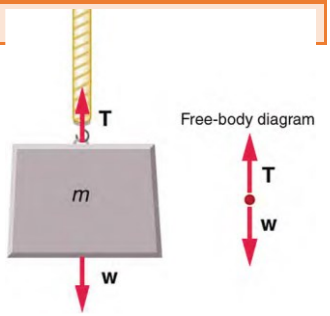
Physics 02-01 Newton's Laws *Name:* _____

Force



- A _____ or a _____
- Is a _____
- Unit: _____ (N)
- Measured by a _____

Free-body Diagram

- Picture of object with all the _____ acting _____ the object

Newton's First Law of Motion

A body at _____ remains at _____, or, if in motion, remains in _____ at a _____ unless acted on by a net external _____.

Inertia

- Property of objects to remain in _____ motion or rest.
- _____ is a measure of inertia

Newton's Second Law of Motion

Acceleration of a system is directly proportional to and in the same _____ of as the net _____ and inversely proportional to the _____.

$$a = \frac{F_{net}}{m} \text{ or } F_{net} = ma$$

Newton's Third Law of Motion

Whenever one body exerts a _____ on a second body, the first body experiences a force that is equal in _____ and opposite in _____ to the force that it exerts.

- ***Every force has an equal and opposite reaction force.***

A football player named Al is blocking a player on the other team named Bob. Al applies a 1500 N force on Bob. If Bob's mass is 100 kg, what is his acceleration?

What is the size of the force on Al?

If Al's mass is 75 kg, what is his acceleration?

A 0.046 kg golf ball hit by a driver can accelerate from rest to 67 m/s in 1 ms while the driver is in contact with the ball. How much average force does the golf ball experience?

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Practice Work

1. Forces are vectors. Look back in previous lessons and explain how to add vectors.
2. You are riding in a car when it turns to the left abruptly. Why do you feel like you are being forced to the right?
3. Which statement is correct? (a) Net force causes motion. (b) Net force causes change in motion. Explain your answer and give an example.
4. A system can have a nonzero velocity while the net external force on it is zero. Describe such a situation.
5. An airplane has a mass of 3.1×10^4 kg and takes off under the influence of a constant net force of 3.7×10^4 N. What is the net force that acts of the plane's 78-kg pilot? (Cutnell 4.1) **93 N**
6. In the amusement park ride known as Magic Mountain Superman, powerful magnets accelerate a car and its riders from rest to 45 m/s (about 100 mph) in a time of 7.0 s. The mass of the car and riders is 5.5×10^3 kg. Find the average net force exerted on the car and riders by the magnets. (Cutnell 4.3) $\mathbf{3.5 \times 10^4}$ **N**
7. When a 58-g tennis ball is served, it accelerates from rest to a speed of 45 m/s. The impact with the racket gives the ball a constant acceleration over a distance of 44 cm. What is the magnitude of the net force acting on the ball? (Cutnell 4.5) **130 N**
8. A 1580-kg car is traveling with a speed of 15.0 m/s. What is the magnitude of the net force that is required to bring this car to a halt in a distance of 50.0 m? (Cutnell 4.6) **3560 N**
9. A person with a black belt in karate has a fist that has a mass of 0.70 kg. Starting from rest, this fist attains a velocity of 8.0 m/s in 0.15 s. What is the magnitude of the average net force applied to the fist to achieve this level of performance? (Cutnell 4.7) **37 N**
10. A 350-kg sailboat has an acceleration of 0.62 m/s^2 at an angle of 64° north of east. Find the magnitude and direction of the net force that acts on the sailboat. (Cutnell 4.12) **220 N at 64° N of E**
11. A force vector has a magnitude of 720 N and a direction of 38° N of E. Determine the magnitude and direction of the components of the force that point along the N-S line and the E-W line. (Cutnell 4.10) **440N, 570N**
12. Only two forces act on an object (mass = 3.00 kg), as in the drawing. Find the magnitude and direction (relative to the x axis) of the acceleration of the object. (Cutnell 4.13) **30.9 m/s² at 27.2° above *x*-axis**
13. What net external force is exerted on a 1100-kg artillery shell fired from a battleship if the shell is accelerated at $2.40 \times 10^4\ m/s^2$? What force is exerted on the ship by the artillery shell? (OpenStax 4.15) $\mathbf{2.64 \times 10^7}$ **N,** $\mathbf{2.64 \times 10^7}$ **N**
14. Find the net force for the following forces: 3 N East, 2 N West, 5 N North, and 4 N South. (RW) **1.41 N at 45° N of E**
15. Find the net force for the following forces: 10 N up and 14 N at 30° above the horizontal. (RW) **20.9 N at 54.5° above horizontal**