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Кафедра иностранных языков

ИНОСТРАННЫЙ ЯЗЫК
ТЕХНОЛОГИИ, ОБОРУДОВАНИЕ И
АВТОМАТИЗАЦИЯ
МАШИНОСТРОИТЕЛЬНЫХ ПРОИЗВОДСТВ

*Методические указания к практическим занятиям
для студентов бакалавриата направления 15.03.01*

САНКТ-ПЕТЕРБУРГ
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Данные материалы и методические указания предназначены для студентов бакалавриата направления подготовки 15.03.01 «Машиностроение (Технологии, оборудование и автоматизация машиностроительных производств)», изучающих английский язык. Методические указания включают аутентичные тексты различного уровня сложности по направлению подготовки, которые сопровождаются лексическими заданиями и заданиями на понимание материала. Грамматический раздел направлен на развитие навыков продуктивной речевой деятельности. Упражнения позволяют закрепить лексический и грамматический материал, развить навык работы со словарем и усовершенствовать навыки перевода специализированных текстов на русский язык.

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ПРЕДИСЛОВИЕ

Данные материалы и методические указания предназначены для студентов бакалавриата направления подготовки 15.03.01 «Машиностроение (Технологии, оборудование и автоматизация машиностроительных производств)», изучающих английский язык.

Изучение предложенного материала направлено на формирование и развитие навыков профессионально-ориентированного чтения на английском языке, а также перевода. Аутентичные тексты содержат информацию по темам, изучаемым в рамках направления подготовки, а также представляющим интерес для студентов профильных направлений. Каждый текст сопровождается заданиями и упражнениями, цель которых – активизация познавательной деятельности студентов, формирование активного словарного запаса и развитие навыков аналитического чтения и перевода, а также мотивация интереса студентов к будущей профессии.

Грамматический блок представляет тему "Вводные слова" и дает студентам возможность развить продуктивные навыки речевой деятельности и усвоить необходимый для этого лексический материал.

При изучении данного курса формируются следующие компетенции: способность к коммуникации в устной и письменной формах на русском и иностранных языках для решения задач межличностного и межкультурного взаимодействия (ОК-5).

UNIT 1
ARTIFICIAL INTELLIGENCE: THE FUTURE FOR
MECHANICAL ENGINEERING
INTRODUCTION

*Artificial intelligence will lead to considerable progress in production - without minimising the role of humans. Mechanical engineering companies **place** particular emphasis on the technology of "machine learning" and **face** up to their responsibility.*

Artificial intelligence is a branch of **computer** science that deals with the automation of intelligent behaviour and machine learning. Computer programs **based** on machine learning can independently find solutions for new and unknown problems with the **help** of algorithms. The artificial system "recognises" patterns and laws in the learning data it receives. The technology is already well advanced, but the **kind** of algorithmic calculation of probabilities that is necessary for machine **learning** always requires human action.

MAN AND MACHINE

With the help of artificial intelligence, people will be able to **work** even more closely with machines in the future. Machine learning ensures that machines are increasingly able to recognise and respond to the **needs** of people or the process. For example, people with disabilities can be supported at the workplace and reintegrated into the working world. In the future, even simple monotonous tasks, which are often repeated, can be better carried out or supported by AI-based solutions, such as checking invoices or necessary quality checks. Therefore, more and more engineers and computer scientists are needed to develop these systems and bring them to **product** maturity. As a result, new jobs are increasingly being created in industry.

Companies are also looking for specialists and engineers who can **master** the respective processes, because AI can only **function** in symbiosis with existing process knowledge. The use of AI-based solutions does not replace people in mechanical engineering, but requires them as trainers or managers. Further training in this field therefore plays a decisive role. AI competence is not only required by IT specialists and programmers, but also by employees of all functions, levels and departments.

MACHINE LEARNING IN THEORY

The first step on the way to machine learning is to train the machine with a large amount of learning data in order to later gain a suitable algorithm for production operation. This learning data must be very well **prepared** and correspond exactly to the process that is to be supported later. The selection and preparation of the data therefore **cause** the greatest effort in such a project.

The algorithm is then integrated into the productive system. From this point on it fulfils its learned task, but without gaining new experience or **improving** itself independently. The data input now leads to a data output that corresponds exactly to the **learned** behavior.

Various software tools that are already established on the market help set up such systems. New frameworks and platforms **support** the broad application of these previously rather "academic" topics in everyday project work. Machine Learning thus ensures that software and information technology are increasingly becoming the key drivers of innovation in mechanical engineering.

MACHINE LEARNING IN PRACTICE

Machine learning can be used to optimise both product characteristics and internal processes. The possible uses of machine learning also differ with regard to its use in products: on the one hand, this can take place in the product itself, and on the other in the process environment of the machine, for example in the form of maintenance or additional value-added services.

One field of application of Machine Learning is machine operation. This is simplified by **expert** systems. A successful example of this is an operator assistance system from HOMAG Plattenaufteiltechnik, which reacts intelligently to the actions of the machine operator. The video shows how the system supports the operator using optical signals that appear directly in the work view field. The machine operator **benefits** from the intelligent system's all-round visual support.

MACHINE LEARNING IN PRACTICE: SIGNIFICANCE FOR MECHANICAL ENGINEERING

The significance of machine learning for mechanical engineering is demonstrated by a current survey of the VDMA. Solutions **based** on machine learning are of medium to high relevance, especially in the areas of customer service (64%), design and development (54%) and production (50%).

Around 46% of the participants already have a corresponding solution in use for the company processes or in the products or services. Machine learning is mainly used in design and development (14%), customer service (13%), production (13%), accounting and controlling (10%), condition monitoring (13%) and remote service (13%). In addition, the companies **surveyed plan** to significantly **increase** their use of the processes and products over the next three years. By 2022, for example, more than half of companies want to use machine learning-based solutions in customer service.

