Міністерство освіти і науки України
ВІДОКРЕМЛЕНИЙ СТРУКТУРНИЙ ПІДРОЗДІЛ «БЕРДЯНСЬКИЙ МАШИНОБУДІВНИЙ ФАХОВИЙ КОЛЕДЖ
Національного університету «Запорізька політехніка»

Циклова комісія спеціальних дисциплін

НАВЧАЛЬНИЙ ПОСІБНИК З ДИСЦИПЛІНИ

ІНОЗЕМНА МОВА ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ

Галузь знань	13 Механічна інженерія
Спеціальність	133 Галузеве машинобудування
ОПП	Технологія обробки матеріалів на верстатах і автоматичних лініях

2022 р.

ПЕРЕДМОВА

Посібник має на меті формування професійно спрямованої англомовної компетентності у студентів третього курсу напрямів підготовки 131 «Прикладна механіка», 133 «Галузеве машинобудування» Механіко-машинобудівного інституту.

Навчальне видання відповідає вимогам навчальної програми дисципліни «Іноземна мова професійного спрямування», розраховане на 36 годин навчального часу і може використовуватися на практичних заняттях з англійської мови та для самостійної роботи студентів.

Посібник охоплює пять тем на професійну тематику: “Bearings”, “Brakes”, “Parts of Machine: Linkage, Spring, Ratchet”, “Types of gears”, “How different gears work”. Кожна тема містить автентичні англомовні тексти за фахом та розроблені до них вправи (некомунікативні, умовно-комунікативні, комунікативні).

Розроблені вправи для студентів технічних спеціальностей уможливлюють формування навичок, розвиток і вдосконалення вмінь в аудіюванні, читанні, говорінні (діалогічному і монологічному мовленні), письмі та перекладі.

Розвиваючи інтерес студентів до вивчення іноземної мови та підвищуючи їхню мотивацію до навчання, розроблений курс сприятиме підвищенню ефективності навчального процесу.

CONTENTS

UNIT 1

BEARINGS

https://tryengineering.org/teacher/getting-your-bearings/

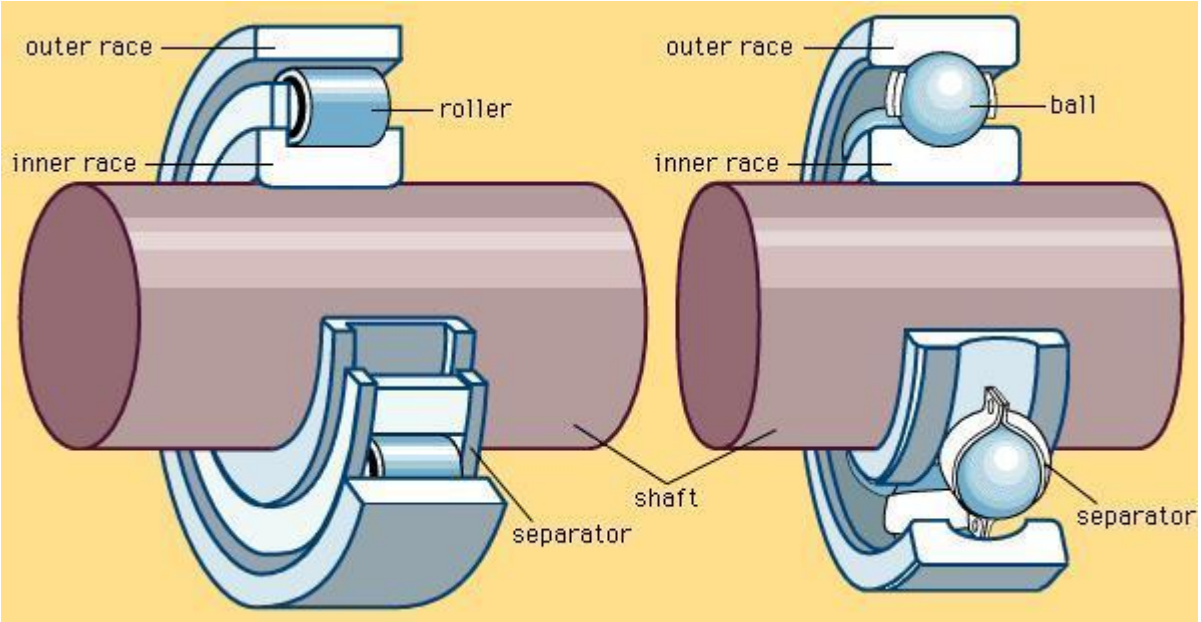
LEAD-IN

1. Try to give definitions to the following words, which are used to talk about bearings:

friction, wheel, axle, to reduce, to rip, housing, groove, clearance, film of oil, to support

2. Look at the diagram and try to explain the difference between a roller bearing and a ball bearing. Use the following words and phrases:

grooved ringlike races, steel balls, width, diameter, groove, outside surface, inside surface, to replace, rollers, line contact between a roller and the races, point contact



https://www.globalspec.com/learnmore/mechanical_components/bearings_bushings/roller_bearings

Self-assessment tip: *use the link above to check the right answer.*

READING

3. Before reading learn new vocabulary with Quizlet flashcards: *https://quizlet.com/568031745/unit-1-bearings-flash-cards/*

4. Read the text and answer the questions that follow.

BEARINGS

Bearing is a mechanical device for decreasing friction in a machine in which a moving part slides or rolls while exerting force on another part. Usually in a bearing the support must allow the moving part one type of motion, for

example, rotation, while preventing it from moving in any other way, for example, sidewise. The commonest bearings are found at the rigid supports of rotating shafts where friction is the greatest.

Bearings were invented early in history; when the wheel was invented, it was mounted on an axle, and where wheel and axle touched was a bearing. Such early bearings had surfaces of wood or leather lubricated with animal fat.

Modern bearings have been arbitrarily designated as friction bearings and antifriction bearings. The first comprises sleeve or journal bearings; the second, ball and roller bearings. Friction and antifriction are misleading terms. Neither type of bearing is completely frictionless, and both are highly efficient in reducing friction. A large, modern aircraft engine, for example, has more than 100 bearings, including both types; yet the total power consumed in overcoming bearing friction is less than 1 percent of the total power output of the engine.

Friction bearings of the sleeve or journal type are simpler than antifriction bearings in construction but more complex in theory and operation. The shaft supported by the bearing is called the journal, and the outer portion, the sleeve. If journal and sleeve are both made of steel, the bearing surfaces, even if well lubricated, may grab or pick up, that is, rip, small pieces of metal from each other. The sleeves of most bearings therefore are lined with brass, bronze, or Babbitt metal. Sleeve bearings are generally pressure-lubricated through a hole in the journal or from the housing that contains the bearing. The sleeve is often grooved to distribute the oil evenly over the bearing surface.

Typical clearance (difference between the diameters of journal and sleeve) is nominally 0.0025 cm (0.001 in) for every 2.54 cm (1 in) of journal diameter. When the journal is rotating, it may be about 0.0000001 cm (about 0.0001 in) from the sleeve at the side with the greatest load. The journal is thus supported on an extremely thin film of oil, and the two parts have no actual contact. As the rotational speed increases, other variables remaining constant, the oil film

becomes thicker, so that the friction increases in less than direct proportion to the speed. Conversely, at lower speeds the oil film is thinner if other factors are unchanged. At extremely low speeds, however, the film may rupture and the two pieces come into contact. Therefore, friction is high when the machine is started in motion, and the bearing may fail if high stresses are put on it during starting. Antifriction bearings, on the other hand, have low starting friction.

In a ball bearing, a number of balls rotate freely between an inner ring, which is rigidly fixed to a rotating shaft, and an outer ring, which is rigidly fixed to a support. Both balls and rings are made of hardened alloy steel, usually finished to extremely fine tolerances. The balls are generally held in position by a cage or separator that keeps them evenly spaced and prevents them from rubbing against each other. The bearing is lubricated with grease or oil.

A roller bearing is similar to a ball bearing, except that small steel cylinders, or rollers, are substituted for the balls. A needle bearing is a roller bearing in which the rollers are extremely long and thin. An ordinary roller bearing may have 20 rollers, each twice as long as it is wide; whereas a needle bearing may have 100 needles, each 10 times as long as it is wide. Needle bearings are particularly useful when space is limited. Among modern types of bearing you might encounter with: Cylindrical Roller bearing, Spherical Roller bearing, Tapered Roller bearing, Needle Roller bearing, Thrust Bearings.

From Encarta Encyclopedia

1. What common mechanism is used to reduce friction?
2. When and why were bearings invented?
3. What are the main types of modern bearings? Are any of them completely frictionless?
4. What do “journal and sleeve” mean in connection with bearings?
5. Why aren’t journals and sleeves usually made of steel?

6. Why may the oil film rupture at extremely low speeds?

7. What type of bearing has high starting friction?

8. How are antifriction bearings classified?

9. What is the structure of a ball bearing?

10. How is it different from that of a roller bearing?

11. What are needle bearings? Where are they used?

LANGUAGE DEVELOPMENT

5. Match the words in column A with the words in column B to form meaningful phrases. Translate them into Ukrainian.

Column A	Column B
1) mechanical	a) stress
2) highly	b) speed
3) antifriction	c) surface
4) rotating	d) terms
5) bearing	e) cylinder
6) high	f) proportion
7) misleading	g) efficient
8) low	h) metal
9) moving	i) device
10) steel	j) bearings
11) direct	k) part
12) Babbitt	l) shaft

6. Fill in the words from the list below and use them in your own sentences. Use each word only once.

proportion, tolerances, film, lubricated, engine, bearing, steel, complex, alloy, friction, speed, metal

1) extremely fine …..
2) ….. with animal fat
3) ordinary roller …..
4) ….. in theory and operation
5) extremely thin …..
6) small ….. cylinders
7) modern aircraft …..
8) hardened ….. steel
9) direct ….. to the speed
10) overcoming bearing …..
11) small pieces of …..
12) extremely low …..

7. Match the English phrases with their Ukrainian equivalents.

Types of bearings

1) adjustable bearing	a) підшипник кулачкового валу
2) double-row bearing	b) упорний підшипник
3) journal bearing	c) підшипник колінчастого валу
4) needle bearing	d) направляюча
5) camshaft bearing	e) підшипник з повітряним мастилом
6) self-alignment bearing	f) самовстановлювальний підшипник
7) air-lubracated bearing	g) двохрядний підшипник
8) guide bearing	h) встроєний підшипник
9) crankshaft bearing	i) радіальний підшипник

10) thrust bearing	j) голчастий підшипник
11) inboard bearing	k) регульований підшипник
12) self-lubricating bearing	l) самозмащувальний підшипник

8. Arrange the words according to similar meaning.

1) engine	a) action
2) stress	b) location
3) device	c) turning
4) power	d) machine
5) motion	e) velocity
6) friction	f) motor
7) mechanism	g) apparatus
8) position	h) bore
9) operation	i) movement
10) speed	j) abrasion
11) hole	k) strain
12) rotation	l) energy

9. Find the definitions to the following words.

device, shaft, engine, load, cylinder, stress, friction, surface, rupture, machine, hole, wheel

1. The amount of work that must be done by a machine.

2. A sudden breaking apart or bursting.

3. A bar which turns, or around which a belt or wheel turns, to pass on power or movement from an engine to something driven by the engine.

4. Force of weight caused by pressure.

5. The tube within which a piston moves backwards and forwards in an engine or piece of machinery.

6. A piece of equipment intended for a particular purpose.

7. An empty space inside something solid; cavity.

8. A piece of machinery with moving parts which changes power from steam, electricity, oil, etc., into movement.

9. A circular object with an outer frame which turns round an inner part to which it is joined.

10. The force which tries to stop one surface sliding over another.

11. The outer part of an object, especially when considered with regard to its roughness or smoothness.

12. An instrument or apparatus which uses power, such as electricity, to perform work.

10. Choose the correct preposition.

The most common bearing is the plain bearing, a bearing which uses surfaces *in / on* rubbing contact, often *with / within* a lubricant such as oil or graphite. A plain bearing may or may not be a discrete device. It may be nothing more than the bearing surface *of / for* a hole *within / with* a shaft passing *through / across* it, or *from / of* a planer surface that bears another (*on / in* these cases, not a discrete device); or it may be a layer *of / from* bearing metal either fused *towards / to* the substrate (semi-discrete) or *in / on* the form *for / of* a separable sleeve (discrete). *From / With* suitable lubrication, plain bearings often give entirely acceptable accuracy, life, and friction *for / at* minimal cost. Therefore, they are very widely used. However, there are many applications where a more suitable bearing can improve efficiency, accuracy, service intervals, reliability, speed *for / of* operation, size, weight, and costs *of / from* purchasingand operating machinery. Thus, there are many types *for / of* bearings,*with / from* varying shape, material, lubrication, principle *of / for* operation, and so on. Reducing friction *on / in* bearings is often important

of / for efficiency, to reduce wear and to facilitate extended use *of / at* high speeds and to avoid overheating and premature failure *from / of* the bearing. Essentially, a bearing can reduce friction *by / with* virtue *from / of* its shape, *with / by* its material, or *by / with* introducing and containing a fluid *between / among* surfaces or *with / by* separating the surfaces *with / by* an electromagnetic field.

11. Read the passage about bearings and choose the correct word.

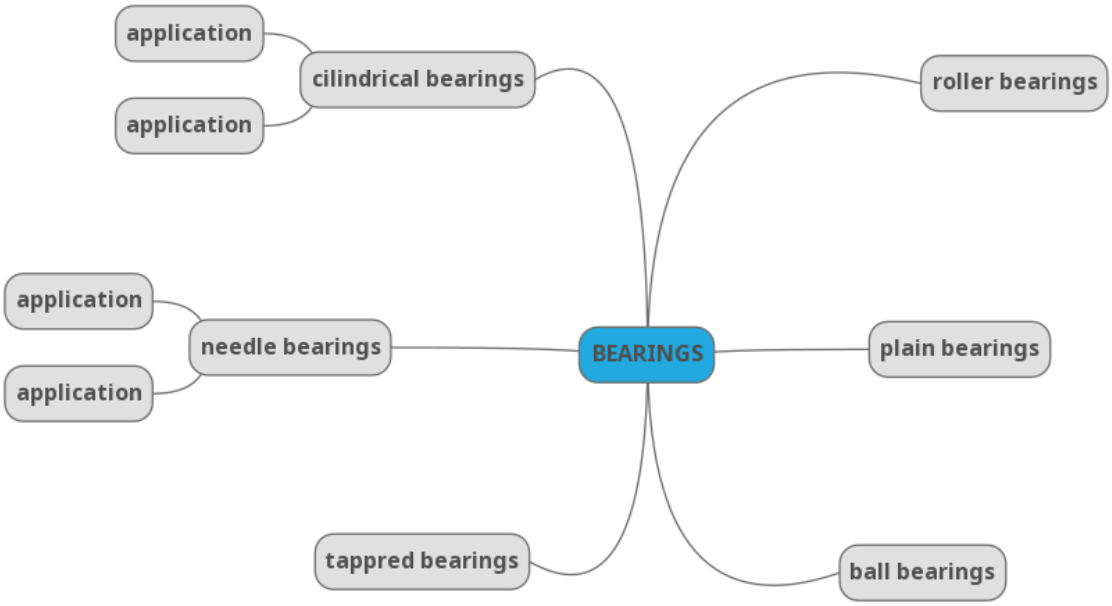
A bearing is a device allows ***constrained / constraining*** relative motion between two or more parts, typically rotation or linear movement. Bearings may ***be classified / be classifying*** broadly according to the motions they ***allow / allowing*** and according to their principle of operation as well as by the directions of ***applied / applying*** loads they ***could / can*** handle.

The invention of the ***rolling / roll*** bearing, in the form of an object ***being moved / been moved*** on wooden rollers, ***is / was*** of great antiquity and can ***predate / predated*** the invention of the wheel.

Bearings ***are used / used*** for holding wheel and axles. The bearings ***are used / used*** there ***were / are*** plain bearings that ***used / were used*** to greatly ***reduce / reducing*** friction over that of ***dragged / dragging*** an object by ***making / make*** the friction ***act / acting*** over a shorter distance as the wheel ***turned / turning***.

Over their history bearings ***have been made / have made*** of many materials ***including / included*** ceramic, sapphire, glass, steel, bronze, other metals and plastic which ***are*** all ***used / using*** today.

12. Create a mindmap about bearings application like you see in the picture: *Bearing mindmap*



LANGUAGE SKILLS

Study the information given below and use it while completing the tasks afterwards.

Compound adjectives and nouns.

A compound noun or an adjective is a word that is made up of two or more words. *Compound adjectives*

13. Match a word in column A with the word in column B to make compound adjectives or nouns.

A	B
remote	efficient
long	consumed

highly	controlled
powel	lubricated
air	gear
pressure	distance
fine	sized
rigitly	spaced
low	scale
full	fixed
evenly	starting
back	pressure
middle	chain
safety	toothed

14. Choose a compound word to complete the sentences.

output, clockwise, hacksaw, flywheel, plywood, screwdriver, steam drive, table saw, toolbox, workbench, sledgehammer, arrowhead

1. _____ is a tool which is used to cut with a narrowed fine toothed blades.

2. _____ motion is one that proceeds in the same direction as a clock's hands.

3. Technician’s _____ is a portable troubleshooting toolkit.

4. Average _____ power of a generator should be 70-100% of the continuous power rating.

5. A _____ is a spinning wheel or disc with a fixed axle so that rotation is only about one axis.

6. He hit the rock with the _____, and sparks flew off.

7. It wasn't a cheap _____ door with a simple push lock but a thick, wooden door.

8. _____ a circular saw mounted on the underside of a table through which its blade projects.

9. This _____ can be used to assist in crafting complicated operations.

10. I'd better get a _____ and tighten that ladder before you fall and break your neck.

11. The _____ vehicles are not used now.

12. The red _____ indicates decrease of the fuel consumption.

SELF-ASSESSMENT

15. Watch the video "Compound adjectives" and test your understanding by answering the questions of the quiz. You will get the answers and your score at the end of the quiz *https://www.engvid.com/advanced-english-vocabulary-compound-adjective*

16. Do a quiz "Compound nouns" online.

https://www.englishclub.com/grammar/nouns-compound-quiz.htm

LISTENING

17. Before listening to the text answer the questions:

What are the features of ball bearings?

Why are they so widely spread?

Scan the QR code and listen to the information about ball bearings and check your answers.

18. Listen again and complete the sentences with the information from the text:

1. The function of a ball bearing is _____ that move relative to one another.
2. In many applications one of the members is a _____ and the other a _____.
3. The larger race has a groove on its _____.
4. The balls fill the space between the _____ and roll with _____ in the grooves.
5. The balls are loosely _____ and separated by means of a _____ or cage.
6. The most common ball bearing, with one row of balls, is usually classified as a _____ bearing
7. The angular-contact bearing has one side of the outer-race groove _____ to allow the insertion of more balls.
8. The _____ in a single-row ball bearing are so _____ that no appreciable misalignment of a shaft relative to a housing can be accommodated.

9. For _____ there are ball thrust bearings that consist of two grooved plates with balls between.

10. The outstanding advantage of a ball bearing over a sliding bearing is its low _____.

11. The races are of the same _____ but different _____.

12. One type of _____ bearing has two rows of balls.

19. In pairs answer the following questions.

1. What is the function of ball bearings?
2. What are the parts of ball bearings?
3. What is the application of ball bearings?
4. How do they perform their function?
5. What is the function of a cage?
6. What are the types of ball bearings?
7. Why is the outer race groove in bearings cut away?
8. What are the parts of ball thrust bearings?
9. What is the advantage of ball bearings?
10. Why isn't there appreciable misalignment of a shaft in a single row ball bearing?
11. Why are races of different diameter?
12. What is the most common ball bearing?

SPEAKING

20. You work for a manufacturer of tools containing bearings. You have been asked to investigate the usage of different types of bearings in your products. Watch a video Types of bearings and read the information in

Appendix A (p. 115). Choose three types of bearings and compare them according to the following criteria from the chart.

CRITERIA	*.....bearing*	*.....bearing*	*…….bearing*
friction reduction			
work speed			
noise			
maintenance			
advantages			
disadvantages			

Use the words and phrases in the box below.

- friction	***- sealed cage***
- rotary motion	***- to sustain pressure***
- lubricant	***- load-carrying capacity***
- ball bearing	***- to be at rest***
- parts wearing	***- holding cage***

21. You and your partner are engineers working for a manufacturer of household appliances. You have to create the troubleshooting section of an instruction book for customers of household appliances (floor polishers, dishwashers, clocks, blenders, washing machines etc.). Discuss with your partner and make a list of the most common bearing faults (you can choose from Appendix A, p. 117) and from Guide bearing with these appliances which should be included in the troubleshooting section.

Use the words and phrases in the box below.

- friction	***- sealed cage***
- rotary motion	***- to sustain pressure***
- lubricant	***- load-carrying capacity***
- ball bearing	***- to be at rest***
- parts wearing	***- holding cage***

22. Work in groups. You and your group mates are in a workshop. A customer came to you for technical maintenance of his electric motor's failure. Read the case study about the electric motor failure (See Appendix A, p. 119). Then, using the list of bearing faults, you have made in the previous exercise, discuss with your groupmates the most likely causes of the problem, and rule out unlikely causes.

