Introduction: Gravitation

Unit: Gravitation

Topics covered in this chapter:

In this chapter you will learn about different kinds of forces and how they relate.

- *Early Theories of the Universe* describes the geocentric (Earth-centered) model of the universe, and the theories of Ptolemy and Copernicus.
- *Kepler's Laws of Planetary Motion* describes the motion of planets and other celestial bodies and the time period that it takes for planets to revolve around stars throughout the universe.
- *Universal Gravitation* describes how to calculate the force of mutual gravitational attraction between massive objects such as planets and stars.

AP® This unit is part of *Unit 2: Force and Translational Dynamics* from the 2024 AP® Physics 1 Course and Exam Description.

Standards addressed in this chapter:

NGSS Standards/MA Curriculum Frameworks (2016):

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation ~~and Coulomb's Law~~ to describe and predict the gravitational ~~and electrostatic~~ forces between objects.

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AP® Physics 1 Learning Objectives/Essential Knowledge (2024):

2.6.A: Describe the gravitational interaction between two objects or systems with mass.

2.6.A.1: Newton's law of universal gravitation describes the gravitational force between two objects or systems as directly proportional to each of their masses and inversely proportional to the square of the distance between the systems' centers of mass.

2.6.A.1.i: The gravitational force is attractive.

2.6.A.1.ii: The gravitational force is always exerted along the line connecting the centers of mass of the two interacting systems.

2.6.A.1.iii: The gravitational force on a system can be considered to be exerted on the system's center of mass.

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2.6.A.2: A field models the effects of a noncontact force exerted on an object at various positions in space.

2.6.A.2.i: The magnitude of the gravitational field created by a system of mass *M* at a point in space is equal to the ratio of the gravitational force exerted by the system on a test object of mass *m* to the mass of the test object.

2.6.A.2.ii: If the gravitational force is the only force exerted on an object, the observed acceleration of the object (in m/s^2) is numerically equal to the magnitude of the gravitational field strength (in N/kg) at that location.

2.6.A.3: The gravitational force exerted by an astronomical body on a relatively small nearby object is called weight.

2.6.B: Describe situations in which the gravitational force can be considered constant.

2.6.B.1: If the gravitational force between two systems' centers of mass has a negligible change as the relative position of the two systems changes, the gravitational force can be considered constant at all points between the initial and final positions of the systems.

2.6.B.2: Near the surface of Earth, the strength of the gravitational field is $\vec{g} \approx 10 \frac{\text{N}}{\text{kg}}$.

2.6.C: Describe the conditions under which the magnitude of a system's apparent weight is different from the magnitude of the gravitational force exerted on that system.

2.6.C.1: The magnitude of the apparent weight of a system is the magnitude of the normal force exerted on the system.

2.6.C.2: If the system is accelerating, the apparent weight of the system is not equal to the magnitude of the gravitational force exerted on the system.

2.6.C.3: A system appears weightless when there are no forces exerted on the system or when the force of gravity is the only force exerted on the system.

2.6.C.4: The equivalence principle states that an observer in a noninertial reference frame is unable to distinguish between an object's apparent weight and the gravitational force exerted on the object by a gravitational field.

2.6.D: Describe inertial and gravitational mass.

2.6.D.1: Objects have inertial mass, or inertia, a property that determines how much an object's motion resists changes when interacting with another object.

2.6.D.2: Gravitational mass is related to the force of attraction between two systems with mass.

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2.6.D.3: Inertial mass and gravitational mass have been experimentally verified to be equivalent.

2.9.B: Describe circular orbits using Kepler's third law.

2.9.B.1: For a satellite in circular orbit around a central body, the satellite's centripetal acceleration is caused only by gravitational attraction. The period and radius of the circular orbit are related to the mass of the central body.

Skills learned & applied in this chapter:

- Estimating the effect of changing one variable on other variables in the same equation.

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