An Inquiry-based Course Using "Physics?" in Cartoons and Movies

Michael Rogers, Ithaca College, Ithaca, NY

Books, cartoons, movies, and video games provide engaging opportunities to get both science and nonscience students excited about physics. An easy way to use these media in one's classroom is to have students view clips and identify unusual events, odd physics, or list things that violate our understanding of the physics that governs our universe.[1,2] These activities provide a lesson or two of material, but how does one create an entire course on examining the physics in books, cartoons, movies, and video games? Other approaches attempt to reconcile events in various media with our understanding of physics[3-8] or use cartoons themselves to help explain physics topics.[9]

The core premise of my School of Humanities & Sciences Honors Seminar is that the physics we see in these media are "real." We see the events occur, so they must be real. Instead of being skeptics when watching these unusual and sometimes usual events occur, students form multiple working hypotheses that might explain the events they witness.[10] Taking a very Newtonian view of the worlds we are studying, students extract position-versus-time data using VideoPoint software (other software such as Vernier's Logger Pro can also be used but currently does not have all of the features of VideoPoint). Line fitting to these data results in an equation of motion informing the students about the acceleration (which is frequently zero), the speed, and the initial conditions. These data and line fits are used to test student's multiple working hypotheses. In the grand tradition of experimental science the students often find themselves forming new hypotheses and questions. Students report their results in written reports and oral presentations.

Structure of The Course

The course is offered Tuesday / Thursday for an hour and 15 minutes. Most class sessions begin with a 10-minute lecture covering kinematics, forces, energy, gravity, bright line emission spectra, quantum mechanics, special relativity, general relativity, and current work on unifying theories. The 10-minute lecture is followed by a 5-minute discussion of experimental techniques and an outline of the objectives for the class period. Students join their self-formed groups to select clips to study, collect data, analyze data, and make conclusions. Approximately every two weeks the class concludes with a discussion of the physics studied, and analysis is conducted with an emphasis on how scientists have developed an understanding of the physics in our world.

During the first few weeks of the semester students analyze clips that I selected from the "Road Runner & Wiley E. Coyote" cartoons and the "Matrix" movies. These "experiments" help the students learn how to use VideoPoint, form hypotheses, do line fits, make conclusions, and submit a mini-project report.

Students followed these "experiments" by selecting their own mini-topics to study. Students selected topics such as: the flying motion of characters in the movie "Crouching Tiger, Hidden Dragon," a free fall from the top of a tall building by the character Peter in the animated show the "Family Guy," the fall of the Balrog and Gandalf from the "Lord of the Rings" mov-

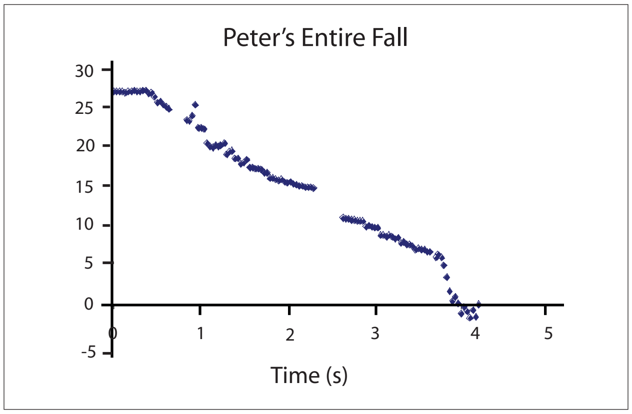

Fig.1. Shows Peter's fall from beginning (*t* = 0 s) to end (*t* = 4.2 s).

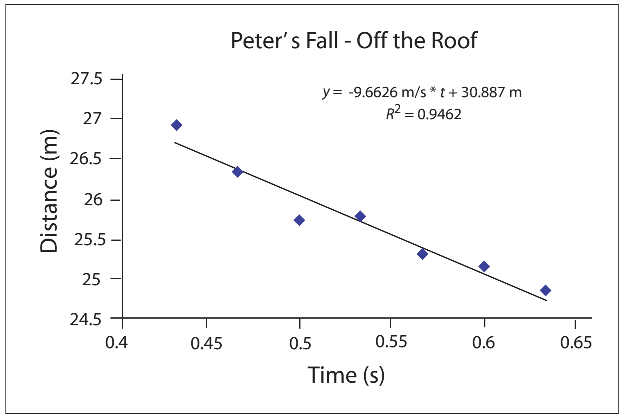

Fig. 2. Shows Peter's initial fall from the roof right after he jumps. The data show a linear correlation with no net acceleration.

