# The Harvard Project Physics Film Program

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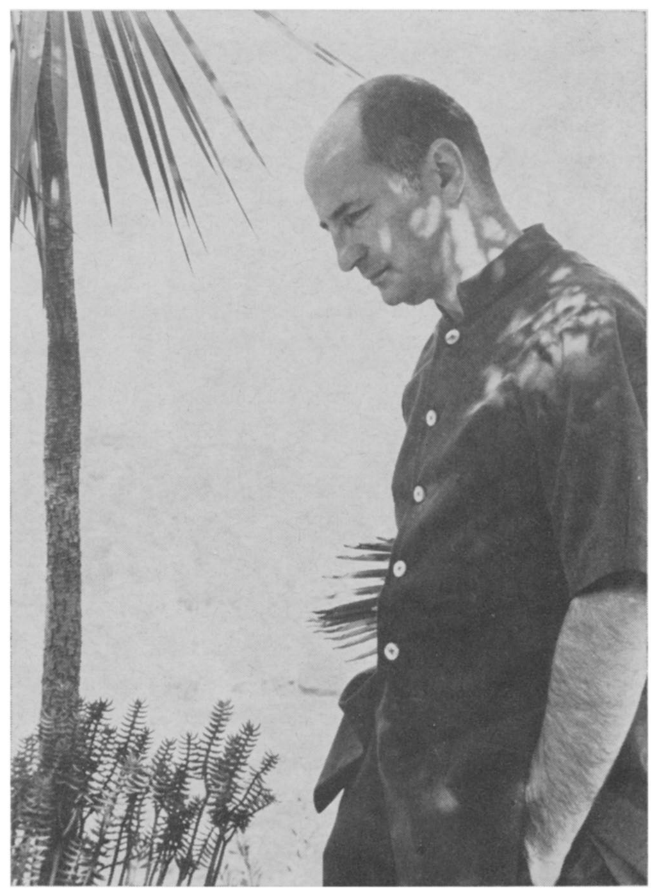
**Introduction**

Large curriculum projects often develop teaching materials in many media. Ideally each project, having considered what it wants to teach, tries to use the best of all conceivable teaching methods and media. But the ideal frequently falls short because of financial restrictions and, perhaps more important, the limited wisdom of the developers, the current state of the art, and the less than perfect skills of the artists.

From the beginning the Harvard Project Physics staff considered film a powerful teaching medium. Hence, in the earliest days of the Project we gave careful attention to the question of what films should be made. Many of us recognized that the wealth of teaching potential in well-done films has often been only partially exploited by traditional educational films. Furthermore, we thought that our films should be specifically designed for typical teaching situations; films should be usable in standard classrooms, within normal classroom periods, or they must be accessible to students outside of the classroom.

We began by asking what films *could* contribute to teaching physics. First, films should have some didactic teaching capacity; some aspects of physics should be easier to learn with the help of films than with printed material or other media. But it is not easy to specify these aspects, nor is it easy to test the effectiveness of a film. Ultimately the decision depends upon the judgment and taste of the course developers, and the funds available.

Educational film makers have often held strong views on the suitability and nonsuitability of particular film techniques. For example, even though it seems reasonable to expect that animation techniques would be particularly appropriate in some situations, very few animated physics



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films are available. Most educational films have been made to teach a particular concept.

Films are also used in physics teaching to provide experiences difficult for the student to attain any other way, experiences that contribute to the understanding or appreciation of physics. These experiences can range from vicarious visits at research laboratories or other inaccessible places, to experimental situations in which the film becomes part of the laboratory equipment. The camera's ability to alter space, time, and size is unique; the experiences it can create are unattainable through any other medium. For example, the slow motion camera shows details of an experience otherwise not observable.

A third use of films in teaching is for student motivation. The student will not choose to take a physics course, or any other elective, unless he considers it relevant to his interests and career ambitions. I need hardly stress the extremely disheartening decline in the percentage of students taking physics in the twentieth century. This steady decline, not suffered by the other high school science courses, indicates that the student environment has worked to discourage students from electing physics; apparently the present environment is *antimotivational* toward high school physics.

Most course development has paid relatively little attention to these motivating forces. Film could be a powerful tool for increasing student interest in physics, just as large corporations have used film to motivate, as well as to instruct. Although film is not the only means for motivation, it is important, even though few educational films have been made with motivation as their prime objective.

After the student is already enrolled in a high school or college physics course, motivational problems are still important. Physics is difficult, and the student must be persuaded to devote much time and effort to study. As a student cannot be "taught" physics in a passive sense, he must actively learn it. Some students can proceed eagerly, but others need constant motivating to stick with the hard tasks. Here too films can be important aids.

