Tensile and Spring

Sanjin Zhao

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Learning Outcome

I highly recommend you to finish this checklist to determine whether you've achieved the learning objectives.

- ☐ explain how tensile and compressive forces cause deformation
- ☐ describe the behavior of springs and use Hooke's Law[1]
- ☐ distinguish between elastic and plastic deformation, limit of proportionality and the elastic limit

[1] formula?

Leadin

In this chapter, a university-level concept has introduced, the *stress*[2]. An common test of the concret is maximum stress

[2] def:

Figure 1: A machine used to increase the stress to test the limit of concrete column

Tensile and Compressive Force

For any materials, if a force tend to stretch the object, such force are said to be 'tensile forces' and by contrast, any forces resulting contraction of the object is said to be 'compressive force'. It would be easy to memorize the compressive, but for tensile you need to keep notice of the spelling, it actually comes from the same as 'Tension'.

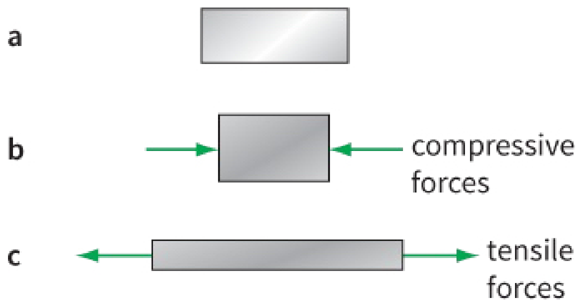


Figure 2: compressive forces and tensile forces acting on same object

However, things become more complicated when a couple of force is acting on the object, causing *bend*[3] of the beam as shown in Fig **??**

[3] def:

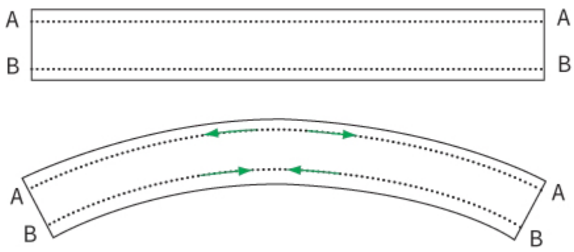


Figure 3: forces on both end of the beam cause bending

Task

According to Fig **??**, state the type of inner force in the beam.

Spring and Hooke's Law

When different load is hung on a spring, the *extension*[4] of the spring will obviously change. From a **qualitative perspective**, it must follows the rule:

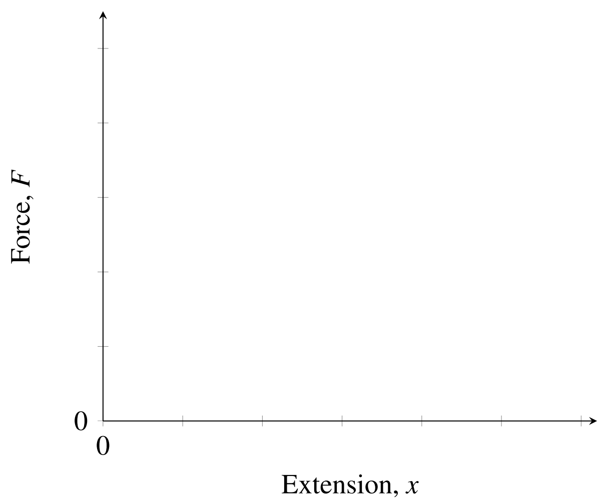
[4] def:

the larger the mass is (or tensile forces F), the longer the extension(x) is

However, that's not enough in the standard of **quantitative research**. Let's carry out the following experiment and record the data below:

Plot the Froce versus extension graph in the following coordinate system, you'll reach the following F-x diagram:

Trial	1	2	3	4	5	6	7	8
number of masses								
Forces on spring/N								
Extension/m								



Task

Label your experiment data in the coordinate system, and use a smooth line or curve to connect your data.

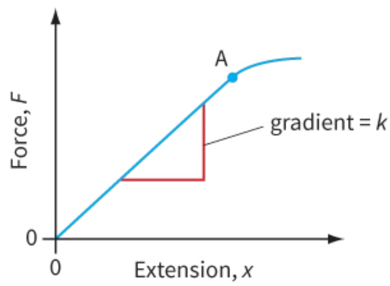


Figure 4: A perfect relationship in a ideal spring

After such investigation, your result will look like in Fig **??**.

There are two thing we'll pay special attention, they are Hooke's Law and *Limit of Proportionality*.

Hooke's Law

We've finally achieve the Hooke's Law finally, It has quantitatively states the relationship between forces exerted on the spring and the extension caused by the force, which states as following:

Summary

Provided the *elastic limit* is not exceeded, the extension of a spring is ______________________________ to the applied force(load)

$$x \propto F \text{ or } F = kx$$

Such law comes so naturally from the ______________________ in the graph. and the coefficient k is called[5] ______________________ The unit for k is ____________________ while to express it in SI base unit, that would be ____________________.

[5] some might refer it to as coefficient of stiffness

Task

What is elastic limit?

Has your spring exceeded the limit during your experiment?

Limit of Proportionaity

If you put too much load on the spring, the spring may be broken, as it can not restore to its original length when no load is carried. Thus, the point of no return is exactly what we want to find

Task

label the point of *limit of proportionality* in Fig **??**

Try to define *limit of proportionality* in your language.

Take the limit of proportionality as a *demarcation point*[6], when the load or extension does not exceed it, *elastic deformation* occurs, which means: . By contrast, if this is exceeded, *plastic deformation* is incurred in the spring, which means ______________________ And Hooke's Law is/is not applicable to the spring. So if load is removed, the Force-Extension diagram will look like this:

[6] def:

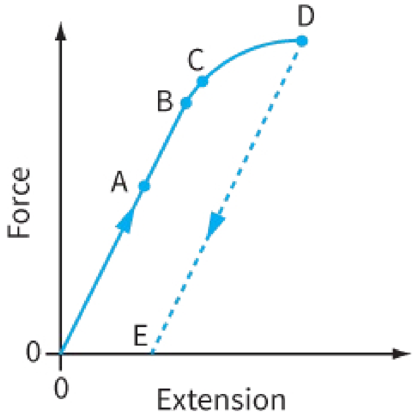


Figure 5: The arrows shows the prcocess of adding and removing loads

Task

Explain the behavior of the spring in the Fig **??**

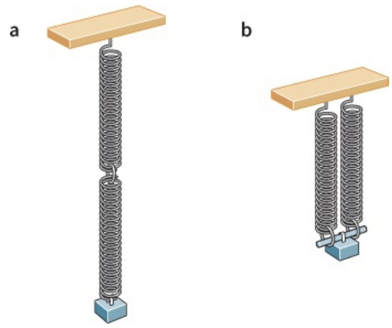


Figure 6: two types of connection of springs

Series and Parallel Connection of Springs

You are required to calculate the *equivalent* spring constant when two springs are connect in (a).series and (b).parallel just as shown in Fig **??**.

If the springs has different spring constant k_1 and k_2. Let's deduce the equivalent spring constant in parallel:

Similarily, the equivalent spring constant in series are calculated through the following way:

Summary

Two springs with spring constant k_1 and k_2 are connected in series, the equivalent spring constant of the system is:

$$k_{\text{eq}} = \underline{\hspace{6cm}}$$

or alternatively,

$$\frac{1}{k_{\mathrm{eq}}} =$$

And if they are connected in parallel, the equivalent spring constant of the sytem is:

$$k_{\mathrm{eq}} =$$