МИНИСТЕРСТВО СЕЛЬСКОГО ХОЗЯЙСТВА
И ПРОДОВОЛЬСТВИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

ГЛАВНОЕ УПРАВЛЕНИЕ ОБРАЗОВАНИЯ, НАУКИ И КАДРОВ

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АНГЛИЙСКИЙ ЯЗЫК

GEODESY

*Сборник текстов и упражнений
для студентов, обучающихся по специальностям
1-56 01 01 Землеустройство,
1-56 01 02 Земельный кадастр*

Горки
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Сборник состоит из десяти разделов, направленных на совершенствование и систематизацию знаний и умений студентов, обогащение их профессионального словарного запаса. Приведены аутентичные тексты по специальности с комплексом упражнений. Текстовые материалы знакомят студентов с профессиональной лексикой на иностранном языке.

Для студентов, обучающихся по специальностям 1-56 01 01 Землеустройство, 1-56 01 02 Земельный кадастр.

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ВВЕДЕНИЕ

Сборник текстов и упражнений предназначен для студентов землеустроительного факультета, обучающихся по специальностям 1-56 01 01 Землеустройство, 1-56 01 02 Земельный кадастр.

Целью материалов сборника является совершенствование и систематизация знаний и умений студентов, обогащение их словарного запаса по предлагаемой тематике, формирование навыков понимания, перевода и реферирования текстов по специальности, развитие навыков монологического высказывания на основе письменного текста, что позволяет сформировать коммуникативную компетентность в различных профессионально ориентированных видах речевой деятельности. Особую значимость имеет углубление и расширение словарного запаса, приобретение обучаемыми навыков правильного понимания и перевода оригинального текста, научной литературы по специальности.

Сборник состоит из 10 разделов, включающих тексты для чтения, комплекс разноуровневых упражнений, а также список ключевой лексики.

В сборник включены оригинальные научные тексты, имеющие познавательную ценность. Все тексты связаны со специальностью студентов. Тексты снабжены упражнениями по изучению и закреплению лексики. Все разделы по своей структуре идентичны, даны ясные формулировки заданий.

Базой для составления сборника послужили оригинальные тексты, для которых в каждом разделе предлагается комплекс упражнений, способствующих активному усвоению профессиональной лексики, правильному употреблению терминов, а также позволяющих проверить общее понимание прочитанного, стимулировать говорение на базе прочитанного текста.

UNIT 1

HISTORY OF GEODESY

Exercise 1. Practise reading the following words.
a) [ð] – the, this, that, therefore, their, logarithm,
[ɜ:] – circle, early, earth, concern, were, determine
[i:] – Greek, east, increase, reason, believe
[ʌ] – much, result, another, such, reduction, sun

b) Anaximenes [ˌanakˈsɪmɪniːz]
Archimedes [ˌɑːkɪˈmiːdiːz]
Aristotle [ˈarɪstɒt(ə)l]
Geodesy [dʒɪˈɒdɪsi]
Picard [ˈpɪkɑːd]
Plato [ˈpleɪtəʊ]
Ptolemy [ˈtɒlɪmi]
Pythagoras [pʌɪˈθagərəs]
Rhodes [rəʊdz].

Vocabulary

accomplish [ə'kɔmplɪʃ] – совершать, выполнять
accuracy ['ækjərəsɪ] – правильность, соответствие
angle ['æŋgl] – угол
arc [ɑːk] – дуга
cast [kɑːst] – бросать, кидать
circle ['sɜːkl] – круг, окружность
circumference [sə'kʌmf(ə)r(ə)ns] – окружность
contribute [kən'trɪbjuːt] – содействовать, способствовать
derived [dɪ'raɪvd] – производный, вторичный, полученный
elevation [ˌelɪ'veɪʃ(ə)n] – высота небесного тела над горизонтом, возвышение
explicit [ɪk'splɪsɪt] – подробный, определенный, точный
flatten ['flæt(ə)n] – выравнивать, разглаживать
graze [greɪz] – слегка касаться, задевать
promulgate ['prɔm(ə)lgeɪt] – объявлять, провозглашать
rectangular [rek'tæŋgjələ] – прямоугольный

HISTORY OF GEODESY

Man has been concerned about the earth on which he lives for many centuries. During very early times this concern was limited, naturally, to the immediate vicinity of his home; later it expanded with the development of means of transportation. Man became interested in his whole world. Much of this early "world interest" was evidenced by speculation concerning the size, shape, and composition of the earth.

The early Greeks, in their speculation and theorizing, ranged from the flat disc advocated by Homer to Pythagoras' spherical figure– an idea supported one hundred years later by Aristotle. Pythagoras was a mathematician and to him the most perfect figure was a sphere. He reasoned that the gods would create a perfect figure and therefore the earth was created to be spherical in shape. Anaximenes, an early Greek scientist, believed strongly that the earth was rectangular in shape.

Since the spherical shape was the most widely supported during the Greek Era, efforts to determine its size followed. Plato determined the circumference of the earth to be 40,000 miles while Archimedes estimated 30,000 miles. Meanwhile, in Egypt, a Greek scholar and philosopher, Eratosthenes, set out to make more explicit measurements. It is remarkable that he obtained accuracy in view of the fact that most of the "known" facts and his observations were incorrect.

It was not until the 15th century that his concept of the earth's size was revised. During that period the Flemish cartographer, Mercator, made successive changes in the size of the Mediterranean Sea and all of Europe which had the effect of increasing the size of the earth.

The telescope, logarithmic tables, and the method of triangulation were contributed to the science of geodesy during the 17th century. In the course of the century, the Frenchman, Picard, performed an arc measurement that is modern in some respects. He measured a base line by the aid of wooden rods, used a telescope in his angle measurements, and computed with logarithms. The results started an intense controversy between French and English scientists. The English claimed that the earth must be flattened, as Newton and

Huygens had shown theoretically, while the Frenchmen defended their own measurement and were inclined to keep the earth egg-shaped.

To settle the controversy, once and for all, the French Academy of Sciences sent a geodetic expedition to Peru in 1735 to measure the length of a meridian degree close to the Equator and another to Lapland to make a similar measurement near the Arctic Circle. The measurements conclusively proved the earth to be flattened, as Newton had forecast. Since all the computations involved in a geodetic survey are accomplished in terms of a mathematical surface resembling the shape of the earth, the findings were very important.

COMPREHENSION CHECK

Exercise 2. Mark the following sentences True or False.

1. Pythagoras believed that the earth was created to be rectangular in shape.
2. Archimedes determined the circumference of the earth to be 30000 miles.
3. Measuring the distance and computing the circumference of the earth Posidonius achieved a fairly accurate result.
4. There was an intense controversy between French and English scientists centuries ago.
5. In 1737 a geodetic expedition was sent to Peru to measure the length of a meridian degree close to the Equator.

Exercise 3. Match the words similar in meaning.

1. boundary	a. estimate
2. method	b. combine
3. backing	c. limit
4. consequently	d. compute
5. value	e. means
6. outstanding	f. accuracy
7. precision	g. therefore
8. unite	h. reduction
9. calculate	i. support
10. lessening	j. remarkable

Exercise 4. Match the words opposite in meaning.

1. correct	a. similar
2. separate	b. increase
3. imprecise	c. unexpected
4. decrease	d. incorrect
5. outdated	e. create
6. expected	f. combine
7. sharpen	g. modern
8. different	h. perfect
9. destroy	i. accurate
10. imperfect	j. flatten

Exercise 5. Read the text and answer the following questions.

1. What interested man about the earth for many centuries?
2. What did Pythagoras and Anaximenes consider the earth to be in shape?
3. Whose maps influenced the cartographers of the middle ages?
4. What measurements did Picard and his followers perform?
5. What controversy was between French and English scientists?
6. What conclusion was made during geodetic expedition to Peru?

UNIT 2

OBJECTIVES OF GEODESY

Exercise 1. Practise reading the following sentences.

[**θ**]

- May is my favorite **month**.
- There were more than a **thousand** people.
- There is **nothing** to do.
- **Thanks** for helping me.
- He lives in the **north**.

[ð]

- I live in **the northern** part of Europe.
- Let's take **another** picture.

- Do you have a **brother**?
- He bought a new **leather** jacket.
- **This** song has a good **rhythm**.
- I want to go to **the Netherlands**.

Vocabulary

definition – определение
validity [vəˈlɪdɪti] – действительность, обоснованность, годность
surface – поверхность
external gravity field – внешнее поле тяготения
ocean floor – дно океана
objective [əbˈdʒɛktɪv] – цель, задача
geoid [ˈdʒiːɔɪd] – геоид

Text A

OBJECTIVES OF GEODESY

According to the classical definition given by F.R. Helmert, geodesy is the "science of the measurement and mapping of the Earth's surface." This definition has to this day retained its validity; it includes the determination of the Earth's external gravity field as well as the surface of the ocean floor. With this definition, which has to be extended to include temporal variations of the Earth and its gravity field, geodesy may be included in the geosciences and also in the engineering sciences.