Use the words in the box below.

- grease	***- impact***
- lubrication	***- discoloration***
- assembly	***- failure***
- cage,	***- dust***
- bearings	***- chamber***
- corrosion	***- collapse***

The following language phrases may be also useful for you.

– It could be .....

– It can't be .....

– It must be .....

– It might be .....

– It sounds like .....

– I doubt it's .....

23. Work out an interactive communication assignment (See Appendix B, p. 139).

WRITING

24. Imagine that you are a professor preparing for a lecture devoted to the history of Bearings. Think about the main ideas that you would like to cover in this lecture and be ready for the questions the students may ask you. Read the information about the history of bearings *Evolution of bearings* ***and information from (Appendix C, p. 152) then complete the presentation*** *Evolution of bearings* ***(you should create your own personal presentation according to the template and points below) about the most significant and important development of bearings in your opinion. You should include the following points mentioned as titles of slides:***

– facts from the history;

– time and author of invention or development;

– actual application and benefits;

– reasons for your suggestion of its importance.

Use the words and phrases in the box below.

- prevent friction	***- alloy steel***
- hydro-dynamic theory	***- life of bearing***
- cutting tools	***- space exploration***
- grinding	***- launch satellite***
- consisted control	***- bearing market***

25. Webquest. Imagine that you work as an engineer and soon are going to take a group of foreign visitors around your enterprise. Prepare what you are going to tell them about different types of modern bearings used in the

complex machines located in the shops. Be ready for the questions the delegation members may ask you during their visit. Search the Web for further details of one type of modern bearings.

https://www.globalspec.com/learnmore/mechanical_components/bearings_bushings/roller_bearings

Guide to bearings

https://www.bearingtips.com/

https://www.motioncontroltips.com/bearings/

Write a review (200-250 words) and present it to your groupmates. Your summary should include the following points:

– type of bearing;

– inventor;

– application;

– materials;

– construction;

– advantages;

– disadvantages.

Use the phrases in the box below.

- bearings	***- lubrication***
- friction	***- motion***
- cage	***- tolerance***
- needles	***- thrust***
- tapered	***- rolling elements***

26. Translate the following passage about bearings from Ukrainian into English.

Вальни́ця (підшипник) — технічний пристрій, призначений для підтримування валу, закріплення на осі чи іншої конструкції у

зафіксованому розташунку, що забезпечує обертання, хитання чи гойдання або лінійне переміщення з найменшим опором, а також для сприйняття й передавання навантаження на інші частини конструкції.

Основні типи вальниць, які застосовуються в машинобудуванні — це вальниці кочення й вальниці ковзання. Вальниці кочення працюють на використанні принципу тертя кочення. Вальниці ковзання працюють на використанні принципу тертя ковзання.

Вальни́ця кочення — це елемент опор осей, валів та інших деталей, що працюють на використанні принципу тертя кочення. Вальниця кочення переважно складається з зовнішнього та внутрішнього кілець, тіл кочення і сепаратора. Відносне обертання внутрішнього кільця відносно зовнішнього забезпечується за рахунок тіл кочення між кільцями.

Вальни́ця ко́взання — це елемент опор валів і осей, поверхня цапфи яких взаємодіє в умовах проковзування через шар мастила або безпосередньо з поверхнею вальниці, що її охоплює.

INDEPENDENT STUDY

27. Try to answer the questions using the information from the unit and then check the answer *https://www.ggbearings.com/en/faq/bearings-faq*

1. How does the performance of sleeve bearings and ball bearings compare?
2. What is a ball bearing?
3. What is a bushing?
4. What is a deep groove ball bearing?
5. What is a roller bearing?
6. What is a sleeve bearing?
7. What is a slide bearing?

8. What is the difference between bearings and bushings?

9. What are the differences between plain bearings and roller bearings?

10. What are cylindrical bearings and how are they used?

11. What are plain bearings?

12. What are flange bearings?

13. What are thrust washers?

14. What are radial and axial bearings?

28. Check your understanding of the unit completing the online tests and quizzes:

Bearing quiz

Test on bearings

UNIT 3

TYPES OF GEARS

(шестерні, зчіплювання)

LEAD-IN

1. Think of as many words as possible related to the topic "Gears". How important are gears in engineering?

2. Match the types of gears (1-5) to the pictures (A-E). What other types of gears do you know?

1) herringbone gear;

2) helical gears;

3) spur gear;

4) worm gear;

5) bevel gears.

https://www.rexnord.com/blog/articles/gear/types-of-gears

A

https://www.rexnord.com/blog/articles/gear/types-of-gears

B

https://www.rexnord.com/blog/articles/gear/types-of-gears

C

https://www.rexnord.com/blog/articles/gear/types-of-gears

D

https://www.rexnord.com/blog/articles/gear/types-of-gears

E

Check the answers here.

3. Before reading learn new vocabulary with Quizlet flashcards: Gears

READING

4. Read the text and decide whether the statements that follow are true or false.

TYPES OF GEARS

Gear is toothed wheel or cylinder used to transmit rotary or reciprocating motion from one part of a machine to another. Two or more gears, transmitting motion from one shaft to another, constitute a gear train. At one time various mechanisms were collectively called gearing. Now, however, the word "gearing" is used only to describe systems of wheels or cylinders with meshing teeth. Gearing is chiefly used to transmit rotating motion, but can, with suitably designed gears and flat-toothed sectors, be employed to transform reciprocating motion into rotating motion, and vice versa.

The simplest gear is the spur gear, a wheel with teeth cut across its edge parallel to the axis. Spur gears transmit rotating motion between two shafts or other parts with parallel axes. In simple spur gearing, the driven shaft revolves in the opposite direction to the driving shaft. If rotation in the same direction is desired, an idler gear is placed between the driving gear and the driven gear. The idler revolves in the opposite direction to the driving gear and therefore turns the driven gear in the same direction as the driving gear. In any form of gearing the speed of the driven shaft depends on the number of teeth in each gear. A gear with 10 teeth driving a gear with 20 teeth will revolve twice as fast as the gear it is driving, and a 20-tooth gear driving a 10-tooth gear will revolve at half the speed. By using a train of several gears, the ratio of driving to driven speed may be varied within wide limits.

Internal, or annular, gears are variations of the spur gear in which the teeth are cut on the inside of a ring or flanged wheel rather than on the outside. Internal gears usually drive or are driven by a pinion, a small gear with few teeth. A rack and pinion a flat, toothed bar that moves in a straight line, operates

like a gear wheel with an infinite radius and can be used to transform the rotation of a pinion to reciprocating motion, or vice versa.

Bevel gears are employed to transmit rotation between shafts that do not have parallel axes. These gears have cone-shaped bodies and straight teeth. When the angle between the rotating shafts is 90, the bevel gears used are called miter gears.

These have teeth that are not parallel to the axis of the shaft but are spiraled around the shaft in the form of a helix. Such gears are suitable for heavy loads because the gear teeth come together at an acute angle rather than at 90° as in spur gearing. Simple helical gear has the disadvantage of producing a thrust that tends to move the gears along their respective shafts. This thrust can be avoided by using double helical, or herringbone gears, which have V-shaped teeth composed of half a right-handed helical tooth and half a left-handed helical tooth. Hypoid gears are helical bevel gears employed when the axes of the two shafts are perpendicular but do not intersect. One of the most common uses of hypoid gearing is to connect the drive shaft and the rear axle in automobiles. Helical gearing used to transmit rotation between shafts that are not parallel is often incorrectly called spiral gearing.

Another variation of helical gearing is provided by the worm gear, also called the screw gear. A worm gear is a long, thin cylinder that has one or more continuous helical teeth that mesh with a helical gear. Worm gears differ from helical gears in that the teeth of the worm slide across the teeth of the driven gear instead of exerting a direct rolling pressure. Worm gears are used chiefly to transmit rotation, with a large reduction in speed, from one shaft to another.

A rack and pinion gears are a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called “the pinion” engages teeth on a linear “gear” bar called “the rack”;

rotational motion applied to the pinion causes the rack to move, thereby translating the rotational motion of the pinion into the linear motion of the rack.

From Encarta Encyclopedia

1. Gearing can only transmit rotating motion.

2. The rotating motion between two shafts with parallel axes is transmitted with spur gears.

3. Simple spur gearing provides the revolution of the driven shaft and the driving shaft in the same direction.

4. A 20-tooth gear driving a 10-tooth gear will revolve twice as slow as the gear it is driving.

5. The bodies of bevel gears have a shape of a cone and spiraled teeth.

6. The teeth of helical gears are parallel to the axis of the shaft.

7. Helical gears can be used for heavy loads because their teeth come together at 90° angle.

8. Herringbone gears have the shape of the letter V.

9. Hypoid gears are used when the axes of two shafts cross each other at a sharp angle.

10. A worm gear is a type of helical gearing.

11. A rack and pinion gears consist of a pair of circular gears which are called “the pinion” and “the rack”.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
T	T	T	T	T	T	T	T	T	T	T
F	F	F	F	F	F	F	F	F	F	F

LANGUAGE DEVELOPMENT

5. Match the words in column A with the words in column B to form meaningful phrases. Translate them into Ukrainian.

Column A	*Column B*
1) heavy	a) shafts
2) rotational	b) mechanisms
3) rear	c) actuator
4) toothed	d) bodies
5) respective	e) radius
6) straight	f) direction
7) linear	g) line
8) acute	h) motion
9) cone-shaped	i) axle
10) opposite	j) angle
11) various	k) bar
12) infinite	l) load

6. Fill in the words from the list below and use them in your own sentences. Use each word only once.

rotation, cylinder, gearing, load, reduction, linear, pressure, gears, helical, continuous, hypoid, motion

1) simple helical …..

2) transmit ….. between shafts

3) a type of ….. actuator

4) helical bevel …..

5) ….. helical teeth

6) direct rolling …..

7) large ….. in speed

8) long thin …..

9) right-handed ….. tooth

10) common ….. gearing

11) suitable for heavy …..

12) linear ….. of the rack

7. Match the English phrases with their Ukrainian equivalents.

Types of gearings

1) spindle gearing	a) рейкова передача
2) feed gearing	b) черв'ячна передача
3) corrected gearing	c) передача з гнучким зв'язком
4) cam gearing	d) знижуюча передача
5) worm gearing	e) зубчаста передача механізму приводу
6) bevel gearing	f) підвищуюча передача
7) rack gearing	g) механізм подачі
8) multiple gearing	h) зубчаста передача
9) flexible gear	i) конічна зубчаста передача
10) speed-reduction gearing	j) зубчаста передача зі зміщенням
11) toothed gearing	k) багатоступінчаста зубчаста передача
12) step-up gearing	l) кулачкова передача

8. Arrange the words according to similar meaning.

1) rear	a) inside
2) limit	b) endless

3) flat	c) drive
4) disadvantage	d) constructed
5) edge	e) decrease
6) direction	f) pulley
7) designed	g) back
8) idler	h) bound
9) reduction	i) tendency
10) actuator	j) plane
11) internal	k) drawback
12) infinite	l) border

9. Find the definitions to the following words.

pressure, rotation, rack, pinion, speed, gear, limit, screw, body, edge, axle, axes

1. A small wheel, with teeth on its outer edge, which fits into a larger wheel and turns it or is turned by it.

2. An apparatus or part of a machine consisting of a set of toothed wheels, that allows power to be passed from one part of a machine to another so as to control the power, speed or direction of movement.

3. An object; piece of matter.

4. A type of fastener that is like a nail but has a raised edge winding round it and a special cut in its top to hold a tool for turning and pressing it into the material to be fastened.

5. The action of rotating; one complete turn round a fixed point.

6. The thin sharp cutting part of a tool.

7. A bar with a wheel on either end, around which the wheels turn or which turns with the wheels.

8. The farthest point or edge, which cannot or must not be passed.

9. The action of putting force or weight onto something.

10. Quickness of movement or action.

11. The usually imaginary line around which a spinning body moves.

12. A part of a machine consisting of a bar with teeth on one edge, moved along by a pinion.

10. Choose the correct preposition.

Worm gears resemble screws. A worm gear is usually meshed *with / from* a spur gear or a helical gear, which is called the gear, wheel, or worm wheel. Worm gears can be right or left-handed, following the long-established practice *from / for* screw threads.

Worm gears can be considered a species *for / of* helical gear, but its helix angle is usually somewhat large (close *to / at* 90 degrees) and its body is usually fairly long in the axial direction. The distinction between a worm and a helical gear is made when at least one tooth persists *from / for* a full rotation around the helix. If this occurs, it is a 'worm'; if not, it is a 'helical gear'. A worm may have as few as one tooth. If that tooth persists *for / to* several turns around the helix, the worm will appear, superficially, to have more than one tooth, but what one *in / at* fact sees is the same tooth reappearing *at / in* intervals *along / among* the length *from / of* the worm. The usual screw nomenclature applies: a one-toothed worm is called single thread or single start; a worm *with / of* more than one tooth is called multiple thread or multiple start. The helix angle *from / of* a worm is not usually specified. Instead, the lead angle, which is equal *to / for* 90 degrees minus the helix angle, is given. Worm-and-gear sets that do lock are called self locking, which can be used *to / for* advantage, as *from / for* instance when it is desired to set the position *for / of* a mechanism *by / with* turning the worm and then have the mechanism hold that position. An example is the machine head found on some types *from / of* stringed instruments.

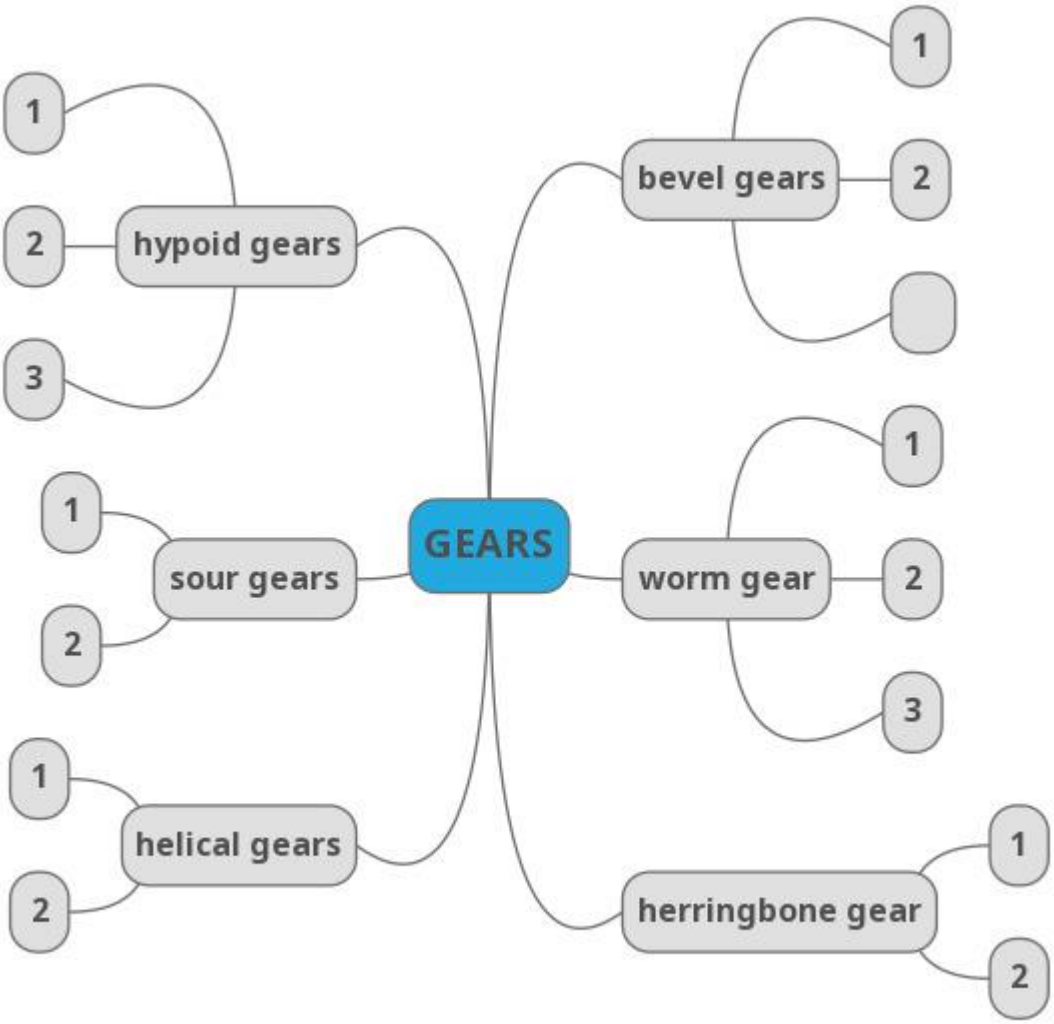
1. Read the passage about gears and underline the correcr word.

A gear is a ***rotating / rotated*** machine part ***having / have*** cut teeth, or cogs, which ***meshed / mesh*** with another ***toothed / toothing*** part in order to ***transmit / transmitting*** torque. Two or more gears ***work / working*** in tandem ***are called / are calling*** a transmission and can ***produce / producing*** a mechanical advantage through a gear ratio and thus may ***consider / be considered*** a simple machine. ***Geared / gearing*** devices can ***cnanging / change*** the speed, torque, and direction of a power source. The most common situation ***is / was*** for a gear ***meshing / to mesh*** with another gear, however a gear ***can / could*** also ***meshing / mesh*** a non - rotating ***toothing / toothed*** part, ***called / calling*** a rack, thereby ***producing / produced*** translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear ***prevent / preventing*** slipping. When two gears of unequal number of teeth ***are combined / are combining*** a mechanical advantage ***produced / is produced***, with both the rotational speeds and the torques of the two gears ***differing / differ*** in a simple relationship.

2. Complete the Mind map about the gears application: *Gears mindmap*.

https://atlas.mindmup.com/2021/02/adfdfc30743e11ebb96981a21f92bf3e/gears/index.html



LANGUAGE SKILLS

Adjectives ending in '-ed' and '-ing'

-ing adjective	**-ed adjective**
describes a thing, person, or an event	**describes an emotion or feeling**
i.e. That book is bor**ing**.	i.e. I am bor**ed**.

3. Decide which participial adjective is correct.

1. Don't bother reading that book. It's _____.

boring

bored

2. The students are _____ in learning more about the subject.

interesting

interested

3. Ms. Green doesn't explain things well. The students are _____.

confusing

confused

4. Have you heard the latest news? It's really _____.

exciting

excited

5. I don't understand these directions. I'm _____.

confusing

confused

6. I read an _____ article in the newspaper this morning.

interesting

interested

7. I heard some _____ news on the radio.

surprising

surprised

8. I'm _____. Let's do something.

boring

bored

9. Mr. Sawyer bores me. I think he is a _____ person.

boring

bored

10. Mr. Ball fascinates me. I think he is a _____ person.

fascinating

fascinated

4. Complete the sentences with the correct form of the word in brackets. You may need to use the word as a verb or as an -ed / -ing adjective

1. My new job is extremely …… . I'm ….. at the end of the day. (tire / exhaust)

2. He's such a ….. person. He never talks. It ….. me to be with him. (bore / bore)

3.He usually ….. me, but I didn't find his last joke very ….. . (amuse / amuse)

4.His stories are not usually very ….., but yesterday we were ….. by what he was telling us. (intrigue / fascinate)

5.Sometimes, when I'm alone and ….., it ….. me to hear my mother's voice on the phone. (depress / comfort)

6. Listening to jazz ….. me. I think it's a very ….. music. (relax / relax)

7. Watching them eating insects ….. me. I would never do such a ….. thing. (disgust / disgust)

8. I was really ….. when I tripped and fell. It was one of the most ….. moments in my life. (embarrass / embarrass)

9. The exam was ….. . The students felt ….. by the difficulty of the questions. (overwhelm / overwhelm)

10. Tim's decision to quit his job ….. everyone. I was very …..when he told us. (shock / surprise)

5. All the translations of the underlined words are correct. Choose the best translation of the underlined word according to the text context.

