Preface and acknowledgments

There are 29 experiments presented in this volume. They are arranged as a set of teacher's notes followed by the student's worksheets. The worksheets and teacher's notes can be photocopied for use within the purchasing institute. The accompanying CD includes the setup files referred to in the Student's notes can be automatically installed into the **EASY**SENSE software.

It is hoped the experiments will make it easier for teachers to introduce data logging to students in a meaningful manner. The experiments cover a wide range of ability levels and curriculum requirements. They have been organised into topic areas, where possible. Within each topic area a higher experiment number indicates a more complex or challenging experiment.

These experiments have been written after use in a classroom and they have come from many sources. It is not the intention to suggest they are original, they are experiments that users have told us are useful in teaching science or for introducing students to data logging.

A correct assessment of the safety risks associated with the experiment should be carried out by the teachers conducting the experiments. The inclusion or exclusion of safety information is not an indication of responsibility by the publisher. Teachers must follow local safety regulations and advice to ensure the safety of the teacher and students is maintained. Disposal and use of chemicals associated with the experiments should follow local regulations.

The help and ideas of the following are gratefully acknowledged,

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Teacher's notes and Information

Students Instructions

Sensors: Light gate
Loggers: Any **EASY**SENSE

Logging time: Speed, momentum and energy at A

Teacher's notes

1T - Why 30 mph?

Read

Research has identified that 70% of all drivers admit to speeding. Drivers will justify their speeding as being "ordinary, safe speeding" saying that they dislike drivers who "are dangerous speeding drivers". Most drivers approve of speed and believe they are in full control when speeding and even feel that driving just above the speed limit is correct.

In the time period 2000 to 2004 excessive speed was found to be responsible for:

1. 13% of all collisions creating injury.
2. 19% of all collisions creating serious injury.
3. 29% of all collisions producing a fatality.

The impact of speed on injury is indicated by the simple comparison of the damage to a child hit by a car at 30mph and 40mph.

Speed of collision	Damage on impact	Distance thrown by impact	Secondary injury	Outcome
30 mph	Severe bruising to pelvis	16 metres	Broken arm, scrapes to face and exposed skin	Survival
40 mph	Pelvis broken	28 metres	Fractured skull, exposed fracture to arm, severe abrasion to exposed skin	Virtually instant death (likely time of death at first impact)

- The car used to calculate the injuries was a Ford Fiesta, the child is assumed to have stepped out from behind a parked car into the path of the Fiesta.
- Simple statistics tell us that the chance of a child dying in a 40 mph contact is 90%, with survival leaving a life changing set of disabling injuries.
- The physics tells us that the energy of a moving object (Kinetic energy) is equal to one half of the mass of the object multiplied by the square of the objects speed or $1/2mv^2$.
- In this demonstration investigation you will use software to calculate the speed and energy of a moving object to show this relationship.

The activity shows the relationship between energy and speed, you should be able to show that the doubling of speed quadruples the energy. It is not (as written) an activity to prove 1/2mv2. It is a demonstration of its application. The software provides all the information that the students need.

There are some good road safety clips around which can be used to set the scene.

The idea is to show that a small increase in speed produces a very large increase in energy, it is the energy transfer that does the damage. Many students, will of course, deny the evidence and argue that the cars braking system and their skill will not let the accident happen. The point to be made is that this is what happens if all of that fails. The pedestrian is always going to be the loser, it doesn't matter if they were "in the wrong", they still die.

Apparatus

1. Data Harvest Dynamics system with a single Light Gate.
2. An **EASY**SENSE Logger.
3. Dynamics cart with single interrupt card fitted.
4. Sponge and or crumpled paper to slow cart down at end of its run.
5. Balance to weigh cart and interrupt card.

Setting up the software / logger

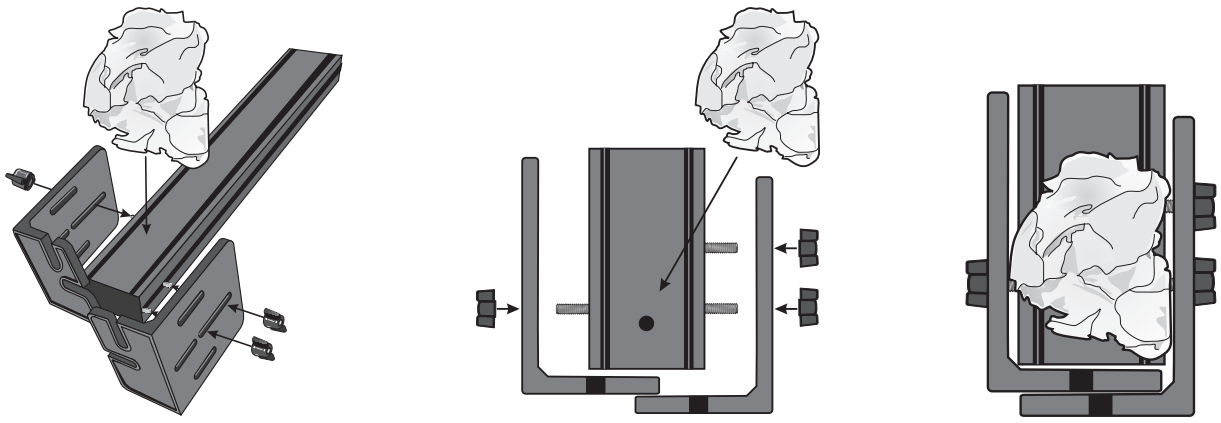
Use the setup file **01 Why 30mph.**

To manually set up the software / logger

Recording method	Record what	Single interrupt card
Timing	Momentum + Kinetic energy	120mm