The objectives of geodesy can be described as, first, to determine accurately the positions of points on the Earth's surface and their variations and, second, to study the gravity field of the Earth, the shape and size of the Earth.

To our knowledge, geodesy is both a foundational and an applied discipline. As an applied discipline, geodesy studies all forms of the Earth's surface; therefore the shape and size of the Earth and its gravity field are studied and measured, and a unified coordinate system should be established to show the exact geometric positions. On the other hand, as a foundational discipline, geodesy is primarily concerned with the Earth's movement, state, components, acting force, and all kinds of physical processes. Hence, geodesy provides instant, dynamic spatial geometric and physical information with high accuracy which serves as an important means of studying the Earth's rotation, movement of its crust, and changes of sea surface, and is used for prediction of geological disasters.

Geodesy can be classified into ellipsoidal geodesy, geodetic control survey, marine geodesy, and engineering geodesy (i.e., plane surveying). Ellipsoidal geodesy studies the body of the Earth as a whole, determines the shape of the Earth and its external gravity field, and establishes the geodetic reference system. Geodetic control survey measures the coordinates and heights of a sufficient number of surface points. Marine geodesy establishes a geodetic control network on the Earth's surface covered by oceans to realize positioning on the sea surface and underwater and to measure the marine gravity field, sea surface topography, and marine geoid.

Engineering geodesy determines the details on the Earth's surface regionally in a small area and usually refers to the horizontal plane for measurement. Ellipsoidal geodesy, geodetic control survey, marine geodesy, and engineering geodesy are closely related to one another.

COMPREHENSION CHECK

Exercise 2. Translate the phrases into Russian.

1. external gravity field
2. the shape and size of the Earth
3. a unified coordinate system
4. a sufficient number of surface points
5. physical processes
6. information with high accuracy
7. prediction of geological disasters.
8. marine geoid

Exercise 3. Match the words with their definitions.

geodesy	surface	coordinate	high accuracy	gravity field

1. a natural phenomenon by which physical bodies attract with a force proportional to their masses

2. any of a set of numbers used in specifying the location of a point on a line, on a surface, or in space

3. the science of the measurement and mapping of the Earth’s surface

4. the outside part or uppermost layer of something

5. the quality or state of being correct or precise

Exercise 4. Complete the sentences.

1. Geodesy is the science of …
2. Geodesy studies ...
3. The objectives of geodesy are ....
4. Geodesy provides instant, dynamic spatial geometric and physical information with high accuracy which serves as ...
5. Marine geodesy establishes a geodetic control network on the Earth’s surface covered by ...

Exercise 5. Answer the following questions.

1. What does geodesy study?
2. What are the objectives of geodesy?
3. Is geodesy a foundational discipline?
4. Does geodesy serve as a means of studying the Earth’s rotation and movement of its crust?
5. Speak about the classification and branches of geodesy.

Text B

THE FIVE MAIN AREAS OF THE SURVEYOR'S WORK

Vocabulary

acquisition – сбор, приобретение
to be regarded – считаться, полагаться
to encompass – заключать в себе, окружать
to gather – собирать
conventional – обычный, традиционный
indispensable – необходимый, незаменимый
to process – обрабатывать
to evolve – развивать, развертывать
to plot – составлять план, делать схему, рассчитывать
to portray – описывать, изображать
to delineate – очерчивать, описывать, изображать

Surveying has traditionally been defined as the science and art of determining relative positions of points above, on, or beneath the surface of the earth, or establishing such points. In a more general sense, however, surveying can be regarded as that discipline which encompasses all methods of gathering and processing information about the physical earth and environment. Conventional ground systems are now supplemented by aerial and satellite surveying methods, which evolved through the defense and space programs.

In general, the work of a surveyor can be divided into five parts:

1. Research analysis and decision making. Selecting the survey method, equipment, most likely corner locations, and so on.

2. Field work or data acquisition. Making measurements and recording data in the field.

3. Computing or data processing. Performing calculations based on the recorded data to determine locations, areas, volumes, and so on.

4. Mapping or data representation. Plotting measurements or computed values to produce a map, plat, or chart, or portraying the data in numerical or computer format.

5. Stakeout. Setting monuments and stakes to delineate boundaries or guide construction operations.

Surveying is one of the oldest and most important arts practiced by man because from the earliest times it has been necessary to mark boundaries and divide land. Surveying has now become indispensable to our modern way of life.

Surveying continues to play an extremely important role in many branches of engineering. For example, surveys are required to plan, construct, and maintain highways, railroads, buildings, bridges, tunnels, canals, land subdivisions, sewerage systems, pipelines, etc. All engineers must know the limits of accuracy possible in construction.

COMPREHENSION CHECK

Exercise 1. Fill in the table with appropriate derivatives if possible.

Noun	**Verb**	**Adjective**
	to define	
information		
decision		
	to measure	
		indispensable
accuracy		

Exercise 2. Match the terms with their definitions.

a) surveying b) surface c) satellite d) equipment e) acquisition f) measurements g) calculations h) representation i) accuracy	1) a set of tools, devices, kit, etc, assembled for a specific purpose; 2) an amount, extent, or size determined by measuring; 3) the study or practice of measuring altitudes, angles, and distances on the land surface so that they can be accurately plotted on a map; 4) the act, process, or result of calculating; 5) a man-made device orbiting around the earth, moon, or another planet transmitting to earth scientific information or used for communication; 6) faithful measurement or representation of the truth; correctness; precision; 7) the act or an instance of representing or the state of being represented; 8) the process of locating a spacecraft, satellite, etc, esp by radar, in order to gather tracking and telemetric information 9) the uppermost level of the land or sea.

Exercise 3. Match the English and Russian equivalents.

1) relative positions	a) установление точек
2) establishing points	b) размещение углов
3) processing information	c) сбор данных
4) research analysis	d) полевые работы
5) corner locations	e) замеры участка земли
6) field work	f) обработка сведений
7) data acquisition	g) анализ изысканий
8) plotting measurements	h) относительное положение

Exercise 4. Answer the following questions.

1. What is a traditional definition of surveying?
2. What is surveying in a more general sense?
3. What are conventional systems supplemented by?
4. How many main parts are there in surveyor’s work?
5. Surveying is one of the modern arts practiced by man, isn’t it?

6. Does surveying play an important part in engineering?

7. What spheres surveying is needed in?

Exercise 5. Translate into Russian.

a) Геодезические изыскания – это целый комплекс работ по исследованию местности.

b) Данные аэрофотографических, картографических, топографических и топографо-геодезических съемок.

c) Визуальные наблюдения за территорией.

d) Сложные геологические условия (овраги, реки).

e) Создание комплекса планово-высотной и опорной геодезических сетей.

f) Проведение наземной топографической съемки.

g) Проведение аэро- и стереофотографических съемок объектов или акватории.

h) Привязка объекта на местности.

i) Камеральная обработка материалов исследований и составление технического отчета по геодезическим изысканиям.

j) Наружные обмеры зданий и координирование их элементов в период подготовки их к ликвидации.

k) Все исследования в области геодезических изысканий необходимо проводить в строгом соответствии с нормативными документами.

UNIT 3

GEODETIC SURVEYING TECHNIQUES
Astronomic positioning and Triangulation

Exercise 1. Practise reading the following words.

a) [u:] – through, evolution, include, conclude

[aɪ] – define, line, combine, highway, satellite, wide

[æ] – latitude, angular, manner, tract, catalogue, azimuth

[k] – tract, function, exact, closely, technological

[s] – surface, science, precise, reference, distance, accuracy

b) catalogue ['kæt(ə)lɔg], chronometer [krɔ'nɔmɪtə], equator [ɪ'kweɪtə], geoid [ˈdʒiːɔɪd], perpendicular [ˌpɜːp(ə)n'dɪkjulə], geodetic [ˌʤiːəu'detɪk], geometry [ʤ(ɪ)'ɔmɪtrɪ], zenith ['zenɪθ], hydrographic [hʌɪdrəˈgrafɪk], triangulation [trʌɪaŋgjuˈleɪʃn], trigonometry [ˌtrɪgə'nɔmɪtrɪ], trigonometric [ˌtrɪgənə'metrɪk], zenith ['zenɪθ].

