

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY  
«KHARKIV POLYTECHNIC INSTITUTE»

**Methodological instructions**  
for the organization of the business game  
"Design Bureau"  
in the discipline of  
«Theory of mechanisms and machines»  
for students of «Mechanical Engineering» and «Transport» branches of  
knowledge

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## Content:

Introduction	4
Features of interactive learning	4
Business games	5
1. Goals of the game "Design Bureau"	8
2. Description of the game model	9
3. Evaluation system	10
4. Periods in game design	11
5. Game design algorithm	13
6. Deadlines and evaluation system for design sections of stage 4	15
7. Reminders to all members of game	20
8. Stimulation s system	21
APPENDICES	22
APPENDIX 1	22
APPENDIX 2	25
List of references	28

## **Introduction**

In accordance with the modern requirements of higher education, the implementation of the educational process should include classes in interactive and active forms.

The implementation of interactive forms of education is one of the most important directions for improving student training in modern universities. Using interactive approaches is the most effective way to promote students' learning. Therefore, the main methodological innovations today are associated with the use of interactive learning methods, in which students are included in the studied situation, which prompts them to take active efforts, experience a state of success and motivate their behavior in a certain way.

The educational process, based on the use of interactive learning methods, is organized with taking into account the involvement of all students in the group without exception in the learning process. Joint activity means that everyone makes their own special individual contribution, in the course of work there is an exchange of knowledge, ideas, methods activity. Interactive methods are based on the principles of interaction, student activity, reliance on group experience, mandatory feedback, which encourages learning participants to independent search.

### **Features of interactive learning**

Interactive method. Interactive ("Inter" – mutual, "act" – to act) means work jointly, to be in the mode of conversation, dialogue with anyone. In other words, in contrast to active methods, interactive methods are focused on a wider interaction of students not only with the teacher, but also with each other and on the dominance of student activity in the learning process. The role of the teacher at interactive classes is reduced to directing the activities of students to achieve the goals of the class.

Interactive learning is a special form of organizing cognitive activity, the purpose of which is to create learning conditions in which the student feels his success and his intellectual ability, which makes it possible to create a basis for work on solving problems after graduation.

The main tasks of interactive forms of education are:

- awakening students' interest in the discipline;
- effective assimilation of educational material;
- students' independent search for ways and options to solve the given problem;
- establishment of mutual communication between students, learning to work in a team;
- formation of life-related and professional skills.

### **Business games**

A business game is a form of reproducing the subject and social content of a specialist's future professional activity, modeling those systems of relationships that are characteristic of this activity, modeling professional problems, real contradictions and difficulties experienced in typical professional problem situations.

Essential signs of a business game:

- modeling of the work process (activity) of managers and specialists in the generation of professional solutions;
- presence of a common goal for the entire group;
- distribution of roles between game participants;
- difference in role goals when making decisions;
- interaction of participants performing certain roles;
- group decision-making by game participants;
- implementation of a chain of decisions in the game process;
- a wide range of alternative solutions;
- the presence of controlled emotional tension.

Psychological and pedagogical principles of a business game:

- The principle of simulation modeling of the content of professional activity, specific conditions and dynamics of production.

- The principle of reproducing problematic situations, typical for this professional activity, through a system of game tasks that contain some contradictions and cause difficulties for students.

- The principle of joint activity of participants in the conditions of interaction of the specialists' production functions simulated in the game.

- The principle of dialogic communication and interaction of partners in the game as a necessary condition for completing educational tasks, preparation and making agreed decisions.

- The principle of duality reflects the process of development of real personal characteristics of a specialist in "imaginary" game conditions. The developer sets two types of goals for students that reflect the real and the game contexts in educational activities.

Stages of developing a business game:

1. Setting the problem and defining the theme of the game. The teacher must first determine for what purposes he is going to introduce a business game into the training, whether it will be thematic or last through the course.