ETHICS AND AI

In mechanical engineering, artificial intelligence brings with it a major change: data-based business models will also become a focus of future value creation in industry. In a data-based economy, however, ethical issues are of fundamental importance. This **concerns** the question of human-machine interaction as well as the question of data sovereignty. It is necessary to take a close **look** at the problem to be solved, since data ethical questions are not equally relevant in all industrial applications. It makes a significant difference whether data is used to optimise a manufacturing process in a machine or to make a medical diagnosis. There are numerous regulations and guidelines regarding safety, health protection or product liability which machine manufacturers must comply with today and which also apply to the **use** of new technologies. In industrial use, artificial intelligence also offers considerable advantages in **producing** more resource-efficiently and sustainably and in maintaining innovation leadership in mechanical engineering. The successful use of AI thus secures millions of jobs in Europe in the long term. This is also an ethical responsibility.

Task 1 Find the English equivalents of the following words and word combinations in the text. The list is in the order of appearance in the text.

Introduction

Значительные успехи/ существенное увеличение объема; придавать особое значение; отрасль, сектор, раздел; интеллектуальное поведение, интеллектуальные характеристики; компьютерное/ машинное обучение/ обучение машин; находить решения; образец/ схема/ модель; хорошо развитый, успешно развивающийся; алгоритмическое вычисление вероятностей; действие/ работа/ участие человека;

Man and machine

тесно сотрудничать; все более/ все чаще; получать поддержку; основанный на ИИ; контроль качества; доработать/ довести до завершения/ окончательно доработать продукт; промышленность, отрасль промышленности; соответствующий; знание процессов/ техническая информация; машиностроение / инженерная механика; повышение квалификации/ переподготовка/ дальнейшее образование; решающая роль; наемные работники, сотрудники, штат;

Machine learning in theory

обучающая информация; разработать необходимый / подходящий / соответствующий алгоритм; производственная/ технологическая операция; требовать наибольших усилий; затем, после этого; ввод/ вход данных/ формирование входа данных; формирование выходных данных/ выход данных; приобретенное/ заученное поведение; программное обеспечение/ средство/ инструмент; зарекомендовать себя на рынке; основа/ концептуальная схема; широкое применение; определяющий фактор/ движущая сила;

Machine Learning in Practice

характеристики товара/ изделия; внутренний процесс; в части/ в том, что касается; происходить; технологическая среда/ особенности технологического процесса; ремонт и содержание; дополнительная услуга/ связанная с приращением стоимости; область применения; эксплуатация/ работа машины; успешный / хороший пример; система помощи/ участие оператора; область рабочего окна; всесторонняя визуальная поддержка;

Machine Learning in Practice: Significance for Mechanical Engineering

от средней до высокой степени важности; обслуживание клиентов/ предоставление услуг; проектирование и разработка/ техническое проектирование; производство / выпуск продукции; соответствующее решение; технологические процессы/ операции компании; учет и контроль; мониторинг состояния; дистанционное обслуживание; значительно возрастают;

Ethics and AI

существенное/ значительное изменение; бизнес-модели, основанные на данных; создание ценностей/ добавленной стоимости; взаимодействие человек-машина/ человеко-компьютерное взаимодействие; суверенитет данных/ суверенитет/ сохранение контроля над данными; внимательно разобраться/ подробно исследовать; производственный процесс/ метод; поставить медицинский диагноз/ провести медицинскую диагностику; многочисленные; в отношении/ применительно к; безопасность; охрана здоровья; ответственность за изделие/ за качество продукции; производитель машин и механизмов; иметь отношение к; сохранять лидерство/ поддерживать лидирующую роль; обеспечивать наличие рабочих мест/ создавать новые рабочие места; в долгосрочной перспективе.

Task 2

Part 1 Read the text and fill the gaps with the right prepositions where necessary (Note that in some word combinations word order and form of verbs have been changed). Translate the word combinations.

Introduction

to place particular emphasis _____ smth.; to face _____ responsibility; to deal _____ smth; necessary _____ machine learning; to require _____ human action;

Man and machine

_____ the help _____ artificial intelligence; to work closely _____ machines; to respond _____ the needs _____ people; people _____ disabilities; _____ the workplace; to be reintegrated _____ the working world; to carry _____ monotonous tasks; to check _____ invoices; to develop _____ systems;

Machine learning in theory

the first step _____ the way _____ machine learning; to train _____ the machine; to correspond _____ the process; to be integrated _____ the system; _____ this point _____; to be established _____ the market; to set _____ systems;

Machine learning in practice

_____ regard _____ smth.; _____ the form _____; to react _____ the actions _____ smb.; to benefit _____ support;

Machine learning in practice: Significance for Mechanical Engineering

to be _____ medium _____ high relevance; to have a solution _____ use; _____ addition; _____ the next three years;

Ethics and AI

to bring _____ it _____ a major change; to become a focus _____ smth; to be _____ fundamental importance; to concern the question _____ human-machine interaction; to take a close look _____ smth; to make _____ a significant difference; to comply _____ regulations and guidelines; to apply _____ the use _____ technologies.

Part 2 Use 5 to 10 word combinations to make up sentences in English for the group to translate.

Task 3 *In the text, find the underlined words and word combinations and explain them in English by giving definitions and/or synonyms. While reading the words consider which part of speech they are, and only explain the meanings they have in the text. Use a good English-English online dictionary when necessary. ATTENTION! The task also includes the underlined words given in bold type.*

Task 4

Part 1 In column B of the table, find antonyms (opposites) to the words from the text given in column A.

A	B
unknown	minor, unimportant
receive	inactive, future, or exterminated
necessary	minus, drawback
existing	outside, external
everyday	give, output
internal	optional, needless
current	familiar, identified
major	irregular, rare, uncommon
advantage	old, past

Part 2 Translate the pairs of antonyms based on the meanings the words in Column A have in the text.

Part 3 Make up 5 to 8 collocations using words from either column A or column B. In pairs or groups, develop the collocations into sentences for other pairs or groups to translate into Russian.

