July 9, Week 6

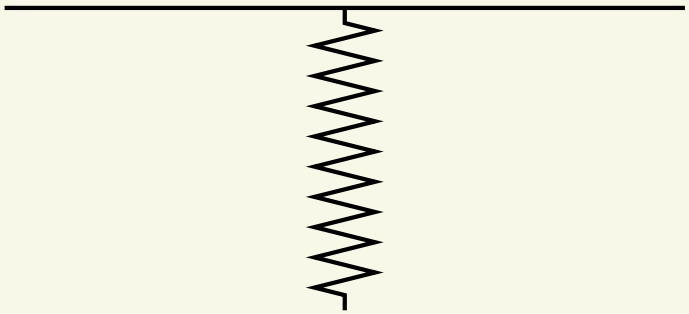
Today: Chapter 10, Elastic Potential Energy

Homework #6 due Friday

Office hours today, 1:00-5:00

Hooke’s Law

A simple example of a variable force is the force needed to stretch a spring.



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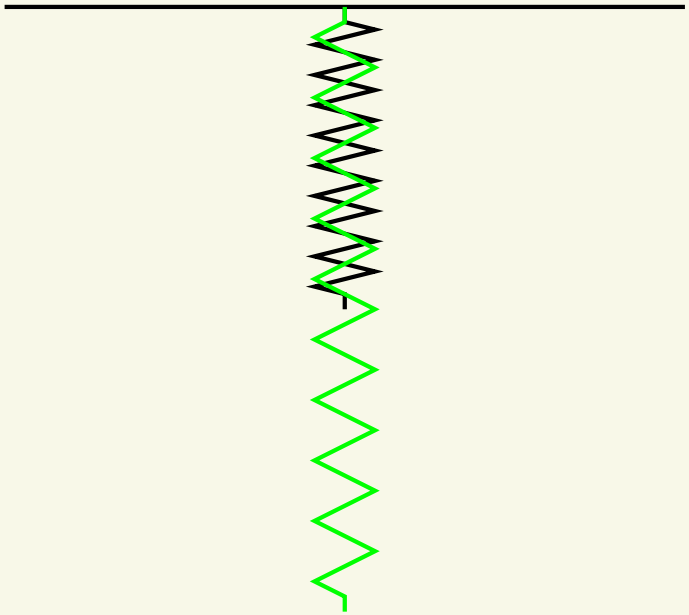

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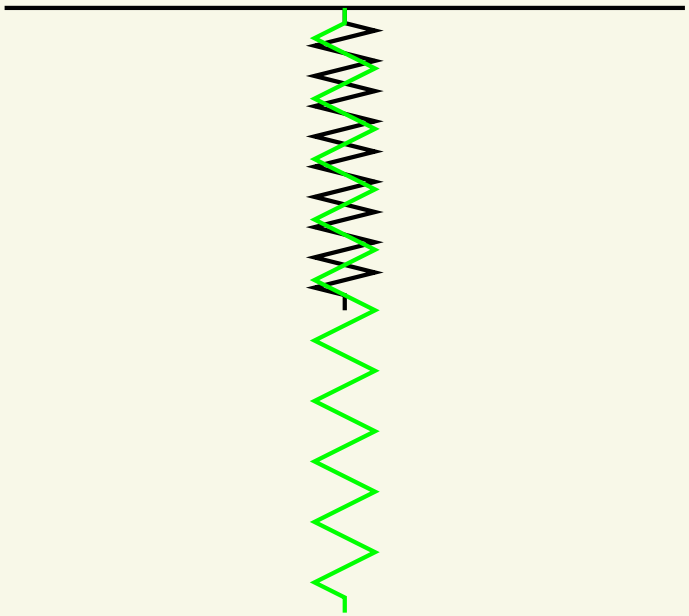

Hooke’s Law - The force needed to stretch or compress a spring increases linearly with stretching distance

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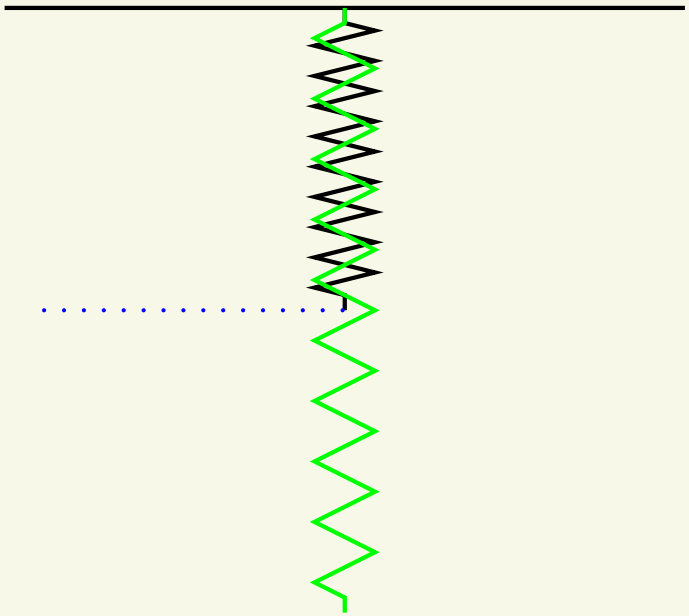

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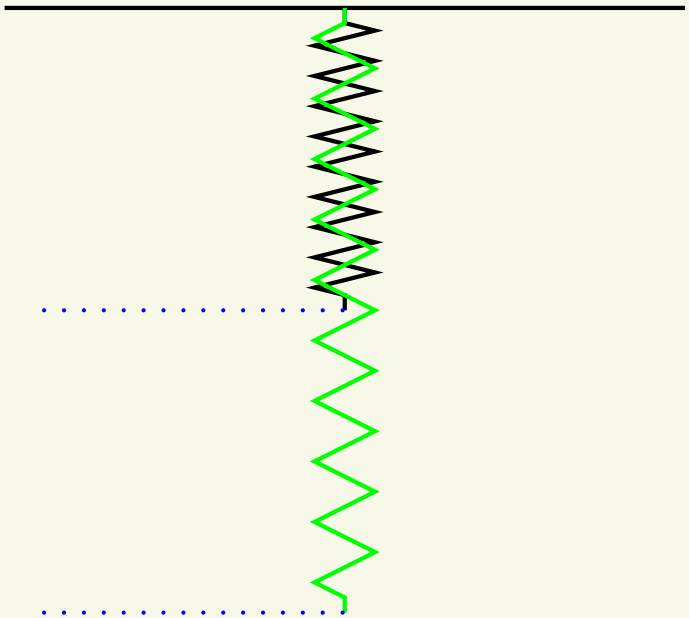

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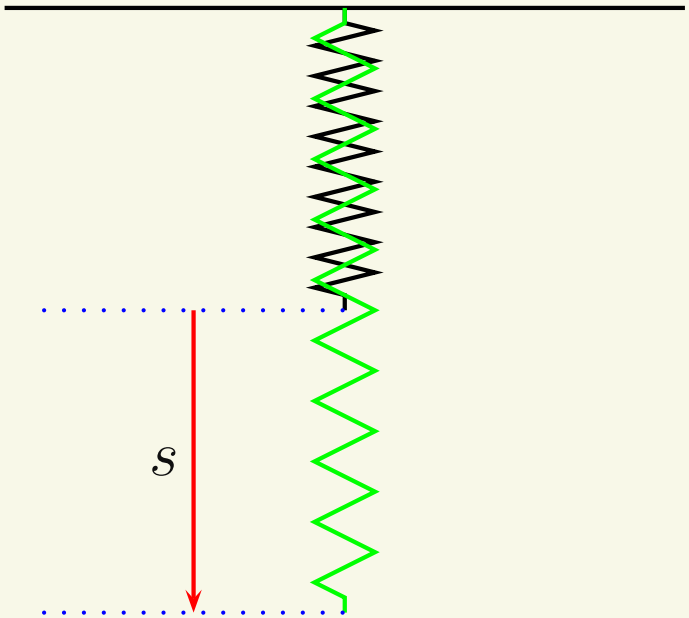

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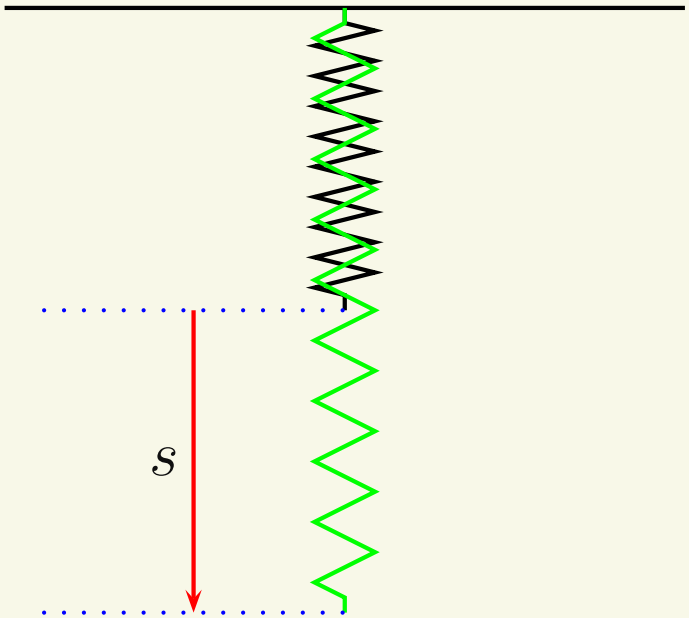

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$$F_{sp} = ks$$

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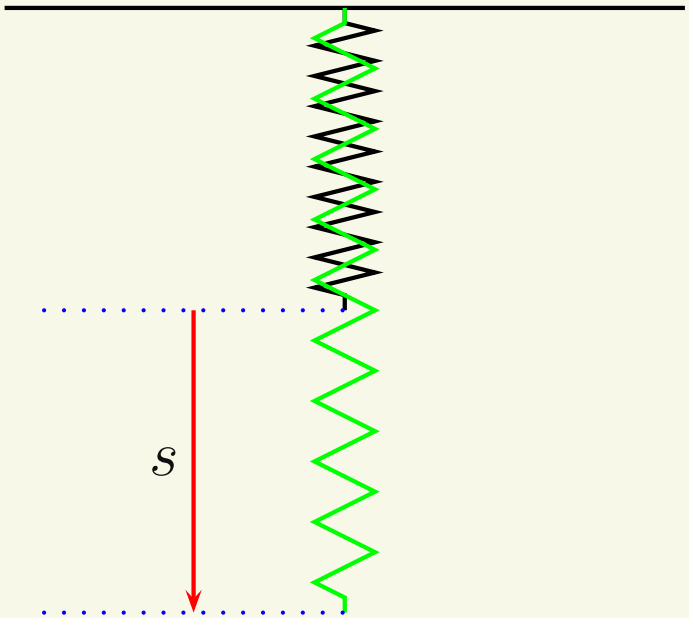

Hooke's Law - The force needed to stretch or compress a spring increases linearly with stretching distance

$$F_{sp} = ks$$

k = spring constant, Unit: N/m
s = stretching distance

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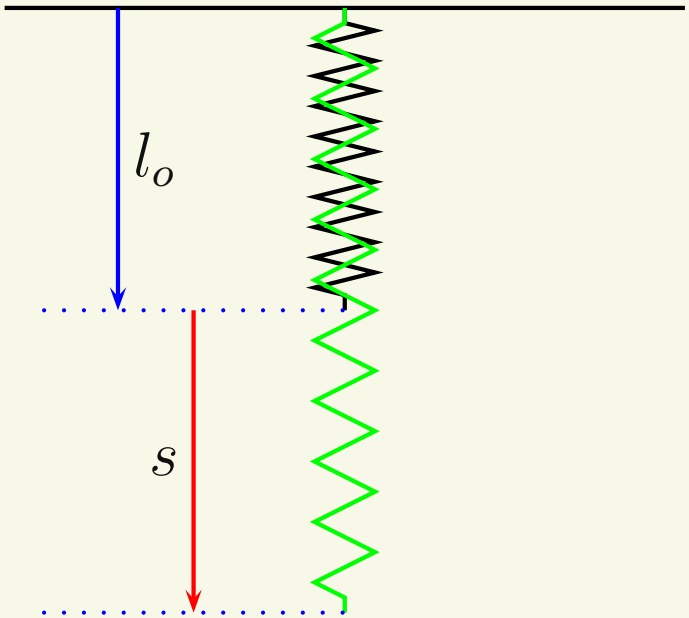

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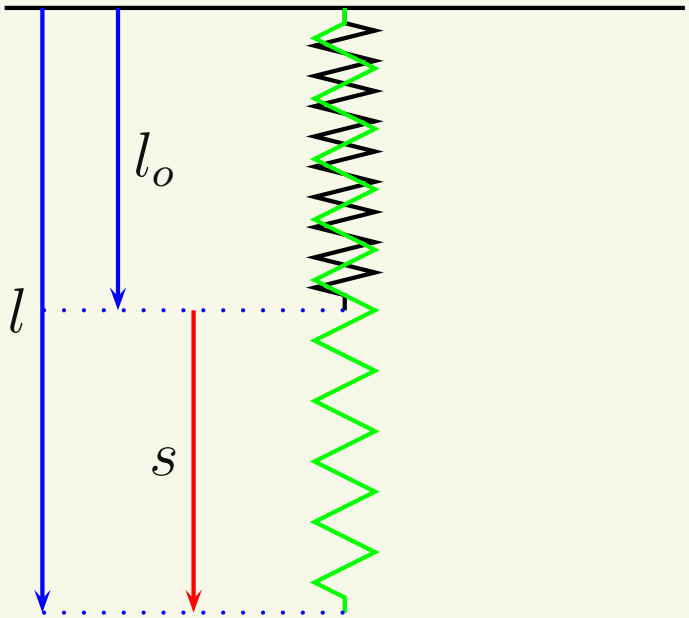

