SIR Publishers
CENTER FOR INTERNATIONAL SCIENTIFIC PUBLICATIONS
JOURNAL OF ENGINEERING SCIENCES
ISSN(Online): 2984-6714
Volume-9, Issue-02, Published |06-05-2026|

METHODOLOGY FOR TRAINING FUTURE ENGINEERS ON NON-STANDARD TASKS RELATED TO LABOR FORCE BASED ON AN INTEGRATIVE APPROACH

Baratov Joraqozi Shukurjon oglu,
Doctoral student at the Uzbekistan National Pedagogical University
Tel:+99891-698-16-15
baratovjoraqozi@gmail.com

ABSTRACT

This article aims to develop and recommend a methodology for teaching non-standard tasks related to friction force for future engineers based on an integrative approach. The main goal is to teach students to combine theoretical knowledge with practical skills and apply an integrated approach to solving multidisciplinary problems. It is intended to use non-standard methods and teach convenient solutions to problems that future engineers encounter in their work activities.

Keywords: integrative approach, non-standard tasks on friction force, engineering education

Today, an important direction of higher technical education institutions is to integrate the tasks of various fields of science and production into a single system, to prepare future engineers for professional training, to express their creative ideas and to increase their interest in science, and at the same time , to educate them in an environment of an integrative approach to explaining processes occurring in nature and phenomena encountered in everyday work activities . Let us first consider the concept of "Integration". This term was first used by German and Swedish scientists in the 1930s. Currently, it is widely used in various fields: biology, physics, chemistry, politics, information, social, cultural spheres, etc. The most commonly used meaning of this term is unification, mutual penetration [1; p. 3.]. Many scientists have given several definitions, for example, " Integration is the unification of the achievements of many scientists in order to positively influence the development of educational work, using not only psychology, sociology, physiology, which are traditionally associated with pedagogy, but also the basis of computer science, statistics, economics, management theory and other sciences. Only when the new achievements of these sciences are combined into a single idea, they become the basis for the development of new teaching technologies," M. Dzhoraev emphasizes, as we can see in his textbook "Physics Teaching Methodology" on the topic "Physics Teaching Technology" [3; p. 42].

One of the first to reveal the multifaceted interrelation of educational subjects in the process of education was I.G. Pestalozzi. He emphasizes: "Bring to mind all objects that are naturally interconnected in relation to their location in nature," he emphasizes, as J.A. Comenius said, and I.G. Pestalozzi wrote: "We need to unite in our minds similar and interconnected things, thereby giving greater clarity to our ideas and, having fully clarified them, to raise them to concrete concepts" [2, 31].

We see the concept of an integrative approach being illustrated in the existing curriculum of three required geophysics courses at the University of Colorado Geophysics: Seismology: seismic waves, earthquakes, and earth structure; Geodesy and gravity; Heat, mantle convection, fluid dynamics, and the earth's magnetic field. Plate tectonics is a theory that unifies much of modern geophysics and, in many ways, geology. According to this theory, the Earth's surface consists of about twenty separate plates that move relative to each other. This movement is directly or indirectly responsible for many surface features (such as ocean basins, mountains, etc.) and for earthquakes and volcanoes. The driving force behind plate tectonics is a kind of mantle convection: plates are thermal boundary layers of convective cells in the mantle (the mantle behaves like a sticky layer for a long time). However, the details are not yet well understood. People have determined the average speed of movement over millions of years by looking at magnetic anomalies in materials on the seafloor.