Task 5 *In the text, find the words given in bold type and identify the part of speech. Explain your choice. Possible options: verb, noun, adjective/ participle, gerund, infinitive. ATTENTION! The task also includes the underlined words given in bold type.*

Task 6 *Read and translate the text.*

Task 7 *Say if these statements are true or false. For both true and false statements, find evidence in the text.*

- 1 With the advance of AI, the role of people in mechanical engineering will be reduced to a minimum.
- 2 Algorithms allow computer programs to deal with new challenges without outside help.
- 3 AI creates new prospects for coordination between people and machines.
- 4 Use of AI in industry results in reduced job opportunities.

5 AI competence is a necessity for employees with qualifications in Computer Sciences.

6 The algorithm operating in the productive system develops autonomously.

7 Machine learning is also applied in repairing the product.

8 Machine learning solutions are only relevant in production.

9 Machine learning is most extensively used in condition monitoring, accounting, and controlling.

10 By 2022, over 50% of companies are eager to apply machine learning-based solutions in client support.

11 In a data-based economy, ethical issues are a matter of major relevance.

12 The degrees of relevance for ethical questions vary from one industrial application to another.

UNIT 2 DIGITALISATION AND AUTOMATION IN MECHANICAL ENGINEERING INTRODUCTION

When we speak about technological progress in mechanical engineering in general terms, the major topics usually are Artificial Intelligence (AI) and the Industrial Internet of Things (IIoT).

In modern glass production there are also numerous developments in these areas that have outgrown the research stage. **A** _____.

Engineering has made enormous advances over the past few years. Machines boast increasingly higher output, they operate more precisely **B** _____. This last parameter is becoming more and more important, especially against the backdrop of sustainability.

In the course of events new technologies achieve market readiness while other technical solutions become obsolete and vanish from the market. One example of this trend is most definitely laser technology, which was considered exotic and too expensive especially for glass finishing until a few years back. However, machines became cheaper and more efficient **C** _____. Even laser-based surface **finishing** is growing more worthwhile, now offering more possibilities than sandblasting, for example.

DRASTIC DIGITALISATION

While for years automation was in the foreground, the focus has now shifted to other areas thanks to the ever new possibilities of digitalisation. **D** _____.

“In order to fully leverage the potential of this equipment, the tasks associated with it, and the interdependencies, internal logistics in manufacturing must also be considered as the degree of automation rises. The term ‘Shop-Floor Logistics’ aptly describes this ongoing change process in classic production: with up-to-date equipment, efficiency in production does not depend any more on machine output but rather on the speed and precise cycle time needed for the glass to arrive at the various finishing stations,” explains Bernhard Hötger, General Manager of the Hegla Group. The volume of glass and great time pressure require a smooth, precise and transparent material flow **E** _____.

NEW CHALLENGES FOR ENTERPRISES

Despite plenty of optimisation and a high degree of automation, companies are constantly challenged by time limits. One reason is the current labour market because many companies are now already lacking skilled labour. Even though in theory companies’ machinery and equipment capacities are often sufficient to process customers’ jobs, in practice the increasing shortage of skilled labour along with high requirements on coordination plus rising time and cost pressure **causes** bottlenecks in many firms.

F _____. Modern software in manufacturing can – depending on the control concept and integration depth – not only **map** parts of production but even display individual “slices” digitally and optimise their workflow.

One prerequisite for this is to select, capture and collect the required data and output parameters thereby making them actionable insights. Furthermore, staff on the machine side of the business must be consistently supported in their efforts. This is done by providing assistance for workflow, supplying data for jobs, by control instructions and information on the equipment state or by even more user-friendly and intuitive controls.

G _____. Machine operators will be less and less dependent on local data access at the machine or the control panel, and will be able to use an App to start a new job order for a damaged glass sheet, find the storage place of a glass rack or establish the downstream process, retrieve maintenance information, report malfunctions or re-order consumables.

In modern manufacturing man and machine virtually work hand in hand. **H** _____.

“Of course, this includes the complete value chain from the batch plant and furnace, the cold end to the warehouse and downstream processing. In a nutshell: a consistent digitalisation of all processes speeds up the workflow, makes it transparent, thereby ensuring that all required information is highly available at any time,” stresses Egbert Wenniger, Senior Vice President Business Unit Glass at Grenzebach.

Of course, digitalisation does not stop at the company premises. The field team at digitalised companies naturally also has App-based access to all required data when talking to customers or working on site.

Many larger companies have already taken up the idea of digitalisation. **I** _____. They probably **shy** away from the associated investment. But just **like** in people’s everyday **lives** where digitalisation is on an unstoppable advance, the digitalisation of processes is indispensable for glass manufacturers to remain competitive and future-proof in their business.

Task 1 *Nine sentences and parts of sentences have been removed from the text. Read the text and put the sentences or sentence parts given below (1 to 11) back in their places (A to I). There are two extra sentences you do not need.*

- 1 All threads run together in the “brain” of the Industry 4.0 solution.
- 2 ... so today they can be economically used for drilling ...
- 3 Digitalisation that ideally covers a complete company promises to bring improvements here.
- 4 As digitalisation and connection increase, additional possibilities for digital **support** and process control will emerge.

5 The reorganisation of manufacturing into holistic processes will in future simplify and improve the interfaces between machines as well as their communication with humans.

6 ... and as a rule consume significantly less energy than just a few years ago.

7 But there still are many SMEs that **view** this development with a critical eye.

8 However, there are also other aspects in this context that we would like to shed some light on in the article.

9 The system sets the cycle in this process and man supports it.

10 As a result, manufacturing is reconstructed into a comprehensive process intended to further optimise the transitions and interactions between machines and machine operators, cycle times and material **flows**.

11 ... in order to reduce or avoid downtimes caused by manual handling or missing sheets.

Task 2

Find the English equivalents of the following words and word combinations in the text. The list is in the order of appearance in the text with all (parts of) sentences from Task 1 put back in.