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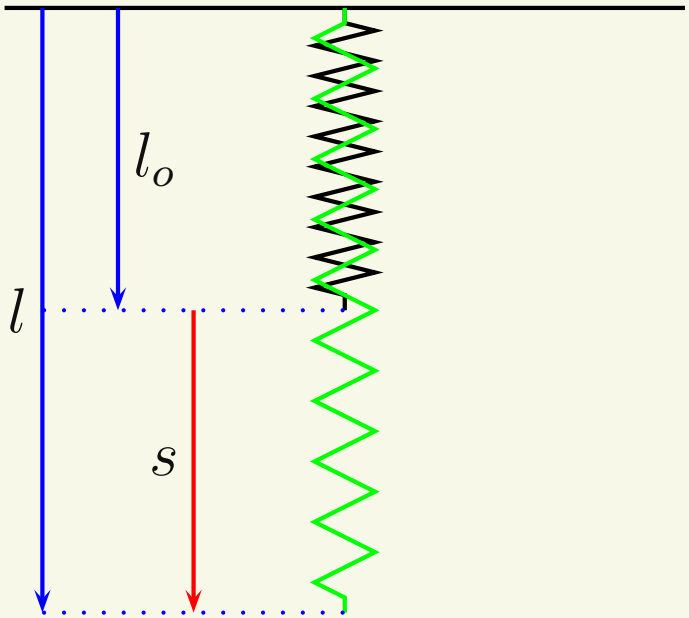


$$s = l - l_o$$

Hooke's Law - The force needed to stretch or compress a spring increases linearly with stretching distance

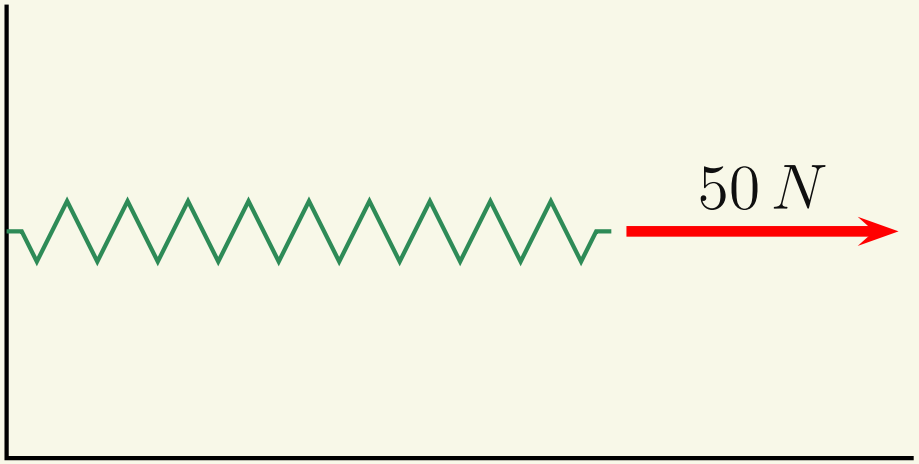
$$F_{sp} = ks$$

k = spring constant, Unit: N/m
s = stretching distance

Spring Exercise

$$F_{sp} = ks$$

A horizontal 50-N force is applied to a $100\ N/m$ spring whose unstretched length is $0.5\,m$. What is the spring's length after the force has been applied?



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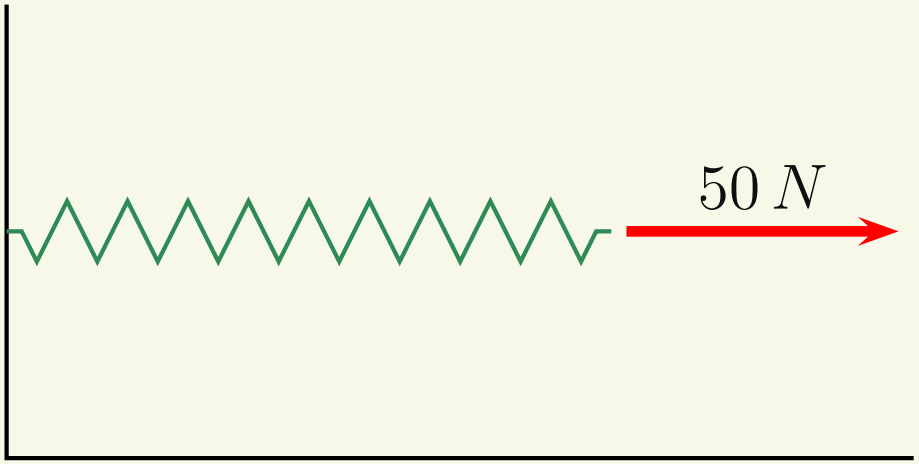
(a) $0\,m$



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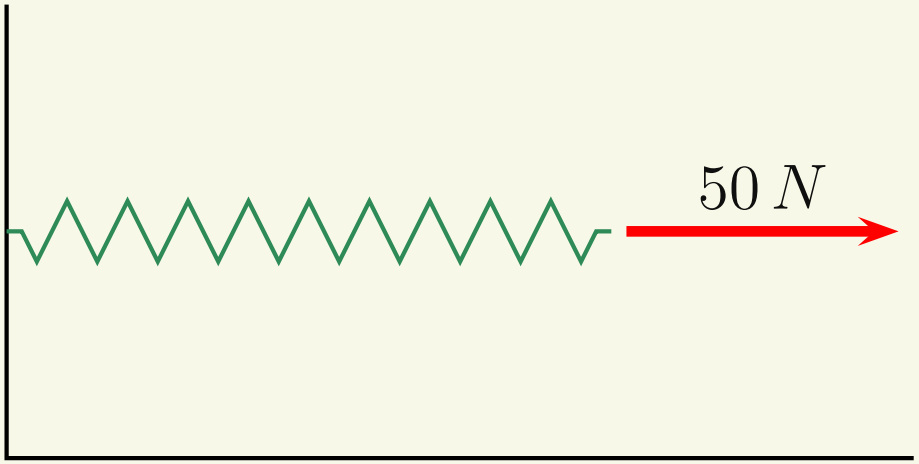

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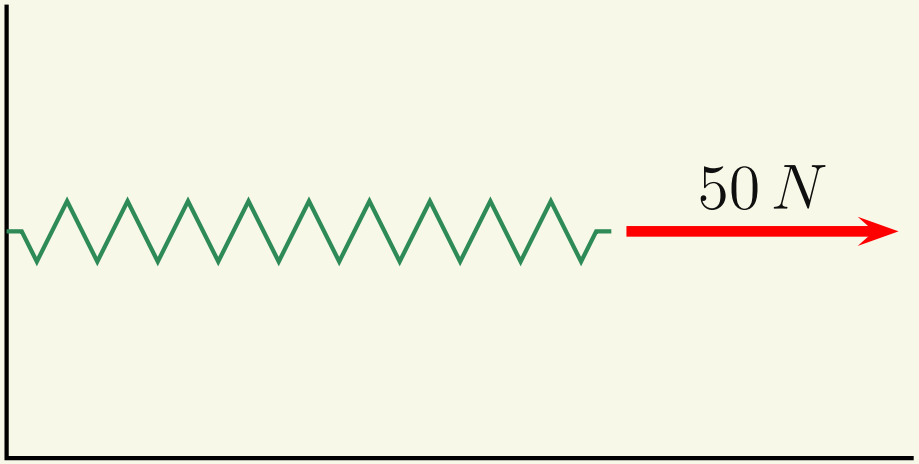
(b) $0.5\,m$

(c) $1\,m$



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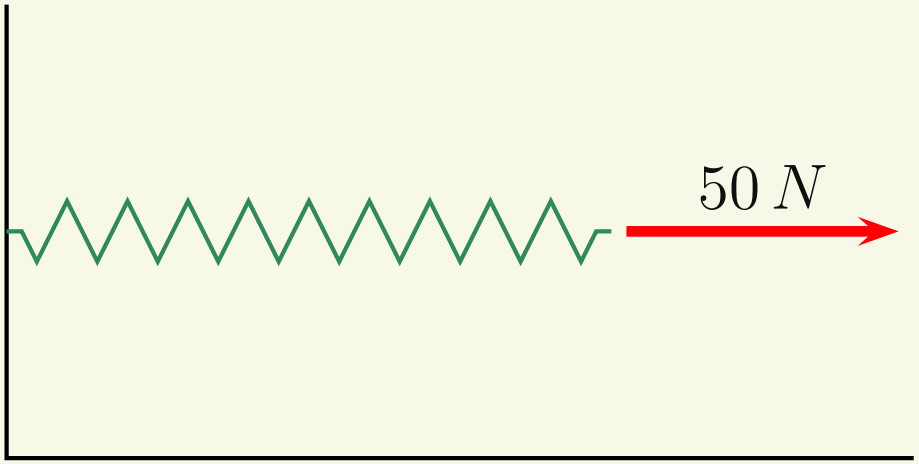

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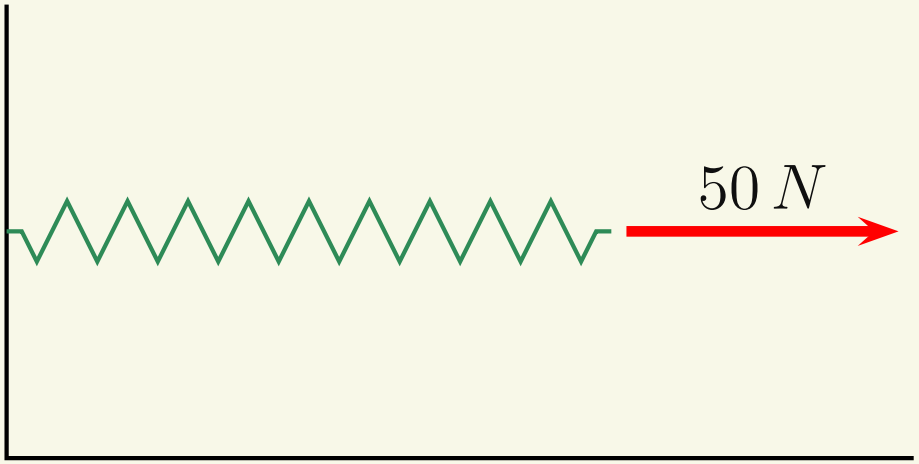

(a) $0\,m$

(b) $0.5\,m$

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(e) $2\,m$

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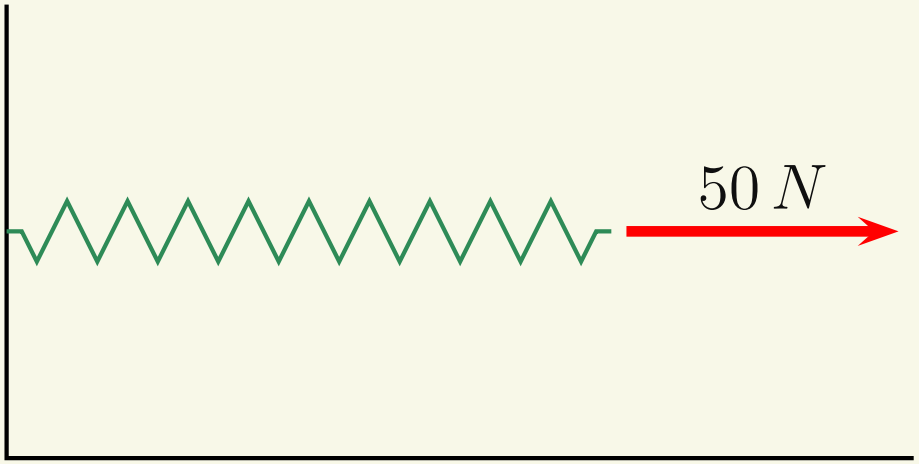

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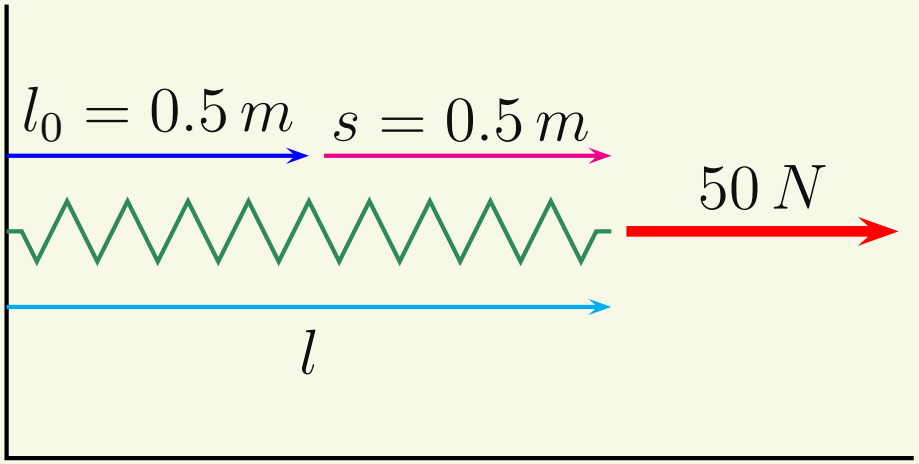


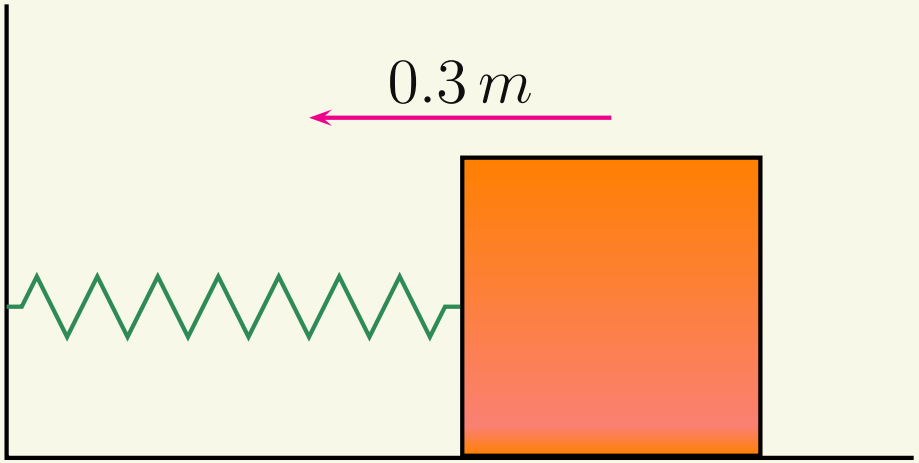
(c) $1\,m$

$$s = \frac{50\ N}{100\ N/m} = 0.5\,m$$

Spring Exercise II

$$F_{sp} = ks$$

A 5-kg mass is attached, as shown, to a $100\,N/m$ spring whose unstretched length is $0.5\,m$. If the mass is pushed $0.3\,m$ to the left, what is the magnitude and direction of the force exerted by the spring on the mass?