A fourth use of film for teaching physics is closely related to the purpose of the Harvard Project Physics course. This course is a *humanistic* physics course. It is not restricted to presenting physics only as a collection of theories verified by experiment, but also emphasizes that physics is a living, growing body of ideas, developed by people, interacting with our society in many different ways. We realized from the beginning that it was ambitious to develop a course relating physics to the people who produce it and to their ideas and dreams. And we hoped that the film medium might contribute some unique possibilities to the teaching of humanistically oriented science courses. I have in mind not the typical old biographical films with fake sequences obviously created in Hollywood-type studios, but instead the more subtle treatments available from the best contemporary film makers, particularly the masters of the documentary and cinema verité traditions.

The film projects, and other aspects of the course, were under the general supervision of the three codirectors of Harvard Project Physics, Fletcher Watson, F. James Rutherford, and Gerald Holton.

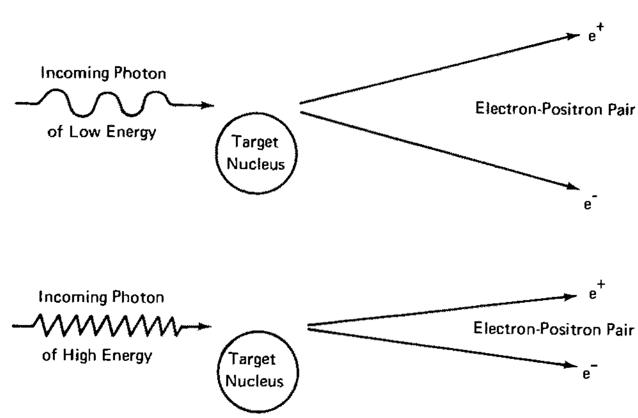
### Other Films

Before I describe the films made by Harvard Project Physics, I should stress that the staff has continually reviewed films in our attempt to use already existing films wherever they were appropriate to the purposes of the course. The Teacher Guide for each of the six units lists both Project Physics and other films and notes for the teacher just what contribution each film can make to the course at that point. Thus we have *not* been obliged to begin from scratch in film development, but have used numerous existing films that can serve our course well.

### Types of Films Produced by Project Physics

We have speculated on how films can be used in teaching, but practical considerations of talent, time, money, and other factors have determined just what was put on film in the Project Physics course development.

Roughly speaking, the Project has made two quite different types of films: long films and film loops.

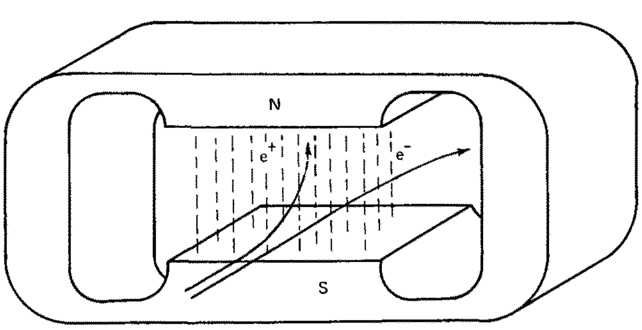



Schematic of pair production.

Harvard Project Physics has made relatively few long and expensive films in the past. But we hope that our long films will be of sufficient interest to encourage further progress in the same directions and to encourage additional financial backing for such films. We feel that physics education is a fertile field for these types of films, mostly ignored heretofore.

From the earliest days of Harvard Project Physics, consideration was given to making a film which would serve as an introduction to the study of physics and give the student insight into what it is like to work in physics. Many factors, including motivation, were considered. We felt it important to convince the high school student at the beginning of the course that physics is interesting, that the people engaged in it enjoy their work, that physics is a human product, very much influenced and controlled by human beings. We consulted experienced film makers who had successfully filmed people. Robert Gardner, from the Carpenter Center for Visual Studies at Harvard University, worked closely with us, drawing on his background of such excellent anthropological films as *The Hunters* and *The Birds.* After many months of discussion and some false starts, we finally settled into making the film that we now call *People and Particles.*

*People and Particles* is in the cinema verité tradition, with hand-held cameras, available light, black and white film, and no posed scenes. After considerable exploration we chose to film an experiment in progress at the Cambridge Electron Accelerator on the Harvard University campus. The experiment was a pair-production experiment involving a test of quantum electrodynamics, conducted by a group under Karl Strauch and James Walker of the Harvard University physics department. The camera work, by Barry Ferguson and Michael Butler, extended over a two-year period, from the first conception of the experiment to the time when the apparatus worked for a test run. Over 50 000 ft (10 miles!) of film were shot, with the film makers visiting all aspects of the project. We could have edited several different films from this wealth of material, and perhaps we shall do it some day. The




