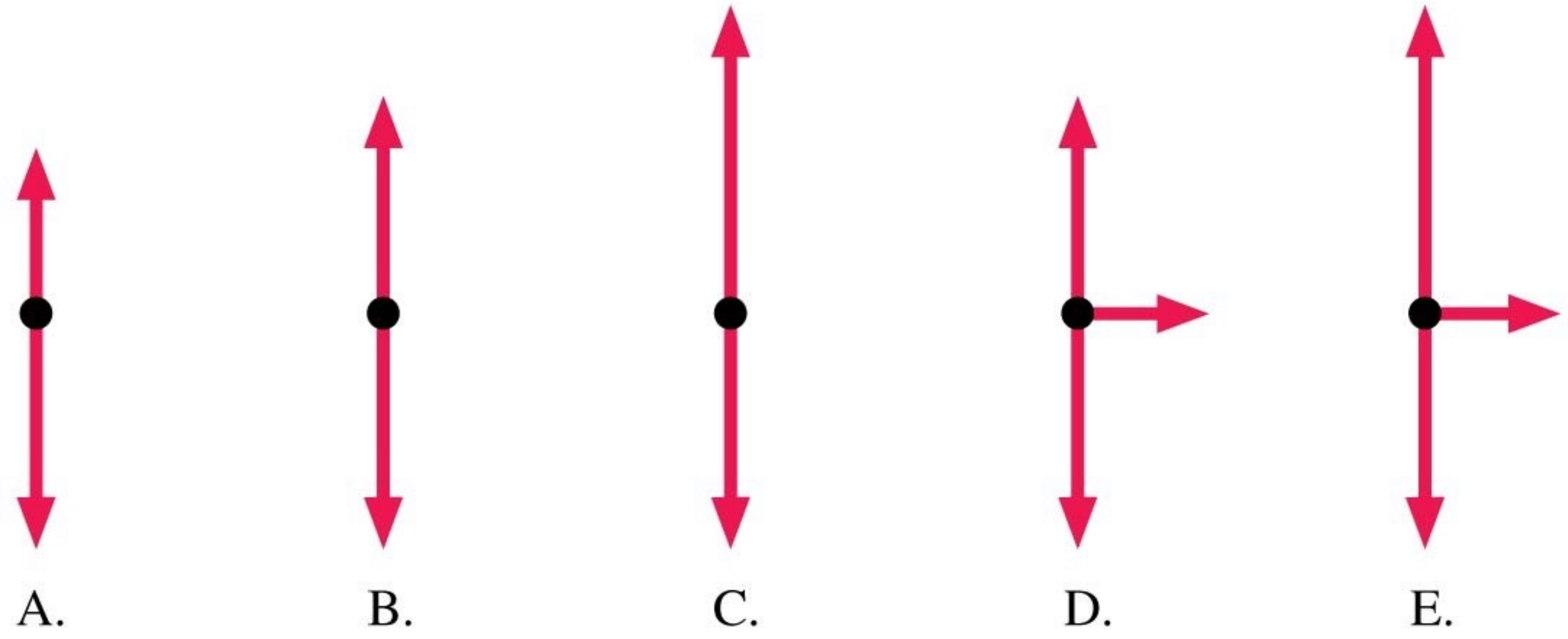




Question #5

A car that's out of gas coasts over the top of a hill at a steady 20 m/s. Assume air resistance is negligible. Which free-body diagram describes the car at this instant?