ies, and the unbelievable martial arts ability of Jet Li in "Romeo Must Die." Students presented their results in mini-reports and oral presentations. The course concludes with students working on an advanced project where they examine different events across multiple scenes or movies. An example of an advance project is one group's work on examining flying motion in four different Peter Pan movies. Advanced projects require more rigorous testing of working hypotheses compared to the mini-topics. This work results in a formal report and a final oral presentation where each student has a defined role in their group analysis by each student selecting a particular effect, scene, or movie to study in support of their group's overall goals.

Examples of Student Work

Students reviewed several movies, cartoons, and video games to identify physics topics to study. Their selections mainly focused on finding usable scenes in their desired media. Their introductory investigations directed by my selection of clips and our classroom discussions helped students identify clips with the potential for successful analysis. My course differs from the usual experiment in that we cannot control the setting of our experiment. If we could exert control my students would have the camera be stationary, not pan and not zoom. The view would be wide enough to include all of the motion of the characters being studied and incorporate a scale into the frame. Rarely does this ideal situation appear in cartoons and movies (one creative team chose to analyze gravity in the video game "Halo I" and "Halo II," where they could control many aspects of the scene). Once the students selected usable scenes they used a variety of methods to extract clips from videotape, DVD, and video games. These clips were shortened using VideoPoint Capture or QuickTime Pro to only include the region of interest, reducing the file size and making analysis in VideoPoint smoother.

Reduced clips were imported into VideoPoint, where students set the scale using features in the scene. Students commonly used the height of a character and obtained the actual height of the actor from an internet movie database (www.imdb.com). With the scale established, students selected an origin and began tracking one or more points frame by frame. VideoPoint records these data in tabular form and presents options for graphing the data in various forms. An unexpected outcome of my course was student use of graphs to find interesting changes in the data, which led to looking at events in the clip. VideoPoint allows students to move the cursor along the data points, which triggers the video clip to track along the connect frames. This sequence of analysis was unexpected due to my previous experience of students looking at clips (or events) first and then going to the data. Instead, students used their data to guide their investigations.

VideoPoint helps students deal with camera pans, an origin that leaves the scene, and camera zooms. Using VideoPoint or MS Excel, students conduct line fits to the position-versus-time data. These fits result in a kinematics equation of motion. Figures 1 and 2 show student data extracted from the clip they chose to study and the position-versus-time graph with a line fit for a portion of the fall. The students in this group chose to study a very challenging scene from the animated TV show "The Family Guy.' The character Peter is standing on the top of a building in the beginning of the scene. Peter jumps with the camera situated halfway up the building and pointing up at the sky, and Peter falls toward the camera. After Peter fills the scene, the camera angle switches to pointing down, and Peter can be seen falling away from the camera. The final scene has the camera positioned level with the ground showing Peter falling vertically the last few meters. Each of these distinct aspects of the scene are identifiable in Fig.1.

Suggestions for Success

The biggest challenge to this course is extracting usable clips from a variety of media. The easiest method is to use a videotape player, VideoPoint Capture software, and a USB to RCA adapter (I used one from Belkin). These tools can also be used to extract scenes from video games by plugging the game controller into the VCR line-in port. There are also various ways to extract clips from DVDs and I found these methods to be time consuming. I recommend that appropriate time be built into such a course as mine to allow for extraction of the desired media.

To satisfy copyright laws I purchase videotapes or DVDs equal to the number of clips used in my class. Students access these clips through a campus server, limiting them to use of the clips in my class. Because I have paid for a full version of the movie or cartoon for each clip in use, there are no copyright issues. This procedure complies with the copyright policies of Ithaca College, which may be different from other institutions.

During my first offering of this course, I had the students purchase a conceptually oriented physics textbook. This turned out to be not necessary. The 10-minute lectures at the start of each class are sufficient to teach the students the needed physics.