Digitalisation and automation in mechanical engineering

машиностроение; в общих чертах, в широком смысле; искусственный интеллект; промышленный интернет вещей; многочисленные; достижение, изменение; перерасти, вырасти из ...; разъяснять, давать представление; добиваться успеха, продвигаться; потреблять энергию; значительно меньше; в условиях, в контексте, на фоне; устойчивое развитие, экологичность, рациональное использование ресурсов; в ходе событий, в процессе, со временем; готовность к условиям рынка; устаревать; скорее всего, совершенно определенно; доработка, чистовая/ конечная обработка, обработка поверхности; всего несколько лет назад; экономно, без экономического ущерба, рационально; сверление; определение размера, обработка в размер, задание размеров; стекло дисплея; лазерная обработка поверхности; выгодный, целесообразный, перспективный; пескоструйная обработка;

Drastic digitalization

на первом месте, на первом плане; акцент сместился; всесторонний, комплексный, целостный; направленный, предназначенный; передача информации; оперативное время, продолжительность/ время цикла; движение/ перемещение материалов; полностью, в полной мере; максимально / эффективно использовать; взаимосвязь, взаимозависимость; внутренняя логистика; уровень/ степень автоматизации; логистика цеха, логистика производства; лучше всего описывать; текущий/ непрерывный процесс изменения; современное оборудование; производительность станка/ машины; станция доводки/ чистовой обработки; простой, непроизводительное время; ручная обработка, ручное обслуживание/ управление; пропущенный/ неправильно поданный лист;

New challenges for enterprises

высокая/ значительная степень; постоянно сталкиваться; нормы времени, ограничения по времени; современный/ сегодняшний рынок труда; нуждаться, испытывать недостаток, не хватать; квалифицированный труд, квалифицированные работники; достаточный, соответствующий, необходимый; обрабатывать/ выполнять индивидуальные заказы; растущая нехватка; высокие требования; нехватка/ дефицит времени; необходимость сокращения расходов; помеха, препятствие, ограничивающий фактор; относиться к, распространяться на; приводить к улучшениям; концепция системы управления, принцип контроля; степень интеграции; схема работы, ход работ; предварительное условие/ требование; получать/ считать/ загружать данные; собирать данные; требуемые/ необходимые/ обязательные данные; эффективные/ реализуемые идеи, практический механизм; персонал, сотрудники; последовательно, систематически; состояние оборудования; удобный для пользователя, эргономичный; появляться, возникать; доступ к местным данным; блок управления, приборная панель, коммутационная доска; дефектный, поврежденный; место хранения, склад; стеллаж/ стойка для хранения стекла; наладить/ разработать процесс; последующий технологический процесс; извлекать/ получать информацию о техническом обслуживании; сбой, неисправность; расходные материалы; формировать (производственный) цикл; цепь создания стоимости, произ-

водственно-технологические связи; дозирующая установка; выход/холодный конец печи; высокодоступный; территория компании; полевая группа/ группа, работающая на выезде; доступ через приложение; на месте эксплуатации, на выезде; не рисковать, не решаться, избегать; связанный с чем-либо, сопутствующий; неудержимое наступление, неостановимое продвижение; перспективный, готовый к будущему.

Task 3

In the text, find the words given in bold type and identify the part of speech. Explain your choice. Possible options: adjective, gerund, verb, noun.

Task 4

Part 1 Read the text and fill the gaps with the right prepositions where necessary (Note that in some word combinations word order and form of verbs have been changed). Translate the word combinations.

Digitalisation and automation in mechanical engineering

_____ general terms, to outgrow _____ the research stage, to shed some light _____ smth, _____ the past few years, to consume _____ energy, _____ the backdrop _____, _____ the course _____ events, to vanish _____ the market, an example _____ smth, _____ a few years back;

Drastic digitalization

_____ the foreground, thanks _____ smth, to be reconstructed _____, to depend _____ smth, to arrive _____ a finishing station, caused _____ smth;

New challenges for enterprises

to be faced _____ smth, to lack _____ skilled labour, shortage _____ skilled labour, high requirements _____ smth, to cover _____ a complete company, _____ the machine side _____ the business, to be supported _____ their efforts, information _____ smth, possibilities _____ smth, to work hand _____ hand, _____ a nutshell, to speed _____ the workflow, _____ any time, to have access _____ smth, to work _____ site, to take _____ the idea _____, to view smth. _____ a critical eye, to shy _____

_____ investment, _____ everyday life, to be _____ an unstoppable advance, indispensable _____ smb/smith.

Part 2 Use 5 to 10 word combinations to make up sentences in English for the group to translate.

Task 5 Read and translate the text.

Task 6 In the table, there are 17 questions to the text. Match the beginnings of the questions (A) with their endings (B), then answer the questions.

	A	B
1	Which branch of production	in equipment operation are mentioned in the article?
2	In what areas have the developments in this	and which one(s)?
3	Is it the only branch of production	as a driving force in industry today?
4	What changes	unsure about digitalisation?
5	Do these changes	of consistent digitalisation?
6	How does the article describe the evolution	the efficiency of production depend on now?
7	What does the author see	of technologies? Give an example from the text.
8	How has this factor	to the company's location?
9	Which factor does	production branch outgrown the research stage?
10	What major challenge do companies	will industrial applications be able to perform?
11	How many reasons for this does the author mention,	be organised?
12	Optimally, which	that the article covers?
13	How must staff support	constantly deal with?
14	Which tasks	is the article related to?
15	In summary, what are the outcomes	offer any advantages?
16	Are the advantages of digitalisation limited	parts of a company must be digitalised?
17	Why do many small and middle-sized enterprises still feel	changed the manufacturing process?

Task 7 Write a short summary of the text.

UNIT 3

AI AND THE FUTURE OF THE MACHINE DESIGN

Not all that long ago, engineering was a profession **conducted** with pencils and paper. Calculations were done by hand and designs were sketched out on large sheets. From actual blueprints, physical models would be made to **work** out how the final product should look and be made.

A _____

Although these tools have enhanced the powers of engineers, the engineer is still clearly in control of the design process. But that control is now in question. There is increasing interest in using new artificial intelligence and other technologies to reach higher levels of product automation and accelerate innovation of new products. Advances in AI, combined synergistically with other technologies such as cognitive computing, Internet of Things, 3D (or even 4D) printing, advanced robotics, virtual and mixed reality, and human machine interfaces, are transforming what, where, and how products are designed, manufactured, assembled, distributed, serviced, and upgraded.

