ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research (ASSEHR), volume 93
2017 3rd Conference on Education and Teaching in Colleges and Universities (CETCU 2017)

The Practice and Exploration of Engineering Mechanics Teaching Methods for Biomedical Engineering Profession

Qingyun Meng
School of Medical Institute
Shanghai University of Medicine & Health Science
Shanghai, China
E-mail: mengqy@sumhs.edu.cn

Jun Ni
School of Medical Institute
Shanghai University of Medicine & Health Science
Shanghai, China
E-mail: nij@sumhs.edu.cn

***Abstract*—The development of instruments for medical diagnosis and treatment involves in biomedical problem and engineering. In order to assist the student who is major in biomedical engineering to understand and dispose mechanics questions, this paper employs two medical equipment projects as training programs in the engineering mechanics teaching because of their medicine engineering's characteristics. So those student would further step in specialty in advance in practice teaching besides studying the academic knowledge about engineering mechanics. Consequently, they could directly solve project question. By this training and practice, the application ability of student to analyze and resolve problems in engineering practice would be cultivated.**

Keywords—Medico Engineering Cooperation; Case Method; Combining of Theory and Practice; Application Ability Cultivation

I. INTRODUCTION

Engineering mechanics is one subject to research generally existing stress and deformation phenomenon in all kinds of engineering structures. In engineering design and calculation a project, the usually method and mean by engineering mechanics is that firstly applied mechanics and mathematical knowledge to extract the corresponding engineering calculation model, and then adopt the analysis and calculation method according to the calculation model[1].Student major in biomedical engineering should be introduced by medical equipment training projects in engineering mechanics teaching before they could understand and deal with the practical engineering mechanics problems. And, consequently, the students' ability to analyze engineering problems and solve actual problem would be improved[2][3].

II. TRAINING PROJECT TEACHING DESIGNS OF ENGINEERING MECHANICS IN BIOENGINEERING

In order to conforming to the applied biomedical engineering professional training target of our school, we should pay more attention to cultivate the students' engineering awareness and ability in the engineering mechanics course standard. Here, we adapt medical research and treatment equipment in engineering mechanics case teaching. All this results would link the theory with the practice and connect engineering mechanics course with follow-up professional courses. This teaching methods enhance the students' ability to analyze and solve practical problems. Accordingly,the teaching effect can be improved.

A. Statics Practice Teaching Process and Content Design-Stability Analysis of Wheelchair on the Slope

As shown in figure 1, the wheelchair is a kind of frequently used transport for the disabled and the elderly. According to the national standard of manual wheelchair GB/T13800-2009, the wheelchair under braked must also keep static on slope stability, namely, it cannot tip-over, which directly affect the safety of the user.

This paper adapts the no-load wheelchairs as an example for stability analysis. Mechanics problems in the analysis show that this project belongs to the balance problem of statics plane force system. After analyzing the force of the front wheels and rear wheels on the test bench slope, we could establish the mechanical model of the wheelchair on the slope, as shown in figure 2.Before the test,we must measure the wheelchair's values of weight $\vec{G}$ and the center position o and the dimension of a、b、e and L ,etc .Then the balance equation can be set up as follows (in this case, the coordinate system origin established on wheelchair center of gravity)[4].

$$\sum X = 0 \qquad N_3 - G\sin\alpha = 0 \tag{1}$$

$$\sum Y = 0 \qquad N_1 + N_2 - G\cos\alpha = 0 \tag{2}$$

$$\sum M_O(F) = 0 \qquad N_1 b - N_2 a + N_3(e - R) = 0 \tag{3}$$

Consequently:

①when $\alpha < \alpha_{\max}$ ($\alpha_{\max}$ is the critical value of wheelchair tipping-over),if the value of α is a constant value, according to equation (1) and (2) and (3), we can get the value of N_1、 N_2 and N_3;

②when α is tending to the critical value $\alpha_{\max}$, $N_1 = 0$.And the value of α is unknown. According to equation (1) and (2) and (3):

$$N_1 = \frac{G(\cos\alpha - \sin\alpha(e-R))}{(a+b)} = \frac{G(\cos\alpha - \sin\alpha(e-R))}{L} = 0 \quad (4)$$

And then, we can find out the value of N_2, N_3 and α_{max}.