2. Definition of the type of business game. At this stage to suit the specific conditions, the teacher chooses the type of business game that will give the maximum educational result at a certain stage of mastering the material.

3. Determination of the main regularities of the game - connections, relations based on the problem, which is the basis of the business game. At this stage, the necessary degree of detailing of the presentation of the game object is determined.

4. Creating a game plan. The situation should assume the ambiguity of solutions, contain an element of uncertainty, which ensures the problematic nature of the game and the personal participation of students. The rules of the game are formulated unambiguously and unconditionally. In the game, it is necessary to provide an

opportunity for each player to make decisions. This is achieved through a set of game documents (or instructions for participants).

5. A list of decisions that students can make is defined. In the game, it is necessary to reflect not all the variety of factors operating in a real situation, but only the most significant ones. The subjective probability of events occurring should be neither too low (otherwise private patterns of behavior will be reproduced) nor too high (there is a danger of making habitual decisions). The greater the freedom to choose solutions, the more actively students are included in the game.

6. Defining the parameters of the relationships between the factors to be displayed in the game. They should be such as to cause effects specific to the simulated activity. It is necessary to determine the interaction of parameters at each stage of student activity. Not all parameters can be quantified. In this case, expert evaluations are used when designing the game.

7. Formation of data. At this stage, the dimensions of the main parameters, regularities and interactions are determined, and tables and figures are given as well.

8. Formulation of rules, distribution of roles between players, determination of the system of penalties and incentives, criteria for winning (or evaluation) and bringing them to the attention of students. The results of the game can be obvious, expressed quantitatively, or can be evaluated by experts. The teacher also determines the principle of student participation in each group. It is important to think in advance of incentives that ensure high involvement of students in game activities. It is necessary to constantly maintain feedback with students.

9. The final correction of the game – clarification of connections, parameters, verification of calculations, analysis of the reality of situations. Such a correction can be made before each new stage of reproduction. The game will not bring a proper result if the sequence of actions and relationships of the participants is poorly thought out, the events do not develop in time, the list of decisions is given, but it is not clear how feedback on the taken decisions is carried out, the course of the game requires the constant intervention of the teacher.

## **1. Goals of the game "Design Bureau"**

The student's participation in the defense of the course project in the form of mock design provides an opportunity to better reveal their abilities and skills in solving a specific task – designing a machine unit in such a way that its work satisfies the preset working conditions.

Course design in the "Theory of Mechanisms and Machines" course and subsequent defense in the form of a game provides an incentive to intensify the student's independent work and his work in a group. The work of students in a group makes it possible to deepen the scientific knowledge of each individual in the process of collective work, to learn to use other students' results at a certain stage of the task, helps to align with the best students in the group.

The advantage of such active learning is that students inspire each other to work, learn to work in a group, discuss the results of work, engage in mutual reviews, find pros and cons in each other's work, and also learn to display the results of their work in the form of reports and answers to questions, and at the end of the project, the team of their group tries to rank better among other groups.

The course design of the course includes the design of several types of mechanisms: hinge-lever, gear, cam. The course project consists of 6 sections, for each of which the student receives points. Then the sum of points is calculated for each of the students and for each separate group of students. For example, if there are five students in the group and each of them gets 4 points for the first section, then the group receives a total of 20 points for this section. Groups compete with each other to score more points. To do this, they study alternative ways of solving the problem for each section, by which they add individual points. Each student in the group who completed the task first can take on the role of assistant for a weaker student. Thus, a "stronger" student earns himself additional points for help, while his entire group also has a higher total score.

The goal of game design is to teach students to:

1) independently use scientific and technical, methodical and reference literature;

- 2) make both individual and group decisions;
- 3) master design methods, both those considered in the lecture and alternative ones;
- 4) perform tasks in groups;
- 5) report on the completed work;
- 6) be able to defend one's point of view;
- 7) be able to convey the results of one's work to other students;
- 8) be able to ask production questions about design, as well as answer the questions posed by students from other groups;
- 9) be able to competently defend your course project.