Notes

The catching system is important for the experiment, without it the cart is free to fly across the room. It is a secondary investigation, but the relationship between the stopping material and its ability to stop the speeding trolley is worth pursuing, almost as a hidden objective.



Step 1 **Step 2** **Step 3**

Crash Box

You need to collect a good number of results to develop the smooth curve, using 2cm height differences up to 50cm will give 25 results, this should be ample. Constant repetitions will in the end be counter productive as the interest in the experiment wanes, the advantage of the software doing the math is easily lost. Ideally you would like to get a doubling of speed to let the data "speak" to the audience.

The height of the ramp and the mass of the cart are incidental measurements that can be made. The height has no immediate role in the data analysis and the default value of the cart at .33Kg will still produce the data for analysis.

Analysing the data collected

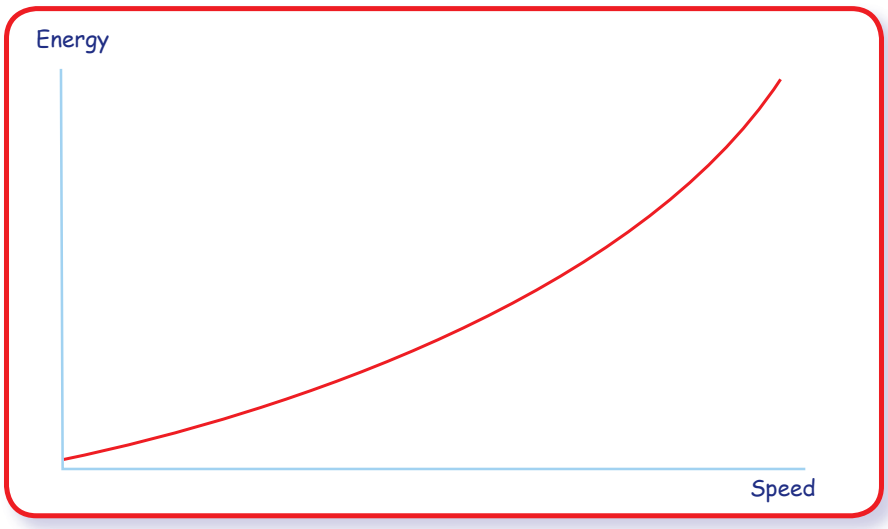
The data will have been collected as a set of bar lines against the reading number. You need to convert the display to a line graph of Energy (y or vertical axis) against Speed (x or horizontal axis).

1. Click on the **Options** on the toolbar and select Line graph to create the line graph from the bar chart.
2. Click on X axis tab and click Channel to make the graph use the collected data on each axis.
3. Click OK to return to the graph screen.

Click in the area just to the left of the vertical axis, watch the label at the top of the axis change, keep clicking until the label reads **Energy**.

Click in the area just below the horizontal axis, watch the label at the far left, keep clicking until the label reads **Speed**.

To finish the changes to the display, place the mouse cursor in the drawn graph area and right click. In the box that opens select **Autoscale** to make the graph completely fill the area available.



Conversions

*30 mph = 48 kmh = 13.33 m/s

*40 mph = 64 kmh = 17.77 m/s

Extensions

1. Repeat the experiment but fit a Force sensor to the runway to measure the forces generated at the collision. You will need to use only the lower runway heights to prevent damage to the sensor.
2. With a Force sensor attached, fit various soft materials to the cart and see if you can lessen the force at impact.
3. Investigate what happens if you increase the load of the cart, keep the ramp angle constant.

1 - Why 30 mph?

Read

Research has identified that 70% of all drivers admit to speeding. Drivers will justify their speeding as being "ordinary, safe speeding" saying that they dislike drivers who "are dangerous, speeding drivers". Most drivers approve of speed and believe they are in full control when speeding and even feel that driving just above the speed limit is correct.