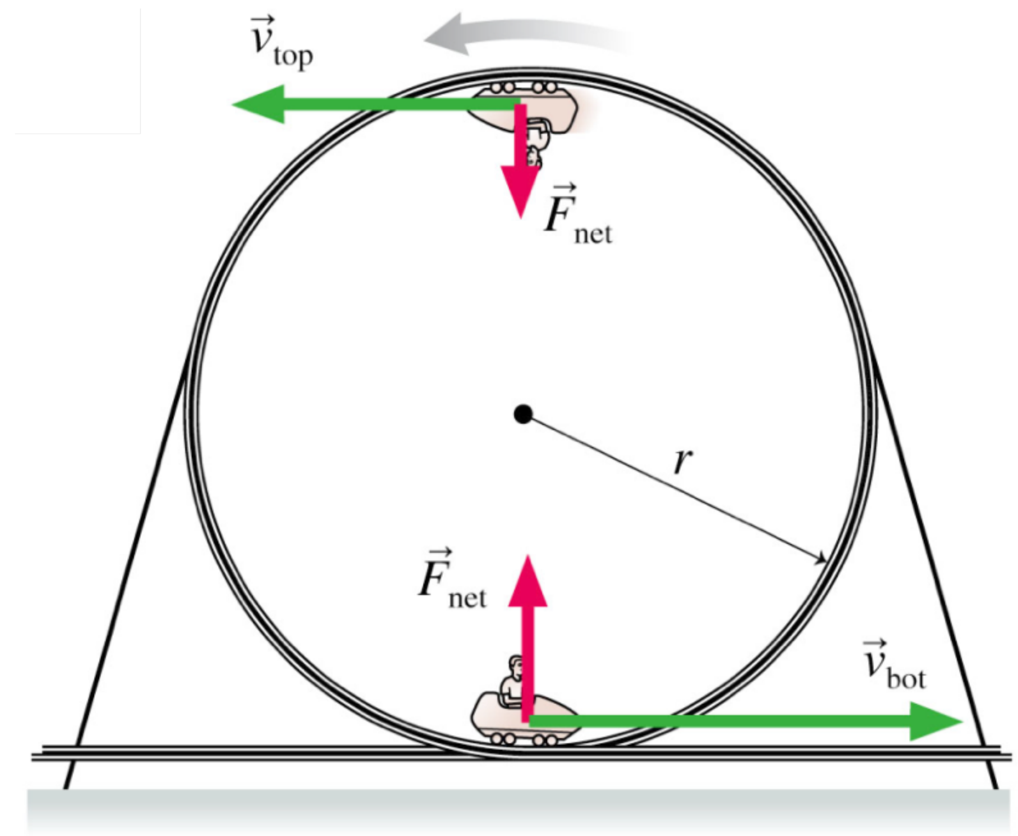




Loop-the-loop **Question #1**

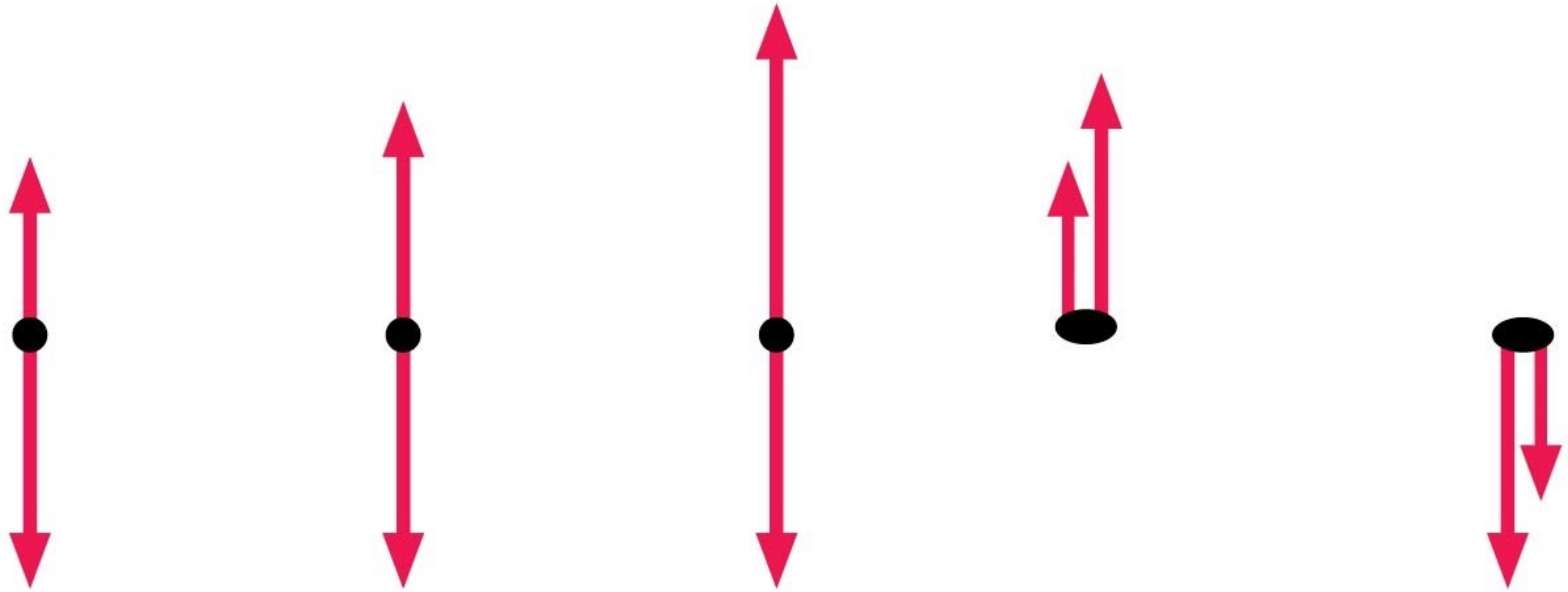
After gaining some speed, a roller coaster car travels through a loop-the-loop. Is this uniform circular motion?

d) Yes
e) No



Question #2

A roller coaster car does a loop-the-loop. Which of the free-body diagrams shows the forces on the car at the bottom of the loop? Rolling friction can be neglected.



E C A D B

Loop-the-loop (at the bottom)

Draw a free-body diagram for the car at the bottom of the loop.

Hint: Do you feel "heavy" or "light" as you go through the valley of a roller coaster?

Loop-the-loop (at the bottom)

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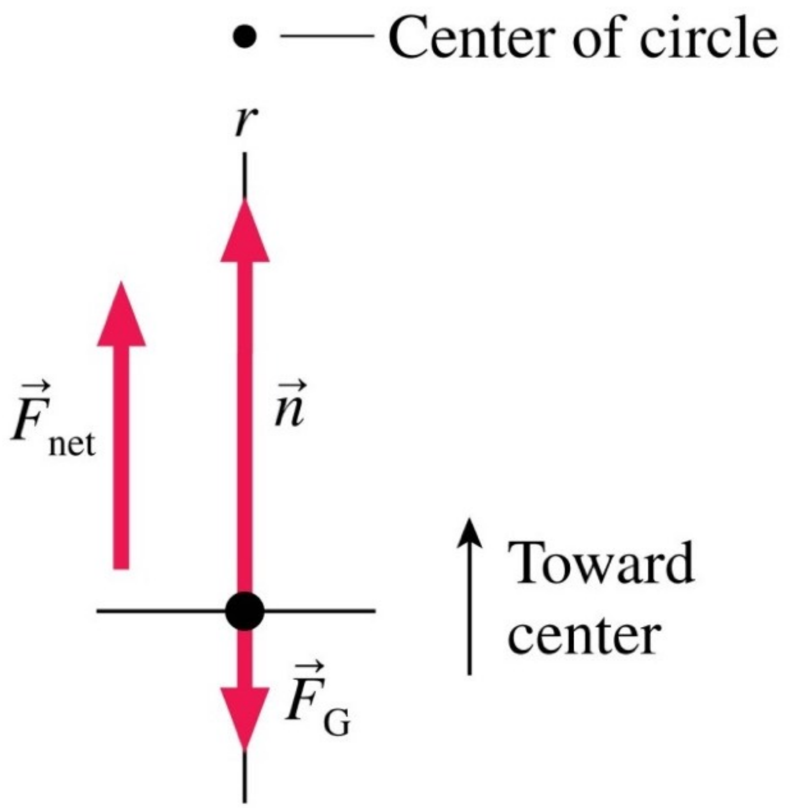