The movement of plates on a time scale from year to year has only just begun to be observed. Indeed, one of the goals of modern geodesy is to actually determine the movement from year to year. Is this the same as a long-term average? Do the plates move rigidly? Etc. Geodesy has a legitimate claim to being the oldest branch of geophysics. It was originally concerned only with global surveying. Its main purpose was, and probably still is, to connect local surveying networks by surveying over long distances. Geodesists tell local surveyors where their lines are in relation to the rest of the world. This includes telling them their elevation above sea level. This is still the primary function of most surveyors, many of whom are not geophysicists [4]. Thus, solving problems in the practical classes of physics courses for surveyors, power engineers, and other prospective engineers is one of the best ways to understand the laws of physics. In order to better understand the general laws of physics and their application in real-life problems, students will find carefully selected problems in this book. The book contains 100, mostly non-standard, tasks covering classical mechanics, classical electrodynamics, thermodynamics, optics, fluid mechanics, etc. A relatively large number of tasks are new, high-quality, and their solutions are presented for the first time, along with detailed descriptions. However, the reader or student may be familiar with some of the presented problems. The author looked for problems that consider some physical phenomena that are of interest to everyone, such as wave formation, the formation of a sandstorm, the bursting of a soap bubble, the origin of planetary rotation, estimating the thickness of the earth's crust, etc. The author also addresses some theoretical problems, such as the Abraham-Minkowski dilemma, which is more than a century old in the study of photon impulses in a dielectric medium. To avoid an unusual approach that might bore someone, the author arranged the problems in a random order. In my opinion, this would be a more natural way, since a large number of problems may require knowledge from several physical fields. The presented solution to each problem is only one of many possible solutions. We can see that non-standard tasks are included, which naturally encourage the student or students to find their own way to solve problems based on an integrative approach [5]. Studying the integrative approach, IDZverev and VNMaksimova emphasized the important role of MPS in the formation of students' scientific worldview, the development of systematic and creative thinking, and came to the following important conclusions. First, in the conditions of a separate subject system of education, students perceive the subjects they are studying in separate parts, which leads to a fragmentation of knowledge, since the students' thinking is programmed to master separate knowledge. All this leads to dishonesty in education. Secondly, studies have shown that a multifaceted integrative approach, combined with interdisciplinary connections, forms a holistic scientific and humanistic worldview in students [7; p. 100].

This research is currently being conducted by the departments of technical higher education institutions: " 60710400–Power Engineering", "60710500–Electrical Engineering", "60710700–Electronics and Instrumentation", "60710900–Technological Processes and Production Automation and Control (by Branches)", "60712500 – Vehicle Engineering", "60720400–Technological Machines and Equipment (Mechanical Engineering and Metalworking)", 60720300–Materials Science (by Branches)", "60721500–Geodesy and Geoinformatics", "60720700–Light Industrial Engineering", "60710100–Chemical Engineering (Inorganic Materials Technology)" It is envisaged to conduct scientific research on future engineers and teach non-standard tasks based on an integrative approach. We can see in many studies the interrelationship of their specialization and compulsory subjects, the understanding of the concept of an integrative approach to textbooks and educational materials with modern information media and interactive methods, and the improvement of their skills in applying them in educational and practical periods. "60721500–Geodesy and geoinformatics" and other educational areas are specialized in such areas as management and

JOURNAL OF ENGINEERING SCIENCES
ISSN(Online): 2984-6714
Volume-9, Issue-02, Published |06-05-2026|

organization, ensuring seamless integration between types and areas of education, and the use of (software) tools along with teaching methods. At the same time, one of the important processes in the development of logical thinking abilities of future engineers is creativity – the product of thinking, which is based on previously acquired knowledge to create something new, to discover. It means to create something that did not exist before or to innovate existing technologies [6; p. 176 .].

The educator also identifies the advantages and disadvantages of the methods used, evaluates his/her own activities. This study is devoted to improving the methodology of teaching non-standard tasks based on an integrative approach to providing future engineers with knowledge in accordance with the programs of general education, general vocational and elective subjects, forming and developing in them the skills of comprehensive thinking in the process of education, as well as developing them in the process of education. A future engineer who has the skills of unconventional thinking in teaching non-standard tasks is one who has mastered non-standard, new and original methods of solving the problems set. This field consists of acquired skills and qualifications in their domain. The list of professional competencies of future engineers includes competencies that are directly related to the practical activities of a specialist in production. Participation, this is the development of hardware components, the ability to design equipment, the application of theoretical knowledge of specialized disciplines (physics, mathematics and technical cycles) to solve professional tasks, etc. [8].

The following requirements are imposed on engineers to popularize and test non-standard tasks based on an integrative approach:

To determine the specific features of the theoretical position of local and foreign professors and teachers on the problem of forming students' knowledge, skills, qualifications and competencies as a specific subsystem of the culture of thinking in the educational and work process ;

2. Identify classification criteria for non-standard tasks used to form the knowledge, skills, qualifications, and competencies of future engineers;

3. To have the basis of the concept of forming the basis of students' authorial model and interconnected thinking (within disciplines) using non-standard tasks;

4. Development of diagnostic tools based on an integrative approach for future engineers and experimental testing of the effectiveness of their use in non-standard tasks;

5. Non-standard tasks to form the knowledge of future engineers It is necessary to create didactically important conditions that ensure learning effectiveness.

