



DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS
AP PHYSICS



STUDENT OF THE WEEK

BEST MULLET BY AN UPPERCLASSMAN

*Student
of the Week*



GIANCOLI LESSONS 4-1 TO 4-6
DYNAMICS: FORCE AND MOTION

Big Idea(s):

- Objects and systems have properties such as mass and charge. Systems may have internal structure.
- Fields existing in space can be used to explain interactions.
- The interactions of an object with other objects can be described by forces.
- Interactions between systems can result in changes in those systems.

Enduring Understanding(s):

- 1.C: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
- 2.B: A gravitational field is caused by an object with mass.
- 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.

Enduring Understanding(s):

- 3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using .
- 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- 3.G: Certain types of forces are considered fundamental.
- 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where

$$\vec{a} = \frac{\vec{F}}{m}$$

Essential Knowledge(s):

- 1.C.1: Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems.
- 1.C.2: Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.
 - The gravitational mass of an object determines the amount of force exerted on the object by a gravitational field.
 - Near the Earth's surface, all objects fall (in a vacuum) with the same acceleration, regardless of their inertial mass.

Essential Knowledge(s):

- 1.C.3: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
- 2.B.1: A gravitational field at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field.
 - On the Earth, this gravitational force is called weight.
 - The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force.
 - If the gravitational force is the only force exerted on the object, the observed free-fall acceleration of the object (in meters per second squared) is numerically equal to the magnitude of the gravitational field (in newtons/kilogram) at that location.

Essential Knowledge(s):

- 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.
 - Displacement, velocity, and acceleration are all vector quantities.
 - Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.
 - A choice of reference frame determines the direction and the magnitude of each of these quantities.

Essential Knowledge(s):

- Forces are described by vectors.
 - Forces are detected by their influence on the motion of an object.
 - Forces have magnitude and direction.

Essential Knowledge(s):

- 3.A.3: A force exerted on an object is always due to the interaction of that object with another object.
 - An object cannot exert a force on itself.
 - Even though an object is at rest, there may be forces exerted on that object by other objects.
 - The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects.

Essential Knowledge(s):

- 3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.
- 3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.

Essential Knowledge(s):

- 3.C.4: Contact forces result from the interaction of one object touching another object and they arise from interatomic electric forces. These forces include tension, friction, normal, spring (Physics 1), and buoyant (Physics 2).
- 3.G.1: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.
- 4.A.3: Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center-of-mass velocity of that system.

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Essential Knowledge(s):

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Learning Objective(s):

- (1.C.1.1): The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration.
- (1.C.3.1): The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass, and to distinguish between the two experiments.
- (2.B.1.1): The student is able to apply to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.

Learning Objective(s):

- (3.A.1.1): The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
- (3.A.1.2): The student is able to design an experimental investigation of the motion of an object.
- (3.A.1.3): The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

Learning Objective(s):

- (3.A.2.1): The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
- (3.A.3.1): The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.
- (3.A.3.2): The student is able to challenge a claim that an object can exert a force on itself.

Learning Objective(s):

- (3.A.3.3): The student is able to describe a force as an interaction between two objects and identify both objects for any force.
- (3.A.4.1): The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.
- (3.A.4.2): The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.

Learning Objective(s):

- (3.B.1.1): The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension.
- (3.B.1.2): The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
- (3.B.1.4): The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations.

Learning Objective(s):

- (3.C.4.1): The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.
- (3.C.4.2): The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.
- (3.G.1.1): The student is able to articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored.

Learning Objective(s):

- (3.G.1.2): The student is able to connect the strength of the gravitational force between two objects to the spatial scale of the situation and the masses of the objects involved and compare that strength to other types of forces.
- (4.A.3.1): The student is able to apply Newton's second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system.

Learning Objective(s):

- (4.A.3.2): The student is able to use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system.