Trajectory of electron–positron pair.

film that we did make, using only some 1 500 ft of film in order to fit it into a normal high school class period, represents one selection from the full documentary material. A slightly longer version, primarily for college use, has also been prepared. For future reference and the use of others, all footage has been deposited with the History of Physics Section of the American Institute of Physics. In addition to those already mentioned, editing of the film involved Andrew Ahlgren, Alfred Bork, Stanley Goldberg, and William Shurcliff.

We expect that many classes, Project Physics and others, will use the film early in the year. In a short introductory brochure, we point out to the students that our purpose is not to teach the details in the experiment. The theory, quantum electrodynamics, is too complex to discuss fully with high school or beginning college students. One sequence in the film gives the basic description of the apparatus and techniques in the experiment, but even this may be beyond the ken of many students. Since our purpose is primarily motivational and sociological, it is the people, not the particles, that dominate in this initial showing.

So far our results have been very encouraging. We have shown the film in a variety of trial classes and in classes not using the Project Physics course, and then talked with the students to obtain their impressions. Also we have obtained written evaluations from students and comments from many classes in the Project Physics trial schools.

We also suggest to instructors that the film be shown a second time near the end of the course, after students have learned some atomic and nuclear physics in Unit 6. For such use more concentration on physics of the experiment is appropriate, although the details will probably again be too much for many high school students.

To aid the more able students to extend their knowledge of the experiment, we have prepared a longer Film Guide for *People and Particles.* It describes the purpose and the apparatus of the experiment in more detail than was possible within the film itself. This brochure, together with the film and other units of the course, might lead to individual projects. The Project Physics materials cover a very wide range and are intended to appeal to everyone from the very weak to the extremely able student; the wealth of material allows the teacher to give attention to individual student needs.

A 15-min color film, *Synchrotron,* describing in detail the construction of the Cambridge Electron Accelerator, has also been produced with a grant from the Sloan Foundation to Project Physics. The primary purpose of this film, narrated by William Shurcliff and directed by Barry Ferguson, is to provide information about the accelerator to students who wish to learn how it works, information not detailed in *People and Particles.* This guided tour of a modern accelerator will usually be shown in the spring term, probably before the second showing of *People and Particles*.

Another long film has been prepared with the financial support of the Ford Foundation. It is called *The World of Enrico Fermi* and deals with the rise of the new physics in the middle of this century. This historical documentary film focuses on *one* superb but believable physicist. The film technique is to use both archival materials—pictures, film, apparatus, and tape—and also interviews with Fermi's friends and students. An advisory board has made valuable suggestions in the development of this film, and James Rutherford, Gerald Holton, Alfred Bork, and Andrew Ahlgren have assisted with the production.

In this film the film makers have almost turned themselves into historians of science. To gather comments about Fermi, John Kemeny and Donald Brittain of the National Film Board of Canada conducted extensive tape interviews with some eighty physicists and friends of Fermi in this country and abroad. This rich material assisted greatly in developing the film outline. Then many of the same people were interviewed again on film. In contrast to the physics of large machines shown in *People and Particles*, the physics covered during the early part of Fermi's life could be done with simple equipment and few people. So we see a different cross section of the world of physics. Furthermore, sociological and political factors often intruded into, or resulted from, Fermi's work, and even the delicate issues of bomb development, much on the mind of some students today, had to be dealt with.

If the technique used in the Fermi film proves to be as successful as we anticipate, we or others can hopefully make more documentary films of this kind, because very few good biographical films are currently available. The production is under the direction of Grant McLean and Gordon Burwash of the Visual Education Centre of Toronto, and John Kemeny of the National Film Board.

## Film Loops

More of the film effort in Project Physics has gone into producing short loop films rather than the three long films. Physicists with Project Physics have worked with the National Film Board of Canada, and particularly with Jacques Parent, in developing forty-eight color loops, synchronized with text materials. The loops were tested in more than one hundred trial classes and re-edited before being released. Other loops are being considered for production.

