11-14 Stretching

Prerequisites:

Students should have already completed the **Forces** sheet.

The Main Points

- **Extension** = Stretched total length of spring - **Original** total unstretched length
    - Note a common misconception: If a spring is 5.0cm long, then 6.0cm long with a 1.0N stretching force, students will correctly say that the extension is 1.0cm.
    - However, if you stretch it some more, and it is 7.0cm long with a 2.0N stretching force, many students will say that the extension is 1.0cm (ie the extra length since the last measurement). This is not correct. The extension with 2.0N is 7.0 - 5.0 = 2.0cm.
- **Elastic** stretching (deformation) means that there is no permanent damage, and the spring goes back to its original length when the force is removed. Depending on your course, the opposite of 'elastic' might be 'plastic' or 'inelastic'.
- If you plot stretching force (tension) on the vertical axis of a graph, and extension on the horizontal, for most materials, the first part of the graph is a straight line going through the origin.
    - In this first, straight part of the graph, **Hooke's Law** is obeyed: force is proportional to extension. This means that doubling the force will double the extension. It also means that each additional 1N of force (for example) will cause the same increase of extension.
    - The point on the graph where the line stops being straight is called the **limit of proportionality**. At higher forces, Hooke's Law is not obeyed.
- When Hooke's Law is obeyed, the force and extension are related by the equation
    - Force (in newtons) = Spring constant (in N/m or N/cm) x Extension (in m or cm)
    - The spring constant, *k*, measures the force needed to cause an extra centimetre (or metre) of extension.
    - In symbols, we usually write $F = k\,e$ where F is the force, and e is the extension.

Teacher Quarter Briefing

- Introduction: https://youtu.be/jEuQtzt4-P4
- Practice: https://isaacphysics.org/gameboards#teach_quart_stretch
- Review: https://youtu.be/F4M1HnGGIcc
- If you want to go further: https://isaacphysics.org/pages/covid19_gcse_archive#37

Class Question Notes

The worksheet can be printed either in full, or in cloze text form (where the red text is missing, and students can complete these blank spaces after class discussion). The online version of the notes requires the appropriate text to be dragged to the right place in the sentences.

1. Students calculate extension from length measurements. In (b) note that to work out the extension the student must subtract the original length, so their answer is 10 - 6 = 4cm. In part (c) the spring has not gone back to its original length, so this is not elastic stretching.
2. Here students take data on the stretching of a chest expander by an athlete.
    a. The original length is the same as the length when the force is 0N.
    b. The missing length should be filled in by spotting the pattern in the numbers: each is 4cm longer than the one on its left.

    c. Extensions are filled in by subtracting the original length (42.5cm) from each thickness in turn. Two of them have been done already as examples.
    d. Students read off the extension caused by a force of 100N.
    e. Students use the data to predict how much force would be needed to stretch the chest expander by 1cm. They could, for example, see that it takes 100N to stretch it by 8cm, so it will take 100/8 = 12.5N to stretch it by 1cm.
3. In this question, the student calculates the extension of a spring for different forces. This spring gets 0.2cm longer for each 1.0N added. For example, a 3.0N force will cause it to stretch by 3.0 x 0.2cm = 0.6cm.
4. Students work out the force needed to stretch the spring in Question 3 by 1cm. Given that 1.0N causes it to get 2.0cm longer, halving this gives a 0.5N force making it 1.0cm longer.
5. In this question, students plot a graph of extension against force for a spring. They add a best fit line and mark the limit of proportionality (where the line begins to curve). They comment on whether it would obey Hooke's Law with a 5.0N force (if it is on the straight part of the graph, then 'yes'). They also comment on whether a stiffer spring (more force for the same extension) would make the line steeper (no, it will make it shallower).
6. Students complete word equations using force, extension and spring constant.
7. Students make symbolic equations using F for force, e for extension and k for spring constant.
8. Students calculate the force = spring constant x extension = 20 N/cm x 7.0cm
9. Students calculate the spring constant = force / extension = 10N / 0.20cm
10. Students calculate the extension = force / spring constant = 400N / 8N/cm

Homework Question Notes

These questions have a very similar form to the questions in the class task, so students can refer back to their earlier answers to help.

- Questions 1-4 are very similar to the equivalent questions on the class sheet.
- In Question 5, students complete the blanks to form a set of notes about Hooke's Law. The students do not need to use all of the words given in the list at the end.
- Question 6 involves a graph (like class Question 5), but here the student also has to work out the extension caused by 1N of force. They should calculate this from the best fit line, using an argument like 'A 25N force causes 0.5cm of extension, so 1N would give 0.5cm/25 = 0.02cm'. They should not read the graph for 1N directly, as a reading of 1N is so near the origin as to make an accurate reading impossible.
- In Question 7, students form word equations.
- Question 8 is similar to Class Questions 8-10.
- In Question 9, students have to think further
    a. Students work out the extension, then add the 8.0cm original length to get the new length.
    b. Students calculate 10.8N / 2.4N/cm to get the extension at the limit of proportionality.
    c. For a 12.0cm length, the extension is 12-8 = 4.0cm. If this is smaller than their answer to (b), then the spring is obeying Hooke's Law. The student must remember to calculate the extension before making the comparison.

Extension questions from 'Step Up to GCSE Physics':
https://isaacphysics.org/gameboards#step_up_phys_33_b1