

Newton's Second Law and Circular Motion

Lesson Notes

Learning Outcomes

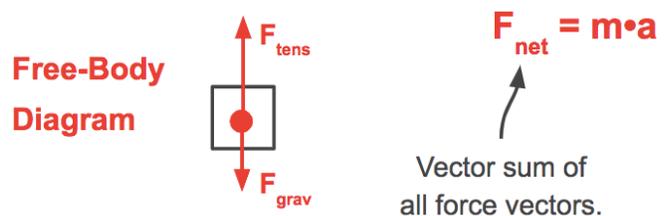
- How can you combine a free-body diagram, Newton's second law, and circular motion equations to solve a physics word problem?

Newton's Second Law - Revisited

Solutions to $F_{\text{net}} = m \cdot a$ 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})
$v = 2 \cdot \pi \cdot R / T$	$a = v^2 / R$	$F_{\text{net}} = m \cdot v^2 / R$

A free-body diagram and force analysis is typically a central part of the solution. The net force is related to $m \cdot a$. 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).



Follow the solutions to the five example problems. For each, draw the free-body diagram, the $F_{\text{net}} = m \cdot a$ 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.