This revolution will make possible a new type of design process, one where AI-enabled programs iterate and optimise with **little** human intervention. The resulting designs seem impossibly complex, but thanks to advanced manufacturing technology, they are no more difficult to print than conventional designs. Already, parts that are the result of this generative design process are being readied for use in commercial aircraft and other critical systems.

The transition from drafting boards to CAD was disruptive to engineering. The next transformation to generative design is expected to be more disruptive.

Artificial intelligence is a concept that encompasses a wide spectrum of technologies, and some types of AI have been applied to engineering systems for some time. Knowledge-based systems and AI rule-based expert systems were first used in the 1980s to automate many of the mundane tasks for engineers. The intelligent agent paradigm was introduced in 1990s and provided a common language to describe problems and share their solutions.

Those applications are considered to be “weak” AI.

B _____

Artificial intelligence is moving forward in leaps and bounds (indeed, some researchers now speak of developing artificial superintelligence—ASI) and much of the excitement about AI is directed toward applications where computer systems will operate with great autonomy. The self-driving car is the poster child for AI, but there are a number of intriguing applications—from robotic clinicians who will be able to diagnose illnesses more accurately than any human doctor to AI-directed corporations that can orchestrate company activities without flesh-and-blood management.

C _____

First, artificially intelligent systems will **ease** the laborious tasks that designers face, such as having to continually search for appropriate content, **fix** errors, determine optimal solutions, communicate changes, and monitor for design failure. Machine learning will be able to take on those jobs and do them much, much faster.

Next, AI will be able to assist in the creation of sophisticated designs. Intelligent systems will work at the designer's elbow, suggesting alternatives, incorporating sensor-based data, generating design precursors, optimizing supply chain processes, and then delivering the designs to intelligent manufacturing facilities.

The final stage would have more profound implications. Engineering systems that incorporate stronger AI will be able to **function** more like human assistants during the design and creation process. Actual human designers will be able to “design” merely by expressing **intent** and curating results, while intelligent systems and machines will act on these intentions to create new design iterations for review.

The AI would not **approach** the project the way a human designer would, however. Instead, the computing power would be harnessed to mimic Nature's evolutionary approach — taking the best existing solution to a problem and iterating to optimise performance in a **given** environment. In this way, the AI would explore the variants of a design beyond what is currently possible using the traditional design process. This approach is called generative design.

D _____

With the boundaries of the design problem established, the AI generative design system, such as Autodesk's Dreamcatcher, explores permutation of a design solution, quickly cycling through thousands—or even millions—of design choices and running performance analyses for each design. For the most intensive calculations, the system can tap available cloud computing processing power.

One key component of a generative design system is its machine learning algorithm. That algorithm detects patterns inherent in millions of 3D models and generates taxonomies without human direction or intervention. Using that capability, generative design software can learn what all of the components of a complex system are, identify how they relate to each other, and determine what they do. It can then serve up dozens of different design options for a specific dimension of a component and provide them as components for the next design.

Task 1 *Four paragraphs have been taken out of the text. Read the text and put them back in place matching 1-4 to A-D.*

1

The product-design process has already been affected by existing artificial intelligence, and AI will change the way we embed connected sensors and employ mixed or augmented reality headsets going forward. Based on the current trajectory, it is likely we will see AI **impact** product design and the creation of engineering systems in three distinct stages in the coming decade.

2

Today, of course, engineering is a discipline intensely involved with computational and software tools. Computer-assisted design, computational fluid dynamics, and finite-element analysis applications are some of the basic tools that engineers deploy when creating new product designs. When physical models must be tested, prototypes can be printed directly from the computer files.

3

Although much of the generative design process is conducted autonomously, the process starts with choices made by a human. The engineer or industrial designer **sets** high-level design goals, along with design

parameters and constraints, including material type, manufacturing capability, and price points.

4

In contrast, “strong” AI would behave more **like** general intelligence and be capable of sensing, perceiving, learning from, and responding to the environment and users. Strong AI, also known as artificial general intelligence (AGI), refers to machine intelligence and deep learning systems that show complex behavior similar to living systems like swarms, ant colonies, and neural systems. These systems will have the ability to adapt to most situations.

Task 2 Find the English equivalents of the following words and word combinations in the text. **ATTENTION!** The words and collocations are given in the order they appear in the text with all paragraphs in the right place.

вычисления; выполнять вручную; проект, конструкция; делать наброски; копия чертежа, предварительный проект; тесно связанный; вычислительные и программные средства; компьютерное моделирование, автоматизированное проектирование; гидродинамическое моделирование, расчетная/ вычислительная гидродинамика; исследование/ анализ/ расчет методом конечных элементов; физический макет; модель, опытный образец; напрямую; усилить потенциал, дополнить возможности; процесс конструирования/ разработки; растущий интерес; когнитивные/ познавательные вычисления; современный, продвинутый, передовой; робототехника; гибридная/ смешанная/ дополненная реальность; интерфейс «пользователь-машина», автоматизированное рабочее место; выполнять операцию/ цикл, повторять; участие/ вмешательство оператора; стандартная конструкция, традиционное конструктивное решение; генеративный дизайн, порождающее проектирование; пассажирский самолет; особо важный; чертежная доска (кульман); разрушительный / революционный; ожидается; объединить/ сосредоточить в себе; инженерная/ техническая система; система с базами знаний/ элементами искусственного интеллекта; экспертная система на базе правил; рутинная задача; система, концепция, модель; создавать, предоставлять, обеспечивать; делиться, совместно использовать; общий ин-

