INTERACTIVE FUNDAMENTAL PHYSICS

DOE/ER/75716--1

DE93 007014

November 24, 1992

Sponsored by

The United States Department of Energy

Office of University and Science Education Program

Contract # DE – FGO2 – 92ER75716

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Reporting Period: 4 / 15 / 92 – 11 /14 / 92

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I. SUMMARY

THE REAL STUFF is an Expanded Media Physics Course aimed at students still in the formative early years of secondary school. Authors Sheldon Renan, Ephraim Rubin and Harry Soodak have created a working script for an interactive multimedia study unit in basic concepts of physics. The unit begins with a prologue on the Big Bang that sets the stage, and concludes with a lesson on Newton's first law of motion.

The format is interactive, placing the individual student in control of a layered "hypermedia" structure that enables him or her to find a level of detail and difficulty that is comfortable and meaningful. The intent is to make physics relevant, intellectually accessible and fun. On-screen presenters and demonstrators will be females and males of various ages, ethnicities and backgrounds, and will include celebrities and physicists of note. A lean, layered design encourages repeated, cumulative study and makes the material useful for self-directed learning even by college students.

THE REAL STUFF introduces a new science teaching paradigm, a way to teach science that will engage even students who have "declined" to be interested in science in the past. Increased participation in science by women, African-Americans and Spanish-speaking students is a particular goal.

2. THE REAL STUFF

THE NEW
EXPANDED MEDIA
PHYSICS COURSE

GOALS

The goal of THE REAL STUFF, the new Expanded Media Physics Course, is to create a new science teaching paradigm. We want to create a new way to teach science that will engage a wider variety of students than have been reached in the past. The students we want to reach include those in groups which have "declined" to be interested in science education in the past: women, minorities, and the science-averse. And we want to reach them in their formative high school years.

We want:

- To develop a new kind of "expanded media" approach for teaching materials that can be broadly applied. We believe the same approach that will work for a physics course for the science-averse, will be equally successful teaching other subjects and skills.

- To leverage fully the power and economies of the new technologies in creating, publishing and distributing educational materials.

- The Real Stuff to serve as a powerful proactive prototype.

- The Real Stuff to stimulate many constituencies -- people in education, people in business, and a whole generation of people committed to life-long learning.

- To set a new standard for accessibility, ease-of-use, and effectiveness of materials.

UNDERLYING AGENDAS

In seeking to provide a "proactive prototype" for the field of education, we are working with a broader agenda in view.

1. We want to teach the teachers as well as the students. Thirty five years ago the first "new physics" materials were introduced to American schools. They brought a fresher, more up-to-date look at physics that helped educate teachers as well as students. Many teachers were empowered to improve their science thinking and teaching. America's current strength in high technology is, in part, a direct result of that program. We want to see this happen again in a manner appropriate to today's America.

2. We want to create a generation of citizens who can think rationally, and who can use and value science. Our students face a challenging future that will require thoughtful, knowledgeable and resourceful citizens. We want every American student to be "science literate."

3. We want to help future scientists and engineers identify themselves early in their education. And we want to create materials that will let them go as far as their abilities, vision, and passion can take them.

4. We want to help students understand the universe as a continuing process. We want them to realize in a deep way that, no matter who they are, or what they have been told about themselves, they are a part of that process.

THE STRATEGY

- To focus on reaching younger students -- students with fresh minds, who are open to new ideas. Although physics has traditionally been taught at the 12th grade level, we are focusing this material towards students as early as the 9th grade.

- To keep the material **lean, layered** and **STUDENT-FOCUSED**.

By **lean**, we mean we will focus on the essentials, simply stated. We will not bury the student in too much detail, or confuse him/her with overdone design.

By **layered**, we mean that additional information will always be available to the interested student, at different layers within a "hypermedia" structure. We want the student to always find his/her own level of involvement, consistent with the student's ability, interest, and level of science background. Such a layered approach will make the Expanded Media Physics Course useful for students into the college years.

And by **student-focused**, we mean that the orientation and information in the course will fit the student's world. It will be about things that make sense for the student to know about.

- To use **interactivity** whenever possible. When we talk about interactivity, we are not just talking about technology. We are talking about a state of mind. By "thinking interactively," we make the student a partner in the learning process. So we want to use interactivity that is designed to be easy, and intuitive to use.

- To provide students with a positive experience of science. To show them that science makes sense. To show them that knowing science and how to think it, talk it, and use it, can be enjoyable and empowering.

- To expose students to a scientific world view -- mostly Newtonian -- with emphasis on basic concepts.

- To teach real, interesting and exciting physics, keeping formalism and technicalities to a minimum.

- To present science in such a way so that, like Marianne Moore's poem says, it gives the student "real toads in imaginary gardens." The video stage set should be realistic, comfortable, interesting and even exciting.

- To use on-screen presenters who reflect the full range of diversity of American society. We want the student to be able to find himself/herself within the material in a metaphorical way. The student should be able to say that "that person can be in the science world, and therefore so can I."

CORE TACTICS

The course is designed to reveal to the student that beneath the apparently helter-skelter world lies a hidden world of order.

There is a world of laws that never change.

There is a reality that can always be counted on.

We want the student to learn to look behind the surface and find this world of order everywhere.

And that in the world of science and physics, the rules do not change with one's color, culture, economic circumstance, gender or age.

COURSE REQUIREMENTS

The requirements of our proposed course are:

The science and the physics must be impeccable.

Course materials:

- Must be equally engaging for students with various levels of ability, interest, and science background.

- Must function, with minor adjustments, equally well for both teacher-guided learning in a formal classroom setting and for self-teaching.

- Must be easy to use by both teacher and student. The powerful new technology must not complicate, but simplify.

- Must be low cost. We want the materials available to every student who is ready for them.

- Should, by the use of "hypermedia", be able to offer students a virtual world in which they can explore and learn.

STYLE

The **style** of the Expanded Media Physics Course will be clean and clear, friendly, and layered.

The **clarity** of the materials will be reflected in the words, the pictures, the use of video, and the integrating design. We do not want to overwhelm the student. We want to provide a clear and easy structured expression of ideas, wisdom, information and data.

The course material will be layered so that each student can find his or her level. Therefore, there will be a surface level that features a radical simplification of the material. There will then be an "information space" underneath, which is easy to access in "hypermedia" format.

The entire course will be information-rich, but only give the student as much information and as much complexity as the student can deal with at the time. The information should be organized and designed so that the student can easily find the information appropriate to his or her level of readiness and interest.

And it will all be under the user's control.

Extra attention will be paid to **sound**. Sound is a medium that reaches the students at a visceral level, and is an effective way to get and hold attention, as well as enriching content.

By sound we mean, sound effects, sound environments, audio cues and stings, and where appropriate, music.

The student will be able to hear all text, as well as read it, in both English and Spanish. (This will also expand the usefulness of the material to the seeing-impaired.) Certain sequences will support surround sound for dramatic effect in projected video in classroom and special seminar settings.

All of these requirements have been addressed in our sample script, THE REAL STUFF.

AUTHORING / DELIVERY TECHNOLOGIES INVESTIGATED

We have explored a number of currently available technologies for supporting the Extended Media Physics course we envision. The highlights of our investigation into software and hardware systems are summarized.

We considered the possibilities offered by **linear video**, which includes video programs produced for broadcast over instructional television, and video segments for classroom use. We concluded that linear video, presented in linear format -- either by broadcast or by video cassette -- lacked the necessary flexibility for use in our educational approach.

Interactive videodiscs provide more flexibility, but do require a videodisc player, have an expensive authoring process, and high additional costs for modifying materials. Level three interactive discs, that use a separate computer to control the disc and provide additional on-screen data, address some of these concerns. But the combination of videodisc player and dedicated computer provide an additional price barrier for the schools. And no level three videodisc facilities are found in the student's home environment.

CDI, the new **Compact Disc Interactive** technology, may be more widespread. It is limited, however, in the presentation of live action. And the establishment of the standard is not yet widely accepted.

Customized multi-media environments are another approach to teaching science used by science museums and theme parks such as EPCOT. These feature sophisticated and costly exhibit and ride technology. There is much here that can be adopted, with time, to more general educational use. But as a whole, the cost is too great and the functionality too limited for the needs of a course such as we have described.

The final technology investigated was **personal computer** with multi-media software. Personal computers are now widespread, both in schools and homes. Costs of systems have dropped steadily, even as PC capabilities have climbed.

We examined three platforms: **Amiga, Intel** and **Macintosh**.

Amiga provides a sophisticated, low cost multi-media computer with good, easy to use software. It was designed around the use of NTSC video (the American video standard). What it lacks is wide-spread acceptance, and therefore widespread technical and software support.

The most successful platform, in terms of sheer numbers, is the **Intel / Microsoft / IBM- compatible** platform. Intel alone ships up to 25 million CPU chips every year, and additional CPUs are shipped by other semi-conductor suppliers. There have been attempts to make this into a multi-media platform in the last three years. These involve additional chip sets and standards, including DVI (Digital Video Interactive.) The Intel platform remains, however, constructed on a character-based interface. A certain lack of user-friendliness is a continuing barrier to many students and teachers. New standards have recently been announced for bringing video to the Intel platform for use in multi-media. This platform continues to be more difficult for both authoring and use of materials.

The third platform is Apple's **Macintosh**, which is the dominant platform for personal computing in multi-media format. More Apple Macintosh PCs are sold than any other brand of personal computer. (Apple replaced IBM this year as the number one supplier of PCs.) Mac established the standard for the GUI (graphical user interface), adapting the technology developed at the Xerox PARC research center in the seventies. The user software was designed around an intuitive approach that many have now copied, but not surpassed.

Apple has been the most aggressive in supporting the creation of easy-to-use and powerful multimedia tools. It provided QUICKTIME, the first widespread solution for the digital integration of television into personal computing programs. Indications are that Apple will remain as the driving force in the expanding use of multimedia for the near future.

There are additional computing platforms with multimedia support, but these tend to be higher end UNIX-based platforms that are considered to be for "professional workstation" market segments. These include SUN, Next, Silicon Graphics,

Hewlett-Packard and IBM. These are all trying to move down market, but the aggressively rising price/performance offered by personal computing platforms will probably defeat this. Additionally, IBM is partnering with Macintosh to introduce a next-generation "power platform" which will try to bring the best of both PC and workstation worlds to the personal computer user in the next two years.

Incompatibilities between platforms will be overcome as CPU chip transistor counts continue to rise. The commitment to intuitive ease-of-use, combined with aggressive marketing, may keep Macintosh (via the Power Platform partnership with IBM) in the lead in the multimedia area.

Because technology in this field advances so rapidly, we are not at this point prepared to make a final selection for either the hardware or the authoring software for the Expanded Media Physics Course.

III

SCRIPT AND STORYBOARDS

OPENING SCREEN:

THE REAL STUFF
PHYSICS
AND THE WAY
THINGS REALLY ARE

INITIALIZING DEFAULT TO ↓

PROMPT SCREEN:

Please enter your name:

(HOT BLINKING SPACE
TO ENTER NAME LIKE THAT
FOR VIDEO GAME WINNERS.)

Please enter your face:

(SPACE TO SCAN IN FRAME
GRAB OF STUDENT'S FACE.)

Thank you.
One moment please.

(SOUND EFFECT - followed by this screen:)

NORMAL DEFAULT TO ↓

3.1A

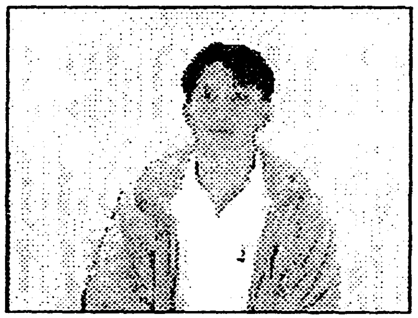
The REAL Stuff

Welcome

John

to

The Physics Zone



You are Cleared for Access

WELCOME SCREEN:

Welcome (STUDENT NAME)

to *THE PHYSICS ZONE*

(STUDENT PHOTO)

(SOUND EFFECT - followed by this message:)

You are cleared for access.

ALWAYS DEFAULTS TO ↓

ORIENTATION SCREEN

TABLE OF CONTENTS

NAVIGATION TOOLS

OPEN
FIND
MARK
RETRACE
- PAGE
- CHAPTER
- INFOSPACE
- YOUR NOTES
- TEACHER P.O.V.

MODE CHOICE

MULTIMEDIA
TEXT/PIX ONLY
AUTO PAGE TURN

[WRITE] [DRAW] [CALCULATE]

[HELPER]

When chapter clicked, it drops menu of all units in chapter for further choice.

When unit chosen, CHAPTER HEADER is visible on every page, on every hypermedia screen connected to chapter.

TOOLS PANEL remains visible unless student chooses to hide it.

Tools and options also available in drop down menus bar which appears whenever cursor goes to top of screen.

Click HELPER to get narrated tutorial on using the table of contents and tools.

IF STUDENT MAKES NO CHOICE, THIS DEFAULTS TO ↓

PROLOGUE:

HOW THIS COURSE WORKS

FADE IN

QUICKTIME BOX: TWO HOSTS -- ONE MAN, ONE WOMAN:

QUICK TIME VIDEO FRAME is in upper right corner. Most of what Hosts say is also visible in frame as TEXT.

QUICKTIME FRAME: HOSTS

HOST 1
Welcome to THE REAL STUFF, a course about Physics... and the way things really work.

HOST 2
This course is part book, part movie, and part adventure game. You can use it to find out why things work the way they work... here on earth... and almost everywhere else in the universe.

HOST 1
Each chapter is divided up into parts. There's a STORY about a how something works, including a law or principle.

There's a demonstration of that law or principle done by a member of our PHYSICS DEMO TEAM.

FADE OUT QUICKTIME FRAME...

VOICES OF HOSTS CONTINUE as...

3.4A

The REAL Stuff

How This Course Works

Welcome to *The Real Stuff*, a course about Physics and the way things really work.

This course is part book, part movie, and part adventure game. You can use it to find out why things work the way they work – here on earth – and almost everywhere else in the universe.