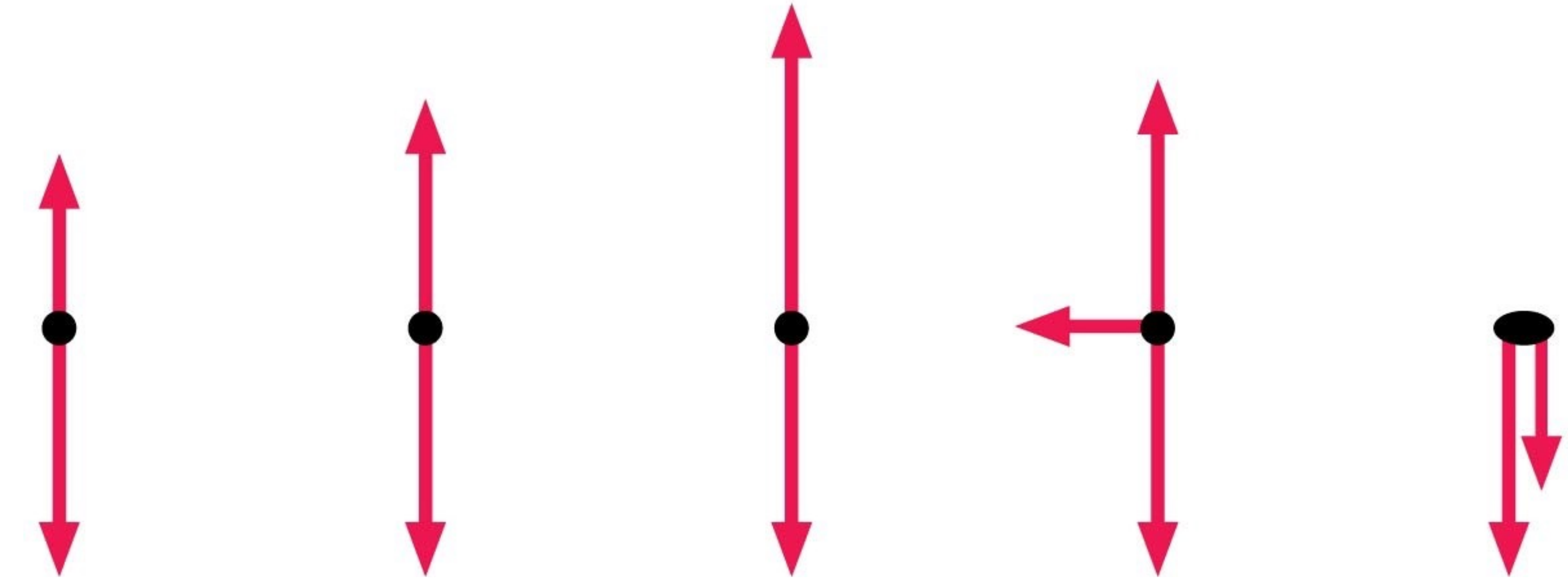
$$\sum F_r = n_r + (F_{\text{G}})_r = n - mg = ma_r = \frac{m(v_{\text{bot}})^2}{r}$$

$$n = mg + \frac{m(v_{\text{bot}})^2}{r}$$

The normal force at the bottom is *larger* than *mg*.

Question #3

A roller coaster car does a loop-the-loop. Which of the free-body diagrams shows the forces on the car at the top of the loop? Rolling friction can be neglected.



