Physics At The Movies

A New Way of Teaching

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Physics At The Movies

Aims:

- Devise a method to teach undergraduate Physics using movie clips
- Implement the methods and obtain feedback
- Investigate the accuracy of "Hollywood-Physics"

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Background Research:

- Entertaining films use exaggerated physics.
- Decline in physics teachers
- Knowledge of “Refreshing Physics”
- Physics not currently taught through films
- Introduced into American Air Force Institution
  - “….went very well, with both students and instructors learning some things……..analysing movie clips in light of physics principles helped reinforce the utility and relevance of the material they had learned in the course”

Capt. Lori.R. Everitt. Department of Phys

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The ideas were based on:

- Extending the current project at Kent called ‘Refreshing Physics’
- Making physics more interesting and appealing by including examples from movie clips
- First year Physics - PH301

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To test the aims, we used the following:

- A first year exam paper
- A first year laboratory experiment
- A first year lecture
- An A-Level class

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The Exam Paper's Aims:

- How many concepts within the PH301 module could be related to movies?
- Show the potential use of movies in exam papers or weekly problems
- Investigate the authenticity of 'movie physics' using the solutions obtained

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The Exam Paper's Structure:

- Shown movie clip on a workstation
- Work at their own pace
- New style of examination for Kent

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Example Long Question (i):

The asteroid is 1000km in diameter and is 3 hours 57 minutes away from the Earth.
Calculate the energy required to split the asteroid so that the two remaining halves do not hit the Earth.
Assume the asteroid is spherical and that it splits into two identical hemispherical pieces.

$R_E = 6380$ km $\qquad\qquad$ $\rho_{asteroid} = 2100$ kgm^{-3}

[10]

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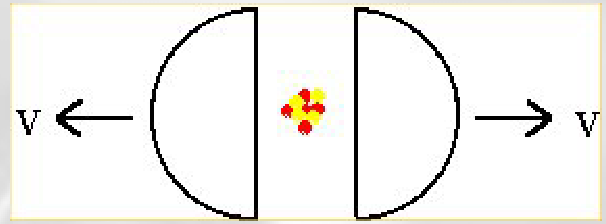
Model Answer:



To just miss the Earth, each half must travel 6 380 000m in 3h57m

$$v = \frac{s}{t} = \frac{6380000}{(3\times 60\times 60)+(57\times 60)} = 449ms^{-1} \qquad \text{(3SF)}$$

Must be given this speed/kinetic energy at point of explosion.

Volume of hemisphere = $\frac{1}{2}\cdot\frac{4}{3}\pi r^3 = \frac{2}{3}\times\pi\times\left(\frac{1000000}{2}\right)^3 = 2.62\times 10^{17}\,m^3$

Mass of hemisphere = $\rho V = 2100\times 2.62\times 10^{17} = 5.50\times 10^{20}\,kg$

Kinetic Energy of both halves = $2\cdot\left(\frac{1}{2}mv^2\right) = 5.50\times 10^{20}\times(449)^2 = 1.11\times 10^{26}\,J$

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Example Long Question (ii):

The atomic bomb dropped on Hiroshima was a 13-kiloton explosive device. The most powerful nuclear detonation was the Tsar Bomba fusion bomb in 1961 with a 50 Megaton explosion. How many of each of these bombs would be needed for the energy required in part (i)?

$$1 \text{ kiloton} = 4.2 \times 10^{12} \text{ J} \qquad 1 \text{ Megaton} = 4.2 \times 10^{15} \text{ J}$$

[3]

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Model Answer:

13kt = $13 \times 4.2\times10^{12} = 5.46\times10^{13}$ J (½)

No. of bombs = $\dfrac{1.11\times10^{26}}{5.46\times10^{13}} = 2.03\times10^{12}$ (3SF) (1)

50Mt = $50 \times 4.2\times1015 = 2.1\times10^{17}$ J (½)

No. of bombs = $\dfrac{1.11\times10^{26}}{2.1\times10^{17}} = 527{,}000{,}000$ (3SF) (1)