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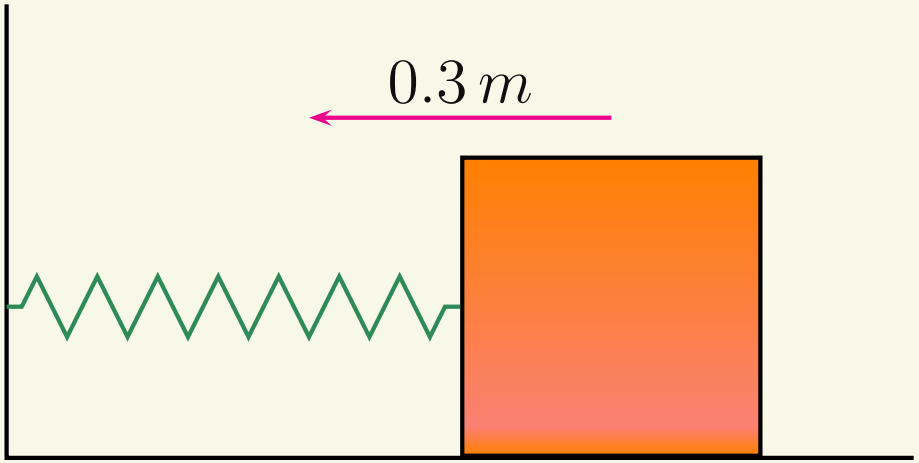
(a) $30\,N,$ Left



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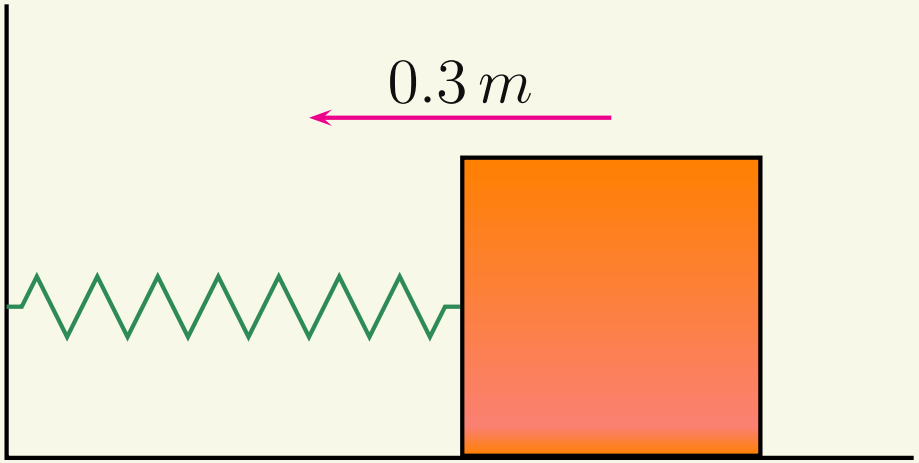
(a) $30\,N,$ Left

(b) $30\,N,$ Right



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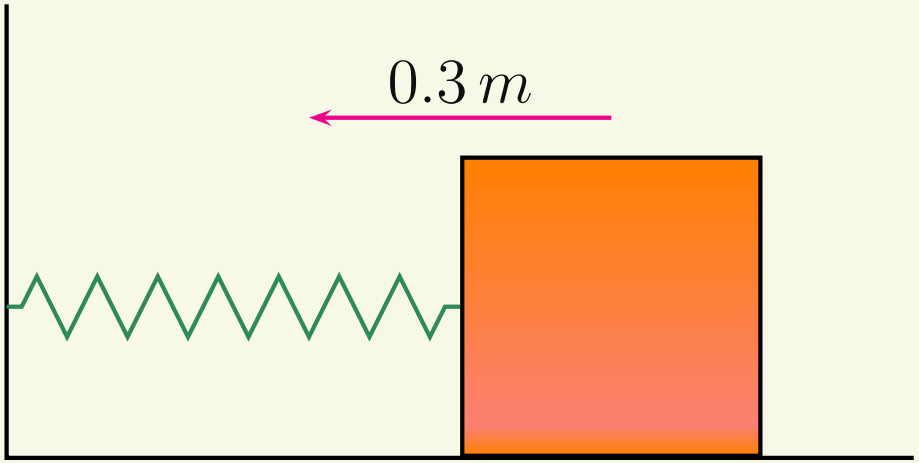

(a) $30\,N,$ Left

(b) $30\,N,$ Right

(c) $20\,N,$ Left

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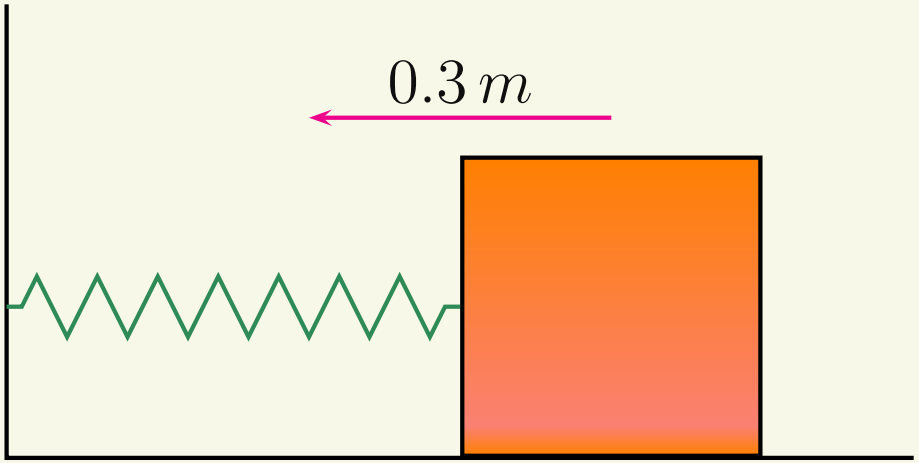

(a) $30\,N,$ Left

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(c) $20\,N,$ Left

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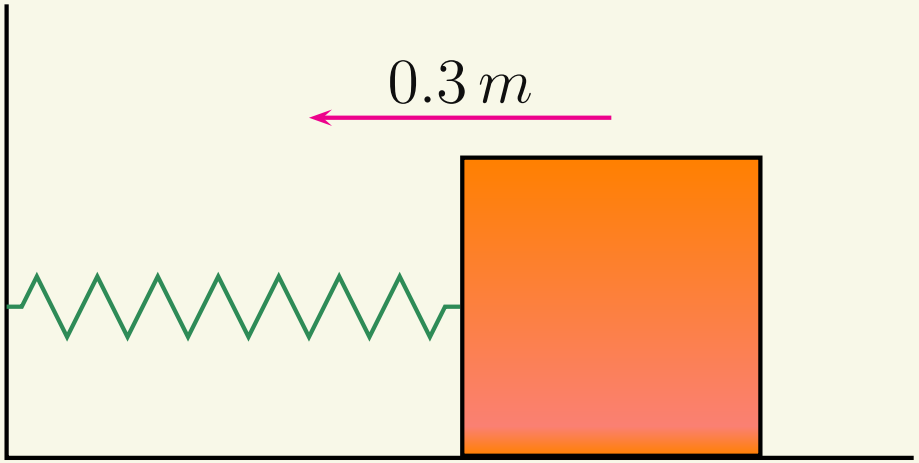

(a) $30\,N,$ Left

(b) $30\,N,$ Right

(c) $20\,N,$ Left

(d) $20\,N,$ Right

(e) $50\,N,$ Right

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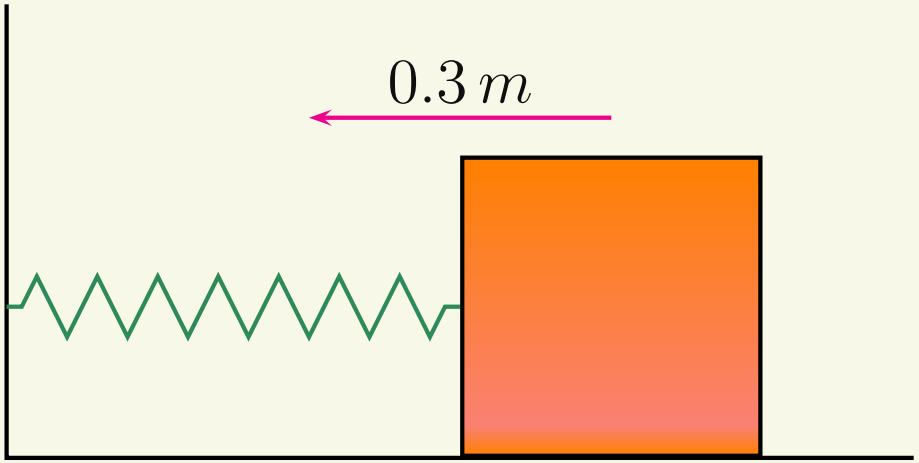

(a) $30\,N,$ Left

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(e) $50\,N,$ Right

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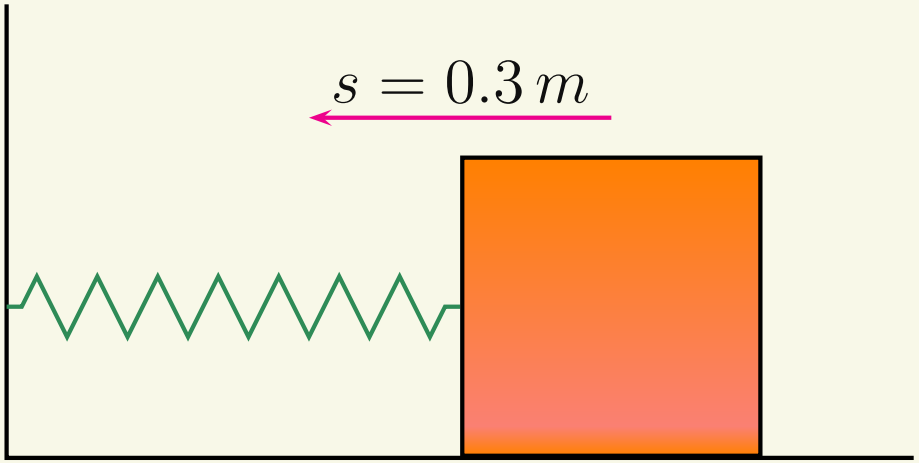
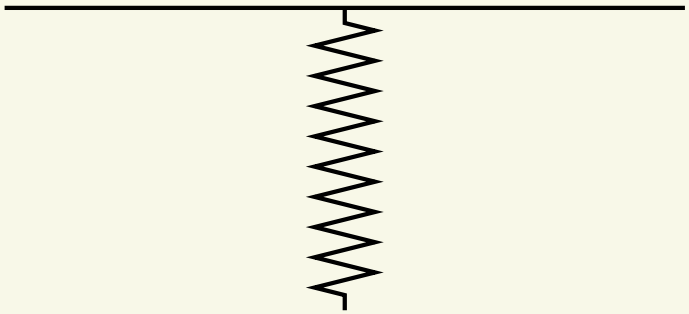
$$F_{sp} = (100\,N/m)\,(0.3\,m)$$



(b) $30\,N$, Right

Springs pull when stretched and push when compressed

Work to Stretch a Spring



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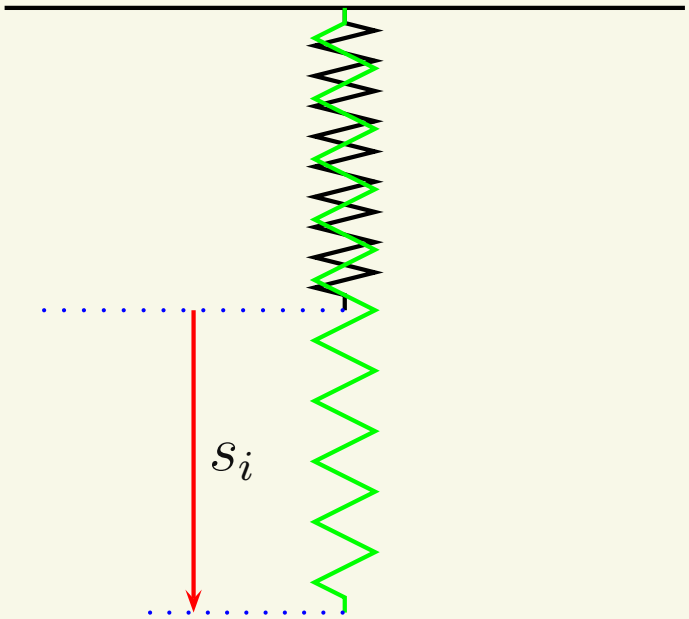