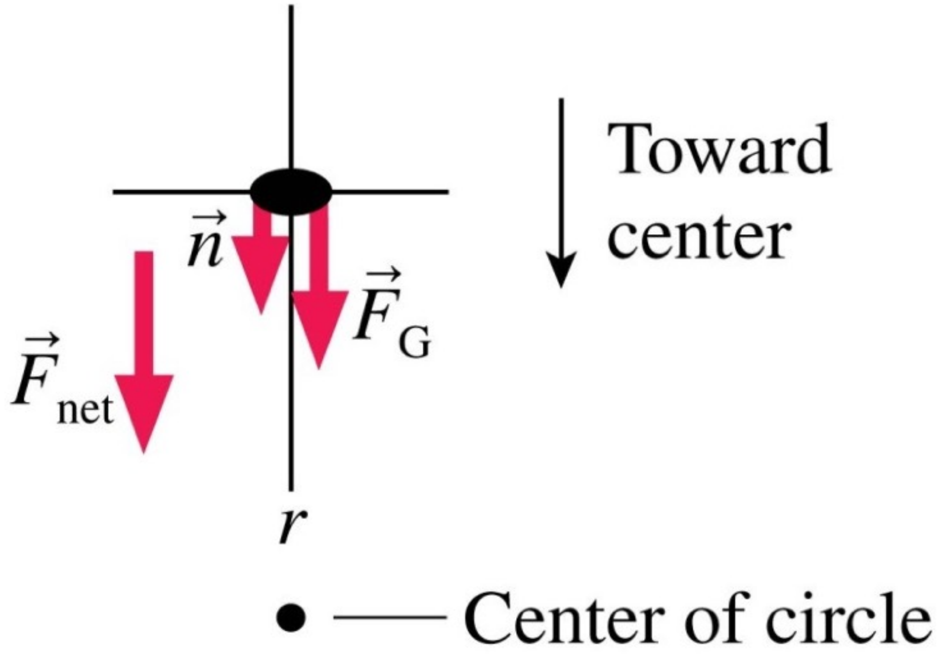
E A D B C

Loop-the-loop (at the top)

Draw a free-body diagram for the car at the top of the loop.

Loop-the-loop (at the top)

Draw a free-body diagram for the car at the top of the loop.



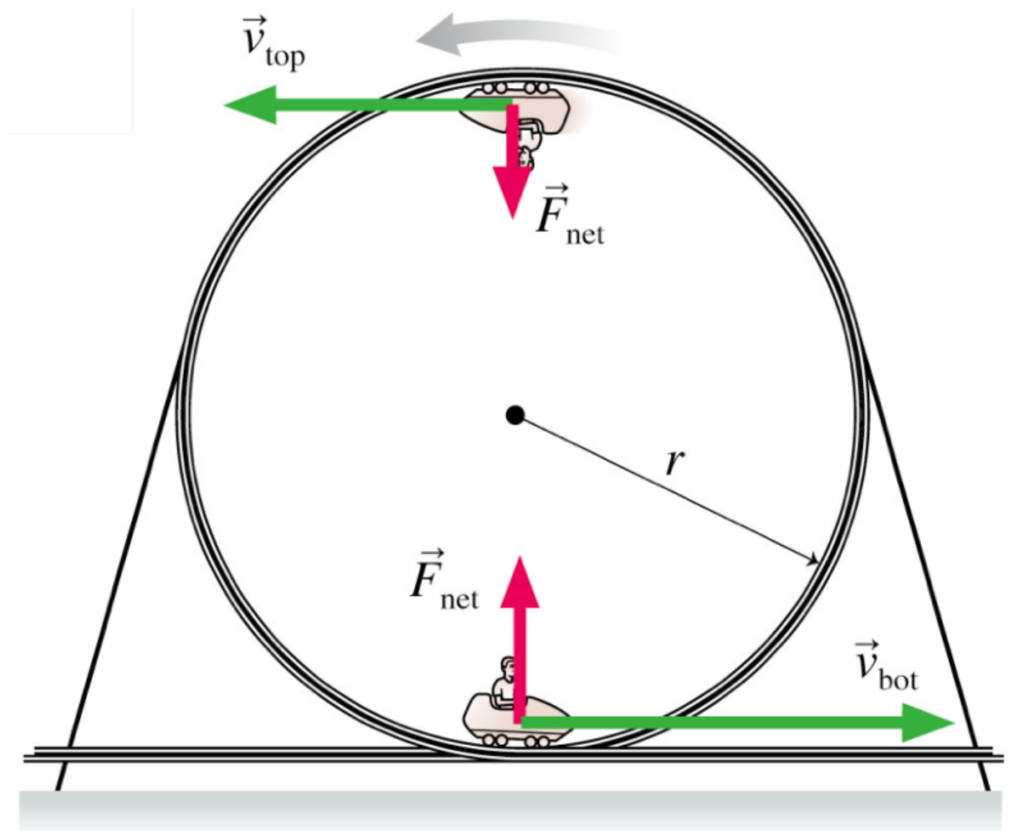
$$\sum F_r = n_r + (F_G)_r = n + mg = \frac{m(v_{top})^2}{r}$$

$$n = \frac{m(v_{top})^2}{r} - mg$$

Will the normal force be greater than mg, less than mg, or zero?