Vocabulary

adjust [ə'ʤʌst] – подгонять, приспосабливать, регулировать
anticipate [æn'tɪsɪpeɪt] – ожидать, предвидеть, предчувствовать
astrolabe ['æstrə(u)leɪb] – астролябия
compile [kəm'paɪl] – собирать, накапливать, составлять
establish [ɪs'tæblɪʃ] – учреждать, устанавливать
framework ['freɪmwɜːk] – основа, структура, строение
justify ['ʤʌstɪfaɪ] – подтверждать, доказывать
latitude ['lætɪt(j)uːd] – широта
longitude ['lɔngɪt(j)uːd] – долгота
measure ['meʒə] – измерять, мерить, отмерять, отсчитывать
plumb line [plʌm] – отвес (прибор для определения перпендикулярности чего-л.)
positioning [pə'zɪʃ(ə)nɪŋ] – ориентация, определение положения, позиционирование
precise [prɪ'saɪs] – точный, определѐнный
survey ['sɜːveɪ] – съемка
traverse [trə'vɜːs] – полигонометрия
triangle ['traɪæŋgl] – треугольник

GEODETIC SURVEYING TECHNIQUES
(Astronomic positioning and Triangulation)

Four traditional surveying techniques for determining the exact positions of points on the earth's surface include:

- ❖ astronomic positioning
- ❖ triangulation
- ❖ trilateration
- ❖ traverse

Astronomic positioning is the oldest positioning method. It has been used for many years by mariners and, more recently, by airmen for navigational purposes. Geodesists must use astronomic positions along with other types of survey data such as triangulation and trilateration to establish precise positions.

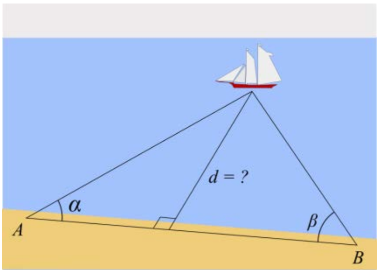
As the name implies, astronomic positions are obtained by measuring the angles between the plumb line at the point and a star or series of stars and recording the precise time at which the measurements are made. After combining the data with information obtained from star catalogues, the direction of the plumb line (zenith direction) is computed.

While geodesists use very precise techniques for determining astronomic latitude, the simplest method, in the northern hemisphere, is to measure the elevation of Polaris above the horizon of the observer. Astronomic latitude is defined as the angle between the perpendicular to the geoid and the plane of the equator.

Astronomic longitude is the angle between the plane of the meridian at Greenwich and the astronomic meridian of the point. Actually, it is measured by determining the difference in time – the difference in hours, minutes, and seconds between the time a specific star is directly over the Greenwich meridian and the time the same star is directly over the meridian plane of the point.

Astronomic observations are made by optical instruments – theodolite, zenith camera, prismatic astrolabe – which all contain leveling devices. When properly adjusted, the vertical axis of the instrument coincides with the direction of gravity and is, therefore, perpendicular to the geoid. Thus, astronomic positions are referenced to the geoid.

Triangulation. The most common type of geodetic survey is known as triangulation. It differs from the plane survey in that more accurate instruments are used. Another very important difference is that all of the positions established by triangulation are mathematically related to each other.



Basically, triangulation consists of the measurement of the angles of a series of triangles. The principle of triangulation is based on simple trigonometric procedures.

If the distance along one side of a triangle and the angles at each end of the side are accurately measured, the other two sides and the remaining angle can be computed.

Normally, all of the angles of every triangle are measured for the minimization of error and to furnish data for use in computing the precision of the measurements.

There are four general orders of triangulation. First-Order (Primary Horizontal Control) is the most accurate triangulation. It is costly and time-consuming using the best instruments and rigorous computation methods.

First-Order triangulation is usually used to provide the basic framework of horizontal control for a large area such as for a national network. It has also been used in preparation for metropolitan expansion and for scientific studies requiring exact geodetic data.

Second-Order, Class I (Secondary Horizontal Control) includes the area networks between the First-Order arcs and detailed surveys in very high value land areas.

The demands for reliable horizontal control surveys in areas which are not in a high state of development or where no such development is anticipated in the near future justifies the need for a triangulation classified as Second-Order, Class II (Supplemental Horizontal Control). This class is used to establish control along the coastline, inland waterways and interstate highways. The control data contributes to the National Network and is published as part of the network.

Third-Order, Class I and Class II (Local Horizontal Control) is used to establish control for local improvements and developments, topographic and hydrographic surveys, or for such other projects for which they provide sufficient accuracy.

(from http://www.ngs.noaa.gov/ PUBS_LIB/Geodesy4Layman)

COMPREHENSION CHECK

Exercise 2. Match words similar in meaning.

1. purpose	a. method
2. data	b. surveyor
3. along with	c. aim
4. imply	d. establish
5. observer	e. information
6. technique	f. mistake
7. compute	g. together
8. accurate	h. measure
9. error	i. precise
10. determine	j. mean

Exercise 3. Translate the phrases into English.

1. определять точное положение
2. измерение углов
3. широта

4. долгота
5. правильно установленный
6. исключать ошибки
7. требовать точные сведения
8. подтверждать необходимость
9. обеспечивать точность
10. группа исследователей

Exercise 4. Translate the phrases into Russian.

1. surveying techniques
2. to measure the elevation
3. the Greenwich meridian
4. a leveling device
5. to be related to each other
6. to be costly and time-consuming
7. to provide the basic framework
8. the area networks
9. to establish control
10. to accomplish all the measurements

Exercise 5. Complete the sentences.

1. Astronomic positioning is …. method.
2. Geodesists must use … to establish precise positions.
3. … differs from the plane survey in that more accurate instruments are used.
4. Triangulation consists of the measurement of the angles of a series of ...
5. There are … general orders of triangulation.
6. Astronomic positions are obtained by … and recording the precise time at which the measurements are made.
7. Astronomic latitude is defined as the angle between the … and the plane of the equator.

Exercise 6. Answer the following questions.

1. What are traditional surveying techniques? What are they used for?
2. How are astronomic positions obtained?
3. How is astronomic latitude defined?
4. What is astronomic longitude? How is it measured?
5. What are the differences between the plane survey and triangulation?
6. What is the principle of triangulation based on?
7. What are four general orders of triangulation?
8. When is each triangulation order used?
9. Which accuracy should four orders of triangulation indicate?

UNIT 4

GEODETIC SURVEYING TECHNIQUES
Trilateration and Traverse

Exercise 1. Practise reading the following words.

a) **[aɪ] – i**sland, h**ei**ght, upr**i**ght, beh**i**nd, impl**y**, l**i**ne

[əʊ] – old, locate, closure, c**oa**stline, p**o**le

[**eɪ] –** navig**a**tion, calibr**a**te, obt**ai**n, w**a**ve, rem**ai**n

[dʒ] – a**g**ency, ad**j**oin, chan**g**e, **g**eodetic, ad**j**ust

b) barometer [bə'rɔmɪtə], barometric [ˌbɑːrəu'metrɪk], bubble ['bʌbl], interior [ɪn'tɪərɪə], mountainous ['mauntɪnəs],) radar ['reɪdɑː], technique [tek'niːk], telescope ['telɪskəup], thermometer [θə'mɔmɪtə], surface ['sɜːfɪs].

Vocabulary

aneroid ['ænərɔɪd] – барометр-анероид
calibrate ['kælɪbreɪt] – градуировать, калибровать
conterminous [kɔn'tɜːmɪnəs] – смежный, примыкающий
correspond [ˌkɔrɪ'spɔnd] – соответствовать, согласовываться
differential, adj.[ˌdɪf(ə)'ren(t)ʃ(ə)l] – дифференциальный
execute ['eksɪkjuːt] – осуществлять, выполнять, делать
gauge [geɪʤ] – измерительный прибор
leveling ['lev(ə)lɪŋ] – нивелирование
loop [luːp] – петля
mercurial [mɜː'kjuərɪəl] – ртутный
missile ['mɪsaɪl] – реактивный снаряд, ракета
reconnaissance [rɪ'kɔnɪs(ə)ns] – разведка, зондирование
sparsely ['spɑːslɪ] – редко
supplementary [ˌsʌplɪ'ment(ə)rɪ] – добавочный, дополнительный
tidal ['taɪd(ə)l] – связанный с приливом и отливом, периодический
traverse [trə'vɜːs] – полигонометрия
trilateration [traɪˌæŋgjuˈleɪʃn] – трилатерация
undulation [ˌʌndjə'leɪʃ(ə)n] – волнообразное движение
upright ['ʌpraɪt] – вертикальный, прямой
yield [jiːld] – давать, выдавать, вырабатывать

GEODETIC SURVEYING TECHNIQUES
Trilateration and Traverse

Trilateration is the measurement of the lengths of the three sides of a series of touching or overlapping triangles on the earth's surface for the determination of the relative position of points by geometrical means (as in geodesy, map making, and surveying). It involves the use of radar and aircraft. The SHORAN, HIRAN and SHIRAN electronic distance measuring systems have been applied to performing geodetic surveys by a technique known as trilateration. Since very long lines (to 500 miles) could be measured by these systems, geodetic triangulation networks have been extended over vast areas in comparatively short periods of time. In addition, the surveys of islands and even continents separated by extensive water barriers have been connected by the techniques.