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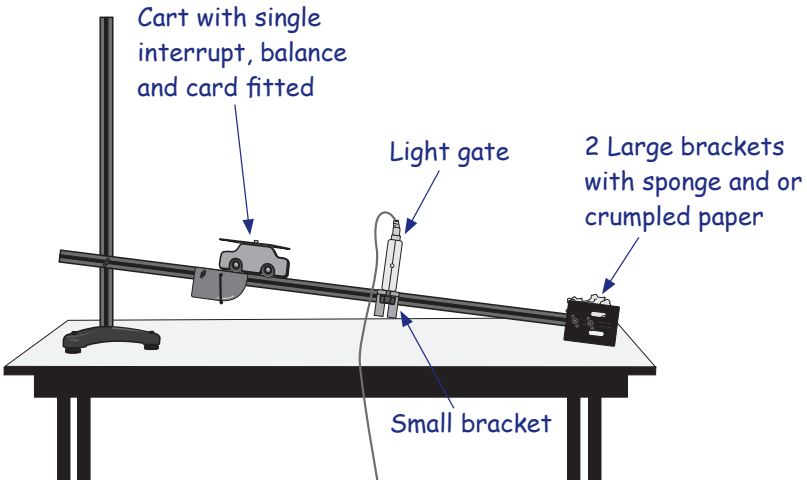
- The car used to calculate the injuries was a Ford Fiesta, the child is assumed to have stepped out from behind a parked car into the path of the Fiesta.
- Simple statistics tell us that the chance of a child dying in a 40 mph contact is 90%, with survival leaving a life changing set of disabling injuries.
- The physics tells us that the energy of a moving object is equal to one half of the mass of the object multiplied by the square of the objects speed or $1/2mv^2$. To "lose" that energy when you are trying to stop needs very good brakes, and the faster you go the more difficult it becomes.

When someone is hit by a moving car, the car will quickly accelerate them up to the speed of the car and push them along. When the driver becomes aware of the collision they start to brake, and the speed of the car is reduced. The person who has been hit will continue to move forward with the speed

of the car at impact (giving the impression they were pushed in front of the car). The energy the person has gained will carry them forward until they hit the ground and friction starts to slow them down. The transfer of energy takes place over such a short period of time, that parts of the body start to fail, bones break, brain damage occurs and internal organs are disrupted.

In this demonstration investigation you will use software to calculate the speed and energy of a moving object and use this information to consider the relationship between speed, stopping distance and fatality.



What you need

1. Data Harvest Dynamics system with a single Light Gate.
2. An **EASY**SENSE Logger.
3. Dynamics cart with single interrupt card fitted.
4. Sponge and or crumpled paper to slow cart down at end of its run.
5. Balance to weigh cart and interrupt card.

What you need to do

Ideally you need someone to release the cart and someone to stop / catch the cart. It will be moving fast enough that it will bounce back through the Light Gate unless held back.

1. Set the Dynamics system up as shown in the diagram. Make sure the stop zone is constructed correctly, the interrupt card of the cart should be able to pass over the top of the side barriers.
2. You need to part fill the "crash section" with loosely crumpled paper to absorb the movement of the cart, too loose and it will not stop, too crumpled and it will act as a "spring" and bounce the cart back! Try a few runs to work out the amount of crumple needed.
3. Connect the Light Gate to timing port "a" on the logger.
4. Set the ramp angle to 2cm (as indicated on the vertical support pole).
5. Start **EASY**SENSE and select **Timing** from the **Home page**.
6. Click on **New** and select **Momentum and Kinetic energy**, next.
7. Select at **A**, next.
8. Select **single interrupt card**, next.

9. Enter the **Mass of the cart, interrupt card and thumbscrew** (as Kg). Enter the **length of the interrupt card** (as mm), next.
10. Change units of **Momentum** to **g m/s** and Energy to **mJ**. **Finish**.
11. Place the cart at the end of the ramp furthest from the Light Gate, make a note of where the cart is – you will need to release it from the same position for each run.
12. Release the cart, try to catch the cart and stop it before it can bounce back through the Light Gate.
13. Adjust the ramp up by 2cm and repeat.
14. Keep going for 10 -15 trials. Do not go higher than 50cm on the scale, the speed of the cart will make it increasingly difficult to control and stop. If it bounces back off the apparatus onto the floor the wheels may become misaligned / damaged.

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Questions

1. Find the speed and energy for the first trial and for the last trail.
   a. How much has the speed increased?
   b. How much has the energy increased?
   c. What is the connection between doubling the speed and the energy increase?
2. If you travel at 40 mph in a 30 mph* zone, how much has the speed increased by? How much is the extra speed as a fraction / percentage of the correct speed?
3. Assume a car is travelling at 30 mph* and it weighs 500kg what is its energy.
4. If the same car is now travelling at 40 mph what is its energy? How much has the energy in creased by?
5. What would be the speed of the person hit at,
   a. Impact.
   b. 1 second after impact.
   c. 10 seconds after impact.

6. In the introduction the table shows the child is thrown through the air, why does the person get thrown through the air after impact? Use physics to explain the energy changes / transfers taking place.
7. When the driver applies the brakes where is the energy used to keep the car moving going?
8. Find out the stopping distances for cars (as used in the driving test), how does speed affect the stopping distance?
9. Think about what the experiment has shown, how does the energy of the car affect the stopping distance?
10. What will happen to stopping distance if two cars are travelling at the same speed but one is a small car like a Ka and the other is a big car like a "Hummer"?

Conversions

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