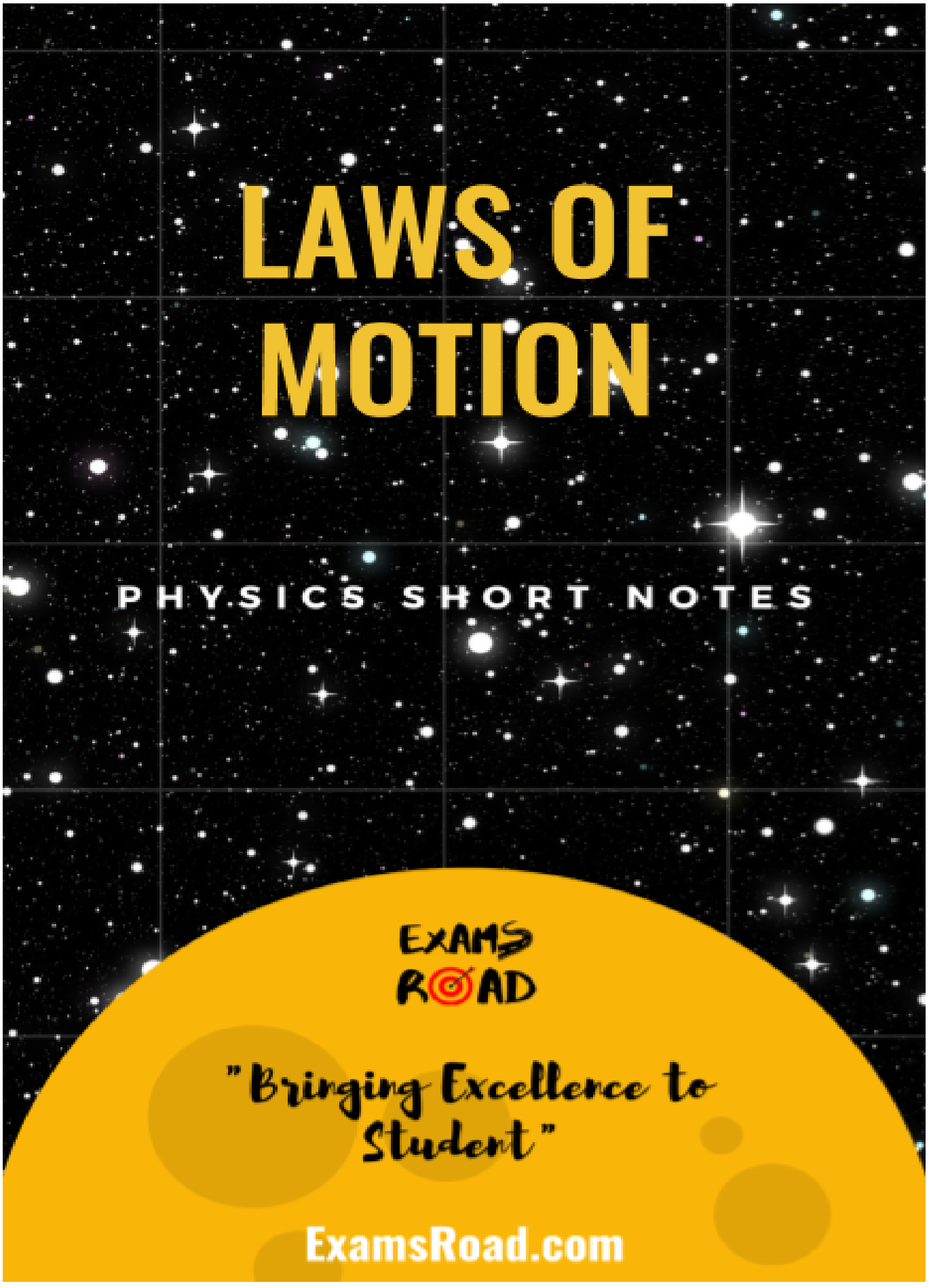
LAWS OF MOTION
PHYSICS SHORT NOTES
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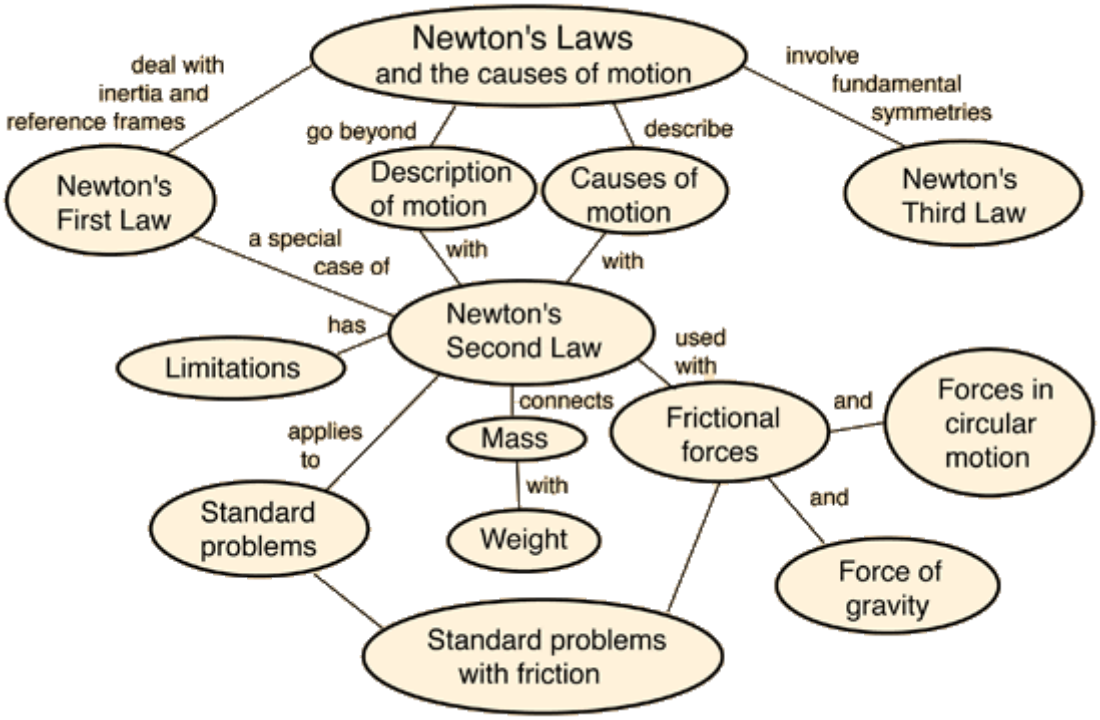
Laws of Motion

