

Newton's Laws

Big Picture

Newton's laws form the basis for all of mechanics and describe the effects of forces on an object's motion. Newton's laws can be applied to all sorts of problems in mechanics and even some in electrostatics. Anytime a force is involved, Newton's laws will determine the motion of the object the force is acting on.

Key Terms

Inertia: An object's resistance to changes in its motion.

Forces: Any push or pull. SI unit: N

Normal Force (N): The reaction force exerted on an object by the surface that is supporting it. SI unit: N

Friction: The force that acts between moving materials. It always acts opposite the direction of the object's motion or applied force (if the object isn't moving). The frictional force is proportional to the coefficient of friction μ , which depends on the surface the object is moving over, and the normal force N . SI unit: N

Newton's Laws

Newton's First Law

Known as law of inertia, it states that an object in motion tends to stay in motion and an object at rest tends to stay at rest unless acted on by an external force.

- This means that an object moving with a constant velocity, speed, and direction will continue moving with that velocity. An object that is not moving will not move unless there a force acts on it.
- The value of an object's inertia can be measured. Mass is the measure of an object's inertia while it is at rest.

Newton's Second Law

Explains how the force acting on an object will affect its motion. The acceleration a (change in velocity) of an object is directly proportional to the force F exerted on it and inversely proportional to the mass m (inertia) of the object. $F = ma$

- If there are multiple forces on the object, the acceleration is proportional to the net (overall) force.
- Any net force causes an acceleration, but only forces in the direction of motion causes a change in speed.
- Forces applied perpendicular to direction of motion will change the direction of motion, but not the speed.

Free Body Diagrams

The forces on an object are often visualized using a free-body diagram (FBD). FBDs are useful for looking at the different types of forces acting on an object.

Be careful when assigning signs. For each of the x - and y -components, remember which direction is positive and which is negative. Typically the "downward" direction is assigned as the negative direction, but you do not have to follow this convention as long as your signs are consistent.

Coefficient of Static Friction: Coefficient of friction used for objects at rest to determine how much force is required to make it begin moving.

Coefficient of Kinetic Friction: Coefficient of friction used for objects moving across a surface to determine the force resisting the motion.

Tension: Force on an object provided by a wire, string, cable, or similar object.

Newton's Third Law

This law states that for any force exerted by one object on another, the other object exerts an equal force in the opposite direction on the first object. For example, if a person is pushing on a wall, the wall is also pushing back on them with an equal force in the opposite direction.

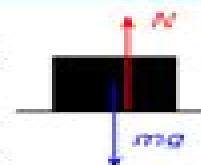
- This law holds for all situations in which objects come into contact, even when the objects are accelerating.
- While it seems like the third law would prevent the object from moving because the reaction force would cancel the initial force, the two forces act on different objects so there is still a net force on the individual objects.
- Pairs of forces described by the third law must be: the same type of force, exerted on two different objects, and equal in magnitude in opposite directions.

Mass on a Table

Gravity is a force that acts on all objects. Near the surface of the Earth, the force due to gravity (F_g) is equal to mg , where g is approximately 9.8m/s^2 .

- mg is what we call the weight of an object. It is not the same thing as mass!

Normal force (N) can be understood using Newton's third law. It is the force opposing gravity so that the net force on both objects (the mass and the table) is zero. $N = mg$



Newton's Laws Study Guide Answers

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