P1. A billiard ball rolls without slipping on a billiard table, as shown in the figure below. The edge of the table is surrounded by a sharp raised edge to keep the ball on the table. Find the minimum value of the ratio of the height of the table edge to the radius of the ball, as well as the minimum value of the coefficient of friction between the ball and the table, such that the ball does not slip when the ball and the edge of the table collide head-on. Assume that the collision between the ball and the edge of the table is perfectly elastic. The surface of the table and the edge of the table are covered with the same material.

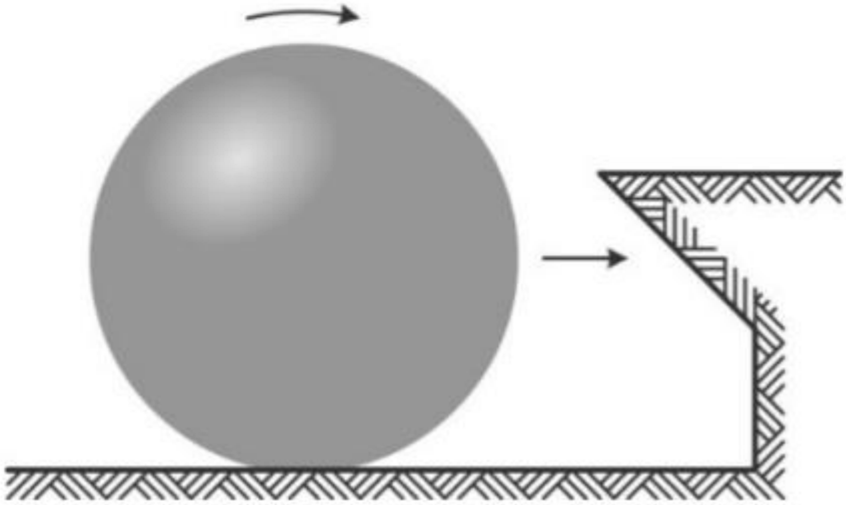

Figure 1.

S1. The analysis begins with the following figure, which shows all the relevant parameters for the analysis when the ball hits the edge of the table. Only the direction of the ball's velocity ϑ and angular velocity ω change during the impact with the edge of the table, where their intensity remains unchanged, are taken into account. This is because there is no slippage of the ball when it hits the edge of the table and the impact is perfectly elastic.

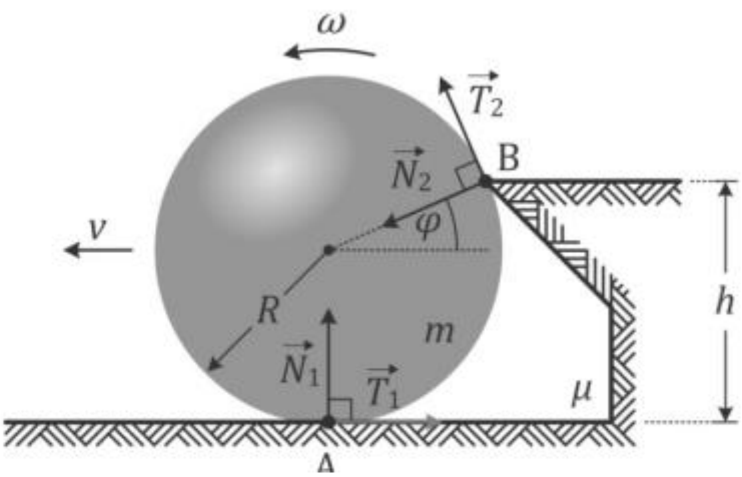

Figure 1.1.

between two points, namely the center of the sphere and the impact point B, and the horizontal line, φ the following holds:

$$\sin\varphi = \frac{h}{R} - 1 \text{(S1.1)}$$

where h is the height of the table edge and R is the radius of the ball and where the following is satisfied: $R < h < 2R$ and as a result $\varphi \in [0, \frac{\pi}{2}]$. When the ball is rotating without slipping, before the impact, point B on the ball's circumference has a total velocity with a horizontal component directed towards the table edge and a vertical component directed towards the table surface. Based on the direction of the velocity of point B at the time of impact, the reaction forces of the table edge

