Finding g With Interferometry

Background Information:

Interference is the addition or superposition of two or more waves, which results in a new wave pattern. Constructive interference occurs when the waves meet in phase and add together. Destructive interference occurs when the crests and troughs of the two waves meet and cancel out. Soap bubbles' colourful patterns are due to the interference between light waves reflecting off the top surface of a film with the waves reflecting from the bottom surface. Poor television reception as trains or planes pass is due to interference and the headphone on some air flights now deliberately use destructive interference to block out background noise.

Interferometers are not used on the GOCE satellite, but oceanographers working on separate experiments use them to determine the acceleration due to gravity. This provides another way of monitoring sea level changes. Interferometers are also used to study earthquakes by monitoring small movements in the Earth's crust. Scientists are even using them to search for gravitational waves which are fluctuations in the curvature of spacetime. They were predicted by Einstein's theory of general relativity and sources are thought to include neutron stars, black holes and quasars.
Learning Objectives:
Pupils will improve their understanding of interference patterns and appreciate how they can be used to monitor the Earth and the Universe.

Outcomes:
Write a description and explanation of the effect increasing the gravitational pull has on the interference pattern produced.

Curriculum Links:
The Twenty First Century Science suite GCSE Physics A (J635)
P6.2.10: Recall that where two waves meet, their effects add and this is called interference
P6.2.11: Recall that where two waves arrive in step they reinforce and where they arrive out of step they cancel out
P6.2.12: Recall that two light beams can be shown to produce an interference pattern
P6.2.13: Explain interference patterns in terms of constructive and destructive interference
P6.2.14: Explain how the diffraction and interference of light and sound are evidence of their wave nature
P6: Illustrate the use of ICT in science, for example simulating the shape of wavefronts and interference effects in a variety of engineering applications

Suggested activities:
1) Ask the class what they think will happen if you hold a hair vertically in front of a laser beam. It acts like a diffraction grating and an interference pattern is observed. Interestingly, if the hair is inclined at a grazing angle using a clamp, a circle with bright and dark bands forms.

2) Draw waves on to two acetate sheets and attach them to a drawing board with pins as shown. Discuss maxima and minima in terms of path difference.

3) In a room with blackout, place a sheet of tissue paper between two flat and clean glass plates (microscope slides).
Angle a reflecting glass plate at 45° and direct the light from a sodium lamp towards it. Place a sheet of writing on the bench and adjust a travelling microscope until it is focused on the writing. Move the travelling microscope over so it is now above the reflecting plate as shown. By previously focusing on the sheet of paper, the travelling microscope should already be focused correctly. A series of vertical fringes should be visible. A viewcam can be used to display the interference fringes on a TV screen. Place different masses on top of the bottom slide and observe the changing interference pattern produced. In a similar way, when an interferometer passes over a region with a higher gravitational field strength, a glass plate is made to move, causing a change in the interference pattern observed.

**Extension**
Calculations relating the path difference and wavelength could be carried out. The search for gravitational waves uses interferometers. Students could watch the following videos.
The search for gravitational waves: http://www.youtube.com/watch?v=RzZgFKoIfQI.
Brian Cox explains gravitational waves: http://www.youtube.com/watch?v=6EJ8r9Rhfw8
Brian Cox in search of gravitational waves: http://www.youtube.com/watch?v=JeXMWc9wbqU

**References/Resources:**
Activities explaining interference:
Java applet on interference:
http://vsg.quasihome.com/interfer.htm
Java applet on interference:
http://www.mhhe.com/physsci/physical/jones/double-slit_experiment/
A site on the search for gravitational waves:
http://www.einsteinathome.org/
The Laser Interferometer Space Antenna:
http://lisa.nasa.gov/