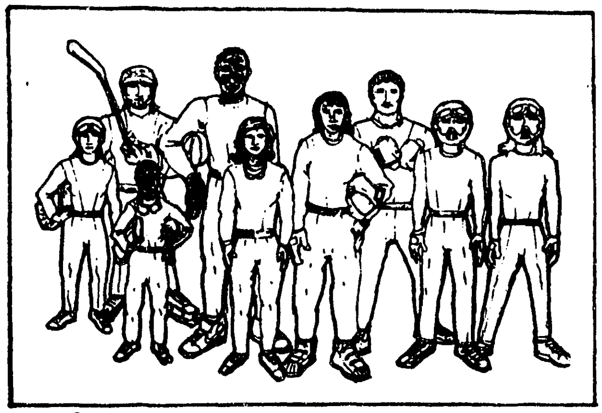
Each chapter is divided up into parts.

There's a *story* about how something works, including a law or principle.

There's a demonstration of that law or principle done by a member of our *Physics Demo Team*.

PHYSICS / THE REAL STUFF

PHOTO POPS UP on screen: Group of individuals of diverse races, ages and genders. All are posed in "demo team cover-alls." Demo team includes stunt drivers, an ex-astronaut, two parachutists, and sports figures. Each has some prop -- the parachutists have packed parachutes, for example -- that identify their area of expertise.



"THE PHYSICS DEMO TEAM."

TITLE in frame: "**THE PHYSICS DEMO TEAM.**"

HOST 1 (V.O. CONT.)
The Physics Demo Team demonstrates each
principle in action.

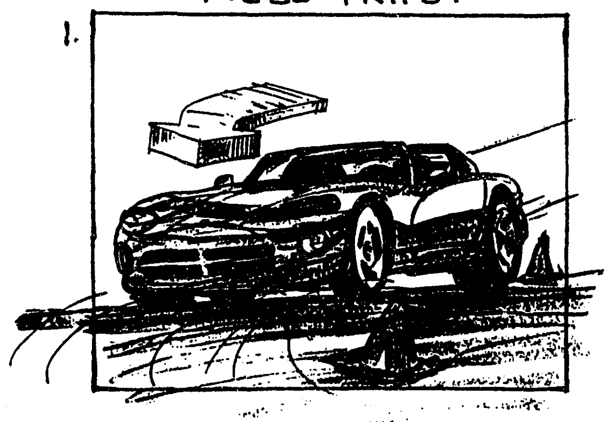
<u>And</u>...

SECOND PHOTO POPS UP on screen:

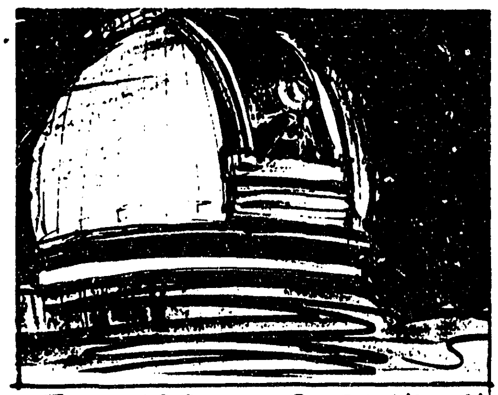
In the frame are multiple photos showing locations of field trips, including observatory, roller coaster design studio, shuttle in space, etc.

FIELD TRIPS :

1.

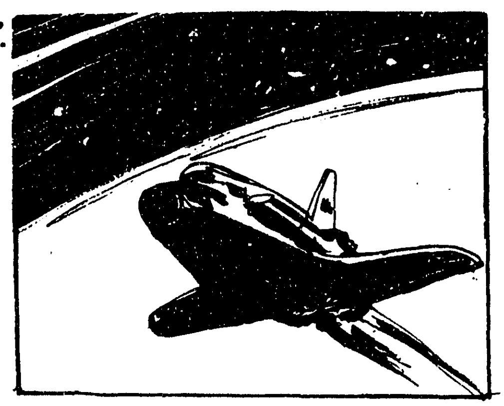


2.



FIELDTRIPS: OBSERVATORY

3.



... SHUTTLE IN SPACE

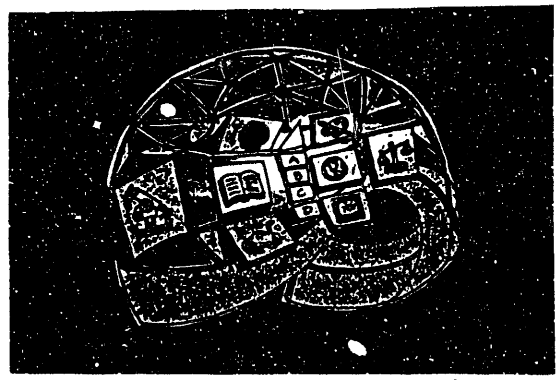
TITLE in frame: "**FIELD TRIPS.**"

HOST 1 (V.O. CONT.)
...there's a FIELD TRIP in each chapter.
So <u>you</u> can take a quick trip and work with this principle <u>yourself</u>.

HOST 2 (V.O.)
There are also many hidden places in The Physics Zone that are not part of the regular course... These are in what we call THE INFOSPACE, a world of extra data for you to explore.

They come up in INFOBOXES with interesting or weird facts...
and extra information and activities.

HOST 2 (V.O. CONT.)
You can explore these whenever you want. Just look for the INFOSPACE ICON. Click the icon... and an INFOBOX will pop up with the information. Or access them with your navigation tools.



INFO SPACE ICON

WHAT IS DESCRIBED IS SIMULATED IN THE TEXT SECTION. For example... an ICON appears in the text and blinks as if clicked.

FADE IN

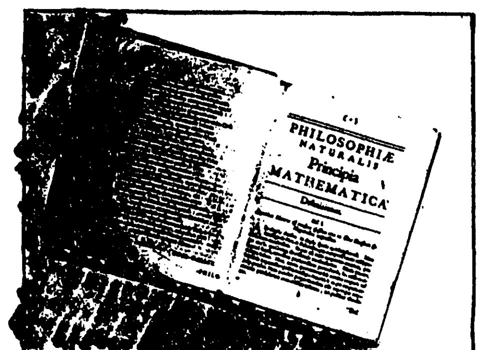
NEW QUICKTIME FRAME -- EXAMPLES OF WHAT IS DESCRIBED:

HOST 1 (V.O.)
Infoboxes tell you how something was discovered... the history of an idea or scientific law...

STEVEN HAWKING

HOST 2 (V.O.)
Let you meet a scientist face to face...

HOST 1 (V.O.)
Go into more detail about a subject...



THE PRINCIPIA

HOST 2 (V.O.)
Or show you unusual footage shot in space.

DEMONSTRATION CONTINUES in the text that describes it.

HOST 1 (V.O.)
If there's ever a word in the text you don't understand... just click it. And the meaning of the word pops up in seconds.

NASA FOOTAGE IN SPACE.

HOST 2 (V.O.)
You can mark any page...
and mark up any text...
including underlining...
bolding... or italicizing.

HOST 2 (V.O. CONT)
You can put in your own notes and drawings in the margin next to the text.
And your notes and drawings are automatically entered into your own COURSE NOTEBOOK.

POP UP - COURSE NOTEBOOK. Header of notebook box reads:

(STUDENT'S NAME)'S PHYSICS NOTEBOOK.

FADE IN

QUICKTIME FRAME -- HOSTS:

HOSTS

HOST 1
The Real Stuff Physics Course is designed with a complete set of tools that put everything in The Physics Zone under your control.

All right here in your computer.

HOST 2
Just point... and click...
And have a great trip.

FADE OUT QUICKTIME FRAME...

POP UP ACTION BOXES:

START CHAPTER ONE	SHOW TOOL HELPER	SHOW TABLE OF CONTENTS	REPEAT THIS SECTION

IF STUDENT CHOOSES CHAPTER ONE,

GOES TO ↓

CHAPTER ONE:

BEGINNINGS

FADE IN

QUICKTIME BOX: TWO HOSTS:

TEXT displays same words.


HOSTS

HOST 2

We start with three questions.

Where are you?

When are you?

Who are you?

HOST 1

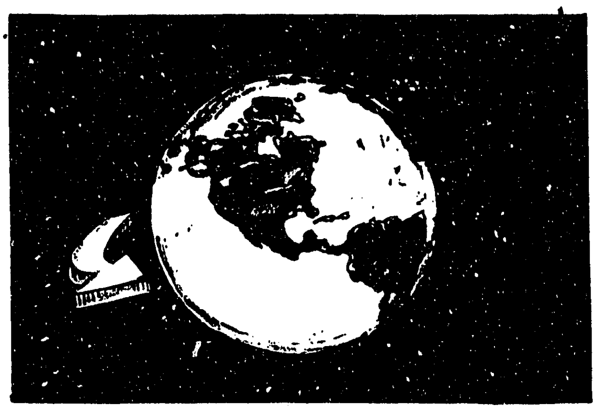
<u>Where</u>?

FADE OUT QUICKTIME FRAME...

VOICE CONTINUES OVER TEXT

GRAPHICS / SERIES OF FRAMES: Show location of student as indicated by text.

1.


ANIMATED SEQUENCE OF EARTH SPINNING ON AXIS... PULL OUT TO REVEAL — ...

HOST 1 (CONT. V.O.)

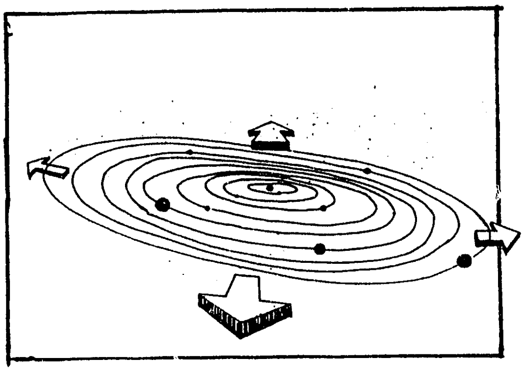
Where you are is on the earth. The earth, of couse, is a planet.

It spins on it's axis at over a thousand miles an hour at the equator.

The planet orbits around the star we callthe sun... at 18 miles a second.

The sun and its solar system orbits around the center of our galaxy.

2.

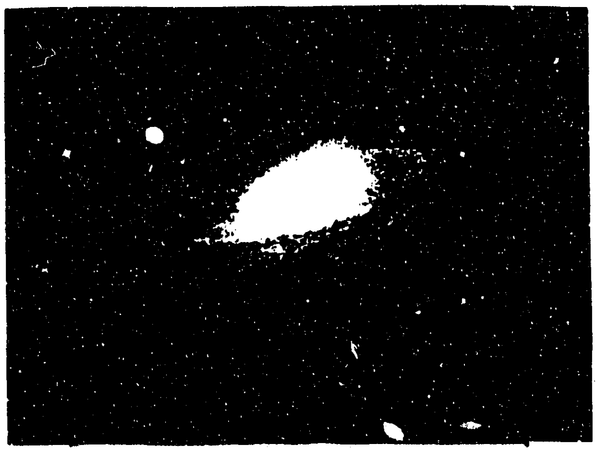

PLANETS ORBITING AROUND SUN.

HOST 1 (CONT. V.O.)
Our galaxy moves around the center
of our local group of galaxies...

which orbitsaround superclusters.

And of course, everything is moving
away from everything else...
because the universe is expanding.

Why it's expanding has to do with the
second question -- "when" you are.



GALAXY...

HOST 2 (V.O.)
When are you?

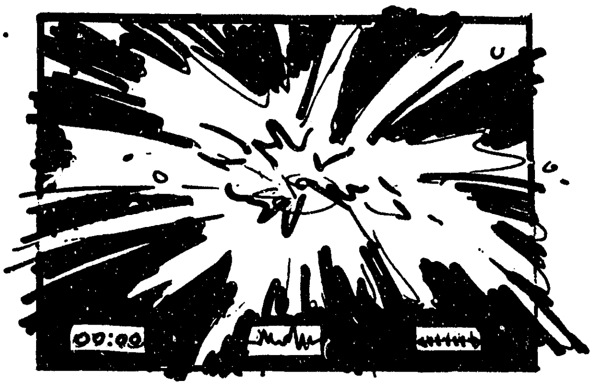
Time and the universe began
at the same moment...
at Cosmic Time Zero...

...with that Hot Big Bang
15 billion years ago.

FADE IN

BIG QUICKTIME FRAME - THE BIG BANG:

1.



QUICKTIME ANIMATION - BIG-BANG

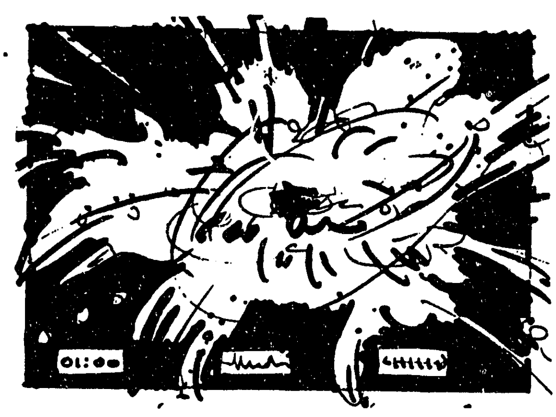
Pre-big-bang universe which is blank.

BOXES WITHIN FRAME keep track of TIME,
SIZE, TEMPERATURE. Indicator will display
a zero for time and size at the beginning.

HOST 2 (V.O. CONT.)
Because in the beginning...
there was nothing.

And then in one instant ....
all the matter and all the energy
in the universe... exploded into being...
starting the cosmic clock.

2.



QUICKTIME CONTINUES -- COMPUTER ANIMATION of BLINDINGEXPLOSION

BIG SOUND EFFECT.

HOST 2 (V.O. CONT.)
And at the start, all the visible universe was contained in a space smaller than the size of this computer screen.

QUICKTIME VIDEO CONTINUES as indicators start working.

Time starts. Size expands. Temperature drops.

All that is described below is shown in "realistic" animation.

HOST 2 (V.O. CONT.)
Imagine it...
Almost infinitely dense...
Almost infinitely hot.