Mock design contributes to the education of discipline, activity, a conscious attitude to work and makes it possible to better learn the material of the discipline "Theory of Mechanisms and Machines" (TMM).

## **2. Description of the game model**

**The customer** – the teacher – sets the goal, formulates the task, and gives the input data to the students. The customer supervises the execution and evaluation of the results.

**Developers (executors)** are formed from groups of students (5(4) people each) in the form of technical bureaus, each of which chooses the head of the bureau and a deputy from among its members. The technical bureau receives a technical task for implementation. The head of the bureau and the deputy perform the duties of supervision and counseling of students within the bureau, act as a link of communication and monitor implementation.

**Technical council** – one student representative from each technical bureau – is formed. It evaluates the report of each head of the technical bureau and the quality of the submitted illustrative materials (drawings) and technical documentation

(explanatory notes) of all game participants, as well as the report and completeness of answers to questions by each member of the technical bureau.

The technical council is engaged in filling out the **calculation cards**, which include the points of the participants of the game.

The head of the technical bureau enters points by section to the calculation cards, and the technical board assigns points for the report, for the completed **technical task**. Additional points for other types of work are assigned by the customer.

The result of the game is a duly completed formal technical task consisting of formal drawings and explanatory notes.

The final evaluation of the game is carried out by the customer in the form of receiving the completed technical tasks of the developers with analysis and evaluation of the performance according to calculation charts, which reflect the effectiveness of the work of all students (including members of the technical council).

### **3. Evaluation system**

Points for design are assigned by the teacher together with the head and deputy of each bureau. These points are transferred to the technical board, which enters them in the appropriate columns of the evaluation cards and also assigns points within the limits of its powers. The work of the members of the technical board is evaluated by the teacher, who enters the points assigned to its members into the corresponding evaluation card.

The incentive system is aimed at collectivization of work while simultaneously encouraging the personal initiative of each of the game participants.

To achieve a better target goal, there must be clarity of interaction between all roles: between each student in the technical office, between the technical offices and the technical council.

Students are encouraged with bonuses, i.e. additional points (1 point per section) for shortening the deadlines for completion of sections. Points are deducted for increasing the completion time (1 point per section). The distribution of points by

sections and for each type of work is presented in the section **Design section execution deadlines and evaluation system.**

Evaluation cards are provided in Appendix 1.

#### **4. The periods of game design**

Mock design from in the "TMM" course is divided into periods: preparatory, main, final.

During the preparatory period, the teacher familiarizes the students with the sections of the course design: 1. Structural analysis of the hinge-lever mechanism. 2. Kinematic study of the hinge-lever mechanism. 3. Synthesis of gear mechanism. 4. Power calculation of the hinge-lever mechanism. 5. Synthesis of cam mechanism. 6. Study of movement of a machine unit under the action of given forces; announces the deadlines for each of the sections and announces the maximum number of points that can be obtained for each of the sections.

*The main period* is divided into several stages:

The preparatory stage, during which the teacher explains the rules of conducting the game to groups of performers, informs the content of each section of the task, issues the necessary methodological literature, and introduces the evaluation and incentive system. S(he) also informs about the deadlines for completing tasks.

*The first stage* is when technical bureaus are formed and a chairman and a deputy are appointed in each of the bureaus.

*The second stage*, at which the customer submits tasks and options to the head of the technical bureau according to the number of executors in the bureau. In real production conditions, this step corresponds to the Customer's transfer of the development application to the Developer.

*The third stage*, at which within every technical bureau the head of the bureau and his deputy explain the problem to the members of the bureau and choose more convenient methods and approaches to solving the problem.

