LESSON MAKER PRO

Forces in Orbit

Calculate circular motion and show its forces.

HIGH SCHOOL · P.5.a

P.5.a "Use mathematics and free-body diagrams to relate the tangential velocity, the radius of orbit, the centripetal acceleration, and force to each other for an object moving in a circle."

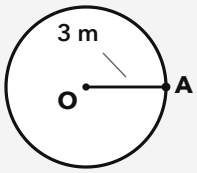
NAME _____ DATE _____

THE BIG IDEA

For circular motion at constant speed, velocity is tangent to the path, while acceleration and net force point toward the center. Use $a = v^2/r$ and $F = ma$, where v is speed, r is radius, and m is mass. If speed changes, there is also tangential acceleration. In a free-body diagram, draw the real forces, not an extra net-force arrow.

WORKED EXAMPLE

A 2 kg puck tied to a string moves at 6 m/s on a smooth, level table. At A, find its inward acceleration and the string's force.



1. $a = v^2/r = 6^2/3 = 12$ m/s^2
2. $F = ma = 2(12) = 24$ N
3. The string pulls from A toward O.

Answer: 12 m/s^2; 24 N toward O

PRACTICE 4 problems

1 Find a when v = 8 m/s and r = 4 m.

ANSWER _____

2 Find a and F when m = 5 kg, v = 10 m/s, and r = 5 m.

ANSWER _____

3 Find r when v = 12 m/s and a = 9 m/s^2.

ANSWER _____

4 Find v when a = 25 m/s^2 and r = 4 m.

ANSWER _____

APPLY IT Show your work

1 A go-kart and driver have a total mass of 80 kg. They turn at 8 m/s on a flat track with a radius of 16 m. Find their acceleration and net inward force. Name the force that pulls the kart inward.

WORK SPACE

ANSWER _____

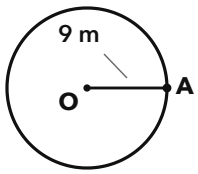
2 A 50 kg rider on a spinning ride sits 5 m from its center and travels at 10 m/s. Find the rider's acceleration and net inward force.

WORK SPACE

ANSWER _____

CHALLENGE One step up

A 4 kg puck tied to a string moves counterclockwise on a frictionless, level table. At A, the string pulls inward with 144 N. Find the puck's speed. Sketch a free-body diagram at A with every force, then state the puck's velocity direction.



WORK SPACE AND ANSWER

Forces in Orbit

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Find a when v = 8 m/s and r = 4 m.	**16 m/s²**
2	Find a and F when m = 5 kg, v = 10 m/s, and r = 5 m.	**a = 20 m/s²; F = 100 N inward**
3	Find r when v = 12 m/s and a = 9 m/s².	**16 m**
4	Find v when a = 25 m/s² and r = 4 m.	**10 m/s**

PART 2 · APPLY IT

1. **4 m/s²; 320 N inward; friction from the track on the tires** a = $8^2/16$ = 4 m/s², so F = 80(4) = 320 N. On a flat turn, tire-track friction provides the inward force.
2. **20 m/s²; 1,000 N inward** a = $10^2/5$ = 20 m/s². Then F = 50(20) = 1,000 N.

CHALLENGE

v = 18 m/s. At A, tension points left toward O. The normal force points vertically above the table and weight vertically below it; these are perpendicular to the plane of the circular-path picture. Velocity is tangent to the path, toward the top of that picture.

Accept equivalent expressions with correct units. In the challenge, do not accept net force as an extra arrow in the free-body diagram.