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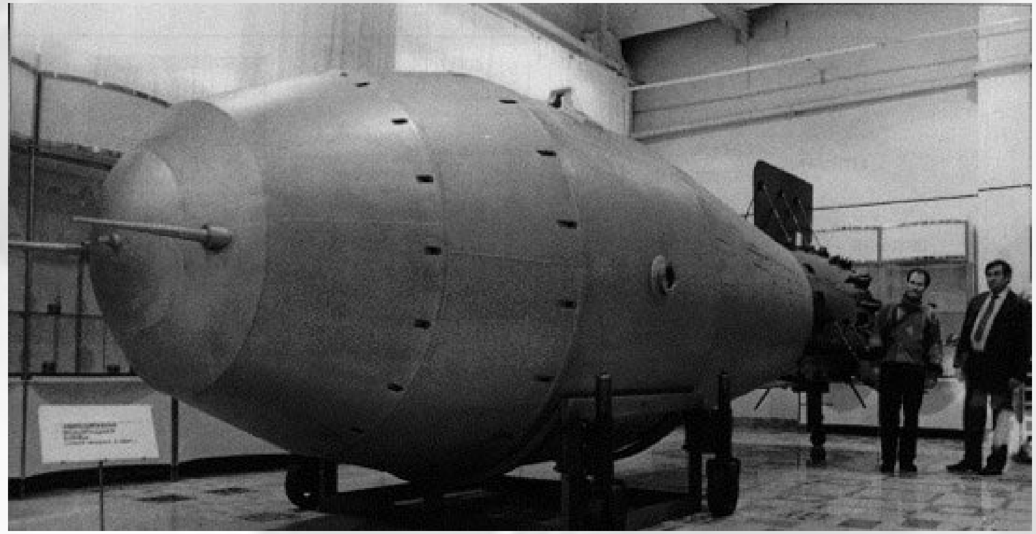
Reality?



- Tsar Bomba was 27 tonnes!
- 8m long!
- Effective yield of 50 Mt
- Armageddon’s bomb was 9 feet long (2.74m) and approximate yield of 26 200 000 000Mt?

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Laboratory Experiment:

- Produced to integrate with one of the topics covered in the first year physics module
- Based on the film *Robin Hood Prince Of Thieves*.
- Chosen, based on the interest of students at "Refreshing Physics" conference.

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- Integrated into the first year laboratory module and carried out by two students.
- Procedure:
  - – Watch movie clip
  - – Background information
  - – Evaluate flight path of projectile
  - – Calculate forces involved
  - – Report writing

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Dr. George Dobre

“ The *Robin Hood and the Manganol* experiment has now been run for three weeks in the 1st year lab and is proving to be quite a useful addition to our experiment suite in a number of ways. ”

“ It reinforces the theory of projectile motion, moment of inertia, energy conservation as well as elasticity. ”

“ It has the potential to be run as a full day experiment next year which is important for the department as we are trying to raise the profile of lab work and welcome 1st year students into a much more “hands on” Physics degree course.”

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The Lecture:

- Movie clip
- Theory behind the phenomenon
- Example in real life
- Workshop style question

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The Lecture Content:

- Electromagnetic Pulse from *The Matrix*
    - Electromagnetic radiation
    - Compton scattering

Effects of EMP

- Separation of charges

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Lecture Question:

In this scene of the movie, Morpheus and the team use a weapon based on the concept of "electromagnetic pulse" to defeat the squiddies chasing after their ship. This scene takes place in the real world and must therefore obey the laws of physics.

Write down what you understand by the concept of EMP. Hence is this a plausible way of defeating the squiddies?