*The fourth stage* is the most important and responsible stage. This is the independent work of students. The final result of the game and the Customer's acceptance of the Developer's work depend on the activities at this stage. At this stage, it is advisable to consult with the teacher. Work at this stage provides an opportunity for a more in-depth study of the subject and is more effective in comparison with traditional practical classes. Members of the bureau prepare illustrative material (drawings) for each of the sections and prepare the material according to the standards for drawings design and explanatory notes. At this stage, meetings and discussions of problem solving methods, etc. are also held in each of the bureaus.

The student's independent work involves mutual training of members of the technical bureau through the exchange of information and design results. This work involves presentations by heads of technical bureaus, discussion of reports by all participants of technical bureaus.

*The fifth stage*, at which the technical board is formed. The technical board consists of members of the bureau (in the number of no more than one person from each bureau). The board prepares questions for the participants of the game, which will then be asked in the defense of the course project, and prepares evaluation cards, to which the points will be entered in the defense. The obtained points for the sections are entered into the defense of the course project (CP) by the heads of each of the technical bureaus.

*The sixth stage*, during which the preliminary defense of the CP takes place. It includes an open discussion of the results of all types of work (on each of the sections of the course design). The groups compete with each other for the right to score the "best place" according to the number of points obtained for the completion of individual sections and for the subsequent submission of the results of the work performed. A report is prepared by each of the participants in the game (without the players who work in the technical council). Each participant of the game at this stage has the right to ask questions to the speaker and enter into a debate with him.

*The seventh stage*, in which the open defense of the CP is carried out. Participants make reports: they report on the task they received, what position they held in their technical office, what they were responsible for, and how they solved the task.

*The eighth stage*, at which the technical council together with the teacher get down to work: first evaluate the reports of the heads of all bureaus, and then of each of the bureau members, evaluate the quality of the execution of illustrative drawings, as well as the correctness of technical documentation (notes to the CP). The decisions of the technical board and the teacher are recorded in the evaluation card (the card of the points received by all participants of the game and the sum of points for each of the bureaus). The technical board asks questions during the reports of other participants of the game, calculates points for all participants, and at the end of all reports, each member of the technical board makes a comparative report on the results of the work carried out by each of the bureaus. The technical board together with the teacher identifies the winner (one of the bureaus, as well as one participant from this bureau) and points out the shortcomings and advantages of the work done.

*The ninth stage*, in which the technical board announces the results of the game.

*In the final period*, the results of the game are analyzed. This period of the game is conducted by a teacher who evaluates the work of the technical bureau and the technical board. Special attention is paid to the original solutions that were proposed. This period in the game corresponds to the approval stage of the technical task. The teacher approves the results of the mock design.

## 5. Game design algorithm

Table 1

Preparatory period	Main period	Final period
Familiarization with design sections	Stage 1. Formation of technical bureaus and election of heads and their deputies	The teacher gives an analysis of the work of all bureaus
Familiarization with the deadlines of the sections	Stage 2. Handing over the tasks and options to the head of the bureau	The teacher approves the results of the game design

Preparatory period	Main period	Final period
Familiarization with the scale of points that must be obtained	Stage 3. Explaining the problem to the members of the bureau and choosing more convenient methods and approaches to solving the problem	
	Stage 4. Independent work of students: <ol style="list-style-type: none"> <li>1) familiarization with methodological literature;</li> <li>2) familiarization of each of the bureau members with their functional duties;</li> <li>3) study by each member of the bureau of the semantic content of each of the sections;</li> <li>4) discussion of methods and ways of solving tasks;</li> <li>5) consultations with the teacher;</li> <li>6) calculations and design of drawings, explanatory notes, materials;</li> <li>7) preparation of explanatory notes</li> </ol>	

Preparatory period	Main period	Final period
	Stage 5. Formation of the technical board and its work on the preparation of issues for the defense of the CP and evaluation cards	
	Stage 6. Pre-defense of the CP	
	Stage 7. Defense of the CP	
	Stage 8. The work of the technical council and the teacher on counting the points and identifying the winners	
	Stage 9. Announcement of results by the technical council	

## 6. Deadlines and the system of evaluation of design sections at stage 4

*Chapter 1* (“Structural analysis of the hinge-lever mechanism”) should be done in the first practical session. The maximum score is 2.

