BTU 1113 Physics

Chapter 3: Newton's Laws of Motion

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Chapter Description

- Aims
  - Explain the concept of force and Newton's three laws of motion.
  - Illustrate and solve the problems related with Newton's First Law and inertia.
  - Illustrate and solve the problems related with Newton's Second Law.
  - Differentiate the gravitational force and weight.
  - Interpret the forces of friction.

- Expected Outcomes
  - Students should be able to explain the concept of force.
  - Students should be able to illustrate and solve the problems related with Newton's First Law and inertia.
  - Students should be able to illustrate and solve the problems related with Newton's Second Law.
  - Students should be able to differentiate the gravitational force and weight.
  - Students should be able to interpret the forces of friction.

- Other related Information
  - Relationship between force and motion will be discussed further in this chapter.

- References

  - Giancoli, D.C., 2008. Physics for Scientists & Engineers. 4th edition. Prentice Hall, USA.
  - Jones, E., 2002. Contemporary College Physics. 3rd Ed, McGraw-Hill, Singapore.
  - Young, H. D. and Freedman, R. A., 2012. University Physics with Modern Physics. 13th edition, Pearson, San Francisco

1st aim:
Explain the concept of force and Newton's three laws of motion.

Newton's Laws of Motion

1st Law – An object at rest will stay at rest, and an object in motion will stay in motion at constant velocity, unless acted upon by an unbalanced force.

2nd Law – Force equals mass times acceleration.

3rd Law – For every action there is an equal and opposite reaction.

2nd aim:
Illustrate and solve the problems related with Newton's First Law and inertia.

1st Law of Motion (Law of Inertia)

An object at rest will stay at rest, and an object in motion will stay in motion at constant velocity, unless acted upon by an unbalanced force.

1st Law

Inertia is the tendency of an object to resist changes in its velocity: whether in motion or motionless.

By Danielle Scott
https://commons.wikimedia.org

These pumpkins will not move unless acted on by an unbalanced force.

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3rd aim:
Illustrate and solve the problems related with Newton's Second Law.

2nd Law

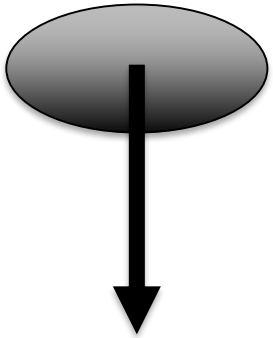
Definition:The net force of an object is equal to the product of its mass and acceleration.

$$F = ma$$

2nd Law

When mass is in kilograms and acceleration is in m/s^2, the unit of force is in Newtons (N).
One newton is equal to the force required to accelerate one kilogram of mass at one m/s^2.

Newton's 2nd Law proves that different masses accelerate to the earth at the same rate, but with different forces.



$$a = \frac{F}{m} = \frac{98N}{10kg} = 9.8\ m/s^2$$

$$a = \frac{F}{m} = \frac{9.8N}{1kg} = 9.8\ m/s^2$$

We know that objects with different masses accelerate to the ground at the same rate.

However, because of the 2nd Law we know that they don't hit the ground with the same force.

3rd Law

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According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body.

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Newton's 3rd Law in Nature

There are two forces resulting from this interaction - a force on the chair and a force on your body.

These two forces are called *action* and *reaction* forces.

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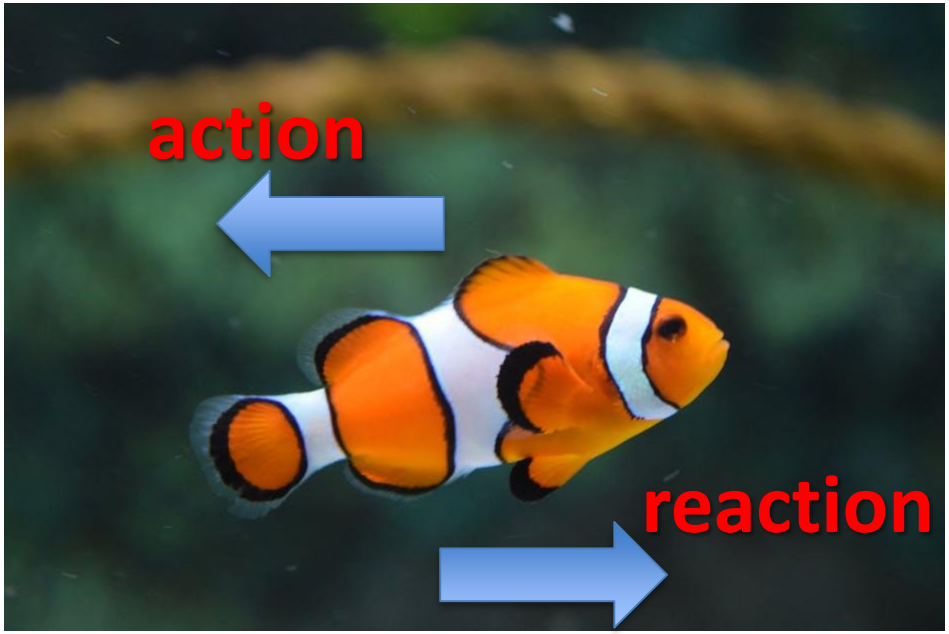
Newton's 3rd Law in Nature

Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. In turn, the water reacts by pushing the fish forwards, propelling the fish through the water.



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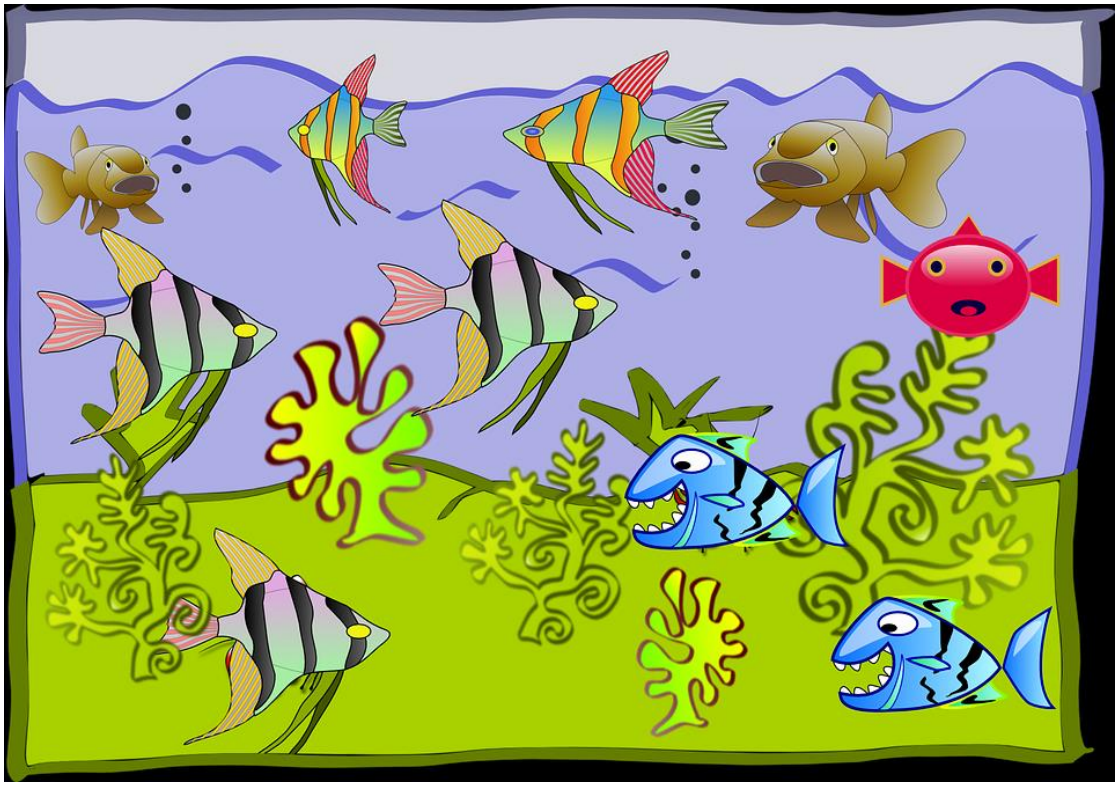

