Family Dynamics from the View of Theoretical Mechanics

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**Abstract.** The research object of theoretical mechanics is usually rigid rod and disc. In order to activate the teaching atmosphere of theoretical mechanics, some elements of life can be introduced in the conceptual explanation. For this reason, the family dynamics model based on force and couple is established preliminary by matching the force and couple with some elements in the family. Enlivened the classroom atmosphere and deepened students' understanding of key concepts. This teaching imaginative, broke through the engineering of the original category, associated with life, enrich the students' humanistic feelings and home care, blend in people's rational and perceptual, people become a whole person, classroom has become a whole class.

**Introduction**

Theoretical mechanics is the basic course of mechanics, machinery, civil engineering, energy, power, material and so on. But for many students involved in mechanics, theoretical mechanics research object is too single, such as rigid rod and disc, mainly due to the stress analysis and calculation, the class atmosphere is usually more boring. How to improve the classroom atmosphere of theoretical mechanics is a problem that teachers have been exploring.

At present the reform in teaching of theoretical mechanics can be divided into two main categories. One is based on students as the center of the reform, such as collaborative learning [1], engineering case discussion[2], flipped classroom[3] and the research-oriented teaching [4, 5] and 3S learning model as the core of drive learning [6] and so on. The other is the reform of the curriculum system itself, such as interdisciplinary teaching [7] and visualization teaching based on engineering software [8]. The cases adopted by the two types of teaching mainly come from the engineering practice or simplified model, which is too "cold" or beyond the scope of students' cognitive experience, difficult to fully mobilize the students' interest in the class.

People are a combination of sensibility and rationality. If we can properly introduce some perceptual factors in theoretical class, it may helpful to activate the classroom atmosphere. When the Zhejiang university professor SU dekuang teaches calculus using love philosophy, he said when you love a person, your eyes are full of her figure, she is the only variable, and others all turned out to be constant, then the change rate made by her is called partial derivatives. This kind of teaching can make students capture immediately the essence of partial derivatives, can make the classroom full of joy.

Can we also introduce some perceptual factors in the theoretical mechanics class? The author made some attempts in teaching as follows.

**Case: Family Dynamics Models Based on Force and Couple**

Force and force couple are the core concepts of statics mechanics, and force couple is a pair of forces, which have equal size, opposite direction, but not collinear. The force can be shifted along its action line, while the force couple can be shifted, rotated, or even scaled equally on its action surface (the force in the force couple is shortened by $k$ times if the arm extends $k$ times). After explained the basic concepts and properties of the forces and couples in class, we did not immediately go to the corresponding exercises, but turn to introduce the family dynamics based on the force and couple model, which aroused immediately the students' attention and interest.
As shown in Fig. 1, a rigid body is used to represent the family, and a force $F$ on the rigid body represents the father's action, force $f$ represents the mother's action. In Chinese traditional concept, father is the *Yang* and mother is the *Yin*, so the two forces are opposite to each other. If the *Yin* and *Yang* match perfectly, the force $F$ and $f$ are equal in magnitude. So the two forces representing parents form a perfect force couple, resulting a moment of $M$.

![Figure 1. Family Dynamics Based on the Force and Couple Model.](image)

From Fig. 1(a) it seems that the father's force $F$ is pulling the family to right while the mother's force pulling the family to left. That is to say, although the parents' way of doing things is different, and the parents' role in the family is different, but the force couple produced by the parents make the family rolled as a wheel. So we can use the magnitude of the force couple to describe the driving force of a family.

At a certain moment, if the father’s force has an incremental $\Delta F$ for some reason, while the mother's force hasn't adjusted at the same time, we know that the resultant force of the rigid body is no longer zero, the family is no longer harmony, and the family will deviate from its trajectory under the action of force $\Delta F$. So we can use the resultant force to describe the degree of harmony in the family.