> **NOTE**
> Triangulation Measures Angles, Not Distance
> Trilateration Measures Distance, Not Angles

Only distances are measured in trilateration and each side is measured repeatedly to insure precision. The entire network is then adjusted to minimize the effects of the observations errors. The angles of the triangles are computed so the geodetic positions are obtained as in triangulation. In addition, the surveys of islands and even continents separated by extensive water barriers have been connected by the techniques.

Traverse. The simplest method of extending control is called traverse. Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point. In performing a traverse, the surveyor starts at a known position with a known azimuth (direction) to another point and measures angles and distances between a series of survey points. With the angular measurements, the direction of each line of the traverse can be computed; and with the measurements of the length of the lines, the position of each control point computed. If the traverse returns to the starting point or some other known position, it is a closed traverse, otherwise the traverse is said to be open.

Since electronic distance measuring equipment has become available, the accuracy of traverse surveys has increased significantly. The tellurometer (microwave) has been used in Australia to complete a network

(Australian Geodetic Datum) covering that continent. The average loop length is about 900 miles; the average loop closure of this work is 2.2 parts per million. The laser equipped geodimeter has been used to produce internal accuracies better than one part per million in establishing the transcontinental traverse in the United States. The traverse consists of a series of high-precision length, angle and astronomic azimuth determinations running approximately east-west and north-south through the conterminous states, forming somewhat rectangular loops. This traverse will be the "backbone" of a re-adjustment of the horizontal control network in this country.

Traverse networks have many advantages, including:

❖ Less organization is needed;

❖ The traverse can change to any shape and thus can accommodate a great deal of different terrains;

❖ Only a few observations need to be taken at each station, whereas in other survey networks a great deal of angular and linear observations need to be made and considered;

❖ Scale error does not add up as the traverse is performed. Azimuth swing errors can also be reduced by increasing the distance between stations.

COMPREHENSION CHECK

Exercise 2. Match words with their definitions.

barrier	**azimuth**	**technique**	**loop**	**level**	**ellipsoid**	**elevation**

1. ………. – a way of carrying out a particular task, especially the execution or performance of an artistic work or a scientific procedure;

2. ………. – the direction of a celestial object from the observer, expressed as the angular distance from the north or south point of the horizon to the point at which a vertical circle passing through the object intersects the horizon;

3. ………. – a three-dimensional figure symmetrical about each of three perpendicular axes, whose plane sections normal to one axis are circles and all the other plane sections are ellipses;

4. ………. – a height or distance from the ground or another stated or understood base;

5. ………. – the action or fact of raising or being raised to a higher or more important level, state, or position;

6. ………. – a circumstance or obstacle that keeps people or things apart or prevents communication or progress;

7. ………. – a length of thread, rope, or similar material, doubled or crossing itself, used as a fastening or handle

Exercise 3. Mark the following sentences True or False.

1. Only distances are measured in trilateration.

2. If the traverse returns to the starting point or some other known position, it is an open traverse.

3. Reckoning navigation methods in geodesy involve the determination of an observer's position from observations of the moon, stars and satellites.

4. Vertical surveying is the process of determining heights-elevations above the mean sea level surface.

5. Trigonometric, differential and barometric leveling techniques turn in information of varying accuracy.

6. Differential leveling measures a vertical angle from a known distance with a theodolite and computing the elevation of the point.

7. In barometric leveling, differences in angles are determined by measuring the difference in atmospheric pressure at various elevations.

Exercise 4. Match adjectives with suitable nouns.

1. extending	a. technique
2. surveying	b. length
3. rectangular	c. control
4. trilateration	d. instruments
5. high-precision	f. traverse
6. vertical	e. method
7. angular	g. pressure
8. air	h. loops
9. closed	i. angle
10. optical	j. measurements

Exercise 5. Answer the questions.

1. What is trilateration?

2. Give the examples of the application of the trilateration technique.

3. Does trilateration survey islands and continents separated by extensive water barriers?

4. What does triangulation measure?
5. What does trilateration measure?
6. What is traverse?
7. What advantages do traverse networks have?
8. Can the traverse accommodate a great deal of different terrains?
9. What does the traverse consist of?
10. What has increased significantly the accuracy of traverse surveys?

UNIT 5

DIFFERENCE BETWEEN PLANE SURVEYING AND GEODETIC SURVEYING

Exercise 1. Practice reading these words.

wrap	wrote	wristband
wrapper	wrench	write
wreck	wrist	writer

Read these sentences.

- Did you **wr**ite a note and **wr**ap the gift?
- Does your **wr**ist hurt when you **wr**ite?
- I **wr**apped the **wr**eath in the **wr**ong paper.
- The **wr**estler had a very **wr**inkled face.

Vocabulary

reservoir [ˈrezəvwɑ:] – водохранилище, источник
extent [ɪksˈtent] – степень, пространство, предел
irrigation [ˌɪrɪˈɡeɪʃən] – ирригация
curvature [ˈkɜːvəʧə] – кривизна, изгиб, искривленность
triangulation – триангуляция
trilateration – трилатерация
to plot – прокладывать курс, нанести
to correlate – соотносить
to categorize классифицировать
to neglect пренебрегать, игнорировать, упускать

DIFFERENCE BETWEEN PLANE SURVEYING AND GEODETIC SURVEYING

Surveying can simply be defined as the process or technology of making measurement in a scientific manner on, above, or below the earth's surface in order to determine points to produce a plan or map. When the area of surveying is small, and the scale to which its result plotted is large, then it is known as plan, and the vice versa of this is Map. Surveying is widely used in almost all civil engineering projects such as construction of building, bridges, reservoirs, dams, railways, roads, irrigation projects etc. Surveying can be classified based on different factors such as field of survey (like land survey, marine survey, photogrammetric, etc), object of surveys (like Engineering purpose, military purpose, etc), method of survey (like Triangulation, Trilateration, etc), and instruments used (Like chain surveying, theodolite surveying, levelling, etc). However the prime classification of surveying is plane surveying and geodetic surveying.

Plane Surveying

Plane surveying is a branch of surveying in which the surface of the earth is considered as plane surface. This is the most commonly practicing form of surveying. This is used when the extent of the area to be surveyed is small (area less than 260 square km) as this method neglects the curvature of earth. In order to make calculations, normally triangles are formed on the ground and these triangles are also assumed as plane triangles and the rules of plane triangles are used to do the computations. The area to be surveyed, and the error associated to the survey results are positively correlated that is more the area more the error. So, this method is not suitable for more accurate or precise large area surveying. Normally Plane surveying is useful for engineering projects. Normally, survey for location and construction of railroads, highway, cannel, and landing fields are categorized under this method.

Geodetic Surveying

Geodetic surveying is another branch of surveying in which the curvature of the earth is considered when taking measurements on earth's surface. That is the actual spherical shape of earth is taken into account. This is also known as trigonometrical surveying. The triangles formed are spherical triangles and calculations are made using spherical trigonometry. In this method, measurements are taken using high precision instruments. This method is used to determine or establish control points for other surveys, and to long lines and areas. The position of each geodetic station is expressed using longitude and latitude and Global Positioning System (GPS) is normally used for this purpose.

What is the difference between Plane Surveying and Geodetic Surveying?

Though, both plane surveying and geodetic surveying are the methods of making measurement on earth, they are having some distinguishing features.

1. Mainly, plane surveying ignores the curvature of the earth, while geodetic surveying considers it.
2. Plane surveying is suitable for small areas, whereas Geodetic surveying suits for surveying of large area.
3. Geodetic surveying is more accurate than plane surveying.
4. Triangles formed in plane surveying are plane triangles, but triangles formed in geodetic surveying are spherical triangles.
5. Geodetic stations are in huge distance compared to stations formed in plane surveying.
6. Moreover plane surveying uses normal instruments like chain, measuring tape, theodolite, etc. to locate points on earth, while geodetic surveying uses more precise instruments and modern technology like GPS.

COMPREHENSION CHECK

Exercise 2. Fill in the correct prepositions and translate the phrases

1) _ order to determine points
2) to use _ civil engineering
3) construction _ irrigation projects
4) to be based _ different factors
5) field _ survey;
6) to consider _ plane surface
7) the curvature _ earth
8) to be categorized _ the method
9) to take _ account
10) to be used_ the purpose

11) to compare___ smth;

12) to locate points _ earth.

Exercise 3. Complete the following sentences according to the text.

