Force Sensor

for the LogIT Microsense® system

Overview

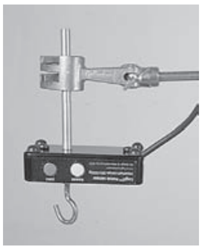
This Force sensor is a precision engineered Microsense® sensor designed to measure the applied force in the range -3 to +3 and -30 to +30 Newtons or -300g to +300g and -3Kg to +3Kg.

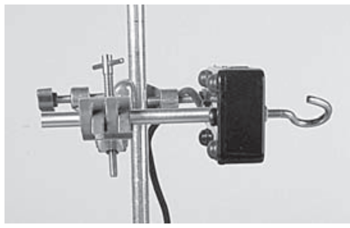
Contents

- Force sensor
- Force plate (Round)
- Hook
- Clamping rod

In Use

The clamping rod screws into the bottom of the force sensor DO NOT OVERTIGHTEN (the bottom also has the rubber feet). This can then be clamped securely into a clamp stand as shown.





The force plate is used for impact type experiments, 'push' type forces and as a balance. The hook is designed for 'pull' type forces and to facilitate attachment of springs and pendulums. To zero the force sensor, hold the zero button for a couple of seconds. To change the range, press the range button and release.

Specifications

Standard Range:	-3.00 to +3.00 Newtons or -30.0 to +30.0 N
Alternative Range (via software):	-300g to +300g or -3Kg to +3Kg
Accuracy:	Better than +/- 3%

Care

Never immerse the sensor in liquid or permanent damage will result.
Permanent damage may be caused if more than +/-3kg, 30N is applied to the sensor.
Do not disassemble this sensor.

Troubleshooting

If the sensor is not recognised by your software or datalogger, see www.logitworld.com
To upgrade the software click on the 'Downloads' tab followed by 'Software Updates'.
The installation instructions are available from the same page.
To upgrade the datalogger, select the logger from the list on the left of the page followed by the 'Support' tab and then select 'Logger Updates'. Follow the on screen instructions.
Note: Sensorlink, LogIT SL and LIVE only require a software update and so do not have an 'update' option on their respective pages.
Note the Force sensor is not compatible with CheckIT.

Instructions & Resources

The resources shown overleaf are available in PDF form at www.logitworld.com

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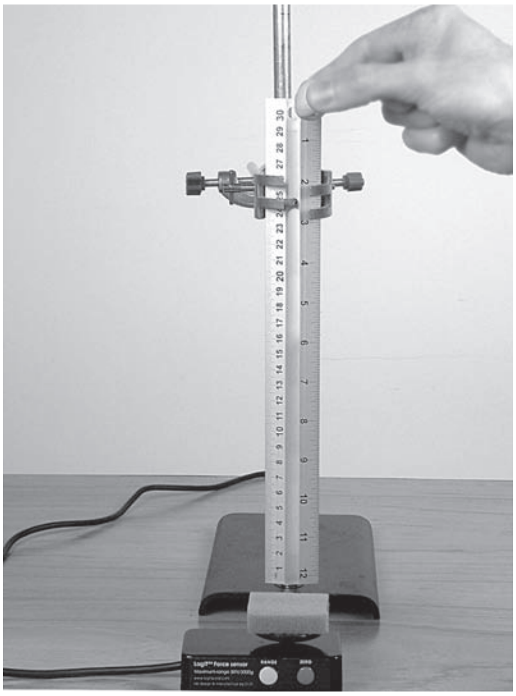
Force of Impacts

Subject: Physics

Overview:
When an object strikes another object, the amount of force involved in the collision is determined by how quickly the objects involved slow down. When an object slows down very quickly a larger force is exerted. This can be derived from the formula F=ma where 'm' is the mass of the object and 'a' is the acceleration (or deceleration if slowing). Since 'a' is calculated from 'change in speed divided by the time taken for that change (dv/dt)', it can be seen that the quicker the object stops (dt becomes small) then the deceleration is large and hence the resultant force is large.
This simple experiment uses the Force sensor to record the resultant force of impact when a 10 gram ball of modeling clay, dropped from a known height, hits the sensor. By subsequently adding layers of foam, the effect of slowing the deceleration on the resultant force can be observed.
This experiment works best using the logging interval suggested and a suitably fast datalogger such as DataVision, Voyager or Black Box. DataMeter, LogIT SL and LIVE can be used but bear in mind the speed of the impact which may produce odd results if the logging interval is too long.