By the second hundredth of a second of <u>time</u>...
are born the basic particles...
that fill most of the universe.
The basic forces that rule the universe were born earlier.

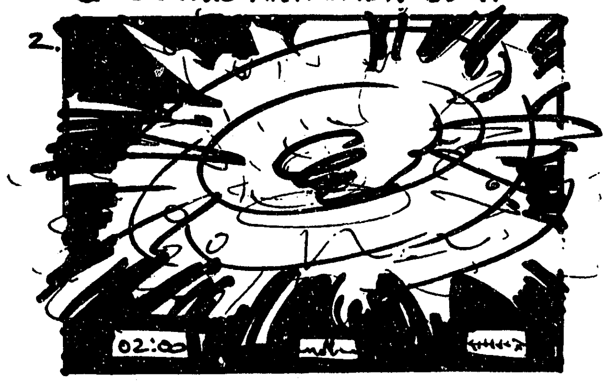
As the temperature and energy level drops over the next 300,000 years...
the first simple atoms are born.

Cooling and expansion continue for perhaps two billion years more until galaxies begin to form...
with clumps of matter gathering into <u>protostars</u>.

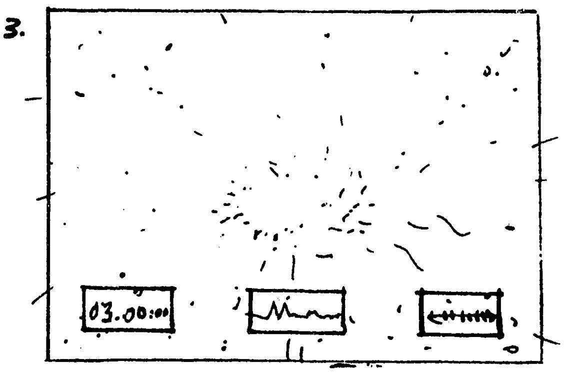
Inside these protostars the temperature rises to millions of degrees...
Thermonuclear <u>ignition</u> occurs, and the star shines.

QUICKTIME ANIMATION CONT.

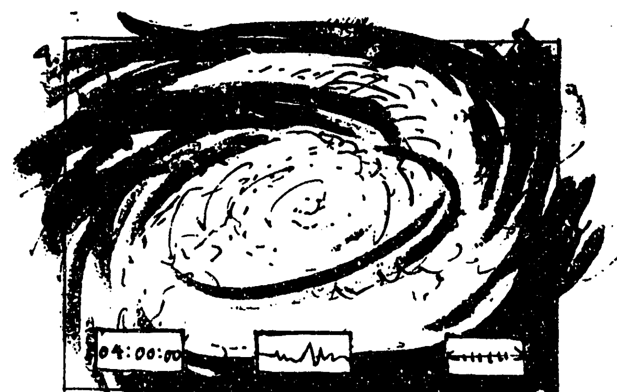
2.



3.



4.



5.

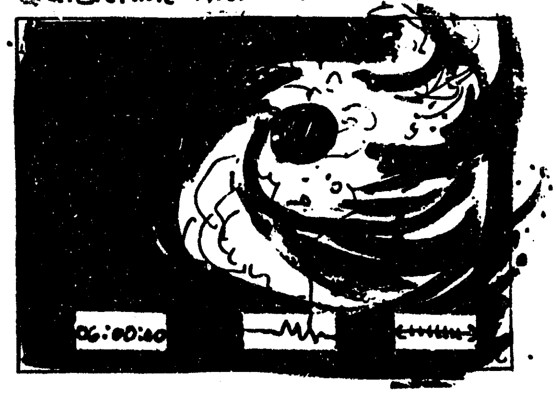
HOST 2 (V.O. CONT)

The first stars are born, then die...
creating the more complex atoms
that will later lead to life.

Some implode into <u>black holes</u>.

QUICKTIME ANIMATION CONT.

6.

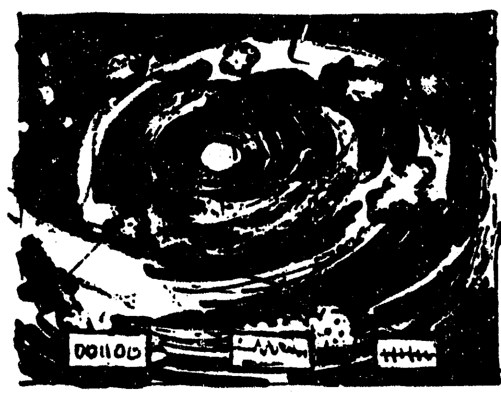


HOST 1 (V.O.)

Cosmic time 10.2 billion years...
4.8 billion years ago...
our own galactic cloud is born.

And a hundred million years later...
our sun and planets congeal into
being.

7.

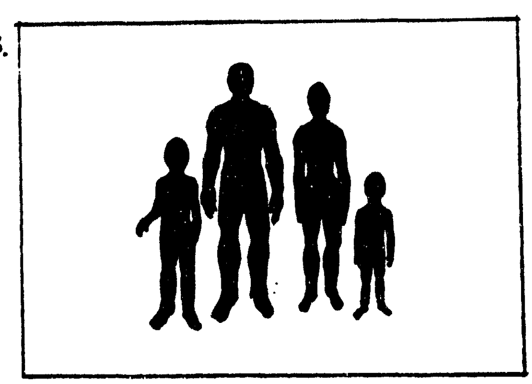


Moving us towards the third
question...
<u>Who</u> are you?

Life begins on earth 3.8 billion years
ago.
with single celled creatures...
that evolve...
respond to the changing planet...
and grow in complexity.

Until humankind emerges...
perhaps 150,000 years ago.

8.



HOMINID FAMILY

FINAL FRAME OF QUICKTIME VIDEO
shows outline of HOMINID FAMILY, backlit,
emerging from the past.

FREEZE FINAL QUICKTIME FRAME...

FADE IN

NEW QUICKTIME FRAME - HOSTS:

Hosts face camera.

HOSTS

HOST 1

Who are you?

You are product of that Hot Big Bang...

HOST 1 (V.O. CONT.)
A process of explosion, expansion and evolution...

that continues today.

Everything around you...
All the matter...
All the forces...

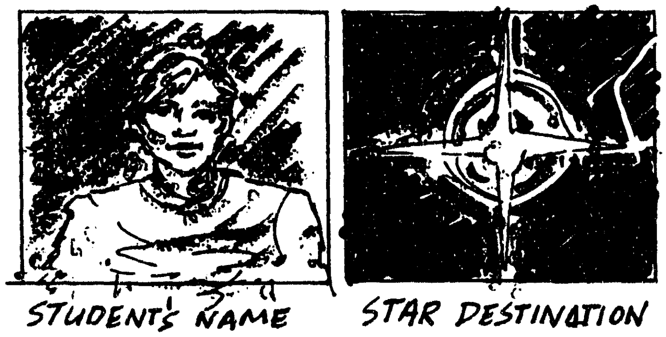
And all the natural laws that govern them...
were created in that hot big bang.

HOST 2
The particles that make up your body now...
were created early in that same big bang.

FADE OUT QUICKTIME FRAME...

FADE IN

2 GRAPHIC FRAMES, side by side, STUDENT'S FACE and NAME next to shot of BIG STAR with NAME:



HOST 2 (CONT. V.O.)
In effect... the same particles in every star are in you.

The same forces apply to the star...
and to you and your world.

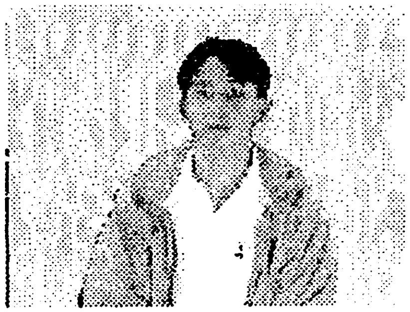
And the same laws of physics apply to both the star and you.

In fact those "natural" laws control everything in your world...
and in your universe.

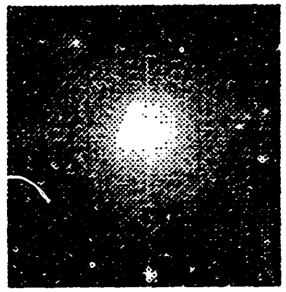
So you need to know what those natural laws are... and how they work..

3.12A

Beginnings **The REAL Stuff**



John



Tau Ceti

In effect, the same particles that are in every star are in you. The same forces that apply to the star, apply to you and your world.

And the same laws of physics apply to both the star and you.

In fact those "natural" laws control everything in your world and in your universe.

HOST 2 (V.O. CONT)

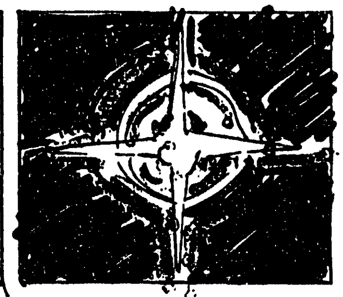
Because they are the <u>secret</u> behind how everything <u>really</u> works in the physical world...

And they work the same same for everybody...

Everywhere...

All the time.

STUDENT'S NAME



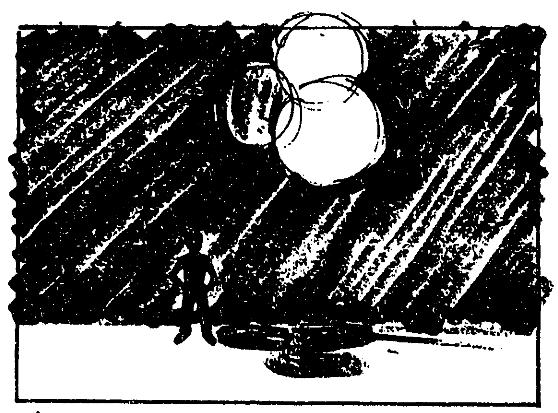
STAR DESTINATION

FADE OUT 2 GRAPHIC FRAMES...

FADE IN

NEW QUICKTIME FRAME: PARTICLES:

HOST 1 walks onto stage with three giant models of particles that tower above him.



HOST 1. W/ THREE PARTICLES.

HOST 1 (V.O.)

It all begins with three particles that make up all normal matter...

The <u>electron</u>...

The <u>protron</u>...

and the <u>neutron</u>...

These are the particles that make up all the objects you see and use every day......

And they are also the particles that make up all <u>per</u>-sons.

FADE OUT QUICKTIME FRAME...

FADE IN

GRAPHIC FRAME showing four forces.

THE FOUR FORCES...

HOST 1 (V.O. CONT.)

Those three particles are affected by the <u>four forces</u>...

The gravity force...

The electromagnetic force...

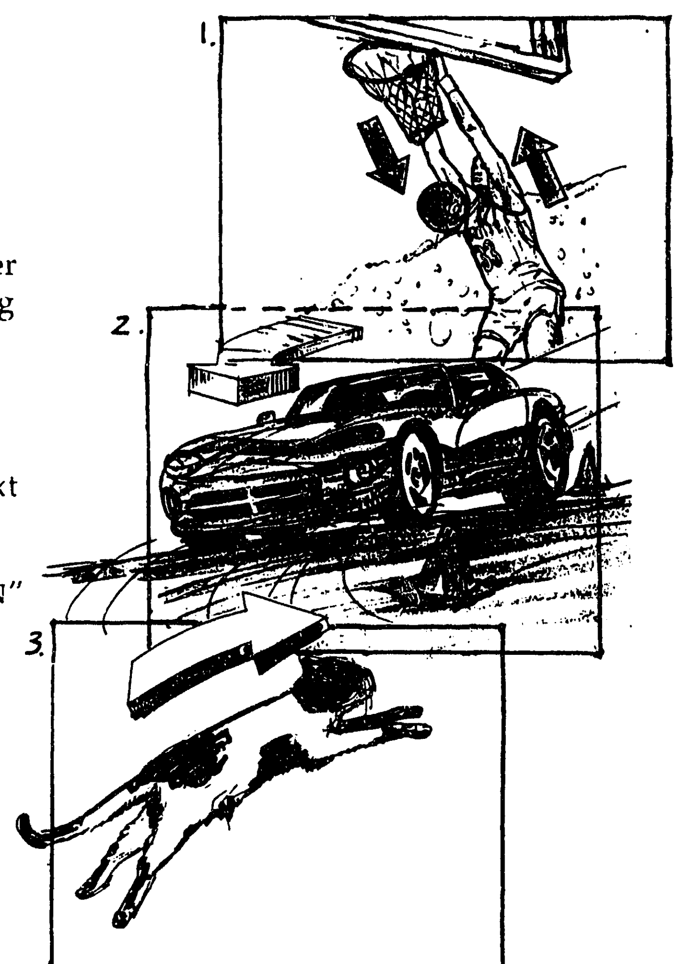
And the strong and weak forces.

THE FOUR FORCES-CONTINUE...

And those particles and forces behave according to the three laws of motion in all normal circumstances.

FADE OUT GRAPHIC FRAME...

MOVEMENT MONTAGE...



MOVEMENT MONTAGE (CONTINUES)

FADE IN

NEW QUICKTIME WINDOW - MOVEMENT MONTAGE:

VIDEO MONTAGE of elements from Student's world. Includes basketball jam, auto stunt, leaping cat, roller coaster, bumper cars, woman high board diver, shuttle taking off.

Each element transitions into ANIMATED DYNAMIC DIAGRAM showing forces at work on each... before transitioning into next object.

TEXT TITLE: "THE THREE LAWS OF MOTION"

QuickTime video is accompanied by following narration...

HOST 2 (V.O.)