теллект; также называемый/ известный также как; система глубокого/ глубинного обучения; сложное поведение, сложные формы поведения; биологическая/ живая система; ажиотаж, шумиха, интерес; беспилотный автомобиль; яркий пример, лицо кампании/ движения; множество, ряд, некоторое количество; правильно, безошибочно, с высокой степенью точности; организовывать/ планировать деятельность компании; разработанный ранее, уже существующий; помещать, устанавливать; подключенные/ соединенные друг с другом датчики; шлем/ гарнитура дополненной реальности; развиваться, улучшаться; современный, существующий, действующий; вероятно, скорее всего; следующее десятилетие; трудоемкий; устранять неполадки; информировать об изменениях; отказ из-за ошибки проектирования, конструкционный отказ; браться за работу, приступить к работе; усложненная конструкция, сложный проект; рядом/ вместе с проектировщиком/ разработчиком; включать данные, полученные с датчиков; производственные средства/ мощности/ оборудование; версия проекта; копировать, имитировать; конкретная среда, определенные/ существующие/ заданные условия; формулировать/ ставить цели; ограничения; технологические/ производственные возможности, производительность; рекомендуемая цена, ценовой ориентир/ уровень; устанавливать границы; задача проектирования, основные проектные требования; комбинация, сочетание; проводить анализ работы/ характеристик/ эффективности; доступный; облачные вычисления, вычисления в удаленной среде; вычислительная мощность, возможности по обработке данных; ключевой элемент, важная составляющая; без управления или вмешательства со стороны оператора; проектное решение, вариант разработки; конкретная характеристика, определенный параметр.

Task 3

Part 1 Read the text and fill the gaps with the right prepositions **where necessary** (Note that in some word combinations word order or the form of verbs have been changed). Translate the word combinations.

ATTENTION! The word combinations are given in the order they appear in the text with all paragraphs in the right place.

done _____ hand, to sketch _____ designs, to be involved _____ smth , _____ control _____, to be _____ question, increasing interest _____ smth, advances _____ smth, thanks _____ smth, readied _____ use, transition _____ drafting boards _____ CAD, to be disruptive _____ engineering, transformation _____ smth, to apply _____ engineering systems, _____ the 1980s, _____ contrast, to be capable _____ smth, to show _____ complex behavior, similar _____ smth, to adapt _____ most situations, to move _____ leaps and bounds, excitement _____ AI, to be directed _____ smth, affected _____ smth, to impact _____ product design, to search _____ content, to monitor _____ design failure, to assist _____ smth, to act _____ intentions, a solution _____ a problem, to start _____ smth, inherent _____ 3D models, to generate _____ taxonomies, to relate _____ each other.

Part 2 Use 5 to 10 word combinations to make up sentences in English for the group to translate.

Task 4

In the text, find the words given in bold type and identify the part of speech. Explain your choice. Possible options: verb or infinitive, noun, adverb, adjective or participle.

Task 5

Translate the text.

Task 6

Spell out the following abbreviations from the text: AI, 3D, 4D, CAD, AGI, ASI. Give full versions of the abbreviations and explain them (give definitions).

Task 7

*The text is divided into 17 paragraphs. Number the paragraphs after you have done Task 1, and find a synonym for the verb “use” in each of the following paragraphs: **2, 6, 10, 14, and 16.***

Task 8

Answer the questions.

- 1 What tools do engineers have today at their disposal?
- 2 What is the effect of using these tools for engineers?
- 3 Why is human control over design process in question now?
- 4 What is the purpose of using new artificial intelligence and other technologies?
- 5 Does the complexity of design present any challenge for manufacturing? Why (not)?
- 6 In what areas are the products of generative design already applied?
- 7 Does the word “disruptive” in paragraph 5 have a positive or a negative meaning? Explain your point of view.
- 8 Which elements of artificial intelligence were introduced as far back as in 1980s and 1990s?
- 9 What natural systems is AGI similar to? What abilities does this involve?
- 10 Apart from self-driving car, what are other applications where AI can operate with great autonomy?
- 11 How is AI likely to impact product design in the next 10 years? Give a brief description of each of the three possible stages.
- 12 What is the connection between generative design, traditional design, evolutionary approach, and going beyond the existing limitations?
- 13 How is labour divided between people and AI in generative design? What tasks does AI deal with in the process?
- 14 How does generative design software use its machine learning algorithm? What is the final result like?

Task 9

Write a paragraph to explain and comment on the following statement taken from the text:

The self-driving car is the poster child for AI.

UNIT 4
GRAMMAR SECTION
ВВОДНЫЕ СЛОВА

В английской грамматике термином "linkers" (или "linking words"), переводящимся в большинстве случаев как "слова-связки", называют слова, относящиеся к различным частям речи и выполняющие различные функции в предложении. Слова-связки являются одним из инструментов, формирующих структуру отдельных предложений и всего текста: они создают логические связи внутри предложений (например, объединяя простые предложения в составе сложных), а также между отдельными предложениями и/или абзацами. Таким образом, их использование значительно улучшает качество текста, который в результате становится более похожим на непринужденную естественную речь, и обеспечивает целостное восприятие передаваемой в тексте информации.

Слова-связки делят на группы в соответствии с их функциями (смысловой нагрузкой). В большинстве существующих классификаций выделяются следующие группы:

- подтверждение мысли/ выражение точки зрения: to my mind, in my opinion, from my point of view

She was wearing a hat which in my opinion was really stylish.

To my mind we have enough money to start the repairs now.

- приведение примеров: for example (for instance), as follows, namely, such as

There are three major advantages of the design, namely/such as cheapness, simplicity and availability.

- дополнение высказывания, добавление информации: in addition to, moreover, furthermore, besides, as well (as), also, apart from, too

Apart from Johnson's intelligence, he was extremely hard-working.

We look forward very much to seeing you again and to meeting your wife as well.

She has invited Jill as well as Kate.

- установление последовательности: first(ly), second(ly), the third point, lastly, finally, to begin with ... then... to conclude

Finally, we discuss the main policy implications of our findings.

First(ly), we need something to eat. Second(ly), we need to find a place to live in. And third(ly), we need to find work.

- указание на выбор или вероятность: either ... or; if/whether; anyway, in any case, either way;

You can stay either with me or with Janet.

Either I drive to the airport or I get a taxi.

I don't know whether the answer is right or wrong.

I cannot really say if they are coming to the meeting.

In any case, there is no doubt about the importance of what they are doing.

Either way, I start a new job next week.

- указание причины: because (of), due to (the fact that), owing to, as, since, for;

He was kept in after school due to/owing to his bad behaviour.

His accident occurred due to/owing to the fact that he was talking on his mobile phone.