Force – Aristotle → Galileo

- Push or pull on an object
- May or may not produce motion
- For a given object, the force needed to move the object may change based on the surface it's resting on
- For a body already in motion, force is needed to change the direction or speed

Newton's First Law of Motion

Newton's First Law of Motion

- **Every body continues in its state of rest or of uniform speed in a straight line unless acted on by a nonzero net force**

Newton's First Law of Motion

- **Every body** continues in its state of rest or of uniform speed in a straight line unless acted on by a nonzero net force
 - Everything that has mass
 - Just about everything except light and heat

Newton's First Law of Motion

- Every body **continues in its state of rest or of uniform speed** in a straight line unless acted on by a nonzero net force
 - Inertia – tendency of a body to maintain its state of rest or uniform motion
 - First law also called law of inertia

Newton's First Law of Motion

- Every body continues in its state of rest or of uniform speed **in a straight line** unless acted on by a nonzero net force
 - Important concept to remember for second law
 - Something must happen for an object to change direction

Newton's First Law of Motion

- Every body continues in its state of rest or of uniform speed in a straight line **unless acted on by a nonzero net force**
 - Force is required to change a body's state of rest
 - Force is required to change a body's uniform straight-line speed
 - Force is required to change a body's direction of motion

Reference Frames

- Accelerating Reference Frame
 - Coffee sliding off the dashboard as you accelerate from the traffic light
- Inertial Reference Frame
 - Fixed, or at constant velocity, in space
- Can anything on earth really be called an inertial reference frame?

Reference Frames

- Accelerating Reference Frame
 - Coffee on the dashboard
- Inertial Reference Frame
 - Fixed, or at constant velocity, in space
- Can anything on earth really be called an inertial reference frame?
 - Rotation of the earth
 - Orbit of the earth
 - Movement of the solar system

Mass

- Not a Catholic church service
- Chemistry - Quantity of matter

Mass

- Not a Catholic church service
- Chemistry - Quantity of matter
- **Physics – measure of the inertia of a body**

Mass vs Weight

- What's the difference?

Mass vs Weight

- Mass
 - Property of the body itself
 - Quantity of matter
 - Measure of inertia
- Weight
 - Property of a body in relation to other bodies
 - Gravitational attraction between two bodies
 - It is dependent on proximity to other bodies (gravity)
 - **Weight is a force and is a vector – points in the direction of the attracting body's center of mass**

Newton's Second Law of Motion

- The acceleration of an object is directly proportional to the net force acting on it and is inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object.

$$\Sigma F = ma$$

Newton's Second Law of Motion

- The **acceleration** of an object is directly proportional to the net force acting on it and is inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object.
 - Movement
 - Inertia has been overcome
 - Change in speed
 - Change in direction

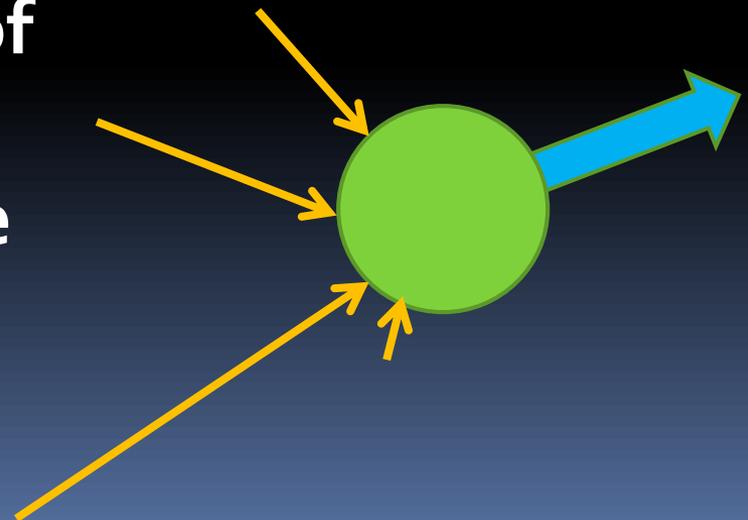
Newton's Second Law of Motion

- The acceleration of an object is **directly proportional to the net force** acting on it and is inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object.