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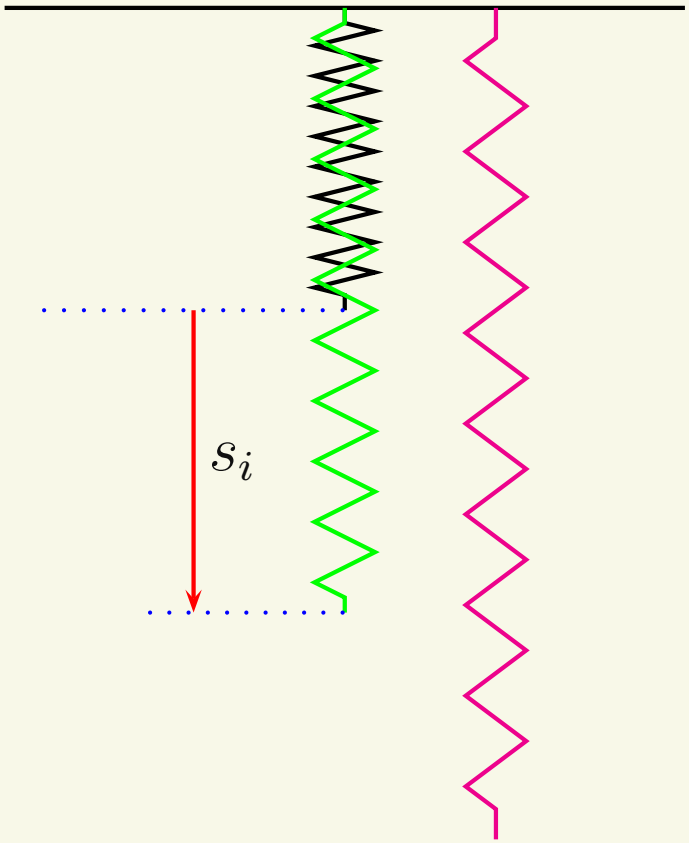

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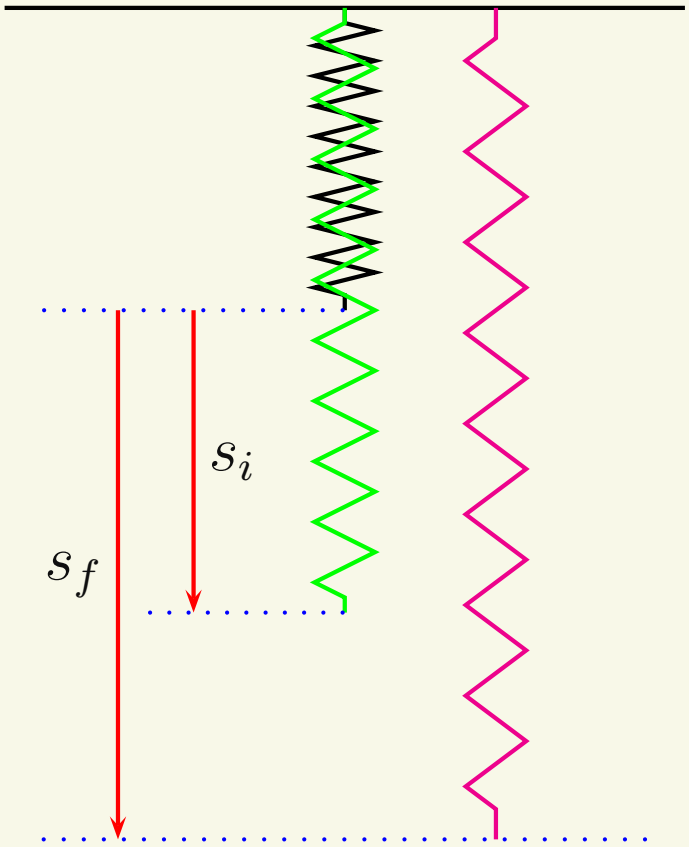

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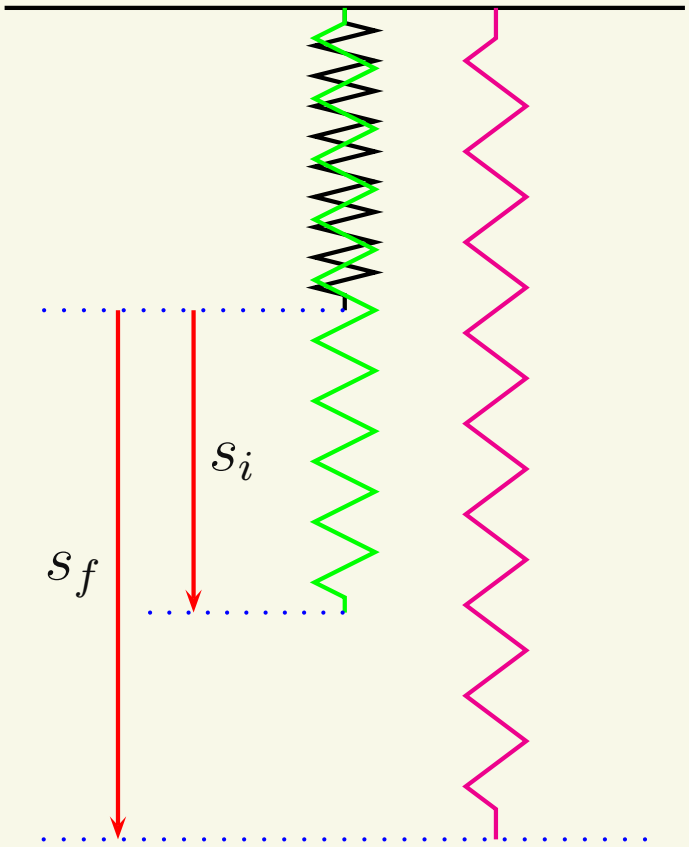

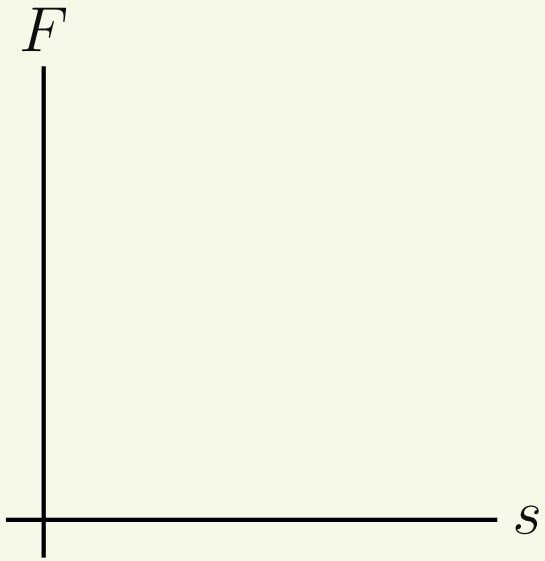

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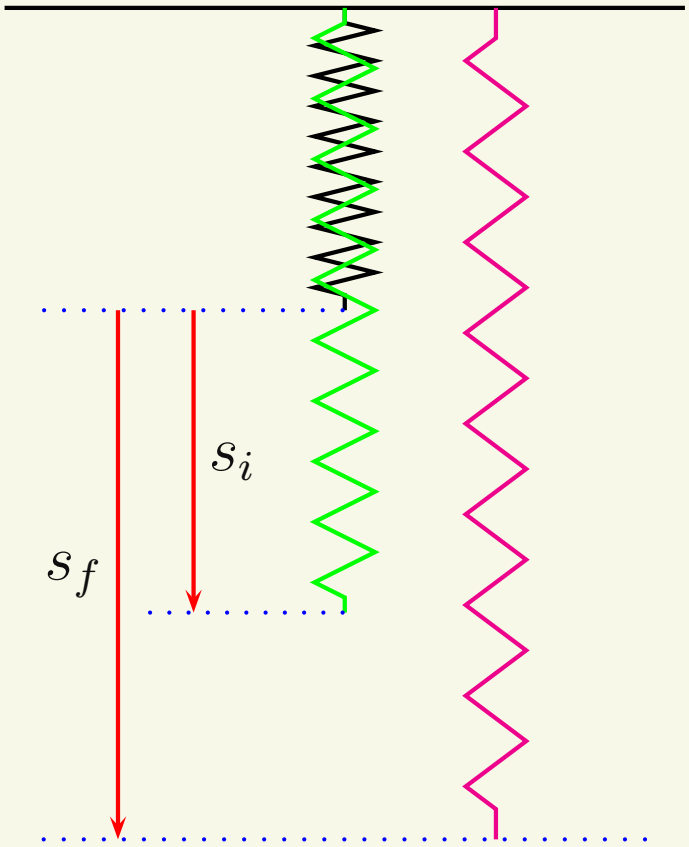

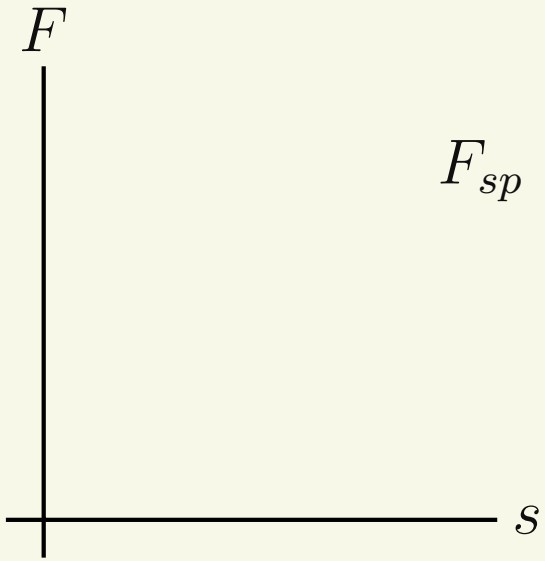

$$F_{sp} = ks$$

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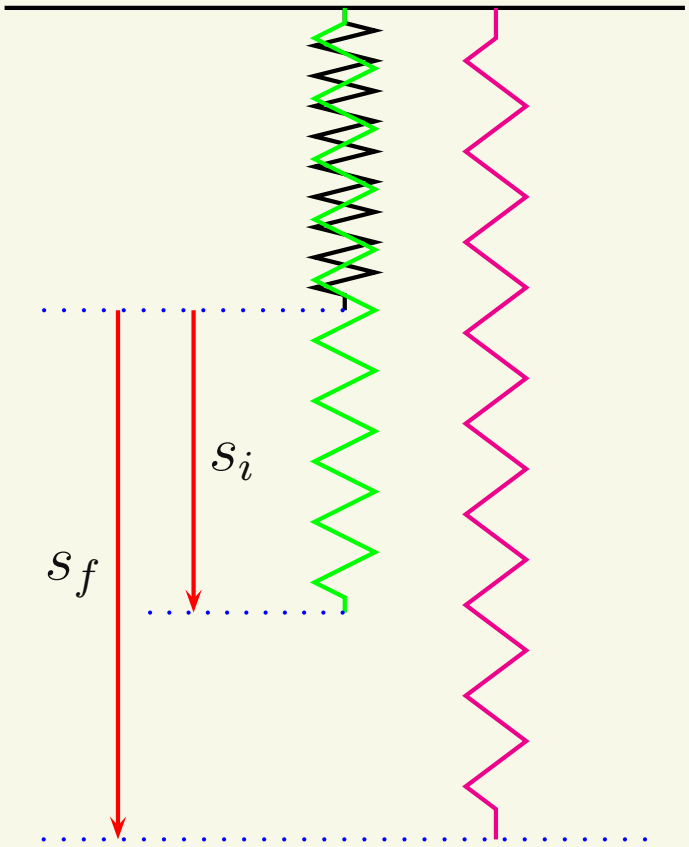

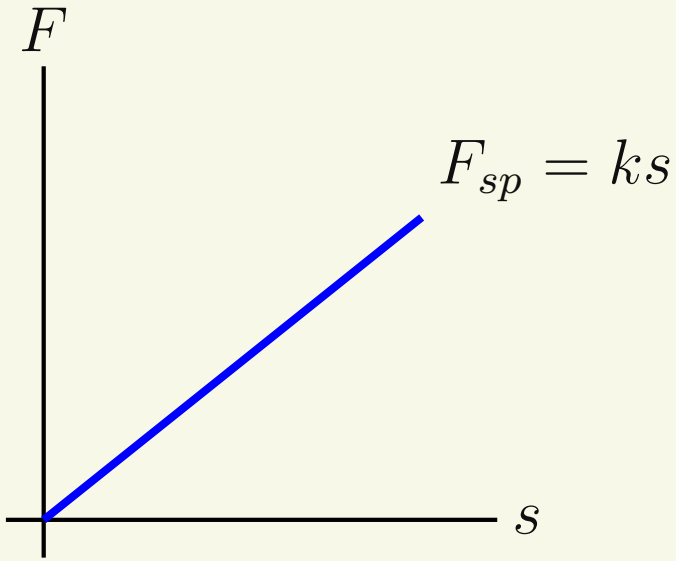

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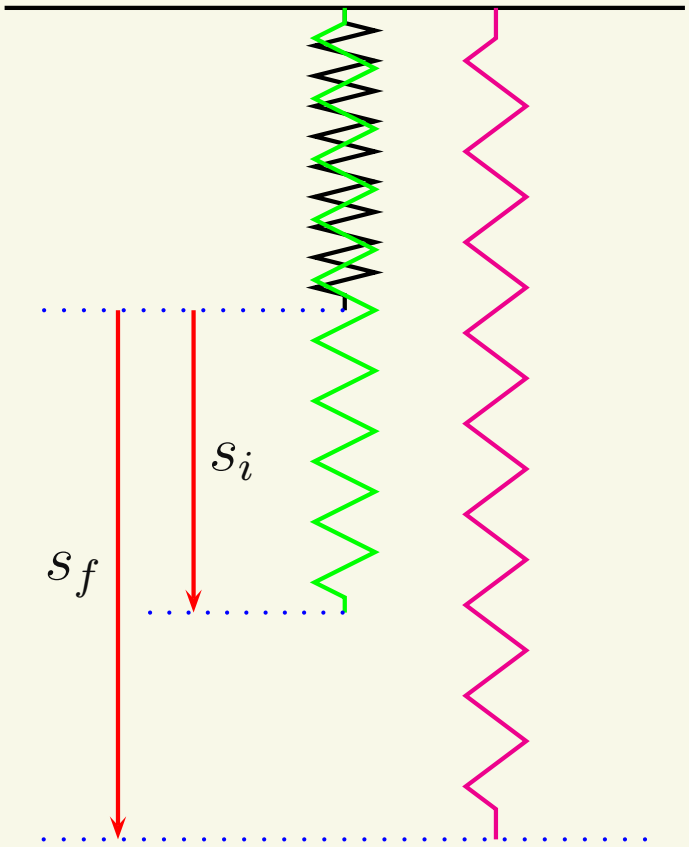