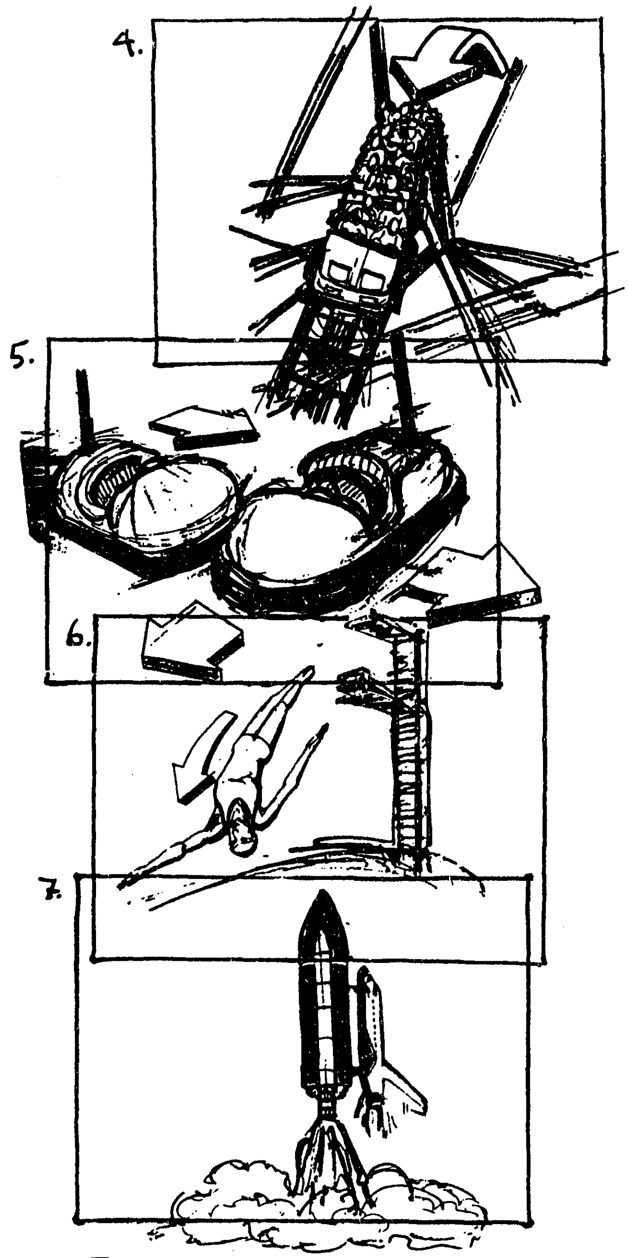
The laws of motion are a good place to begin because they form a unity... a complete theory of motion and force.

The first law of motion describes how particles move when no forces are acting upon them.

The second law of motion describes the effect of forces on the motion of a particle.

The third law of motion describes the nature of force... How forces arise. How forces come only from other particles... How particles attract or repel each other by charges or powers in the particles.

These laws affect every object... in your life... No matter what you do... or where you live.



END: MOVEMENT MONTAGE.

FADE OUT QUICKTIME FRAME...

POP UP ACTION BOXES:

START CHAPTER TWO	SHOW TOOL HELPER	SHOW TABLE OF CONTENTS	REPEAT THIS SECTION

IF STUDENT CHOOSES CHAPTER TWO, GOES TO ↓

CHAPTER TWO:

THE FIRST LAW OF MOTION

FADE IN

QUICKTIME BOX -- TWO HOSTS:

HOSTS

HOST 1
The three laws of motion are simple.
They are the foundation for
everything that happens in the world
around us.

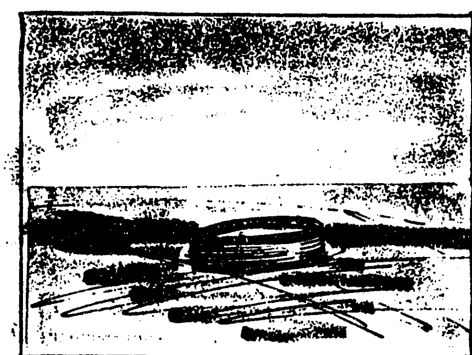
HOST 2
The first law describes the motion of a
particle when no force acts on it.
You can state the law in two parts.

HOST 1
Part One...
A particle at rest remains at rest.

FADE OUT QUICKTIME FRAME...

FADE IN

GRAPHIC - HOCKEY PUCK ON ICE



HOCKY PUCK ON ICE

HOST 1 (V.O. CONT.)
We can apply this law to objects as
well as elementary particles.
(clarifies)
As long we understand we are actually
following the central point of an
object...
the <u>center</u> of mass...
we can use this law with objects of <u>any</u>
size..

From an atom...
to a space shuttle...
to this hockey puck.

HOST 1 (V.O. CONT.)
This object is not moving.

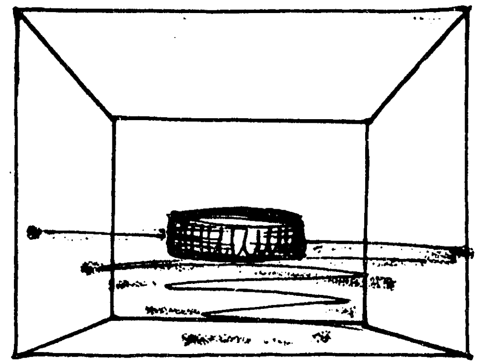
No visible force is acting on it.

There are no nearby particles or objects to push it, pull it, or lift it.

What happens?

Will this object remain at rest....
Or will it begin to move?

What do you think?



ZOOM IN ON HOCKEY PUCK.

FADE IN

CHOICE BUTTONS:

OBJECT REMAINS AT REST	OBJECT STARTS MOVING

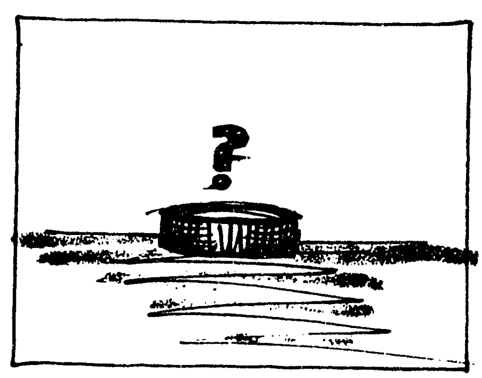
HOST 1 (V.O. CONT.)
Which makes more sense?

"CHOOSE" PROMPT BUTTON APPEARS

AFTER STUDENT MAKES CHOICE,

PROGRAM BECOMES ACTIVE AGAIN.

PHOTO OF PUCK ON ICE



HOST 1 (V.O. CONT.)
With no reason to start moving, with no force acting on it, the object remains stationary.

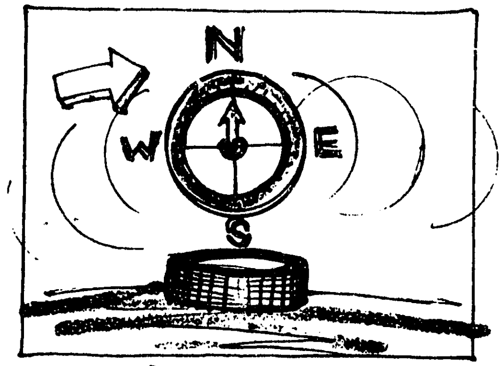
It makes sense.

But is there any other reason it doesn't move?

HOST 1 (V.O. CONT.)
Imagine it does begin to move.

What direction should it start?

Eastward? Westward?
To the north?
To the south?



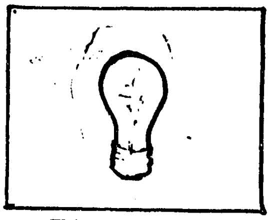
ANIMATED COMPASS SUPERIMPOSED OVER HOCKEY PUCK – HIGHLIGHTED N, S, E, & W, DIRECTIONS.

GRAPHIC OF THE FOUR COMPASS DIRECTIONS APPEAR SUPERIMPOSED OVER PHOTO OF PUCK.

HOST 2 (V.O. CONT)
Without a reason to prefer any one of these directions over the others, it makes sense that it doesn't move in any of these directions.

It makes sense that it remains at rest.

ICON IN TEXT -- FURTHER DISCUSSION IN INFOSPHERE.



ICON.

IF STUDENT IGNORES ICON, CHAPTER ONE CONTINUES (SEE SCRIPT PAGE 23)

IF STUDENT CLICKS ICON, INFOBOX POPS UP ↓

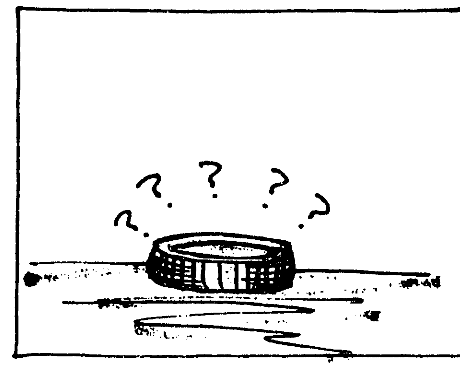
INFOBOX: MORE DISCUSSION

TITLE TEXT: "MORE DISCUSSION OF FIRST LAW OF MOTION - PART ONE"

HOST 1 (V.O.)

Here's a tough question.
Can you think of any reason
for this object to start moving
when no force acts on it?

Think about it for a moment.



FADE IN

PROMPT BUTTON:

CLICK
WHEN
READY TO
CONTINUE

When Student clicks PROMPT BUTTON,
Narration/Text continues.

HOST 1 (V.O. CONT.)

Perhaps, for example, there could be
some special positions...
positions that are more important
than others.

If this were the case, a particle might
want or prefer to be at a special place
rather than where it is.

If that were the case, it might move
towards that special position all on its
own.

But there is no special location.

Space is the same all over.

People didn't always believe that.

You can look at the historical view of
physics if you choose and see what
people used to think.

FADE IN

CHOICE BUTTONS:

TAKE ME BACK IN TIME TO ARISTOTLE IN 335 B.C.	RETURN ME TO CHAPTER TWO	REPEAT THIS UNIT

INFOBOX: HISTORY UNIT

TITLE TEXT: "**ARISTOTLE - 335 B.C.**"

ARISTOTLE - 335 B.C.

FADE IN

GRAPHIC: Aristotle's bust with his name on it.

The hockey puck is prominently placed next to bust.

HOST 1 (V.O.)
In the years between 300 and 400 BC, Aristotle, a Greek philosopher and scientist, wrote down a description of physics of the world that was believed by most interested people until 2,000 years later.

In Aristotle's physics, the universe had a center...

And was divided into two different realms.

GRAPHIC: Aristotle's view of world.

ARISTOTLE'S VIEW OF WORLD.

HOST 1 (V.O. CONT.)

The earthly realm extended from the center of the earth up to the orbit of the moon.

Aristotle called everything beyond the orbit of the moon "the heavenly realm," including the sun, the planets and the stars.

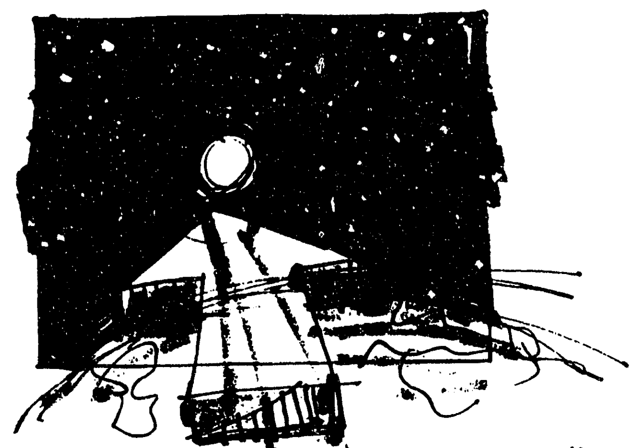
In Aristotle's physics, the center of the earth was located at the center of the universe. And the earth was stationary.

Different laws of nature applied to the two realms.

The physics was highly simplified and very incomplete. It could not even begin to explain many motions found in common experience.

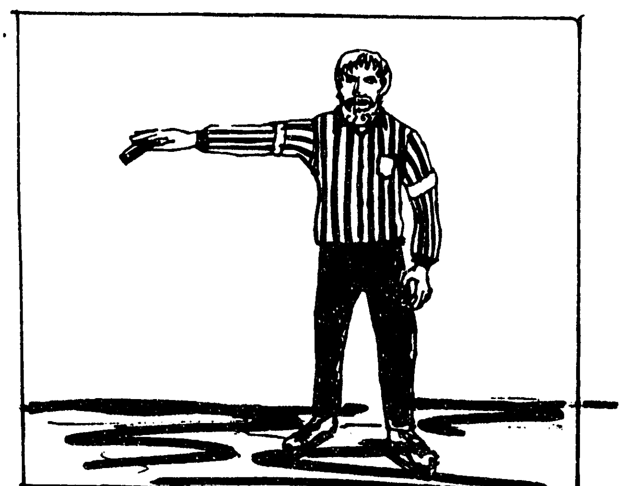
It could not, for example, explain the motion of a thrown object.

Aristotle believed all solid objects... including that hockey puck... preferred to be as close as possible to the center of the universe.



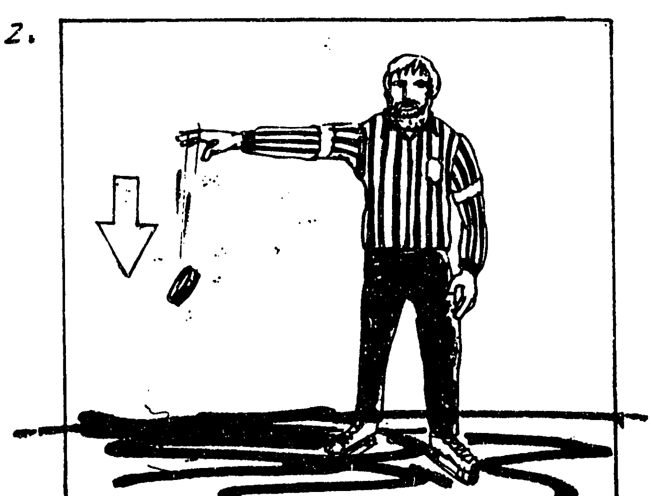
"THE HEAVENLY REALM".

1.



ARISTOTLE WITH HOCKEY PUCK.

2.



ARISTOTLE: DROPS HOCKEY PUCK

FADE IN

QUICKTIME ANIMATION of Aristotle dressed in referee's uniform holding hockey puck. He drops hockey puck.

