Creating interesting integrated materials to enhance physics instruction

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Moving About
Icons

- Practical Activity
- Teacher Demonstration
- Text questions to do
- Another document to reference.
- Internet Link
- Video Link
Energy

- ‘Energy can not be created or destroyed, it can only be converted from one form to another.’

- The types of energy that we deal with in motion are
  - Kinetic Energy (energy related to movement of an object)
  - Gravitational Potential energy (related to the energy that can be gained by an object when gravity does work on it).
Kinetic Energy

- Any object that is moving has kinetic energy ($E_k$).
  - $m = \text{mass (kg)}$
  - $v = \text{velocity (ms}^{-1}\text{)}$
  - Energy is measured in joules (J)

- Don’t forget prefixes.
  - $\text{MJ} = \text{mega joules} = 1,000,000\text{J}$
  - $\text{kJ} = \text{kilo joules} = 1,000\text{J}$
Gravitational Potential Energy

- The further an object is moved away from the centre of the earth, the greater potential there is for gravity to do work on it.
- This is a form of stored energy.

\[ \text{Gravitational Potential Energy} = mgh \]

- \( m \) = mass (kg)
- \( h \) = change in height (m)
- \( g \) = gravitational field strength (\( \text{ms}^{-2} \) or \( \text{Nkg}^{-1} \))

(NB – this assumes the gravitational field strength is constant – which it is over small distances, but not during rocket launches or other large motions)
Work

- When energy is transformed or transferred from one form to another (eg. $E_{gp}$ to $E_k$) or one object to another (eg. bat hits ball) the amount of energy that is transformed or transferred is referred to the WORK done on that object.

- $W = F_{net}s$
  - $W$ = work (J)
  - $F_{net}$ = net force (N)
  - $s$ = displacement
  - [http://www.youtube.com/watch?v=w8Gau6BAqlw&feature=related](http://www.youtube.com/watch?v=w8Gau6BAqlw&feature=related)
Example

Georgina jumps off a 10m diving platform. She has a mass of 60kg.

- a) calculate the gravitational potential energy Georgina has when standing on the platform.

- b) determine the work done by gravity as she falls.

- c) what is Georgina’s kinetic energy just before she hits the water?

- d) what is Georgina’s velocity as she enters the water?
Thinking – Total Mechanical Energy

- Think about the Energy in a system as a circle.
- This amount of energy can not change! It can only be converted into different types of energy or transferred to a different object.
- The circle stays the same size, it is just the proportion of the circle allocated to the different forms of energy that changes.
- Applying this to our diving example.
Energy in Collisions

- Other types of energy
  - Thermal (heat)
  - Light
  - Sound
  - Deformation (potential energy)
Source: http://www.car-accidents.com/
Video files to engage and provoke discussion

- Sourcing files
  - YouTube
  - funny emails
  - Videos/DVD’s (if you have video editing capabilities)
  - Get your students to find them and ask them to bring them in on a flash stick
DOWNLOADING FROM YOUTUBE

- One way – Use Firefox web browser (instead of Internet Explorer)
  - It is freeware (http://www.mozilla.com/en-US/)
  - Has a add on that enables YouTube videos to be downloaded with one click!

- Once downloaded, you can
  - Link to the file
  - Embed the file (only some file types)
Option 1 - Linking to file

- It can be time consuming to convert all the flv. files so linking may be better.
- Linking to a file is less seamless but much easier.
  - Go to Slide Show → Action buttons → then click and drag to position and size icon.
  - Click Run Program: → select “all files” from drop down box.
  - Browse to find file.
  - Simplify the address to be the filename only (ie. delete the rest of the details)
Option 2 – Embedding

- To embed these videos into PowerPoint you will need to convert them into avi or mpg files.
  - Use an online converter such as http://www.media-convert.com/
  - Freeware file converter download http://www.erightsoft.com/SUPER.html
- Once converted, these files can be inserted by going to Insert → Movies and Sounds → Movie from file.
- Browse to find file.
Keeping links when moving files

- If you want to move your ppt. file to a common drive or to another computer it is best to keep all linked material in a folder.
- We use a “multimedia” folder and link all material in the PowerPoints to this.
- Once you have this folder in the same location as the PowerPoint, you can simplify the hyperlink address to enable the whole folder (containing PowerPoint and “Multimedia” folder) to any drive or location on your computer without losing the links.
- Links simply becomes the file name.
- Ppt automatically finds the corresponding name in the folder in closest proximity to the powerpoint file it is linking from.
Momentum
What is Momentum?