This section is drawn up only in an explanatory note. The note is drawn up on sheets of A4 paper.

Table 2

Names of stage items	Recommended points
1. Acquaintance with methodological literature	0.25
3. Study by each member of the bureau of the semantic content of the section	0.25
4. Discussion of methods and ways of solving the task	0.25
5. Consultations with the teacher	0.25
6. Carrying out the structural analysis	1

*Chapter 2* (“Kinematic study of the hinge-lever mechanism”) should be completed within weeks 1-4 of classes.

The maximum score is 12. This section is drawn up both in the note and on the first sheet of A-1 format drawings.

Table 3

Names of stage items	Recommended points
1. Acquaintance with methodological literature	1
3. Study by each member of the bureau of the semantic content of the section	2
4. Discussion of methods and ways of solving the task	1
5. Consultations with the teacher	1

Names of stage items	Recommended points
6. Carrying out the calculations and drawings	7

*Chapter 3* (“Gear Mechanism Synthesis”) should be completed within weeks 5-7 of classes. The maximum score is 10. This section is drawn up both in a notebook and on the second sheet of A-1 format drawings.

Table 4

Names of stage items	Recommended points
1. Acquaintance with methodological literature	1
3. Study by each member of the bureau of the section	1
4. Discussion of methods and ways of solving the task	1
5. Consultations with the teacher	1
6. Carrying out the calculations and drawings	6

*Chapter 4* (“Calculation of forces in the hinge-lever mechanism”) should be done during 8-10 weeks of classes.

The maximum score is 10. This section is drawn up both in the note and on the third sheet of A-1 format drawings.

Table 5

Names of stage items	Recommended points
1. Acquaintance with methodological literature	1
3. Study by each member of the bureau of the section	1
4. Discussion of methods and ways of solving the task	1
5. Consultations with the teacher	1
6. Carrying out the calculations and drawings	6

*Chapter 5* (“Synthesis of cam mechanism”) should be completed during weeks 11-12 of classes. The maximum score is 8. This section is drawn up both in the note and on the fourth sheet of A-1 format drawings.

Table 6

Names of stage items	Recommended points
1. Acquaintance with methodological literature	0.5
3. Study by each member of the bureau of the section	0.5
4. Discussion of methods and ways of solving the task	1
5. Consultations with the teacher	1

Names of stage items	Recommended points
6. Carrying out the calculations and drawings	5

*Chapter 6* (“Study of the movement of a machine unit under the action of given forces”) should be completed during weeks 13-14 of classes. The maximum score is 10. This section is drawn up both in the note and on the fourth sheet of format drawings A-1.

Table 7

Names of stage items	Recommended points
1. Acquaintance with methodological literature	1
3. Study by each member of the bureau of the section	1
4. Discussion of methods and ways of solving the task	1
5. Consultations with the teacher	1
6. Carrying out the calculations and drawings	6

Thus, the maximum score obtained in the design process at stage 4 is 52.

The maximum score for the defense of the course project (report, answers to questions) is 8. Writing a note - 3 points, making drawings - 5 points.

During the game, students also earn additional points for the following types of work:

attending lectures - 8 points;

testing at the end of the game - 8 points;

test papers for testing knowledge - 6 points;

performance and submission of laboratory work - 6 points.

Evaluation of the work of the Technical Council. Distribution of maximum points by sections for stage 5 for members of the technical council (column "work in the council" in calculation card No. 2 of appendix 2):

Chapter 1 – 1 point.

Chapter 2 – 1 point.

Chapter 3 – 1 point.

Chapter 4 – 1 point.

Chapter 5 – 1 point.

Chapter 6 – 1 point.