JOURNAL OF ENGINEERING SCIENCES
ISSN(Online): 2984-6714
Volume-9, Issue-02, Published |06-05-2026|

act on ball B in the directions shown in Figure 1.1 above, i.e. in the opposite directions from the velocity of point B. Due to the reaction forces between the ball and the table edge, reaction forces also act between the ball and the table surface at point A (the point of rotation of the ball at the moment of impact). The corresponding reaction forces $\overrightarrow{N_1}$ and $\overrightarrow{T_1}$ affect the motion of the ball during the impact as shown in the figure above. It should be noted that the approximation can be considered if the duration of the impact time τ is much shorter than: $mg << N_1, T_1, N_2, T_2$ where m is the mass of the ball and g is the gravitational acceleration or the forces resulting from the impact are much larger than the weight of the ball.

Based on the impact dynamics, the following equations are obtained:

$$N_2 \sin\varphi = N_1 + T_1 \cos\varphi (S1.2)$$

$$N_2 \cos\varphi + T_2 \sin\varphi - T_1 = \frac{2m\vartheta}{\tau} (S1.3)$$

$$(T_1 + T_2)R = \frac{2J\omega}{\tau} (S1.4)$$

where ϑ - the speed of the ball before and after the impact, J - the moment of inertia of the ball, where $J = \frac{2}{5}mR^2$ is satisfied, and ω - the angular velocity of the ball, where is the condition that the ball rolls without slipping, we obtain: $\omega = \frac{\vartheta}{R}$. After substituting all these relations into equation (S1.4) and rearranging, we obtain the following equation:

$$\frac{5}{4}(T_1 + T_2) = \frac{m\vartheta}{\tau} (S1.5)$$

By combining equations (S1.3) and (S1.5), the following equation is obtained:

$$N_2 \cos\varphi + T_2 \sin\varphi - T_1 = \frac{5}{2}(T_1 + T_2)(S1.6)$$

If we rearrange equations (S1.2) and (S1.6), the following system is obtained:

$$T_2 \cos\varphi = N_2 \sin\varphi - N_1 (S1.7)$$

Or

$$7T_1 + (5 - 2\sin\varphi)T_2 = 2N_2 \cos\varphi (S1.8)$$

To prevent the ball from slipping when it hits the edge of the table, the following conditions must be met: $T_1 \le \mu N_1$ or $T_2 \le \mu N_2$ where is μ the coefficient of friction between the table and the ball. Combining these inequalities with equations (S1.7) and (S1.8), we obtain:

$$\mu N_2 \cos\varphi \ge N_2 \sin\varphi - N_1 (S1.9)$$

Or

$$7\mu N_1 + (5 - 2\sin\varphi) \ge 2N_2 \cos\varphi (S1.10)$$

By rearranging the inequalities given in expressions (S1.9) and (S1.10), we obtain:

$$N_1 \geq N_2(\sin\varphi - \mu\cos\varphi) \text{(S1.11)}$$

Or

$$N_1 \geq \frac{1}{7\mu} N_2(2\cos\varphi + 2\mu\sin\varphi - 5\mu) \text{(S1.12)}$$

One way to solve inequalities (S1.11) and (S1.12) is that inequalities (S1.11) and (S1.12) are absolutely satisfied if their right-hand sides are less than zero. In this case, we have:

$$\sin\varphi - \mu\cos\varphi \leq 0 \text{(S1.13)}$$

Or

$$2\cos\varphi + 2\mu\sin\varphi - 5\mu \leq 0 \text{ (S1.14)}$$

Based on inequality (S1.13), we have: $\mu \geq \tan\varphi$. If we rearrange inequality (S1.14), we get:

$$\frac{2\cos\varphi}{\mu} + 2\sin\varphi - 5 \leq 0 \text{(S1.15)}$$

If we replace the coefficient of friction with another smaller quantity, then inequality (S1.15) is satisfied. If such an inequality is satisfied, then inequality (S1.15) is also satisfied. Thus, $\mu \geq \tan\varphi$ based on inequalities and (S1.15), we have:

$$\frac{2\cos\varphi}{\tan\varphi} + 2\sin\varphi - 5 \leq 0 \text{(S1.16)}$$

By rearranging the inequality (S1.16), the following finally becomes clear.

