A chain of 40 identical springs linked end to end has a stiffness of 470 N/m. What is the stiffness of one spring?

$$k_{n\ springs} = \frac{1}{n} k_{1\,spring}$$

$$470 = \frac{1}{40} k_{1\,spring}$$

$$k_{1\,spring} = 18800\ N/m$$

10 identical springs are placed side by side and are connected to a massive block. The stiffness of the 10 springs combined is 4400 N/m. What is the stiffness of one spring?

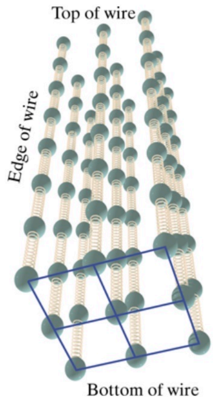
$$k_{n\ springs} = n \cdot k_{1\,spring}$$

$$4400 = 10\, k_{1\,spring}$$

$$k_{1\,spring} = 440\ N/m$$

One mole of iron (6×10^{23} atoms) has a mass of 56 grams, and its density is 7.87 grams per cubic centimeter, so the center-to-center distance between atoms is 2.28×10^{-10} m. You have a long thin bar of iron, 2.1 m long, with a square cross section, 0.11 cm on a side.

You hang the rod vertically and attach a 125 kg mass to the bottom, and you observe that the bar becomes 1.06 cm longer. From these measurements, it is possible to determine the stiffness of one interatomic bond in iron.



1) What is the spring stiffness of the entire wire, considered as a single macroscopic (large scale), very stiff spring?

k_s = ______ N/m

2) How many side-by-side atomic chains (long springs) are there in this wire? This is the same as the number of atoms on the bottom surface of the iron wire. Note that the cross-sectional area of one iron atom is $(2.28 \times 10^{-10})^2$ m^2.

Number of side-by-side long chains of atoms = ______

3) How many interatomic bonds are there in one atomic chain running the length of the wire?

Number of bonds in total length = ______

4) What is the stiffness of a single interatomic "spring"?

$k_{s,i}$ = ______ N/m

An interatomic bond in iron is stiffer than a slinky, but less stiff than a pogo stick. The stiffness of a single interatomic bond is very much smaller than the stiffness of the entire wire.

Part One

$$F = ks$$

$$mg = ks$$

$$(125\,kg)(9.8\,m/s^2) = k(0.011\,m)$$

$$k_{wire} = 1.1557e5\ N/m$$

Part Two

$$n_{parallel} = W_{atoms}^{2}$$

$$= \left(\frac{0.0011\,m}{2.28e{-10}\,m}\right)^2$$

$= 2.327e13$ atoms

Part 3

$$n_{series} = \left(\frac{2.1\,m}{2.28e{-10}\,m}\right)$$

$$= 9.211e9$$

Part 4

$$k_{wire} = \left(\frac{1}{n_{series}} \cdot n_{parallel}\right) k_{bond}$$

$$k_{bond} = \frac{k_{wire}\, n_{series}}{n_{parallel}}$$

$$= 45.746\ N/m$$

A hanging wire made of Iron with a diameter of 0.12 cm is 2.8 m long initially. When a mass of 120 kg is hung from it, it stretches 1.46 cm. 1 mol Fe = 56 grams and its density is 7.87 g/cm³. What is Young's modulus?

$$Stress = \frac{F_t}{A} \qquad Strain = \frac{\Delta L}{L}$$

$$= \frac{mg}{\pi\left(\frac{d}{2}\right)^2} \qquad = \frac{0.0146\,m}{2.8\,m}$$

$$= 1.0398e9\ N/m^2 \qquad = 5.214e{-3}$$

$$Y = \frac{\text{Stress}}{\text{Strain}} = 1.994e11 \ N/m^2$$

Find the spring stiffness if the diameter of one atom of Iron is 2.28e-10.

$$Y = \frac{k_b}{d}$$

$$k_b = Yd$$

$$= 45.467$$