Critical speed

$$n = \frac{m(v_{\text{top}})^2}{r} - mg$$

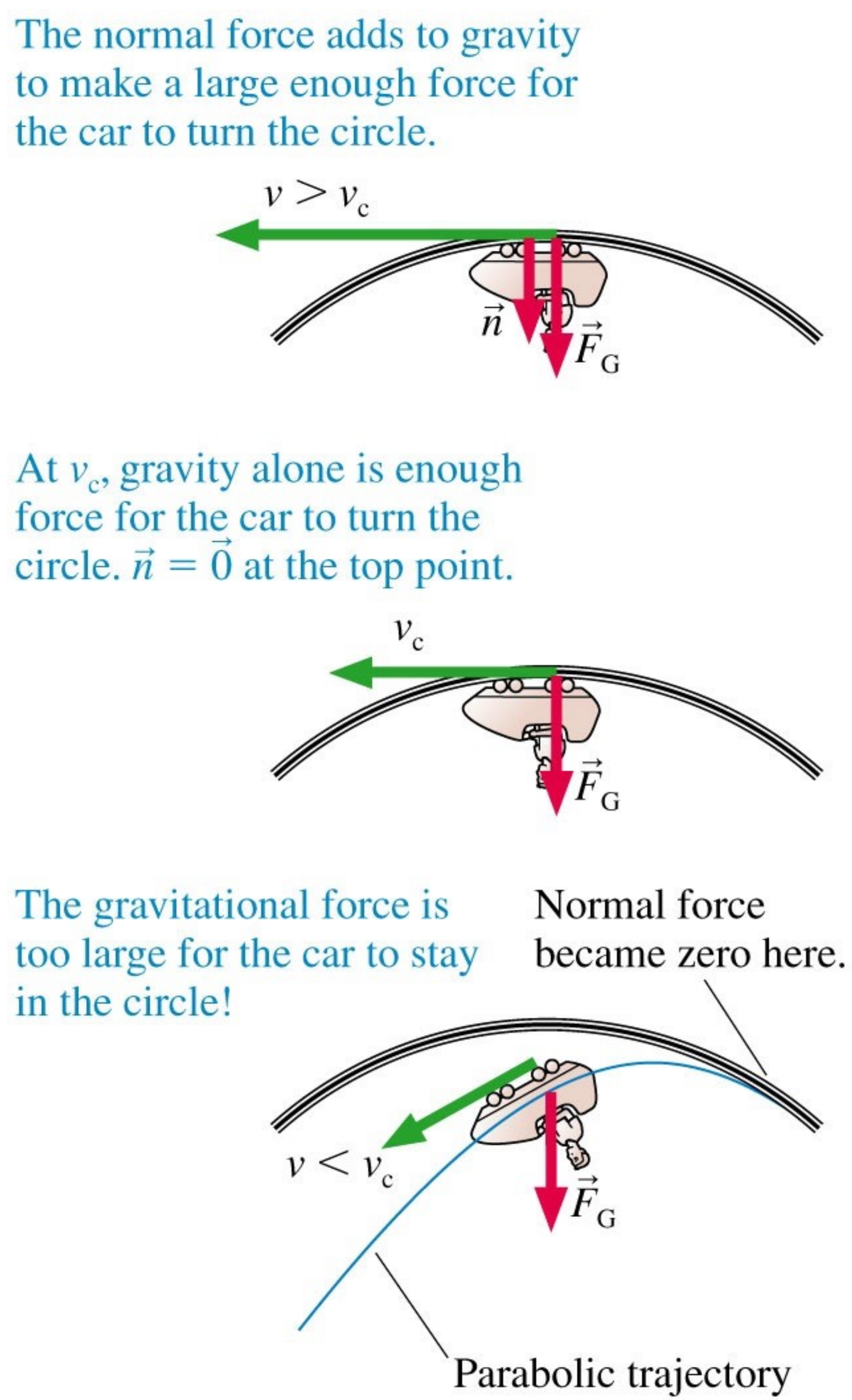


- The speed at which $n = 0$ is called the *critical speed*:

$$v_c = \sqrt{\frac{rmg}{m}} = \sqrt{rg}$$

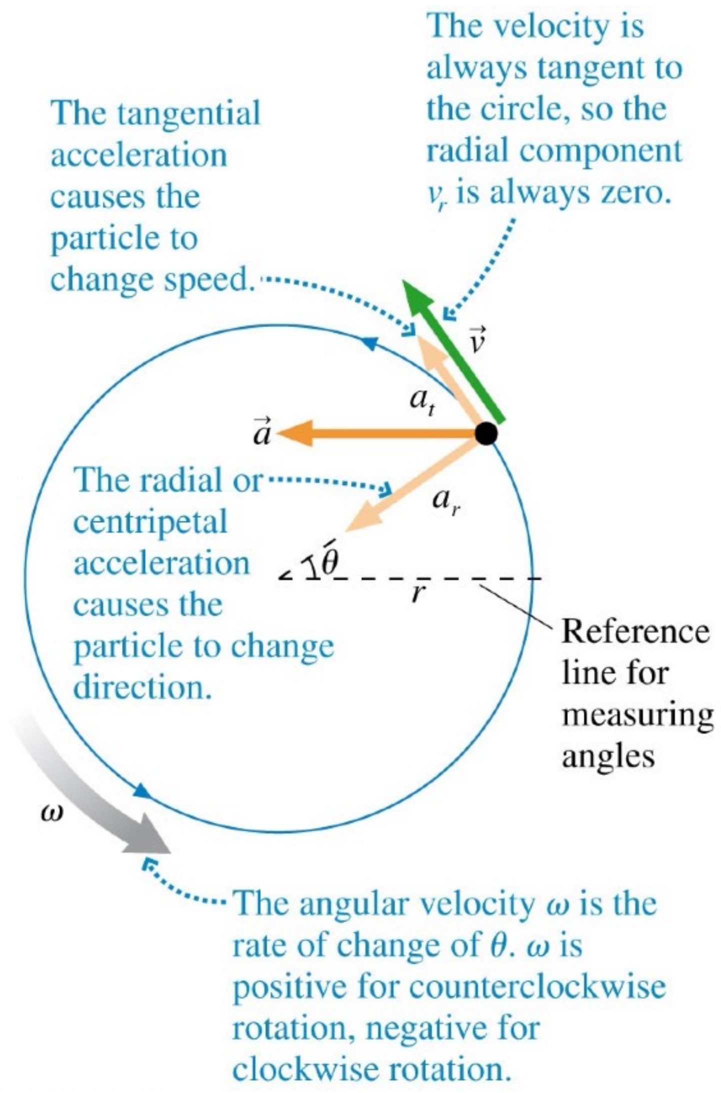
- This is the slowest speed at which the car can complete the circle without falling off the track near the top.

