4. Increasing Magnetic Flux

Hob Nilre & Bo C. Herlin
hob.nilre@gmail.com

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Contents

1 Abstract

By using the template in our third paper[4] it becomes easy to make a template for the 'elastic collision' and then show if magnetic flux increase in a CLL-system.

2 The Template

The template assumes a lossless system:

$$ay'' + by' + cy = 0 \tag{1a}$$
$$a > 0 \tag{1b}$$
$$b = 0 \tag{1c}$$
$$c = c_1 + c_2 \tag{1d}$$
$$ay'' + (c_1 + c_2)y = 0 \tag{1e}$$
$$y_0 = \frac{z_1 - z_2}{c} \tag{1f}$$
$$y_0' = 0 \tag{1g}$$
$$y = y_0 \, cos(\sqrt{\frac{c}{a}} t) \tag{1h}$$

At $t = 0$ the 'elastic collision' begins and $y = y_0$. At $t = \pi \sqrt{\frac{a}{c}}$ it is completed and $y = -y_0$, therefore the template is:

$$y_0 = \frac{z_{1old} - z_{2old}}{c_1 + c_2} \tag{2a}$$
$$y_{1old} = \frac{z_{1old}}{c_1} \tag{2b}$$
$$y_{2old} = \frac{z_{2old}}{c_2} \tag{2c}$$
$$y_{1new} = y_{1old} - 2y_0 \tag{2d}$$
$$y_{2new} = y_{2old} + 2y_0 \tag{2e}$$
$$z_{1new} = c_1 y_{1new} \tag{2f}$$
$$z_{2new} = c_2 y_{2new} \tag{2g}$$

Which corresponds to our previous paper[3].

If $c_1 > c_2$ and $z_{1old} > 0$ then $\sum |y|$ will increase when $y_{1old} < 2y_0$.

3   Increasing Absolute Momentum Revisited

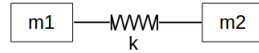The system used is a lossless kbm[4]: $k^{-1}p'' + (m_1^{-1} + m_2^{-1})p = 0$.

Figure 1: Transfer of momentum

From the template above we have:

$$p_0 = \frac{m_1 m_2 (v_{1old} - v_{2old})}{m_1 + m_2} \tag{3a}$$

$$p_{1old} = m_1 v_{1old} \tag{3b}$$

$$p_{2old} = m_2 v_{2old} \tag{3c}$$

$$p_{1new} = p_{1old} - 2p_0 \tag{3d}$$

$$p_{2new} = p_{2old} + 2p_0 \tag{3e}$$

$$v_{1new} = \frac{p_{1new}}{m_1} \tag{3f}$$

$$v_{2new} = \frac{p_{2new}}{m_2} \tag{3g}$$

If $m_1 < m_2$ and $v_{1old} > 0$ then $\sum |p|$ will increase when $p_{1old} < 2p_0$. Let us reuse the example from the previous paper[2]:

$$m_1 = 2\,kg \tag{4a}$$

$$v_1 = 1\,m/s \tag{4b}$$

$$m_2 = 3\,kg \tag{4c}$$

$$v_2 = 0\,m/s \tag{4d}$$

And so:

$$p_0 = \frac{2 * 3 * (1 - 0)}{2 + 3} = \frac{6}{5}\,kg\,m/s \tag{5a}$$

$$p_{1old} = 2 * 1 = 2\,kg\,m/s \tag{5b}$$

$$p_{2old} = 3 * 0 = 0\,kg\,m/s \tag{5c}$$

$$p_{1new} = 2 - 2 * \frac{6}{5} = -\frac{2}{5}\,kg\,m/s \tag{5d}$$

$$p_{2new} = 0 + 2 * \frac{6}{5} = \frac{12}{5}\,kg\,m/s \tag{5e}$$

$$v_{1new} = -\frac{\frac{2}{5}}{2} = -\frac{1}{5}\,m/s \tag{5f}$$

$$v_{2new} = \frac{\frac{12}{5}}{3} = \frac{4}{5}\,m/s \tag{5g}$$

$\sum |p|$ has increased from $2\,kg\,m/s$ to $\frac{14}{5} = 2.8\,kg\,m/s$.