HOST 1 (V.O CONT.)

So if he had dropped the puck... Aristotle thought it would move by its <u>own</u> action... <u>downward</u>...

And <u>not</u> by a force exerted by some other object.

HOST 1 (V.O CONT.)
Aristotle thought it was trying to get as close to the center of the earth.
And that described to him <u>why</u> it was dropping straight down.

Of course...
if you were there at the time...

And you asked Aristotle
"How does the puck know
where the center is?

Or maybe...
"How does it start to move?"
"What is it's power to move?"

Aristotle would have no answer.

ARISTOTLE - FROWN

ANIMATE: Aristotle around to frown at viewer.

FREEEZE QUICKTIME FRAME...

FADE IN

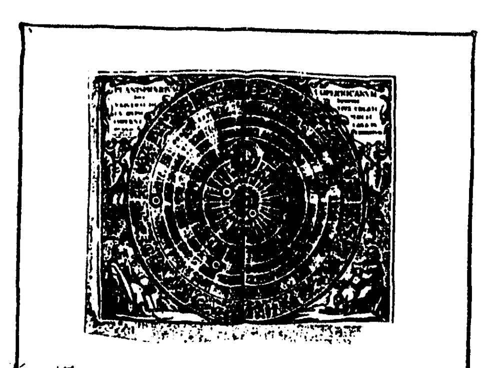
GRAPHIC OF COPERNICUS WORLD VIEW

HOST 1 (V.O CONT.)
In our modern view, of course, earth is the third of nine planets, all moving in orbits around the sun of our solar system.

If you looked down on the solar system from a location out in space... we could say the earth is in the heavens.

The modern view was proposed in 1543 by Copernicus, and advanced later by Kepler, Galileo, and others.

In this view the earth moves. It spins once a day around the north-south axis and completes its orbit around the sun once a year.



COPERNICUS WORLD VIEW

FADE IN
CHOICE BUTTONS:

CONTINUE HISTORY ON TO SIR ISAAC NEWTON	RETURN ME TO CHAPTER TWO	REPEAT THIS UNIT

IF STUDENT CHOOSES TO CONTINUE ON TO NEWTON, JUMPS TO NEWTON INFOBOX (SEE SCRIPT PAGE 40)

IF STUDENT CHOOSES TO RETURN TO CHAPTER, ↓

CHAPTER TWO CONTINUES

FADE IN

QUICKTIME FRAME -- HOST 2:

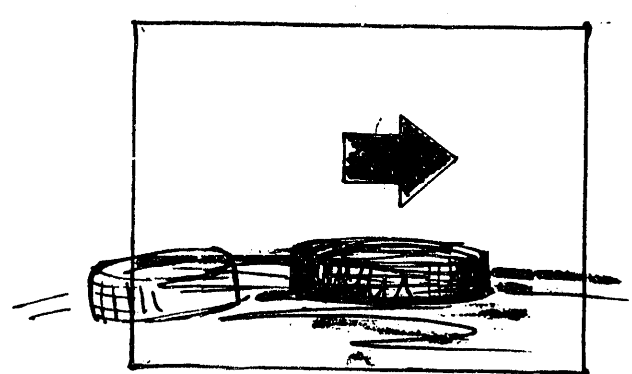
HOST 2.

HOST 2
Suppose we have a particle that is already in motion.

FREEZE QUICKTIME FRAME...

FADE IN

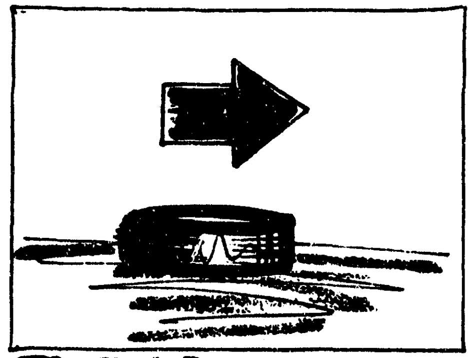
NEW QUICKTIME FRAME -- HOCKEY PUCK ON ICE:



HOCKY PUCK - ENTERS LEFT.

HOCKEY PUCK enters from left edge of screen, gliding on ice...

AN ARROW hovers over puck as it enters frame. Arrow travels with puck. FREEZE PUCK AND ARROW at center of frame.



FREEZE PUCK AND ARROW.

HOST 2 (V.O.)
Now a good question here is...

Why is this object in motion?

To find out why an object is in motion you always have to go back in time for the answer.

QUICKTIME FRAME CAMERA PANS over to WAYNE GRETZKY standing down the ice in his number 99 jersey with his hockey stick.

CAMERA PANS UP TO REVEAL WAYNE GRETSKY...

HOST 2 (V.O. CONT.)
The answer to motion is always in the past. More about this later.

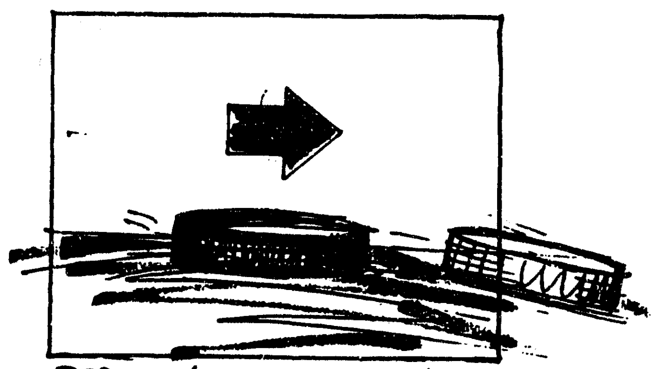
REPEAT QUICKTIME FRAME of hockey puck coming into frame with ARROW OVER IT... and FREEZE.

HOST 2 (V.O. CONT.)
What are the possibilities for continued motion?

The simplest possibility is that the motion continues without change...
No change of direction...
No change of speed...

UNFREEZE IMAGE. Puck and hovering arror gracefully exit off right edge of screen. They travel off at constant speed.

HOST 2 (V.O. CONT.)
Let's investigate some other possiblilities...
The speed changing, for example.
It could speed up.



REPEAT – 'HOCKEY PUCK' – FREEZE...

UNFREEZE IMAGE... MOVE OFF RIGHT EDGE OF SCREEN.

WIPE QUICKTIME FRAME. REPEAT puck and arrow in center of frame. ARROW increases visibly in size....

ANIMATE SPEED WIGGLES behind puck.

SOUND EFFECT of cartoon RoadRunner: "BEEP BEEP"....

PUCK accelerates off almost like cartoon RoadRunner.

HOST 2 (V.O. CONT.)
It could slow down.

WIPE QUICKTIME FRAME. REPEAT puck coming into frame with arrow. This time it begins to slow down, and the arrow diminishes in size until puck stops at the right edge of the frame.

SOUND EFFECT of puck slowing down.

HOST 2 (V.O. CONT.)
How about changing direction?

WIPE QUICKTIME FRAME. REPEAT puck coming into frame with arrow and freezing in the center.

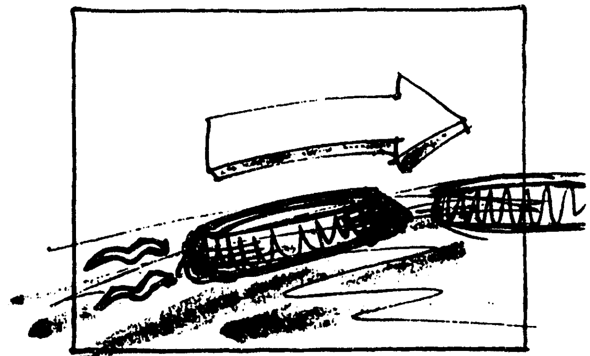
Ghost of frozen puck and arrow curve to move north towards top of frame.

SOUND EFFECT of SCREECHING TIRES.

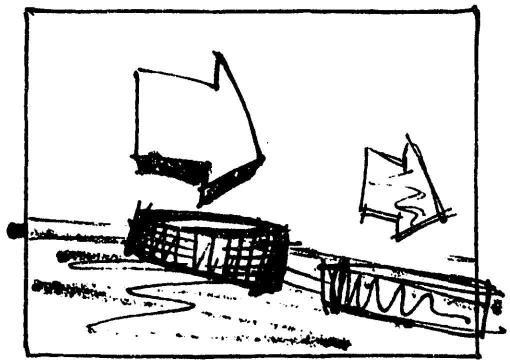
FREEZE WITH GHOST PUCK NEAR TOP OF FRAME...

HOST 2 (V.O. CONT.)
According to the first law of motion...

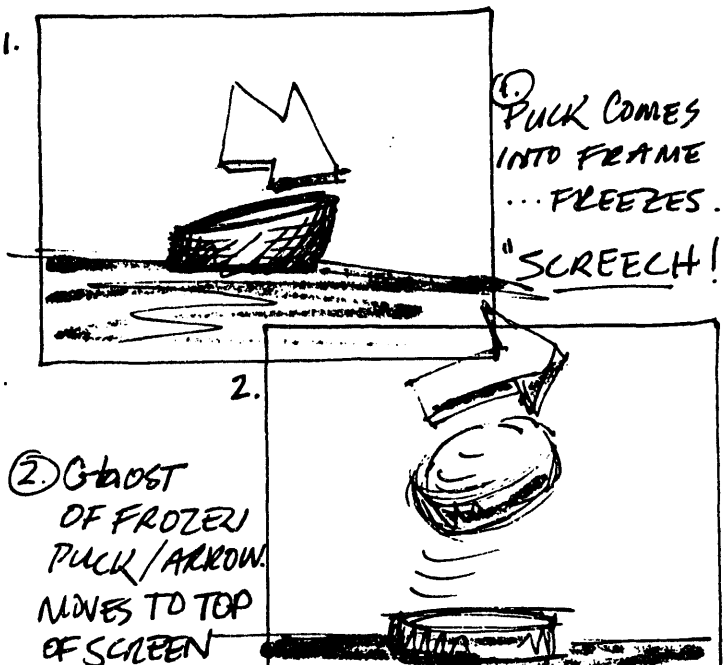
Without any force acting on it...
a puck should simply move
in a straight line...
at a constant speed.



PUCK INCREASING SPEED... ACCELERATES OFF SCREEN – "BEEP BEEP"...



PUCK SLOWING DOWN... STOPS AT RIGHT EDGE. ARROW DIMINISHES...



1\. (1) PUCK COMES INTO FRAME ... FREEZES. "SCREECH!

2\. (2) GHOST OF FROZEN PUCK/ARROW MOVES TO TOP OF SCREEN AND FREEZES.

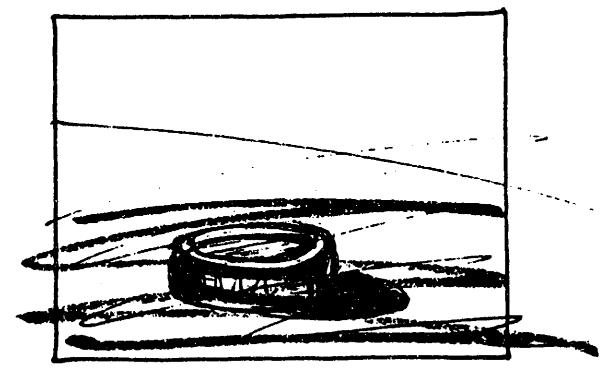
HOST 1 (V.O.)
Why doesn't the object change direction -- when no force acts on it?

Without a reason to change direction... it can't change direction.

And there's a second answer to this question.
If there is no reason for the puck to turn north rather than south...

No reason for the puck to turn west rather than east....

It makes sense it doesn't turn at all.



FREEZE FRAME ...

FADE OUT.

FREEZE QUICKTIME FRAME...

FADE IN
WAYNE GRETSKY ...

HOST 2 (V.O.)
Does it make sense for speed to change?

No... it doesn't make sense for speed to change without a reason.

Speed cannot change without a force.

We know from common experience... that speeding up requires the application of some kind of force.

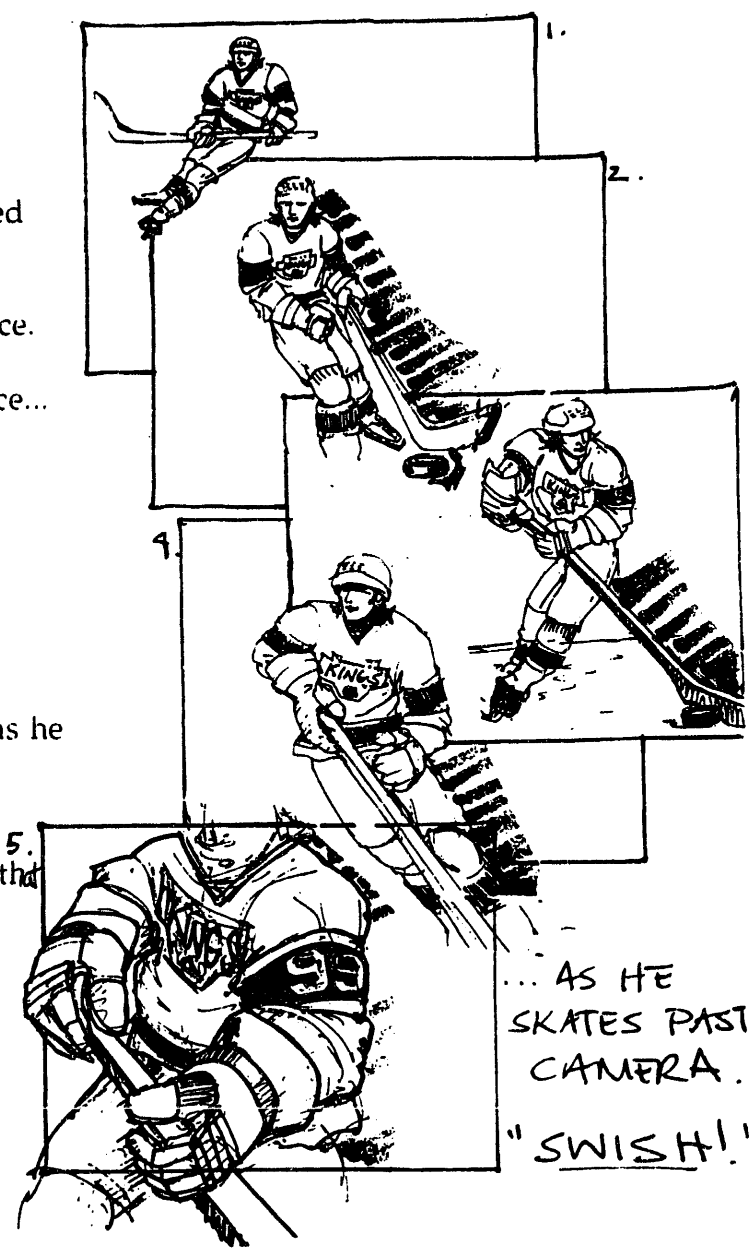
FADE IN

NEW QUICKTIME FRAME -- WAYNE GRETSKY SKATING ON ICE:

Wayne Gretsky pushing puck with stick as he accelerates with his skates on the ice.