1. Surveying serves to produce … .
2. Surveying is widely used in … .
3. Objects of surveys are … .
4. Methods of survey are ... .
5. The most commonly practicing form of surveying is ... .
6. … is not suitable for accurate or precise large area surveying.
7. Global Positioning System is normally used for … .

Exercise 4. Correct the following statements if necessary.

1. When the area of surveying is small, and the scale to which its result plotted is large, then it is known as Map.
2. The broad classification of surveying is plane surveying and geodetic surveying.
3. Plane surveying is a branch of surveying in which the curvature of the earth is considered.
4. Geodetic surveying neglects the curvature of earth.
5. Plane surveying is suitable for more accurate or precise large area surveying.
6. In geodetic surveying, measurements are taken using high precision instruments.

Exercise 5. Answer the following questions and give examples.

1. How can surveying be defined?
2. Where is surveying widely used?
3. What is surveying classification based on?
4. What is the prime classification of surveying?
5. What is plane surveying?
6. What is geodetic surveying?
7. What is the main difference between Plane Surveying and Geodetic Surveying?

UNIT 6

APPLICATIONS OF GEODESY IN TOPOGRAPHIC MAPPING, ENGINEERING CONSTRUCTION, AND TRANSPORTATION

Exercise 1. a) **Practice reading ing [ŋ]**

king	doing	listening
sing	looking	singing
ring	running	ringing
bring	reading	bringing
thing	writing	thinking

b) **Read the words**

sink	sing
rink	ring
wink	wing

c) **Practise reading the following sentences**

1. John is singing a song.
2. I was thinking about what you were saying.
3. Alison was laughing while watching Mark's dancing.
4. Jack is thinking about selling his car.
5. Don't forget to bring the wedding ring!

Vocabulary

topographic mapping – составление топографических карт, топографическая съемка
error accumulation – накопление ошибок, неточностей
inevitable [ɪnˈevɪtəbl] – неизбежный, неминуемый
deviating [ˈdiːvɪeɪtɪŋ] – отклоняющийся, уклоняющийся
unify [ˈjuːnɪfaɪ] – унифицировать
overlapping layers – перекрывающиеся слои, наложенные один на другой
resolve a conflict – разрешить конфликт
workforce – рабочая сила

APPLICATIONS OF GEODESY IN TOPOGRAPHIC MAPPING, ENGINEERING CONSTRUCTION, AND TRANSPORTATION

The important functions of geodetic control network in **topographic mapping** are primarily:

1. To control error accumulation in mapping. Errors are inevitable in mapping, for instance, they arise when we depict a line of direction or measure a certain distance. They are hardly noticeable in small areas, but would gradually accumulate in mapping of large areas, greatly deviating the topographic positions and features on a map.

2. To unify coordinate systems. National basic topographic maps are generally mapped subdivisionally by different departments at different stages in different places. Because the coordinate system of points in the geodetic control network is unified nation-wide with homogeneous accuracy, missing or overlapping layers do not occur in mapping, ensuring an integrated map.

3. To resolve a conflict between an ellipsoid surface and a plane. A map is flat, but the Earth is approximately like a rotating ellipsoid with a curved surface that would crumple or split if forced to flatten, indicating that nobody can directly map the features from an ellipsoid surface onto a plane. However, the positions of geodetic control points on an ellipsoid can be projected onto a plane via certain mathematical methods.

Traditional geodetic surveying has lower efficiency, consumes more time, and requires a greater workforce and a huge investment. With the fast-paced development of the economy, the demands for various quick and precise positioning and rapid mapping techniques are needed to provide a guaranteed product. Modern Global Navigation Satellite Systems (GNSS), such as a Global Positioning System (GPS), can locate the position of a point within 5–10 min (compared with several hours to days using traditional methods) with centimeter-level accuracy. GPS allows rapid large-scale mapping when used for aerial photography and surface auto-mapping systems.

In **engineering construction**, the important roles of geodesy are:

1. To build a mapping control network for large-scale topographic mapping. Designers design buildings and plan districts on large-scale topographic maps. Geodesy serves to establish the mapping control network as the basis for mapping control.

2. To build a construction control network during project construction. A construction survey is mainly used to set out the designed buildings on a

map and make sure that they are built in the intended locations. For example, the major task of a tunnel construction survey is to ensure that the tunnel dug from reciprocal directions runs through in accordance with the specified accuracy.

3. To build a special control network with the purpose of monitoring deformation of buildings during the operation stage after completion of the project. A change in the original state of the Earth's surface during project construction, together with the weight of buildings, would cause changes in its surrounding area. Besides, the building itself and its foundation will also deform due to changes in the ground base. Such deformation, once exceeding a certain limit, would affect the normal use of the building or even jeopardize its safety. In some cities (such as Shanghai and Tianjin in China) overexploitation of underground water could cause land subsidence in downtown areas on a large scale and bring about damage. Therefore, during the operational phase after completion of the construction, deformation needs to be monitored for these buildings or downtown.

With regard to **transportation**, geodetic surveying has provided important guarantees for improving traffic efficiency and decreasing traffic accidents. The navigation and positioning level of ancient transportation means is from several kilometers to tens of kilometers whereas that of today's air and ocean transportation is from several meters to tens of meters. Modern GPS equipment can provide real-time positioning with decimeter-level or even centimeter-level accuracy, which is highly significant for large airports with frequent take-offs and landings.

Currently, the number of automobiles in the world is increasing rapidly. According to statistics, traffic accidents in recent years are mostly due to drivers' failure to quickly determine the positions of and distances between automobiles and to their lack of quick response capability while passing obstacles. At present, GPS autopositioning systems are applied extensively, which will effectively reduce traffic accidents caused by automobiles. Such installations are also needed for inland navigation in narrow channels and ports to avoid ship collision accidents. Satellite navigation and positioning ability with high efficiency and accuracy enables traffic accidents to be greatly reduced and transportation efficiency to be highly improved.

COMPREHENSION CHECK

Exercise 2. Translate the following phrases into Russian.

1. topographic mapping

2. error accumulation in mapping
3. to depict a line
4. to measure a certain distance
5. to unify coordinate systems
6. an integrated map.
7. an ellipsoid surface
8. traditional geodetic surveying
9. to consumes more time
10. engineering construction
11. to make sure
12. in accordance with
13. monitoring deformation of buildings
14. on a large scale
15. satellite navigation

Exercise 3. Match the words with their definitions.

a) topographic mapping	1. строительство
b) coordinate system	2. съемка
c) map	3. карта
d) survey	4. мониторинг
e) positioning	5. определение местоположения
f) construction	6. спутник
g) monitoring	7. система координат
h) satellite	8. топографическая съемка

Exercise 4. Complete the sentences with information from the text.

1. The important functions of geodetic control network in topographic mapping are to control error accumulation in mapping, to unify coordinate systems and…

2. National basic topographic maps are generally mapped subdivisionally by ...

3. A map is flat, but the Earth is approximately like …

4. Traditional geodetic surveying has lower efficiency, consumes more time, and ...

5. GPS can locate the position of a point within … minutes compared with ...

6. A change in the original state of the Earth's surface during project construction, together with the weight of buildings, would cause ...

7. Modern GPS equipment can provide ...

Exercise 5. Answer the following questions.

1. What are the functions of geodetic control network in topographic mapping?
2. Are errors inevitable in mapping?
3. Why do errors occur in mapping?
4. How are national basic topographic maps generally mapped?
5. What sort of a conflict is there between an ellipsoid surface and a plane?
6. Why does traditional geodetic surveying have lower efficiency?
7. What are the functions of geodetic control network in engineering construction?
8. Does geodesy serve to establish the mapping control network as the basis for mapping control?
9. What is the major task of a tunnel construction survey?
10. How has geodetic surveying improved traffic efficiency?

UNIT 7

APPLICATIONS OF GEODESY IN DISASTER PREVENTION, RESISTANCE, AND MITIGATION

Exercise 1. Practise reading the following words.

[i:] – h**ea**t, **e**ven, f**ea**ture, fr**ee**ze, b**ea**m l**ea**d
[əʊ] – rem**o**te, l**o**cation, pr**o**cess, z**o**ne, l**o**cator, **o**ver
[aʊ] – all**ow**, with**ou**t, am**ou**nt, h**ow**ever, b**ou**ndary, d**ow**n
[ʌ] – res**u**lt, fl**u**ctuation, destr**u**ct, constr**u**ction, p**u**lse, **u**nderground

Vocabulary

natural disaster **–** стихийное бедствие
earthquake [ˈɜːθkweɪk] **–** землятресение
flood **–** наводнение
predict **–** прогнозировать
mitigate **–** смягчать
plate subduction zones **–** зоны субдукции пластин
intra-plate fault zones **–** внутриплитных зон разломов
crustal strain **–** деформация земной коры

APPLICATIONS OF GEODESY IN DISASTER PREVENTION, RESISTANCE, AND MITIGATION

Natural disasters, especially earthquakes, floods, and severe tropical storms, usually bring huge damage and loss to human beings. Countries worldwide set great store on preventing and fighting disasters. At present, excluding tropical storms (which can be forecast quite accurately), it is still hard to predict massive earthquakes successfully, which reflects the inadequacy of man's knowledge of the science of the Earth. There is still a long way to go to improve our ability to prevent and mitigate natural disasters, which is an important mission of the geosciences, including geodesy.