4   Increasing Absolute Charge Revisited

The system used is a lossless LRC[4]: $LQ'' + (C_1^{-1} + c_2^{-1})Q = 0$.
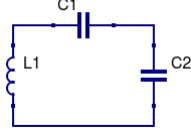   From the template above we have:

Figure 2: Transfer of charge

$$Q_0 = \frac{C_1 C_2 (V_{1old} - V_{2old})}{C_1 + C_2} \tag{6a}$$

$$Q_{1old} = C_1 V_{1old} \tag{6b}$$

$$Q_{2old} = C_2 V_{2old} \tag{6c}$$

$$Q_{1new} = Q_{1old} - 2Q_0 \tag{6d}$$

$$Q_{2new} = Q_{2old} + 2Q_0 \tag{6e}$$

$$V_{1new} = \frac{Q_{1new}}{C_1} \tag{6f}$$

$$V_{2new} = \frac{Q_{2new}}{C_2} \tag{6g}$$

If $C_1 < C_2$ and $V_{1old} > 0$ then $\sum |Q|$ will increase when $Q_{1old} < 2Q_0$. Let us reuse the example from the previous paper[2]:

$$C_1 = 2\,F \tag{7a}$$

$$V_1 = 1\,V \tag{7b}$$

$$C_2 = 3\,F \tag{7c}$$

$$V_2 = 0\,V \tag{7d}$$

And so:

$$Q_0 = \frac{2 * 3 * (1 - 0)}{2 + 3} = \frac{6}{5}\,C \tag{8a}$$

$$Q_{1old} = 2 * 1 = 2\,C \tag{8b}$$

$$Q_{2old} = 3 * 0 = 0\,C \tag{8c}$$

$$Q_{1new} = 2 - 2 * \frac{6}{5} = -\frac{2}{5}\,C \tag{8d}$$

$$Q_{2new} = 0 + 2 * \frac{6}{5} = \frac{12}{5}\,C \tag{8e}$$

$$V_{1new} = -\frac{\frac{2}{5}}{2} = -\frac{1}{5}\,V \tag{8f}$$

$$V_{2new} = \frac{\frac{12}{5}}{3} = \frac{4}{5}\,V \tag{8g}$$

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$\sum |Q|$ has increased from $2\,C$ to $\frac{14}{5} = 2.8\,C$.

5   Increasing Absolute Distance

The system used is a lossless mbk[4]: $mx'' + (k_1 + k_2)x = 0$.

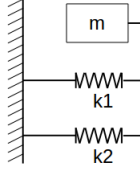
Figure 3: Transfer of distance

From the template above we have:

$$x_0 = \frac{F_{1old} - F_{2old}}{k_1 + k_2} \tag{9a}$$

$$x_{1old} = \frac{F_{1old}}{k_1} \tag{9b}$$

$$x_{2old} = \frac{F_{2old}}{k_2} \tag{9c}$$

$$x_{1new} = x_{1old} - 2x_0 \tag{9d}$$

$$x_{2new} = x_{2old} + 2x_0 \tag{9e}$$

$$F_{1new} = k_1 x_{1new} \tag{9f}$$

$$F_{2new} = k_2 x_{2new} \tag{9g}$$

If $k_1 > k_2$ and $F_{1old} > 0$ then $\sum |x|$ will increase when $x_{1old} < 2x_0$. Let us reuse the numbers from the previous paper[2]:

$$k_1 = \frac{1}{2}\,N/m \tag{10a}$$

$$F_1 = 1\,N \tag{10b}$$

$$k_2 = \frac{1}{3}\,N/m \tag{10c}$$

$$F_2 = 0\,N \tag{10d}$$

And so:

$$x_0 = \frac{1-0}{\frac{1}{2}+\frac{1}{3}} = \frac{6}{5}\,m \tag{11a}$$

$$x_{1old} = \frac{1}{\frac{1}{2}} = 2\,m \tag{11b}$$

$$x_{2old} = \frac{0}{\frac{1}{3}} = 0\,m \tag{11c}$$

$$x_{1new} = 2 - 2*\frac{6}{5} = -\frac{2}{5}\,m \tag{11d}$$

$$x_{2new} = 0 + 2*\frac{6}{5} = \frac{12}{5}\,m \tag{11e}$$

$$F_{1new} = -\frac{1}{2}*\frac{2}{5} = -\frac{1}{5}\,N \tag{11f}$$

$$F_{2new} = \frac{1}{3}*\frac{12}{5} = \frac{4}{5}\,N \tag{11g}$$

$\sum |x|$ has increased from $2\,m$ to $\frac{14}{5} = 2.8\,m$ where x is the offset from where the spring exerts no force.