HOST 2 (V.O. CONT.)
But, it is also common experience that objects in motion slow down... unless there continue to be force applied.

Gretsky releases puck and it slows.

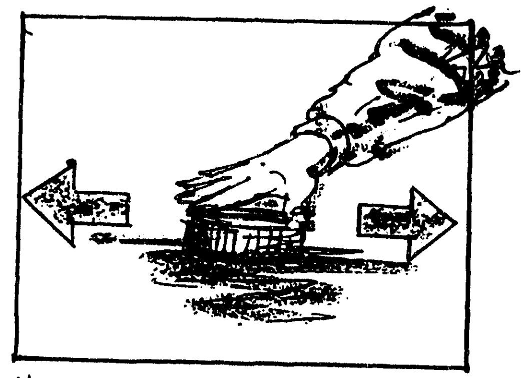


HOST 2 (V.O. CONT.)
Is the first law of motion wrong?
Or...

Puck stops.

HOST 2 (V.O. CONT.)
Is there a force operating here that we cannot see?

HOST DEMONSTRATES ON THE ICE.



HOST 2 - DEMONSTRATION OF "FRICTION."

HOST 2
The surface exerts a friction force on the object which opposes the motion... and slows it down.

HOST 2 enters frame and picks up puck and shows it to camera.

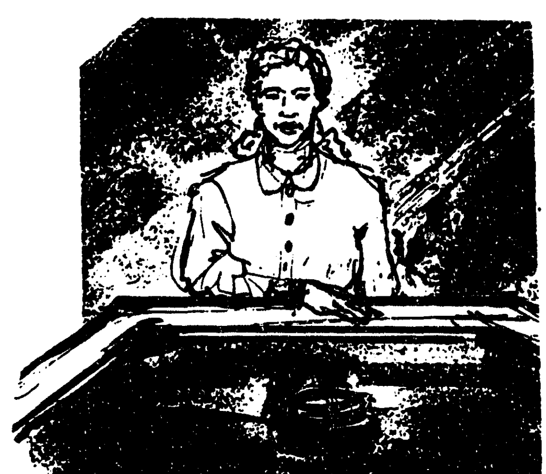
HOST 2 WITH HOCKEY PUCK.

HOST 2
(to camera)
The reason the puck couldn't go on forever...is a rubbing action between the puck and the surface it travels over....
A rubbing action called "friction."

You can put the same object on a surface that has almost no friction...

Host walks with puck over to air table...

HOST 2 (CONT.)
Like this air table...



HOST 2 - HOCKEY PUCK ON AIR TABLE.

Host places puck down on air table and slides it softly.

HOST 2 (CONT.)
...and it will move at almost constant speed.

FADE OUT QUICKTIME FRAME...

FADE IN

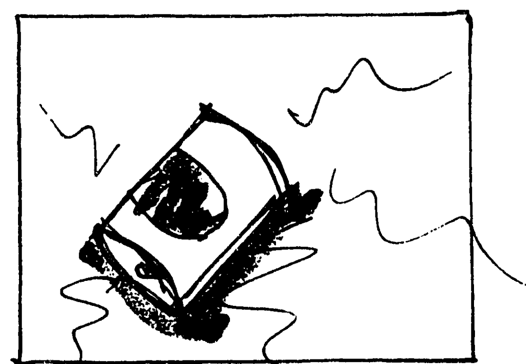
NEW QUICKTIME FRAME -- NASA FILM FROM ORBITING SHUTTLE:

Astronaut releases can which hovers in space.

ASTRONAUT RELEASING CAN.

HOST 2 (V.O.)

In the space shuttle...
coasting in orbit around the earth...
when you release an object at rest...
the object appears to <u>remain</u> at rest...
acting as if there were no gravity.



CLOSE UP OF CAN FLOATING.

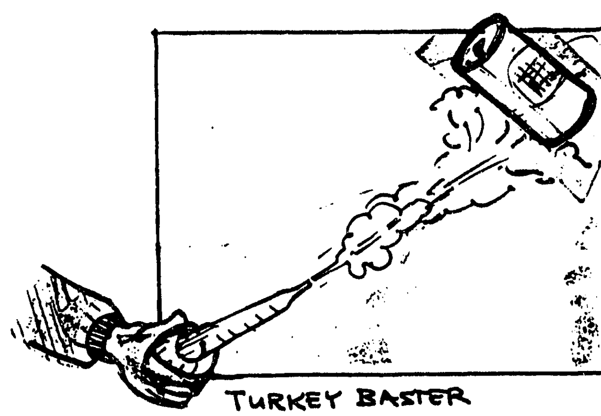
Apply a force for a short time...

Show air being squirted at can with small baster.

Can starts to move.

HOST 2 (V.O. CONT.)

And the object moves.
And with no additional force, it will move with constant speed and direction.
Of course, there is no <u>visible</u> friction here.



TURKEY BASTER BLOWING CAN.

FADE OUT QUICKTIME FRAME...

FADE IN

NEW QUICKTIME FRAME -- HOST 1:

HOST 1

Now let's bring back our demo team member to demonstrate the first law of motion one more time.

HOST 1

DEFAULTS TO ↓

UNIT TITLE FRAME:

"CHAPTER TWO /
FIRST LAW OF MOTION

PHYSICS DEMO TEAM"

FADE IN

NEW BIG QUICKTIME FRAME -- WAYNE GRETSKY

Wayne Gretsky skates into frame still suited up in hockey player suit.

WAYNE GRETSKY
(to camera)

If an object is rest, and nothing is applying force on that object... it's just going to sit there...

GRETSKY: TO CAMERA...

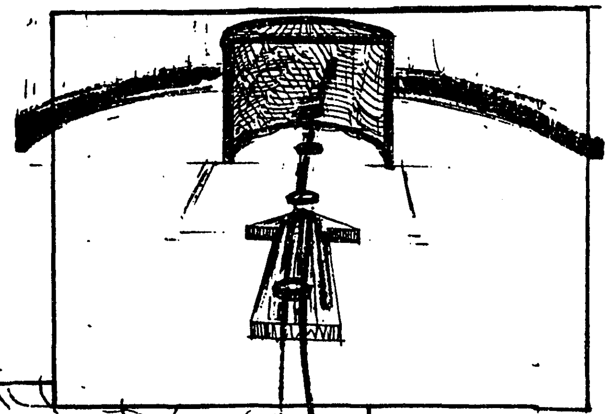
Gretsky looks down at puck. It just sits there.

WAYNE GRETSKY (CONT.)
...until acted on... by a force.

POW! - Gretsky SLAPS puck with his hockey stick.

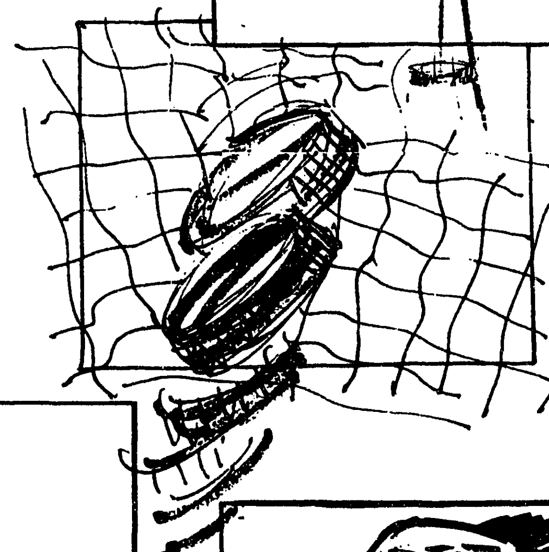
CAMERA TRAVELS with puck.

GRETSKY- SLAPS PUCK WITH HOCKY STICK.



WAYNE GRETSKY (V.O.)
Once in motion, an object continues
with no change in speed or direction.
It travels straight...
(pause)
unless acted on by an outside force.

Puck SLAPS into net of goal.



PUCK SLAPS INTO NET.

WAYNE GRETSKY
(smiles)
See what I mean?

FADE OUT QUICKTIME FRAME...

DEFAULTS TO ↓

UNIT TITLE FRAME: **"CHAPTER TWO / FIRST LAW OF MOTION FIELD TRIP"**

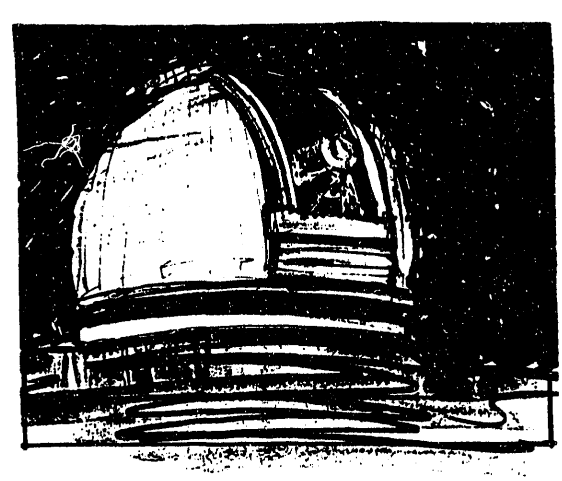
GRETSKY: "SEE WHAT I MEAN?"

FADE IN

NEW QUICKTIME FRAME -- SOLAR OBSERVATORY:

BIG BEAR SOLAR OBSERVATORY rises out of Big Bear Lake.

Inside astronomy students from CalTech work with the telescopes recording solar activity.



OBSERVATORY

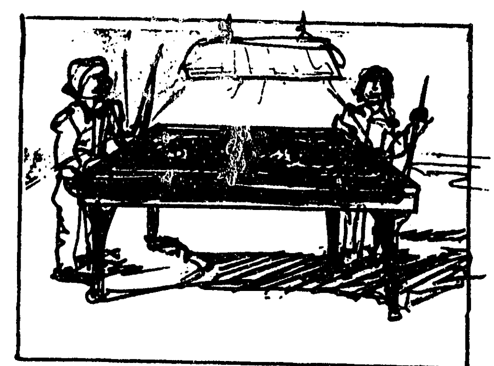
ASTRONOMER OBSERVING...

HOST 1 (V.O.)

During the day, astronomers at the Solar Observatory at Big Bear Lake in California spend their time observing the sun.
The first law of motion affects how the telescope is moved to keep focused on the sun.

But at night... when the sun is below the horizon and beyond direct observation...

The astronomers spend their time studying...

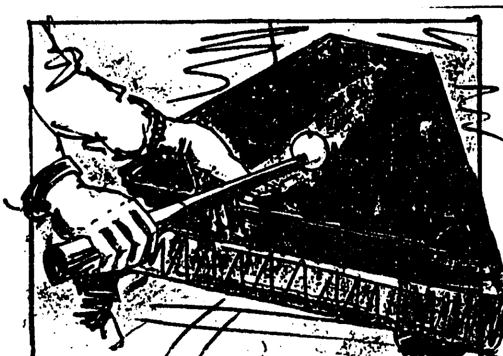


BILLIARD TABLE – ASTRONOMERS BEND OVER IT...

Cut to BILLIARD TABLE in bright light, as same astronomers bend over the table.

HOST 1 (V.O. CONT.)

...the art of billiards -- which also depends on understanding of the laws of motion.



ASTRONOMER ONE – SHOOTS WHITE CUEBALL...

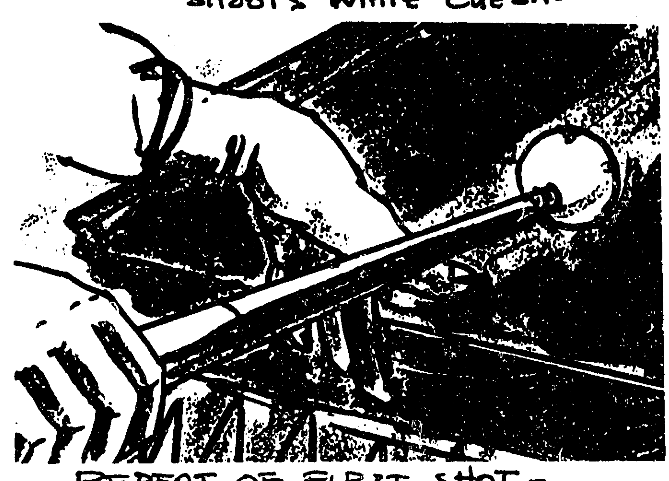
ASTRONOMER ONE shoots white cueball towards a red ball.

The cueball hits the red ball into a side pocket.

HOST 1 (V.O. CONT.)

Let's describe what's happening here in terms of Newton's laws of motion.

REPLAY BEGINNING OF THE SHOT, but this time much closer up.



REPEAT OF FIRST SHOT – ONLY MUCH CLOSER UP.

HOST 1 (V.O. CONT.)

The cueball began at rest... and then was put into motion.
Was a force exerted on the ball?

FREEZE QUICKTIME FRAME...