Modern geodetic techniques, especially space geodesy, will be increasingly crucial in research on the monitoring and forecasting of earthquakes. Most earthquakes are distributed along the plate subduction zones and active intra-plate fault zones. According to historical statistics of earthquakes, the seismic activity of a seismic zone has a certain statistical periodicity.

The basis for using the geodetic method to monitor crustal strains in a seismic zone over a long period provides information for the medium- and short-term forecast of earthquakes.

Geodesy can monitor the whole process of the preseismic, coseismic, and postseismic strain accumulation. The earthquake is related to global plate movements, so when the speed deviates from the average, indicating that the strain accumulation at the borders of plates is higher, an earthquake would probably occur. Some countries such as the USA and Japan have established dense geodetic deformation monitoring systems, including GPS automatic monitoring stations on seismic zones.

Earthquake prediction is extremely complex. We might know that an earthquake is due to occur, but no information about date and time, position of the epicenter or any other important data will be predictable within the next 100 years.

Geodesy is equally important in preventing other kinds of geological disasters, for instance, the monitoring of landslide and mudflow. The Research Institute of Hubei accurately predicted a destructive landslide near the Xintan Area of the Yangtze River through geodetic monitoring, successfully preventing casualties and greatly reducing the financial losses to residents.

The change in atmospheric mass distribution causes a change in the Earth's angular momentum and influences the Earth's rotational velocity. Disasters happen in the world every year-plane crashes, shipwrecks, traffic accidents, people missing in severe environments, and so on. How to conduct timely and effective rescue becomes people's primary concern. In the past, wireless SOS distress signals were used to seek help, but often the exact position of the site could not be determined so the speed of rescue would be affected. Now, a satellite rescue system has already been established internationally and uses GPS rapid positioning and satellite communication technology to allow international rescue organizations to locate the site rapidly and organize rescue activities in time.

COMPREHENSION CHECK

Exercise 2. Match the parts of the sentences according to the text.

1. Natural disasters, especially earthquakes, floods, and severe tropical storms, usually bring … 2. There is still a long way to go to improve our ability to prevent and mitigate natural disasters, which is an important mission of... 3. Modern geodetic techniques, especially space geodesy, will be increasingly crucial in research on... 4. The basis for using the geodetic method to monitor crustal strains in a seismic zone over a long period provides …. 5. Geodesy can monitor the whole process of the preseismic, coseismic, and postseismic… 6. Geodesy is equally important … 7. Some countries such as the USA and Japan have established	a) the geosciences, including geodesy. b) strain accumulation. c) dense geodetic deformation monitoring systems, including GPS automatic monitoring stations on seismic zones. d) the monitoring and forecasting of earthquakes e) information for the forecast of earthquakes. f) in preventing other kinds of geological disasters. g) huge damage and loss to human beings.

Exercise 3. Translate into Russian.

a) natural disasters
b) bring huge damage
c) human beings
d) at present
e) ability to prevent and mitigate natural disasters
f) modern geodetic techniques
g) space geodesy
h) certain statistical periodicity
i) strain accumulation
j) dense geodetic deformation monitoring systems
k) to locate the site rapidly

Exercise 4. Answer the questions.

1. Is it still hard to predict massive earthquakes successfully?
2. What is the role of modern geodetic techniques in research on the monitoring and forecasting of earthquakes?
3. Does the seismic activity of a seismic zone have a certain statistical periodicity?
4. Can geodesy monitor the whole process of the preseismic, coseismic, and postseismic strain accumulation?
5. Is earthquake prediction extremely complex?
6. What other geological disasters can geodesy forecast and monitor?

UNIT 8

GEODETIC SYSTEMS

Exercise 1. Practise reading the following words.

a) [eɪ] – elevation, may, nation, major, survey, base
[aʊ] – hour, however, our, found, out
[ʃ] – condition, accomplish, expansion, establish, initial, official
[ɔ:] – for, order, launch, therefore, more

b) ellipsoid [ɪ'lɪpsɔɪd]	basis ['beɪsɪs]
numerical [njuː'merɪkl]	error ['erə]
geometric(al) [ˌʤɪə'metrɪk((ə)l)]	geocentric [ˌʤiːəu'sentrɪk]

Vocabulary

adjustment [ə'ʤʌstmənt] – наладка, настройка
axis, pl. axes ['æksɪs] – ось
coincident [kəu'ɪnsɪd(ə)nt] – совпадающий, соответствующий
concurrent [kən'kʌr(ə)nt] – совпадающий; согласованный
conterminous [kɔn'tɜːmɪnəs] – смежный, примыкающий
curvature ['kɜːvəʧə] – изгиб, искривление, кривизна
datum ['deɪtəm] – база, базовая точка
deflection [dɪ'flekʃ(ə)n] – отклонение
discrepancy [dɪs'krep(ə)nsɪ] – разница; различие, разногласие
extend [ɪk'stend] – простираться, тянуться, длиться
involve [ɪn'vɔlv] – привлекать, вовлекать, втягивать
leveling ['lev(ə)lɪŋ] нивелирование
overlap [ˌəuvə'læp] – частично покрывать; перекрывать
particular [pə'tɪkjələ] – особенный, специфический, особый
scope [skəup] – масштаб, предел, размах, сфера, область действия
stretch [streʧ] – пространство, участок, отрезок
survey ['sɜːveɪ] – землемерная, геодезическая, топографическая съемка местности

GEODETIC SYSTEMS

Datum is an abstract coordinate system that provides information. In geodesy two types of datums must be considered: a horizontal datum which forms the basis for the computations of horizontal control surveys in which the curvature of the earth is considered, and a vertical datum to which elevations are referred. In other words, the coordinates for points in specific geodetic surveys and triangulation networks are computed from certain initial quantities (datums).

Horizontal Geodetic Datums.

A horizontal geodetic datum may consist of the longitude and latitude of an initial point (origin); an azimuth of a line (direction) to some other triangulation station; the parameters (radius and flattening) of the ellipsoid selected for the computations; and the geoid separation at the origin. A change in any of these quantities affects every point on the datum.

In areas of overlapping geodetic triangulation networks, each computed on a different datum, the coordinates of the points given with respect to one datum will differ from those given with respect to the other. The differences occur because of the different ellipsoids used and the probability that the centers of each datum's ellipsoid is oriented differently with respect to the earth's center. In addition, deflection errors in azimuth cause a relative rotation between the systems. Finally, a difference in the scale of horizontal control may result in a stretch in the corresponding lines of the geodetic nets.

Datum Connection.

There are three general methods by which horizontal datums can be connected. The first method is restricted to surveys of a limited scope and consists of systematic elimination of discrepancies between adjoining or overlapping triangulation networks. The second one is the gravimetric method of Physical Geodesy and the third – the methods of Satellite Geodesy. These methods are used to relate large geodetic systems to each other and/or to a world system. Both the gravimetric and satellite methods produce necessary "connecting" parameters from reduction of their particular observational data.

Vertical Datums.

Just as horizontal surveys are referred to specific original conditions (datums), vertical surveys are also related to an initial quantity or datum. Elevations are referred to the geoid because the instruments used either for differential or trigonometric leveling are adjusted with the vertical axis coincident to the local vertical. As with horizontal datums, there are many discrepancies among vertical datums. There is never more than 2 meters variance between leveling nets based on different mean sea level datums; however, elevations in some areas are related to surfaces other than the geoid; and barometrically determined heights are usually relative. In the European area, there are fewer vertical datum problems than in Asia and Africa. Extensive leveling work has been done in Europe and practically all of it has been referred to the same mean sea level surface. However, in Asia and Africa the situation has been different. In places there is precise leveling information available based on mean sea level. In other areas the zero elevation is an assumed elevation which sometimes has no connection to any sea level surface. China has been an extreme example of this situation where nearly all of the provinces have had an independent zero reference. There is very little reliable, recent, vertical data available for much of the area of Africa and Asia including China.

The sea level surface in the United States was determined using 21 tidal stations in this country and five in Canada. This vertical datum has been extended over most of the continent by first-order differential leveling.