- указание на следствие/результат: so, consequently, therefore, hence, thus, as a result (of);

He didn't wake up early. Consequently, he was late for work.

As a result of this mishap, he was not on work for a week.

David twisted his arm and, as a result, he won't be taking part in the basketball tournament.

- противопоставление одной идеи другой: but, although/ even though, however, in spite of/ despite (the fact that), whereas, while, unlike, in contrast, nevertheless, on the one hand... on the other hand, in theory... in practice;

Unlike in the US, the British radio and television operate on a national scale.

He was very tired; nevertheless he went on walking.

In spite of/ despite his age, he still leads an active life.

English became the official language for business in spite of/ despite the fact that the population was largely Chinese.

Although she is young, she is very independent.

She hasn't phoned, even though she said she would.

- акцентирование внимания: actually, in fact, typically/ generally/ as a (general) rule, obviously, especially, surprisingly, no doubt;

Actually, I'd rather spend the weekend at my sister's.

Typically, it relates to single-parent families.

This rule is difficult to understand, especially for beginner English language learners.

Surprisingly, they all agreed at once.

No doubt feasibility study is a necessity.

- подведение итогов: in brief, in short, in a nutshell, in conclusion, to sum up, to conclude, in summary;

In a nutshell, parents do their best to make their children happy.

In conclusion, walking is a cheap, safe, enjoyable and readily available form of exercise.

Роль вводных слов играют различные части речи, например союзы (whereas, although), наречия (however, therefore, on the other hand, furthermore), предлоги, состоящие как из одного слова, так и из фразы (despite, in spite of). С этим связаны особенности их употребления в предложении и грамматическая (синтаксическая) сочетаемость.

В частности, из вводных слов, используемых для дополнения высказывания, в начале предложения используются in addition to, besides, apart from, moreover, furthermore.

Also используется в начале предложения только в том случае, если в нем содержится информация, дополняющая предыдущее предложение:

E.g.: I am now working on a study guide. Also, I have a big piece of translation to complete by the middle of April.

В остальных случаях also не используется в начале предложения:

E.g.: Apart from a series of experiments, there were also some tests to be done.

As well (as) может использоваться как в начале, так и в середине или в конце предложения:

E.g.: As well as witty, the quote is extremely wise.

The dining facility offers vegetarian as well as traditional meals.

We are looking forward to seeing you and meeting your colleagues as well.

Too, как правило, находится в конце предложения:

E.g.: I got the invitation; some of my friends were invited too.

У вводных слов, используемых для указания причины, есть две модели грамматической сочетаемости:

После because of, due to и owing to используется существительное или герундий:

E.g.: Because of the adverse weather conditions, the flight was delayed.

Our success is due to months of hard work.

The project was running late owing to poor financing.

После because, as, since, for, due to the fact that необходимо придаточное предложение. При этом because и for по соображениям стиля редко используются в начале предложения:

E.g.: They were really angry because all their plans for the holiday were upset.

The children were all dressed up, for it was a family occasion.

As the day was going to be fine, we decided to go on a trip to the countryside.

Since she did not answer three phone calls, they stopped calling.

Due to the fact that she suffered from poor eyesight, the old woman was not aware of what she was signing.

Существительное или герундий также используется после вводных слов despite, in spite of, необходимых для противопоставления одной идеи другой:

E.g.: Despite / In spite of her good communication skills, she never made lasting friendships.

В конструкции с придаточным предложением используется вариант despite / in spite of the fact that:

E.g.: Despite / In spite of the fact that she was wearing a seat belt, she got injured in the accident.

Unlike также сочетается с существительными:

E.g.: Unlike her sister, she had brown hair and blue eyes and looked European.

Although/ Even though используются в сочетании с придаточным предложением, которое в случае с although чаще всего предшествует главному:

E.g.: Although they followed the instructions thoroughly, they did not achieve the desired effect.

She took a loan for a car, even though her friends advised her against it.

Although также может использоваться в сочетании с прилагательным:

E.g.: Although small, the car is quite roomy.

Задача however и nevertheless чаще всего заключается в том, чтобы связать между собой противоречащие факты. В этом случае используется конструкция из двух простых предложений или сложное предложение, разделенное точкой с запятой, и вводные слова находятся в начале второй части конструкции:

E.g.: Thank you for the invitation. However, I have already made plans for the weekend.

It was around midnight; nevertheless, there were a lot of people in the street.

Вводные слова не являются ни главными, ни второстепенными членами предложений, в которых они используются (это не сложно проверить, если попытаться задать вопрос от одного/ любого из членов предложения к вводному слову). Таким образом, синтаксическая связь между ними и этими предложениями полностью отсутствует.

Использование вводных слов в начале предложения – это самый распространенный случай, поскольку они связывают его с предыдущим предложением или абзацем. В то же время вводное

слово, которое находится в середине или в конце предложения, позволяет придать выражаемой мысли тот или иной яркий оттенок.

E.g.: They were unaware of the incident. Therefore, there was no way to make an informed decision.

To sum up, for a healthy heart you must take regular exercise and stop smoking.

The situation does not look very good, especially because your family is involved.

I had seen the film before, but I enjoyed it anyway.

The experiment was unsuccessful, an absolute disaster, in fact.

EXERCISES

Task 1 Find linkers in the texts given before. State their meaning.

Task 2 Choose the right linker to complete the sentences.