Equipment required:

LogIT Force sensor.
LogIT datalogger.
10 gram ball of modeling clay.
Clamp stand
Ruler
Several foams of different thickness.



Hazards:

Do not allow large masses to be dropped in the lab as damage to person or equipment can result.
Always check your local regulations or the school advisory service such as CLEAPSS or SSERC for guidance on the use of any hazardous material.

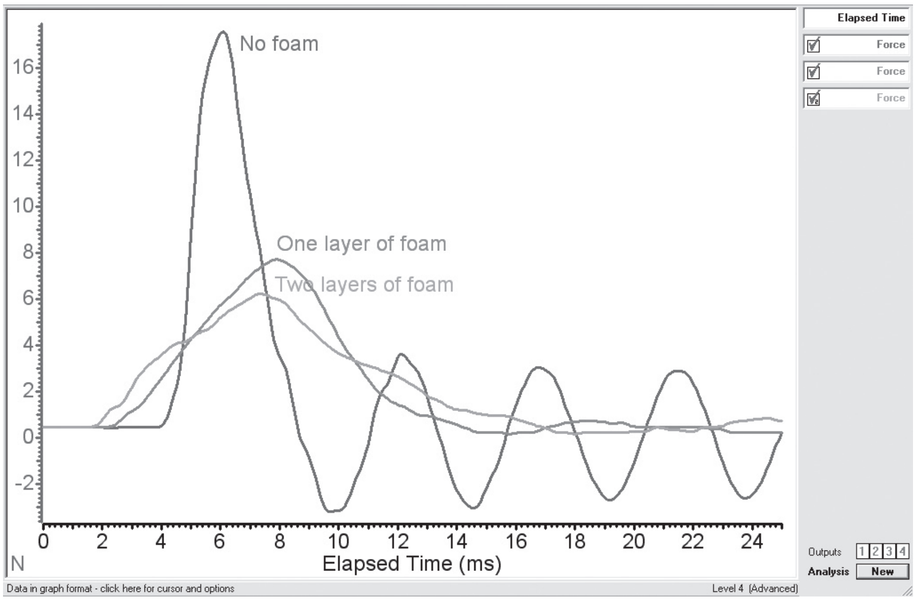
Suggested method:

1. Clamp the ruler into the clamp stand as shown to indicate the drop point.
2. Use the round force plate and screw into the top of the force sensor.
3. Carefully line the ruler up with the top of the force plate so as to ensure the ball is dropped from the same place each time.
4. Plug the force sensor into the datalogger and the datalogger into the computer.
5. Start the logging software and zero the sensor using the 'Zero' button.
6. If using LogIT Lab, select the 'Setup' option on the 'Select New Activity' screen.
7. Select 'Fast with Trigger (one sensor)' and then select '100 microseconds for 20 milliseconds' as the logging rate.
8. Drop the ball onto the force plate from a set height. (We used 30cm)
9. Place a piece of foam onto the force plate and if using LogIT Lab press 'O' to overlay the next trace.
10. Repeat step 8 for each layer of foam used.
11. When finished, use the 'smooth' function for each trace by placing the cursor into the readings box on the right of LogIT Lab and right click. From the menu select 'smooth'.

Note: The photo shows one layer of foam placed on the force plate. Remember to line the ruler up with the top of the foam to ensure the ball is dropped from the same point each time. By using the 'smooth' option, any signal to noise ratio errors which may have occurred during the experiment can be smoothed out.

Force of Impacts (continued)

Results



The graph shows clearly how the addition of layers of foam greatly reduces the resultant impact force of the 10 gram ball.
Without any foam, the force sensor displays an oscillation after the ball has hit the force plate due to the spring action of the sensor.
After a layer of foam is added this oscillation disappears and the sensor displays a more uniform trace after the impact.

Note: The number of foam layers that are added depends on how thick each piece of foam is. We used 10 mm thick foam rubber. Other items could be used such as bubble wrap or varying thicknesses of clothing materialand cloth.

