ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2024
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR SURVEY ENGINEERING

Date : October 5, 2024
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions
     All questions under SECTION A are **COMPULSORY.**
4. **SECTION B** consists of **THREE** Case Studies. Attempt any **TWO** case study
5. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
6. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
7. Begin each Section and Part on a fresh page of the Answer Booklet.
8. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
9. Use of any other paper including paper for rough work is not permitted.
10. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
11. This paper has **9 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. The latest national vertical geodetic datum realized through ground gravimetric observation of Bhutan is defined as …..
   a) DrukGeoid2000
   b) DrukGeoid2010
   c) DrukGeoid2015
   d) DrukGeoid2020

2. One degree of latitude is approximately ….. kilometers.
   a) 111
   b) 222
   c) 333
   d) 444

3. The distance value of one degree of longitude varies depending on the latitude. The distance decreases as you move towards the poles, following the…….
   a) Cosine of the latitude
   b) Cosine of the longitude
   c) Sine of the latitude
   d) Sine of the longitude

4. Which of the following is a common error source that RTK surveying must correct for?
   a) Ephemeris errors
   b) Clock drift
   c) Multi-path effects
   d) All of above

5. In RTK surveying, what is the significance of ambiguity resolution?
   a) It determines the base station location.
   b) It calculates the initial position of the rover.
   c) It resolves the integer number of wavelengths between the satellite and receiver.
   d) It corrects for clock errors in the GPS system.

6. Why is a dual-frequency receiver preferred over a single-frequency receiver in RTK surveying?
   a) It is less expensive.
   b) It can mitigate ionospheric errors more effectively.
   c) It requires fewer satellites for a fix.
   d) It provides faster processing speeds

7. In which portion of the electromagnetic spectrum do GPS signals operate?
   a) Infrared
   b) Visible light
   c) Microwave
   d) Ultraviolet

8. Which statement is true regarding the L5 GPS frequency (1176.45 MHz)?
   a) It has been in use since the inception of GPS.
   b) It is primarily used for nuclear detonation detection.
   c) It was introduced as part of the GPS modernization effort for high-precision and safety-of-life applications.
   d) It is the primary frequency used by civilian GPS devices.

9. What is the primary difference between GPS and GNSS?
   a) GPS is a global system, while GNSS is a regional system.
   b) GNSS includes multiple satellite systems, while GPS is one specific system.
   c) GPS is used for navigation, while GNSS is used for surveying.
   d) GNSS is more accurate than GPS.

10. What does the term "multipath" refer to in GPS surveying?
    a) Using multiple satellites for positioning
    b) Errors caused by GPS signals reflecting off surfaces before reaching the receiver
    c) Using multiple receivers to improve accuracy
    d) Interference from multiple GPS signals

11. Datum transformation require transformation parameters that define the mathematical relationship between the old and new datums. What are the transformation parameters?
    a) Translations
    b) Rotations
    c) Scale factor
    d) All above

12. What is the value of latitude of origin for the National Grid projection of Bhutan 'DrukRef 03'?
    a) 0^0
    b) 90^0
    c) 180^0
    d) 360^0

13. For a map of 1:5000, what is the plottable error of the map?
    a) 1.25 m
    b) 2 m
    c) 3.5 m
    d) 4 m

14. The total station machine has the horizontal accuracy specification as 2 mm + 2 ppm. What would be the maximum potential error when the horizontal distance measured is 5 km?
    a) ±10 mm
    b) ±11 mm
    c) ±12 mm
    d) ±13 mm

15. The precision total station machine has the horizontal accuracy specification as 1 mm + 1 ppm. What is distance dependent error when horizontal distance measured is 5 km?
    e) ±1 mm
    f) ±1.5 mm
    g) ±3 mm
    h) ±5 mm

16. In surveying, which method involves determining the location of a point by measuring distances from known points rather than angles?
    a) Trilateration
    b) Triangulation
    c) Rectification
    d) Refracting

17. In GPS, which Dilution of Precision (DOP) represents the geometric quality of the satellite constellation specifically in determining the horizontal position (latitude and longitude)?
    a) PDOP
    b) HDOP
    c) VDOP
    d) TDOP

18. What is the key difference between triangulation and trilateration in surveying?
    a) Triangulation uses distance measurements from known points, while trilateration uses angle measurements.
    b) Triangulation uses angle measurements from known points, while trilateration uses distance measurements.
    c) Triangulation forms circles from known points, while trilateration forms triangles.
    d) Triangulation is used only in 2D surveying, while trilateration is used only in 3D surveying.