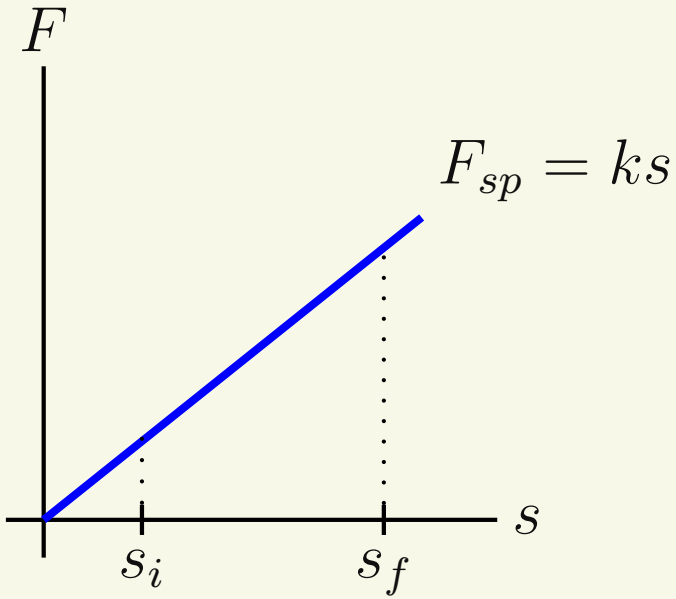

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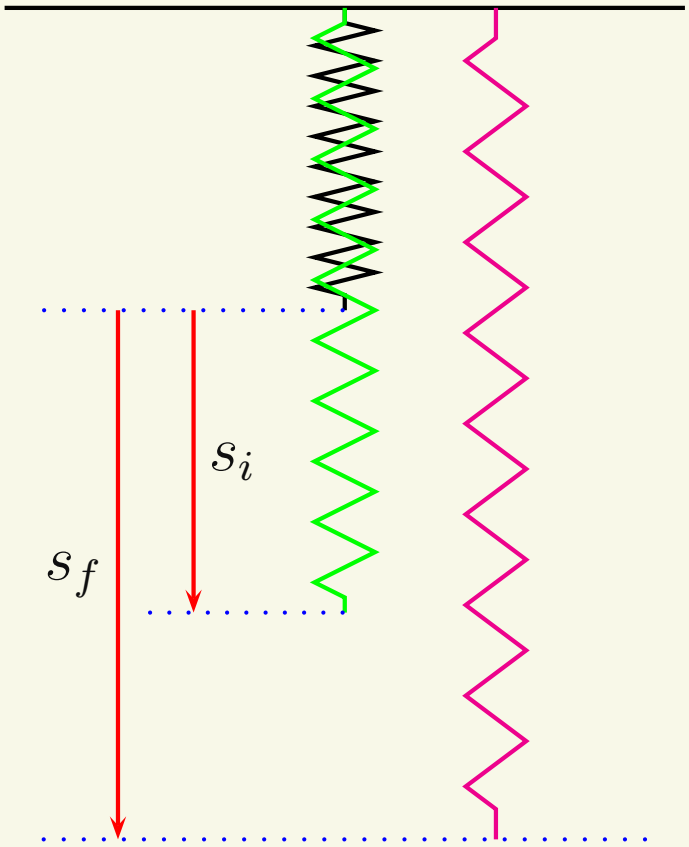

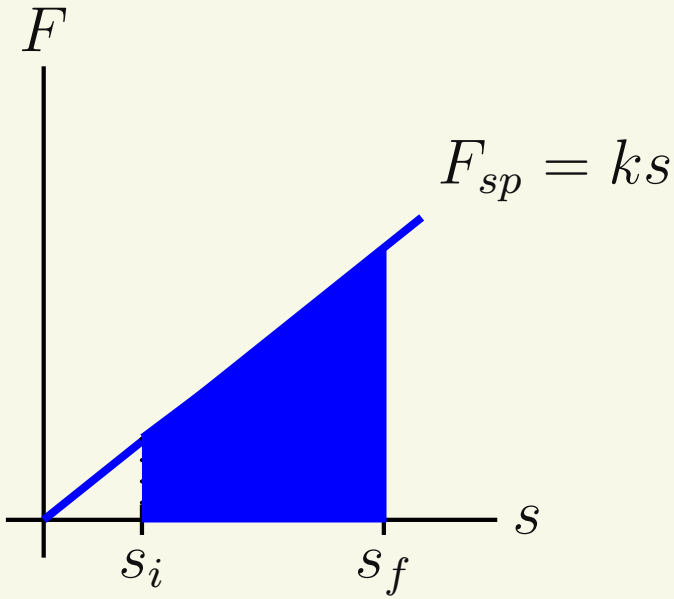

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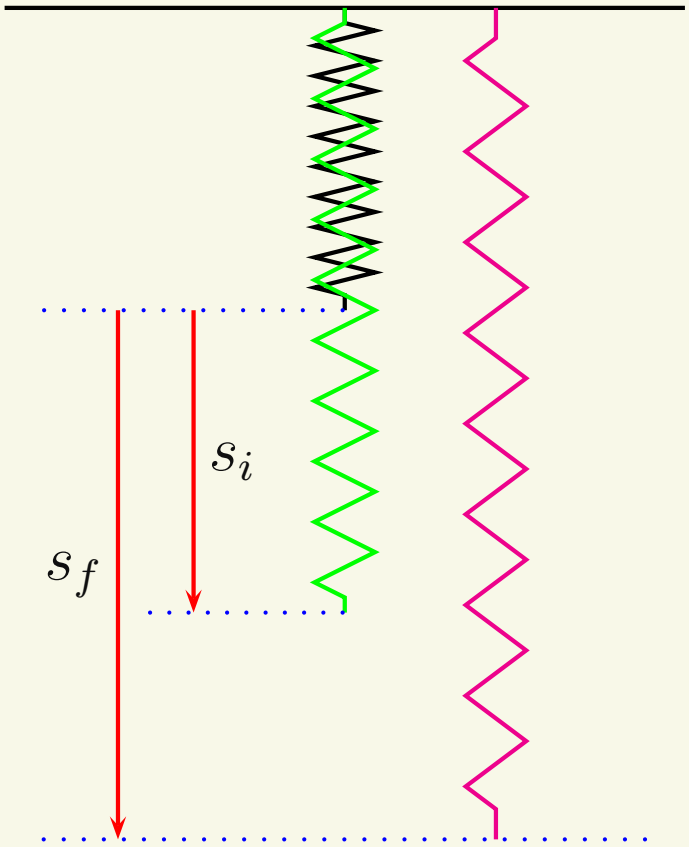
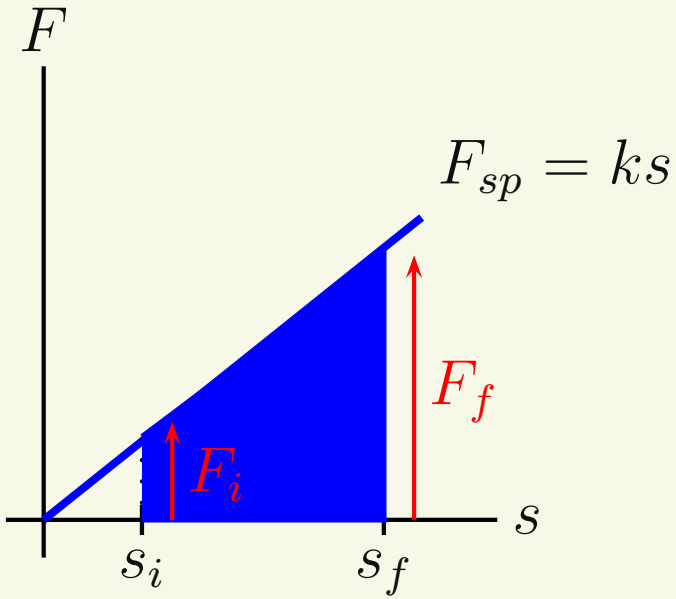
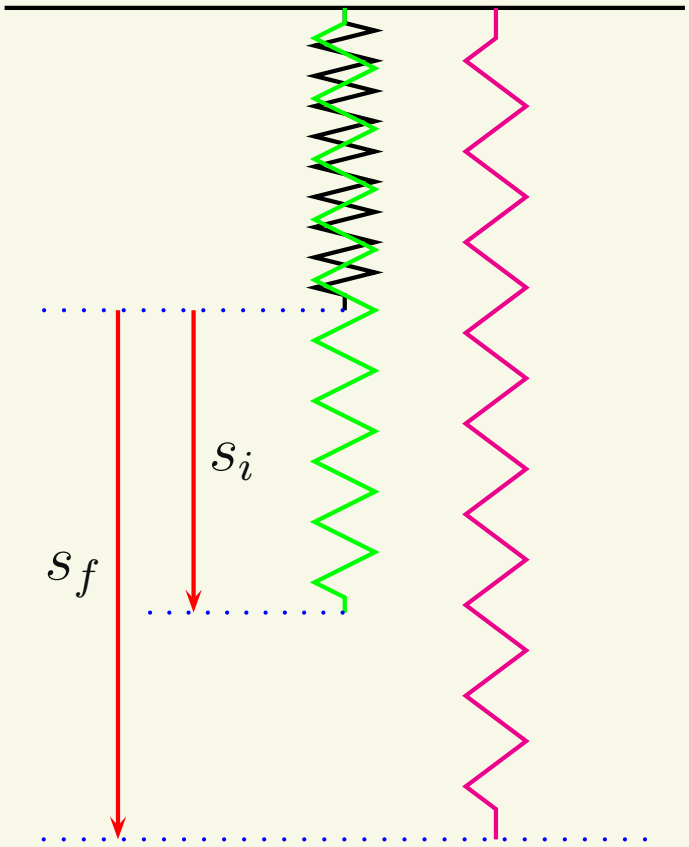
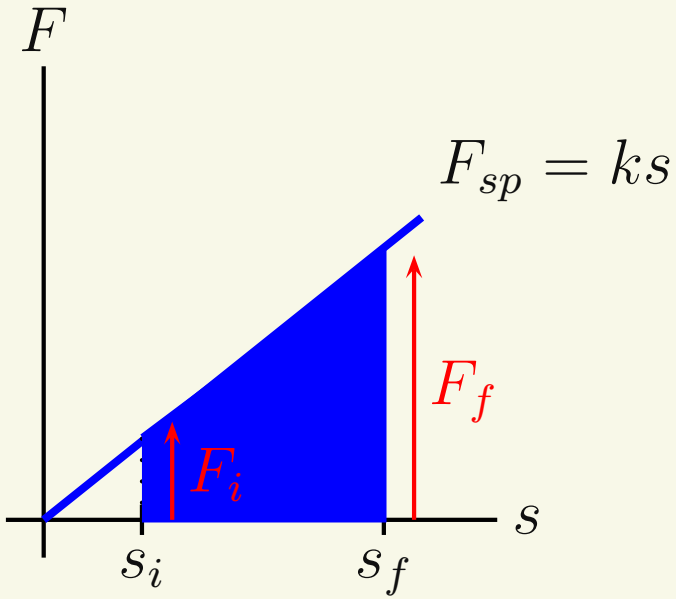




$$W = \tfrac{1}{2}(s_f)(F_f) - \tfrac{1}{2}(s_i)(F_i)$$

Work to Stretch a Spring





$$W = \tfrac{1}{2}(s_f)(F_f) - \tfrac{1}{2}(s_i)(F_i)$$

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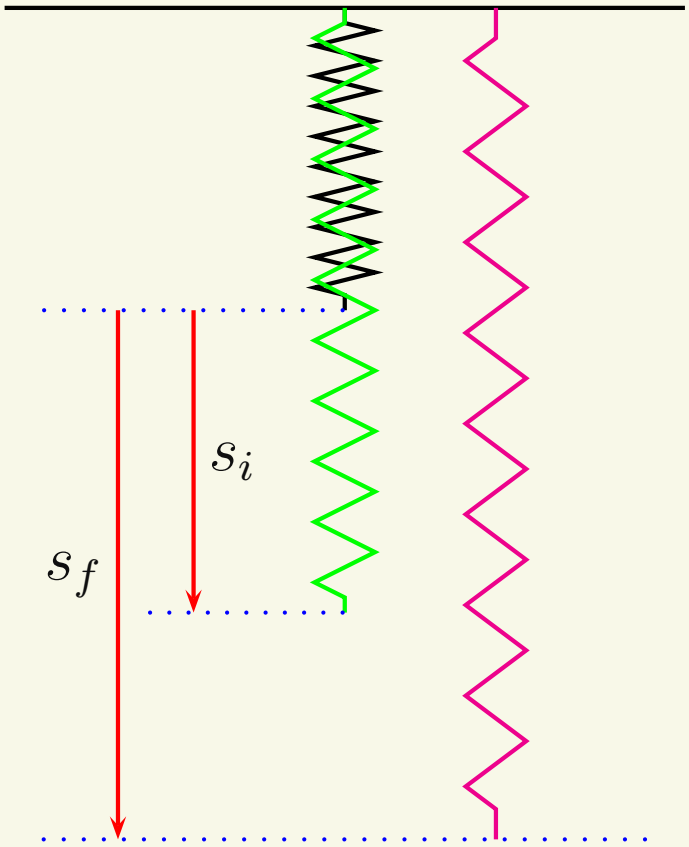