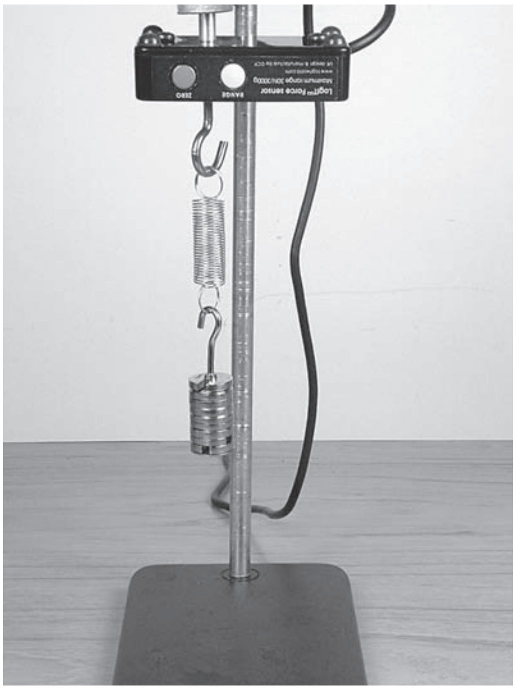
Going further

Study the affects of airbags in cars on the reduction in impact force by using a partially inflated balloon. Its best not to inflate the balloon too much.

Force and displacement

Subject: Physics

Overview:
This simple experiment shows how the resultant force exerted by a spring and mass changes as the starting displacement is changed.



Equipment required:

LogIT Force sensor.
LogIT datalogger.
Small spring.
Mass (we used 300g)
Clamp stand.
Ruler.

Hazards:

Do not allow large masses to be dropped in the lab as damage to person or equipment can result.
Always check your local regulations or the school advisory service such as CLEAPSS or SSERC for guidance on the use of any hazardous material.

Suggested method:

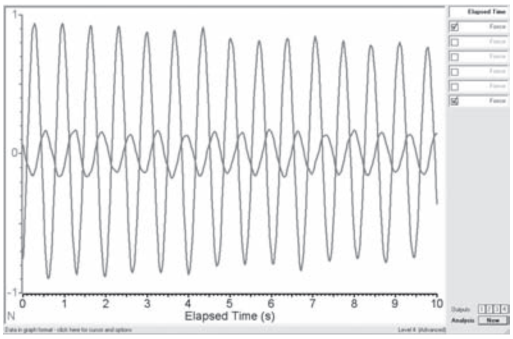
1. Screw the clamping rod into the base of the Force sensor.
2. Screw the hook into the top of the Force sensor.
3. Mount the force sensor into the clamp stand.
4. Gently hang the mass from the hook.
5. Start the logging software.
6. If using LogIT Lab, select the 'Setup' option on the 'Select New Activity' screen.
7. Choose 'Periodic', then '500' readings, then a timing interval of '20 milliseconds for 10 seconds'.
8. With the spring stationary, zero the force sensor using the 'Zero' button on the side.
9. Displace the mass and release, then start logging.
10. Alter the displacement amount and press the 'O' key to Overlay the next trace.
11. When finished, use the 'smooth' function for each trace by placing the cursor into the readings box on the right of LogIT Lab and right click. From the menu select 'smooth'.

Note: By using the 'smooth' option, any signal to noise ratio errors which may have occurred during the experiment can be smoothed out. Some other third party force sensors use a switch mounted on the sensor to achieve the same result.

Results:

The graph shows two plots. The smaller one is a displacement of 1 cm and the larger plot is a displacement of 6 cm.
What has happened to the resultant force?
Has anything happened to the frequency of oscillation?
What does the graph show with regard the movement of the mass?
What would happen if you kept increasing the displacement?

Note: For clarity, the plots for 2,3,4 and 5 cm have been removed but can easily be analysed for further study.



Going further:
This experiment keeps the mass the same but varies displacement. What might happen if you kept the displacement the same but varied the mass? What effect might this have on the time period?
Investigate the simple pendulum using the force sensor. How might the time period for the pendulum be derived from the results?

