Question 1

a)

GNSS is a satellite that operates in a medium altitude circular orbit. This type of satellite is more moderate in altitude, operational period, signal coverage area and signal strength. Medium Earth Orbit (MEO): orbital radius 26,600 km, altitude 20,100 km, 11 hours 58 minutes period (1/2 sidereal day)

Such as GPS, using 6 planes at 55° inclination and 60° longitude interval orbits.

b)

The total number of satellites is estimated at 93 with the current situation.

GPS currently has 31 satellites, GLONASS has 24 satellites, Galileo currently has 26 satellites in orbit and Beidou has 12 satellites.

c)

The GNSS satellite transmission signal, consisting of (1) a carrier wave, a sine wave with frequency at the frequency point (2) a PRN code, a pseudo-random sequence of ranging codes by which different satellite signals can be distinguished. (3) The navigation message, which contains the ephemeris parameters used to calculate the position of the satellite, the satellite clock correction and other information.

d)

The user receives the signal from the GNSS satellite, processes it through the input and reference signals, adjusts the reference signal timing to find the maximum correlation value, and thus determines the transmitted signal.

The specific calculation is as follows.

图表, 雷达图

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The distance of the user from the satellite is: 手表的卡通人物

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Split up to get: 卡通人物

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And pseudo-range = range + receiver clock, so the function to calculate pseudo-range is: 黑色的钟表

低可信度描述已自动生成

Since the pseudo-range can be calculated from the time difference of the signal transmission: 图片包含 徽标

描述已自动生成, i.e. the pseudo-range is known. And the satellite position (green part) is known from the resolved signal, so by solving the pseudo-range equation for the 4 satellites (below) we can obtain the position of the user.

墙上的钟表

中度可信度描述已自动生成

The signals from 4 satellites are needed, because there are four unknown quantities, which are user's position Xa, Ya, Za and the clock error 黑色的钟表

低可信度描述已自动生成. This allows precise positioning of the user and eliminates the clock error of the satellites.

e)

As shown in the diagram below, the reflection of glass mirrors in tall buildings leads to non-linear signal propagation and multiple sources, i.e. it increases the error of Multipath & non-line-of-sight reception.

The signals arriving at the receiver via different paths interfere with each other or the direct signal is blocked and only the reflected signal is received. This leads to an increase in the time interpolation of the pseudo-range calculated by the user receiver resulting in inaccurate positioning.

图示

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f)

(1) Pseudo distance differential

As GNSS has errors in its own positioning, it can adjust its own positioning by using a reference station with known position.

As the ephemeris error and clock error have a strong receiver correlation and the ionospheric and tropospheric propagation error has a strong receiver correlation within 100km, the use of the differential method of the reference station can eliminate these errors and improve the accuracy.

The receiver on the known position reference station is given its distance to the visible satellite and this calculated distance is compared with the measured value containing the error. The range error for all satellites is then transmitted to the satellite to calibrate the position and then encoded to the user, who uses this range error to correct the measured pseudo-range. Finally, the user uses the corrected pseudo-range to solve for its own position, which eliminates the common error and improves positioning accuracy. The distance between the user and the reference station has a decisive influence on accuracy.

(2) Carrier phase differentiation

Good for reducing signal tracking and multipath errors

Due to the large code element width of the ranging code, the pseudo-range measurement accuracy is not high, so the carrier phase is introduced to improve the positioning accuracy.

The receiver and satellite phase deviation is obtained from the satellite input signal and the reference signal. Signal tracking and multipath errors can be reduced by differential phase measurement between satellite and receiver.

(3) Combining two differentials

Pseudo-range is not as accurate as carrier phase, but pseudo-range can achieve absolute positioning, while carrier phase has an unknown perimetric ambiguity and cannot achieve absolute positioning, if the two can be combined, the use of carrier phase smoothing pseudo-range can achieve very good positioning results.

Question 2

The formula and diagram for the Planck energy distribution function is as follows

It explains and predicts the shape of the blackbody curve and can be used to predict the energy between a given wavelength.

From the diagram we can see that the radiant energy of a blackbody decreases with increasing wavelength; it increases with increasing temperature. That is, the energy of a blackbody depends on both wavelength and temperature.

电脑屏幕的照片上有字

中度可信度描述已自动生成

图示

描述已自动生成

In addition from the Planck function we can introduce Boltzmann's law and Wein's law as follows

(1) Stefan-Boltzmann law

The total radiation of a blackbody is 图片包含 文本

描述已自动生成, depending on the temperature of the object.

(2) Wien's law

Referring to the formula and the illustration, it can be seen that the energy radiated by a black body depends on the wavelength and temperature. The wavelength of the maximum radiant energy increases with the radiant energy decreases.

文本, 信件

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图示

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The following is an explanation of the application of remote sensing to monitor chlorophyll content and thus infer water quality.

As the water bloom phenomenon in water bodies mainly originates from algae, which are rich in chlorophyll, by measuring the chlorophyll content in water bodies we can obtain the concentration of algae in water bodies and thus analyse the water quality and eutrophication situation.

The difference in chlorophyll a content corresponds to a significant difference in the reflectance of the water body in a certain wavelength range, which is the basic principle for the extraction of chlorophyll a remote sensing information from the water body, and the chlorophyll concentration in the water body can be obtained by analysing the reflectance spectral characteristics of water bodies with different chlorophyll concentrations. The spectral characteristics of a water body are determined by the nature of absorption and scattering of light radiation by various optically active substances in the water body.

