Gravitational Fields

Unit: Dynamics (Forces) & Gravitation

NGSS Standards: HS-PS2-1

MA Curriculum Frameworks (2006): 1.5

AP Physics 1 Learning Objectives: 2.B.1.1

Knowledge & Understanding:

- Understand the representation of gravity as a force field.

Language Objectives:

- Understand the specific use of the level 2 word "field" in the context of gravity.
- Understand and correctly use the terms "force field" and "gravity field".

Labs, Activities & Demonstrations:

- Miscellaneous falling objects

Notes:

Gravity is an attractive force between two or more objects that have mass. For reasons that are not yet understood, masses exert attraction to each other in proportion to the masses of the objects and in inverse proportion to the square of the distance between them. (This concept will be discussed more fully in the section on Universal Gravitation on page 272.)

When considering objects near the Earth's surface (give or take a few hundred meters) that are small in relation to the size and mass of the Earth, gravity may be considered to be a force field.

force field: a region in which a force acts upon all objects that have some particular characteristic or property.

In the case of gravity, that property is the mass of the object, and the force acts in proportion to the strength of the field.

Other types of force fields include electric fields, in which an electric force acts on all objects that have electric charge, and magnetic fields, in which a magnetic force acts on all objects that have magnetic susceptibility (the property that causes them to be attracted to or repelled by a magnet).

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The strength of a gravitational field is a vector quantity described by the variable $\vec{g}$ and is equal to the force that the field applies on an object per unit of the object's mass:

$$\frac{\vec{F}_g}{m} = \frac{m\vec{g}}{m} = \vec{g}$$

Conveniently, force per unit of mass equals acceleration, which is why $\vec{g}$ represents ***both*** the strength of the gravitational field ***and*** the acceleration that the gravitational field causes. This is why the value of $\vec{g}$ and how it is used in equations is the same, regardless of how we choose to derive it.

The value of $\vec{g}$ depends on the mass of the object causing the field (usually the Earth) and the distance to its center of mass (usually the radius of the Earth).

The direction of $\vec{g}$ is always toward the center of mass of the large object (*i.e.,* toward the center of the Earth or toward the ground).

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