6   Increasing Absolute Magnetic Flux Linkage

The system used is a lossless CRL[4]: $C\Lambda'' + (L_1^{-1} + L_2^{-1})\Lambda = 0$ where $\Lambda = \Phi N$ and is referred to as magnetic flux linkage.
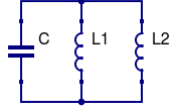
Figure 4: Transfer of magnetic flux linkage

From the template above we have:

$$\Lambda_0 = \frac{L_1 L_2 (I_{1old} - I_{2old})}{L_1 + L_2} \tag{12a}$$

$$\Lambda_{1old} = L_1 I_{1old} \tag{12b}$$

$$\Lambda_{2old} = L_2 I_{2old} \tag{12c}$$

$$\Lambda_{1new} = \Lambda_{1old} - 2\Lambda_0 \tag{12d}$$

$$\Lambda_{2new} = \Lambda_{2old} + 2\Lambda_0 \tag{12e}$$

$$I_{1new} = \frac{\Lambda_{1new}}{L_1} \tag{12f}$$

$$I_{2new} = \frac{\Lambda_{2new}}{L_2} \tag{12g}$$

If $L_1 < L_2$ and $I_{1old} > 0$ then $\sum |\Lambda|$ will increase when $\Lambda_{1old} < 2\Lambda_0$. Let us reuse the numbers from the previous paper[2]:

$$L_1 = 2\,H \tag{13a}$$

$$I_1 = 1\,A \tag{13b}$$

$$L_2 = 3\,H \tag{13c}$$

$$I_2 = 0\,A \tag{13d}$$

And so:

$$\Lambda_0 = \frac{2 * 3 * (1 - 0)}{2 + 3} = \frac{6}{5}\,Wb \tag{14a}$$

$$\Lambda_{1old} = 2 * 1 = 2\,Wb \tag{14b}$$

$$\Lambda_{2old} = 3 * 0 = 0\,Wb \tag{14c}$$

$$\Lambda_{1new} = 2 - 2 * \frac{6}{5} = -\frac{2}{5}\,Wb \tag{14d}$$

$$\Lambda_{2new} = 0 + 2 * \frac{6}{5} = \frac{12}{5}\,Wb \tag{14e}$$

$$I_{1new} = -\frac{\frac{2}{5}}{2} = -\frac{1}{5}\,A \tag{14f}$$

$$I_{2new} = \frac{\frac{12}{5}}{3} = \frac{4}{5}\,A \tag{14g}$$

$\sum |\Lambda|$ has increased from $2\,Wb$ to $\frac{14}{5} = 2.8\,Wb$. But remember that $\Lambda = \Phi N$ so what happened to the flux Φ without the linkage N?

A_L is frequently specified by transformer-core manufacturers and is defined as:

$$A_L = \frac{L}{N^2} \tag{15}$$

It can be used for any coil. As an example, for a multilayer air-core coil[1]:

$$L = \frac{4}{5}\frac{r^2 N^2}{6r + 9l + 10d} \tag{16a}$$

$$A_L = \frac{4}{5}\frac{r^2}{6r + 9l + 10d} \tag{16b}$$

If we assume $A_{L_1} = A_{L_2}$ we can substitute $N = \sqrt{L/A_L}$ and calculate:

$$\Lambda = \Phi N = \frac{\Phi\sqrt{L}}{\sqrt{A_L}} \tag{17a}$$

$$\frac{\Lambda}{\sqrt{L}} = \frac{\Phi N}{\sqrt{L}} = \frac{\Phi}{\sqrt{A_L}} \tag{17b}$$

which since $A_{L_1} = A_{L_2}$ will enable us to calculate:

$$\frac{\sum |\Phi_{new}|}{\sum \Phi_{old}} = \frac{\sum |\Lambda_{new}/\sqrt{L}|}{\sum \Lambda_{old}/\sqrt{L}} = \frac{\frac{2}{5}/\sqrt{2} + \frac{12}{5}/\sqrt{3}}{2/\sqrt{2}} \approx 1.18 \tag{18a}$$

