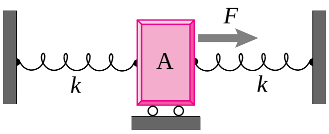
7.1 Springs

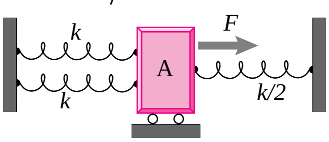
Preparatory Problems

7.1.1 Find the force F required to push the massless block by 1 cm to the right if $k = 500\,\text{N/m}$. *



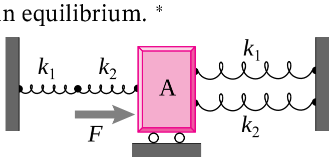
Problem 7.1.1

7.1.2 A force $F = 20\,\text{N}$ is applied on the massless block shown in the figure. Find the displacement of the block for equilibrium if $k = 100\,\text{N/cm}$. *



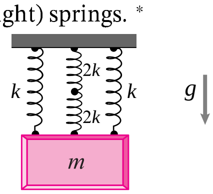
Problem 7.1.2

7.1.3 A network of relaxed springs holds a massless block as shown in the figure where $k_1 = 100\,\text{N/cm}$ and $k_2 = 400\,\text{N/cm}$. If the block is pushed to the right by 2 cm, find the force F to hold the block in equilibrium. *



Problem 7.1.3

7.1.4 A block of mass $m = 300\,\text{kg}$ hangs from the ceiling with the help of a network of springs in series and parallel as shown. Taking $k = 20\,\text{kN/m}$ and $g = 10\,\text{m/s}^2$, find the stretch in the two side (the left and right) springs. *



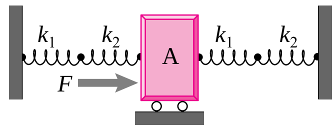
Problem 7.1.4

7.1.5 For the arrangement of springs shown in the figure, $k_1 = 50\,\text{N/cm}$ and $k_2 = 100\,\text{N/cm}$. Find

a) the equivalent spring stiffness of the arrangement,

b) the displacement of the block if a force $F = 50\,\text{N}$ acts on the block.

*

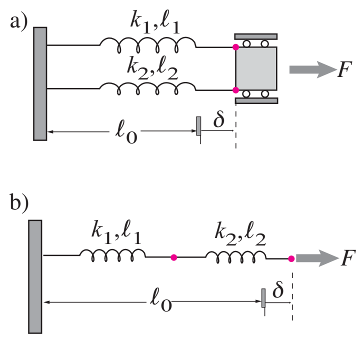


Problem 7.1.5

7.1.6 Find F in terms of some or all of $k_1, \ell_1, k_2, \ell_2, \ell_0$ and δ. Note that F is generally not zero even if δ is zero.

a) Springs in parallel.

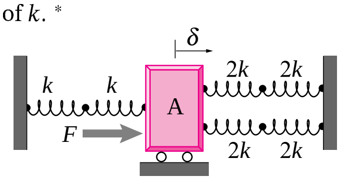
b) Springs in series.



Problem 7.1.6

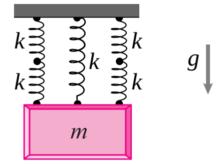
More-Involved Problems

7.1.7 A massless block is held in position by a network of springs shown in the figure. If the block is displaced to the right by 1 cm from the relaxed position of the springs, a force of $F = 50\,\text{N}$ is required to keep the block in equilibrium. Find the value of k. *



Problem 7.1.7

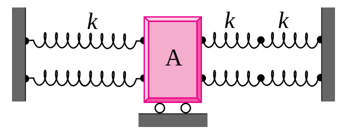
7.1.8 A box weighing 1000 N is hung from the ceiling using a network of springs, each with stiffness $k = 500\,\text{N/cm}$. Find the stretch in each spring. *



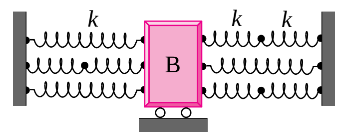
Problem 7.1.8

7.1.9 For the network of springs, find the net stiffness and strength of each network if the stiffness and strength of individual springs are $k = 10\,\text{kN/m}$ and $T_0 = 2\,\text{kN}$, respectively. The load is applied to the central mass and the springs are all relaxed when no load is applied.

(a)

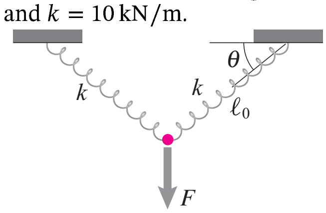


(b)



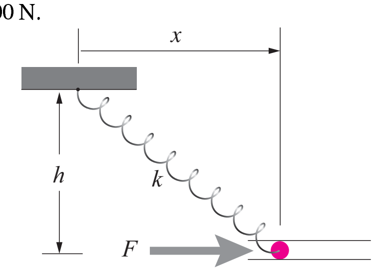
Problem 7.1.9

7.1.10 Find the stretch in each spring to hold the pin in equilibrium for $F = 10\,\text{kN}$ if the relaxed length (in the horizontal position) of each spring is $\ell_0 = 15\,\text{cm}$ and $k = 10\,\text{kN/m}$.