Thus, two force sensors installed under front wheel and rear wheel on the equipment can test the changing numerical changes of N_1.Hence, the static stability of wheelchair can be inspected on the slope.

Figure 1 Stability testing wheelchair prototype with different install angles

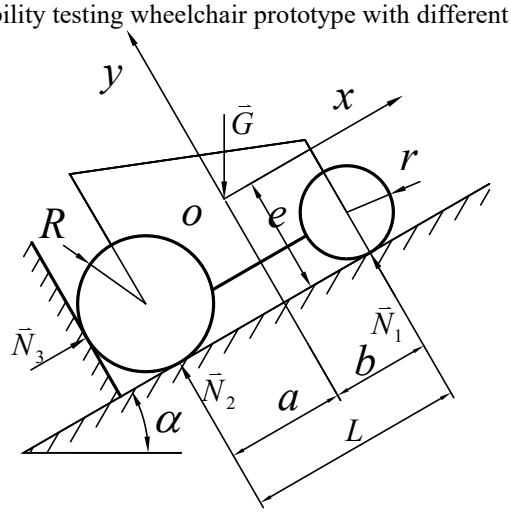


Figure 2 Force diagram of wheelchair property experiment

B. Material Practice Teaching Process and Content Design- Shank Prosthesis Strength Analysiss

Known to all, the bending strength of the lower limb prosthesis directly affects its service life. So we must analyze the force of shank prosthesis.

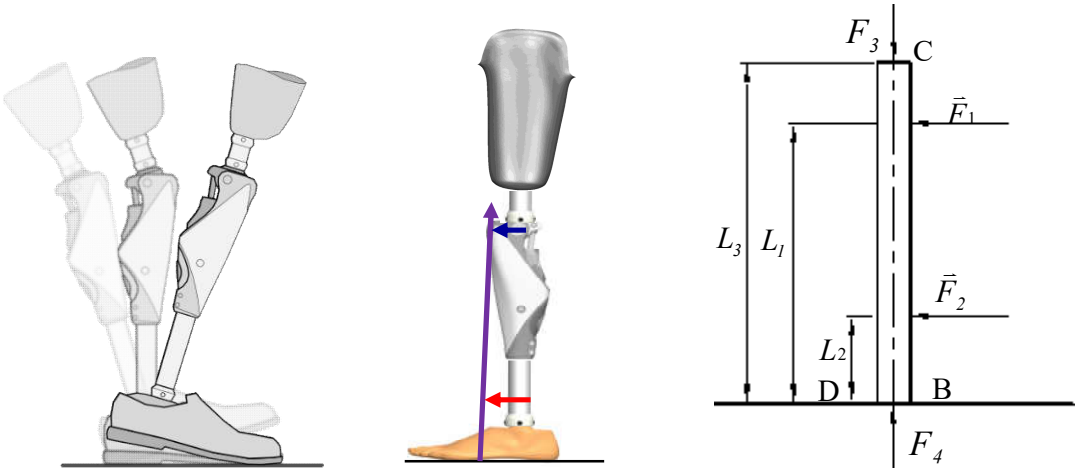
As shown in figure 3(a), the stresses of lower limb prosthesis are different around the walk cycle as the heel contact with the earth, stand upright and toe landing. And it can be simplified as three kinds of position model to analyze in the figure 3(a) in this article. The figure 3(b) is a diagram for standing phase in the walk cycle, and the force diagram for standing upright is shown in figure 3(c).

According to figure (c),the shank prosthesis is under the coefficient effect of the transverse force F_1 of knee joint、 axial force F_2 on ankle joint from drive motor、 axial force F_3 on knee joint from drive motor and ground support force F_4 (here

ignore the friction). So the shank prosthesis can be treated as one common composite deformation component. And the student can calculate the bending strength of the lower limb rod in the vertical support phase according to formula (5) and formula (6).Here, $M_{\max}$、 W_z and A represent respectively the maximum bending moment and bending section modulus and cross sectional area[4].