1 There was a description of 20 pretty villages of Scotland, _____, Crovie in Aberdeenshire.

a too **b** therefore **c** for instance

2 _____ Quentin Tarantino is my sister's favourite film director, she has watched his every film many times.

a As **b** Owing to **c** Finally

3 _____ you have made a good progress, so I cannot really see why you refuse to take the test now.

a Because **b** To my mind **c** Especially

4 The three most popular male names in the US over the last 100 years are _____: James, John, and Robert.

a apart from **b** as follows **c** thus

5 No one was sure _____ their plan would work.

a either way **b** no doubt **c** whether

6 Swedish is spoken in Finland _____ in Sweden.

a for example **b** as well as **c** in summary

7 _____ lack of interest, no tickets were sold, and so the event was cancelled.

a Also **b** Namely **c** Due to

8 _____, they paid more than we had agreed; _____, they left the room in a terrible mess.

hand **a** moreover... furthermore **b** on the one hand ... on the other hand **c** in theory... in practice

9 Well, that is about all I was going to say. _____, I would like to thank you for your active and effective cooperation.

a For example **b** Unlike **c** To conclude

10 _____ she was not invited, she decided to come and give me the present.

a Even though **b** To sum up **c** Since

11 The match was scheduled for Thursday _____ the weather forecast said it would rain.

a moreover **b** in spite of the fact that **c** and

12 The whole story would be too long, but _____, the main character finds herself in the end.

a nevertheless **b** in a nutshell **c** consequently

13 The children wanted to stay up _____, because it was Christmas Eve.

a too **b** to conclude **c** the third point

14 I like winter most of all seasons. _____, all my new friends love summer.

a Moreover **b** In contrast **c** In fact

15 I did not feel guilty at all. _____ I was not going to apologise.

a Hence **b** Although **c** In comparison

Task 3 Study the table and join the sentences/ parts of sentences using the linkers given. The resulting sentences follow the order given in the table (A + B+ C). Write down the sentences you get.

	A	B	C
1	Secondly, I don't know anyone in that city.	<u>namely,</u>	when the waves are heavy.
2	Always listen to your heart because	<u>Then</u>	everything is fine.
3	<u>Since</u>	but I'll ask her	one to three days.
4	There are three core subjects in the national curriculum,	<u>The third point,</u>	inform us if they get any news.
5	They enjoy surfing,	<u>typically</u>	it's on your left side, it's always right.

	A	B	C
6	<u>Apart from</u>	<u>especially</u>	he grew up in a big family.
7	To begin with, they arrived unexpectedly.	it is Friday,	all offices close at 4.30 p.m.
8	I don't think she knows anything about this,	<u>so</u>	<u>anyway.</u>
9	They will,	the fact that our luggage got lost,	it is too far to travel.
10	In this city rain can start at any moment,	most of his classmates,	they said they were going to stay for a month.
11	<u>Unlike</u>	<u>even though</u>	I always carry an umbrella.
12	The guests stay here for short periods of time,	<u>no doubt,</u>	English, Math, and Science.

- 1 _____
- 2 _____
- 3 _____
- 4 _____
- 5 _____
- 6 _____
- 7 _____
- 8 _____
- 9 _____
- 10 _____
- 11 _____
- 12 _____

Task 4 Determine the relationship between the sentences in each pair. Join the pairs of sentences using an appropriate linker of your choice. There may be several ways of joining, so make any changes you need.

E.g.: This market offers very cheap fruit and vegetables.
People from all over town shop here.

People from all over town shop at this market because it offers very cheap fruit and vegetables.

OR

As this market offers very cheap fruit and vegetables, people from all over town shop here.

OR

This market offers very cheap fruit and vegetables, so people from all over town shop here.

- 1 I really have no time to tell you the whole story.
They got away with what they did.
- 2 She bought herself a new hat.
She looks ridiculous in it.
- 3 For James, this was a great achievement.
He was not happy with it at all.
- 4 Tommy started eating healthy food.
He gave up smoking a week ago.
- 5 I know there are products called brain foods.
The list includes coffee, fatty fish and dark chocolate.
- 6 She did not hear the fire alarm.
All of her colleagues heard it.
- 7 She did not hear the fire alarm.
She stayed in her office.
- 8 The choice is between Italy and Spain.
I really cannot decide where to go on holiday.
- 9 A year ago I took an advanced language course.
My writing skills improved.
- 10 Some people are really careless with their money.
My neighbours regularly ask me for a loan.

Task 5 *In pairs or groups, make up 3 to 5 sentences in English for the other students to translate using any linkers of your choice.*

Task 6 *Write one to three paragraphs containing a sentence/ sentences with linkers used in any of the texts or in the exercises given in this section.*

БИБЛИОГРАФИЧЕСКИЙ СПИСОК

ОСНОВНАЯ ЛИТЕРАТУРА

1. Вводные и завершающие слова в английском языке. - EnglishFull. - <https://englishfull.ru/grammatika/vvodniye-slova.html>
2. Вводные слова в английском языке – English Dom. - <https://www.englishdom.com/blog/vvodnye-slova-v-anglijskom/#>
3. Слова-связки в английском языке <engblog.ru. - <https://engblog.ru/linking-words>
4. Слова -связки в английском языке – Linking words – LEARN ENGLISH BEST. - <http://www.learnenglishbest.com/english-linking-words.html>
5. AI and the future of the machine design // Artificial Intelligence and Deep Learning. - <https://asmedigitalcollection.asme.org/memagazineselect/article/139/10/38/380304/AI-and-the-Future-of-the-Machine>
6. Digitalisation and Automation in Mechanical Engineering. - <https://www.glassonweb.com/article/digitalisation-and-automation-mechanical-engineering>
7. ELTbase.com // Linkers in English – grammar reference notes. - <https://www.eltbase.com/notes-155-linkers>
8. VDMA: Artificial Intelligence – the future for mechanical engineering. - <https://www.vdma.org/en/v2viewer/-/v2article/render/36900765>

ДОПОЛНИТЕЛЬНАЯ ЛИТЕРАТУРА

1. <https://dictionary.cambridge.org/ru>
2. <https://idioms.thefreedictionary.com>
3. <https://sentence.yourdictionary.com>
4. <https://sentencedict.com>

5. <https://www.bbc.co.uk/worldservice/learningenglish/grammar/learnitv56.shtml>
6. <https://www.dailywritingtips.com>
7. <http://www.englishcollocation.com>
8. <https://www.foboko.com/sentence-dictionary/english/typically>
9. <https://www.ielts-practice.org/linking-words>
10. <https://www.merriam-webster.com/dictionary/actually>
11. <https://site.uit.no/english/grammar/aswellas/>

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МАШИНОСТРОИТЕЛЬНЫХ ПРОИЗВОДСТВ

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