$$a \propto F_{net}$$

$$F_{net} = \sum F$$

$$a \propto \sum F$$



Newton's Second Law of Motion

- The acceleration of an object is **directly proportional to the net force** acting on it and is **inversely proportional to its mass**. The direction of the acceleration is in the direction of the net force acting on the object.

$$a \propto \sum F$$

$$a \propto \frac{1}{m}$$

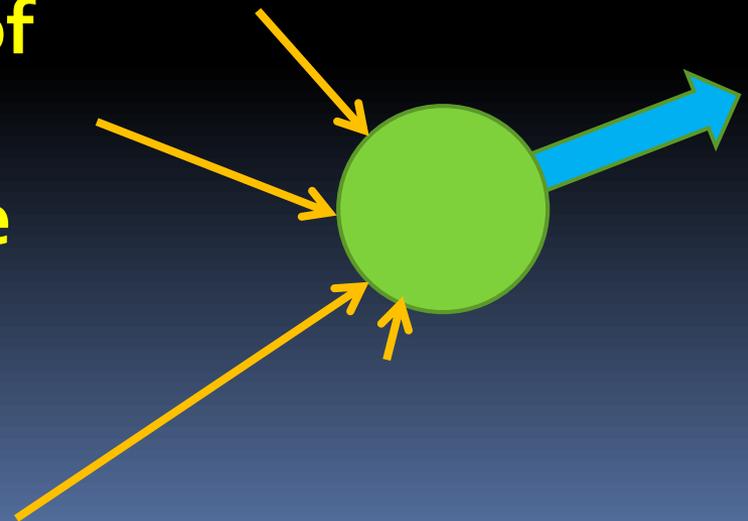
$$a = \frac{\sum F}{m}$$

$$\sum F = ma$$

Newton's Second Law of Motion

- The acceleration of an object is directly proportional to the net force acting on it and is inversely proportional to its mass. **The direction of the acceleration is in the direction of the net force acting on the object.**

$$\Sigma \vec{F} = m\vec{a}$$



Weight as a Force

- Weight is a Force
- $F = ma$
- What's the a ?

$$\Sigma \vec{F} = m\vec{a}$$

Weight as a Force

- Weight is a Force
- $F = ma$
- What's the a ?
 - Acceleration due to gravity
 - $g = 9.81 \text{ m/s}^2$