As shown in the figure, the specific location and values of the spectral reflectance peaks in the water column vary depending on the chlorophyll a content. Chlorophyll a has absorption peaks in the blue-violet wavelength band (400-500nm) and near 675nm.[1] When the concentration of chlorophyll a in the water column is high, the spectral reflectance of the water column shows a valley at these two bands due to the strong absorption of chlorophyll a. At the 550-570 nm band, the water column reflectance spectrum exhibits a reflectance peak due to weak absorption and cellular scattering of chlorophyll and carotene, which is related to the pigment composition and can be used as a quantitative chlorophyll marker.[3,4] In the red band (680nm) chlorophyll a shows maximum absorption; in the near-infrared band (near 700nm), its spectral characteristics show a reflection peak due to the fluorescence effect of phytochromes, and with the increase of chlorophyll a concentration, the position of the reflection peak keeps moving towards the long-wave direction; this reflection peak is the most significant spectral characteristic of water bodies containing algae, and is usually the basis for judging water bodies containing algae, and its position and The position and value of the peak are an important indicator of chlorophyll concentration.

图表

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Relationship between chlorophyll wavelength and radiation[4]

[1] Kirk J T O. Light and photosynthesis in aquatic ecosystems [M]. Cambridge: Cambridge University Press, 1994.

[2] Gitelson A, Laorawat S, Keydan G P, et al. Optical properties of dense algae cultures outdoors and its application to remote estimation of biomass and pigment concentration in Spirulina platensis [J]. Jouranl of Phycology, 1995, 31(5): 828-834.

[3] Yacobi Y Z, Gitelson A, Mayo M. Remote sensing of chlorophyll in lake Kinneret using high spectral resolution radiometer and Landsat TM: Spectral features of reflectance and algorithm development [J]. Journal of Plankton Research, 1995, 17(11): 2155-2173.

[4] course of UCL, CEGE0094, Introduction to Remote Sensing part, the courseware of Prof. Mathias (Mat) Disney.

Due to time constraints, I apologise for the use of non-canonical references

Question 6

The distance calculation diagram and formula are as follows

矩形

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卡通人物

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Distance: D = 1/2×1x10-5×3x108 = 1.5x103 m

1. oscillating mirror

High density point acquisition at the turn is achieved by rotating the mirror, decelerating at the turn and then accelerating, creating a zigzag curve with varying densities.

1. rotating polygon

No mirror swing is required, point density capture is achieved by rotating the mirror to change the mirror surface, creating parallel straight lines of equal density. The distance between the left and right of the points cannot be changed, it is determined by the angle of the mirror.

1. fibre scanner

The pulses are concentrated into the fibres, which are lined up in a regular pattern of point spacing.

图片包含 游戏机, 钟表

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**Question 7**

1. Explanation of terms
2. geoid.

The surface of the earth's gravitational field that coincides with the surface of mean seawater at free standstill.

1. ellipsoid.

As different measurement systems use different datums, ellipsoid refers to the surface of the ellipsoid.

The difference between the reference ellipsoid and the geoid is shown in Figure 6-1, green is the geoid, red and blue are the different reference ellipsoids and their elevation differences are shown in Figure 6-2.

图表

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**Figure 6-1**

**图表, 折线图

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**Figure 6-2**

1. Ordnance Datum (e.g. ODN)

The local geoid, ODN, is the geoid used in the UK. The geoid varies from country to country due to the use of different reference stations measuring local mean sea level as the elevation datum in different regions and the gravitational influence of the mean sea level deflecting downwards. This is shown in Figure 6-3.

图表

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**Figure 6-3**

1. equipotential surface

A gravitational isosurface is a surface formed by linking the same points of gravity, which is perpendicular to the direction of gravity at all times, hence the term horizontal or level surface.

There are an infinite number of gravity levels, of which the one that coincides exactly with the surface of the resting ocean is called the geoid. The geoid is an irregular, closed surface formed by the surface of the still sea and extending towards the mainland. The geoid or geoid-like surface is the datum of elevation for obtaining geospatial information.

1. Mean sea level (MSL)

Mean sea level is the basis for establishing the geoid.

However, mean sea level must be tilted with respect to gravity (and therefore the geoid), as well as the effects of salinity variations (and therefore density), permanent pressure differences, temperature effects, etc. MSL and geoid do not coincide. Mean sea level tilts "downwards" in this direction relative to the geoid, as shown in Figure 6-4.

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**Figure 6-4**

1. Chart Datum

The chart datum is the depth datum that defines a depth of zero in a nautical chart, where the water level is so low that the water does not regularly drop below it. The lowest astronomical tide (LAT) is used in the UK as shown in Figure 6-5. It is commonly used for bathymetry and for preparing nautical charts.

图表, 折线图

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Chart Datum

**Figure 6-5**

(2) Conversions

This chapter focuses on the UK system as an example, as shown in Figure 6-6.

图表, 折线图

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**Figure 6-6**

Geoid and ellipsoid are calculated as h=H+N, by means of the elevation difference as in Figure 6-2.

ellipsoid and Ordnance Datum can be converted from recorded ellipsoid values and geoid values, for example converting ETRF89 (ellipsoid) to ODN (Ordnance Datum) can be done using OSGM02 or OSGM15 provided by OS.

Conversion of ellipsoid and Chart Datum, e.g. from ETRF89 (ellipsoid) to UK Chart Datum can be done using VORF provided by OS

Geoid and MSL can be converted by SST, which is the height of MSL above the geoid.

Ordnance Datum and geoid, Ordnance Datum is the local geoid and can be found through papers such as Intercontinental height datum connection with GOCE and GPS-levelling data. T. Gruber / C. Gerlach / R. Ha . Gerlach / R. Haagmans. Journal of Geodetic Science. Volume 2, Issue 4, Pages 270-280, ISSN (Print) 2081-9943, DOI: 10.2478/v10156-012- 0001-y, January 2013.