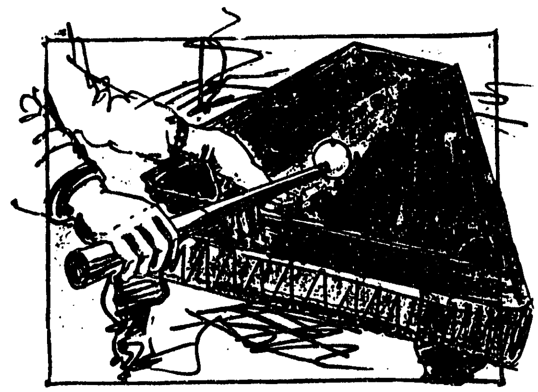
FADE IN

ANSWER BUTTONS BELOW TEXT:

YES	NO

IF STUDENT CLICKS "NO", last QuickTime shot is played again with following commentary.

HOST 1 (V.O. CONT.)
Look carefully.
Force was exerted on the ball.



REPEAT OF FIRST SHOT IF STUDENT CLICKS "NO."

IF STUDENT CLICKS "YES", another question is asked.

HOST 1 (V.O. CONT.)
Why is this the correct answer?
Does the first law of motion tell us this answer?
(pause)
According to the first law there must have been a force, because without a force, the cueball would remain stationary.

What object exerted the force on the ball?

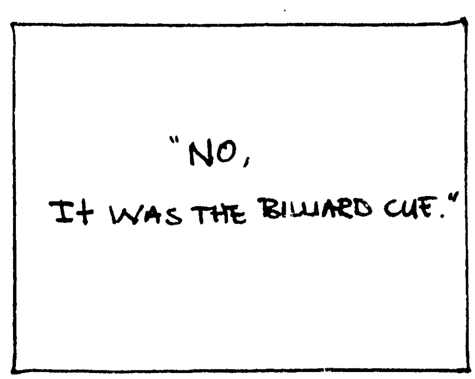
FADE IN

ANSWER BUTTONS BELOW TEXT:

ASTRONOMER	BILLIARD CUE

IF STUDENT CLICKS "ASTRONOMER", screen displays this message:

"NO, IT WAS THE BILLIARD CUE."



MESSAGE ON SCREEN IF STUDENT CLICKS "ASTRONOMER."

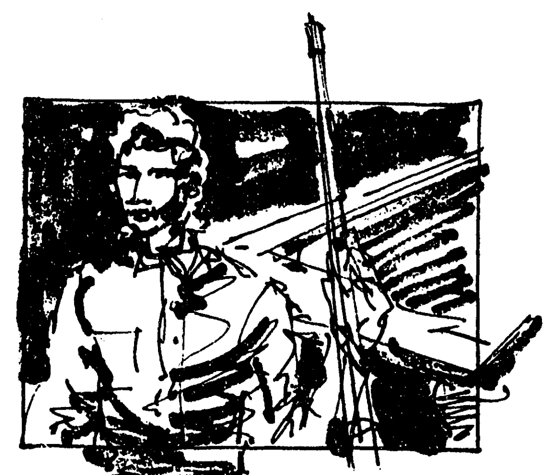
HOST 1 (V.O. CONT.)
The Astronomer held the billiard cue, but it was actually the cue itself that exerted the force on the ball.

IF STUDENT CLICKS "BILLIARD CUE", the commentary says:

HOST 1 (V.O. CONT.)
The cue stick exerted the force...

AFTER EITHER ANSWER, the commentary continues:

HOST 1 (V.O. CONT.)
The atoms of the tip of the cue stick pushed on the atoms of the cueball.



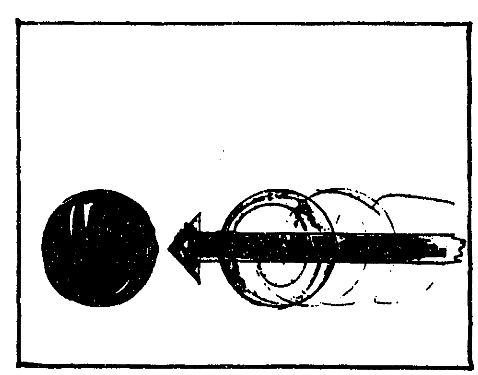
SHOW ASTRONOMER WITH CUESTICK.

But what object exerted force on the cue stick to put it into motion and cause it to exert a force on the ball? (pause)

The object was the Astronomer. The Astonomer put the cuestick into motion...
by exerting force on it.

Let's observe what happens next.

RESUME QUICKTIME. Cueball moving towards red ball, after being put into motion by stick, up till just before the collision.



CUEBALL IN MOTION JUST BEFORE COLLISION WITH RED BALL.

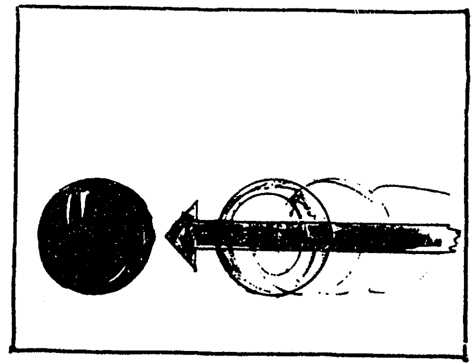
HOST 1 (V.O. CONT.)
Assume no rubbing friction is exerted on ball by surface.

Is there a force causing the cueball to continue?

FADE IN

ANSWER BUTTONS BELOW TEXT:

YES	NO



REPEAT OF SHOT IF STUDENT CLICKS "YES."

IF STUDENT CLICKS "YES", last QuickTime shot is played again with following commentary.

HOST 1 (V.O. CONT.)
Look closer. A force is not required for motion to continue.

IF STUDENT CLICKS "NO", the commentary goes....

HOST 1 (V.O. CONT.)
Correct. A force is not required for motion to continue.

AFTER EITHER ANSWER, the commentary continues:

HOST 1 (V.O. CONT.)
A force is required only to change motion, to change speed, or to change direction.

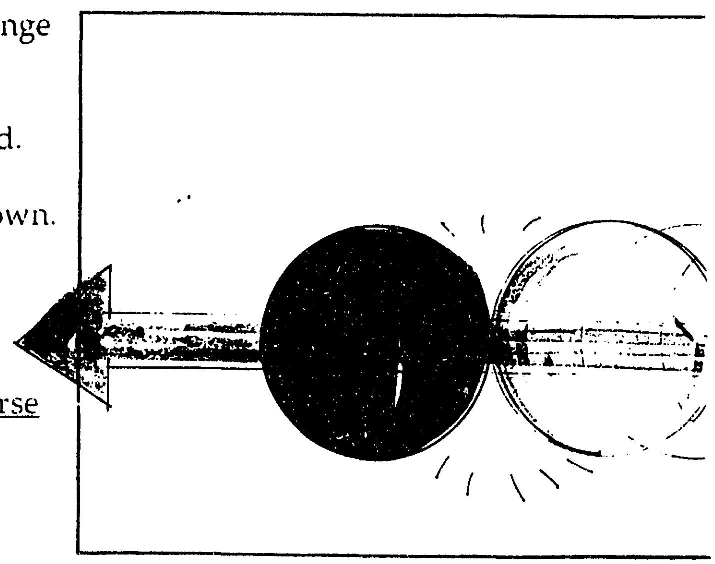
A forward force increases the speed.

A backward force slows the ball down.

It takes a sideways force to change direction.

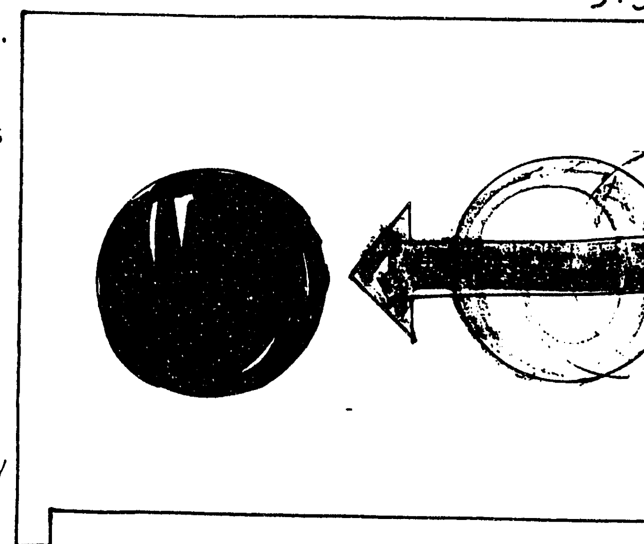
Or a strong backward force to reverse direction suddenly.

QUICKTIME FRAME shows SLOW MOTION CLOSE-UP of collision of balls.



CLOSE UP: SLOW MOTION OF COLLISION OF BALLS.

1.

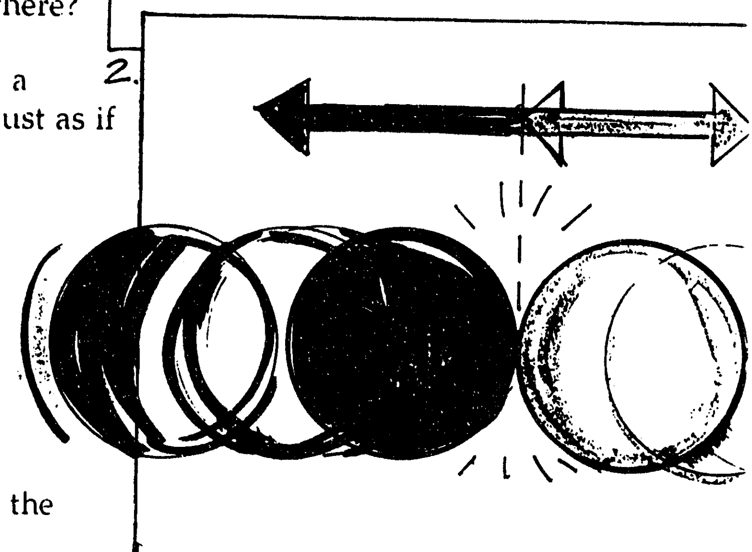


HOST 1 (V.O. CONT.)
Now what happens when these balls meet?
(pause)

If we imagine that the balls cannot exert force on each other...
What would happen?
(pause)

Would the red ball remain stationary just as if the cueball were not there?

2.



COLLISION OF BALLS SHOWING CUEBALL CHANGE DIRECTIONS AND SPEED...

Would the cueball continue in a straight line at constant speed just as if the red ball was not there?

FADE IN

ANSWER BUTTONS BELOW TEXT:

YES	NO

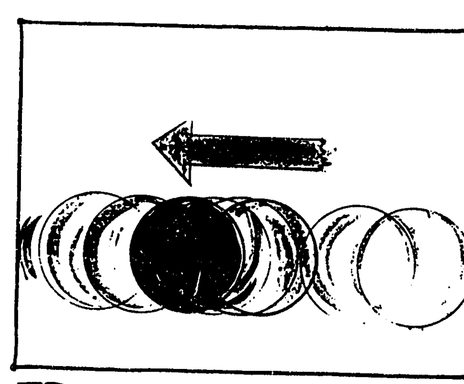
IF STUDENT RESPONSE was "NO", the commentary goes....

HOST 1 (V.O. CONT.)
No, motion can be changed only by force.

IF STUDENT RESPONSE was "YES", the commentary goes....

HOST 1 (V.O. CONT.)
Correct.
Motion can be changed only by force.

Objects that don't exert force on each other behave as if the other was not there. The red ball would remain stationary and the cueball would pass right through the red ball... like this.



TRICK-PHOTOGRAPHY SHOWING BALLS PASS THROUGH EACH OTHER.

QUCKTIME FRAME SHOWS TRICK PHOTOGRAPHY that makes the balls appear to pass through each other as if both were ghosts.

HOST 1 (V.O. CONT.)
What actually happens is that balls collide and bounce off each other.

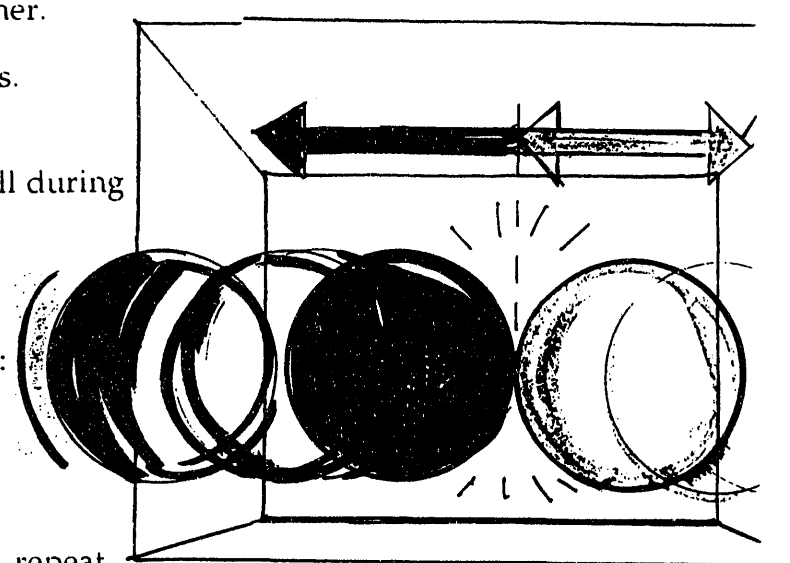
CLOSE-UP of collision of billiard balls.

HOST 1 (V.O. CONT.)
Is a force exerted on the red ball during the collision?

FADE IN

ANSWER BUTTONS BELOW TEXT:

YES	NO



CLOSE-UP OF COLLISION OF BAL
CAMERA ZOOMS IN UPON COLLISI

IF STUDENT RESPONSE was "NO", repeat the collision footage as commentary goes....

HOST 1 (V.O. CONT.)
No, there must be force. Otherwise the red ball would have remained stationary.

IF STUDENT RESPONSE was "YES", the commentary goes....