Investigating surface tension

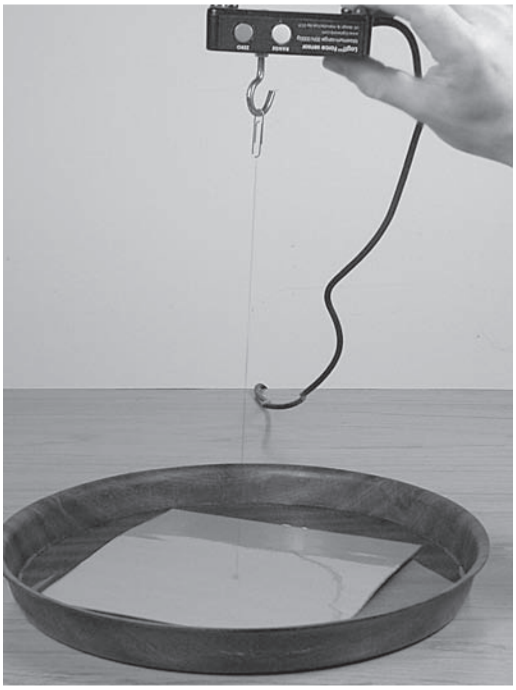
Physics

Subject: Physics/Biology

Overview:
This experimental procedure shows the relationship between surface tension and surface area. It uses the LogIT force sensor to record the force needed to break the surface tension of different sized card which are floating on the surface of a tray of water.

Equipment required:

LogIT Force sensor.
LogIT datalogger.
Tray of water.
Laminated cards of different size. (eg. 10 x 10cm, 15 x 15cm etc.)
Paper clips
Cotton



Hazards:

Do not allow any electrical equipment to come into contact with water.
Keep the cotton length quite long to prevent the force sensor getting wet.
Always check your local regulations or the school advisory service such as CLEAPSS or SSERC for guidance on the use of any hazardous material.

Biology

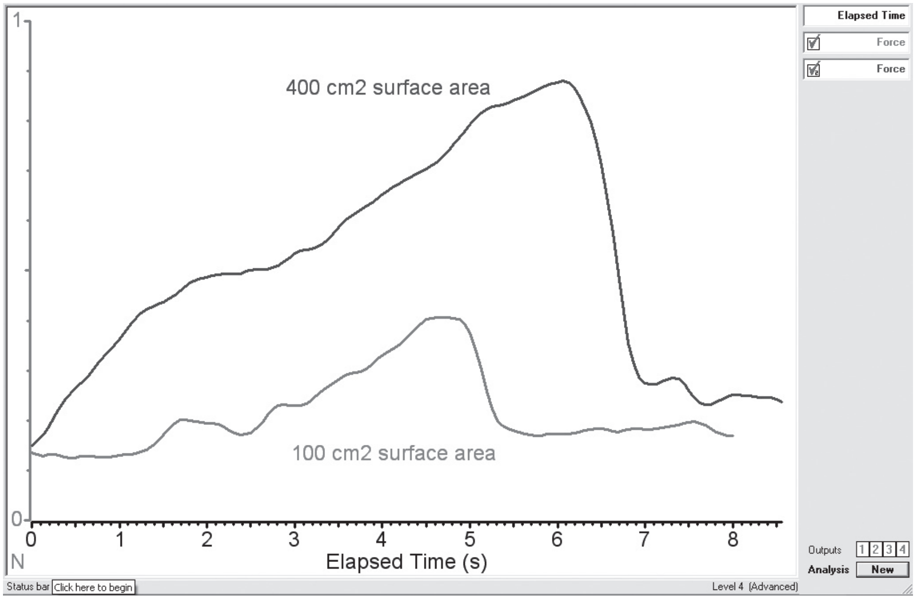
Suggested method:

1. Laminate some cards of varying surface area.
2. Put a hole into the centre of each card and attach cotton through the card using a paper clip or similar on the under side.
3. Attach a paper clip at the top of the cotton and slip this over the force hook.
4. Start the datalogging software and if using LogIT Lab select 'Autolog'. Zero the sensor using the 'Zero' button.
5. Place the card onto the surface of the water expelling any air trapped underneath.
6. Gently take up a little of the slack in the cotton.
7. Start logging and slowly lift the force sensor.
8. When the card breaks the surface, you should see a definite peek on the graph.
9. Repeat for different surface area's.

