# Mass and Weight

***by***

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**P3.6C** Explain how your weight on Earth could be different from your weight on another planet.

**P2.1F** Distinguish between rotation and revolution and describe and contrast the two speeds of an object like the Earth.

**Items:**

1. Mass.

2. Acceleration Due to Gravity (*g*).

3. Weight.

## *The Concept of Mass (m)*

*Mass* is a measure of the amount of “stuff” contained in an object.

It is some “intrinsic property” of an object.

If the amount of “stuff” in an object does not change, the mass does not change.

*mass # weight*

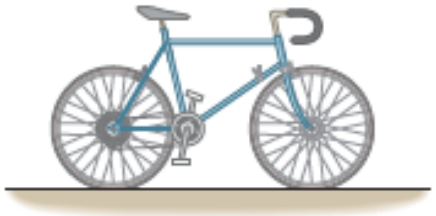
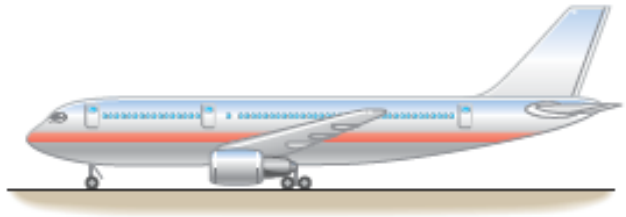
## *Newton's First Law of Motion*

*Inertia* is the natural tendency of an object to remain at rest or in motion at a constant speed along a straight line.

The *mass* of an object is a quantitative measure of inertia.

SI unit of mass is kilogram (Kg). The symbol of mass is m.

## Example 1:

| The Mass (m) of Various Objects | | |
|---|---|---|
|  Penny (0.003 kg) |  Bicycle (15 kg) |  Jetliner ($1.2 \times 10^5$ kg) |
| m = 0.003 kg | m = 15 kg | m = 120000 kg |

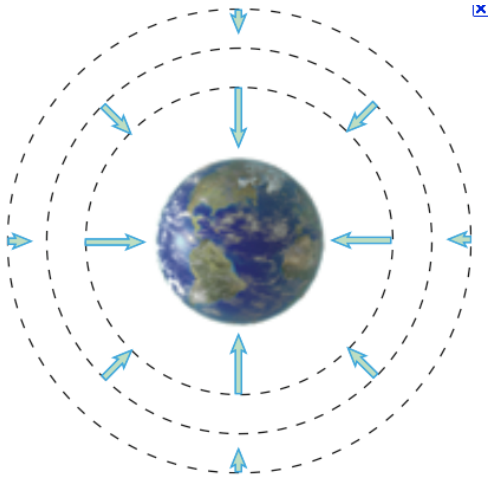
The mass of the penny is 0.003 kg ( m = 0.003 kg)

The mass of the bicycle is 15 kg ( m = 15 kg)

The mass of the jetliner is 120000 kg ( m = 120000 kg)

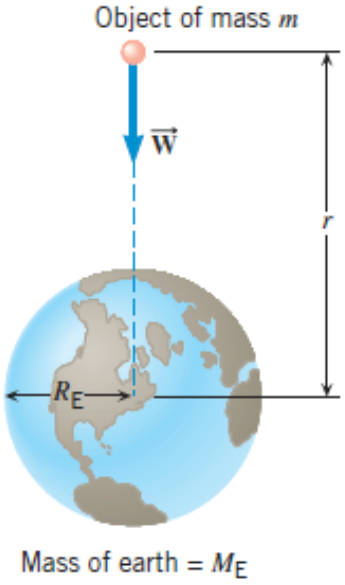
## *Definition of Weight (W)*

Earth is surrounded by a gravitational force field (blue- greenish vectors ⇒, in the picture below). This means that every mass large or small feels a force pulling it towards its center.



The *weight* of an object on or above the earth is the gravitational force that the earth exerts on the object.

The weight always acts downward, toward the center of the earth. The picture below shows how the weight (W) of an object of mass (m) is a force directed toward the center of the earth.




On or above another astronomical body, the weight is the gravitational force exerted on the object by that body.

SI Unit of Weight: newton (N)

## *Relation Between Mass and Weight*

How to calculate the weight of an object if we know the mass of that object? There is a formula to do the calculation. It is related to Newton's Second Law of Motion. The formula is shown in the table below.

| Weight (W) |
| --- |
| Weight = (Mass) x (Acceleration due to Gravity)<br>$W = m \times g$<br>---<br>W: Weight is measured in Newton (N)<br>m: Mass is measured in kilogram (Kg)<br>***g: Acceleration due to gravity or*** gravitational field strength. It is different on each planet. |

At the surface of the Earth, $g = 9.8$ N/kg.

## Acceleration due to gravity (g)

The acceleration of a freely falling body is called the acceleration due to gravity.

The acceleration due to gravity is:

a) directed toward the center of the Earth,

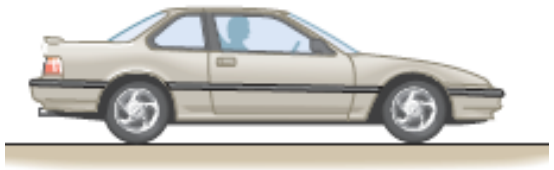
b) has the symbol g

c) has the constant value of $9.80 m/s^2$.

**Acceleration due to gravity = a = g = $9.80 m/s^2$ or $32.2 ft/s^2$**

In the absence of air resistance, all bodies at the same location above the Earth fall vertically with the same acceleration due to gravity **= a = g = $9.80 m/s^2$**

**Example 2:** *Mass and Weight of a Car at the Surface of the Earth*.



Car
(2000 kg)

At the surface of the earth, the car has a mass of 2000 kg and the acceleration is 9.8 $m/s^2$ . The weight of the car can be calculated as shown below, using the formula of weight.

| Weight (W) |
| --- |
| $W = m \times g = 2000 \times 9.8 = 19600$ Newton |

So, the car has a weight of 19600 N.

**Example 3:** *Mass and Weight at different Planets*

The table below shows how the weight of a 57 kg person changes at the surface of different planets.

| Planet | g : gravitational field strength at surface (N/kg). | Mass (m) on planet's surface in kg | Weight (w) of this mass in Newton |
|---|---|---|---|
| Jupiter | 26 | 57 | 1482 |
| Earth | 9.8 | 57 | 558.6 |
| Venus | 8.1 | 57 | 462 |
| Mercury | 3.3 | 57 | 188 |
| Moon | 1.63 | 57 | 92.91 |

## *References:*

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Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

*The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"*

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

4) Zitzewitz, P. W. (1999). *Glencoe Physics Principles and Problems*. New York: McGraw-Hill Companies, Inc.

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