$$\sin\varphi \geq \frac{2}{5} \text{(S1.17)}$$

Combining equation (S1.1) and inequality (S1.17), we finally obtain the following for the required ratio of the height of the table edge and the radius of the sphere:

$$\frac{h}{R} \geq \frac{7}{5} \text{(S1.18)}$$

Finally, according to inequality (S1.18) for the minimum ratio of the height of the table edge to the radius of the sphere, we obtain:

$$\left(\frac{h}{R}\right)_{\min} = \frac{7}{5} = 1{,}4 \text{ (S1.19)}$$

for the friction coefficient, $\mu \geq \tan\varphi$ based on the inequalities (S1.17), the following is obtained:

$$\mu \geq \frac{2}{\sqrt{21}} \text{(S1.20)}$$

so, finally, μ for the minimum (my) by inequality (S1.20):

$$\mu = \frac{2}{\sqrt{21}} \approx 0{,}44 \quad (S1.20)$$

The solution of the inequalities (S1.11) and (S1.12) given above is one possible way to find the solution to these inequalities. This solution is not the most rigorous solution, but it gives results that definitely satisfy the required conditions. A second possible solution is given below. In this second solution, the inequalities (S1.11) and (S1.12) can be observed in two possible ways. First, we start with inequality (S1.11). This inequality is satisfied if the inequality is satisfied by substituting a smaller quantity for N $_{1.}$ Since this is a small quantity, we can take the value on the right-hand side of inequality (S1.12). In this case, we have:

$$\frac{1}{7\mu} N_2(2\cos\varphi + 2\mu\sin\varphi - 5\mu) \geq N_2(\sin\varphi - \mu\cos\varphi) \quad (S1.22)$$

here if this inequality is satisfied, then inequality (S1.11) is clearly satisfied. By rearranging inequality (S1.22), it becomes:

$$\sin\varphi - \left(\frac{2}{5\mu} + \frac{7\mu}{5}\right)\cos\varphi \leq 1 \quad (S1.23)$$

If we now start with inequality (S1.12), then this inequality is definitely satisfied if it is satisfied for a value smaller than inequality (S1.11). In this case, inequality (S1.12) becomes:

$$N_2(\sin\varphi - \mu\cos\varphi) \geq \frac{1}{7\mu} N_2(2\cos\varphi + 2\sin\varphi - 5\mu) \quad (S1.24)$$

where if this inequality is satisfied, then inequality (S1.12) is clearly satisfied. By rearranging inequality (S1.24), it becomes:

$$\sin\varphi - \left(\frac{2}{5\mu} + \frac{7\mu}{5}\right)\cos\varphi \geq -1 \quad (S1.25)$$

If we now take this for the parameter p, the following is true:

$$p = \frac{2}{5\mu} + \frac{7\mu}{5} \quad (S1.26)$$

then inequalities (S1.23) and (S1.25) become:

$$\sin\varphi - p\cos\varphi \leq 1 \quad (S1.27)$$

Or

$$\sin\varphi - p\cos\varphi \leq -1 \quad (S1.28)$$

Based on inequalities (S1.27) and (S1.28), we have:

$$\sin\varphi - 1 \leq p\cos\varphi \quad (S1.29)$$

$$\sin\varphi + 1 \leq p\cos\varphi \quad (S1.30)$$

JOURNAL OF ENGINEERING SCIENCES
ISSN(Online): 2984-6714
Volume-9, Issue-02, Published |06-05-2026|

Inequality (S1.29) is certainly $\varphi \in \left[0, \frac{\pi}{2}\right]$ satisfied for each p and φ $\sin\varphi - 1 \le 0$ from the set of values and , since in this case the following condition holds: $p > 0$ and $p\cos\varphi \ge 0$ Moreover, we only observe inequality (S1.30). After rearrangement, it becomes:

$$\left(1+p^2\right)\sin^2\varphi + 2\sin\varphi + \left(1-p^2\right) \ge 0 \text{ (S1.31)}$$