- Everyday experience tells us that both the mass and velocity of an object are important in determining things like (i) how hard it is to stop the object or (ii) the effect the object has in a collision with another object. An 85 kg man running at 5 m/s is a lot harder to stop than a 15 kg six year old child running at the same speed. A 50 gram bullet fired from a rifle with a muzzle velocity of 500 m/s will do a lot more damage than an identical bullet thrown at the target by hand.

- Isaac Newton spoke of the “quantity of motion” of an object. Today we define the momentum of an object to be the product of mass (m) and velocity (v).

\[ p = mv \]

- Momentum is a vector quantity with SI Units of kgms\(^{-1}\) (or Ns, since 1N = 1kgms\(^{-2}\)).
Momentum and Impulse

- Newton’s 2nd Law can be re-written as:

\[ F = \frac{\Delta p}{\Delta t} \]

- where \( \Delta p \) = the change in momentum of the object and \( \Delta t \) = the time taken for the change in momentum to occur.

- This quantity \( \Delta p \) (the change in momentum) is given the name impulse. Clearly, from the above equation, impulse, \( I \), is defined as the product of force and time and has SI Units of Ns. Impulse is a vector quantity.

\[ I = \Delta p = Ft \]
There are numerous physics applets on the web. It is possible to download the code and embed these in PowerPoint but it is quite an involved process. It is easier to simply create the links.

- Go to SlideShow → Action Buttons

- [http://www.msu.edu/~brechtjo/physics/airTrack/airTrack.html](http://www.msu.edu/~brechtjo/physics/airTrack/airTrack.html)
Conservation of Momentum

- if no net external force acts on a particular system, the total momentum of the system must be constant.
- This is known as the principle of the conservation of linear momentum.

\[ m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2 \]
Conservation of momentum example: cannon and cannonball

A cannon of mass 1000 kg fires a 10-kg shell at a velocity of 200 ms$^{-1}$. At what speed does the cannon recoil?

The law of conservation of momentum tells us that

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

If we choose a coordinate system in which the cannon points in the positive direction, the given information is

- $p_{i\text{cannon}} = 0$
- $p_{i\text{shell}} = 0$
- $p_{\text{shell}f} = 2000 \text{ kgms}^{-1}$

We must have $p_{\text{cannon}f} = -2000 \text{ kgms}^{-1}$, so the recoil velocity of the cannon is -2 ms$^{-1}$. 
Conservation of Momentum in Collisions

In the case of collisions between bodies, if we assume that no external net force acts during the collision, we can also say that the total momentum of the system before collision equals the total momentum of the system after collision.
Flash Animation Example

- How to procure them!
  - Go to the site and run the flash object
  - Open internet options → browsing history “settings” → View Files
  - Sort via last accessed, find flash files, copy and paste
Embedding into PowerPoint

Go to view → Toolbars → control Toolbox

Click on the hammer and wrench icon and scroll to select “shockwave flash object”

Click and drag to draw size of object in ppt. (can be resized later)

Right click on box created and select “properties”

Under the “alphabetic” tab, next to EmbedMovie, select “true”

Next to “Movie” write complete location including file extension (.swf).
Question: Rear-end smash

Ms. Chang is rear-ended at a stop light by Mr. Nelson, and sues to make him pay her medical bills. He testifies that he was only going 35 kmh\(^{-1}\) when he hit Ms. Chang. She thinks he was going much faster than that. The cars skidded together after the impact, and measurements of the length of the skid marks and the coefficient of friction show that their joint velocity immediately after the impact was 19 kmh\(^{-1}\). Mr. Nelson's Nissan has a mass of 1500 kg, and Ms. Chang 's Mercedes 4WD has a mass of 2500 kg. Is Mr. Nelson telling the truth?
Since the cars skidded together, and Ms Chang’s car was stationary before the collision, we can simplify the equation for conservation of momentum using only two velocities, $u_1$ for Mr. Nelson's velocity before the crash, and $v$ for their joint velocity afterward