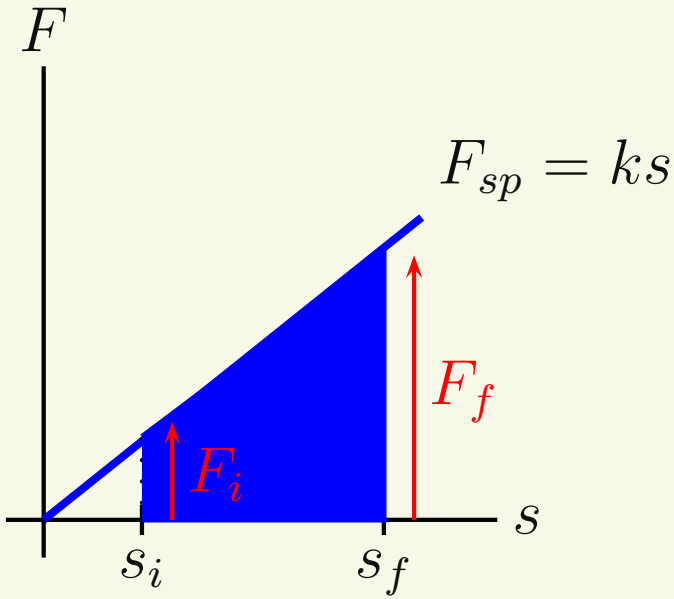

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Elastic Potential energy - Potential energy due to a spring.

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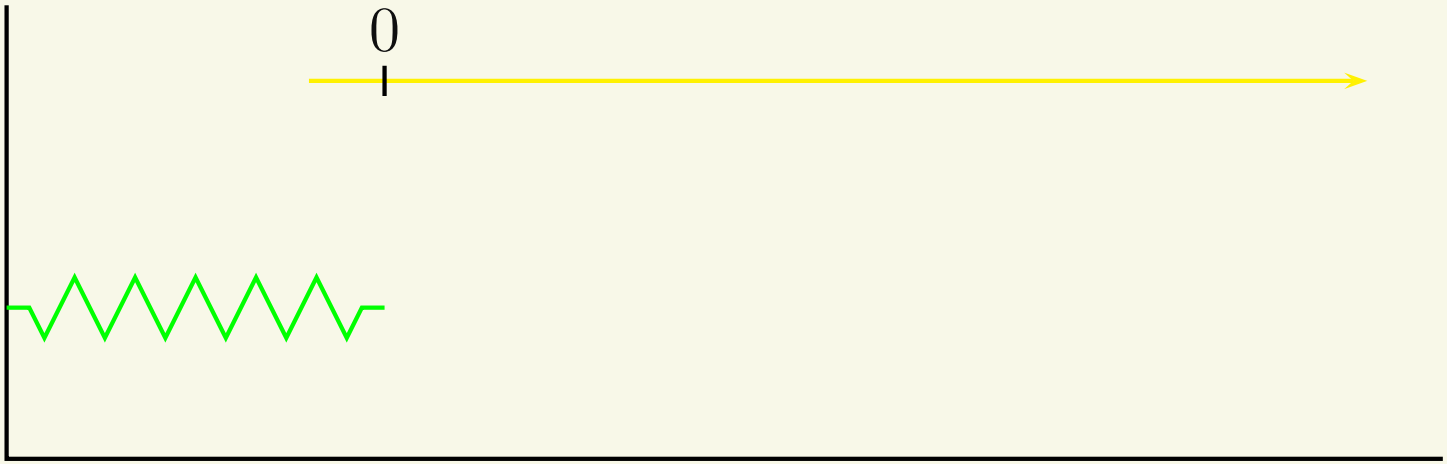

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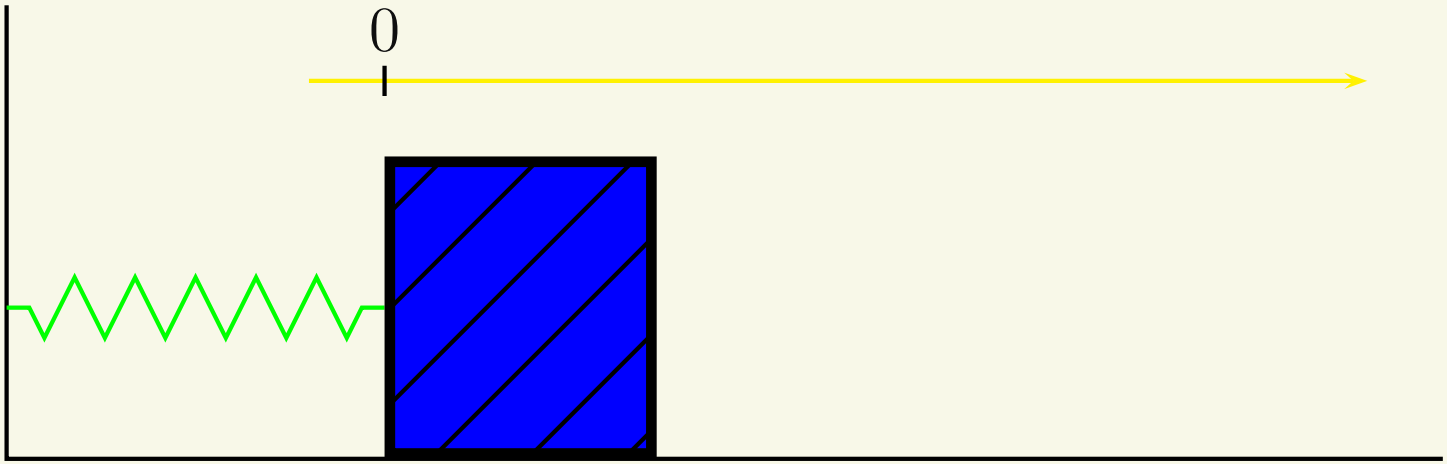

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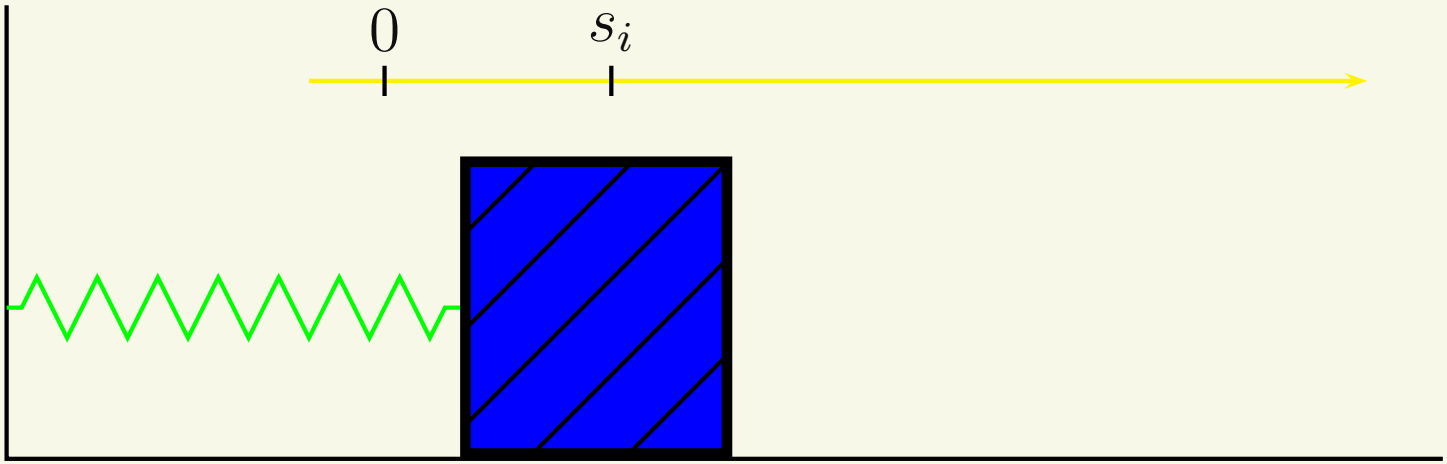

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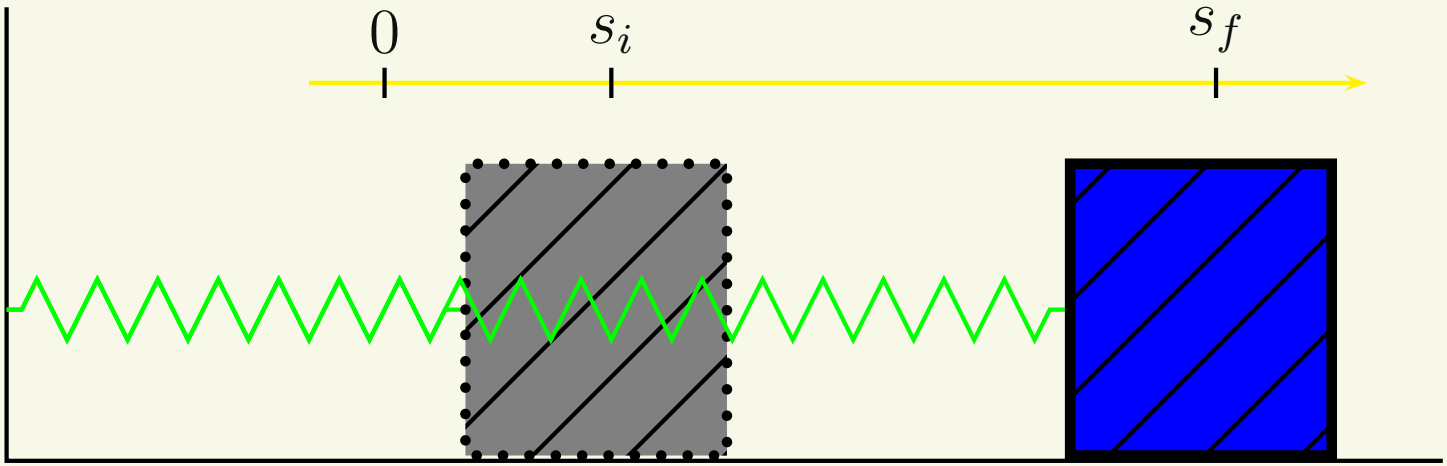

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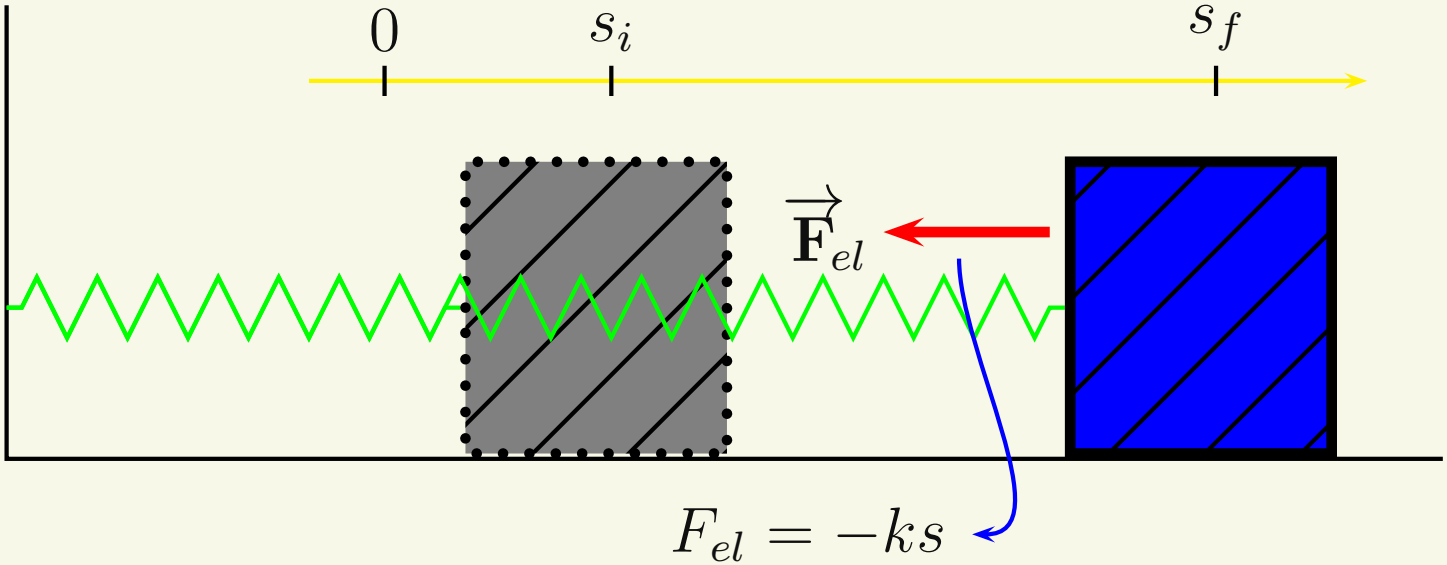