Newton's laws of motion are three physical laws that, together, laid the foundation for classical mechanics. They describe the relationship between a body and the forces acting upon it, and its motion in response to those forces. More precisely, the first law defines the force qualitatively, the second law offers a quantitative measure of the force, and the third asserts that a single isolated force does not exist.



Newton's First Law

What is Newton's First Law of Motion?

Newton's first law states that

> ***A body remains in the state of rest or uniform motion in a straight line unless and until an external force acts on it.***

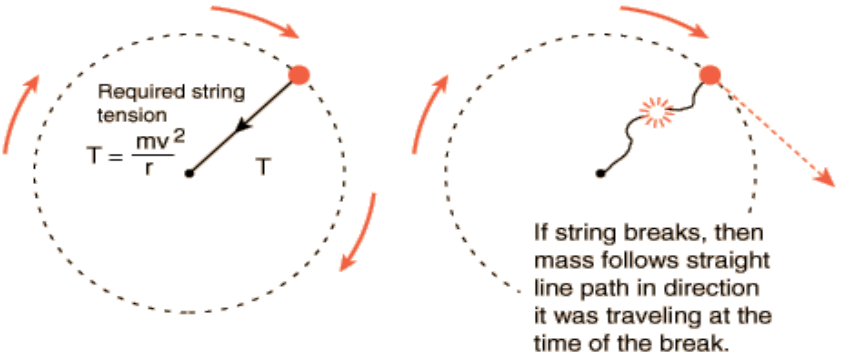
Putting Newton's 1st law of motion in simple words, a body will not start moving until and unless an external force acts on it. Once it is set in motion, it will not stop or change its velocity until and unless some force acts upon it once more. The first law of motion is sometimes also known as the law of inertia.