CONCEPTS OF MOTION
- Acceleration Due to Gravity 1
- Acceleration Due to Gravity 2
- Vector Addition 1: Velocity of a Boat
- A Matter of Relative Motion
- Galilean Relativity
  - —Ball Dropped from Mast of Ship
  - —Object Dropped from Aircraft
  - —Projectile Fired Vertically
- Analysis of a Hurdle Race 1
- Analysis of a Hurdle Race 2

MOTION IN THE HEAVENS
- Retrograde Motion 1: Geocentric Model
- Retrograde Motion 2: Heliocentric Model
- Jupiter Satellite Orbit
- Program Orbit 1
- Program Orbit 2
- Central Forces: Iterated Blows
- Kepler's Laws
- Unusual Orbits

ENERGY
- One-Dimensional Collisions 1
- One-Dimensional Collisions 2
- Inelastic One-Dimensional Collisions
- Two-Dimensional Collisions 1
- Two-Dimensional Collisions 2
- Inelastic Two-Dimensional Collisions
- Scattering of a Cluster of Objects
- Explosion of a Cluster of Objects
- Finding the Speed of a Rifle Bullet 1
- Finding the Speed of a Rifle Bullet 2
- Recoil
- Colliding Freight Cars
- Dynamics of a Billard Ball
- A Method of Measuring Energy
- Gravitational Potential Energy
- Kinetic Energy
- Conservation of Energy 1: Pole Vault
- Conservation of Energy 2: Aircraft Takeoff
- Superposition
- Standing Waves on a String
- Standing Waves in a Gas
- Vibrations of a Rubber Hose
- Vibrations of a Wire
- Vibrations of a Drum
- Vibrations of a Metal Plate
- Reversibility of Time

LIGHT AND ELECTROMAGNETISM
- Standing Electromagnetic Waves

MODELS OF THE ATOM
- Production of Sodium by Electrolysis
- Thomson Model of the Atom
- Rutherford Scattering

THE NUCLEUS
- Collisions with an Unknown Object

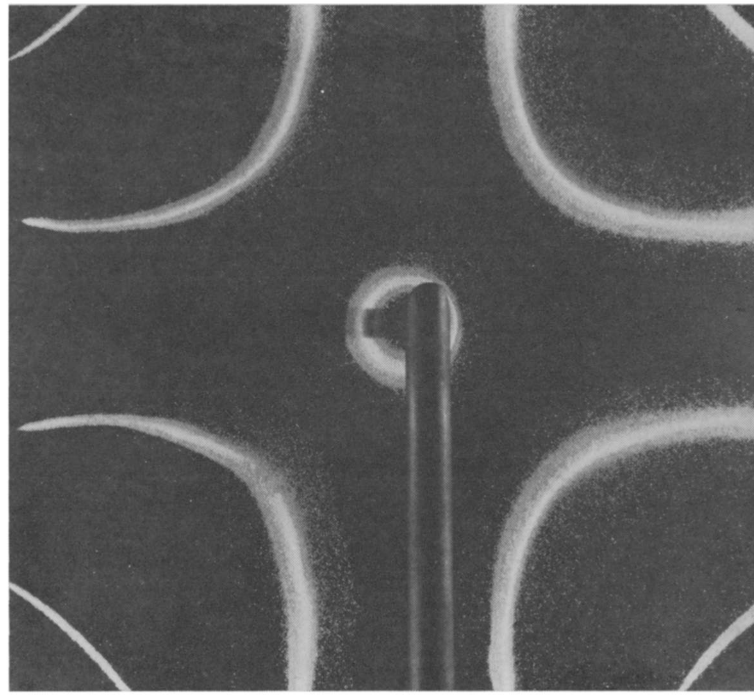
The Project Physics course was being developed when many of us were becoming enthusiastic about the pedagogical possibilities inherent in the 8-mm silent loop, only recently available as a result of the development of the Technicolor loop projector. The 8-mm loop can contain a maximum of 4 min of material, and no sound is available with the present commercial models. The term "loop" implies that the film continues to recycle until the projector is turned off. The films will also be usable in the recently announced Kodak automatic cartridge projector.

Franklin Miller, whose pioneering efforts produced widely available 8-mm single concept loops in physics, and Alfred Leitner made major contributions to the Project Physics loops while members of the project. Others involved were the codirectors, Owen Gingerich, Albert Stewart, Andrew Ahlgren, and Alfred Bork.