1. Gears <u>transmit</u> motion from one shaft to another.

a) повідомляють b) віддають c) передають d) поширюють

2. An idler gear is placed between the driving gear and the driven gear.

a) ледачий b) проміжний c) направляючий d) порожній

3. A rack operates like a gear wheel with an infinite radius.

a) полиця b) рейка c) рама d) розорення

4. Bevel gears are employed to transmit rotation between shafts.

a) застосовані b) задіяні c) виконані d) працевлаштовані

5. Thrust can be avoided by using double helical gear.

a) пафос b) поштовх c) тиск d) осьове навантаження

6. A large reduction in speed is provided with worm gears.

a) скорення b) пониження c) зменшення d) зміна

7. Worm gears can be right or left-handed screw threads.

a) нитки b) різьби c) зв'язки d) шнури

8. The reforceinment mostly consists of mild steel and sometimes of wrought iron.

a) підкріплення b) підсилення c) поповнення d) арматура

9. It is impossible to engage these gears whilst engine is running.

a) заручитися b) зустрічати c) погоджувати d) зачеплювати

10. Pitting affects antifriction bearings, cams, and other machine components.

a) впливає b) торкається c) хвилює d) шкодить

11. Ehe engineer specified a tolerance of ±0.01 mm in detail drawing.

a) звичка b) терпіння c) похибка d) витривалість

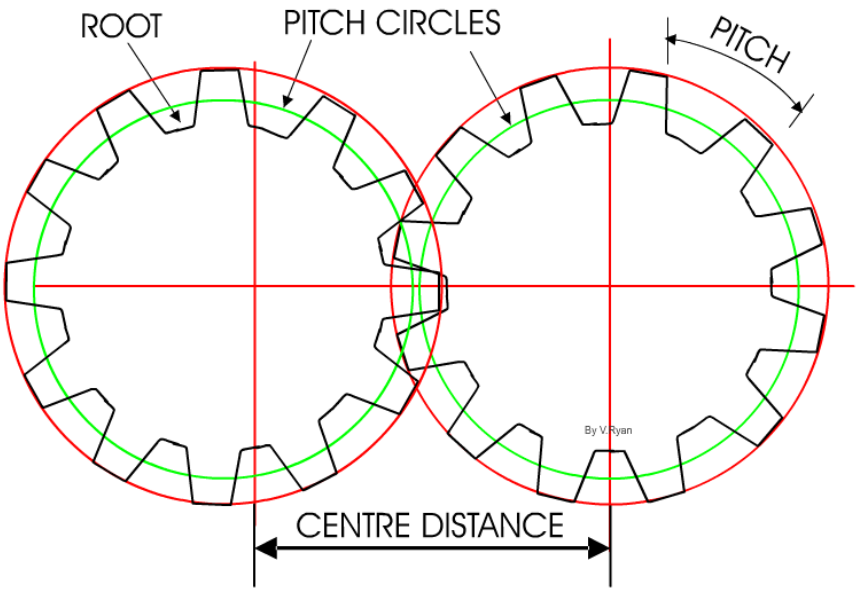
12. This versatile tool has a number of different uses in the home.

a) рухливий b) мінливий c) універсальний d) багатогранний

6. In the text, find English equivalents of the following Ukrainian words and phrases.

Шестірня, забезпечувати, зубчасте колесо, гвинт, передавати, ковзати, обертальний рух, тиск, зворотньо-поступовий рух, обертання, вал, зменшення, зубчаста передача, швидкість, лінійний рух, залежати від, мале зубчасте колесо, зубчаста рейка, вісь, протилежний напрямок, обертати, зубці, внутрішній, межа, спіраль, велике навантаження, пересувати, гострий кут, недолік, запобігати, з'єднувати.

7. Look at the picture and insert the words into the text: spur gears, tooth, pitch circles, root, shape, ratio distance. Answer is here.



The gears above are known as _____ The circle marked in red shows the outer limit of the teeth whilst the green circles are known as the _____ The pitch circle of a gear is very important as it is used by engineers to determine the _____ of the teeth and the between gears.

The pitch of a gear is the _____ between any point on one tooth and the same point on the next _____.

The _____ is the bottom part of a gear wheel.

SELF-ASSESSMENT

8. Watch a video and learn why some adjectives in English end in -ING and others in -ED. You will understand when we use each of these endings, as well as the correct grammar and structure for each. Test your understanding by answering the questions of the quiz. You will get the answers and your score at the end of the quiz.

https://www.engvid.com/adjective-endings-ing-ed/

9. Fill in the gaps by turing the verbs in brackets into -ed /-ing adjectives.

https://test-english.com/grammar-points/b1/ed-ing-adjectives-adjectives-verbs/

https://wordwall.net/resource/4473561/ed-ing-adjectives

LISTENING

10. Before listening to the text, answer the questions.

- What gear failures do you know?

- What are their causes?

Listen to the text to check your answers.

11. Listen to the text again and complete the table.

	Cause	***Damage process stages***	***Part of affection***
Bending fatigue			
Pitting			
Micropitting			
Scuffing			

12. Explain your groupmates why:

– is assessing gear damages a challenge;

– is the first failure repair important;

– is cyclic bending stress dangerous for gear teeth;

– is pitting one of the most common causes of gear failure;

– does pitting affect antifriction bearings, cams, and other machine components;

– has micropitting become more prevalent;

– are modern lubricants with sophisticated additive packages dangerous;

– do engineers sometimes label micropitting as a kind of abrasive wear;

– can scuffing lead to catastrophic failure;

– does scuffing appear.

SPEAKING

13. Work in pairs. Imagine you are famous inventors: one of you is William Murdoch and your partner is Arthur Ernest Bishop. You tell each other about your invention. Read the text and ask your partners questions to complete the table about these gears.

Student A. *Appendix A, p. 127.*

Student B. *Appendix A, p. 128.*

Characteristics	***Sun and planet gearing***	***Rack and pinion***
Description		
Application		
History		
Operation		

14. You are still Arthur Ernest Bishop and William Murdoch. Using your notes from the table tell your partner what you have learnt from his report. Your partner listens and checks your information with the original text. Then try to prove that your invention is the best.

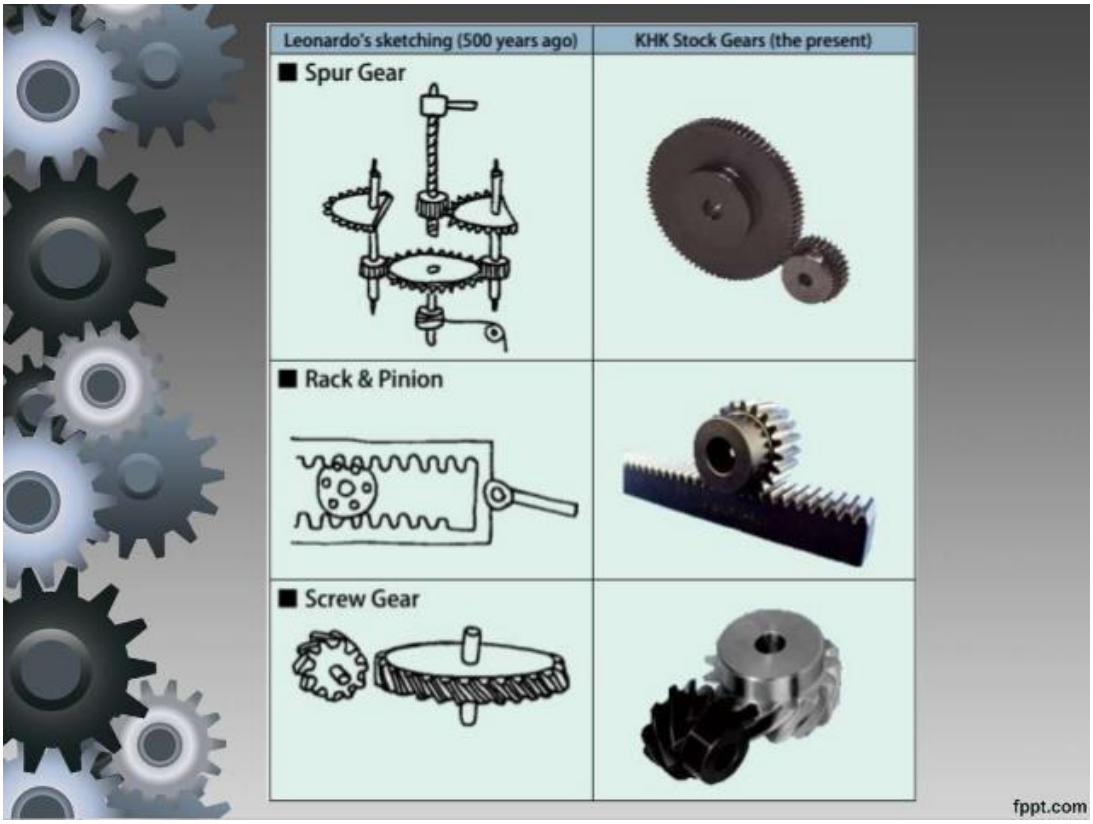
Use the words and phrases in the box below.

- reciprocating motion	***- linear motion***
- steam engines	***- variable rack***
- flywheel speed	***- toothed bar***
- connecting rod	***- to convert the rotation***
- axle of the planet gear	***- the steering mechanism***

15. Imagine you are a guide at the museum of gears: "Geararium". Using the information, History of gears and pictures from Appendix A (p. 129) prepare a short excursion around the exhibition.

https://www.slideshare.net/abirtasrif1/history-of-gear

https://www.slideshare.net/abirtasrif1/history-of-gear



https://www.slideshare.net/abirtasrif1/history-of-gear

Use the words and phrases in the box below.

- toothed wheels	***- sprockets***
- industrial art	***- reminders***
- industrial revolution	***- windmill***
- reinforcement	***- ratchets***
- transmission	***- spokes***

The following language phrases may be also useful for you.

– I would like to introduce you a .....

– In front of you is .....

– We are now coming up to .....

– You may have noticed .....

– Take a good look at .....

– I'd like to point out .....

– Keep your eyes open for .....

WRITING

16. You are creating a dictionary of technical terms on the topic "Gears" for students. Write short definitions for the following terms:

– gear ratio;

– rim force;

– rotational speed;

– how compound gears work;

– torque;

– the relationship between gear ratio and torque;

– the relationship between gear ratio and speed.

Use the words and phrases in the box below.

- the drive torque	***- tooth pitch***
- transmit motion	***- spindle work***
- direction of motion	***- load capability***
- engagement	***- resist wear***
- rotating shaft	***- velocity***

17. Webquest. You are a journalist and you have to write a scientific article about "Noncircular gears". Search the Web to find the information about these gears. Your article (200-250 words) should include the following points:

– functions performed by noncircular gears;

– types of noncircular gears;

– aplication of noncicular gears;

– advantages and disadvantages of noncircular gears.

Use the words and phrases in the box below.

- to transmit torque	***- ration variations***

- common applications	***- combined rotation***
- axle displacement	***- constant-speed segments***
- manufacturing tolerances	***- variable output speed.***
- versatility	***- triangular gear***

18. Translate the following passage about gears from Ukrainian into English.

Зу́бчасте ко́лесо (шестірня) – основна деталь зубчастої передачі у вигляді диска з зубами на циліндричній або конічній поверхні, що входять в зачеплення із зубами іншого зубчастого колеса або рейки.

У машинобудуванні прийнято мале ведуче зубчасте колесо незалежно від числа зубів називати шестернею, а велике ведене – колесом. Проте часто усі зубчасті колеса називають шестернями.

Зубчасті колеса зазвичай використовуються парами з різним числом зубів з метою перетворення обертового моменту і числа обертів валу на виході. Колесо, до якого обертовий момент підводиться ззовні, називається ведучим, а колесо, з якого момент знімається, – веденим. Якщо діаметр ведучого колеса менший, то обертовий момент веденого колеса збільшується за рахунок пропорційного зменшення швидкості обертання, і навпаки. Відповідно до передавального відношення, збільшення обертового моменту викликатиме пропорційне зменшення кутової швидкості обертання веденої шестерні, а їх добуток – механічна потужність – залишиться незмінним. Це співвідношення справедливе для ідеального випадку, що не враховує втрати на тертя та інші ефекти, характерні для реальних пристроїв.

Прямозубі колеса – найпоширеніший вид зубчатих коліс. Зуби у них розміщені радіально, а лінія контакту зубів обох шестерень паралельна до

осі обертання. При цьому осі обох шестерень також повинні розташовуватися строго паралельно.

INDEPENDENT STUDY

29. Answer the questions:

- Draw and explain -driven and driver gears. (key)
- WHAT IS THE PURPOSE OF AN ‘IDLER’ GEAR? (key)
- WHEN ARE RACK AND PINION GEARS VERY USEFUL? (key)
- DESCRIBE A PRACTICAL APPLICATION, OF A SET OF BEVEL GEARS (key)
- WHAT IS A WORM and WORM WHEEL? (key)

30. Check your knowledge of the unit completing the online quizzes:

Gear test

Gear quiz

Gear ratio

UNIT 5

HOW DIFFERENT GEARS WORK

(приводи)

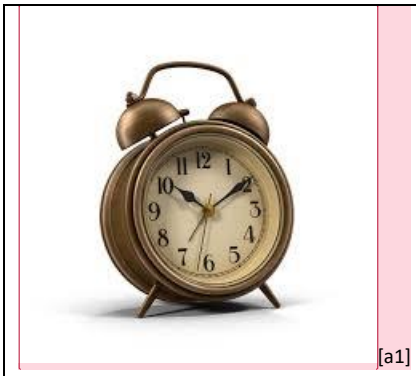
LEAD-IN

1. Discuss the following questions with a partner.

1. What are the functions of gears?

2. What types of gears can be found in different sorts of mechanical gadgets?

2. Look at these pictures. How are gears used in these products? Where else are gears used in everyday life?

<table>
<tr>
<td>  [a1]
https://www.pixelsquid.com/png/alarm-clock-869060316661553105?image=G02</td>
<td> 
https://www.dreamstime.com/photos-images/red-car.html</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>  </td>
<td>  </td>
</tr>
</table>

https://en.wikipedia.org/wiki/Helicopter	*https://www.transitionbikes.com/Bikes.cfm*
C	***D***

3. Before reading learn new vocabulary with Quizlet flashcards: *How do gears work*

READING

4. Read the text and match the sentences (A-D) to the numbered spaces (1-4) in the text.

A. To reduce the noise and stress in the gears, most of the gears in your car are helical.

B. For instance, in a device with two gears, if one gear is twice the diameter of the other, the ratio would be 2:1.

C. This is because the angle on the worm is so shallow that when the gear tries to spin it, the friction between the gear and the worm holds the worm in place.

D. They have straight teeth, and are mounted on parallel shafts.

HOW DIFFERENT GEARS WORK

Gears are used in lots of mechanical devices. They do several important jobs, but most important, they provide a gear reduction in motorized equipment. This is key because, often, a small motor spinning very fast can provide enough power for a device, but not enough torque. For instance, an electric screwdriver has a very large gear reduction because it needs lots of torque to turn screws, but the motor only produces a small amount of torque at a high speed. With a gear reduction, the output speed can be reduced while the torque is increased.

Another thing gears do is adjust the direction of rotation. For instance, in the differential between the rear wheels of your car, the power is transmitted by

a shaft that runs down the center of the car, and the differential has to turn that power 90 degrees to apply it to the wheels.

There are a lot of intricacies in the different types of gears. We will learn exactly how the teeth on gears work, and we will talk about the different types of gears you find in all sorts of mechanical gadgets.

On any gear, the gear ratio is determined by the distances from the center of the gear to the point of contact. _ 1 _

One of the most primitive types of gears we could look at would be a wheel with wooden pegs sticking out of it.

The problem with this type of gear is that the distance from the center of each gear to the point of contact changes as the gears rotate. This means that the gear ratio changes as the gear turns, meaning that the output speed also changes. If you used a gear like this in your car, it would be impossible to maintain a constant speed – you would be accelerating and decelerating constantly.Gear ratios and mechanical advantage values are quite easy to understand.

Many modern gears use a special tooth profile called an involute. This profile has the very important property of maintaining a constant speed ratio between the two gears. Like the peg wheel above, the contact point moves; but the shape of the involute gear tooth compensates for this movement.

Now let us take a look at how some types of gears work.

Spur gears are the most common type of gears. _ 2 _ Sometimes, many spur gears are used at once to create very large gear reductions.

Spur gears are used in many devices that you can see around us, like the electric screwdriver, dancing monster, oscillating sprinkler, windup alarm clock, washing machine and clothes dryer. But you will not find many in your car.

This is because the spur gear can be really loud. Each time a gear tooth engages a tooth on the other gear, the teeth collide, and this impact makes a noise. It also increases the stress on the gear teeth.

_ 3 _ The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement.

Bevel gears are useful when the direction of a shaft's rotation needs to be changed. They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well.

The teeth on bevel gears can be straight, spiral or hypoid. On straight and spiral bevel gears, the shafts must be perpendicular to each other, but they must also be in the same plane. If you were to extend the two shafts past the gears, they would intersect. The hypoid gear, on the other hand, can engage with the axes in different planes.

Worm gears are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater.

Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm. _ 4 _

This feature is useful for machines such as conveyor systems, in which the locking feature can act as a brake for the conveyor when the motor is not turning. One other very interesting usage of worm gears is in the Torsen differential , which is used on some high-performance cars and trucks.

Rack and pinion gears are used to convert rotation into linear motion. A perfect example of this is the steering steering system on many cars. The steering wheel rotates a gear which engages the rack. As the gear turns, it slides the rack either to the right or left, depending on which way you turn the wheel.

Rack and pinion gears are also used in some scales to turn the dial that displays your weight.

From: http://science.howstuffworks.com/transport/engines-equipment/gear.htm

LANGUAGE DEVELOPMENT

5. Match the words in column A with the words in column B to form meaningful phrases. Translate them into Ukrainian.

Column A	*Column B*
1) full	a) wheel
2) electric	b) system
3) motorized	c) pegs
4) linear	d) example
5) conveyor	e) screwdriver
6) mechanical	f) feature
7) pinion	g) teeth
8) steering	h) motion
9) perfect	i) engagement
10) locking	j) equipment
11) gear	k) gear
12) wooden	l) device

1. Fill in the words from the list below and use them in your own sentences. Use each word only once.

high, bevel, gear, reduction, pinion, perpendicular, profile, maintain, planes, direction, ratio, torque

1) ….. of a shaft's rotation

2) special tooth …..

3) spiral ….. gears

4) large gear …..

5) ….. a constant speed

6) helical ….. system

7) ….. to each other shafts

8) axes in different …..

9) …..-performance cars

10) constant speed …..

11) rack and ….. gears

12) small amount of …..

2. Match the English phrases with their Ukrainian equivalents.

Types of gears

1) admission gear	a) рульва передача
2) driven gear	b) ходовий механізм
3) steering gear	c) пусковий механізм
4) worm gear	d) блокуючий механізм
5) drive gear	e) ведений механізм
6) starting gear	f) зубчаста передача
7) protective gear	g) черв'ячна передача
8) locking gear	h) пусковий пристрій
9) traveling gear	i) механізм впуску
10) launching gear	j) захистний пристрій
11) screw gear	k) коробка швидкостей
12) transmission gear	l) ведучий механізм

8. Arrange the words according to similar meaning.

1) intricacy	a) gearing
2) equipment	b) turning
3) engagement	c) method

4) device	d) engine
5) motor	e) movement
6) property	f) velocity
7) motion	g) mass
8) power	h) machinery
9) way	i) complication
10) speed	j) characteristics
11) rotation	k) energy
12) weight	l) apparatus

9. Find the definitions to the following words.

equipment, property, power, ratio, motor, profile, torque, intricacy, engagement, feature, dial, scale

1. A set of numbers or standards for measuring or comparing.

2. A figure showing the number of times one quantity contains another, used to show the relationship between two amounts.

3. Twisting force; power that produces rotation.

4. A typical or noticeable part or quality.

5. A stated quality, power or effect that belongs naturally to something.

6. The engaging of parts of a machine.

7. An edge or shape of something seen against a background.

8. The quality or state of being intricate.

9. Force that can be used for doing work, driving a machine or producing electricity.

10. The face of an instrument showing measurements by means of a pointer and figures.

11. The set of things needed for a particular activity, especially an activity of a practical or technical kind.

12. A machine that changes power, especially electrical power, into movement and is used for working other machines.

10. Choose the correct preposition.

A bevel gear is shaped like a right circular cone *with / from* most *from / of* its tip cut *on / off*. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their shaft axes also intersect *at / on* this point, forming an arbitrary non-straight angle *among / between* the shafts. The angle *between / among* the shafts can be anything except zero or 180 degrees. Bevel gears *with / from* equal numbers *from / of* teeth and shaft axes *at / on* 90 degrees are called mitre gears.

Hypoid gears resemble spiral bevel gears. The pitch surfaces appear conical but, to compensate *for / from* the offset shaft, are *in / on* fact hyperboloids *for / of* revolution. Hypoid gears are almost always designed to operate *with / by* shafts *on / at* 90 degrees. Depending *on / in* which side the shaft is offset too, relative *to / for* the angling *from / of* the teeth, contact between hypoid gear teeth may be even smoother and more gradual than *with / from* spiral bevel gear teeth, but also have a sliding action *along / among* the meshing teeth as it rotates and therefore usually require some *of / from* the most viscous types *for / of* gear oil. Also, the pinion can be designed *for / with* fewer teeth than a spiral bevel pinion, *with / for* the result that gear ratios *for / of* 60:1 and higher are feasible using a single set *from / of* hypoid gears. This style *for / of* gear is most commonly found driving mechanical differentials; which are normally straight cut bevel gears; *in / on* motor vehicle axles.

