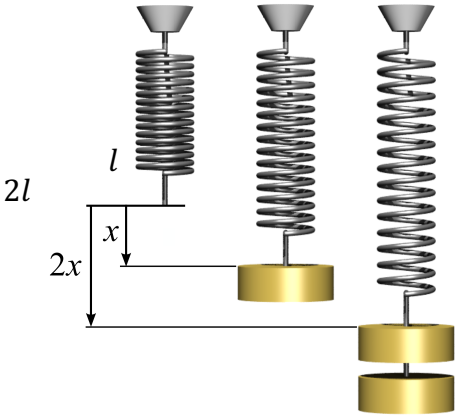
## 4.9.2 Stretching springs

videos

When we apply a tensile (stretching) force ($F$) to a spring it gets longer. The amount of stretch is called the extension ($\Delta l$).

We find that, up to a limit, the extension is directly proportional to the extension. This means that if a force $F$ stretches a spring by $l$, a force of $2F$ will stretch the spring by $2l$.




This relationship is known as Hooke's law after the English scientist Robert Hooke.

$$F = k\Delta l$$

*where k is a constant called the spring constant*

*(1) What is the unit for the spring constant?*

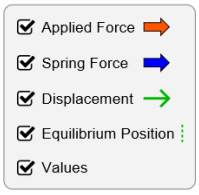
*(2) A force of 10N extends a spring by 30cm. What is the value of the spring constant?*

**PhET SIM**

Goto: https://tinyurl.com/pa57fn4

Start by clicking 

and checking all of the boxes.
Leave the other settings as they are.
Apply a stretching force (to the right).




*(3) Compare the displacement (extension) and the applied force. How are they related?*

Now apply a compressive force.

*(4) Compare the displacement and the applied force. How are they related?*

*(5) What does 'equilibrium position' mean?*

Apply a stretching force of +100N. Now adjust the spring constant.

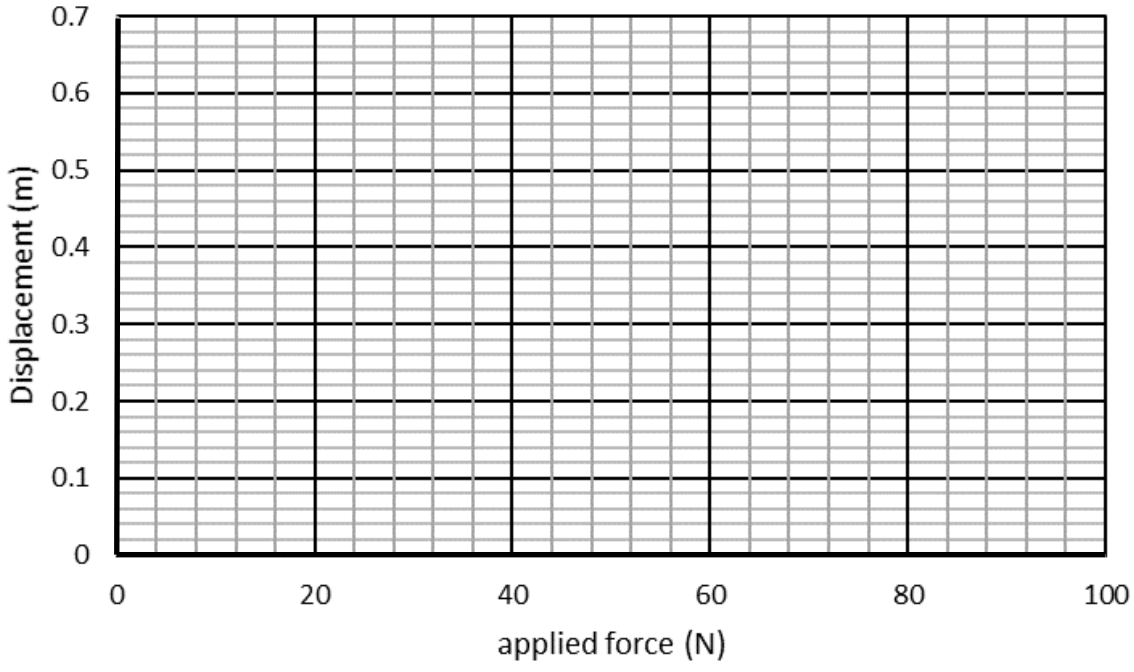
*(6) How does the value of spring constant affect the displacement?*

*(7) Set the value of the spring constant to 200Nm$^{-1}$, and record the following:*

| Applied force (N) | Displacement (m) |
|---|---|
| 0 | |
| 10 | |
| 20 | |
| 30 | |
| 40 | |
| 50 | |
| 60 | |
| 70 | |
| 80 | |
| 90 | |
| 100 | |

*(8) Looking at the data in the table, describe the relationship between applied force and displacement.*

*(9) Now plot a graph of displacement against applied force:*




*(10) Make sure that you fit your data with a line of best fit.*

*(11)✎ Now sketch a line on the graph you would expect to get if the spring constant was bigger. (You might need to check this by adjusting the spring constant slider.)*

*(12)✎ Now sketch a line on the graph you would expect to get if the spring constant was smaller. (Again, you can check this).*

*(13)✎ Work out the gradient of your line of best fit on your graph. What is the unit for the gradient?*

*gradient = _____ _____*

*(14)✎ How is the gradient related to the spring constant? (You might like to check this mathematically)*

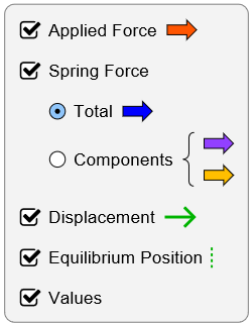
**Combining springs**

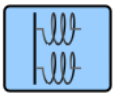
We are now going to have a go combining springs in series and parallel.

*(15)✎ How do you think combining 2 springs in parallel (side by side) will compare to one spring on its own?*

Choose 

and check these boxes.



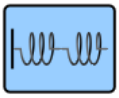

Choose springs  in parallel.

Keep the spring constants at 200Nm$^{-1}$.
Change the applied force and observe the displacement.

*(16)✎ How does the displacement compare to that you got for one spring?*

*(17)✎ Estimate the combined spring constant.*
*combined spring constant = _____ Nm$^{-1}$*

*(18)✎ How do you think adding springs in series (one after the other) will compare to one spring on its own?*

Choose  springs in series.

Keep the spring constants at 200Nm$^{-1}$
Change the applied force and observe the displacement.

*(19)✎ How does the displacement compare to that you got for one spring?*

*(20)✎ Estimate the combined spring constant.*
*combined spring constant = _____ Nm$^{-1}$*