#25 Equations of Angular Motion Pre-class

Due: 11:00am on Monday, October 22, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

Exercise 9.25

A flywheel with a radius of 0.600m starts from rest and accelerates with a constant angular acceleration of 0.600$\mathrm{rad/s^2}$.

Part A

Compute the magnitude of the tangential acceleration of a point on its rim at the start.

ANSWER:

a_{tan} = 0.360 $\mathrm{m/s^2}$

Correct

Part B

Compute the magnitude of the radial acceleration of a point on its rim at the start.

ANSWER:

a_{rad} = 0 $\mathrm{m/s^2}$

Correct

Part C

Compute the magnitude of the resultant acceleration of a point on its rim at the start.

ANSWER:

a = 0.360 $\mathrm{m/s^2}$

Correct

Part D

Compute the magnitude of the tangential acceleration of a point on its rim after it has turned through 60.0 °.

ANSWER:

a_{tan} = 0.360 $\mathrm{m/s^2}$

Correct

Part E

Compute the magnitude of the radial acceleration of a point on its rim after it has turned through 60.0 °.

ANSWER:

a_{rad} = 0.754 $\mathrm{m/s^2}$

Correct

Part F

Compute the magnitude of the resultant acceleration of a point on its rim after it has turned through 60.0 °.

ANSWER:

a = 0.836 $\mathrm{m/s^2}$

Correct

Part G

Compute the magnitude of the tangential acceleration of a point on its rim after it has turned through 120.0 °.

ANSWER:

a_{tan} = 0.360 $\mathrm{m/s^2}$

Correct

Part H

Compute the magnitude of the radial acceleration of a point on its rim after it has turned through 120.0 °.

ANSWER:

a_{rad} = 1.51 $\mathrm{m/s^2}$

Correct

Part I

Compute the magnitude of the resultant acceleration of a point on its rim after it has turned through 120.0 °.

ANSWER:

a = 1.55 $\mathrm{m/s^2}$

Correct

Marching Band

A marching band consists of rows of musicians walking in straight, even lines. When a marching band performs in an event, such as a parade, and must round a curve in the road, the musician on the outside of the curve must walk around the curve in the same amount of time as the musician on the inside of the curve. This motion can be approximated by a disk rotating at a constant rate about an axis perpendicular to its plane. In this case, the axis of rotation is at the inside of the curve.

Consider two musicians, Alf and Beth. Beth is four times the distance from the inside of the curve as Alf.

Part A

If Beth travels a distance s during time Δt, how far does Alf travel during the same amount of time?

Hint 1. Find the angle through which Alf rotates

If Beth rotates through an angle of θ during time Δt, through what angle does Alf rotate during the same amount of time?

Hint 1. Angular velocity

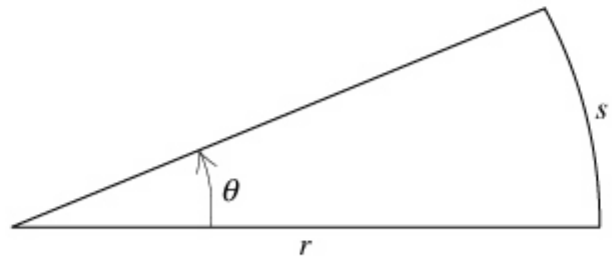
At any given instant, every part of a rigid body has the same angular velocity ω, where ω is given by the relationship

$$\omega = \frac{\Delta\theta}{\Delta t}.$$

ANSWER:

- 4θ
- 2θ
- θ
- $\frac{1}{2}\theta$
- $\frac{1}{4}\theta$

Hint 2. Arc length



If an angle θ (measured in radians) is subtended by an arc of length s on a circle of radius r, as shown in the figure, then

$$s = r\theta.$$

Use this formula to compare the lengths of the arcs that Alf and Beth trace out during equal time intervals.

ANSWER:

- $4s$
- $2s$
- $\frac{1}{2}s$
- $\frac{1}{4}s$
- s

Correct

The musician on the outside of the curve must travel farther than the musician on the inside of the curve in order to maintain the marching band's straight, even rows.

Part B

If Alf moves with speed v, what is Beth's speed? Speed in this case means the magnitude of the linear velocity, not the magnitude of the angular velocity.

ANSWER:

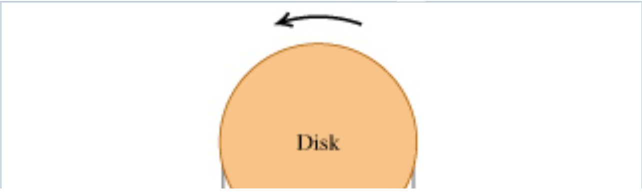
- (selected) $4v$
- v
- $\frac{1}{4}v$

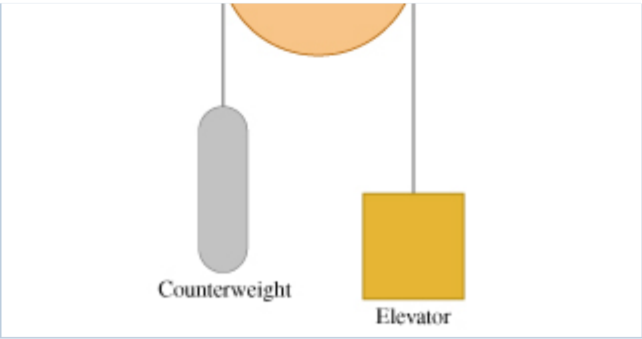
Correct

The musician on the outside of the curve must travel faster than the musician on the inside of the curve. This is why most of the musicians on the outside of a curve appear to be jogging while their colleagues on the inside of the curve march in place.