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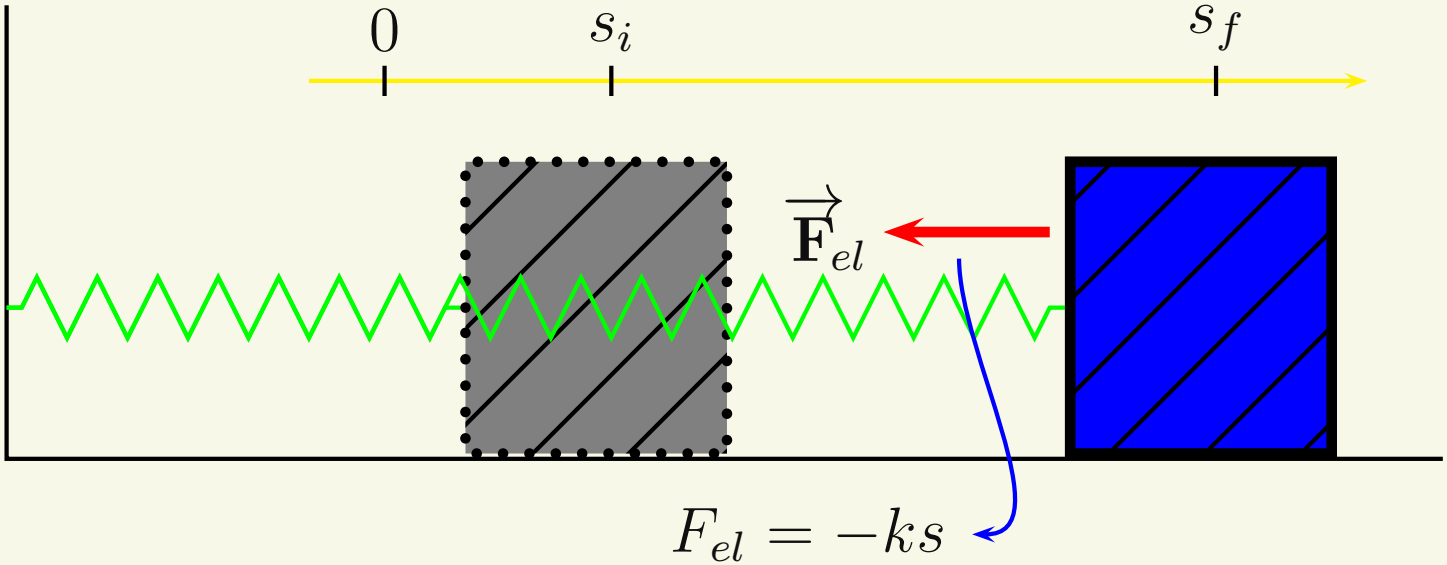

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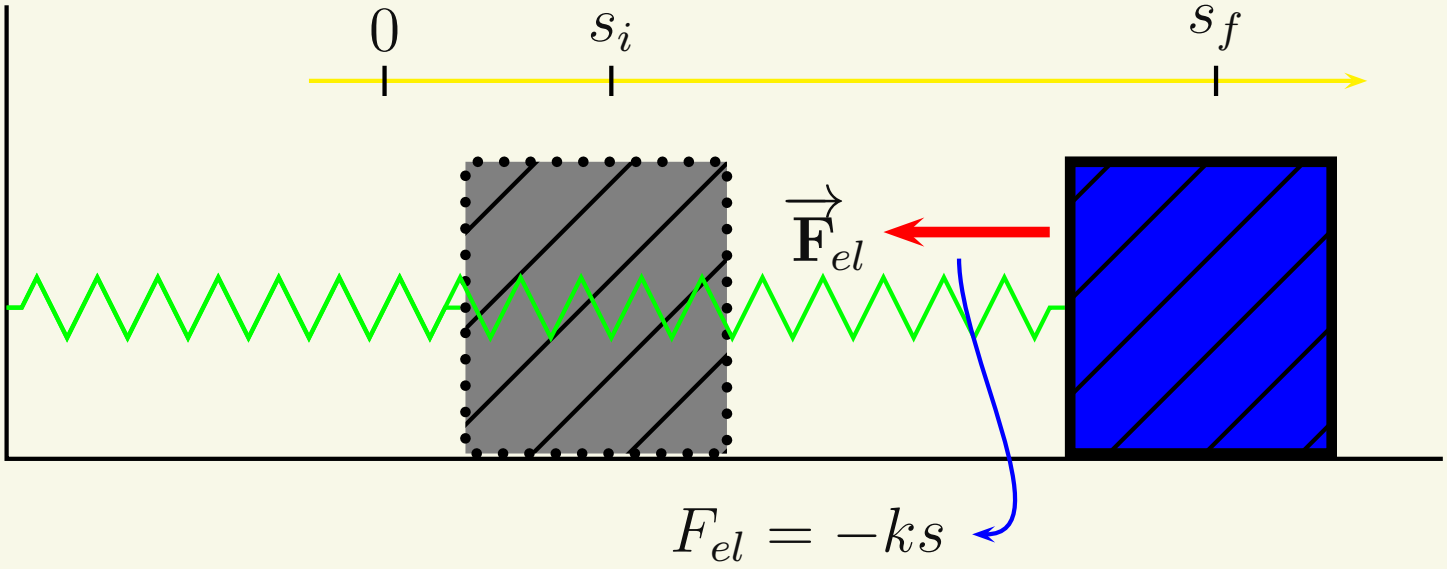

$$W_{el} = -\Delta U_{el} \Rightarrow \boxed{U_{el} = \frac{1}{2}ks^2}$$

Conservation of Elastic Energy

If a spring is the only force doing work on something,

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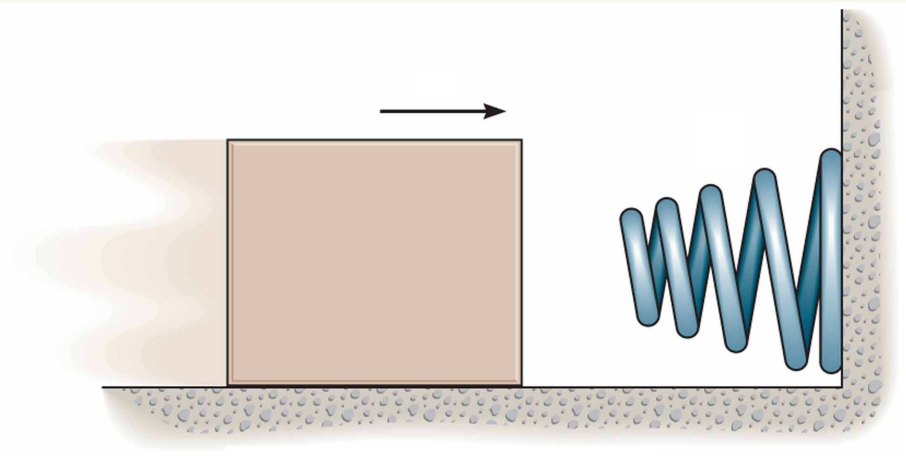
Elastic Potential Energy Exercise

A 10-kg mass slides across a frictionless, horizontal floor going $5\,m/s$ (and therefore has $125\,J$ of kinetic energy) when it collides with the $k = 500\,N/m$ spring shown. What is the maximum compression of the spring?



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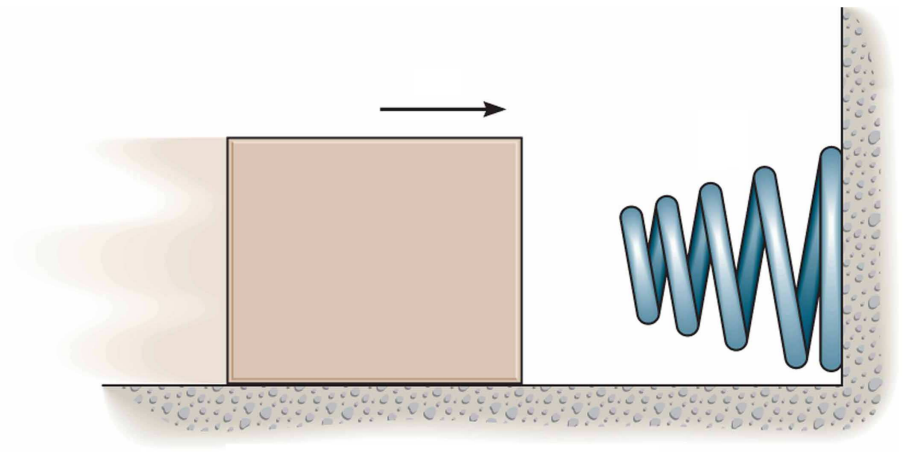

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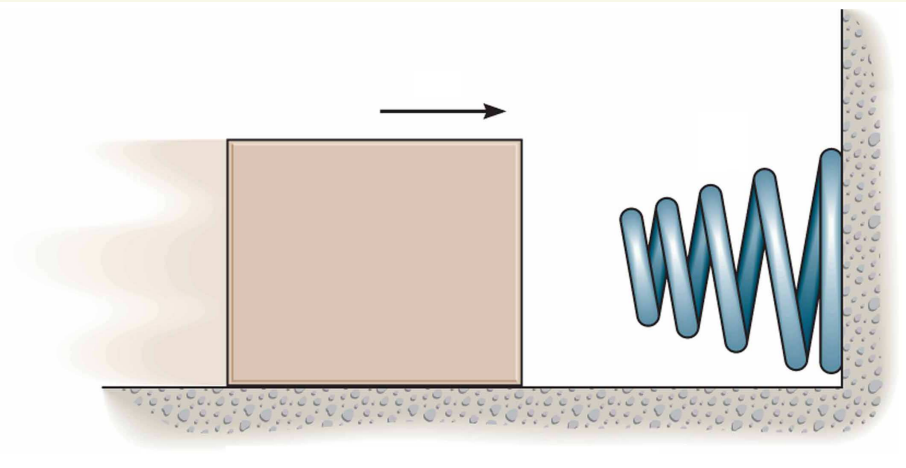

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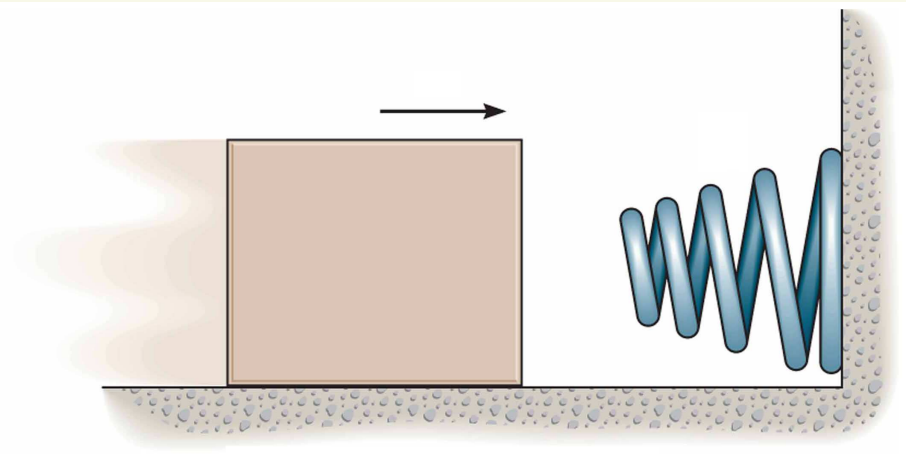

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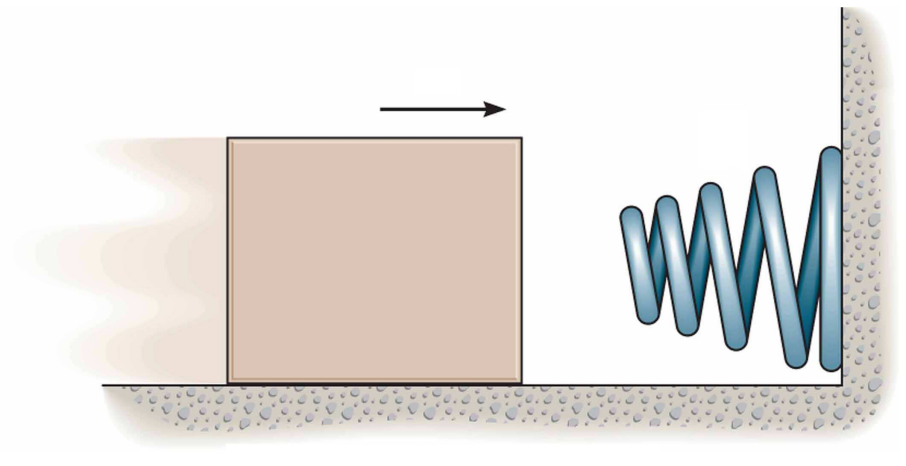

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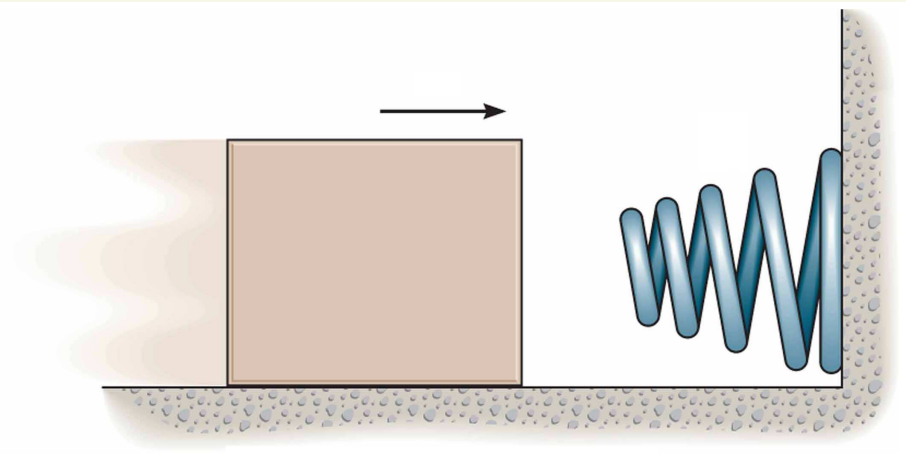