Concurrent with the new adjustment of the horizontal network, mentioned previously, is the readjustment of the vertical network. Countries of North and Central America are involved. In the conterminous United States 110,000 kilometers of the basic network are being releveled.

COMPREHENSION CHECK

Exercise 2. Match words similar in meaning.

1. kind	a. error
2. suppose	b. initial
3. primary	c. restrict
4. chose	d. deflection
5. deviation	e. type
6. adjust	f. determine
7. mistake	g. consider
8. limit	h. instrument
9. tool	i. orient
10. resolve	j. select

Exercise 3. **Match the words with their definitions.**

1. Horizontal	a) perpendicular to the horizon
2. Vertical	b) information
3. Discrepancy	c) level corresponding to the surface of the sea
4. Datum	d) inconsistency
5. Sea level	e) a process of adapting
6. Network	f) parallel to the ground
7. Adjustment	g) a group or system of interconnected objects.

Exercise 4. Mark the following sentences True or False.

1. A horizontal datum is a datum to which elevations are referred and vertical one is a datum in which the curvature of the earth is considered.

2. There are some quantities which may affect every point on the datum.

3. The survey of the limited scope, the gravimetric method of Physical Geodesy and the methods of Satellite Geodesy are methods of horizontal datum.

4. There are no differences among vertical datums.

5. There are more vertical datum problems in Europe than in Asia.

6. China is an example of zero elevation which has no connection to the sea level surface.

7. The mean sea level surface in Canada was determined by 31 tidal stations.

Exercise 5. Read the text and answer the following questions.

1. What is datum?
2. How many types of datums are there in geodesy?
3. What does a horizontal datum consist of?
4. Why do discrepancies between datums occur?
5. What are three methods of datum connection?
6. Why are elevations in vertical datums referred to the geoid?
7. What are discrepancies among vertical datums?
8. What are vertical datum problems in Europe and in Asia?

UNIT 9

GPS

Exercise 1. Read the words.

knew	knight
knock	knit
know	knowledge
knee	knock-off
kneecap	knife
kneel	knuckle
kneeling	knot

Read the words paying attention to the combination of letters <u>mn</u> and <u>mb</u>.

In the combination mn, "n" is silent.

In the combination mb, "b" is silent.

(**mn**)	(**mb**)	(**mb**)
autumn	bomb	lamb
column	climb	limb
solemn	comb	thumb
hymn	dumb	plumber

Text A

GLOBAL POSITIONING SYSTEM

A Global Positioning System, also known as GPS, is a system of satellites designed to help navigate on the Earth, in the air, and on water. Originally designed for military and intelligence applications at the height of the Cold War in the 1960s, with inspiration coming from the launch of the Soviet spacecraft Sputnik in 1957, the global positioning system (GPS) – is a network of satellites that orbit the earth at fixed points above the planet and beam down signals to anyone on earth with a GPS receiver. These signals carry a time code and geographical data point that allows the user to pinpoint their exact position, speed and time anywhere on the planet.

A GPS receiver shows where an object is. It may also show how fast it is moving, which direction it is going, how high it is, and maybe how fast it is going up or down. Many GPS receivers have information about places. GPSs for automobiles have travel data like road maps, hotels, restaurants, and service stations. GPSs for boats contain nautical charts of harbors, shallow water, rocks, and waterways. Other GPS receivers are made for air navigation, hiking and backpacking, bicycling, or many other activities. Most GPS receivers can record where they have been, and help plan a journey. While traveling a planned journey, it predicts the time to the next destination.

How it works.

A GPS unit takes radio signals from satellites in space in orbit around the Earth. There are 31 satellites 20,200 kilometres above the Earth. The orbital period is 11 hours and 58 minutes. Each circle is 26,600 kilometres radius due to the Earth's radius. Far from the North Pole and South Pole, a GPS unit can receive signals from 6 to 12 satellites at once. Each satellite contains an atomic clock which is carefully set by NORAD several times every day.

The radio signals contain information about the time and position of the satellite, including its ephemeris. The GPS receiver subtracts the current time from the time the signal was sent. The difference is how long ago the signal was sent. The time difference multiplied by the speed of light is the distance to the satellite. The GPS unit uses trigonometry to calculate where it is from each satellite's position and distance. Usually there must be at least four satellites to solve the geometric equations. A GPS receiver can calculate its position many times in one second.

Many inexpensive consumer receivers are accurate to 20 metres almost anywhere on the Earth. A GPS unit can usually also calculate its current speed. Cheap ones like in a mobile phone do this by comparing present position with recent position. Expensive ones like in an airliner use the Doppler effect and are very accurate.

Though availability of GPS was made public, high quality GPS signals were confined to military use until recently. However, on May 1, 2000, this practice was taken off. At present, the GPS for civilian purposes is more accurate.

GPS was first introduced in automobiles in 1996. With 31 active satellites in the orbit, GPS has become a part of every gadget we use, ranging from mobiles phones to cars. GPS has become very popular that GPS shoes are available in the market now, mainly aimed at locating people with Alzheimer’s disease, in case they get lost.

Today, GPS is used for dozens of navigation applications, route finding for drivers, map-making, earthquake research, climate studies, and an outdoor treasure-hunting game known as geocaching.

COMPREHENSION CHECK

Exercise 2. Match the words with their definitions.

1) technique	a) the number of times that something happens during a period of time; the rate at which a sound wave, light wave, or radio wave vibrates
2) satellite	b) to send out messages or programmes to be received by radios or televisions
3) frequency	c) a quantity, value, or fact used as a standard for measuring other quantities, values, or facts
4) instantly	d) a way of doing something by using special knowledge or skill
5) sophisticated	e) programs used by computers for doing

	particular jobs
6) simultaneous	f) the skill of choosing a path so that a ship, plane, or car can go in a particular direction, especially by using maps or instruments
7) baseline	g) an object that is sent into space to travel round the Earth in order to receive and send information
8) navigation	h) happening or done at the same time
9) to broadcast	i) complicated and advanced
10) software	j) happening or done quickly or suddenly

Exercise 3. Complete the sentences.

1. A GPS is a system of satellites designed to help …
2. The global positioning system – is a network of satellites that orbit the earth at fixed points above the planet and ...
3. These signals carry a time code and geographical data point that allows the user to pinpoint their exact position, speed and time anywhere on the planet.
4. GPS receivers are made for air navigation … many other activities.
5. A GPS unit takes radio signals from satellites in space in orbit ...

Exercise 4. Answer the questions.

1. What is GPS?
2. What was GPS originally designed for?
3. Do signals carry any geographical data that allows users to pinpoint their position anywhere on the planet?
4. What does a GPS receiver show?
5. What sort of travel data does GPS for automobiles and boats provide?
6. Can GPS receivers help plan a journey and predict the time to the next destination?
7. How does GPS work?
8. How many satellites are there above the Earth?
9. What is the minimal amount of satellites required for GPS data connection?
10. Has GPS become very popular?

Text B

PROBLEM: SURVEYING LAND AREAS FOR HIGHWAY INFRASTRUCTURES IS TIME AND LABOR INTENSIVE

There are considerable costs associated with conventional surveying technology. Methods are time-consuming and often require multiple trips to the same site to gather data and to ensure the collected data is accurate. In addition, workers must be trained to operate conventional surveying equipment properly. Weather also can delay data collection and highway surveys; crews are not always able to work under certain weather conditions, such as snow, rain, or extreme temperatures.

Solution: GPS Increases Survey Accuracy, Improves Productivity, and Reduces Costs. Over the past 5 years, studies across the United States have shown that GPS technology increases the productivity of conventional survey crews, reduces data collection time, improves survey accuracy, and allows crews to work under a broad range of weather conditions. Moreover, less expertise is required to operate a GPS surveying unit than is needed to operate conventional surveying technologies.

What is GPS?

GPS is a space-based, radio-navigation system that provides worldwide, all-weather, three-dimensional position, velocity, navigation, and time data to both civilian and military users. Potential uses for GPS within the highway community are diverse and range from providing traveler information to mapping (GPS technology can be integrated easily with Geographic Information Systems).

How does it work?

GPS can provide a very accurate digital map of the highway infrastructure. The technology operates on the principle of triangulation – if the difference from an observer to three known points can be measured, the position of the observer can be calculated. The system includes at least 24 satellites in orbit 19,320 kilometers above the earth. These satellites continuously broadcast their position, aiming signal, and other information. By combining the measurements from 4 different satellites, users with receivers can determine their 3-dimensional position, currently within 4–20 meters.

Putting it in Perspective.

It takes many days to survey small sections of road using traditional techniques. Complete road inventories may take years.

Successful Applications: Research Indicates Improved Survey Accuracy and Reduced Costs

It has been proved that one person operating GPS equipment is generally twice as fast as a conventional survey crew, and a GPS system with two units is potentially four times faster than crews using conventional surveying technologies. Other advantages of GPS technology include the ability to use the technology across long distances with minimal setups.