There are two conditions on which the 1st law of motion is dependent:

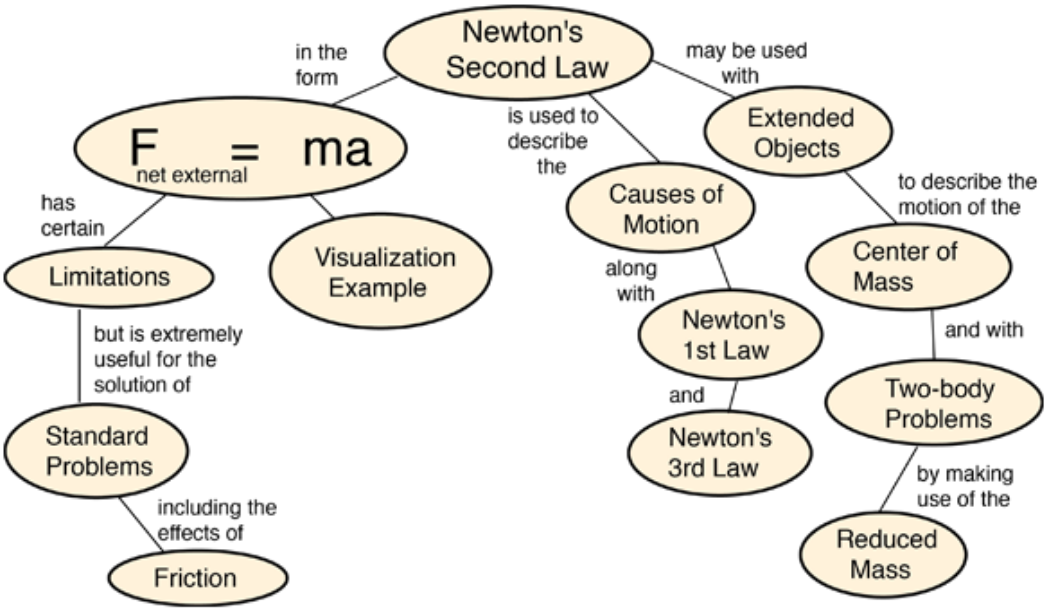
- Objects at rest: When an object is at rest velocity (v= 0) and acceleration (a = 0) are zero. Therefore, the object continues to be at rest.
- Objects in motion: When an object is in motion, velocity is not equal to zero (v ≠ 0) while acceleration (a = 0) is equal to zero. Therefore, the object will continue to be in motion with constant velocity and in the same direction.

Centripetal Force Example

The string must provide the necessary centripetal force to move the ball in a circle. If the string breaks, the ball will move off in a straight line. The straight line motion in the absence of the constraining force is an example of Newton's first law. The example here presumes that no other net forces are acting, such as horizontal motion on a frictionless surface. The vertical circle is more involved.



Newton's Second Law



What is Newton's Second Law of Motion?

Newton's Second law states that

> ***The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.***

Newton's Second Law as stated below applies to a wide range of physical phenomena, but it is not a fundamental principle like the Conservation Laws. It is applicable only if the force is the net external force. It does not apply directly to situations where the mass is changing, either from loss or gain of material, or because the object is traveling close to the speed of light where relativistic effects must be included. It does not apply directly on the very small scale of the atom where quantum mechanics must be used.

Data can be entered into any of the boxes below. Specifying any two of the quantities determines the third. After you have entered values for two, click on the text representing the third to calculate its value.

$$F_{net\ external} = ma$$

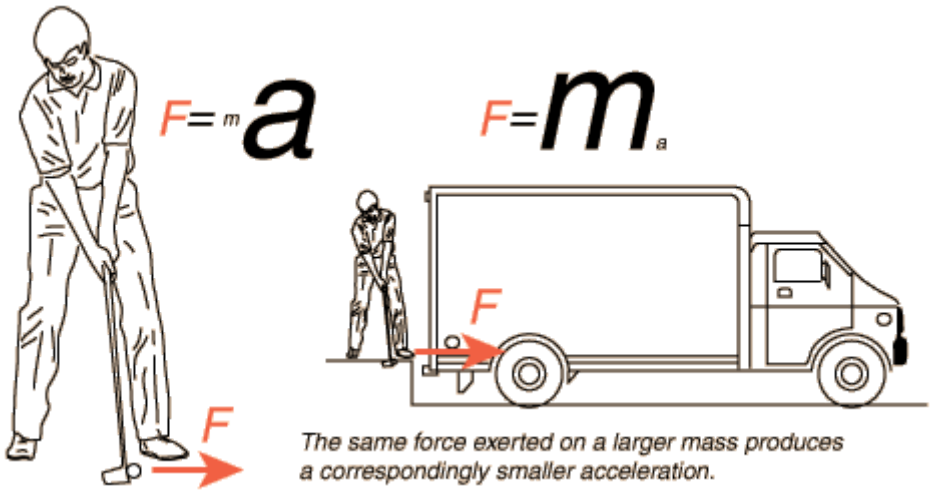
Net force on object = mass of object x acceleration