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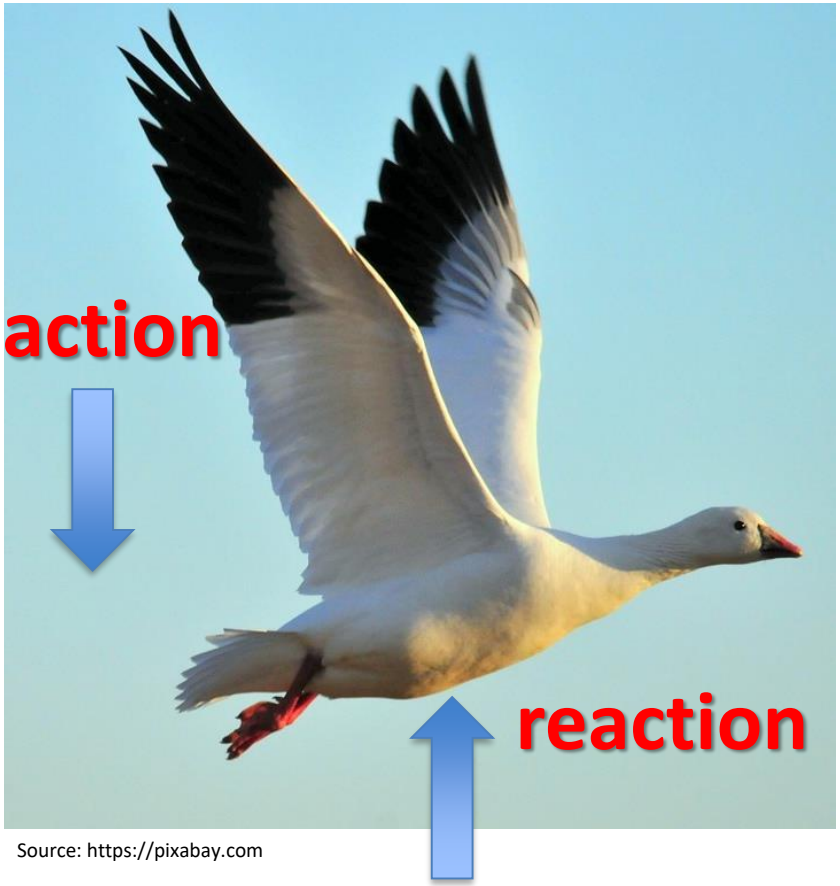
The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards).

Newton's 3rd Law in Nature



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Flying gracefully through the air, birds depend on Newton's third law of motion. As the birds push down on the air with their wings, the air pushes their wings up and gives them lift.

4th aim:
Differentiate the gravitational force and weight.

MASS vs WEIGHT

MASS

* The property of a body of fluid that is a measure of its inertia or resistance to a change in motion.
* It is also a measure of the quantity of fluid.
* Symbol = *m*

WEIGHT

* The amount that a body weighs, that is, the force with which a body is attracted toward the earth by gravitation.
* Symbol = *w*

How they are relate to each other?

GRAVITATIONAL FORCE vs WEIGHT

Weight

- the gravitational force acting on a body

Gravitational force

- a force that attracts any objects with mass.

5th aim:
Interpret the forces of friction.

Why then, do we observe every day objects in motion slowing down and becoming motionless seemingly without an outside force?

It's a force we sometimes cannot see – friction.

Objects on earth, unlike the frictionless space the moon travels through, are under the influence of **friction**.

What is this unbalanced force that acts on an object in motion?

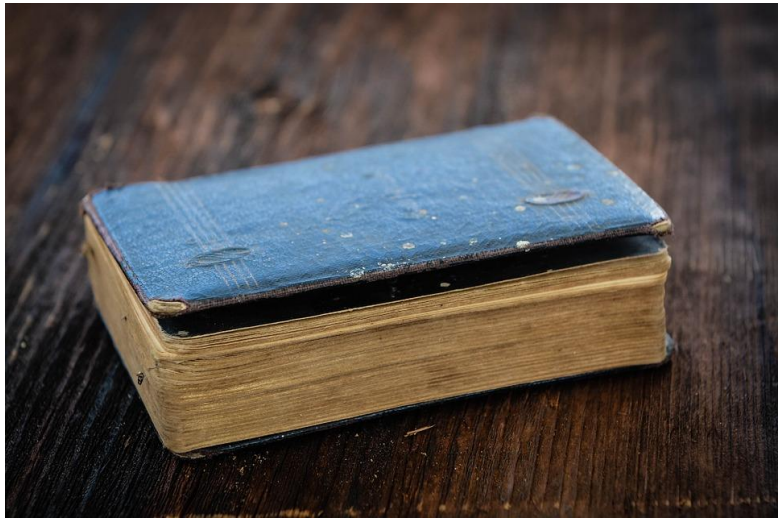
Friction!

There are four main types of friction:

- **Sliding friction: ice skating**
- **Rolling friction: bowling**
- **Fluid friction (air or liquid): air or water resistance**
- **Static friction: initial friction when moving an object**

Example of friction

Slide a book across a table and watch it slide to a rest position. The book comes to a rest because of the *presence* of a force - that force being the force of friction - which brings the book to a rest position.



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In the absence of a force of friction, the book would continue in motion with the same speed and direction - forever! (Or at least to the end of the table top.)

Conclusion of The Chapter

Newton's first law describing the law of inertia and the second law relates force and acceleration. Meanwhile, Newton's third law states that there is an equal and opposite reaction for every action.

Reference

Giancoli, D.C., 2008. Physics for Scientists & Engineers. 4th edition. Prentice Hall, USA.