HOST 1 (V.O. CONT.)
Correct.
Why <u>is</u> that a correct answer?
(pause)

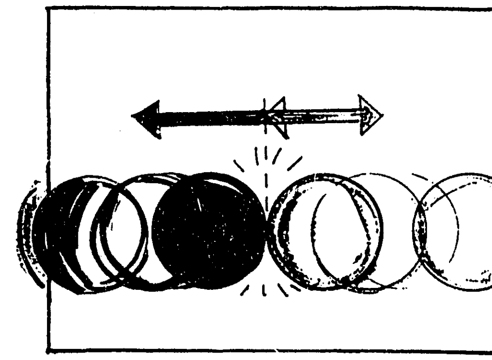
HOST 1 (V.O. CONT.)
With no force the red ball would remain stationary.

What object exerts force on the red ball?
And in what direction is this force applied?

PROMPT: "PRESS BUTTON TO CONTINUE."

HOST 1 (V.O. CONT.)
The force was exerted by the cueball. The direction of the force is the direction of the motion of the red ball.

The atoms of the cueball push on the atoms of the red ball at the place where the balls make contact with each other. Is a force exerted on the cueball during the collision?



REPEAT SHOT: DIRECTION OF THE FORCE IS THE DIRECTION OF THE MOTION OF THE RED BALL...

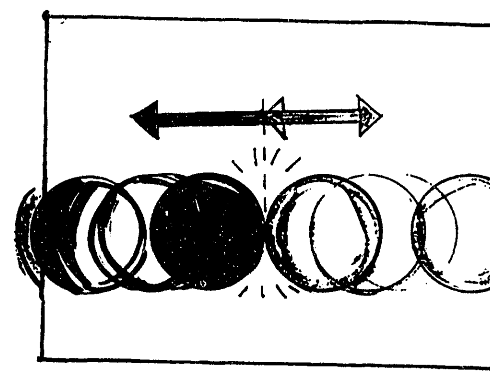
FADE IN

ANSWER BUTTONS BELOW TEXT:

YES	NO

IF STUDENT RESPONSE was "NO", repeat the collision footage again as commentary goes....

HOST 1 (V.O. CONT.)
Watch again. With no force, the cueball would continue moving the way it was before the collision. If there was no force, there would have been no change in speed or direction. There was a change, therefore there was a force exerted.



REPEAT SHOT AGAIN IF STUDENT CLICKS "NO!" CUEBALL HITS RED BALL, THEN CHANGES DIRECTION AND SPEED.

IF STUDENT RESPONSE was "YES", the commentary goes....

HOST 1 (V.O. CONT.)
Correct.
Why is <u>that</u> a correct answer?
(pause)

With no force, the cueball would continue moving the way it was before the collision, with no change in speed or direction.

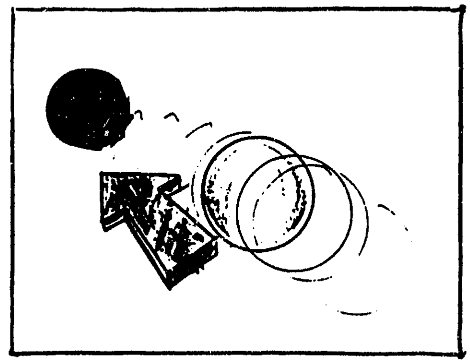
What object exerts the force on the red ball?

REPLAY COLLISION FROM ANOTHER ANGLE. THEN FREEZE.

HOST 1 (V.O. CONT.)
Click button to continue when you're ready to check your answer.

CONTINUE

When student clicks continue button, commentary resumes.



REPEAT OF COLLISION FROM ANOTHER ANGLE. FREEZE FRAME.

HOST 1 (V.O. CONT.)
The force was exerted by the red ball.

The atoms of the red ball push on the atoms of the cueball at the place where the balls make contact with each other.

This is an example of mutual repulsion.

Because when the two balls are forced to press into each other, they act to repel each other....
They push each other apart.
Each pushes the other away from it.

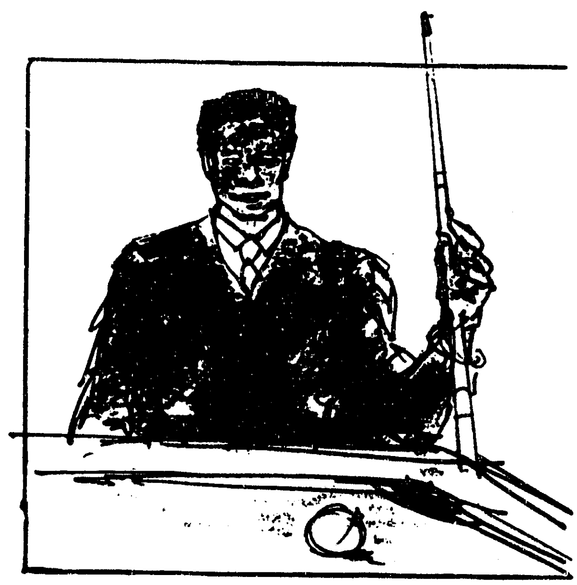
The force exerted on the cueball by the red ball changes the speed and the direction of the cueball.

FADE UP

NEW QUICKTIME FRAME - HOST AT BILLIARD TABLE:

Host 1 holds billiard stick.

HOST 1
(to camera)
As you can see, the laws of motion affect just about <u>anything</u> you do -- work... <u>or</u> play.



HOST 1. AT BILLIARD TABLE

DEFAULTS TO ↓

UNIT TITLE FRAME:

"CHAPTER TWO /
FIRST LAW OF MOTION

WRAP UP"

FADE IN

NEW QUICKTIME FRAME -- HOSTS:

HOST 2

Although the three laws of motion form a unity...

We have mainly discussed in this chapter the first law of motion...

A body... or object... or particle at rest... remains at rest.

A body... or object... or particle in motion remains in motion... if no force is applied to it.

It doesn't matter whether we are talking about an electron...

FADE OUT QUICKTIME FRAME...

FADE IN

NEW QUICKTIME FRAME -- MONTAGE OF OBJECTS:

MONTAGE of objects described. They dissovle from one to another.

HOST 1 (V.O.)
or a billiard ball...
or a hockey puck...
or a can floating in space...
or a star in a galaxy...
or....

HOST 1 (V.O. CONT.)
...you.

MONTAGE ENDS... with scanned PHOTO OF STUDENT apparently in QuickTime frame.

FREEZE QUICKTIME FRAME...

HOST 2 (V.O.)
The law remains the same.

Remember you can use your navigation gear to jack into other information...
on this subject...

Including an InfoBox on Sir Isaac Newton...

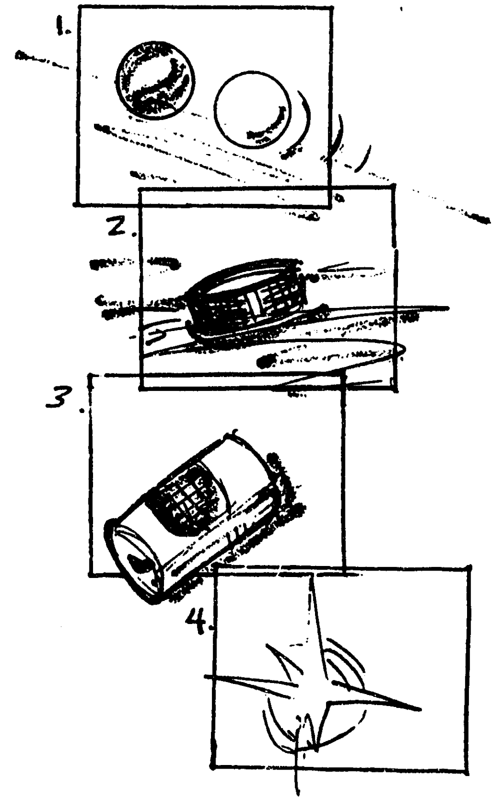
FADE IN

INFOSPACE ICON:

HOST 2 (V.O. CONT.)
who was in his twenties when he began working on discovering the laws of motion.

HOST 1 (V.O. CONT.)
Or you can go onto the next chapter...

MONTAGE:



STUDENT'S PHOTO
END MONTAGE

INFO SPACE ICON.

PHYSICS / THE REAL STUFF

FADE IN

CHOICE BUTTONS:

TAKE ME BACK IN TIME TO DISOVERY OF FIRST LAW OF MOTION BY ISAAC NEWTON IN 1667.	START CHAPTER THREE / THE SECOND LAW OF MOTION	REPEAT THIS UNIT

HOST 1 (V.O. CONT.)
...and start the next chapter...
which is going to jump you right to
the Third Law of Motion... which
describes how forces arise.

HOST 2 (V.O. CONT.)
Choose...
because in "THE REAL STUFF"
the choice is always yours.

IF STUDENT CHOOSES TO START CHAPTER THREE,
JUMPS TO BEGINNING OF CHAPTER THREE.
(SEE SCRIPT PAGE 45)

IF STUDENT CHOOSES NEWTON, ↓

INFOBOX: HISTORY UNIT

TITLE TEXT: "SIR ISAAC NEWTON"

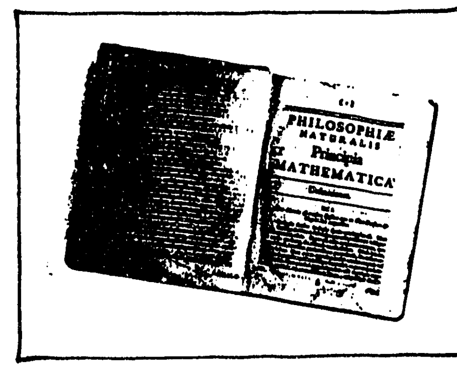
FADE IN

GRAPHIC: Illustration of Sir Isaac Newton

"SIR ISAAC NEWTON"

HOST 2 (V.O.)
The three laws of motion are usually described as Newton's Laws of Motion, because they were discovered by a brilliant young science instructor at Cambridge in England, Isaac Newton.

At age 25, in the year 1667, Newton began the discoveries which led to his book MATHEMATICAL PRINCIPLES OF NATURAL PHILOSOPHY (published as PHILOSOPHIAE NATURALIS PRINCIPIA MATHEMATICA, because science texts were written in Latin in those days.)



THE PRINCIPIA

More simply known as the PRINCIPIA,
this book contained Newton's three laws of motion, his law of gravity force, and accurate explanations of many phenomena not previously understood.

These included the motion of the planets and comets around the sun...

The motion of dropped and thrown objects on the earth...

The motion of the moon around the earth...

The existence of tides on the earth's seas...
And many others.

This set of laws was so powerful, Newton could use them to calculate how the spinning of the earth causes our planet to be 13 miles fatter in radius at the equator than at the north and and south poles.
Measurements later showed Newton's calculations to be correct.

HOST 2 (V.O. CONT)
Newton's creation of a complete theory of force and motion was actually the culmination of the scientific revolution begun by Copernicus.

Newton acknowledged his debt to those who preceeded him when he wrote...

"If I have seen further than other men, it is because I have stood on the shoulders of giants."

And in turn, Newton's work became the foundation... the starting point.... for the rapid development of modern science and technology.

Newton's physics is based on a mental image of the universe...
which scientists call the Newtonian World View. Here is a description.

Newton wrote that the universe extends forever in all directions. Space is infinite.

This space is populated by elementary particles of matter which influence the motions of one another by exerting forces on each other.

The same laws of motion and laws of force between particles hold everywhere in the universe and at all times.

There is only one realm, and one physics. The same types of particles and same types of forces occur on the earth, inside the earth... in stars... and everywhere.

HOST 2 (V.O. CONT.)
Everything that happens can be described and understood in terms of the motions of particles... the forces acting between the particles... and the relationship between the forces and the motions.

Newtonian mechanics provides a complete description of this kind. And Newton's law of gravity force gives a complete description of the gravitational attraction between particles.

As an example... planet Earth consists of an enormous number of particles which were brought together some time in the past by forces of gravitational attraction between all the particles.

The same gravity forces hold the particles together and prevent the earth from "flying apart"... prevent the separate particles from going their own ways.

Newton regarded the forces to be the "active agents of nature." If particles did not exert forces on each other, then nothing could ever really happen, even if all the particles were in motion.

Without forces, particles couldn't attract each other to form structures. There would be no atoms... no molecules... no stars or planets. There would only be individual particles moving along their straight line paths at constant speed.

They couldn't even bounce off each other. Without forces, two particles whose paths crossed would simply pass right through each other.

HOST 2 (V.O. CONT.)
Newton's physics cleared the path for scientific development. He established a clear strategy for the practice of scientific work... including...

Discovery, by observation and experiment, of the particles and objects existing in nature. In other words, his methods led to the identification of the matter and structure of the universe.

Discovery, by observation and experiment, of the forces of nature that these particles and objects exert on ech other. This is done by observing the effects these objects have on each other's motion and by using the second law of motion.

Evaluation of the effects of now known forces on the motions in order to understand and predict these motions in more general situations.

In the PRINCIPIA, Newton described this strategy as follows:

"...the whole burden of philosophy seems to consist in this -- from the phenomena of motion to investigate the forces of nature, and then from the forces to demonstrate the other phenomena."


EINSTEIN FACING PAINTING OF NEWTON.

FADE IN

GRAPHIC: PHOTO of Einstein facing PAINTING of Newton.

HOST 2 (V.O. CONT.)
Today much of our view of the world has been shaped by Dr. Albert Einstein (1879-1955), the greatest physicist of this century.

But Einstein, in turn, paid tribute to Sir Isaac Newton. After discussing the ways in which his own theory of relativity goes beyond the physics of Newton, Einstein still wrote...

"Let no one suppose... that the mighty work of Newton can really be superseded by this or any theory. His great and lucid ideas will retain their unique significance for all time as the foundation of our whole modern conceptual structure in the sphere of natural philosophy."

FADE IN

CHOICE BUTTONS:

SHOW ME MORE MATERIAL ABOUT SIR ISAAC NEWTON	START CHAPTER THREE / THE SECOND LAW OF MOTION	REPEAT THIS UNIT

If more material about Newton chosen, give choice of the following:

1) brief article on the world of Newton's time;

2) cover of the PRINCIPIA;

3) translation of excerpts from the PRINCIPIA;

4) text and illustrations from SCIENTIFIC AMERICAN article assessing Newton's influ

5) bibliography of additional reading on Newton and his principles.

END

DATE
FILMED

5/6/93