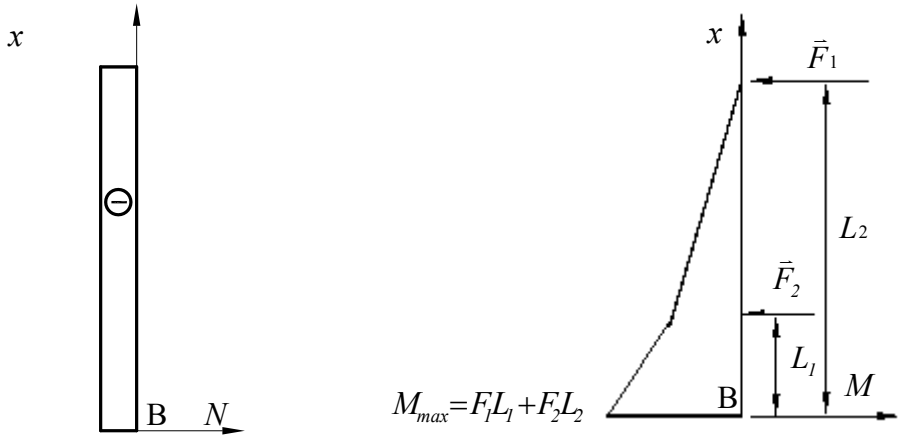
$$\sigma_1 = \frac{M_{\max}}{W_z} \le [\sigma] \text{（here the lower limb prosthesis can be seen as a beam）} \tag{5}$$

$$\sigma_2 = \frac{F_3 - F_4}{A} \le [\sigma] \tag{6}$$



(a) (b) (c)

Figure 3 the lower limb prosthesis analysis of stress and strength



(a) (b)

Figure 4 internal force diagrams for the lower limb prosthesis

Figure 4(a) presents the internal force distribution of shaft under the action of axial load F_3 and ground support force F_4. Figure 4(b) presents the internal force distribution of the transverse force of knee joint F_1 ankle axial force F_2. And it can be seen that the fixed end B is the dangerous section of the lower limb prosthesis model. Meanwhile the point D on the left side of section B is the dangerous point whose stress value is $\sigma = \frac{M_{max}}{W_z} + \frac{F_3 - F_4}{A}$ and it's a compressive resistance.

III. Practices and Exploration of Engineering Mechanics Teaching methods for Speciality of biomedical Engineering Cooperation

Biomedical engineering profession is different from the other mechanical major. And it's project involved mechanical models and teaching methods requires professional pertinence [2][3].At the same time, there are less class hours in engineering mechanics teaching schedules now. How to exercise the students' ability of analysis problem and problem-solving in limited class hours have been the difficulties and emphases in engineering mechanics teaching.

But after we arranged the engineering mechanics training program in the teaching with biomedical engineering characteristics, students would be exercised directly by the practice of professional project. This develop the students' thinking mode .At the same time, the student would realize that the mechanical widespread everywhere. All this improve the students' ability to solve the problem. Students can not only solve the problem of pure mechanics theory but all so they can explore more extrapolate case employed from life to force analysis. Thus would improve the innovation ability of students too.

In addition, if we adapt diversity of teaching methods including the biomedical engineering case teaching method and group discussion teaching method and numerical simulation analysis method and heuristic teaching approach,etc., considering the medical professionals specialized background at the same time, perfecting the design of the teaching process, the improvement of teaching quality will be more apparent [5].

References

[1] Meng Qingyun,Ni Jun,Ding Lijun, Shen Lixing. Medical project practice and exploration in engineering mechanics teaching.Mechanics in Engineering, 2012 Vol.34(5):72-74, 15

[2] Tang Keke, Wang Huaning. Study on teaching system of theoretical mechanics oriented by the development of innovation and creativity. Mechanics in Engineering, 2017, 39(1): 68-70, 67

[3] MA Xing,WU Xiaoming,WU Yaoping,Ma Yaoming. Application of problem-based learning (PBL) in orthopaedic biomedical education.China Higher Medical Education, 2010, 6:97-98.

[4] Fan Qinshan, etc. Engineering mechanics (second edition).Beijing:Tsinghua University Press,2012

[5] Zhang Yongcun,Yu Shen,Ma Hongyan.Numerical simulation application in the teaching of theoretical mechanics.LABORATORY SCIENCE, 2013,16(3):74-77.