VideoPoint has some useful tools for plotting velocity versus time, acceleration versus time, potential energy, and kinetic energy. All of these tools are not useful for this type of course, because they rely on our understanding of physics. Cartoons, movies, and video games often have different equations of motion. A line fit to the position-versus-time data produces one of the kinematics equations that help students identify the physics of the world they are studying. This—in my opinion—is the strength of my class. Students have to create the physics to describe the worlds they are studying and in doing so develop an understanding of how our physics community has come to understand the physics of our world. This is inquiry at its best!

A challenge of my course that I am still working on resolving is how to assess each student individually compared to assessment of group work. I plan on trying new methods during the next offering of the course, and I welcome suggestions from readers.

Conclusions

Evaluating student reports, presentations, and individual discussions with students identified student progression from skeptics trying to identify tricks filmmakers used to create the events students were seeing to students forming creative, testable hypothesis and conducting such tests. Without specific instruction on my part but clearly relying on a previous knowledge base, students ended the course talking about density, terminal velocity, what happens if the mass of the Earth is zero, and what scene is a good scene to extract data from. Students responded especially well to my discussions of Einstein's miraculous year. Time dilation, length contraction, and the equivalence principal engaged and excited the students. Many students seemed frustrated that they agreed with every step of my arguments while explaining these topics but did not want to believe that these effects occur. Sharing with students the complex nature of science, the creative nature of science, the controversial nature of science, and how ideas survive rigorous testing by scientists inspired my students to be more creative and rigorous.

This course engaged science and nonscience majors in pursing scientific endeavors. It is not clear to me if this type of course can be as successful as a regular general education course instead of an honors course. Honors students are definitely a different population than students in a general education course. Future work will look at how this successful honors course can be morphed into a successful general education course. A definite challenge posed by moving this course from a specialty course to a general course is dealing with having more than 20 students. The time required to extract usable cartoon and movie clips under my current method is unrealistic with the usual 100+ general education class size.

Acknowledgments

The author would like to thank the School of Humanities and Sciences Honor Program and the honors students in the first offering of Ithaca College's "Physics?" in Cartoons and Movies course. Student patience, creativity, and feedback helped make the course better. Thanks are also in order to students Erin Morrell, Jaclyn Kelley, Sarah Forbes, Jack Hammond, and Susan Meyer for their contribution of the data in Figs. 1 and 2.

References

1. Intuitor, *Insulting Stupid Movie Physics*, 2005; http://intuitor.com/moviephysics/.
2. C. Dennis, "Start using 'Hollywood Physics' in your classroom!" *Phys. Teach*. **40**, 420–424 (Oct. 2002).
3. T. Feder,"Teaching physics with superheroes," *Phys. Today* **55**, 29–30 (2002).
4. L.H. Gresh and R.E. Weinberg, *The Science of Supervillains* (Wiley, Hoboken, NJ, 2005).
5. L.H. Gresh and R.E. Weinberg, *The Science of Superheroes* (Wiley, Hoboken, NJ, 2002).
6. R. Highfield, *The Science of Harry Potter* (Penguin Books, 2002).
7. J. Kakalios, *The Physics of Superheroes* (Gotham, New York, 2005).
8. L.M. Krauss, *The Physics of Star Trek* (Basic Books, New York, 1995).
9. L. Gonick and A. Huffman, *The Cartoon Guide to Physics,* 1st ed. (HarperPerennial, New York, 1991).
10. L. Levine, "Classes strive to be anything but boooring," *Chicago Tribune*, April 24, 2005: Chicago. Section 17, pp. 1, 5.

PACS codes: 01.40.gb, 01.90.+g

Michael Rogers *is an assistant professor of physics at Ithaca College, NY. He received a M.S. and Ph.D. in physics and an M.A.I.S in archaeology from Oregon State University. His interests are ground-based remote sensing and physics education research. Along with teaching "Physics?" in Cartoons and Movies, Rogers introduced student polling devices and Peer Instruction to physics, anthropology, chemistry, biology, math, and school of music classes. He is also the PI of an NSF proposal under consideration to adapt and implement SCALE-UP at Ithaca College.*

Center for Natural Science, Department of Physics, Ithaca College, Ithaca, NY 14850; mrogers@ithaca.edu