$$\Sigma \vec{F} = m\vec{a}$$

$$F_{\text{weight}} = mg$$

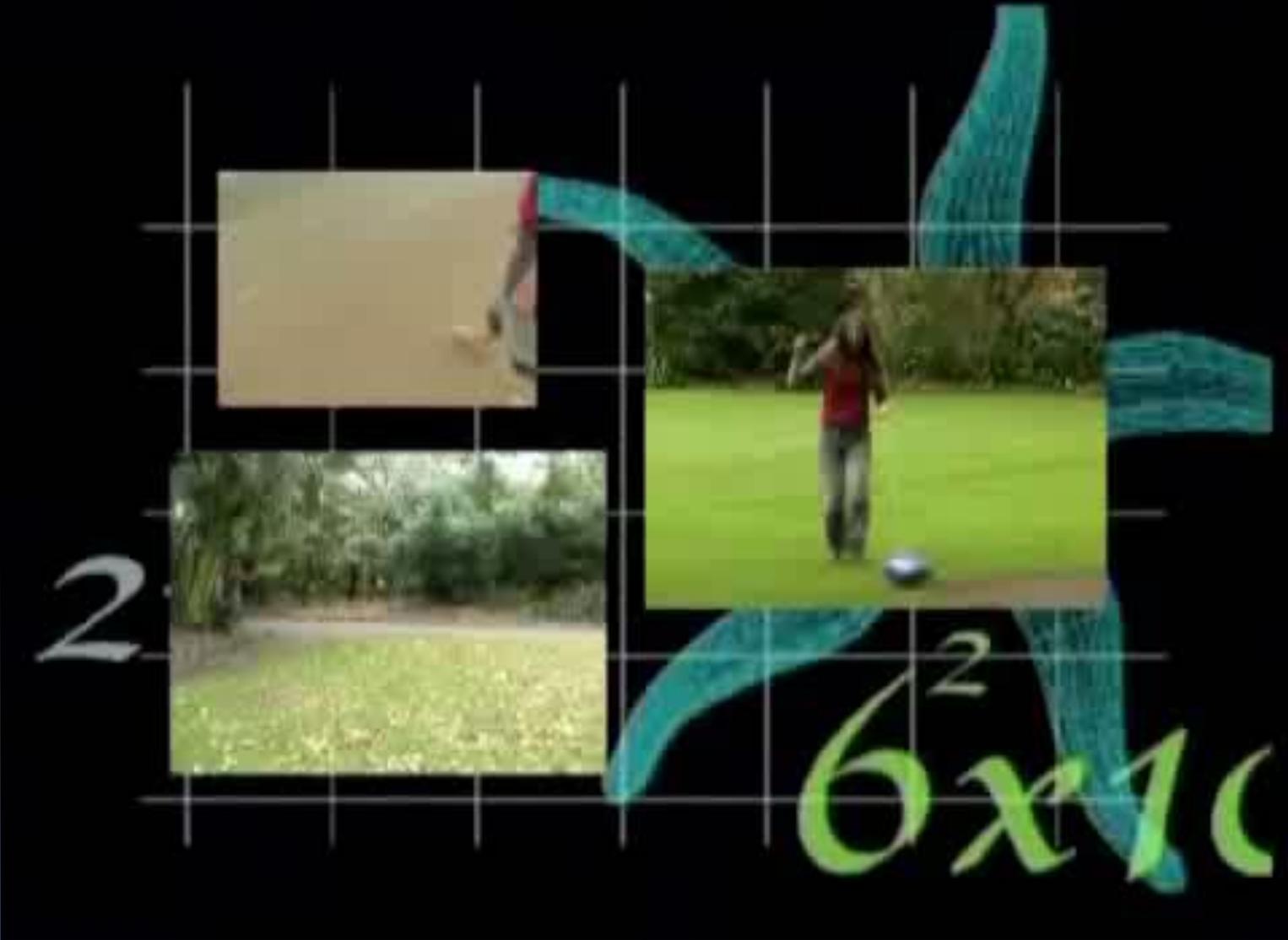
Force - Units

- Weight is a Force
- $F = ma$
- Unit of mass is the kilogram
- Units for acceleration are m/s^2
- Units for ma are $kg \cdot m/s^2$
- This is called a **Newton (N)**
- $1 \text{ N} = 1 \text{ kg} \cdot m/s^2$

$$\Sigma \vec{F} = m\vec{a}$$

$$F_{\text{weight}} = mg$$

Newton's Third Law of Motion



Newton's Third Law of Motion

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Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - Consider a book on a table
 - The book has weight, so it is exerting a force on the table
 - Since the book isn't moving, the table is exerting an equal and opposite force on the book
 - The table is said to be exerting a reaction force, contact force or normal force on the book

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - Consider a book on a table
 - If the book has a mass of 5kg, what force is the table exerting on the book?

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - Consider a book on a table
 - If the book has a mass of 5kg, what force is the table exerting on the book?
 - $F = mg$
 - $F = (5)(9.81) = 49.1 \text{ N}$

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - What about 100 books on the table?

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - What about 100 books on the table?
 - $F = mg$
 - $F = (100) (5) (9.81) = 4,910 \text{ N}$

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - What about 1000 books on the table?

Newton's Third Law of Motion

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first
 - What about 1000 books on the table?
 - This would probably exceed the capability of the table to produce a normal force equal to the force of the weight of the books
 - As the table broke, the books would accelerate in the downward direction, $F = ma = mg$

Example 4-5

- Contact force
- Normal force
- Sum of the forces

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Big Idea(s):

- Objects and systems have properties such as mass and charge. Systems may have internal structure.
- Fields existing in space can be used to explain interactions.
- The interactions of an object with other objects can be described by forces.
- Interactions between systems can result in changes in those systems.