Note: By using a paper clip or similar under the card the load is spread and should prevent the card from bending too much when lifted from the surface of the water. We found that $100cm^2$ was the smallest we could go to obtain meaningful results. By using the 'smooth' option, any signal to noise ratio errors which may have occurred during the experiment can be smoothed out.

Investigating surface tension (continued)

Results



The graph shows the increase in force up to the point that the card breaks the surface of the water.
Does the graph show the amount of force required to break the surface tension? How does it show this?
Is there a relationship between surface area of the card and tension?
Is this a true test of the strength of the surface tension of water?
Would other liquids show different values?

Note: For clarity, the values have been inverted to give a positive force as opposed to negative which are the default for the force sensor.

Going further

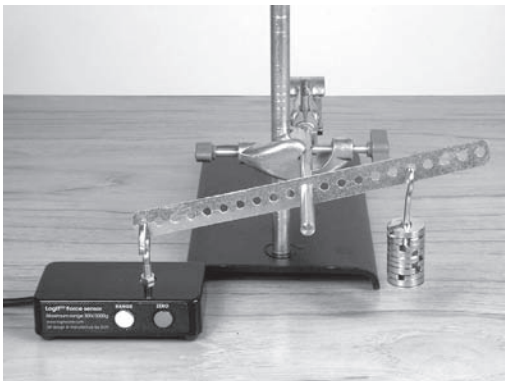
How might you improve the accuracy of the experiment?
If you plot a graph of surface tension against surface area, what might it show?
What other factors might you investigate?
What applications can you think of for surface tension when used in nature?

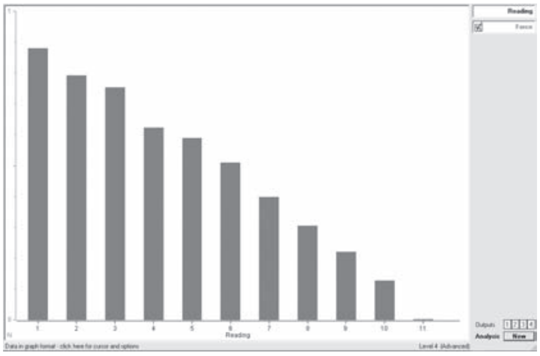
Physics

Biology

Ideas for other experiments

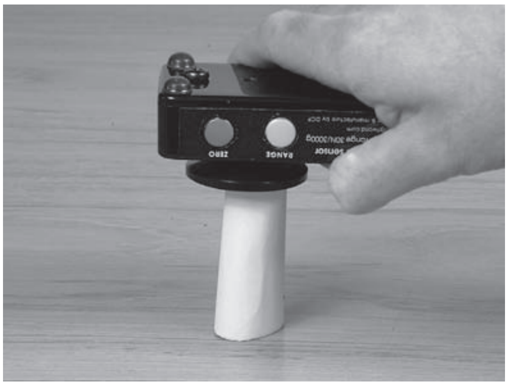
Moments.
By using a piece of metal plate with 1cm spaced holes cut into it and pivoting it in its centre, the law of moments can be investigated.
By hanging different masses on the end of the plate, the resultant force can be shown.
It can be used to demonstrate how levers work in multiplying up the resultant force.

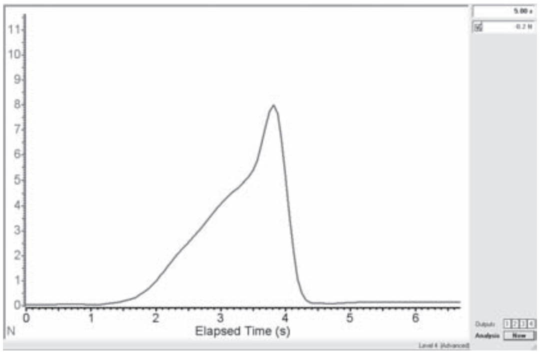




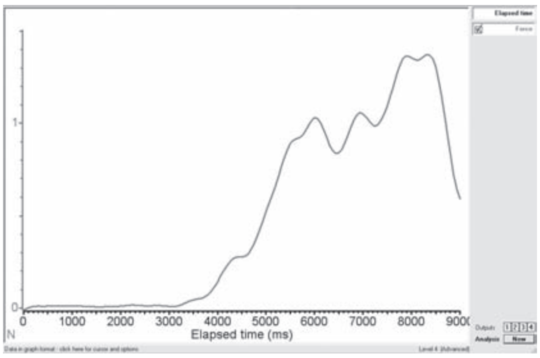
The graph shows how the force is reduced as a 100 gram mass is moved along the metal plate by 1 cm at a time.