In order to restore the harmony of the family, or to reach the zero state of the resultant force, there are two ways, one is as shown in Fig. 1 (a), the mother took the initiative to adapt to the father, producing an incremental $\Delta f$ in the opposite direction of $\Delta F$, with the equal magnitude to the father's incremental $\Delta F$. As a result, the father’s incremental $\Delta F$ and the mother's incremental $\Delta f$ constitute a pair of additional couple termed as $m$. The direction of $m$ depends on the angle $\alpha$ between $\Delta F$ and $F$. If $\alpha < 90^\circ$, the father's incremental still roughly direct along the father's role, and the couple $m$ and $M$ has the same direction, the father’s increment is still in promoting family functioning, so that the driving couple of the family increases, making the family run better. If $\alpha > 90^\circ$, the father’s incremental stray from the father's role, the couple $m$ and $M$ has the opposite direction to each other, letting down the family's driving couple, making the family run poor. If $\alpha = 90^\circ$, then the father's increment does not affect the functioning of the family. This kind of way to achieve family harmonic need the mother take the initiative to quickly adapt to the change of the father, making the combined force zero from $\Delta F$. Therefore, there must be some degree of family disharmony in the process of adaptation due to the nonzero resultant force.

Another way to restore family harmony is to introduce a constraint into the family model, as shown in Fig. 1 (b). In theoretical mechanics, constraint is the restriction on the displacement of a rigid body. The biggest characteristic of constraint is that the binding force can change immediately with the change of external force. Therefore, the existence of constraint forces the family to rotate around the constraint. This constraint has different meanings in different ages, regions and even families. It can be a system of courtesy, children and elders, or economic pressure. when the father generates an incremental force $\Delta F$, a binding force $\Delta \Gamma$ results automatically in the constraint, equal magnitude with $\Delta F$, keeping the family harmonic. Then the father's incremental $\Delta F$ and the binding force $\Delta \Gamma$...
constitute a pair of additional couple termed as $\tau$. The direction of $\tau$ depends on the relative position between the constraint and $\Delta F$. If $\Delta F$ directs through the constraint, the additional moment of couple is zero. If $\Delta F$ doesn’t direct through the constraint, then the direction of the additional couple is the same or opposite to the family's driving couple $M$. If it’s the same, the family's driving couple is increased by the additional couple $\tau$ and works better; On the contrary, the family driving couple is reduced and works poor.

It can be seen that under the action of constraint, the direction of additional couple is independent of the angle $\alpha$, that is independent of whether the increment of the father deviates from the role of father. As shown in Fig. 1 (b), although the increase of the father is still roughly in the direction of the father's role, but the additional couple $\tau$ is hindering the operation of the family.

Constraints in theoretical mechanics are ideal and can respond to any change in the magnitude of external forces in real time, but real constraints may be invalidated by excessive forces. For example, when the father insists on leaving the family, the father's increment will be so large that the constraint cannot provide the corresponding magnitude of binding force, and then the constraint will be invalid.

The above analysis is mainly made with the increment generated by father, but in real life, mother will also generate a certain increment. The analysis method is similar, and not repeated here.

In conclusion, we get the corresponding relationship as shown in Table 1.

Through this analogy, on the one hand, the classroom atmosphere is mobilized; on the other hand, students can have a better understanding of the concepts in theoretical mechanics, such as force, force couple and constraint. With this kind of explanation, students generally respond warmly and the atmosphere of class is very active.

<table>
<thead>
<tr>
<th>Theoretical Mechanical Quantity</th>
<th>Household Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>Father or mother</td>
</tr>
<tr>
<td>Couple moment</td>
<td>Family dynamics</td>
</tr>
<tr>
<td>Constraint</td>
<td>Children, courtesy, legal system, economic pressure, etc</td>
</tr>
<tr>
<td>Resultant force</td>
<td>Degree of family harmony</td>
</tr>
<tr>
<td>The increment of force</td>
<td>Changes in the role of the father or mother, attitudes toward the family, etc</td>
</tr>
<tr>
<td>The angle and increment between the force</td>
<td>The extent to which a parent deviates from his or her current role</td>
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</tbody>
</table>

### Conclusion

To active the class atmosphere of theoretical mechanics, the authors introduce some concepts of the life to explain the engineering concept, match the force and couple to some elements of the family, based on force and couple family dynamics model is established preliminary, active the classroom atmosphere, deepen students' understanding of the key concepts. This teaching imaginative, broke through the engineering of the original category, associated with life, enrich the students' humanistic feelings and home care, blend in people's rational and perceptual. People become a whole person, and classroom becomes a whole class.

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### References