**FOR *ESSENTIAL KNOWLEDGE AND
LEARNING OBJECTIVES*, START
OVER AT THE BEGINNING**



QUESTIONS?

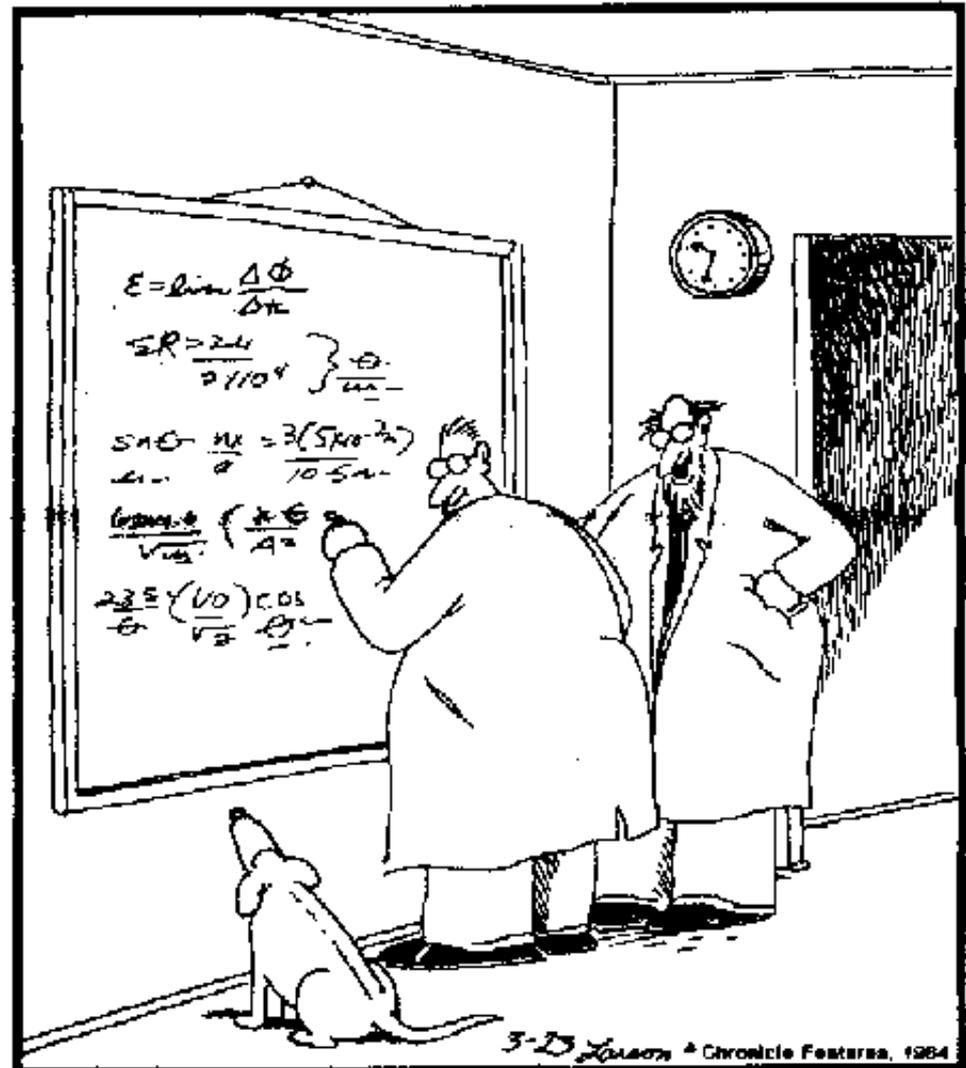
Homework

#1-17



THE FAR SIDE

By GARY LARSON



"Ohhhhhh... Look at that, Schuster...
Dogs are so cute when they try to comprehend
quantum mechanics."