Exercise 9.20

In a charming 19th-century hotel, an old-style elevator is connected to a counterweight by a cable that passes over a rotating disk 2.50m in diameter (the figure). The elevator is raised and lowered by turning the disk, and the cable does not slip on the rim of the disk but turns with it.





Part A

At how many rpm must the disk turn to raise the elevator at 20.0$\mathrm{cm/s}$?

ANSWER:

ω = 1.53 rpm

Correct

Part B

To start the elevator moving, it must be accelerated at $\frac{1}{8}g$. What must be the angular acceleration of the disk, in $\mathrm{rad/s^2}$?

ANSWER:

α = 0.980 $\mathrm{rad/s^2}$

Correct

Part C

Through what angle (in radians) has the disk turned when it has raised the elevator 2.95m between floors?

.

ANSWER:

θ = 2.36 rad

Correct

Part D

Through what angle (in degrees) has the disk turned when it has raised the elevator 2.95m between floors?

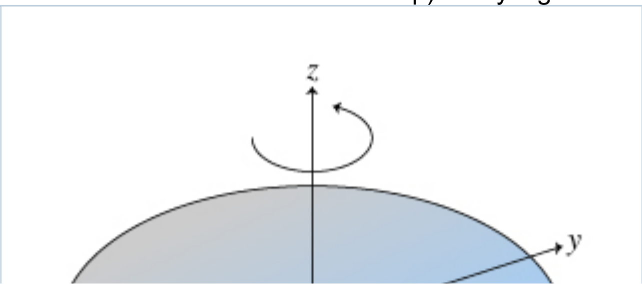
ANSWER:

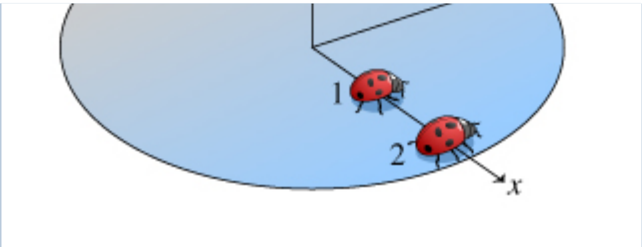
θ = 135 $^\circ$

Correct

Ladybugs on a Rotating Disk

Two ladybugs sit on a rotating disk, as shown in the figure (the ladybugs are at rest with respect to the surface of the disk and do not slip). Ladybug 1 is halfway between ladybug 2 and the axis of rotation.





Part A

What is the angular speed of ladybug 1?

ANSWER:

- one-half the angular speed of ladybug 2
- the same as the angular speed of ladybug 2
- twice the angular speed of ladybug 2
- one-quarter the angular speed of ladybug 2

Correct

Part B

What is the ratio of the linear speed of ladybug 2 to that of ladybug 1?

Answer numerically.

Hint 1. Relation between linear and angular speeds

The relation between the linear speed v and angular speed ω of an object is given by

$$v = \omega r,$$

where r is the distance between the object and the axis of rotation.

ANSWER:

2

Correct

Part C

What is the ratio of the magnitude of the radial acceleration of ladybug 2 to that of ladybug 1?

Answer numerically.

Hint 1. Radial (centripetal) acceleration of an object moving on a circle

The magnitude of the radial (centripetal) acceleration of an object moving on a circle is called the centripetal acceleration. It is given by

$$a_c = \omega^2 r = \frac{v_t^2}{r},$$

where ω is the angular velocity of the object, v_t is its tangential velocity, and r is the distance from the axis of rotation.

ANSWER:

$\frac{a_2}{a_1}$ = 2

Correct

Although the trajectory of ladybug 2 has twice the radius as that of ladybug 1, ladybug 2 also has twice the linear velocity of ladybug 1. Thus, according to the formula $a_c = v^2/r$, where a_c is centripetal acceleration, ladybug 2 has twice the centripetal acceleration of ladybug 1.

Part D

What is the direction of the vector representing the angular velocity of ladybug 2? See the figure for the directions of the coordinate axes.

Hint 1. Direction of the angular velocity vector

The direction of the angular velocity vector is given by the right-hand rule. Curl the fingers of your right hand along the direction of rotation, and your thumb will point along the direction of the angular velocity vector.

ANSWER:

- $+x$
- $-x$
- $+y$
- $-y$
- (selected) $+z$
- $-z$

Correct

Part E

Now assume that at the moment pictured in the figure, the disk is rotating but slowing down. Each ladybug remains "stuck" in its position on the disk. What is the direction of the *tangential* component of the acceleration (i.e., acceleration tangent to the trajectory) of ladybug 2?

ANSWER:

- $+x$
- $-x$
- $+y$
- $-y$
- $+z$
- $-z$

Correct

Score Summary:

Your score on this assignment is 100.3%.
You received 20.06 out of a possible total of 20 points.