11. Read the passage about gears and open the brackets.

In transmissions which _____ (*to offer*) multiple gear ratios, such as bicycles and cars, the term gear, as in first gear, _____ (*to refer*) to a gear ratio rather than an actual physical gear. The term _____ (*to use*) _____

(*to describe*) similar devices even when gear ratio _____ (*to be*) continuous rather than discrete, or when the device _____ (*to do*) not actually _____ (*to contain*) any gears, as in a continuously variable transmission.

The definite velocity ratio which _____ (*to result*) from _____ (*to have*) teeth _____ (*to give*) gears an advantage over other drives such as traction drives and V-belts in precision machines such as watches that _____ (*to depend*) upon an exact velocity ratio. In cases where driver and follower _____ (*to be*) in close proximity gears also _____ (*to have*) an advantage over other drives in the _____ (*to reduce*) number of parts _____ (*to require*); the downside _____ (*to be*) that gears _____ (*to be*) more expensive _____ (*to manufacture*) and their lubrication requirements may _____ (*to impose*) a higher _____ (*to operate*) cost.

LANGUAGE SKILLS

Study the information given below and use it while completing the tasks afterwards.

Adjective Formation:

- at the end of a verb, ***- able / - ible*** make the verb an adjective. This adjective is about ability, something you can do.
  e.g. He is reli**able** (means you can rely on him);
- the suffix ***- ful*** means "full of"+ the meaning of the adjective:
  e.g. use**ful** (full of use);
- the suffix ***- less*** means "without"+ the meaning of the adjective:
  e.g. home**less** (without a place to live).
  Suffixes ***– full*** and ***– less*** are often used to form opposite adjectives (useful-useless). But it is not true for all adjectives, some of them can have only one suffix (successful, homeless).
- ***– ive / – ative / – itive*** form adjectives from nouns
  Meaning A: having the characteristics or nature of the noun this suffix is attached:

e.g. corrosive = corrosion (noun) + ***– ive*** *(having the nature of)* = having the nature of corrosion / the process of corroding
Meaning B: tending to:
e.g. talkative = talk (noun) + ***– ative*** *(tending to)* = tends to talk often

12. Complete the table with the adjectives. All the words have been used in this or earlier units.

Meaning	adjective
can be adapted	*adaptable*
can be converted	
can be seen	
can be noticed	
can be washed	
can not be burnt	
can be moved backward	
can be predicted	
last a long time	
vary	
can be broken	
can be bent	

13. Make a suitable adjective from the noun at the end of each sentence below by adding –ful or – less to the end.

1. Thank you for the books. They will be very _____ for my studies. *(use).*

2. This gear won't work at all. It's completely _____ *(use).*

3. That engine is really _____ *(power).*

4. You should charge the batteries if the device is _____ *(power).*

5. It is _____ to work here without goggles *(harm).*

6. Thank you for all you've done. You've been very _____ *(help).*

7. The _____ number of connections are inside the device *(count).*

8. We are _____ that the missing child will soon be found *(hope).*

9. The proper application of the device can make it duration _____ *(time)*.

10. Without gears that machine will be completely _____ *(motion)*.

11. The worn gears become _____ *(shape)*.

12. The _____ engineers are very experienced ().

14. Match the beginning of the adjective with the suffix.

1. Count	a) ful
2. Combust	b) less
3. Thought	c) able
4. Comfort	d) ive
5. Port	e) ive
6. Convert	f) ible
7. Meaning	g) ive
8. Wire	h) ive
9. Protect	i) ible
10. Explos	j) ful
11. Adapt	k) able
12. Attent	l) able

SELF-ASSESSMENT

15. Practise how to use adjectives ending -ful and -less. Choose the correct answer.

https://www.usingenglish.com/quizzes/135.html

16. Practise how to use adjectives ending -ic & -ical. Choose the correct answer.

https://www.usingenglish.com/quizzes/392.html

LISTENING

17. Before listening to the text, answer the questions.

- What material are usually gears made of?

- Is only metal possible to produce gears?

Listen to the text and tell your groupmates what material for gear production is described.

18. Listen to the text again and complete the sentences.

1. Plastic gears transmit power quietly and often without _____.
2. Previously, plastic gears were limited to ¼-hp drives because of uncertainties about how they respond to environmental conditions such as _____.
3. Though plastic gears give engineers more _____, designing them is more complicated.

4. Crystalline type plastics generally provide characteristics that ensure reliable _____, as well as consistent _____ needed for precision molding.

5. Most plastic gears are made from _____ and _____.

6. Acetal copolymers provide long-term _____.

7. Nylon _____ moisture with resultant changes in properties and dimensions.

8. Long fiber-reinforced plastics provide good dimensional _____.

9. A low coefficient of friction means _____.

10. Chemical and corrosion resistance typically _____ that of metal gears.

11. Liquid crystal polymers give high dimensional _____ and chemical _____.

12. Plastic gear teeth _____ compensating for _____-producing gear misalignment.

19. Comment on the following points considering plastic gear application:

– *cost;*

– *design;*

– *flexibility;*

– *weight;*

– *noise;*

– *efficiency;*

– *lubrication;*

– *accuracy;*

– *durability.*

SPEAKING

20. You are at the workshop and you can see some examples of gear failures. Discuss with your partners the following points: the main features of the failures. Work in 4 groups A, B, C, and D. Each group gets a card with the information about one gear failure description (See Appendix A, p. 135). Ask students from another group about their failure description. While listening to the description complete the table.

	Gluing	*Breakage*	*Pitting*	*Ridging*
Cause				
Description				
How to improve				

Then present this information to groups and compare with the original information.

Use the words and phrases in the box below.

- lubrication failure	*- cantilever beam*
- heavy-duty load	*- fatigue breakage*
- meshing teeth	*- rigidities of shaft*
- extreme pressure	*- sufficient toughness*
- gluing resistance	*- pitch line*

21. Now you can see all the gear failures in your machines in a worshop. Once you have completed the table, look at the pictures and discuss with your colleagues what failures are shown and support your opinion.

Use the words and phrases in the box below.

- ridges	*- cramble*
- fatigue	*- resistance*
- friction	*- lubrication*

- tear	***- meshing***
- melting	***- load***

1. _____

https://www.brighthubengineering.com/cad-autocad-reviews-tips/8443-failure-modes-in-gear-part-one/

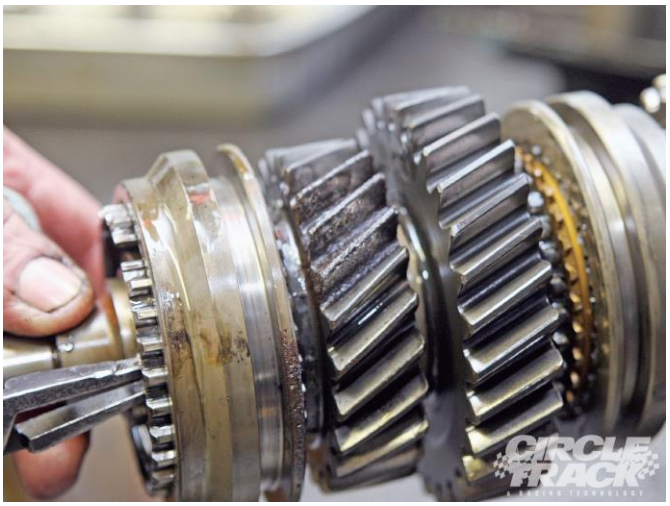
2. _____

https://www.brighthubengineering.com/cad-autocad-reviews-tips/8443-failure-modes-in-gear-part-one/

3. _____

https://www.brighthubengineering.com/cad-autocad-reviews-tips/8443-failure-modes-in-gear-part-one/

4. _____



https://www.brighthubengineering.com/cad-autocad-reviews-tips/8443-failure-modes-in-gear-part-one/

22. Work in groups A and B. You have to describe gears application for students from another group without naming it and they shoud guess which device it is. Look at the pictures of every day gears application (Pictures for group B – Appendix A, p. 138).

Use the phrases in the box below.

- It is used for …
- It transmits …
- This device is powered by …
- The application of gears provides …
- The device is operated by …

- It can help to decriese …

- The application can cause …

- It makes possible …

- It can be a rotating mechanism for …

- It was designed to …

For example:

A: *In this mechanism, bevel gears are used to roll up, turn and open it.*

B: *Garage doors.*

Pictures for group A:

	
https://www.dreamstime.com/real-life-models-toy-car-red-col background-side-view-toy-cars-red-color-white-background-image135268387	*https://en.wikipedia.org/wiki/Helicopter*
	
https://ru.depositphotos.com/195536812/stock-photo-fluvial-port-rusted-and-old.html	*https://www.alamy.com/close-up-of-the-automatic-gearbox-lever-blackinterior-car-automatic-transmission-gearshift-stick-image257236249.html*

23. Work out an interactive communication assignment (See Appendix B, p. 139).

WRITING

24. Webquest. Imagine that you are a post-graduate student and you are going to defend a thesis devoted to the theme «Gears and their application in modern engineering». Search the Web to find the information about application of gears in modern engineering. Write a review (200-250 words) in order to use it in your speech during the defence of the thesis. Include the following information:

– description of a device;

– the type of gear used;

– what the gear is used for;

– comparing with the old verfsion of the device.

Use the words and phrases in the box below.

- gear teeth	***- ratio***
- shaft axes	***- load***
- non-straight angle	***- lubrication***
- gearing	***- transmission***
- sliding action	***- friction***

25. Imagine that you are an engineer working at the enterprise and you have to make a presentation about thermoplastic gears to your foreign colleagues. Read the text about Thermoplastic gears (Appendix C, p. 155). Then, do some research on the Internet and make a PowerPoint presentation about their advantages and applications. The following points should be included:

– the title of the text;

– the main idea of the text;

– the aspects of the text;

– the conclusion.

Use the phrases in the box below.

- The texts consist of … / may be divided into …
- In the first paragraph / exposition the author introduces …
- In the second part of the text / paragraph the author describes …
- Another example can be found …
- As a result …
- To sum up / to conclude …
- In his last remark / with his last remark/statement the author concludes that …
- In the text the reader gets to know ...
- The author argues that ...
- The author contradicts the view ...

26. Translate the following passage about gearings from Ukrainian into English.

Зу́бчаста переда́ча – механізм або частина механізму в складі якого є зубчасті колеса, що використовуються для зміни швидкості й напряму руху ведучої частини при відповідних змінах обертового моменту, коли необхідне точне відношення швидкостей ведучого і веденого вала в будь-який момент часу.

Зубчаста передача складається з ведучого (або декількох) зубчастого колеса, яке називаються шестернею, і веденого (або декількох) зубчастого колеса.

У багатьох машинах здійснення необхідних рухів механізму пов'язане з необхідністю передати обертання з одного валу на інший за умови, що осі цих валів перетинаються. У таких випадках застосовують конічну зубчасту передачу. Робота зубчастого передавача

супроводжується шумом, особливо на високих швидкостях. Зубчасті передавачі можуть бути джерелом вібрації.

Рейкова передача – один із видів циліндричної зубчатої передачі, де радіус ділильного кола рейки рівний нескінченності. Застосовується для перетворення обертового руху в поступний і навпаки.

Ґвинтові, черв'ячні і гіпоїдні передачі відносяться до зубчасто-ґвинтових передач. Елементи цих передач ковзають відносно один одного.

Складні зубчасті механізми, в яких вісь хоча б одного колеса є рухомою, називаються планетарними передачами.

INDEPENDENT STUDY

27. Answer the questions:

1. The distance from the centre of one tooth to the centre of the next tooth, measured along the pitch circle, is called

a) diametral pitch

b) pitch diameter

c) circular pitch

d) outside diameter

2. With an internal spur gear and pinion drive, the shaft centre lines are

a) compounding

b) crossing over at 90 degrees

c) intersecting at 90 degrees

d) parallel

3. The input gear of the train has 32 teeth turning at 32rpm; it is connected to the 24 tooth output gear through a 16 tooth idler. What is the end result?

a) speed reduction, rotation change

b) speed increase, rotation change

c) speed reduction, no change in rotation

d) speed increase, no change in rotation

4. The worm and worm wheel gears

a) have low sliding action

b) are of opposite hand

c) have parallel shafts

d) are of the same hand

5. Of the following variable speed drives, which one would require a heat exchanger?

a) scoop tube

b) torque converter

c) variable speed chain drive

d) wet disc

6. The distance that one tooth on the worm advances in one turn is the

a) lead

b) pitch

c) pressure angle

d) helix angle

7. Gears that have no effect on gear or speed ratios in a gear train are

a) pinion gears

b) idler gears

c) spur gears

d) internal gears

8. To obtain the greatest area of tooth contact in a worm and worm gear, use

a) non throated gear set

b) single throated gear set

c) double throated gear set

d) four start non throated gear set

9. On a worm, the lead is equal to

a) the pitch

b) the pitch times number of starts on the worm

c) the pitch times the ratio of the gears

d) the pitch times the # of teeth on the worm wheel

10. Which of the following types of gears does not produce axial thrust on the shaft?

a) double helical

b) hypoid

c) spiral bevel

d) worm and worm wheel

Scan QR code for answers:

28. Check the knowledge from the unit by completing online tests:

Gear quizz

Gear quizz 2

What is a gear

Gears 3

Gears: true/false

APPENDIX A

COMMUNICATION ACTIVITIES

UNIT 1

Exercise 20, p. 18.

Type	***Description***	***Friction***	***Stiffness***	***Speed***	***Life***	***Notes***
Plain bearing	*Rubbing surfaces, usually with lubricant; some bearings use pumped lubrication and behave similarly to fluid bearings.*	*Depends on materials and construction, PTFE has coefficient of friction ~0.05-0.35, depending upon fillers added.*	*Good, provided wear is low, but some slack is normally present.*	*Low to very high.*	*Low to very high - depends upon application and lubrication.*	*Widely used, relatively high friction, suffers from stiction in some applications. Depending upon the application, lifetime can be higher or lower than rolling element bearings.*
Rolling element bearing	*Ball or rollers are used to prevent or minimise rubbing*	*Rolling coefficient of friction with steel can be ~0.005 (adding resistance due to seals,*	*Good, but some slack is usually present.*	*Moderate to high (often requires cooling).*	*Moderate to high (depends on lubrication, often requires maintenance)*	*Used for higher moment loads than plain bearings with lower friction.*

		packed grease, preload and misalignment can increase friction to as much as 0.125).				
Jewel bearing	*Off-center bearing rolls in seating.*	*Low.*	*Low due to flexing.*	*Low.*	*Adequate (requires maintenance)*	*Mainly used in low-load, high precision work such as clocks. Jewel bearings may be very small.*
Fluid bearing	*Fluid is forced between two faces and held in by edge seal.*	*Zero friction at zero speed, low.*	*Very high.*	*Very high (usually limited to a few hundred feet per second at/by seal)*	*Virtually infinite in some applications, may wear at startup/shutdown in some cases. Often negligible maintenance.*	*Can fail quickly due to grit or dust or other contaminants. Maintenance free in continuous use. Can handle very large loads with low friction.*
Magnetic bearings	*Faces of bearing are kept separate by magnets (electromagnets oreddy*	*Zero friction at zero speed, but constant power for*	*Low*	*No practical limit.*	*Indefinite. Maintenance free (withelectro magnets).*	*Active magnetic bearings (AMB) need considerable power. Electro*

	currents).	*levitation, eddy currents are often induced when movement occurs, but may be negligible if magnetic field is quasi-static.*				*dynamic bearings (EDB) do not require external power.*
Flexure bearing	*Material flexes to give and constrain movement.*	*Very low.*	*Low.*	*Very high.*	*Very high or low depending on materials and strain in application. Usually maintenance free.*	*Limited range of movement, no backlash, extremely smooth motion.*

From: http://en.wikipedia.org/wiki/Bearing_(mechanical)

Exercise 21, p. 19.

Bearing Faults

1. Wear, corrosion and burrs caused by repeated replacement of new bearings, a contaminated or moist environment or heavy handling during bearing removal.

2. Discoloration of cages, rolling elements and raceway rings occurs due to their reacting with lubricant at high temperature or as a result of corrosion.

3. Straight line scratches on surface of raceways or rolling elements caused during mounting or dismounting of bearing.

4. Bearing rust and corrosion are pits on the surface of rings and rolling elements and may occur at the rolling element pitch on the rings or over the entire bearing surfaces.

5. When electric current passes through a bearing, arcing and burning occur through the thin oil film at points of contact between the raceway and rolling elements. The points of contact are melted locally to form "fluting" or groove-like corrugations which can be seen by the naked eye. Magnification of these grooves reveals crater-like depressions which indicate melting by arcing.

6. When sudden overheating occurs during rotation, the bearing becomes discoloured. Then, the raceway rings, rolling elements, and cage will soften, melt and deform as damage accumulates.

7. Creep is the phenomenon in bearings where relative slippage occurs between fitting surfaces and thereby creates a clearance between the surfaces. Creep causes a shiny appearance, occasionally with scoring or wear.

8. Among the different types of fretting, false brinelling is the occurrence of hollow spots that resemble brinell dents and are due to wear caused by vibration and swaying at the contact points between the rolling elements and raceway.

9. Wear occurs due to repeated sliding between the two surfaces. Fretting occurs at fitting surface between raceway rings and the shaft or housing.

10. Fretting corrosion is another term used to describe the reddish brown or black wear patterns often seen on old shafts and worn housings.

10. Flaking due to rolling fatigue occurs when small pieces of bearing material are lifted and broken off the smooth surface of the raceway or the rolling elements. This flaking causes regions with a rough and coarse texture.

11. Cage damage includes: Cage deformation, Fracture and Wear Fracture of cage pillars.

12. Cracks in the raceway ring and rolling elements. Continued use under this condition leads to larger cracks or fractures.

13. Fracture refers to small or large metallic pieces which were broken off due to excessive load or shock load acting locally on a rolling element, rib or section of a raceway ring.

14. Smearing is surface damage which occurs from a collection of small seizures between bearing components caused by oil film rupture and / or sliding. Surface roughening occurs along with melting.

15. Scoring is surface damage due to accumulated small seizures caused by sliding under improper lubrication or severe operating conditions. Linear damage appears circumferentially on the raceway and roller surfaces. Cycloidal shaped damage on the roller ends and scoring on the rib surface contacting roller ends also occur.

16. Tiny microscopic cracks are generated downward from these cloudy spots to a depth of 5-10 μm. Small particles of material then peel from the surface with areas of minor flaking starting to occur.

From: http://jadanalysis.co.uk/bearing-failure-case-studies.php

Exercise 22, p. 20.

Electric Motor Failure

This was a new motor fitted with an insulated bearing on the non-drive end which has failed. The motor has been running for almost two years. The unit has been ‘greased’ every three (3) months by a fitter (employed by the end user)

who apparently puts a couple of shots of grease into the bearing. The unit is controlled via an inverter and is the prime mover for a fan application.

The motor comes under a six (6) monthly Condition Based Monitoring (CMB) programme. This was recently monitored with no alarms or unusual wear patterns showing, a similar result to the previous two years' readings. The end user also takes temperature measurements to check for rises within the bearing locations. No temperature rises have been evident. There was also no evidence that bearing currents where present, or had been identified.

However; within four days of the CBM data being presented, the motor experienced a catastrophic failure / collapse.

The images show the failed bearing. The inner race is fused to the rotor shaft.

REVIEW OF IMAGES

Image 1.

https://www.exportersindia.com/mahek-impex/used-electric-motor-3658778.htm

Image 1 appears to show a used electric motor. The condition and amounts of dirt, dust and similar appear to suggest the motor is from a relatively clean environment if the given service life of two years is correct. No evidence of impact damage can be seen in the picture.

Image 2.

https://www.skf.com/group/products/rolling-bearings/ball-bearings/deep-groove-ball-bearings

Image 2 shows what appears to be a deep groove ball bearing between a shaft and housing. The cage is clearly broken and deformed and evidence of discolouration can be recognised on the cage debris and the ball bearing. There are no signs of moist lubricant within the bearing voids or the housing area. Some evidence of moist grease can, however, be seen on the outer side of the machined surface.

Image 3.

http://jadanalysis.co.uk/bearing-failure-faq.php

Image 3 is not clearly identified but appears to be a bearing or seal end cover. The picture appears to show a section of damaged cage within the centre of the chamber along with dry dust and evidence of surface corrosion.

From: http://jadanalysis.co.uk/bearing-failure-faq.php

UNIT 3

Exercise 21, p. 62.

Spring Material

The objective of the spring is to store then to restore energy. One can thus quickly think that the more one material could be stressed before becoming deformed plastically, the more it will be ready to be used for the manufacture of a spring. There exists of course other criteria which must be taken into account.

The majority of the springs are made out of steel. Here are three types of the most used steels:

1) non-alloy steel, cold drawn, patented (Pr EN 10270-1);

2) non-alloy steel, oil quenched and tempered (Pr EN 10270-2);

3) stainless steel (Pr EN 10270-3).

Standards were defined for all these steels so that the manufacturers can use them in full confidence. The project of European standard distinguishes for example five classes for drawn steels (SL, SM, HS, DM, DH). These classes impose in particular to the manufacturer tolerances on the dimension of the wire as well as a range for the resistance of the wire.