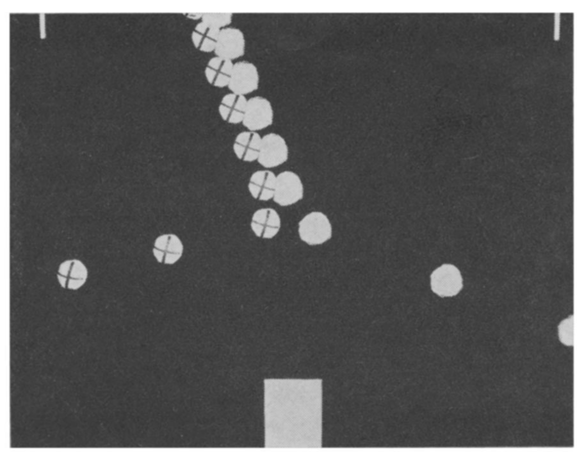
As I remarked years ago, in referring to the pedagogical advantages of computer-produced film loops, with the standard film format, film showing for a class can be a major operation involving assembling equipment and engaging an operator. Automatic threading projectors ease, but do not solve the problem. Furthermore, the instructor must weigh the use of time for showing a film during class against time used for lectures, class discussions, problem-solving, and demonstrations. Class members may be obliged to miss a film shown outside scheduled classes, and it is often difficult to arrange for a student to see a film more than once.

The film loop cartridge allows a different mechanism, corresponding closely to library arrangements for books and records, perhaps even to be handled in the library rather than in the physics department. A typical setup might have several booths equipped with film loop projectors, with the extremely simple operating instructions posted. The film cartridges would be available at a checkout desk in the library. The student would check out the film, take it to the booth, and view it as many times as he wished. (It has been pointed out to me that a student almost never watches a loop only once!) Also, he could view it at another time, perhaps after class discussion emphasized features of the film he had missed on his first viewing. This arrangement allows for short films and versatility.

Principal distinctions of the Project Physics loops are the carefully planned visual details and the attempts to involve the students directly. Many Project Physics loops can be described as "interactive." Jacques Parent had already pioneered in developing interactive loops. Mostly this interaction occurs within the laboratory context in that the loops, along with the film notes for the loops, often suggest measurements that can be made for the projected images. Students can experience phenomena, either real-life or laboratory, that would have been completely inaccessible to them without the loop, either because the students cannot reach them, or because they are observable only by means of photographic processes. Thus, as in one Project Physics loop, a pole vaulter is shown in slow motion with freeze frames so that the viewer can make position-time measurements and follow the conversion of kinetic energy into potential energy. The student could ordinarily observe such a motion, but not in a way that would allow him to make measurements. So loops can extend first-hand laboratory experiments to new contexts, often outside the laboratory.



Inelastic two-dimensional collision.



Inelastic two-dimensional collison.

Sometimes a conventional laboratory might be replaced by one which depends on loops, for part of the class. Or several loops can be viewed during a class discussion. Loops that were first introduced by the teacher can also be made accessible to students in a library-like arrangement, such as that mentioned above, where the student can look at them either passively, just viewing them, or actively carrying out the indicated procedure. Each loop is discussed in the Student Handbook, and the boxes also contain notes for the student. Most loops have introductory sequences which show how the loop was filmed. The Teacher's Guide contains additional information to aid the teacher in maximizing the use of each loop.

We hope that the loops will be usable in a wide variety of classes, both in junior high, high school, and college. They constitute a sizable addition to the collection of loops available to physics teachers.

Further information about this and other aspects of the project can be obtained from:

Harvard Project Physics
8 Prescott Street
Cambridge, Massachusetts 02138.

## Innovative Teaching Award Winners 1969–1970

At the annual meeting in Chicago the AAPT awarded cash prizes of $500 to six secondary school physics teachers whose physics programs were judged to have produced demonstrable improvements in physics enrollments or in student achievements. Six other teachers received letters of honorable mention.

The winners:

LOUIS DEALL
Clayton High School
Clayton, Mo. 63105

DEAN SOUSANIS
Kingswood School Cranbrook
Bloomfield Hills, Mich. 48013

RICHARD J. MIHM
Glastonbury High School
Glastonbury, Conn. 06033

F. DARRELL GOAR
DONALD G. FENTAM
GARY L. BUSHMAN
Moline Senior High School
Moline, Ill. 60265

Honorable mention:

LAWRENCE BROY
Niles Township High School—
West Division
Skokie, Illinois

RODERICK S. DICKENS, JR.
Forrest Senior High School
Jacksonville, Florida 32210

LOWELL G. HERR
Catlin Gabel School
Portland, Oregon 97225

JOHN T. MEYERS
Alhambra High School
Phoenix, Arizona

JOHN R. NICK
Aviation High School
Long Island City, N.Y. 11101

DONALD A. SCHAEFER
Bettendorf Community School District
Bettendorf, Iowa 52722

Descriptions of the winners' programs will be published in THE PHYSICS TEACHER commencing next month, together with the announcement of next year's competition.