The maximum score for stage 8 for members of the technical board ("work on defense" column) is 2 points.

## **7. Reminders to all members of the game**

The teacher can invite other teachers of the department for defending the CP.

The teacher forms a "technical bureau" and appoints the head of this bureau. The head of the technical bureau appoints his deputy and organizes the work of all members of the bureau. The head of the technical bureau determines the strategy of the task, summarizes the results of the work of individual performers, checks the prepared materials, makes a report.

The deputy head of the bureau monitors the timely performance of all stages of the work of each member of his bureau.

In the event of conflict situations in the technical bureau, the chairman and his deputy make decisions on resolving the conflict.

Members of the technical board prepare questions for the defense of the CP, draw up and fill in the evaluation card, together with the teacher, identify the winners.

## **8. The incentive system**

The incentive system is aimed at collectivizing the work of all game participants. This system encourages the initiative of each participant, as well as finding other (alternative) ways to solve the problem, encourages finding original solutions.

For active participation in work, as well as for helping other students in their office, game participants are stimulated with additional points.

Instead of points for the defense of the CP, the technical council receives points for the work in the jury when other participants of the game defend of the CP.

# APPENDICES

## APPENDIX 1

Evaluation card No. 1  
for members of the technical bureau

Technical office No. \_\_\_\_\_ group \_\_\_\_\_

\_\_\_\_\_  
(topic, object of research)

Start of the game \_\_\_\_\_

End of the game \_\_\_\_\_

\_\_\_\_\_  
(date)

\_\_\_\_\_  
(date)

Personnel technical bureau	Name Patronymic surname	Scores for stage 4 of section 1						Total for Chapter 1
		1	2	3	4	5	6	
Head								
Deputy								
Engineer								
Engineer								
Engineer								

Numbers from scheme 1 are marked with numbers in the score columns for stage 4.

In the same way, five more evaluation cards are prepared for sections 2, 3, 4, 5, 6 at stage 4.

Evaluation card No. 2  
for members of the technical bureau

Personnel of the technical bureau	Name Patronymic surname	Points for design by sections						Additional points								
		1	2	3	4	5	6	lectures	tests	control works	laboratory work	other types of work	defense CP	drawings	explanatory note	total
Head																
Deputy																
Engineer																
Engineer																
Engineer																

The head and deputy of the technical bureau transmit data on design points to the technical board, which fills in all other columns.

Points from the columns "total for section 1", "total for section 2", "total for section 3", etc. are taken from evaluation card No. 1.

## APPENDIX 2

Evaluation card No. 1

for members of the technical council

Technical office No. \_\_\_\_\_

group \_\_\_\_\_

\_\_\_\_\_  
(topic, object of research)

Start of the game \_\_\_\_\_

End of the game \_\_\_\_\_

\_\_\_\_\_  
(date)

\_\_\_\_\_  
(date)

Personnel of the technical council	Name Patronymic Surname	Scores for stage 4 of chapter 1						Total for Chapter 1	Stage 5 points of section 1
		1	2	3	4	5	6		
Council member No. 1									
Council member No. 2									
Council member No. 3									
Council member No. 4									
Council member No. 5									

In the same way, five more evaluation cards for sections 2, 3, 4, 5, 6 for stages 4 and 5 are prepared.

Evaluation card No. 2

members of the technical bureau

Personnel of the technical bureau	Name Patronymic Surname	Points for design by sections						Additional points									
		1	2	3	4	5	6	lectures	tests	control works	laboratory work	other types of work	work in the council	defense work	drawing	explanatory note	together
Bureau member No. 1																	
Bureau member No. 2																	
Bureau member No. 3																	
Bureau member No. 4																	
Bureau member No. 5																	

The columns "work in the council" and "work at defense" in total are evaluated with the maximum score of 8 (as at the defense of all other participants in the game).

The work in the council in evaluation card No. 2 includes the sum of points for sections 1- 6 for stage 5.

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