The zeros of the polynomial obtained from the left side of inequality (S1.31) are as follows:

$$\sin\varphi_1 = \frac{p^2-1}{p^2+1}, \sin\varphi_2 = -1 \text{(S1.32)}$$

The second solution is reduced to $\varphi \in \left[0, \frac{\pi}{2}\right]$ and $\sin\varphi \ge 0$ is left as. $1+p^2>0$ Since the quadratic function on the left side of the inequality (S1.31) has a minimum value, the following condition is satisfied:

$$\sin\varphi \ge \frac{p^2-1}{p^2+1} \text{(S1.33)}$$

The function given on the right-hand side of the inequality (S1.33) is an increasing function, so if the inequality is satisfied for the maximum value of the parameter p, then it is satisfied for any other value of this parameter. Based on the expression (S1.26), $\sin\varphi \ge 1$ it is easy to determine that it is true for the maximum value of the parameter p, which is impossible on the other hand. From the problem statement, the minimum possible value of the ratio of the height of the table edge to the radius of the sphere is found. This minimum possible value can be found when the parameter p has a minimum value. According to the expression (S1.26), $\mu = \sqrt{\frac{2}{7}}$ it is easy to show that for the parameter p has the following minimum value: $p_{\min} = \frac{2\sqrt{14}}{5}$. Based on the previous analysis, the following must be satisfied:

$$\sin\varphi \ge \frac{31}{81} \text{(S1.34)}$$

For the required ratio of the height of the table edge and the radius of the sphere, combining expression (S1.1) and inequality (S1.34), we obtain:

$$\frac{h}{R} \ge \frac{112}{81} \text{(S1.35)}$$

Finally, according to inequality (S1.35) for the minimum ratio of the height of the table edge to the radius of the sphere, we obtain:

$$\left(\frac{h}{R}\right)_u = \frac{u}{81} \approx 1{,}3827 \text{(S1.36)}$$

This is very close to the value given in expression (S1.19). This value is obtained if the following is satisfied:

$$\mu = \sqrt{\frac{2}{7}} \approx 0{,}53 \quad (S1.37)$$

this also corresponds to the condition given in expression (S1.21).

Ultimately, the results obtained in the previous analysis can be accepted because they provide a necessary and sufficient condition for the fulfillment of the conditions given in the problem statement, so finally, we can obtain the following:

$$\left(\frac{h}{R}\right)_{\min} = \frac{7}{5} \; yoki \; \mu_{\min} = \frac{2}{\sqrt{21}}$$

P2. A circus artist of mass m performs his artistic act by walking on a ball of mass M, while the ball rolls on the circus podium without slipping. If the coefficient of friction between the acrobat's shoes and the ball is μ_1, and the coefficient of friction between the ball and the podium is μ_2, find the maximum acceleration that the acrobat can achieve by walking on the ball? The ball is considered to be homogeneous.

In conclusion, it should be noted that teaching future engineers non-standard tasks based on an integrative approach allows them to increase their interest in their profession. Although the solution of the above non-standard task takes a little more time, it serves to increase their knowledge base.

REFERENCES

1. Amirkhanova L.B., Selimova G.A. Ob integrirovannom obuchenii filologicheskim disciplinam v schkolnom obrazovanii // Sovremennye problemy nauki i obrazovaniya. – 2016. – No. 2. 13.00.00.
2. Pestalottsi I.G. Izbrannye pedagogicheskie sochineniya /I.G.Pestalottsi. - M.: 7 Izdatelstvo APN RSFSR, 1963., - 278 c .
3. Djorayev M. Physics teaching methodology: textbook / M. Djorayev.-Tashkent: ABU MATBUOT-KONSALT, 2015. - 280 p.
4. Or via the WWW from http://landau.mines.edu/~ samizdat Permission is given to freely copy these documents.
5. Lazo M. Manojlovic. Nonstandard problems in general physics with solutions. 2019 Arcler Press ISBN: 978-1-77361-490-8 (Hardcover). -P. 292.
6. Explanatory dictionary of the Uzbek language. Volume 1. – Tashkent, National Encyclopedia of Uzbekistan, 2020, 25-36 b .
7. Zverev I.D., Maksimova V.N. Mejsubjectnye svyazi in modern school. - M.: Pedagogy, 1991. - C. 159.
8. http://www.publishing-vak.ru/file/archive-pedagogy-2023-1/c11-zorina.pdf