Loop-the-loop



Nonuniform circular motion

The particle in the figure is speeding up as it moves around the circle



$$\boxed{\text{Tangential acceleration}}$$

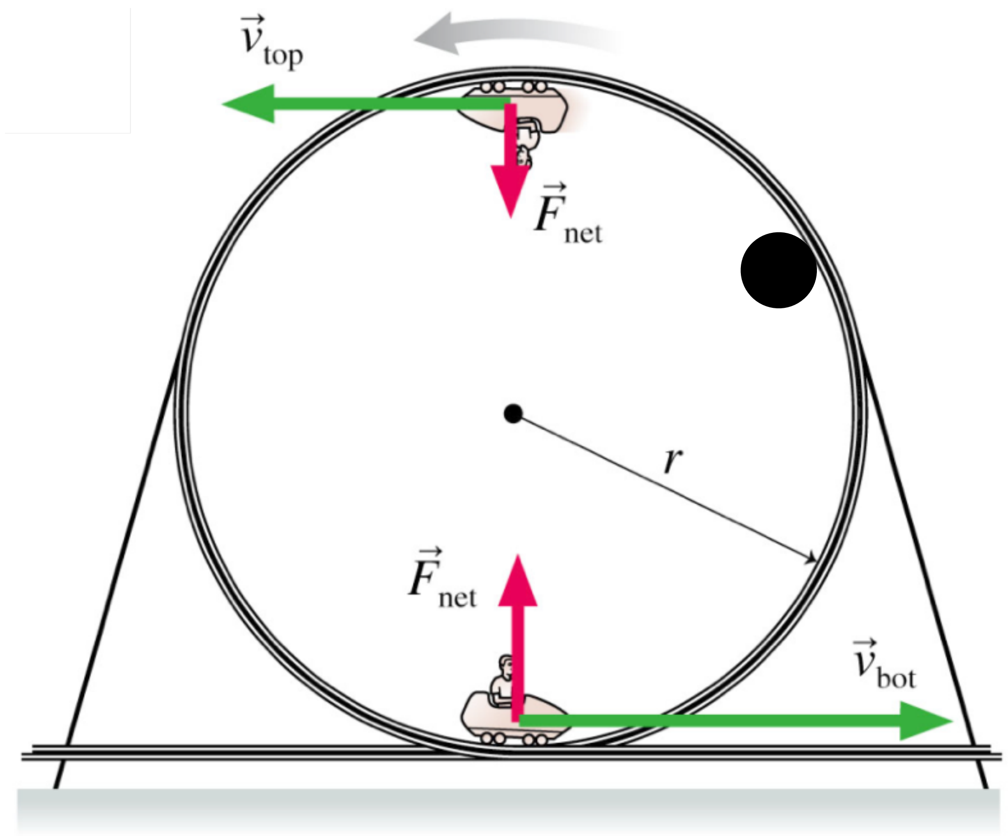
$$a_t = r\alpha$$

$$a_t = \frac{dv_t}{dt}$$

$$\boxed{\text{Centripetal acceleration}}$$

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

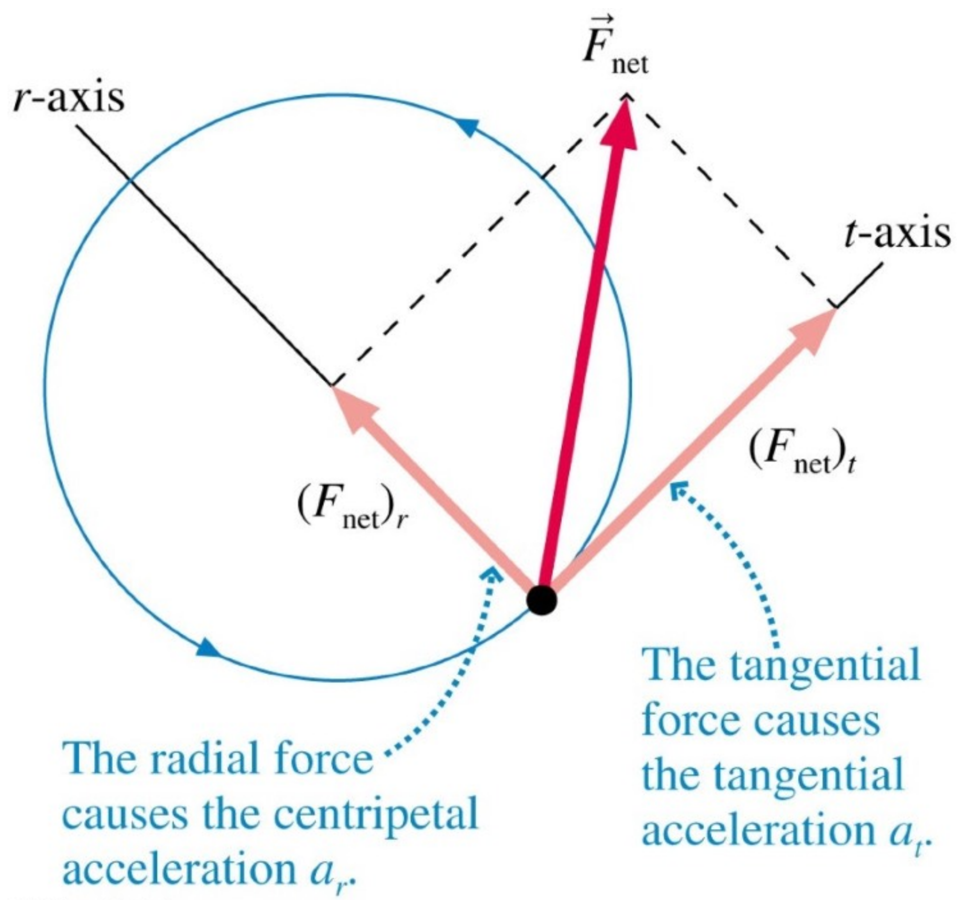
Not top or bottom



Dynamics of nonuniform circular motion

The tangential component of the net force creates a tangential acceleration and causes the particle to change speed.