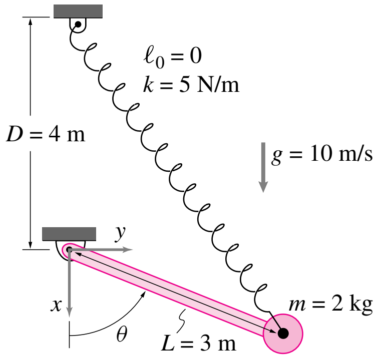
Problem 7.1.10

7.1.11 A mass slides with negligible friction in a rigid horizontal track. It is also pulled by a zero-rest-length spring ($\ell_0 = 0$) of stiffness $50\,\text{kN/m}$. Find the horizontal position x of the pin if it is in equilibrium with an applied force $F = 1000\,\text{N}$.



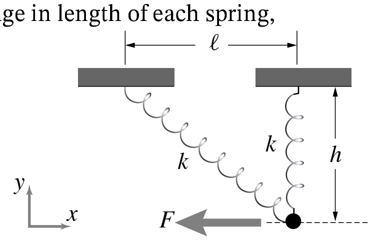
Problem 7.1.11

7.1.12 A zero length spring (relaxed length $\ell_0 = 0$) with stiffness $k = 5\,\mathrm{N/m}$ supports the pendulum shown. Assume $g = 10\ \mathrm{N/\,m}$. Find θ for static equilibrium. *



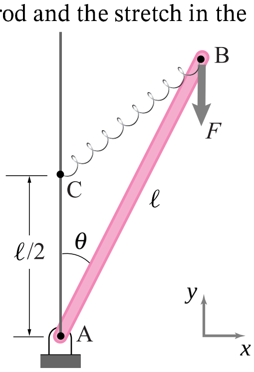
Problem 7.1.12

7.1.13 In the figure shown, the two springs with $k_1 = 50\,\mathrm{N/cm}$ (left spring) and $k_2 = 100\,\mathrm{N/cm}$ (right spring) are in relaxed position when $h = 30\,\mathrm{cm}$ and $\ell = 40\,\mathrm{cm}$ (and, of course, $F = 0$). For $F = 200\,\mathrm{N}$, find the position of the pin on the horizontal frictionless track, and change in length of each spring,



Problem 7.1.13

7.1.14 In the mechanism shown, the relaxed length of the spring is $\ell/2$ and the length of the bar AB is $\ell = 2\,\mathrm{m}$. For $F = 500\,\mathrm{N}$, find the equilibrium angle θ of the rod and the stretch in the spring.

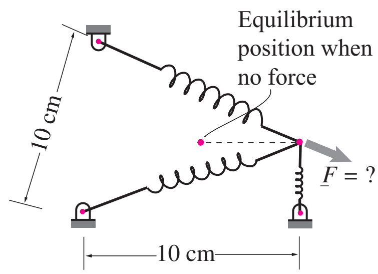


Problem 7.1.14

7.1.15 The ends of three identical springs are rooted at the corners of a 10 cm equilateral triangle with base that is in the $\hat{\imath}$ direction. Find the force $\vec{F}$ needed to hold the ends of the springs 5 cm to the right of the triangle center if

a) $\ell_0 = 0$, $k = 10\,\mathrm{N/\,cm}$?

b) $\ell_0 = 10/\sqrt{3}\,\mathrm{cm}$, $k = 10\,\mathrm{N/\,cm}$?

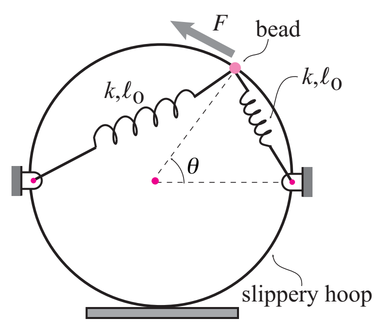


Problem 7.1.15

7.1.16 The hoop is rigid, round and frictionless and the force is tangent to the hoop.

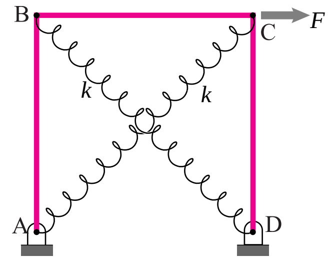
a) In terms of some or all of k, ℓ_0, r, and θ, find F.

b) How does the answer above simplify in the special case that $\ell_0 = 0$? [You can do this by simplifying the expression above, or by doing the problem from scratch assuming $\ell_0 = 0$. In the latter case, an answer can be generated quickly if vector methods are used.]



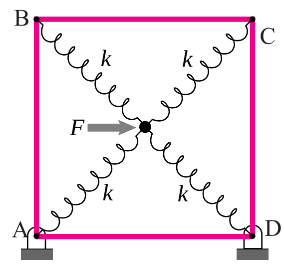
Problem 7.1.16

7.1.17 The square box mechanism shown consists of three identical bars and two identical diagonal springs in their relaxed configuration. Each bar is 0.4 m long. A horizontal force $F = 100\,\mathrm{N}$ acts at C. Find the change in length of each spring if $k = 10\,\mathrm{kN/m}$. *



Problem 7.1.17

7.1.18 In the mechanism shown, the pin is held in the center of the square frame of side 1 m with relaxed springs of stiffness $k = 5\,\mathrm{kN/m}$ in the absence of any force. Find the change in length of each spring when an applied horizontal force $F = 50\,\mathrm{N}$ keeps the pin in equilibrium at a position slightly to the right of the center.



Problem 7.1.18