$\sum |\Phi|$ has increased by a factor 1.18. Let us also calculate:

$$\frac{\sum \Phi_{new}}{\sum \Phi_{old}} = \frac{\sum \Lambda_{new}/\sqrt{L}}{\sum \Lambda_{old}/\sqrt{L}} = \frac{-\frac{2}{5}/\sqrt{2} + \frac{12}{5}/\sqrt{3}}{2/\sqrt{2}} \approx 0.78 \tag{19a}$$

$\sum \Phi$ has decreased by a factor 0.78.
$\sum E$ is still constant and so is $\sum \Phi^2$.

Watch an excellent experiment by youtube user **gotoluc** that we believe is relevant in this context: `https://www.youtube.com/watch?v=XfLcBD3Fy7M`.

7   Conclusion

While $\sum y$ is always constant $\sum |y|$ is sometimes not, just as shown in our previous paper[2] for momentum and charge. When $y = \Lambda = \Phi N$, as in the CRL-system, not even $\sum \Phi$ has to be constant.

A   In Plain English

In our previous paper[2] we proposed a template for comparing different simple harmonic systems, their variables and equations. In this paper, we compile a template to easily calculate the output of an elastic collision, and its equivalent in other systems. Also the conditions under which the sum of the absolute value of the system's momentum is no longer constant can be calculated. If the system comprises two coils and a capacitor in parallel, it is not just the sum of the absolute value of the magnetic fluxe linkages in the coils which may vary but also the sum of their magnetic fluxes.

B   På Ren Svenska

I vår förra artikel[2] föreslog vi en schablon för att kunna jämföra olika enkla harmoniska system, deras variabler och ekvationer. I denna artikel

sammanställer vi en schablon för att enkelt kunna beräkna utgången av en
elastisk kollision och dess motsvarighet i andra system. Även villkoren för
när summan av absolutvärdet av systemets rörelsemängd inte längre är kon-
stant kan beräknas. Om systemet består av två spolar och en kondensator
parallellt är det inte bara summan av absolutvärdet av de magnetiska flödes-
banden i spolarna som kan variera utan även summan av deras magnetiska
flöden.

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- `http://overunity.com/15796/elementary-physics-revisited/`
- `http://idipsum.se/home/elementary%20physics.html`
- `https://github.com/boherlin/elementary-physics/tree/master/pdf`

They are updated with new versions in an unpredictable manner, possi-
bly not on all sites but at least on the last two sites in the list, make sure
you always have the latest version! Their LaTeXsource-codes can be found at
`https://github.com/boherlin/elementary-physics/tree/master/src`. All
papers, but not all versions, have been stamped at `http://www.OriginStamp.org`.

If you enjoyed this paper, found value in it or want to help us, please consider
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References

[1] *Inductance formulas.* URL: `http://en.wikipedia.org/wiki/Inductor#Inductance_formulas`.

[2] Hob Nilre. *Increasing Momentum or Charge.* 2015. URL: `https://github.com/boherlin/elementary-physics/blob/master/papers/2-increasing-momentum-or-charge.pdf`.

Figure 5: 1B79p75vQw4Rb1GQdmGYpDapFwEytFJDqw

[3]   Hob Nilre. *Masses Combined in Series and in Parallel*. 2015. URL: https://github.com/boherlin/elementary-physics/blob/master/papers/1-masses-combined-in-series-and-in-parallel.pdf.

[4]   Hob Nilre. *Mechanical Electrical Analogies*. 2015. URL: https://github.com/boherlin/elementary-physics/blob/master/papers/3-mechanical-electrical-analogies.pdf.