Drawn steels are often used for the manufacture of the springs. These steels have a good fatigue strength. Their yield stress is increased when the forming of a spring is followed of a heat treatment (tempered). This treatment allows to slacken the internal stresses in the material. These steels have a low corrosion resistance, but a protective coating can be easily added to them. They can work at very low temperatures and are prone to relieving at high temperature. The field of application can thus be between – 80 °C and 150 °C.

The tempered steels have a good fatigue strength and are less prone to relieving than drawn steels. According to tolerated relieving, a field

of application from 20 °C to 170 °C can be considered. These steels have a low corrosion resistance.

When problems of corrosion occur, the use of the stainless steels is advised. They have a fatigue strength lower than the two preceding steels. Many grades exist. The stainless steels result mainly from grade 1.4310. Also called AISI 302, it contains 18% of chromium and 8% of nickel. The field of application, rather large, can go from 200 °C until 300 °C. Attention must however be paid to the fact that this grade is non-magnetic only when it is annealed. Grade 1,440 (AISI 316) has an excellent behaviour with corrosion but lower mechanical characteristics. For a better resistance to relieving and fatigue, the grade 1.4568 commonly called 631 following standard AISI or 17/7PH can be used.

Other materials can be employed for specific applications like, for example, alloys of copper with beryllium to have a high electric conductivity.

Music Wire.

This is the most widely used of all spring materials for small springs because it is the toughest. It has the highest strength tensile and can withstand higher stresses under repeated loading conditions than any other spring material. It can be obtained in diameters from 0.12 to 3mm. It has a usable temperature range from 0 to 120°C. Music wire will contract under heat, and can be plated.

Oil-tempered Wire.

This is a general purpose spring material used for spings where the cost of music wire is prohibitive and for sizes outside the range of music wire. This material is not suitable for shock or impact loading. This material is available in diameters from 3 to 12mm. The temperature range for this material is 0 to 180 °C. Will not generally change dimensions under heat. Can be plated. Also available in square and rectangular sections.

Hard-drawn Wire.

This is the cheapest general purpose spring steel and is should only be used where life, accuracy and deflection are not too important. This material is available in sizes 0,8mm to 12mm. It has an operating range 0 to 120 ^{o}C.

Chrome Vanadium Wire.

This is the most popular alloy spring steel for improved stress, fatigue, long endurance life conditions as compared to high carbon steel materials. This material is also suitable for impact and shock loading conditions. Is available in annealed and tempered sizes from 0,8mm to 12mm. It can be used for temperatures up to 220 C. Will not generally change dimensions under heat. Can be plated.

Chrome-silicon Wire.

This an excellent spring material for highly-stressed springs requiring long life and / or shock loading resistance. It is available in diameters 0,8mm to 12 mm and can be used from temperatures up to 250 ^{o}C. Will not generally change dimensions under heat. Can be plated.

Martensitic Stainless steel Wire.

This is a corrosion, resisting steel, which is unsuitable for sub-zero conditions.

Austentic Stainless steel Wire.

A good corrosion, acid, heat resisting steel with good strength and moderate temperatures. Has low stress relaxation.

Spring Brass.

This is a low cost material, which is convenient to form. It is a high conductivity material. This material has poor mechanical properties. This metal is frequently used in electrical components because of its good electrical properties and resistance to corrosion.

Phosphor Bronze.

Popular alloy .Withstands repeated flexures. This metal is frequently used in electrical components because of its good electrical properties and resistance to corrosion. Suitable to use in sub-zero temperatures. They are much more costly than the more common stocks and cannot be plated. Generally will not change dimensions under heat.

Beryllium Copper.

High elastic and fatigue strength. Hardenable. They are much more costly than the more common stocks and cannot be plated. Generally will not change dimensions under heat.

Nickel base alloys.

These alloys are corrosion resistant. They can withstand a wide temperature fluctuation. The materials are suitable to use in precise instruments because of their non-magnetic characteristic. They also poses a high electrical resistance and should not be used as an electrical conductors.

Titanium

Used mainly in aerospace industry because of its extremely lightweight and high strength. This material is very expensive. It is dangerous to work.

From: http://www.meca.insa-toulouse.fr

UNIT 4

Exercise 23, p. 87.

Student A

Sun and planet gearing was a method of converting reciprocating motion into rotary motion in steam engines. It was invented by the Scottish engineer William Murdoch, an employee of Boulton and Watt, but was patented by James Watt in October 1781. It was invented to bypass the patent on the crank, already held by James Pickard. It played an important part in the development of devices for rotation in the Industrial Revolution. It was famously used by James Watt on his early steam engines in order to get around the patent on the crank but also had the advantage of increasing the flywheel speed so that a lighter flywheel could be used.

The sun and planet gear converted the vertical motion of a beam, driven by a steam engine, into circular motion using a 'planet', a cogwheel fixed at the end of the connecting rod (connected to the beam) of the engine. With the motion of the beam, this revolved around, and turned, the 'sun', a second rotating cog fixed to the drive shaft, thus generating rotary motion. An interesting feature of this arrangement, when compared to that of a simple crank, is that when both sun and planet have the same number of teeth, the drive shaft completes two revolutions for each double stroke of the beam instead of one. The planet gear is fixed to the connecting rod and thus does not rotate around its own axis.

Note that the axle of the planet gear is tied to the axle of the sun gear by a link that freely rotates around the axis of the sun gear and keeps the planet gear engaged with the sun gear but does not contribute to the drive torque. This link appears, at first sight, to be similar to a crank but the drive is not transmitted through it. Thus, it did not contravene the crank patent.

Student B

Rack and pinion is a type of linear actuator that comprises a pair of gears, which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack". Rack and pinion combinations are often used as part of a simple linear actuator, where the rotation of a shaft powered by hand or by a motor is converted to linear motion. The use of a variable rack (still using a normal pinion) was invented by Arthur Ernest Bishop, in the 1970s, so as to improve vehicle response and steering "feel," especially at high speeds.

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s). Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii are then derived from that. The rack and pinion gear type is employed in a rack railway.

A rack and pinion is commonly found in the steering mechanism of cars or other wheeled, steered vehicles. Rack and pinion provides a less efficient mechanical advantage than other mechanisms.

From: http://en.wikipedia.org

Exercise 25, p. 87.

https://calibromeasure.in/history-of-gears/

"Occupational CDV photo of engineers and a pattern of a gear"

Origin: United States of America, 1870's.

Note: An occupational photograph, CDV or *Carte De Visite* depicting workers, millwrights or engineers taking measurements of a gear pattern in a studio. Notice a carpet on a studio's floor and missing teeth on the pattern. It seems like this pattern was intended for casting a *wallover*, a toothed wheel for a windmill.

https://calibromeasure.in/history-of-gears/

"Casting pattern of a gear with curved spokes"

Origin: United States of America, late 1800's.

Size: D=700 mm.

https://calibromeasure.in/history-of-gears/

"Pinion and rack demonstational model for a technical school"

Origin: France, 1860's-1880.

Size: L=600 mm, W=145mm, H=200mm.

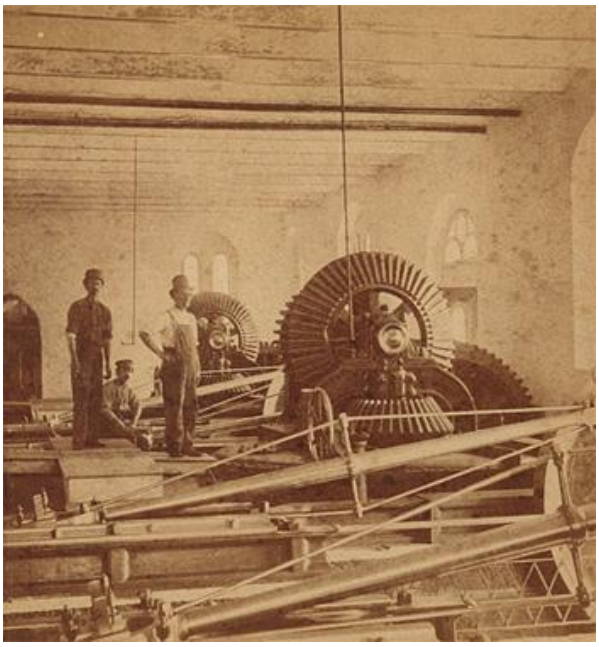
https://calibromeasure.in/history-of-gears/

"Wooden pattern of a ratchet 973"

Material: Wood.

Size: D=140 mm.

Note: Patterrns like this were often used to cast the iron copies of gears that would be used in various types of machinery. The patterns were made of wood so it would be easy for the foundry workers to handle the weight. You can magine how much the cast iron copy would weight.



https://calibromeasure.in/history-of-gears/

"Stereoview of Fairmount Water Works featuring gears of the turbine"

Origin: United States, 1870's.

Note: This card was made by New Jersey Stereoscopic View Co. The beveled gears pictured here have teeth that are made of wood. Such innovation helped to lower the costs and time of any repairment job that had to be done in case of any teeth breakage.

https://calibromeasure.in/history-of-gears/

"Antique foundry pattern of a ratchet with double rows of teeth"

Material: Wood.

Note: This is an extremely rare example of gearing, a pattern of a ratchet type gear that has two rows of teeth goign in opposite direction. Notice also the curved endings of the spokes with knobs.

https://calibromeasure.in/history-of-gears/

"Antique gear with replaceable teeth"

Origin: Japan.

Material: Wood.

Size: D=250 mm.

http://geararium.org

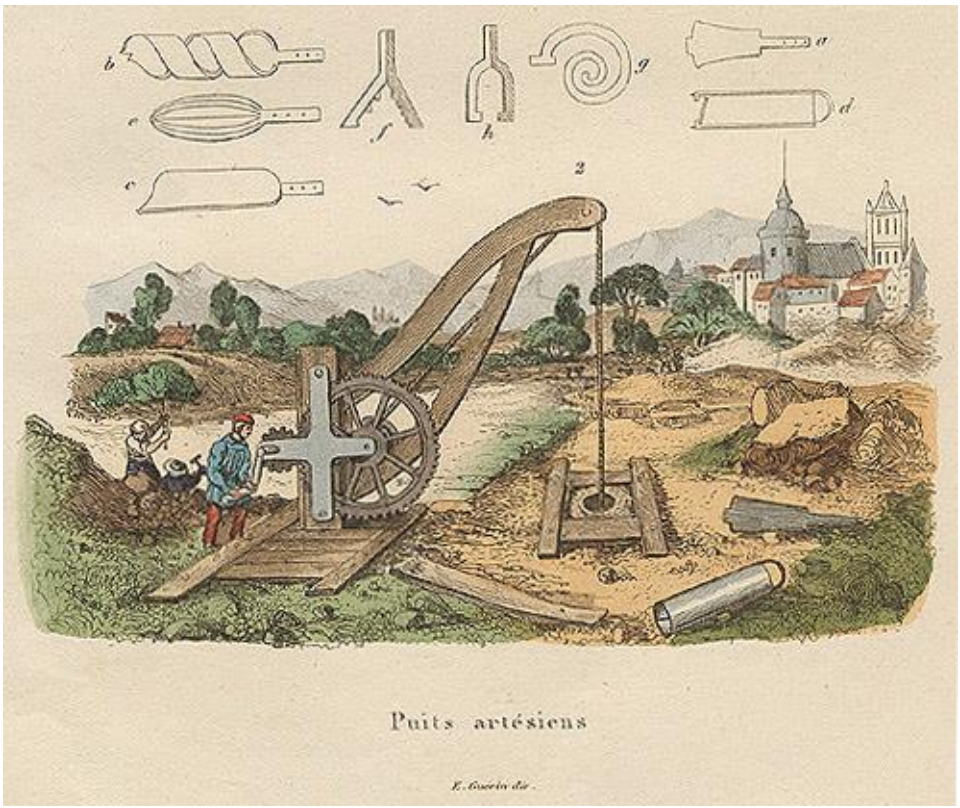
"A smiling gear"

Origin: Japan.

Material: Wood.

Size: D=295 mm, W=35 mm.

Note: This old gear came from Japan. On the left side you see the original photograph of a gear and on the right side, an artistic vision of a gear with a smile. The gear is carved from a single piece of a hardwood. Eight teeth have been replaced and reinforced with the wooden pegs.



http://geararium.org

"Drilling artesian well"

Origin: France.

Note: Hand colored engraving by E. Guerin. Excerpt is taken from Histoire Naturelle, 1836.

Size: Full page 7" x 12".

From: http://geararium.org

UNIT 5

Exercise 20, p. 105.

A. Gluing

Gluing is a kind of lubrication failure. Gears rotating at very high speed on very heavy-duty load will cause a momentary welding. Subsequently, pulling apart will occur between the two meshing teeth. Such damage eventually leads to teeth failure. This type of failure is called gluing.

: http://mece1.bjtu.edu.cn

To improve gluing resistance, the following steps can be taken:

- *supply sufficient lubricants;*
- *add extreme pressure additive into lubricants;*
- *select a lubricant with gluing resistance.*

B. Breakage

Breakage of gear tooth generally occurs at its base, because a gear tooth is somewhat similar to a cantilever beam. There are two types of breakage in gearing:

- fatigue breakage – due to repeated applications of load;
- overload breakage – due to an unexpected shock overload which

equals or exceeds the capacity of the gear.

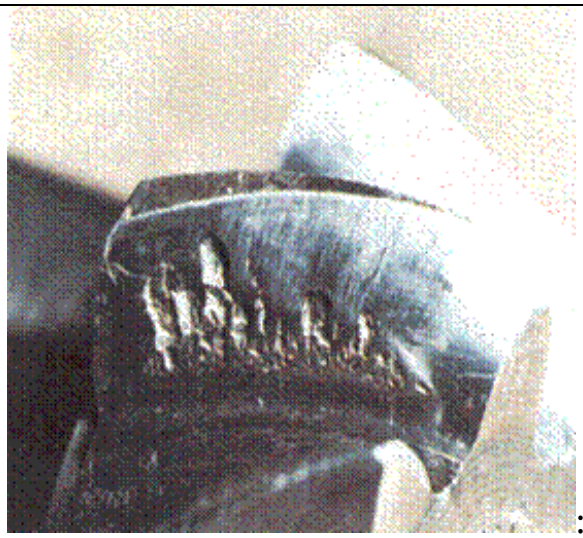
: *http://mece1.bjtu.edu.cn*

To improve bending strength of gears, the following steps can be taken:

- *enlarge fillet radius;*
- *gears can be machined with greater precision;*
- *increase the rigidities of shaft and bearings that carry the gear;*
- *use proper heat treatment to obtain sufficient toughness in the core of the gear tooth;*
- *strengthen the layout of the fillet by blaster or rolling method.*

C. Pitting

Pitting is a phenomenon that small local fractures are lost from the surface of the tooth. It is actually the fatigue failure of the tooth surface because of many repetitions of high contact stresses. Pitting has three features: it begins near the pitch line, develops on flank and operates in grease.



: *http://mece1.bjtu.edu.cn*

In order to improve pitting resistance, the following steps can be taken:

- *use proper heat treatment to improve case hardness of gear teeth;*
- *select materials with greater hardness;*
- *select lubricants with higher viscosity.*

D. Ridging

When gear material is too soft, and the frictional force between two mating gear is too heavy, the surface material of the gear tooth flow along the direction of the frictional force. So, ridging occurs near the pitch line of the tooth surface. The notch is formed at the driving gear, and the crown is formed at the driven gear. This type of failure commonly occurs in the gearing of low-speed, heavy-duty load, starting frequently, and overloading transmission.

: *http://mece1.bjtu.edu.cn*

To improve ridging resistance, the following steps can be taken:

- *increase hardness of the gear tooth surface;*
- *select lubricants with a higher viscosity or containing extreme pressure additive.*

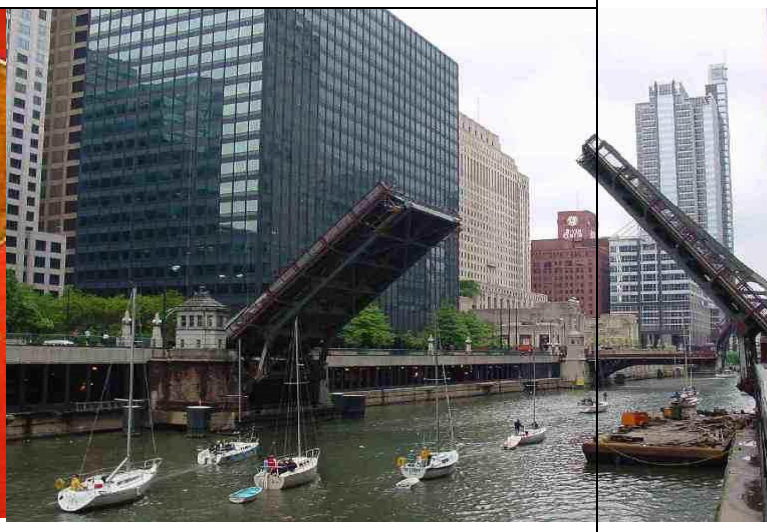
From: http://mece1.bjtu.edu.cn

Exercise 22, p. 108.

List for group B:

https://machtz.com.ua/products/drel-udarnaya-mchtz-mid-131100?gclid=Cj0KCQiA962BBhCzARIsAIpWEL3ue9pTyCKEc79Q-5lC6rmYSyvkMtli31gQ3tgSn-96gGV0VGhmKxEaApn8EALw_wcB

https://dariusmusic.eu/hr/sct/384569/Majstorske-violine



https://en.wikipedia.org/wiki/Wilson_Pigott_Bridge

APPENDIX B

COMMUNICATION GAMES

Engineering Vocabulary Designs and Problem Solving

Discuss together what you would you like to design and describe something from the lists below and / or your own ideas in the same categories. Present your ideas of a new engineering design; if anything about that presentation doesn't make sense, that team loses the score. After all teams have presented, there will also be points for the team whose idea is considered the best. You cannot vote for your own idea.

Things you could design:

- building
- factory / manufacturing process
- gym equipment / sports equipment / new adventure sport
- help for disabled people
- medical equipment
- office equipment
- robot
- safety equipment, e.g. fire fighting equipment or something to stop accidents happening
- something for space travel / living in space
- something you've seen in a sci-fi movie
- spy equipment, e.g. bug or James Bond gadget
- transpor

- way of automating everyday actions

Things you could describe about it:

- appearance
- comparisons to other things
- costs
- ecology
- energy
- manufacturing
- positive aspects
- problems it solves
- use

Useful language:

… and … both … - Neither … nor …

… and … sometimes / often / usually / always go together / … is (usually) accompanied by …

… because (of) … / … due to …

… can be inserted into … (with …)

… can be removed from … (with …)

… can be secured with / attached to …

… can be / should be used with …

… causes / can cause … / … is a reason for …

… is caused by … / … is the result of …

… combines well with … - … doesn't combine well with …

… could destroy / damage / have a negative effect on …

However,… / …, whereas …

… in order to …

… includes … / … is (often / always) a component of …

… contains … / … forms part of …

… is (more or less) equivalent to … (in …)

… is / can be made from / of …

… is more … than … / … is … or than …

… is produced by …

… is similar to … because …

… is superseding / has superseded / will supersede …

… is usually … but could also …

… is usually located …

… should be put / stored / kept …

A combination of … and … / … together with …,…

A simple / An effective solution to … is …

Changing from … to …

If / In the case of / When …, (you should / have to) …

In the future … will / might …

Please (don't) put … in / near / around / on / under …

To choose between … and …,…

You can (move / lift / operate / rotate) … with …

You could improve / fix … with …

You could make … which is / has …

You must not … with …

You should / shouldn't put … and … together.

Future Prediction Game

Choose one of the time period below and make predictions about life in that time until your partner guesses the right time. Use the list of inventions to help you or you can use your own ideas.

Times	***Possible things to speak about***
At the end of this year *This time next year* *At the end of next year* *In two years* *In five years* *At the end of this decade* *In 2030* *In half a century* *At the end of this century* *In 2200* *At the end of this millennium* *In a million years*	Androids / robots which are indistinguishable from people, chips in our brains, computer generated film stars / television personalities,cryonic suspension, driverless cars, robotaxis, face scanner, flexible displays, flying cars, generation ships (= Generations of people living and breeding on a spaceship on their way to another planet), anti-gravity, human cloning, human teleportation, invisibility, limitless cheap electrical energy, lunar and interplanetary tourism,medicines which improve our intelligence, permanent settlements on other planets, reprogramming people's minds,robotic exoskeleton, robots with feelings, selecting characteristics of your future child from a menu,self-replicating machines,space elevators,the complete automation of all work.

Useful language:

It will definitely (100% chance)

It'll almost certainly (95%)

It's bound to (90%)

It'll probably / It's likely to (80%)

It'll possibly / may /might / could (60%)

It might not / unlikely (50%)

It probably won't (20%)

It definitely won't (0%)

Describing Process Game

Variants:

1. Describe a process from below without saying which one and your partner should guess the process;

2. Describe one of the processes below. Then your partner should repeat the process stages back and you should correct anything he gets wrong or misses out;

3. Take turns describing one of the processes below in detail. Whoever gets to the very end of the process loses.

Processes:

1. A manufacturing or construction process of smth.
2. Doing something on a computer (e.g. using some software).
3. Driving or riding something.
4. Emptying or filling something (e.g. a vacuum cleaner).
5. Mending something (e.g. changing a light bulb or bicycle tyre).
6. Operating electronics (e.g. DVD, alarm clock, and dishwasher).
7. Operating something mechanical.
8. Using mechanical tool.
9. A natural process (e.g. the nitrogen cycle, corrosion).
10. Preparing for the test or exam.

