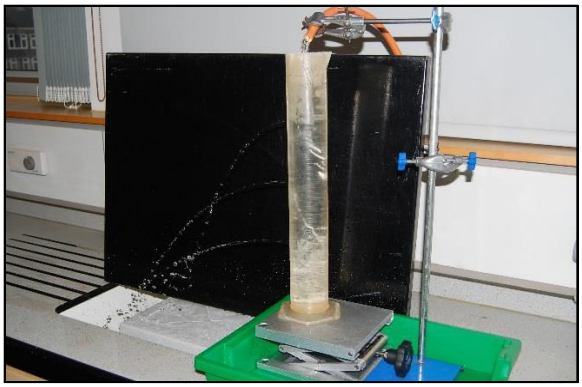
Water pressure - underground
Demonstrating how hydrostatic pressure increases with depth

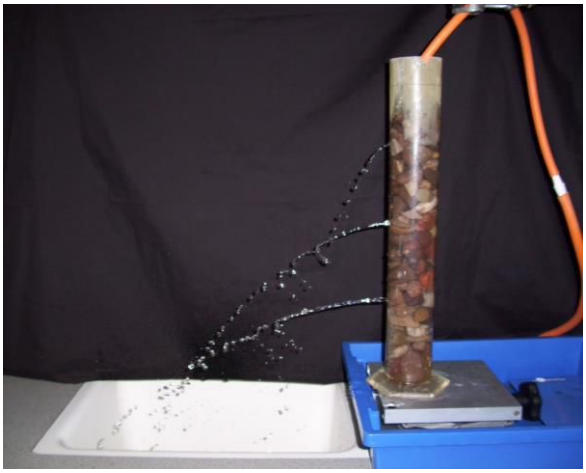
Follow the '*Under pressure - calculating the intense pressures underground'* Earthlearningidea activity where the hydrostatic pressure of water is measured and calculated, by a visual demonstration, as shown below.

Prepare a plastic 1 litre-sized measuring cylinder by drilling three horizontal holes 2mm in diameter at equal intervals from the top, as shown in the photo below (guidance on drilling the holes if given in the 'Resource list'). Then set up the apparatus as shown – the black background makes the jets of water more visible.



Turn on the tap to fill the cylinder and then maintain a constant head. Jets of water will squirt out of the hole under different pressures. The photo shows the lower jet squirting further and with a shallower arc than the upper one, indicating how hydrostatic pressure increases with depth in the cylinder.

Demonstrate that this also happens in rocks by filling the cylinder with coarse gravel and repeating the demonstration. The water doesn't squirt quite as far, The energy is reduced by fluid friction in the narrow channels through which the water flows in the gravel and thus hydrostatic pressure is reduced. Nevertheless, the increase in pressure with depth is still very clear.



Ask the pupils to work out how to adapt the apparatus to compare the rates of flow from each of the holes (*they could collect the flow of water in each jet in three beakers for a given time, and then measure the volumes produced*).

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The back up

Title: Water pressure - underground

Subtitle: Demonstrating how hydrostatic pressure increases with depth

Topic: A lab demonstration of increased hydrostatic pressure with depth.

Age range of pupils: 12-18 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:
- describe how the pressure of water increases with depth;
- explain how flow rates can be measured and compared.

Context:
This activity helps pupils to visualise the increase of hydrostatic pressure with depth that may have previously been explored through the '*Under pressure - calculating the intense pressures underground*' Earthlearningidea activity.

Following up the activity:
For the water-filled cylinder, pupils can test whether the quantity of water which flows through each hole over time is mathematically related to the head of water. As follows, for each hole:
- measure the head of water (h = the distance in mm from the centre of the hole to the surface of the water);
- then the quantity of water (Q) which flows through the hole over time is calculated by using the equation: $Q = k x\sqrt{h}$, where 'k' is a constant.

To test whether there is a mathematical relationship between the flow from each hole and the head of water, pupils should:

- draw a graph to plot Q along the horizontal (x) axis and √h along the vertical (y) axis
- add the data for Q and √h for each hole;
- if there is a relationship – this should plot as a straight line (*A. which it does*).

Ask pupils to discuss the careers where the measurement and calculation of hydrostatic pressure might be important (*Answers include: reservoir engineers; water engineers; hydrogeologists prospecting for underground water; oil/gas engineers drilling for hydrocarbons; designers of bathyspheres for deep-ocean diving*).

Underlying principles:

- Hydrostatic pressure increases with depth.

Thinking skill development:

Devising a method to measure water flow involves construction; any challenges will result in cognitive conflict.

Resource list:

- a large plastic measuring cylinder (eg. 1 litre) with three 2mm diameter holes drilled at intervals, as shown in the photo (the holes should not be vertically above one another, but offset by about 5mm otherwise the jets interfere; use a small piece of sandpaper to remove any curlings of plastic on the outside or inside of the holes)
- a water supply on tap
- a sink to collect the jetting water
- rubber tubing
- supports, trays, stands and clamps
- coarse gravel (when the cylinder is full of gravel, use a small piece of wire to remove any blockages of the holes)
- (optional) beakers and measuring cylinders if the flow of water is to be measured

Useful links:

http://www.nationalstemcentre.org.uk/elibrary/resource/1161/unit-14-who-s-for-a-hot-tight-squeeze-in-inner-space

Source: This idea was devised by David Thompson, and published in '*Who's for a hot, tight squeeze in inner space'*, Unit 14 of the Earth Science Teachers' Association's '*Science of the Earth'* series, 1989, published by Geo Supplies, Ltd, Sheffield. David passed away recently and this Earthlearningidea is published in his memory.

We are most grateful for the help of Keele Education technicians Suzy Allen and Gwyn Jones in setting up and testing the apparatus.