The radial component of the net force is directed towards the center and creates a centripetal acceleration. This force causes the particle to change direction.



Dynamics of nonuniform circular motion

radial equation

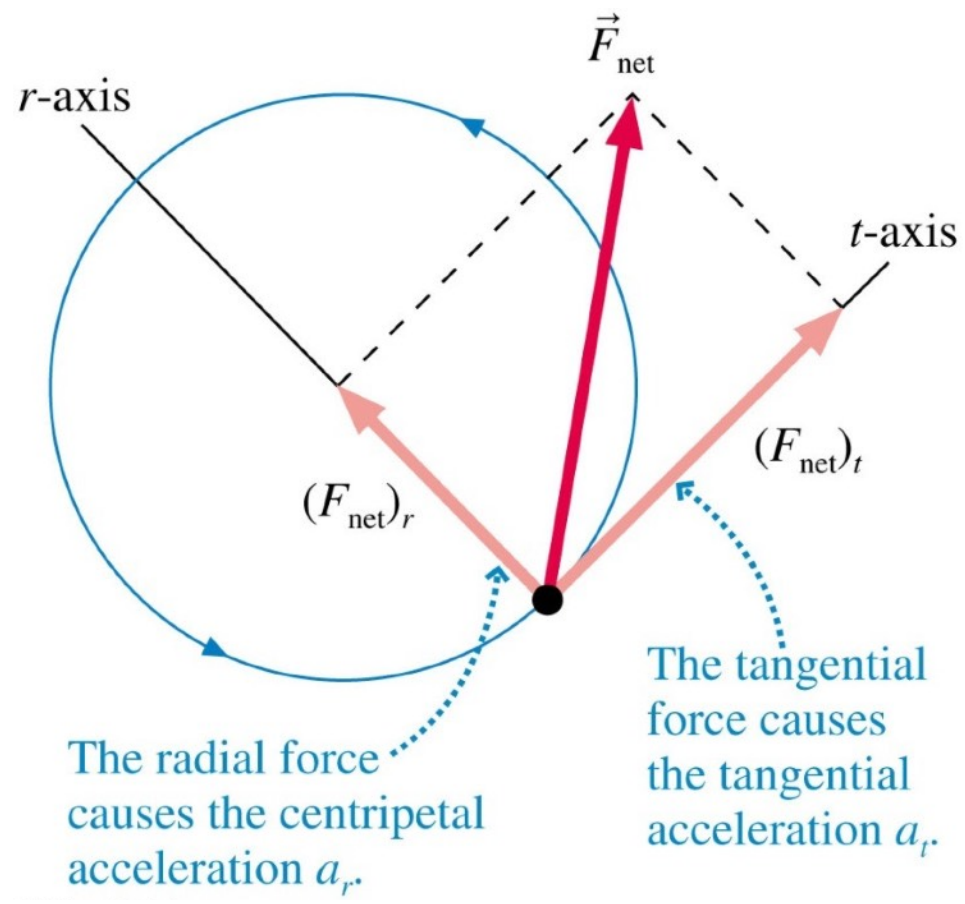
$$\sum F_r = ma_r = m\frac{v^2}{r} = m\omega^2 r$$

tangential equation

$$\sum F_t = ma_t$$

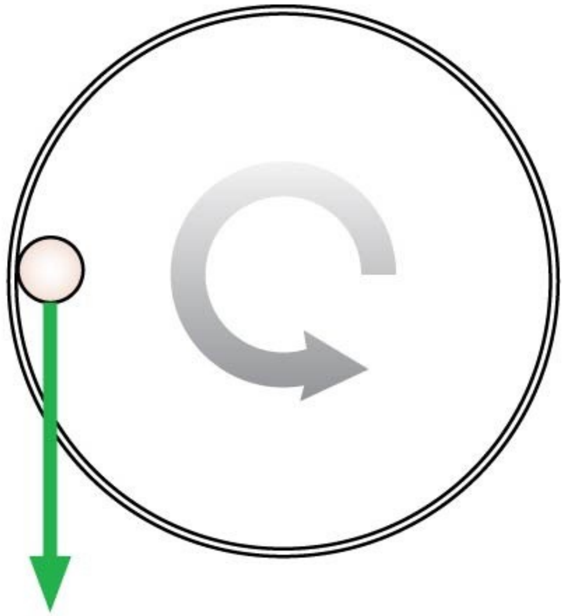
z equation

$$\sum F_z = 0$$



Question #9

A ball rolls ccw around the inside of a horizontal pipe. The ball is fastest at the lowest point, slowest at the highest point. At the point shown, with the ball moving down, what is the direction of the net force on the ball?