Benefits.

✓ Compared to conventional surveying technology, GPS: Is faster.
✓ Requires less labor.
✓ Requires less training.
✓ Is more accurate.

COMPREHENSION CHECK

Exercise 1. Complete the sentences with the information from the text.

1. GPS technology reduces data collection time, improves survey accuracy, and allows crews... 2. GPS is a space-based, radio-navigation system that provides… 3. … for GPS are diverse and range from providing traveler information to mapping. 4. … can provide a very accurate digital map. 5. The technology operates on the principle of … 6. The system includes at least … satellites. 7. By combining the measurements from 4 different satellites, users with receivers can … 8. One person operating GPS equipment is … 9. The advantages of GPS technology … 10. … GPS is faster, requires less labor and is more accurate.	a) worldwide, all-weather, three-dimensional position data b) potential uses c) GPS d) triangulation e) 24 f) to work under a broad range of weather conditions g) generally twice as fast as a conventional survey crew h) include the ability to use the technology across long distances with minimal setups i) compared to conventional surveying technology j) determine their position within 4–20 meters

Exercise 2. Answer the following questions and give examples.
1. Are conventional survey technologies time-consuming? Why?
2. Why can weather delay highway surveys?
3. What have the studies of GPS technologies shown?
4. How can you define GPS?
5. Who are the potential users for GPS within the highway community?
6. How does GPS function?
7. What advantages of GPS technologies can you mention?

UNIT 10

GEODESY AND SATELLITE NAVIGATION

Exercise 1. Practise reading the following words.
a) [eə] – there, where, careful, their, pair, bare
[ɒ] – electronic, concept, long, horizontal, adoption
[i] – limit, initial, signal, position, critical, continuous
[f] – enough, phase, octanographer, off, field, laugh

b) astronomer [ə'strɔnəmə], dynamics [daɪ'næmɪks], interferometry [ˌɪntəfəˈrɒmɪtri] methodology [ˌmeθə'dɔləʤɪ], reservoir ['rezəvwɑː], technical ['teknɪk(ə)l], technology [tek'nɔləʤɪ], tectonics [tek'tɔnɪks]

Vocabulary

advance [əd'vɑːns] – успех, прогресс, достижение
baseline ['beɪslaɪn] – стандарт, критерий, база
carrier ['kærɪə] – носитель, держатель, кронштейн
cumbersome ['kʌmbəsəm] – громоздкий, объемный
drawback ['drɔːbæk] – препятствие, недостаток
frequency ['friːkwənsɪ] – частота
ingenuity [ˌɪnʤɪ'njuːətɪ] – изобретательность, находчивость
instantaneous [ˌɪn(t)stən'teɪnɪəs] – мгновенный; немедленный
offshore [ˌɔf'ʃɔː] – находящийся на некотором расстоянии от берега, в открытом море
pipeline ['paɪplaɪn] – трубопровод, нефтепровод, канал
plate [pleɪt] – плита, лист, полоса
receiver, n. [rɪ'siːvə] – радиоприемник
scaling [skeɪlɪŋ] – масштабирование, шкалирование

strengthen ['streŋθ(ə)n] – усиливать, укреплять
substantial [səb'stænʃ(ə)l] – значительный, существенный
supplement ['sʌplɪment] – добавлять, дополнять, пополнять
suspension [sə'spenʃ(ə)n] – подвешивание, зависание
Terrestrial [tə'restrɪəl] – земной

GEODESY AND SATELLITE NAVIGATION

There has always been a love-hate relationship between geodesy and satellite navigation. Indeed, satellite positioning started life as an extension of terrestrial geodesy. When the first satellite, Sputnik 1, started orbiting the Earth in 1957, geodesists in several countries realised that satellites offered substantial potential as a geodetic positioning and navigation tool.

The basic technologies of terrestrial geodesy of the day, notably triangulation, traversing, and precise leveling, were slow and cumbersome, mainly because of the effect of the curvature of the surface of the Earth, which limited the range of measurements to theodolite observations between points situated on hilltops, observation towers, and triangulation masts. The advent of **EDM (electronic distance measurement)** helped terrestrial geodesy, but it, too, was affected by the same limitation, namely the shortness of observable EDM ranges due to the Earth's curvature.

Earth orbiting satellites did not suffer from this drawback. They could be viewed simultaneously from several points on Earth, and therefore direction and range measurements made, provided that the space vehicles were not obscured by high natural features or tall man-made structures. This led to several new satellite geodesy positioning methodologies.

The first of these was satellite triangulation, which was used initially to supplement and strengthen terrestrial triangulation networks. This situation changed significantly when geodesists realized that they could use the Doppler shift on the signal broadcast from a satellite to obtain differential range measurements that, together with the known Keplerian orbit of the satellite, could lead to a relatively fast positioning, or navigation, method.

This technical advance gave birth to Transit-Doppler, the first satellite navigation technology. Transit-Doppler was used not only for the positioning of ships and submarines surfacing in the polar regions, but also for the strengthening and scaling of national and continental terrestrial triangulation networks.

These were the early days of a new global satellite positioning, navigation, and timing system, first called the NAVSTAR Global Positioning System, a name later shortened to just GPS.

As always, human ingenuity did not disappoint, and two new differential techniques were developed. The first was the differential GPS (DGPS) technique, which improved relative positioning accuracies of GPS by at one order of magnitude, down to a few meters. As a result, DGPS soon became the standard methodology for the offshore positioning of oil platforms, pipelines, etc. The next advance in improving the accuracy of satellite positioning was made on the advice of radio-astronomers, who proposed replacing the standard GPS pseudo-range measurements, which are based on timing the modulated signal from satellite to receiver.

Instead, they suggested making measurements on the basic carrier frequencies of these signals, just as they did with extra-galactic signals arriving at, say, two widely spaced radio telescopes in so-called **very long baseline interferometry (VLBI)**, leading as a by-product to the Cartesian coordinate differences between the two telescopes. This was the beginning of centimetric positioning by the carrier phase GPS method, which was later developed further by geodesists into kinematic GPS and centimetric navigation.

GPS had now become the universal high precision quasi-instantaneous positioning and navigation tool, creating the basis for hundreds of new applications.

Again, geodesists led the way, concentrating on high precision scientific and engineering applications. These included surveying and mapping, positioning in offshore engineering, the monitoring of local crustal dynamics and plate tectonics, the relative vertical movements of tide gauges, and the continuous 3-D movements of critical engineering structures, such as tall buildings, dams, reservoirs, and long suspension bridges.

COMPREHENSION CHECK

Exercise 2. Mark the following sentences True or False.

1. Geodesy and satellite navigation has always got a good relationship.
2. The curvature of the surface of the Earth was the main obstacle to theodolite observations.
3. Transit-Doppler was the first satellite navigation technology.

4. Transit-Doppler technology was used to supplement and strengthen terrestrial triangulation networks.

5. VLBI technique is used for the offshore positioning of oil platform, pipelines, etc.

6. The monitoring of local crustal dynamics and plate tectonics was one of the applications based on GPS.

Exercise 3. Fill in the table with the derivatives if possible.

Noun	Verb	Adjective
1)	to transfer	
2) construction		
3)		
4)	to measure	
5) determination		
6) building		
7)	to analyze	
8) surveyor		
9)		relative
10)	to navigate	

Exercise 4. Match adjectives with suitable nouns.

1. substantial	a. leveling
2. precise	b. signal
3. terrestrial	c. engineering structures
4. global	d. potential
5. human	e. movement
6. modulated	f. geodesy
7. local	g. crustal dynamics
8. differential	h. satellite positioning
9. critical	i. range measurements
10.vertical	j. ingenuity

Exercise 5. Match words with their definitions.

receiver navigation network vehicle
broadcast tectonics magnitude

1 …. – a thing used for transporting people or goods, especially on land, such as a car, lorry, or cart;

2…. – a group or system of interconnected people or things;

3…. – transmit some information by radio or television;

4 …. – the process or activity of accurately ascertaining one's position and planning and following a route;

5. …. – the degree of brightness of a star, as represented by a number on a logarithmic scale;

6. …. – a piece of radio or television apparatus that detects broadcast signals and converts them into visible or audible;

7. …. – large-scale processes affecting the structure of the earth's crust.

Exercise 6. Answer the following questions.

1. What limited the range of measurements to theodolite observations?
2. What was the advantage of satellite observations?
3. What was satellite triangulation used for?
4. What technology was used for strengthening and scaling of national and continental terrestrial triangulation networks?
5. What was the basis of the 3D coordinate system of GPS?
6. What is the difference between DGPS and VLBI?
7. What applications did GPS serve for?

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