Useful language:

First stage	*Next stage*	*Last stage*
The first / initial stage / step / part of the process is …	At this point …	Finally …
To start with …	The next step …	The last / final step is …
At the beginning / start of the process,…	Subsequently …	To bring the process to a close,…
First of all …	After / Following that …	The process concludes with / by …
Firstly …	The following step is …	
To begin with …	…and then …	
Initially …	….after which …	
The process / cycle starts with …	After + ing, …	
The start of the process / cycle is …	After having + PP,…	
At first …	When that stage is finished / completed,…	
	Once …	
	Having completed …,	
	The … moves on to …	
	As soon as …	
	This is followed by …	

Invention Role Plays

Variants:

1. You think that you can invent one of the things on the list below (or can use your own ideas) but the head of the funding committee (your partner) and its members (group) don't think it is a good idea and your research will be successful. Try to persuade them to give you as much money as you can get;

2. You are the committee to award the Nobel Prize for Engineering and three of the things in the list below (or can use your own ideas). Decide together which invention should be given the prize;

3. You bought one of the products from the list below (or can use your own ideas) for the first time at the inventor's suggestion but you aren't happy with this purchase. Call the inventor (your partner) who should persuade you to keep using it.

List of Inventions used now:

- 3D movies
- Air conditioning
- Answering machine
- Anti-virus software
- Ball bearing
- Bulletproof vest
- Chain saw
- Electric drill

- Electric kettle
- Email
- Fridge
- Refrigerator
- Glue stick
- Pritt Stick
- GPS
- Heart transplant
- Hybrid car
- Industrial robot
- Infrared night vision
- Internet
- Low energy light bulb
- Massage chair
- Microscope
- Microwave (oven)
- Mouse MP3 player
- Nuclear power station
- Nut and bolt
- Photocopier
- Pneumatic tyre
- Pocket calculator
- Rechargeable battery
- Reinforced concrete
- Sellotape
- Scotch tape
- Sticky tape
- Sewing machine

- Smoke detector
- Solar panel
- Soldering
- Superglue
- TV remote control
- USB flash drive
- Video game console
- Welding torch
- X ray

Guess the Word

Students get the pile of cards placed face down on the table. One student takes a card and explains the meaning to the others in the group without using the word on the card. The others have to guess what is written on the card.

tyre	compression	force	stress	feasibility
separator	linkage	output	tension	shaft
fading	pinion	spark	hardening	current
piston	pump	combustion	assembly	installation
flywheel	fuel	turbine	turbojet	clutch

Technology Game

This game revises what you have learned in this book. Play in groups of four. You need a dice and a counter for each group. A student from each group throws a dice in turns, completes the task from the square and moves their counter to the correct square. You are allowed one minute for the discussion within the group. If the answer is wrong the counter can not be moved. The first group reaches the Finish is the winner.

1. *Start* Name 4 types of a gear	**11.** Make 3 sentences to compare internal and external combustion engines.	**21.** Talk about the bearing types and their functions.	**31.** Explain how steam is used today.
2. Talk about the Watt's invention (30 sec).	**12.** Go to the square 16.	**22.** Make 2 sentences with the collocations of cause and effect.	**32.** Ask a question about the technology the other part of your group and if they answer wrong - you move a square
3. Give two sentences you could use for charts description.	**13.** Talk about the steam engine invention.	**23.** Go back to 10 square.	**33.** What is the difference between rotary and piston enigns?
4. What are the main advantages and disadvantages of internal combustion engines?	**14.** Make sentences with the words: - exhaust; - transmit; - adjust.	**24.** Give 2 pieces of advice about how to write a CV.	**34.** Name 5 applications of gas turbines.
5. Go back to the second question.	**15.** Which is more efficient: a simple-cycle gas turbine or	**25.** Make adjectives from words: adapt,	**35.** Name 2 skills you have that you would

	a combined cycle power plant? Why?	motion, reinforce.	mention in a letter of application.
6. Name 2 different types of brakes.	**16.** Give 2 pieces of advice about how to write an application letter.	**26.** Make sentences with the words: spring, linkage and ratchet.	**36.** Why is a rotary engine out of use today?
7. Talk about the use of needle bearings.	**17.** Describe the work of gears.	**27.** What do journal and sleeve mean in connection with bearings?	**37.** What are advantages of Wankel engine?
8. Give 3 verbs that describe movement in mechanisms.	**18.** Give the advantages of the disk brakes.	**28.** Talk about the work of brakes.	**38.** Talk about the most possible future technology.
9. Name the parts of the internal combustion engine.	**19.** Move forward one square.	**29.** Name the first inventor of the steam engine.	**39.** Make sentences with the words: to arrange, a chamber, a plug.
10. Describe the second stroke of a combustion engine work.	**20.** Make two sentences what you can do and and you cam make.	**30.** What is the difference between hydraulic and air spring?	**40.** ***Finish***

APPENDIX C

WRITING BANK

UNIT 1

Exercise 24, p. 21.

Bearing Timeline

A brief history of the bearing industry.

2600 BC – The Ancient Egyptians use a form of roller bearings to help move massive bricks during construction of the Pyramids.

40 BC – Early example of a wooden ball bearing supporting a rotating table was retrieved from the remains of a Roman ship in Lake Nemi, Italy.

1500 AD – Leonardo da Vinci described a type of ball bearing.

1600 – Galileo describes caged ball bearing to prevent friction.

1794 – First patent for ball race by Philip Vaughn of Carmarthen, Wales.

1866 – The Torrington Company (under the name Excelsior Needle Company) signs Articles of Association to manufacture sewing machines needles and the machinery to produce the same.

1880 – Rockwell Automation (under the name DODGE Manufacturing Company) incorporates, two years after Wallace H. Dodge began the manufacture of wood hardware specialties.

1883 – FAG begins grinding balls of equal size and roundness forming the creation

of an independent bearing industry.

1898 – First patent issued for Timken Tapered roller bearings.

1907 – Sven Wingquist of SKF invents the modern self-aligning ball bearing.

1912 – FAG originates single-row, barrel type, and spherical roller bearings.

1913 – Hoover Steel Ball Company is founded by Leander J. Hoover in Ann Arbor, MI.

1916 – NSK inaugurated its business in 1916 and produced the first ball bearings made in Japan.***1917*** – U.S. Bearing Manufacturers create an informal group to aid bearing manufacturing for World War I, which led to the founding of ABMA.

1927 – NTN Mfg. Co., Ltd. established with capital of 50,000 yen.

1928 – Fujikoshi Steel Industry Co, Ltd., (Nachi) was founded in Toyama City, Japan, to manufacture cutting and machine tools.

1933 – Articles of Incorporation ratified by United States bearing manufacturers to create AFBMA (Anti-Friction Bearing Manufacturers Association).

1934 – AFBMA is incorporated as an organization in the State of New York.

1960 – Elasto-hydro-dynamic theory explains the mechanism of why bearings and gears work led to advances in grindings precision and ultrasonic equipment.

1969 – Three astronauts in a North American Rockwell "Apollo" spacecraft are launched by North American Rockwell rocket engines toward the moon.

1970 – Intel invents the microprocessor and consistent precision control of machine tools impacting both size and life of bearings.

1980s – Torrington bearings are used in the space shuttle and robot arm to launch and etrieve satellites in orbit.

1992 – ABMA celebrates its 75th anniversary.

1993 – ABMA officially changes its name from the AFBMA (Anti-Friction Bearing Manufacturers Association).

1993 – Leading bearing manufacturers from throughout the world meet for the first time in Key Largo, Florida.

2001 – The Schaeffler Group (INA) acquires FAG.

2002 – Timken Company acquires Torrington Company impacting the global bearing market with a variety of bearing products including tapered roller bearings, needle roller bearings and alloy steels.

2006 – ABMA partners with the American Gear Manufacturers Association (AGMA) for Joint Meeting in Tucson, AZ.

2006 – ABMA, the Japanese Bearing Industrial Association (JBIA) and the Federation of European Bearing Manufacturers Association (FEBMA) create the World Bearing Association (WBA) to focus on issues affecting the global bearing industry.

From: http://www.americanbearings.org

UNIT 5

Exercise 25, p. 110.

Thermoplastic Gears Make Starter Motor Lighter

http://ae-plus.com/case-studies

DSM's high-performance plastics for automotive gears help improve engine efficiency, reduce fuel consumption and reduce production costs.

Plastic annulus gears for starter motors are built to last with Stanyl® polyamide 46 (PA46). This high-performance portfolio of thermoplastics meets the lightweight and efficient needs of the automotive industry by providing exceptionally low wear rates in demanding under-the-hood environments, all while significantly reducing system costs.

With the adoption of demanding start / stop starter motors, annulus gears are subjected to an enormous increase in load cycles. While conventional starter motors see up to 40,000 engine starts or 13 million load cycles per gear tooth, the newer start/stop starter motors see an increase up to 350,000 starts or 45 million load cycles, all under higher temperatures than ever. Stanyl PA46

was engineered to have high durability and low wear, even at operating temperatures up to 170°C. Working together with a leading manufacturer of starter motors, DSM developed new gear designs that reduced weight by 46 percent over metal gears, while cutting costs in three ways: reducing the part count from five to one, eliminating assembly steps and reducing injection molding cycle times.

The result: Decreased overall system costs and lower carbon footprint (less weight and more efficient engines equals less fuel consumption).

From: http://ae-plus.com/case-studies

APPENDIX D

VOCABULARY REFERENCES

UNIT 1: BEARINGS

1.	rotation	обертання
2.	shaft	вал
3.	friction	тертя
4.	sleeve bearings	втулкові підшипники
5.	journal bearings	підшипники колодки
6.	ball bearings	кулькові підшипники
7.	roller bearings	роликові підшипники
8.	frictionless	без тертя
9.	antifriction bearings	антифрикційні підшипники
10.	pressure	тиск
11.	clearance	зазор
12.	load	навантаження
13.	rotational speed	швидкість обертання
14.	oil film	масляна плівка
15.	rupture	розірватися
16.	high stress	висока напруга
17.	rigidly fixed	жорстко закріплені
18.	hardened alloy steel	загартована легована сталь
19.	tolerance	допустиме відхилення
20.	lubricate	мастити
21.	substitute	заміняти
22.	needle bearings	голчасті підшипники
23.	thrust bearings	упорні підшипники

UNIT 2: BRAKES

1.	dissipate kinetic energy	розсіюють кінетичну енергію
2.	drum brakes	барабанні гальма
3.	concave surface	увігнута поверхня
4.	pad	щиток
5.	system of flexible cables	система гнучких тросів
6.	semicircular brake shoes	напівкруглі гальмівні колодки
7.	disk brakes	дискові гальма
8.	effectiveness	ефективність, ККД
9.	vent	вхідний отвір
10.	resistance	опір
11.	caliper	супорт
12.	friction-pad assemblies	фрикційні накладки
13.	suspension	підвіска
14.	dissipate	розсіюватися
15.	antilock braking system	антиблокувальна гальмівна система
16.	subsequently	згодом
17.	tire slippage	ковзання шини
18.	loss of traction	втрата тяги
19.	electric modulator	електричний модулятор
20.	to regulate brake line pressure	для регулювання тиску в гальмівній магістралі
21.	to forestall impending wheel lockup	щоб запобігти блокуванню коліс
22.	retain	зберегти
23.	steer the vehicle	керувати транспортним засобом

UNIT 3: PARTS OF MACHINE: LINKAGE, SPRING, RATCHET

1.	linkage	з’єднання, зчеплення
2.	pin joints (hinges)	штифтові з’єднання (петлі)
3.	sliding joints	розсувні стики
4.	ball-and-socket joints	кульово-гніздові з’єднання
5.	pin-connected links	приєднані штифтами ланки
6.	parallel planes	паралельні площини
7.	regardless	не зважаючи на, не беручи до уваги
8.	constrained motion	стриманий рух
9.	deflected spring	відхилена пружина
10.	torsion	скручування
11.	tension	напруження, напруга
12.	semielliptical shape	напівеліптична форма
13.	groove	паз
14.	expansion of the air	розширення повітря
15.	regardless of load	незалежно від навантаження
16.	deflection	прогин, заломлення
17.	compression	стиснення, здавлювання
18.	stiffness	жорсткість
19.	ratchet	храповик
20.	transmit intermittent rotary motion	передавати переривчастий обертальний рух
21.	oscillation	вібрація, коливання
22.	counterclockwise direction	проти годинникової стрілки
23.	wrench handle	ручка гайкового ключа

UNIT 4: TYPES OF GEARS

1.	reciprocating motion	зворотно-поступальний рух
2.	toothed wheel	зубчасте колесо
3.	meshing	зачеплення
4.	flat-toothed sectors	плоскозубі сектори
5.	rotating motion	обертовий рух
6.	vice versa	навпаки
7.	spur gear	циліндрична шестерня
8.	gearing	передача
9.	driven shaft	ведений вал
10.	revolve	обертати, обертатися
11.	rotation	обертання
12.	idler gear	холоста передача
13.	driving gear	ведуча шестерня
14.	driven gear	ведена шестерня
15.	ratio	співвідношення
16.	Internal, or annular, gears	внутрішні або кільцеві шестерні
17.	flanged wheel	фланцеве колесо
18.	rack	підставка, решітка
19.	pinion	шестерня
20.	miter gears	торцеві шестерні
21.	double helical gears	подвійні гвинтові шестерні
22.	helical bevel gears	гвинтові конічні шестерні
23.	worm gear	черв’ячна передача

UNIT 5: HOW DIFFERENT GEARS WORK

1.	reduction	зменшення
2.	torque	крутний момент
3.	adjust	відрегулювати
4.	rear wheels	задні колеса
5.	a lot of intricacies	багато тонкощів
6.	to maintain	підтримувати в робочому стані
7.	accelerating and decelerating constantly	постійно прискорюючись та сповільнюючись
8.	involute	складний, скручений
9.	feature	особливість, риса
10.	collide	зіткнутися, стикатися
11.	locking feature	функція блокування
12.	high-performance cars	високопродуктивні машини
13.	differential	диференціал
14.	intersect	перетинатися, перехрещуватися
15.	property	якість
16.	mount	установлювати, монтувати
17.	gradually spread	Поступово поширюється
18.	rack gears	зубчасті редуктори
19.	convert	перетворювати
20.	linear motion	лінійний рух
21.	steering system	рульова система
22.	steering wheel	кермо
23.	dial	шкала

APPENDIX E

Dooley J., Evans V. Grammarway 2. Newbury, Berkshire: Express Publishing. – 152 p.

GRAMMAR REFERENCES

The Verb

In English, the verb has four forms, i.e. four endings.

Forms of the Verb

Infinitive	***Past Simple***	***Past Participle***	***Present Participle***
to make	**made**	**made**	mak**ing**
to shock	shock**ed**	shock**ed**	shock**ing**

There are regular and irregular verbs. Regular verbs are those that have the ending **-ed** in the second and third forms. Irregular verbs are those that do not have the ending **-ed** in the second and third forms (See the table of irregular verbs). The fourth form of the verb is formed by adding the ending **-ing** to both regular and irregular verbs.

When adding the suffix **-ed**, the following spelling rules are followed:

- Verbs ending in **-e** only add **-d**: dance – danc**ed**.
- Verbs ending in **a consonant + y** omit **y** and add **-ied**: cry – cr**ied**.
- Verbs ending in **a vowel + y** simply add **-ed**: play – play**ed**.
- Verbs ending in **one stressed vowel between two consonants** double the last consonant and add **-ed**: plan - pla**nned**.
- Verbs ending in **-l** double **l** and add **-ed**: travel - trave**lled**.

When adding the suffix **-ing**, the following spelling rules are followed:

- Verbs ending in **-e** omit **-e** and add **-ing**: dance – danc**ing**.
- Verbs ending in one stressed vowel between two consonants double the last consonant and add **-ing**: plan – pla**nning**.
- Verbs ending in **-l** double **l** and add **-ing**: travel – trave**lling**.
- Verbs ending in **-ie** omit **-ie** and add **-y + -ing**: lie – l**ying**.

There are twenty-six verb tenses in the English language: sixteen tenses of the active voice and ten tenses of the passive voice.

TENSES OF THE ACTIVE VOICE

Aspects / Tenses	Simple	Continuous	Perfect	Perfect-continuous
Present	**I draw** **He draws**	**I am drawing** **He is drawing** **We are drawing**	**I have drawn** **He has drawn**	**I have been drawing** **She has been drawing**
	Usually, sometimes, often, always, every day (week), etc.	*Now, at the moment, at present, these days, still, tonight, etc.*	*Ever, never, just, already, yet, since, for, lately, recently, always, how long, so far, today, this week.*	*For, since, all morning, how long (in questions), etc.*
Past	**I drew**	**I was drawing** **They were drawing**	**I had drawn**	**I had been drawing**
	Yesterday, last week, two days ago, in 1994, etc.	*At six o'clock yesterday, while when, as, all day, etc.*	*Before, after, just, already, till, until, when, by, by the time.*	*For, since, how long, before, until, etc.*
Future	**I will draw**	**I will be drawing**	**I will have drawn**	**I will have been drawing**
	Tomorrow, the day after tomorrow, next year, in two days, soon, etc.	*At six o'clock tomorrow, this time next week, etc.*	*By, by the time, before, until, by then, etc.*	*By, by the time, until, before, etc.*

Future in the Past	**I would draw**	**I would be drawing**	**I would have drawn**	**I would have been drawing**
	*He said that…**	*He said that…**	*He said that…**	*He said that…**

*The Future in the Past tenses are used instead of the corresponding Future tenses in object clauses, if the verb of the main clause is used in the past tense:

He **said** he **would do** his homework later.

He **said** he **would be flying** to Kyiv at that time the next week.

He **said** he **would have returned** home by Sunday afternoon.

He **said** he **would have been working** there for six years by the end of that year.

FORMATION OF THE TENSES OF THE ACTIVE VOICE

Simple Tenses

Present Simple

I/You **work**.-He /She /It **works**.

Do you **work**? – **Does** he **work**? **Yes, I do. / No, he doesn't.**

I **do not (don't) work.** – He **doesn't work.**

Past Simple

I / He / She / We **returned / left.**

Did he **return /leave**? – **Yes, he did. / No, he didn't.**

He **did not (didn't) return / leave.**

Future Simple

He / They **will ('ll) call.**

Will he / they **call? – Yes, he will. / No, they** won't**.**

He / they **will not (won't) call.**

Use

Simple tenses are used to talk about an action as a fact, a repetitive action or a permanent state in the present, past, or future.

*I **go** to the university every day.*

*She **studied** at school last year.*

*He **will be** a good engineer.*

*She said she **would be** busy next week.*

PRESENT SIMPLE

is used to talk about:

- Repeated actions or daily routines (often with adverbs: **always, never, usually, often**, etc.).

E.g. *He usually **starts** work at 9 am. He often **stays** at the office until late in the evening.*

- Permanent states. E.g. *Sandra **works** at university*.
- General truths or laws of nature. E.g. *Water **boils** at 100°C*.
- Programs or schedules (films, trains, buses, etc.). E.g. *The bus **leaves** in ten minutes.*

Time expressions:

always, never, usually, often, seldom, rarely, sometimes, etc. (adverbs of frequency), every day/week/month/year, ma ін., on Mondays/Tuesdays, etc., in the morning/afternoon/evening, at night/the weekend, etc.

PAST SIMPLE

is used to talk about:

- Actions, which happened in the past and the time, is mentioned or implied. E.g. *They **graduated** three years ago.*

- Past habits or actions that repeated in the past but do not happen any more. In this case, we can use adverbs of frequency (**always, never, usually, often**, etc.). E.g. *He often **played** football with his father when he was five*. (But: He doesn't play football with his father any more.)
- Actions that happened one after the other in the past. E.g. *The rotor **turned** against the wind and **started** the turbine*.
- Actions performed by people who are no longer alive. E.g. *Charles Babbage **designed** the first computer in the world*.

Remember:

- We use **used to** to talk about past habits, or actions that no longer occur. This expression has the same form in all persons, singular and plural. It is followed by the infinitive. E.g. *Peter **used to eat** a lot of sweets*. (*Peter doesn't eat many sweets now*.)
- We can also use **Past Simple** instead of **used to**. E.g. *She used to live in the countryside. = She lived in the countryside.*

Time expressions:

yesterday, last night/week/month/year/Monday, etc., two days/ weeks/months/years ago, then, when, in 1992, etc.

