

Important Concepts	Alaska Science Content Standard B4 Students develop an understanding of motions, forces, their characteristics and relationships, and natural forces and their effects.
Forces and Motion	B3 Students develop an understanding of the interactions between matter and energy, including physical, chemical, and nuclear changes, and the effects of these interactions on physical systems. (partially addressed)
9-12 Level	

Grade Level Expectations:

The student demonstrates an understanding of motions, forces, their characteristics, relationships, and effects by:

[9] **SB4.1** explaining the relationship of motion to an object's mass and the applied force

[9] **SB4.2** recognizing that the gravitational attraction between objects is proportional to their masses and decreasing with their distance

[9] **SB4.3** describing the interactions of waves (i.e., reflection, refraction, wave addition)

[10] **SB4.1** recognizing that when one thing exerts a force on another, an equal amount of force is exerted back on it

[10] **SB4.2** explaining that different kinds of materials respond to electric and magnetic forces (i.e., conductors, insulators, magnetic, and non-magnetic materials)

[11] **SB4.1** conducting an experiment to demonstrate that when one thing exerts a force on another, an equal amount of force is exerted back on it (**L**)

[11] **SB4.2** conducting an experiment to explore the relationship between magnetic forces and electric forces to show that they can be thought of as different aspects of a single electromagnetic force (e.g., generators and motors) (**L**)

The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by:

[10] **SB3.3** comparing the relative wavelengths and applications of different forms of electromagnetic radiation (i.e., x-ray, visible, infrared, microwaves, radio)

According to AAAS's Benchmarks for Science Literacy*, some of the things that students should know and understand by the end of twelfth grade are:

Any object maintains a constant speed and direction of motion unless an unbalanced outside force acts on it.

The change in motion (direction or speed) of an object is proportional to the applied force and inversely proportional to the mass.

Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

In most familiar situations, frictional forces complicate the description of motion, although the basic principles still apply.

When electrically charged objects undergo a change in motion, they produce electromagnetic waves around them.

Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength.

Gravitational force is an attraction between masses. The strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.

*Project 2061, American Association for the Advancement of Science, Benchmarks for Science Literacy. New York: Oxford University Press, 1993.

Electric forces hold solid and liquid materials together and act between objects when they are in contact—as in sticking or sliding friction

Most materials have equal numbers of protons and electrons and are therefore electrically neutral. In most cases, a material acquires a negative charge by gaining electrons and acquires a positive charge by losing electrons. Even a tiny imbalance in the number of protons and electrons in an object can produce noticeable electric forces on other objects.

The motion of electrons is far more affected by electrical forces than protons are because electrons are much less massive and are outside of the nucleus.

In many conducting materials, such as metals, some of the electrons are not firmly held by the nuclei of the atoms that make up the material. In these materials, applied electric forces can cause the electrons to move through the material, producing an electric current. In insulating materials, such as glass, the electrons are held more firmly, making it nearly impossible to produce an electric current in those materials.

Magnetic forces are very closely related to electric forces and are thought of as different aspects of a single electromagnetic force. Moving electrically charged objects produces magnetic forces and moving magnets produces electric forces.

The interplay of electric and magnetic forces is the basis for many modern technologies, including electric motors, generators, and devices that produce or receive electromagnetic waves. Electric currents in the earth's interior give the earth an extensive magnetic field, which we detect from the orientation of compass needles.