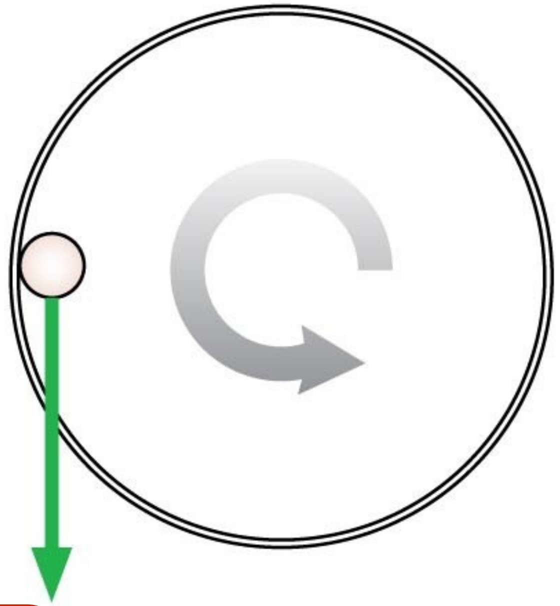


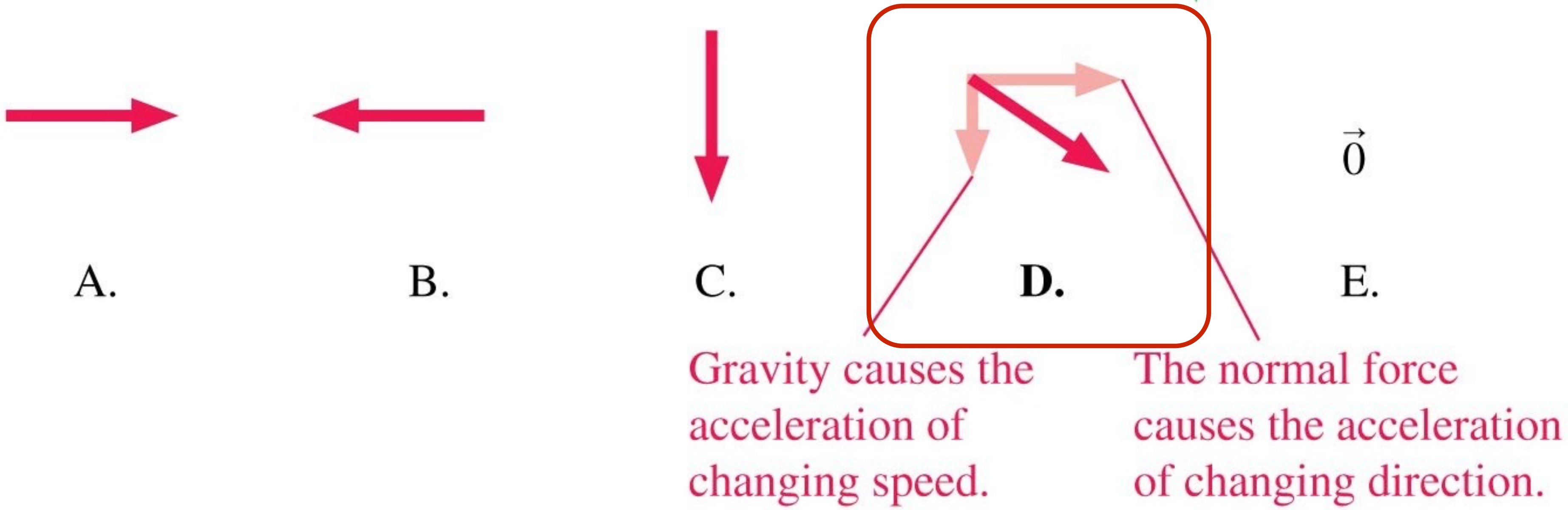
$\vec{0}$

A D B C E

Quiz

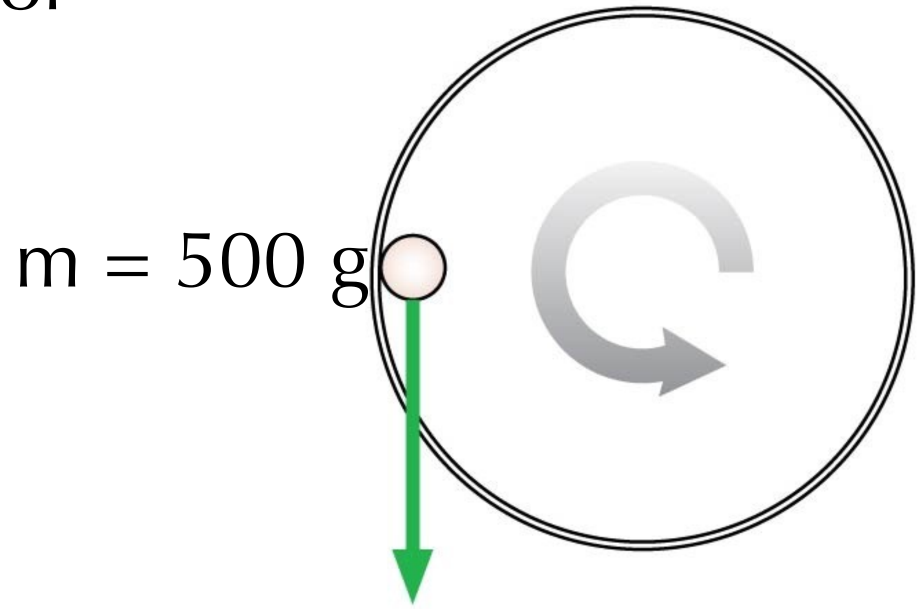
A ball rolls ccw around the inside of a horizontal pipe. The ball is fastest at the lowest point, slowest at the highest point. At the point shown, with the ball moving down, what is the direction of the net force on the ball?





Question #10

If the ball were traveling at 3 m/s at this instant in time and the radius of the tube were 25 cm, what is the magnitude of the net force on the ball?



a) 9.8 N
b) 37.3 N
c) 187 N
d) 4.9 N
e) 18.7 N