For more information about the Past Simple enter the links below, watch the video and do the quiz:

https://www.engvid.com/english-grammar-past-simple-time-markers/

FUTURE SIMPLE

is used for:

- Actions that may or may not occur in the future. E.g. *We **will visit** Disney World one day.*
- Predictions about the future based on what we think. E.g. *Traffic conjestion **will be** a difficult problem to solve.*
- Threats or warnings. E.g. *Stop talking or **I'll** send you out of the classroom*.
- Promises or spontaneous decisions. E.g. ***I'll help** you with your homework.*
- Future actions and used with verbs **hope, think, believe, expect**, and others, expressions **I'm sure, I'm afraid**, and others, and adverbs **probably, perhaps**, and others. E.g. *I **don't think** the course **will be** very interesting. It **will probably take** two hours to fix.*

Remember:

We use **be going to** to express:

- Plans and intentions for the near future. E.g. ***I'm going to meet** the supplier.*
- Predictions about the future based on what we can see. E.g. *Look at those big grey clouds. **It's going to** rain.*

Note:

- We do not use Future Simple in conditional clauses and time clauses (after **when, while, before after, till, until, as soon as, if**). Instead we use present simple. E.g. *Hydrogen fuel cells will get cheaper **when** technology **improves**. (***Not:** ... **when** technology **will improve**.)*

Time expression:

tomorrow, the day after tomorrow, next week/month/year, tonight, soon, in a week/month/year, and others.

Continuous Tenses

Present Continuous

I **am (’m) /** You **are (’re) /** He **is (’s) working.**

Are you / **Is** he **working? – Yes, I am. / No, he isn’t.**

I **am (’m) not /** He **is not (isn’t) /** They **are not (aren’t) working.**

Past Continuous

I /He /She **was /** We /They **were watching.**

Was he / **were** they **watching? – Yes, he was. / No, they weren’t.**

He **was not (wasn’t) /** They **were not (weren’t) watching.**

Future Continuous

I /He / They **will be working.**

Will I / he / they **be working? – Yes, I / he / they will. No, I / he / they won’t.**

I / He / They / **will not (won’t) be working.**

Use

Present Continuous expresses an action that is in progress at the time of speaking, i.e. now; **Past Continuous** expresses an action that was in progress at a stated time or period of time in the past; **Future Continuous** expresses an action that will be in progress at a stated time or period of time in the future.

*He **is reading** a book <u>now</u>.*

*He **was reading** a book <u>when I came in</u>.*

*<u>This time tomorrow</u> we **will be travelling** to Canada.*

PRESENT CONTINUOUS

is used for:

- Actions that are taking place now, at the time of speaking. E.g. *He **is reading** a book right now.*
- Temporary actions that occur around the moment of speaking, but not at the actual moment of speaking. E.g. *She **is preparing** for an exam these days.*
- Actions that occur too often and about which we want to express our irritation or criticism. (The word "always" is used in such sentences). E.g. *You **are always interrupting** me!*
- Fixed arrangements in the near future. E.g. *He **is flying** to London in an hour.*

Time expressions:

now, at the moment, these days, at present, always, tonight, still, and others.

Note:

Some verbs are not used in continuous tenses. They are called "stative verbs". They are:

- Verbs of senses: **see, hear, feel, taste**, **smell.** E.g. *This cake **tastes** delicious.*
- Verbs of mental activity: **know, remember, forget**, **understand, notice, realise, think, believe, recognise, seem, sound**, and others. E.g. *I **don't remember** this rule.*

- Verbs of likes and dislikes: **love, like, dislike, hate, enjoy, prefer,** and others. E.g. *Kate **likes** maths.*
- Other verbs: **include, matter, need, belong, cost, mean, own, appear, want, have** (=**posses**), and others. E.g. *This equipment **costs** a lot of money*.

For further information about the stative verbs enter the link below, watch the video and do the quiz:

https://www.engvid.com/stative-verbs-in-english/

For further information about the Present Continuous enter the link below, watch the video and do the quiz:

https://www.engvid.com/5-ways-to-use-the-present-continuous-verb-tense-in-english/

PAST CONTINUOUS

is used for:

- An action that was in progress at a stated time in the past. We do not know when this action started or finished. Eg. *At three o'clock yesterday afternoon Mike **was working** on the computer.*
- An action that was in progress when another action interrupted it. We use **Past Continuous** to denote an action that was in progress (longer action) and **Past Simple** to denote an action that interrupted it (shorter action). Eg. *As the generator **was turning**, the turbine **broke down**.* (was turning = longer action; broke down = shorter action).
- Two or more actions that occurred at the same time in the past. E.g. *While the wind **was blowing** the wind turbines **were working**.*

- Actions in the background of a story or narrative. E.g. *The sun **was shining** and the birds **were singing**. Tom **was driving** his old truck through the forest.*

Time expressions:

when, while, as, all day/night/morning, and others.

as, when, while, + Past Continuous
when + Past Simple

FUTURE CONTINUOUS

is used for:

- An action that will be in progress at a stated time in the future. E.g. *This time next week **I'll be flying** on a business trip to Japan.*
- An action that will definitely happen as a result of a routine or arrangement. E.g. *I **will be seeing** them at the meeting tomorrow.*

For further information about the Future Continuous enter the links below, watch the video and do the quizes:

https://www.engvid.com/future-progressive-tense/

https://www.engvid.com/learn-to-make-plans-with-the-future-progressive-tense/

Perfect Tenses

Present Perfect

I / You / **have ('ve) left / arrived.**
He / She / It **has ('s) left / arrived.**

Have you **left /arrived? – Yes, I have. / No, I haven't.**

You **have not (haven't) left / arrived.** He / She / It **has not (hasn't) left / arrived.**

Past Perfect

She **had arrived / gone.**

Had she **arrived/ /gone? – Yes, she had. / No, she hadn't.**

She **had not (hadn't) arrived / gone.**

Future Perfect

He / She / They **will ('ll) have left.**

Will he /she / they **have left? - Yes, he / she / they will. No, he / she / they won't.**

He/ She / They **will not (won't) have left.**

Use

Present Perfect denotes an action that finished before the moment of speaking; **Past Perfect** denotes an action that finished before a moment or another action in the past; **Future Perfect** denotes an action that will finish before a moment or another action in the future.

*He **has** already **done** his homework.*

*He **had finished** his homework by nine o'clock yesterday.*

*He **will have finished** his essay by nine o'clock tomorrow.*

*He promised he **would have finished** his essay by nine o'clock.*

PRESENT PERFECT

is used for:

- A past action, when the time of the action is not mentioned but the result is visible now. E.g. *Kim **has bought** a new computer.*
- An action that started in the past and is still going on. E.g. *He has been a teacher since 1990.*

Manufacturers have made a number of improvements in design for the last three dacades.

- An action that happened during a time period which is not yet finished: **today, this week, this morning / afternoon**, etc. E.g. *He **has made** three drafts **this morning***. (It is still morning so this period of time is not finished.)

Time expressions:

ever, never, just, already, yet, since, for, always, so far, how long, lately, recently.

For further information about the Present Perfect enter the link below, watch the video and do the quiz:

https://www.engvid.com/practice-the-present-perfect-tense-in-english/

https://www.engvid.com/english-grammar-how-to-use-since-and-for-with-the-present-perfect/

For further information about the difference between the Past Simple and the Present Perfect enter the links below, watch the videos and do the quizes:

https://www.engvid.com/english-tenses-past-simple-present-perfect/

https://www.engvid.com/english-tenses-present-perfect-present-simple/

PAST PERFECT

is used for:

- An action that finished before a moment or another action in the past. E.g. *She **had prepared** the presentation by five o'clock in the afternoon. They **had done** their homework before they went out yesterday afternoon.*

Time expressions:

before, after, already, just, till/until, when, by, by the time, and others.

For further information about the Past Simple, Past Continuous, Past Perfect and Present Perfect enter the link below, watch the video and do the quiz:

https://www.engvid.com/learn-engish-tenses-past-tenses/

FUTURE PERFECT

is used for:

- •An action that will finish before a moment or another action in the future. E.g. *They **will have finished** their meeting by four o'clock this afternoon.*

Time expressions:

by, by the time, before, until, by then, and others.

Perfect-Continuous Tenses

Present Perfect-Continuous

I / You **have been reading.**
He / She / It **has been reading.**
Have you **been reading? – Yes, I have. / No, I haven't.**

Has he / she / it **been reading?**

You **have not (haven't) been reading.**

He / She / It **has not (hasn't) been reading.**

Past Perfect Continuous

He **had been crying.**

Had he **been crying?- Yes, he had. / No, he hadn't.**

He **had not (hadn't) been crying.**

Future Perfect Continuous

I / you / we / **will ('ll) have been working.**

Will I / you / we **have been working? – Yes, I / we will. No, I / we won't.**

I / You / We / **will not (won't) have been working.**

Use

Present Perfect Continuous expresses an action that was going on and finished before the moment of speaking; **Past Perfect Continuous** expresses an action that was going on and finished before a moment or another action in the past; **Future Perfect Continuous** expresses an action that will be going on and finish before a moment or another action in the future.

*He is tired because he **has been studying** for his exam all morning.*

*She **had been studying** English for three months before she went to Great Britain.*

*By the end of this month he **will have been working** at the factory for twenty years.*

*He told us that by the end of that month he **would have been working** at the factory for twenty years.*

PRESENT PERFECT-CONTINUOUS

is used for:

- An action that began in the past and is still going on now. Eg. *He **has been working** for this company for three years*. (He began working for this company three years ago and he is still working there.)
- An action that began in the past and finished before now. E.g. *His hands are dirty. He **has been fixing** his car.*

Note:

1. We use **Present Perfect** instead of **Present Perfect Continuous** with verbs that are not used in the continuous tenses (know, believe, like, and others). E.g. *I **have known** Sharon since we were at school together.*

2. With the verbs **live, work, feel, teach** we can use **Present Perfect** or **Present Perfect Continuous** without difference in meaning. E.g. *He **has been living/has lived** here since 1994*.

Time expressions:

since, for, all morning/afternoon/evening/week/day, how long (in questions).

For additional information about the **Present Perfect Continuous** (which is also called the **Present Perfect Progressive**) enter the links below, watch the videos and do the quizes:

https://www.engvid.com/present-perfect-progressive-challenge/

https://www.engvid.com/english-grammar-present-perfect-simple-continuous/

PAST PERFECT CONTINUOUS

is used for:

An action that was going on and finished before a moment or another action in the past. E.g. *She **had been waiting** for the bus for half an hour before it came*.

Time expressions:

since, for, how long, before, until, and others.

FUTURE PERFECT CONTINUOUS

is used for:

- An action that will be going on and finish before a moment or another action in the future. E.g. *By the end of next month, Alec **will have been building** houses for ten years. By the time she arrives in Paris, she **will have been traveling** for four hours.*

Time expressions:

by…for.

For further information about the future tenses enter the links below, watch the video and do the quiz:

https://www.engvid.com/using-the-future-tense-in-conversation-english-grammar/

PASSIVE VOICE

Aspect / Tense	Simple	Continuous	Perfect
Present	I **am drawn** She **is drawn** They **are drawn**	I **am being drawn** He **is being drawn** You **are being drawn**	I **have been drawn** It **has been drawn**
Past	I **was drawn** We **were drawn**	I **was being drawn** They **were being drawn**	I **had been drawn**
Future	I **will be drawn**	————	I **will have been drawn**
Future in the Past	I **would be drawn**	————	I **would have been drawn**

The tenses of the Passive Voice are formed using the auxiliary verb **to be** and the main verb in the third form (**Past Participle**).

to be + past participle

Forms of the Passive Voice:

Present Simple: am/is/are + pp The pressure **is measured** twice a day.
Present Continuous: am/is are being + pp The pressure **is being measured** now.
Past Simple: was/were + pp The pressure **was measured** in the morning**.**
Past Continuous: was/were being + pp The pressure **was being measured** when the engineer came in.
Present Perfect: have/ has been + pp The pressure **has just been measured.**
Past Perfect: had been + pp

The pressure **had been measured** before the engineer came in.
Future Simple: will be + pp The pressure **will be measured** in the evening.

Use

The tenses of the Passive Voice are used for the same actions as the corresponding tenses of the Active Voice. We use the Active Voice when the subject performs the action and the Passive Voice – when the action is performed to the subject.

Changing Active to Passive

When we transform the Active Voice into the Passive Voice:

1) the object of the sentence in the Active Voice becomes the subject of the sentence in the Passive Voice;

2) the verb in the Active Voice is changed to the verb in the Passive Voice;

3) the subject of the sentence in the Active Voice becomes the agent of the sentence in the Passive Voice.

For example:

	subject	verb	object
Active Voice	Tom	sent	a letter.

	subject	verb	agent
Passive Voice	A letter	was sent	by Tom.

Passive Voice:

Present Simple	She **teaches** them.	They **are taught**.
Present Continuous	She **is teaching** them.	They **are being taught.**

Past Simple	She **taught** them.	They **were taught.**
Past Continuous	She **was teaching** them.	They **were being taught**.
Present Perfect	She **has taught** them.	They **have been taught**.
Past Perfect	She **had taught** them.	They **had been taught**.
Future Simple	She **will teach** them.	They **will have been taught**.
Modals (modal+be+pp)	She **can teach** them.	They **can be taught**.

- Only verbs which take an object can be used in the Passive Voice. E.g. *Engineers **produce designs** by CAD programs. **Designs are produced** by CAD programs*. **But:** *The designer works quickly.* (This sentence cannot be transformed into Passive because the verb does not take an object).

- If the verb can take two objects (**ask, bring, tell, send, show, teach, promise, offer, give, pay, lend,** and others), the Passive Voice can be formed in two ways, so that each of the two objects can become the subject of the sentence in the Passive.

Active:

He gave **me this book**.

Passive:

a) **I** was given this book.

b) **This book** was given to me.

- If the verb in the Active construction is followed by a preposition, this preposition remains in the same position after the verb in the Passive construction. E.g. *The chief engineer **looked through** the documents and signed them. The documents **were looked through** and signed.*

For further information about the **Passive Voice** enter the links below, watch the videos and do the quizes:

https://www.engvid.com/learn-english-grammar-active-passive/

https://www.engvid.com/passive-responsibility/

APPENDIX F

ТАБЛИЦЯ НЕПРАВИЛЬНИХ ДІЄСЛІВ

№	Infinitive	Past Simple	Past Participle	Ukrainian equivalent
1.	be [bJ]	was (were)[wɒz][wɛ:]	been [bJn]	бути
2.	bear [bɬq]	bore [bʟ]	born [bʟn]	народжувати
3.	bear [bɬq]	bore [bʟ]	borne [bʟn]	носити
4.	beat [bJt]	beat [bJt]	beaten [bJtn]	бити
5.	become [bl'kʌm]	became [bl'kɐlm]	become [bl'kʌm]	ставати
6.	begin [bl'gln]	began [bl'gɤn]	begun [bl'gʌn]	починати
7.	bend [bɐnd]	bent [bɐnt]	bent [bɐnt]	згинатися
8.	bet [bɐt]	bet [bɐt]	bet [bɐt]	битися об заклад
9.	bite [bəlt]	bit [blt]	bitten [bltn]	кусати
10.	blow [blɛV]	blew [blɬl]	blown [blɛVn]	дути
11.	break [brɐlk]	broke [brɛVk]	broken [brɛVkn]	ламати
12.	bring [brlɴ]	brought [brʟt]	brought [brʟt]	приносити
13.	build [bll‌d]	built [bllt]	built [bllt]	будувати
14.	burn [bɛ:n]	burnt [bɛ:nt]	burnt [bɛ:nt]	горіти, палити
15.	burst [bɛ:st]	burst [bɛ:st]	burst [bɛ:st]	розбиватися, вибухати
16.	buy [bəl]	bought [bʟt]	bought [bʟt]	купувати
17.	can [kɤn]	could [kɬld]	been able to	могти
18.	catch [kɤC]	caught [kʟt]	caught [kʟt]	ловити
19.	choose [CɬHz]	chose [CɛVz]	chosen [CɛVzn]	вибирати
20.	come [kʌm]	came [kɐlm]	come [kʌm]	приходити
21.	cost [kɒst]	cost [kɒst]	cost [kɒst]	коштувати
22.	cut [kʌt]	cut [kʌt]	cut [kʌt]	різати
23.	deal [dJl]	dealt [dɐlt]	dealt [dɐlt]	мати справу, обходитися
24.	dig [dlg]	dug [dʌg]	dug [dʌg]	копати
25.	do [dɬl]	did [dld]	done [dʌn]	робити

26.	dream [drJm]	dreamt [drɛmt] dreamed [drJmd]	dreamt [drɛmt] dreamed [drJmd]	мріяти
27.	draw [drɭ]	drew [drɬ]	drawn [drɭn]	тягти, малювати
28.	drink [drlɴk]	drank [drɤɴk]	drunk [drʔɅɴk]	пити
29.	drive [draIv]	drove [drɐVv]	driven ['drlvn]	вести (машину)
30.	eat [Jt]	ate [ɛt]	eaten ['Jtn]	їсти
31.	fall [fɭl]	fell [fɛl]	fallen [fɭln]	падати
32.	feed [fJd]	fed [fɛd]	fed [fɛd]	годувати
33.	feel [fJl]	felt [fɛlt]	felt [fɛlt]	відчувати
34.	fight [faIt]	fought [fɭt]	fought [fɭt]	боротися
35.	find [faInd]	found [faVnd]	found [faVnd]	знаходити
36.	forget [fq'gɛt]	forgot [fq'gɒt]	forgotten [fq'gɒtn]	забувати
37.	forgive [fq'glv]	forgave [fq'gɛlv]	forgiven [fq'glvn]	пробачати
38.	freeze [frJz]	froze [frɐVz]	frozen [frɐVzn]	заморожувати
39.	get [gɛt]	got [gɒt]	got [gɒt]	діставати
40.	give [glv]	gave [gɛlv]	given [glvn]	давати
41.	go [gɐV]	went [wɛnt]	gone [gɒn]	їхати, іти
42.	grow [grɐV]	grew [grɬ]	grown [grɐVn]	рости, ставати
43.	hang [hɤɴ]	hung [hʔɅɴ]	hung [hʔɅɴ]	висіти, вішати
44.	have [hɤv]	had [hɤd]	had [hɤd]	мати
45.	hear [hlq]	heard [hɐ:d]	heard [hɐ:d]	чути
46.	hide [haId]	hid [hId]	hidden [hIdn]	ховати
47.	hit [hIt]	hit [hIt]	hit [hIt]	вдарити
48.	hold [hɐVld]	held [hɛld]	held [hɛld]	тримати
49.	hurt [hɐ:t]	hurt [hɐ:t]	hurt [hɐ:t]	спричиняти біль
50.	keep [kJp]	kept [kɛpt]	kept [kɛpt]	тримати, зберігати
51.	know [nɐV]	knew [njɬ]	known [nɐVn]	знати
52.	lay [lɛl]	laid [lɛld]	laid [lɛld]	класти
53.	lead [lJd]	led [lɛd]	led [lɛd]	вести
54.	lean [lJn]	leant [lɛnt] leaned [lJnd]	leant [lɛnt] leaned [lJnd]	притулятися
55.	learn [lɐ:n]	learnt [lɐ:nt] learned [lɐ:nd]	learnt [lɐ:nt] learned [lɐ:nd]	вивчати
56.	leave [lJv]	left [lɛft]	left [lɛft]	залишати,

				покидати
57.	lend [lɛnd]	lent [lɛnt]	lent [lɛnt]	позичати (комусь)
58.	let [lɛt]	let [lɛt]	let [lɛt]	дозволяти
59.	lie [lаl]	lay [lɛl]	lain [lɛln]	лежати, класти
60.	light [lаlt]	lit [llt]	lit [llt]	освітлювати
61.	lose [lʰʰz]	lost [lƤst]	lost [lƤst]	губити
62.	make [mɛlk]	made [mɛld]	made [mɛld]	робити, виготовляти
63.	mean [mJn]	meant [mɛnt]	meant [mɛnt]	означати, значити
64.	meet [mJt]	met [mɛt]	met [mɛt]	зустрічати
65.	pay [pɛl]	paid [pɛld]	paid [pɛld]	платити
66.	put [pV̈t]	put [pV̈t]	put [pV̈t]	класти
67.	read [rJd]	read [rɛd]	read [rɛd]	читати
68.	ride [rаld]	rode [rЄV̈d]	ridden [rldn]	їхати верхи
69.	ring [rlɴ]	rang [rɤɴ]	rung [rɅɴ]	дзвонити
70.	rise [rаlz]	rose [rЄV̈z]	risen [rlzn]	підніматися
71.	run [rɅn]	ran [rɤn]	run [rɅn]	бігти
72.	say [sɛl]	said [sɤd]	said [sɤd]	сказати
73.	see [si:]	saw [sO:]	seen [si:n]	бачити
74.	seek [si:k]	sought [sO:t]	sought [sO:t]	шукати
75.	sell [sɛl]	sold [sЄV̈ld]	sold [sЄV̈ld]	продавати
76.	send [sɛnd]	sent [sɛnt]	sent [sɛnt]	посилати
77.	set [set]	set [sɛt]	set [sɛt]	встановлювати, заходити (про сонце)
78.	sew [sЄV̈]	sewed [sЄV̈d]	sewn [sЄV̈n] sewed [sЄV̈d]	шити
79.	shake [Ʃɛlk]	shook [ƩV̈k]	shaken [Ʃɛlkn]	трясти
80.	shave [Ʃɛlv]	shaved [Ʃɛlvd]	shaven [Ʃɛlvn]	голитися
81.	shine [Ʃаln]	shone [ƩƤn]	shone [ƩƤn]	сяяти, блищати
82.	shoot [Ʃu:t]	shot [ƩƤt]	shot [ƩƤt]	стріляти
83.	show [ƩЄV̈]	showed [ƩЄV̈d]	showed [ƩЄV̈d] shown [ƩЄV̈n]	показувати
84.	shut [ƩɅt]	shut [ƩɅt]	shut [ƩɅt]	закривати

