Newton's Second Law and Circular Motion

Lesson Notes

Learning Outcomes

- How can you combine a free-body diagram, Newton's second law, and circular motion equations to solve a physics word problem?

Newton's Second Law - Revisited

Solutions to $F_{net} = m \cdot a$ problems pertaining to circular motion will rely on the use of equations for speed (**v**), acceleration (**a**), and net force (**F_{net}**).

Speed (v)	Acceleration (a)	Net Force (F_{net})
$v = 2 \cdot \pi \cdot R/T$	$a = v^2/R$	$F_{net} = m \cdot v^2/R$

A free-body diagram and force analysis is typically a central part of the solution. The net force is related to m•a. Net force is the vector sum of all the forces and can be written from the inspection of a properly drawn free-body diagram. The acceleration is related to the speed (**v**), the radius (**R**), and (sometimes) the period (**T**).

Free-Body Diagram

$F_{net} = m \cdot a$

Vector sum of all force vectors.

Follow the solutions to the five example problems. For each, draw the free-body diagram, the $F_{net} = m \cdot a$ statement, and the logic and algebra leading up to the answer.

Example 1

A 945-kg car can make a 180-degree turn at 22.3 m/s. The radius of the turn through which the car is moving is 56.4 m. Determine the force of friction acting upon the car.

Example 2

A 1.36-kg bucket of water is tied by a rope and whirled in a vertical circle with a radius of 1.09 m. At the top of the circular loop, the speed of the bucket is 4.28 m/s. Determine the tension force in the rope.

Example 3

A 1.36-kg bucket of water is tied by a rope and whirled in a vertical circle with a radius of 1.09 m. At the bottom of the circular loop, the speed of the bucket is 7.81 m/s. Determine the tension force in the rope.

Example 4

A 52-kg airplane pilot is making a vertical loop-the-loop. The radius of curvature at the loop's bottom is 68 meters. With what speed must the pilot move to experience a normal force that is 4 times her weight?

Example 5

A 1.28-kg bucket of water is tied to a rope and spun at 5.49 m/s in a horizontal circle having a radius of 1.05 m. Determine the acceleration, the tension force, and the angle that the rope makes with the horizontal.