Subject:
In the course of the lessons of mechanics and electricity the students get acquainted with the following linear relationships:

<table>
<thead>
<tr>
<th>Equation</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) ( F = -D \cdot s )</td>
<td>Hooke’s law</td>
</tr>
<tr>
<td>(2) ( p = m \cdot v )</td>
<td>none</td>
</tr>
<tr>
<td>(3) ( F = k \cdot v )</td>
<td>sometimes Stokes’ law of friction</td>
</tr>
<tr>
<td>(4) ( n\Phi = L \cdot I )</td>
<td>none</td>
</tr>
<tr>
<td>(5) ( Q = C \cdot U )</td>
<td>none</td>
</tr>
<tr>
<td>(6) ( U = R \cdot I )</td>
<td>Ohm’s law</td>
</tr>
</tbody>
</table>

Deficiencies:
The equations are part of a common structure of mechanics and electricity. They describe for each of both disciplines three passive linear components.

Each of the six equations is valid only within a sufficiently small range of the pertinent independent variable. A spring does no longer obey Hooke’s law if it is overstretched. Momentum is no longer proportional to velocity if the velocity is no longer small compared with \( c \). The frictional force is no longer proportional to the velocity if turbulence sets in. Magnetic flux and electric current intensity are no longer proportional to one another if the solenoid deforms under the action of the magnetic field. Electric charge and voltage do not obey a linear relationship if the distance of the capacitor’s plates changes under the influence of the tensional stress within the electric field. A resistor does no longer conform to Ohm’s law if the electric current gets too strong.

It is seen, that the linearity is each time a special case. This special case, however, is particularly important, since it is always valid provided that the independent variable’s value is not too great.

The well-known examples of the mechanical and the electric harmonic oscillator show how the equations are interrelated. In each of the two differential equations for damped harmonic oscillations three of the components, that correspond to the equations (1) to (6) are represented by a summand. To each component of the mechanical oscillator there is a corresponding component in the electric oscillating circuit. Due to the similarity of the mathematical structure of the differential equations the solutions of these equations have also the same structure.

Seen in this way, a relationship between the equations (1) to (6) becomes apparent and it would be logical to teach this structure to our students. Actually, we are used to proceed quite differently.

First, there are the names: We have well-established names only for equations (1) and (6): Hooke’s law and Ohm’s law. This observation is not at all marginal. An equation with a name is perceived as more important than a nameless formula.
More important is how the equations are “sold” to the students: Only equations (1), (5) and (6) are introduced as described above, i.e. as the expression of an observable linearity and as the definition of the factor of proportionality.

Relation (2) is presented as the equation that defines momentum. Therefore it does not reflect any observable property. As a pure definition it is not a law of nature. From this point of view it seems natural that the equation has no name.

Equation (3) is that law of mechanical friction which corresponds to Ohm’s law in electricity. The students learn it, if at all, only peripherally. In mechanics it is usually not mentioned. Apparently, friction between solids bodies is considered more important. But it is treated as the typical mechanism of friction in the context of oscillations. (It is obvious why.) Moreover, the law is used when teaching the Millikan experiment. One must hope that the students will not believe that Stokes' friction is a peculiarity of the Millikan experiment. The shock absorber of a car, which is not less important than springs and brakes, is usually not treated at school.

**Origin:**
The six equations have been discovered over a time span of about 200 years by different persons in different contexts. Although it is not difficult to recognize the structure, and although this structure is worth a whole semester’s lecture at Faculties of Engineering, the physics curriculum has never taken notice of it, maybe due to the pronounced sense of tradition of the physicists.

**Disposal:**
It would be completely unpromising to try to remove a name from an equation that is attached to it since more that a hundreds years or to give a name to an equation that did not have one in the past. (Although it would not be unreasonable to call equation (2) Huygens’ law or Descartes’s law, in honor of one of its discoverers.) All we can do is to show and to emphasize the analogy and to address the questions of the asymmetric treatment in the text books.

We also show that the proportionality between $p$ and $v$ (equation (2)) is indeed observable. Then the inertial mass is defined as the corresponding factor of proportionality. Together with Newton's second law $\frac{dp}{dt} = F$ we get the beloved (too beloved?) relation: $F = m \cdot a$.

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