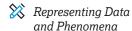
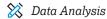


Forces

SUGGESTED SKILLS



3.D Create appropriate diagrams to represent physical situations.



4.E Explain how the data or graph illustrates a physics principle, process, concept, or theory.

Theoretical Relationships

5.E Derive a symbolic expression from known quantities by selecting and following a logical algebraic pathway.



AVAILABLE RESOURCES

Classroom Resources >

- AP Physics Featured **Question: Projectile** Concepts
- AP Physics Featured Question: Raft with **Hanging Weights**
- Critical Thinking **Questions in Physics**
- Physics Instruction **Using Video Analysis Technology**
- **Quantitative Skills in** the AP Sciences
- Teaching Strategies for **Limited Class Time**

TOPIC 7.1 Gravitational

Required Course Content

ENDURING UNDERSTANDING

FLD-1

Objects of large mass will cause gravitational fields that create an interaction at a distance with other objects with mass.

LEARNING OBJECTIVE

FLD-1.A

Calculate the magnitude of the gravitational force between two large spherically symmetrical masses.

FLD-1.B

Calculate the value for g or gravitational acceleration on the surface of the Earth (or some other large planetary object) and at other points outside of the Earth.

ESSENTIAL KNOWLEDGE

FLD-1.A.1

The magnitude of the gravitational force between two masses can be determined by using Newton's universal law of gravitation.

$$\left| \overrightarrow{F}_G \right| = \frac{Gm_1m_2}{r^2}$$

FLD-1.B.1

Using Newton's laws it can be shown that the value for gravitational acceleration at the surface of the Earth is:

$$g = \frac{GM_e}{R_e^2}$$

and if the point of interest is located far from the earth's surface, then g becomes:

$$g = \frac{GM_e}{r^2}$$

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LEARNING OBJECTIVE

FLD-1.C

Describe the motion in a qualitative way of an object under the influence of a variable gravitational force, such as in the case where an object falls toward the Earth's surface when dropped from distances much larger than the Earth's radius.

ESSENTIAL KNOWLEDGE

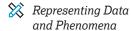
FLD-1.C.1

The gravitational force is proportional to the inverse of distance squared; therefore, the acceleration of an object under the influence of this type of force will be nonuniform.

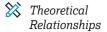
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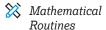
SUGGESTED SKILLS



3.C Sketch a graph that shows a functional relationship between two quantities.



5.D Determine or estimate the change in a quantity using a mathematical relationship.



6.C Calculate an unknown quantity with units from known quantities by selecting and following a logical computational pathway.

X Argumentation

7.F Explain how potential sources of experimental error may affect results and/or conclusions.



AVAILABLE RESOURCES

Classroom Resources >

- AP Physics Featured **Question: Projectile** Concepts
- AP Physics Featured **Question: Raft with Hanging Weights**
- Critical Thinking **Questions in Physics**
- Physics Instruction **Using Video Analysis** Technology
- Quantitative Skills in the AP Sciences
- Teaching Strategies for Limited Class Time

TOPIC 7.2

Orbits of Planets and Satellites

Required Course Content

ENDURING UNDERSTANDING

Angular momentum and total mechanical energy will not change for a satellite in an orbit.

LEARNING OBJECTIVE

CON-6.A

Calculate quantitative properties (such as period, speed, radius of orbit) of a satellite in circular orbit around a planetary object.

CON-6.B

Derive Kepler's third law for the case of circular orbits.

ESSENTIAL KNOWLEDGE

The centripetal force acting on a satellite is provided by the gravitational force between satellite and planet.

a. The velocity of a satellite in circular orbit is inversely proportional to the square root of the radius and is independent of the satellite's mass.

CON-6.B.1

In a circular orbit, Newton's second law analysis can be applied to the satellite to determine the orbital velocity relationship for satellite of mass m about a central body of mass M.

a. With proper substitutions, this can be reduced to expressing the period's dependence on orbital distance as Kepler's third law shows:

$$T^2 = \frac{4\pi^2}{GM}r^3$$

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LEARNING OBJECTIVE

CON-6.C

Describe a linear relationship to verify Kepler's third law.

CON-6.D

Calculate the gravitational potential energy and the kinetic energy of a satellite/ Earth system in which the satellite is in circular orbit around the earth.

CON-6.E

Derive the relationship of total mechanical energy of a satellite/earth system as a function of radial position.

CON-6.F

- a. Derive an expression for the escape speed of a satellite using energy principles.
- b. Describe the motion of a satellite launched straight up (or propelled toward the planet) from the planet's surface, using energy principles.

ESSENTIAL KNOWLEDGE

CON-6.C.1

Verifying Kepler's third law with actual data provides experimental verification of the law.

CON-6.D.1

The gravitational potential energy of a satellite/ Earth system (or other planetary/satellite system) in orbit is defined by the potential energy function of the system:

$$U_g = -\frac{Gm_e m_{sat}}{r}$$

a. The kinetic energy of a satellite in circular orbit can be reduced to an expression that is only dependent on the satellite's system and position.

CON-6.E.1

The total mechanical energy of a satellite is inversely proportional to the orbital distance and is always a negative value and equal to one half of the gravitational potential energy.

CON-6.F.1

In ideal situations, the energy in a planet/ satellite system is a constant.

- a. The gravitational potential energy of a planet/satellite system is defined to have a zero value when the satellite is at an infinite distance (very large planetary distance) away from the planet.
- b. By definition, the "escape speed" is the minimum speed required to escape the gravitational field of the planet. This could occur at a minimum when the satellite reaches a nominal speed of approximately zero at some very large distance away from the planet.

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LEARNING OBJECTIVE

CON-6.G

Calculate positions, speeds, or energies of a satellite launched straight up from the planet's surface, or a satellite that is projected straight toward the planet's surface, using energy principles.

CON-6.H

Describe elliptical satellite orbits using Kepler's three laws of planetary motion.

CON-6.I

- a. Calculate the orbital distances and velocities of a satellite in elliptical orbit using the conservation of angular momentum.
- b. Calculate the speeds of a satellite in elliptical orbit at the two extremes of the elliptical orbit (perihelion and aphelion).

ESSENTIAL KNOWLEDGE

CON-6.G.1

In ideal nonorbiting cases, a satellite's physical characteristics of motion can be determined using the conservation of energy.

CON-6.H.1

The derivation of Kepler's third law is only required for a satellite in a circular orbit.

CON-6.I.1

In all cases of orbiting satellites, the total angular momentum of the satellite is a constant.

a. The conservation of mechanical energy and the conservation of angular momentum can both be used to determine speeds at different positions in the elliptical orbit.