Crushing force.
Challenge students to build small paper models to test the amount of force needed to break such structures. Bridges could be built as a challenge and different shapes in the construction directly compared.



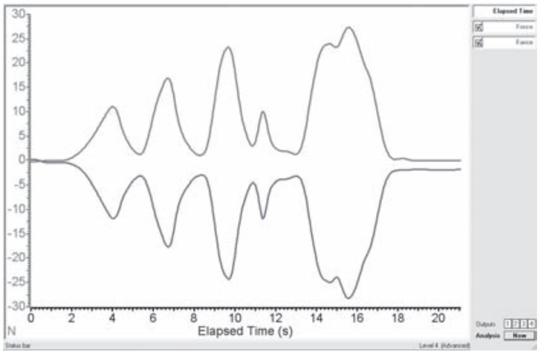


The graph shows a small paper tube being crushed until it collapsed.



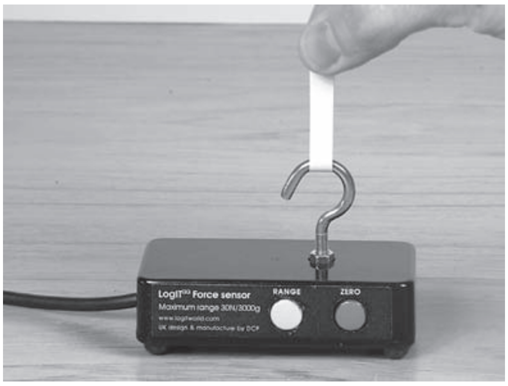
Centripetal force.
Place a large blob of modeling clay onto the force plate.
Put the sensor upright onto a rotating chair and give it a spin.
Note: It is suggested that you use a remote datalogger to prevent damage by a trailing lead and that you also attach the logger securely to the chair otherwise it may fly off. You can hold the sensor at arms length and rotate on the spot but care must be taken with this to prevent falling over or injury to by standers.

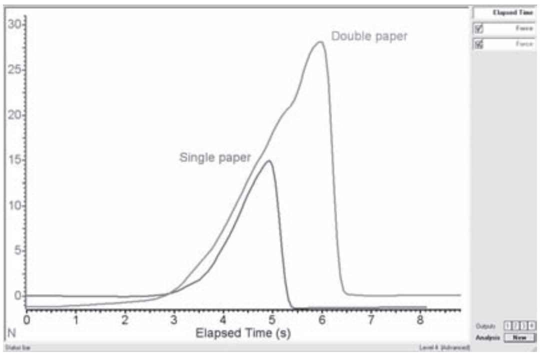
Ideas for other experiments (continued)



Equal and opposite reactions.
Use two force sensors with the hooks.
Link them together and then plot the resultant force as the two are pulled apart.
Note: You will need to invert one of the plots in order to obtain the opposite resultant force.

Tensile strength of paper.
By using thin strips of paper and the hook on the force sensor, the amount of force needed to break the paper can be investigated.
This procedure can be used to investigate the strength of paper with different widths, texture and thicknesses.
We have also had some success using invisible thread used to mend clothing as it stretches and breaks before over ranging the force sensor.





Note: For clarity, the photo does not show the force sensor being held by the other hand to counteract the upward pull of the paper.

Lift movement.
By attaching a large blob of modeling clay to the force plate and placing the sensor on the floor of a lift, the resultant force on the clay can be shown and the movement of the lift plotted.
If the mass of clay used is known, the acceleration and deceleration of the lift can be calculated using the formula F=Ma (where F = Resultant force, M = Mass of clay and a = the acceleration)

Use the Force sensor as a Balance
You can also use the LogIT force sensor as a simple top pan Balance by fitting the force plate and laying it on a flat table or bench LogIT Lab and similar software has scale options to change the default Newtons scale to +/- 300g with a resolution of 1g or +/- 3Kg with a resolution of 10g.

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