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Answer:

EMP is a side effect of a nuclear explosion (1)

When a nuclear weapon goes off, gamma rays are produced (1)

These rays collide with electrons in the surrounding area via the compton scattering process causing the electrons the gain energy and the rays to lose energy (3)

These electrons move outward faster than the remaining positively charged ions creating a separation of charges in the atmosphere (2)

The separation of charges is creates a very strong electric field (1)

This large field will disrupt any working electrical circuits in the blast radius (1)

Yes, since this scene does occur in the confines of the real world, the EMP would destroy the squiddies (1)

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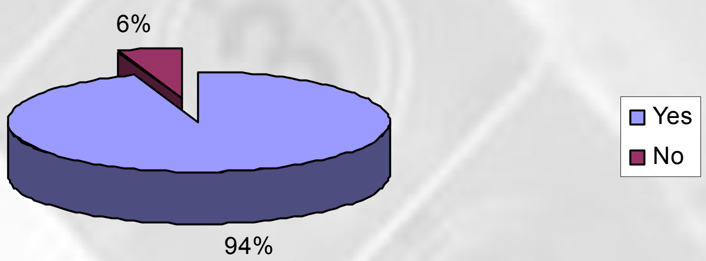
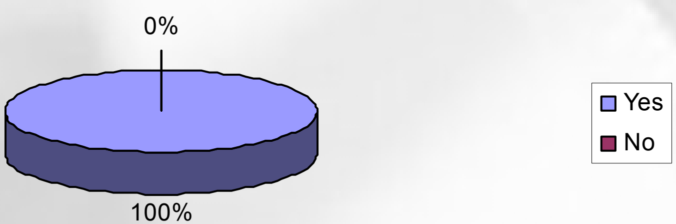
Questionnaire results from lecture:

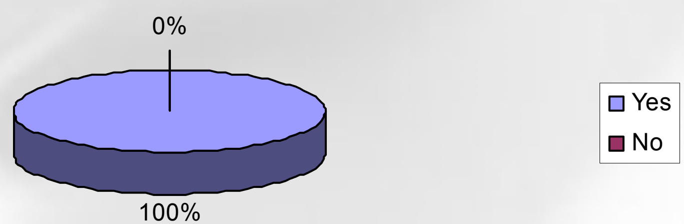
Do you think testing the authenticity of the film used made the lecture more interesting?



Do you think this type of lecturing would make things easier to remember in the exam if you had a visual reference in your mind?



Do you think it would be a good idea to use visual aids such as these in more lectures to give a real life example of the physics being taught?



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A-Level Class:

- Year 12 group at Rainham Mark Grammar School.
- Using current course notes and adapted to involve aspects of physics used in the movie *Die Hard*.
    - mechanics
    - simple harmonic motion
- Students performed an exercise in relation to the clip
- Incentive to choose Physics at Kent

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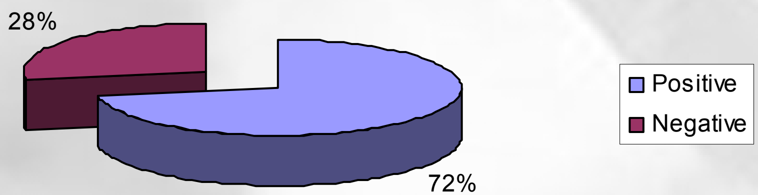
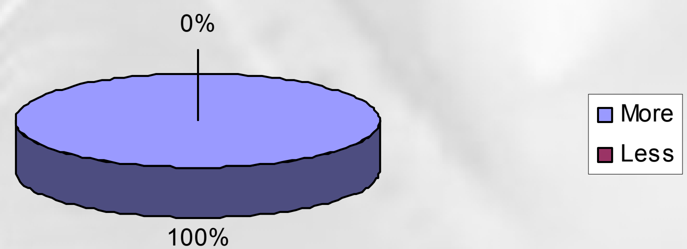
Questionnaire results from A-level Class:

If a University used this method of teaching, would it influence your decision to go there?



If yes, would it make you more or less likely to attend that University?



Positive Teacher feedback:

"I'm kicking myself that I didn't think of this before. There are so many great ideas well expressed in films."

Mr. Riorden – Physics teacher at Rainham Mark

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Conclusions:

- Positive overall impression
- Broad range of concepts
- Other visual stimuli
- Future research
  - Computer simulations
  - Student development
- No sacrifice of theory
- Good or bad Physics

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Acknowledgements:

With thanks to:

- Professor R. J. Newport
- B.Parker
- Professor J. Strange
- Dr. G. Dobre
- Steve Wall
- Mr. Cliff Tipler
- Mr. Riordon
- Karl Butler
- Current First Year Undergraduates