85.	sing [sIŋ]	sang [sxŋ]	sung [sʌŋ]	співати
86.	shrink [ʃrIŋk]	shrank [ʃrxŋk]	shrunk [ʃrʌŋk]	скорочувати(ся), відступати
87.	sit [sIt]	sat [sxt]	sat [sxt]	сидіти
88.	sleep [sli:p]	slept [slɛpt]	slept [slɛpt]	спати
89.	smell [smɛl]	smelt [smɛlt] smelled [smɛld]	smelt [smɛlt] smelled [smɛld]	пахнути
90.	sow [sƐV]	sowed [sƐVd]	sown [sƐVn]	сіяти
91.	speak [spi:k]	spoke [spƐVk]	spoken [spƐVkn]	говорити
92.	spell [spɛl]	spelt [spɛlt]	spelt [spɛlt]	вимовляти (по буквах)
93.	spend [spɛnd]	spent [spɛnt]	spent [spɛnt]	тратити, проводити час
94.	spread [sprɛd]	spread [sprɛd]	spread [sprɛd]	розповсюджувати
95.	spring [sprIŋ]	sprang [sprxŋ]	sprung [sprʌŋ]	стрибати
96.	stand [stxnd]	stood [stu:d]	stood [stu:d]	стояти
97.	steal [sti:l]	stole [stƐVl]	stolen [stƐVln]	красти
98.	stick [stIk]	stuck [stʌk]	stuck [stʌk]	приклеїти
99.	strike [straIk]	struck [strʌk]	struck [strʌk]	вдарити
100.	string [strIŋ]	strung [strʌŋ]	strunk [strʌŋ]	натягувати
101.	swear [swFq]	swore [swO:]	sworn [swO:n]	клястися
102.	sweep [swi:p]	swept [swɛpt]	swept [swɛpt]	замітати, мести
103.	swim [swIm]	swam [swxm]	swum [swʌm]	плавати
104.	take [tɛIk]	took [tuk]	taken [tɛIkn]	брати
105.	teach [ti:C]	taught [tO:t]	taught [tO:t]	вчити (когось)
106.	tell [tɛl]	told [tƐVld]	told [tƐVld]	сказати, розказати
107.	think [TIŋk]	thought [TO:t]	thought [TO:t]	думати
108.	throw [TrƐV]	threw [Tru:]	thrown [TrƐVn]	кидати
109.	understand [ʌndq'stxnd]	understood [ʌndq'stVd]	understood [ʌndq'stVd]	розуміти
110.	wake [wɛIk]	woke [wƐVk]	woken [wƐVkn]	прокидатись
111.	wear [wƐq]	wore [wO:]	worn [wO:n]	носити (одяг)
112.	weep [wi:p]	wept [wɛpt]	wept [wɛpt]	плакати
113.	win [wIn]	won [wʌn]	won [wʌn]	перемагати
114.	write [raIt]	wrote [rƐVt]	written [rItn]	писати

APPENDIX G

AUDIOSCRIPTS

UNIT 1

BALL BEARING

Ball bearing is one of the two members of the class of rolling, or so-called antifriction, bearings (the other member of the class is the roller bearing). The function of a ball bearing is to connect two machine members that move relative to one another in such a manner that the frictional resistance to motion is minimal. In many applications, one of the members is a rotating shaft and the other a fixed housing.

There are three main parts in a ball bearing: two grooved, ringlike races, or tracks, and a number of hardened steel balls. The races are of the same width but different diameters; the smaller one, fitting inside the larger one and having a groove on its outside surface, is attached on its inside surface to one of the machine members. The larger race has a groove on its inside surface and is attached on its outside surface to the other machine member. The balls fill the space between the two races and roll with negligible friction in the grooves. The balls are loosely restrained and separated by means of a retainer or cage.

The most common ball bearing, with one row of balls, is usually classified as a radial ball bearing (*i.e.*, one designed to carry loads perpendicular to the axis of rotation), but its capacity for carrying an axial, or thrust, load (*i.e.*, a load parallel to the axis of rotation) may exceed its radial capacity. The angular-contact bearing has one side of the outer-race groove cut away to allow the insertion of more balls, which enables the bearing to carry large axial loads in one direction only. Such bearings are usually used in pairs so that high axial loads can be carried in both directions. The clearances in a single-row ball bearing are so small that no appreciable misalignment of a shaft relative to a housing can be accommodated. One type of self-aligning bearing has two rows of balls and a spherical inner surface on the outer race. For pure thrust loads there are ball thrust bearings that consist of two grooved plates with balls between. The outstanding advantage of a ball bearing over a sliding bearing is its low starting friction. At speeds high enough to develop a load-carrying oil film, however, the friction in a sliding bearing may be less than in a ball bearing.

From Encyclopædia Britannica

UNIT 2

OTHER BRAKING SYSTEMS

Bicycles have one of three types of brakes. Coaster brakes are used on the rear wheel of single-speed bikes, which do not have shiftable gears. A mechanism inside the rear wheel hub creates a binding action that slows or locks the rear wheel when the pedals are operated in the backward direction. On bicycles with multiple gears, caliper and cantilever brakes (also called side-pull and center-pull brakes, respectively) are used on the wheels. Both of these types of brakes use hand levers and cables to operate the brake mechanism, which consists of two levers that squeeze a pair of rubber pads against both sides of the wheel rim. Both types are spring-loaded to retract the pads when the pull cable is released. Cantilever brakes are considered better for mountain bikes and for bicycle racing, because these brakes provide more leverage for increased braking force.

Aircraft have hydraulic brakes on their landing gear for stopping after they have landed. The antilock brake system was first developed in 1947 for use on the B-47 bomber. Many aircraft also have special flaps or spoilers called air brakes that can be extended from the wings to increase aerodynamic drag. These flaps may be used to slow the aircraft when it is diving or maneuvering in flight and to help slow it after it has landed. Other means of braking aircraft include propeller blades that can change pitch (operating angle) and thrust reversers that redirect the jet blast sideways or forward in jet engines. Many high-performance military aircraft also have special parachutes called drogue chutes that deploy upon landing to assist braking. The space shuttle uses several drogue chutes for braking, because it lands at speeds in excess of 480 km/h (300 mph). Some types of racing cars also use drogue chutes to assist braking.

Electric cars and other electric vehicles use drum and disc brakes to stop, but some vehicles also make use of magnetic brakes, which create opposing magnetic fields to resist motion. Called regenerative braking, this technique recaptures some of the vehicle's momentum as electrical energy. Regenerative braking uses the magnets within the electric motor itself to slow the vehicle. When the driver releases the accelerator pedal, the electric motor changes into a generator, recapturing the energy from the moving car and transforming it back into electricity. The extra electricity is then used to recharge and extend the driving range of the batteries.

From Encyclopædia Britannica

UNIT 3

SPRING HISTORY

We can consider that the first springs appeared in the shape of the bows used by the first men to hunt. They indeed used the energy stored in the piece of wood at the time of the tension of the rope to launch the arrow towards their potential prey. The energy accumulated by twisting enormous hanks of skins is released and projects with force various projectiles. The applications of the springs in more peaceful fields are more recent like, for example, the spiral spring for the clock industry, which is used since the 15th century.

To see the helical springs appearing, it is necessary to turn to the field of transport. At the origin, ancient civilizations knew the wheel. The transport systems, which used it, then did not have great performances in terms of maintenance and stability. During the 16th century, the suspensions appear carried out using chains connected to four pieces of wood. The comfort of the travellers is largely improved even if those can easily be prone to seasickness due to the important pitching of the cabins. To solve the problems of pitching on the engines, Stephenson, since 1816, installs leaf springs between the boiler and the frame.

It is only lately that the helical springs appear because their manufacture requires a good control of the deformation of materials. The methods of manufacture per mechanical rolling up progressed throughout second half of the 19th century. At the time when auto industry is in full expansion, the suspensions using of the helical springs authorize amplitudes of movement higher than the old designs. It is an important advantage because the roads are much less regular than the railways. The helical spring thus knows a fast expansion at the beginning of the 20th century. It is during this century that it becomes unavoidable both from a qualitative and quantitative point of view.

The industry of the spring is coming to birth and its evolution still continues nowadays. It is true that the manufacture of springs of quality remains a delicate operation. Indeed, to adapt to dispersions in the properties of materials, the adjustment of the current machines requires a great know-how on the part of the operators.

From Encyclopædia Britannica

UNIT 4

RECOGNIZING GEAR FAILURES

Metal gears fail for numerous reasons, some, in part, independent from the gears themselves. Assessing gear damage can be a challenge, especially in industrial equipment. And damage that happens after the first failure can alter the final appearance of damaged gears, further complicating the diagnosis.The good news is there are only five common failure modes: bending fatigue, pitting, micropitting, scuffing, and wear.

Bending fatigue failure is the result of cyclic bending stress at the tooth root. Stress comes from a variable-lever-arm load that moves along the tooth profile during mesh. The damage process follows three stages: crack nucleation, crack propagation, and final unstable fracture. The fracture surface typically has two distinguishable parts; a fatigue-crack growth area and a final unstable fracture area.

Pitting *or* ***macropitting*** is surface damage from cyclic contact stress transmitted through a lubrication film that is in or near the elastohydrodynamic regime. Pitting is one of the most common causes of gear failure. It also affects antifriction bearings, cams, and other machine components in which surfaces undergo rolling / sliding contact under heavy load. Pitting starts with the nucleation of subsurface or surface breaking cracks, then propagates under repeated contact loading. Eventually a crack grows large enough to become unstable and reach the tooth surface.

Micropitting is a relatively recent phenomenon that has become more prevalent owing to an increased use of surface hardened gears made of better quality, cleaner steel. Modern lubricants with sophisticated additive packages that let gears work in more extreme conditions may indirectly contribute to micropitting.Micropitting is the formation of small craters on the tooth surface, often in the region of negative sliding below the pitch line.

These craters nucleate from surface short cracks and progressively remove surface material, similar to what happens with abrasive wear. For this reason, engineers sometimes label micropitting as a kind of abrasive wear. But micropits

actually are the result of rolling/sliding contact fatigue of the tooth surface and subsurface layer.

Scuffing is a severe type of adhesive wear, which instantly damages tooth surfaces that are in relative motion. In fact, a single overload can lead to catastrophic failure. Scuffing welds together unprotected surfaces in metal-to metal contact. Metal particles detach and transfer from one or both meshing teeth. During successive rotations, these particles can scratch teeth flanks in the sliding direction. This type of damage generally happens in areas of high contact pressure and sliding velocity, far from the pitch surface. Conditions there are less favorable to form a protective lubricant layer that would prevent direct metal-to metal contact.

From Encyclopædia Britannica

UNIT 5

PLASTIC GEARS MORE DURABLE THAN EVER

Molded plastic gears have long provided alternatives to metal gears in lightly loaded drives. They transmit power quietly and often without lubrication in applications such as food processors, windshield wiper drives, and even watches. They also reduce the number of parts and resist chemicals in many applications. Previously, plastic gears were limited to ¼-hp drives because of variations in their properties and uncertainties about how they respond to environmental conditions such as moisture, temperature, and chemicals.

Today, better molding controls combined with design practices that more accurately encompass environmental factors have boosted plastic gear drive capacity to ¾-hp. Though plastic gears give engineers more flexibility, designing them is more complicated. Their material properties and dimensions vary with changes in environmental conditions, thereby affecting speed reducer capabilities. Crystalline type plastics generally provide characteristics that ensure reliable gear operation, as well as consistent shrinkage needed for precision molding. These materials include nylon 6/6, polyacetal, polyphenylene sulfide (PPS), thermoplastic polyester, long fiber reinforced plastic and liquid crystal polymers (LCP).

Most plastic gears are made from nylon and acetal. But nylon absorbs moisture with resultant changes in properties and dimensions. Acetal copolymers provide long-term dimensional stability as well as high fatigue and chemical resistance over a wide temperature range. Liquid crystal polymers give high dimensional stability and chemical resistance, plus low mold shrinkage and high accuracy. Long fiber-reinforced plastics provide good dimensional repeatability and shrinkage consistency in large parts.

The design opportunities that plastic gears afford are a major advantage. They can be molded in shapes difficult to machine in metal. Other functional elements such as springs and pawls can be molded into them, thereby consolidating parts and trimming the cost, weight, and complexity of geared speed reducers.

They are molded in high volumes at low cost, typically one-half to one-tenth that of stamped, machined, or powder metal gears. They're usually ready to use as-molded and require no finishing.

Plastics inherently weigh less, typically 15 to 20% as much as steel, but plastic gears must be larger to transmit the same power.

Compared with metal, plastic gears run much quieter. Plastic gear teeth deform, compensating for noise-producing gear misalignment and tooth errors, and the material absorbs impacts that would otherwise cause running noise.

A low coefficient of friction means less horsepower wasted in heat. Plastic gears also lend themselves to efficient designs such as split-path planetary drives.

Inherent lubricity and chemical resistance mean plastic gears can be used with or without lubrication as needed for specific applications.

With consistent material quality, and accurate molding process control, plastic gears can achieve high precision – up to AGMA Quality 10.

Chemical and corrosion resistance typically exceeds that of metal gears, especially in wet applications.

From Encyclopædia Britannica

REFERENCES

1. Барабанне гальмо [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Барабанне_гальмо
2. Большой Англо-русский политехнический словарь: в двух томах. / С. М. Баринов, А. Б. Борковский, В. А. Владимиров и др. – М.: Руссо, 1999. – Том I (A-L). –704 с.
3. Большой Англо-русский политехнический словарь: в двух томах. / С. М. Баринов, А. Б. Борковский, В. А. Владимиров и др. – М.: Руссо, 1999. – Том II (M-Z) . –720 с.
4. Важіль [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Важіль
5. Вальниця [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Вальниця
6. Газова турбіна [Electronic resource] – Retrieved from: https://en.wikipedia.org/wiki/Газова_турбіна
7. Двигун Ванкеля [Electronic resource] – Retrieved from: https://en.wikipedia.org/wiki/Двигун_Ванкеля
8. Двигун внутрішнього згоряння [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Двигун_внутрішнього згоряння
9. Зубчасте колесо [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Зубчасте_колесо
10. Парова машина [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Парова_машина
11. Пружина [Electronic resource] – Retrieved from: http://uk.wikipedia.org/wiki/Пружина

12. Abqjournal [Electronic resource] – Retrieved from: http://www.abqjournal.com/279952/opinion/modern-disc-brakes-unaffected-by-water.html

13. American bearings [Electronic resource] – Retrieved from: http://www.americanbearings.org/?page=bearing_timeline

14. Bearing [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Bearing_(mechanical)

15. Blog [Electronic resource] – Retrieved from: http://www.tangiblegreen.net/blog.html

16. Brake [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Brake

17. Checklist [Electronic resource] – Retrieved from: http://www.essaybuilder.net/Checklist.html

18. Common bearing failures [Electronic resource] – Retrieved from: http://jadanalysis.co.uk/bearing-failure-faq.php

19. Comparison diagram [Electronic resource] – Retrieved from: https://en.wikipedia.org/wiki/Comparison_diagram

20. Course Inquiry letter sample [Electronic resource] – Retrieved from:http://www.livecareer.com/letter-samples/ Course Inquiry letter -misc /industrial-engineerрой

21. Cover letter sample [Electronic resource] – Retrieved from:http://www.livecareer.com/letter-samples/cover-letters-misc/industrial-engineerрой

22. Design of springs [Electronic resource] – Retrieved from: http://www.meca.insa-toulouse.fr/~paredes/Springs2K/index.php?ide=Bmaterial

23. Diagram [Electronic resource] – Retrieved from: http://education.alberta.ca/apps/Readtolive/Tools/Reading%20Diagrams.pdf

24. Diagrams [Electronic resource] – Retrieved from: https://www.google.com.ua/search?q=growth+in+city+population+diagram&espv=2&biw=1366&bih=667&tbm=isch&tbo=u&source=univ&sa=X&ved=0CBsQsARqFQoTCK6DmtO_jccCFea_cgod9aMC1g#imgrc=SEjOyP72UmsrHM%3A

25. Electric power generation [Electronic resource] – Retrieved from: https://www.google.com.ua/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=Electric+power+generation+pictures

26. Encarta [Electronic resource] – Retrieved from: Microsoft ® Encarta ® 2006. © 1993-2005 Microsoft Corporation. All rights reserved.

27. Encyclopædia Britannica [Electronic resource] – Retrieved from: Ultimate Reference Suite DVD. – 2006.

28. Gear [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Gear

29. Gear failures [Electronic resource] – Retrieved from: http://mece1.bjtu.edu.cn/otherweb/jpkc/jxsj/eng/jxsj_jxnr_eng/jxnr_search/jxnr_content/d10z/d10z_2.htm

30. Gears pictures [Electronic resource] – Retrieved from: https://www.google.com.ua/?gfe_rd=cr&ei=VZpqU6nDLPK9wAPAhYH4Dg#q=gears+pictures

31. How to write business letters. [Electronic resource] – Retrieved from: Pantcheva M. How to write business letters. http://site.uit.no/english/writing-style/letters/

32. Kale K.B. Elements of Mechanical Engineering / Kale K.B., Karad A.A. – Technical Publications, 2007. – 352 p.

33. Karad A. A. From Basic Mechanical Engineering / Karad A. A., Kale K. B., Phadukule V. N. – Technical Publications, 2006. – 608 p.

34. Kinds of springs pictures [Electronic resource] – Retrieved from: https://www.google.com.ua/search?q=kinds+of+springs+pictures&tbm=isch&tbo=u&source=univ&sa=X&ei=9g2_U5mzC_GB7QbVm4CACQ&ved=0CDAQ7Ak&biw=1366&bih=677

35. Letter sample [Electronic resource] – Retrieved from: https://teamwork.jacobs-university.de:8443/confluence/display/LifeSciCareers/How+to+write+an+application+letter+for+an+internship+or+for+graduate+school

36. Linkage [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Linkage_(mechanical)

37. Locomotive propulsion [Electronic resource] – Retrieved from: https://www.google.com.ua/search?q=Locomotive+propulsion+pictures&espv=2&biw=1366&bih=667&tbm=isch&tbo=u&source=univ&sa=X&ved=0CDAQ7AlqFQoTCLuZ3siai8cCFWu9cgodq0ICFw#tbm=isch&q=+jet+propulsion+pictures&imgrc=Bx58cGlyHekO9M%3A

38. Longman dictionary of contemporary English. / Special edition. Volume I (A-L). – Longman, 1992. – 626 p.

39. Longman dictionary of contemporary English. / Special edition. Volume II (M-Z). – Longman 1992. – 627 p.

40. Microsoft Encarta [Electronic resource]. – Redmond, WA: Microsoft Corporation, 2006. – [DVD].

41. Nice K. How Gears Work / Karim Nice [Electronic resource] – Retrieved from: http://science.howstuffworks.com/transport/engines-equipment/gear.htm

42. Radar chart [Electronic resource] – Retrieved from: https://www.google.com.ua/search?q=Radar+chart&espv=2&biw=1366&bih=667&tbm=isch&tbo=u&source=univ&sa=X&ved=0CBsQsARqFQoTCPHdoqWukscCFculcgodL38A4w&dpr=1#imgrc=cuPYjuw4vfX6oM%3A

43. Ratchet [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Ratchet_(device)

44. Sales diagram [Electronic resource] – Retrieved from: https://www.google.com.ua/search?q=mazda+Wankel+rotary+sales+diagram&espv=2&biw=1366&bih=667&tbm=isch&tbo=u&source=univ&sa=X&ved=0CCEQsARqFQoTCJfJ4tDqmccCFcNYLAodVKwMVA

45. Scientific Planet [Electronic resource] – Retrieved from: http://www.bibalex.org/psc/en/home/sciplanetdetails.aspx?id=71

46. Spring [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Spring_(device)

47. Sun and planet gear [Electronic resource] – Retrieved from: http://en.wikipedia.org/wiki/Sun_and_planet_gear

48. Sustainable solutions [Electronic resource] – Retrieved from: http://www.annualreport2011.wartsila.com/en/ar/sustainability/environmental-performance/towards-more-sustainable-solutions/reducing-nitrogen-oxide-emissions

49. Thermoplastic gears [Electronic resource] – Retrieved from: http://ae-plus.com/case-studies/case-study-thermoplastic-gears-make-starter-motors-lighter