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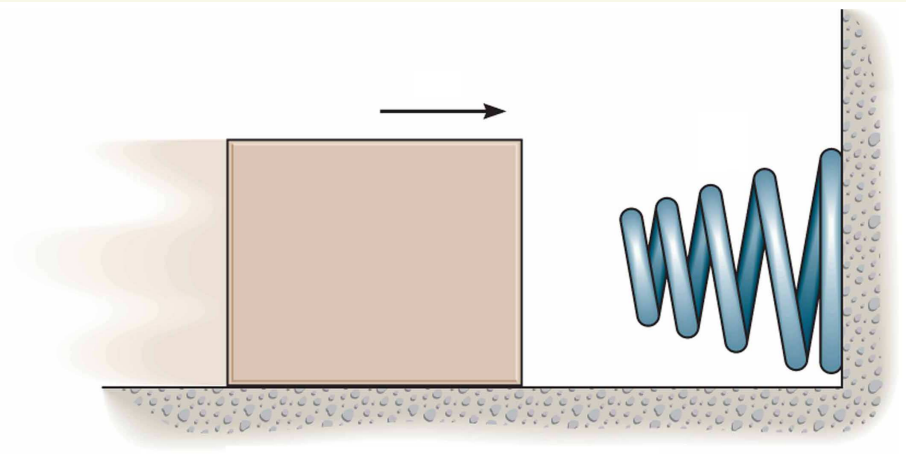

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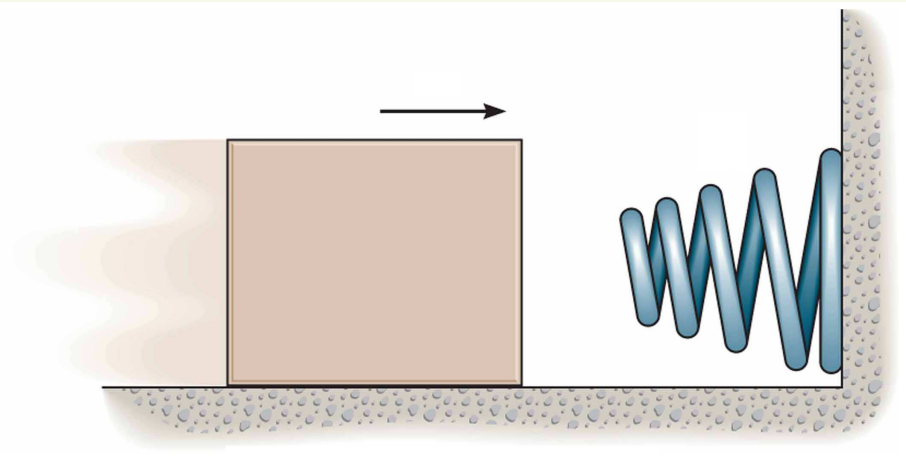

$$\frac{1}{2}mv_i^2 + \frac{1}{2}ks_i^2 = \frac{1}{2}mv_f^2 + \frac{1}{2}ks_f^2$$

$$v_i = 5\,m/s \quad s_i = 0 \quad v_f = 0 \quad s_f = ?$$

$$\Rightarrow 125\,J + 0 = 0 + \frac{1}{2}(500\,N/m)s_f^2$$

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General Energy Problems

The most general problems (this term) involve gravity, springs, and other forces all doing work.

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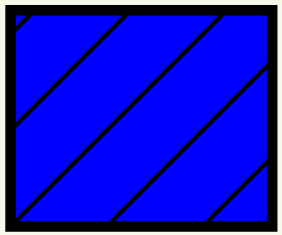

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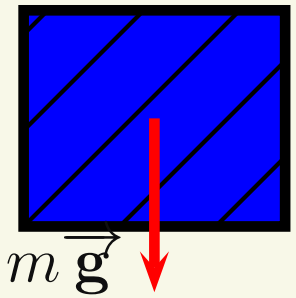

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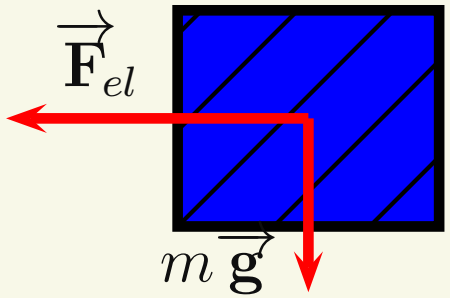

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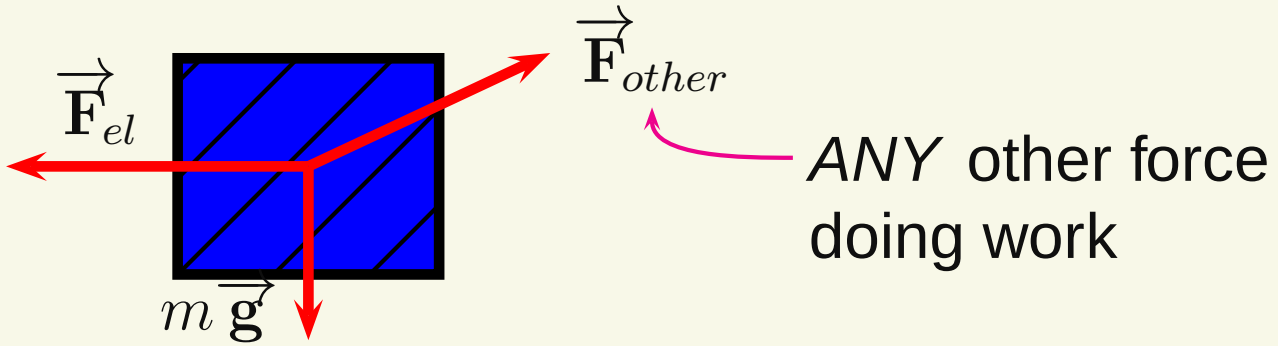

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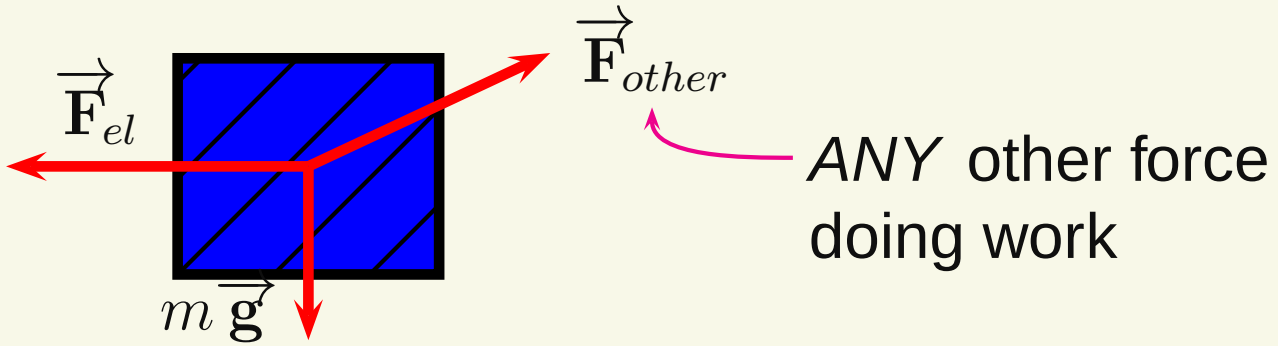

$$W_{total} = W_g + W_{el} + W_{other}$$

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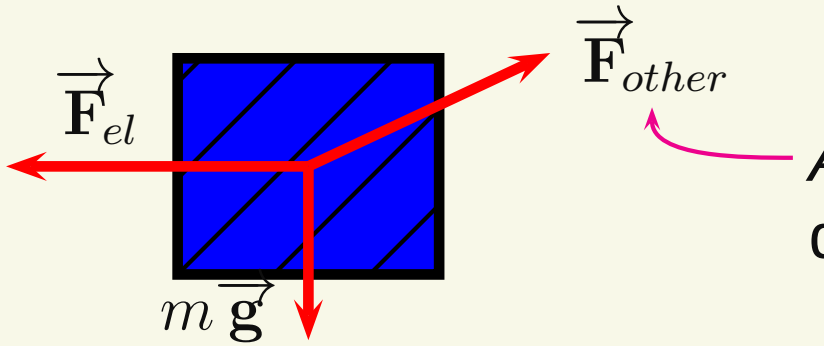

ANY other force doing work

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ΔK

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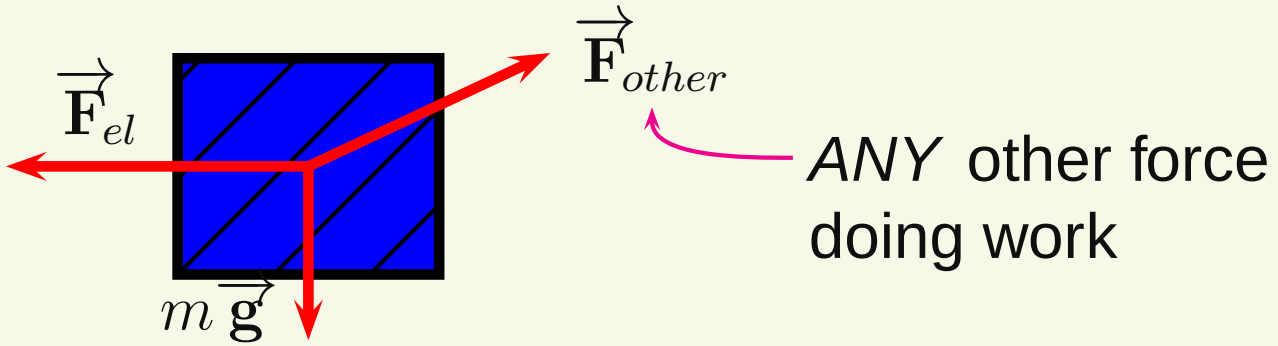

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$-\Delta U_g$

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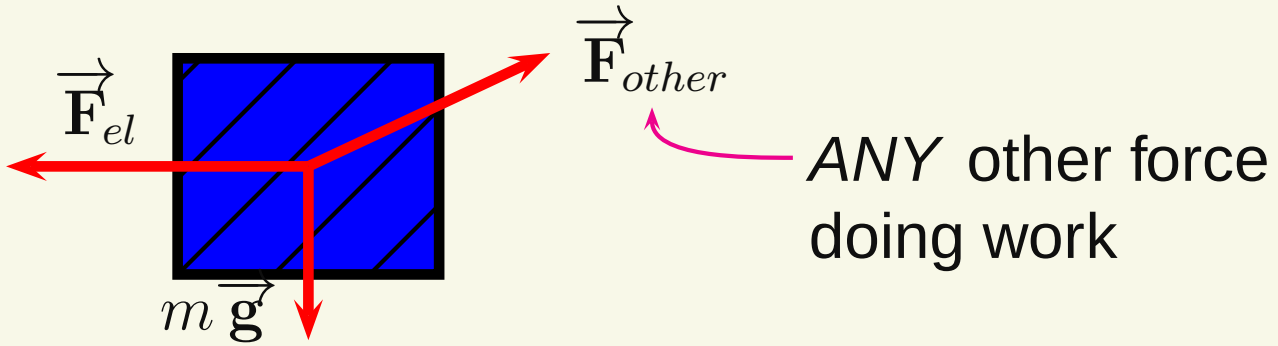

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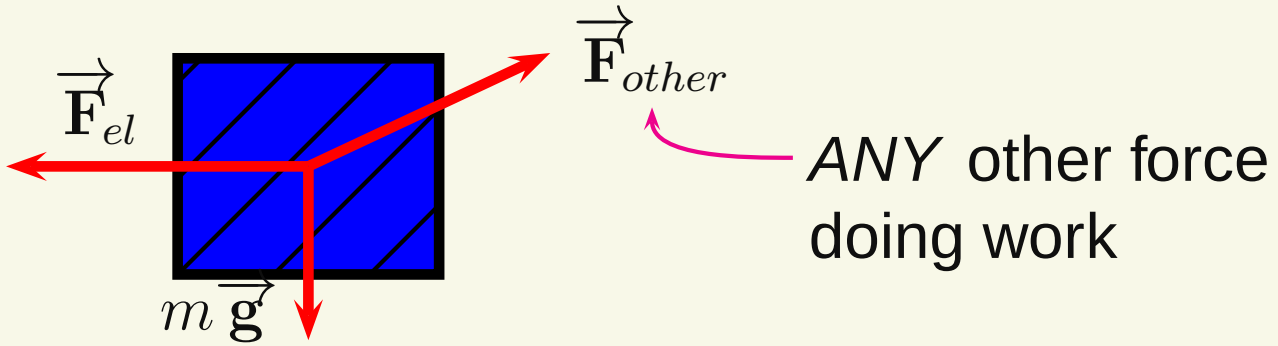

$$W_{total} = W_g + W_{el} + W_{other}$$

$W_{total} \rightarrow \Delta K$

$W_g \rightarrow -\Delta U_g$

$W_{el} \rightarrow -\Delta U_{el}$

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W_{other} = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2$$

General Energy Conservation III

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Example: An $80\,kg$ man jumps onto a spring platform ($k = 18000\,N/m$) going $9\,m/s$. How far does he compress the spring?

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Example: An $80\,kg$ man skydives from a plane $1600\,m$ above the ground. If he lands with a speed of $10\,m/s$ (and was essentially at rest when he jumped), how much work did his parachute do?