Newtons = kg * m/s^2

pounds = slugs * ft/s^2

Newton's Second Law Illustration

Newton's 2nd Law enables us to compare the results of the same force exerted on objects of different mass.



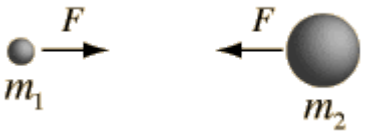
Newton's Third Law

What is Newton’s Third Law of Motion?

Newton’s Third law states that

> ***“When one body exerts a force on the other body, the first body experiences a force which is equal in magnitude in the opposite direction of the force which is exerted”.***

Newton's third law: All forces in the universe occur in equal but oppositely directed pairs. There are no isolated forces; for every external force that acts on an object there is a force of equal magnitude but opposite direction which acts back on the object which exerted that external force. In the case of internal forces, a force on one part of a system will be countered by a reaction force on another part of the system so that an isolated system cannot by any means exert a net force on the system as a whole. A system cannot "bootstrap" itself into motion with purely internal forces - to achieve a net force and an acceleration, it must interact with an object external to itself.



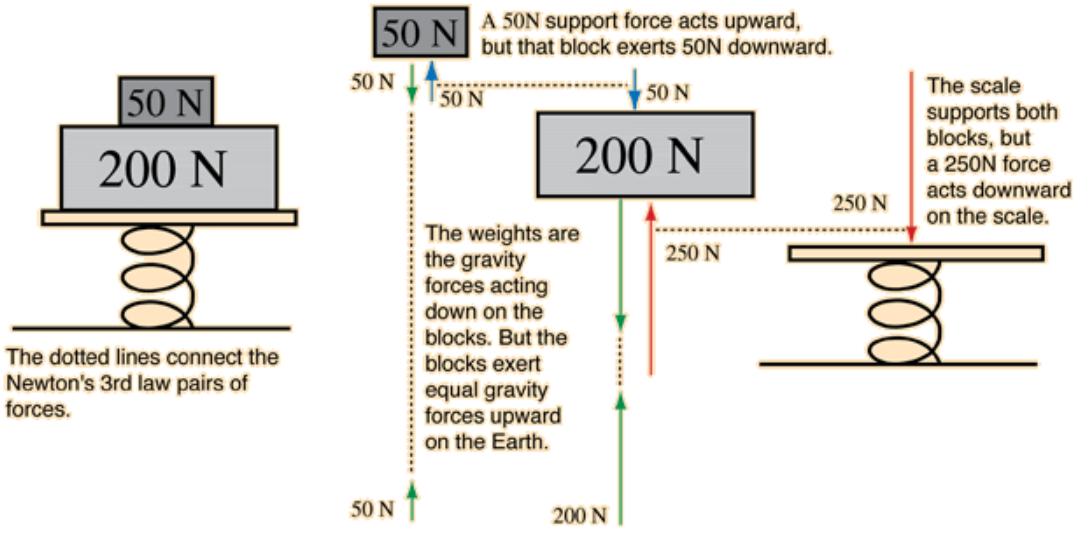
Without specifying the nature or origin of the forces on the two masses, Newton's 3rd law states that if they arise from the two masses themselves, they must be equal in magnitude but opposite in direction so that no net force arises from purely internal forces.

Newton's third law is one of the fundamental symmetry principles of the universe. Since we have no examples of it being violated in nature, it is a useful tool for analyzing situations which are somewhat counter-intuitive. For example, when a small truck collides head-on with a large truck, your intuition might tell you that the force on the small truck is larger. Not so!

Small truck, large truck

Newton's Third Law Example

Newton's third law can be illustrated by identifying the pairs of forces which are involved in supporting the blocks on the spring scale.



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