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2)v$$

$$m_1 u_1 = (m_1 + m_2)v$$

$$u_1 = \frac{(m_1 + m_2)v}{m_1}$$
Impulse and car crashes

Example:

- A car crashes into a wall at 25 ms$^{-1}$ and is brought to rest in 0.1 s. Calculate the average force exerted on a 75 kg test dummy by the seat belt.

We assume that the seat belt does all of the stopping of the test dummy—in other words, we ignore any friction from the seat, normal (support) forces from air bags etc.

We focus our attention on the dummy and forget the car. In terms of its initial velocity ($v^o = 25$ ms$^{-1}$) and its original mass ($m^o = 75$ kg), the dummy’s original momentum, $p_1$, is given by:

$$p^o = m^o \times v^o$$
$$p^o = 75 \text{ kg} \times 25 \text{ ms}^{-1}$$
$$p^o = 1,875 \text{ kgms}^{-1}$$

- The dummy’s momentum after the collision, $p_f$, is determined by its final mass ($m_f = m^o$) and its final velocity ($v_f = 0$):

$$p_f = m_f \times v_f$$
$$p_f = 75 \text{ kg} \times 0 \text{ ms}^{-1} = 0$$

We immediately see that the dummy’s momentum changed by $-1,875 \text{ kgms}^{-1}$
I = f × t = Δp

In this case, we know Δp = −1, 875 kgms⁻¹ and we know the time of interaction is 0.1 s, so we can use this relation to find the average force acting on the dummy:

I = F × Δt = Δp

I = −1, 875 kg · ms⁻¹

F = Δp / Δt

= −1, 875 kgms⁻¹ /0.1s

= −18, 750 N
Interactive Lecture Demo’s

- Interactive Lecture demonstrations are a formalised approach to provoke student thinking and challenge their understanding of fundamental principles and concepts in physics.
- Interactive lecture demonstrations take a particular structure
  - Teacher describes the experiment, and carries it out without recording data.
  - Students record their predictions of the outcome on a Prediction Sheet.
  - Peer discussion follows, with the students discussing their predictions in small groups.
  - Teacher engages class, soliciting predictions and highlighting common predictions.
  - Students record their final prediction on the Prediction Sheet (this is collected).
  - The experiment is run. Real data is recorded and plotted by the computer, with the results displayed graphically for all to see.
  - Teacher engages class, discussing what students say about their predictions and focusing in particular on any common misconceptions. Students record the results on a Results Sheet, which they keep.
  - Teacher discusses variations of the experiment and similar physical situations based on the same underlying concepts.
- Many of these have been developed and teachers who create more are encouraged to share their ideas.
Why use ILD’s?

- “The ILD process is quite involved, and is generally used in just several classes each semester. Even that level is enough to produce substantial benefits, according to recent studies. In the following reference, for instance, D.R. Sokoloff and R.K. Thornton, "Using Interactive Lecture Demonstrations to Create an Active Learning Environment", Phys. Teacher, 35, 340 (1997). (Available through Wiley Publishers)

- The authors compare student understanding of dynamics in a traditional course compared with a course with four ILDs. In a typical case, 10% of the students understand the concept before instruction. This rises to about 20% after instruction in a traditional lecture course, compared with at least 80% in a course involving ILDs.”

Momentum in Collisions Exp

- Scenario 1
  - Velocities of car and truck with same applied force.

- Scenario 2
  - Velocities of car or truck when struck by car travelling at same velocity.

- Scenario 3
  - Force on car or truck when struck by car travelling at same velocity.

- Scenario 4
  - Force on each vehicle during collision.

- Scenario 5
  - Force exerted when colliding with hard and soft materials
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