19. What is the main cause of systematic errors in surveying?
    a) Random fluctuations in measurements
    b) Instrumental imperfections or environmental factors
    c) Human mistakes during data recording
    d) Variations in the gravitational field

20. Which method is commonly used to minimize random errors in surveying?
    a) Using more advanced equipment
    b) Repeating measurements multiple times
    c) Calibrating instruments before each use
    d) Adjusting data based on known error patterns

21. What is the purpose of a "closing error" adjustment in a traverse?
    a) To calibrate the surveying instruments
    b) To compensate for angular errors only
    c) To ensure the sum of angles in a polygon equals the theoretical value
    d) To determine the accurate lengths of traverse lines

22. What is the process of aligning geographic data to a known coordinate system called?
    a) Spatial analysis
    b) Geocoding
    c) Georeferencing
    d) Remote Sensing

23. What does high precision in measurements indicate?
    a) Measurements are spread out over a large range
    b) Measurements are consistently close to each other
    c) Measurements are always accurate
    d) Measurements are taken quickly

24. What is the main function of a theodolite?
    a) Measuring vertical distances
    b) Measuring horizontal and vertical angles
    c) Measuring atmospheric pressure
    d) Measuring time intervals

25. How does NTRIP enhance GNSS-RTK performance?
    a) By reducing the need for a base station
    b) By providing real-time correction data via the internet, extending the range beyond traditional radio communication
    c) By eliminating the need for satellite signals
    d) By increasing the battery life of GNSS receivers

26. Which frequency band is commonly used for radio communication in GNSS-RTK?
    a) VHF (Very High Frequency)
    b) UHF (Ultra High Frequency)
    c) SHF (Super High Frequency)
    d) EHF (Extremely High Frequency)

27. What is the primary principle behind Electronic Distance Measurement (EDM) in total stations?
    a) Measurement of angles using optical instruments
    b) Calculation of distances based on the travel time of electromagnetic waves
    c) Determination of positions using satellite signals
    d) Measurement of elevations using laser beams

28. What is a common source of error in EDM measurements?
    a) Magnetic declination
    b) Atmospheric conditions affecting wave propagation
    c) Inaccurate angle measurement
    d) Incorrect calibration of the optical scope

29. How does EDM in a total station typically deal with the curvature of the Earth?
    a) By using high-frequency waves that are unaffected by curvature
    b) By applying a curvature correction factor to the measured distance
    c) By measuring only very short distances
    d) By aligning the total station with the Earth's magnetic field

30. The unique identifier or primary key that is used to link cadastral data to Thram data is
    a) Plot ID
    b) Thram number
    c) Plot area
    d) CID

PART II – Short Answer Questions [20 marks]

This part has 6 Short Answer Questions. Choose any FOUR questions. Each question carries 5 marks.

1. Describe the relationship between satellite image resolution and the scale of mapping. How would you choose the appropriate resolution for a mapping project focused on urban planning at a scale of 1:10,000? Provide a detailed explanation and justify your choice with examples. **(5 marks)**

2. During a detailed topographic survey with a drone, you need to determine the appropriate flying height for capturing images with a resolution of 10 cm per pixel. The camera on the drone has a pixel size of 5.6 micrometers (0.0056 cm) and a focal length of 18 mm (1.8 cm). Explain the steps to calculate the required flying height and find the height. **(5 marks)**

3. In a GNSS-based survey, you are required to determine the precise coordinates of a point using Differential GPS (DGPS) methods. Describe the process of Differential GPS and its advantages over standard GPS. Additionally, suppose the base station coordinates are known as (X: 500,000 m, Y: 300,000 m, Z: 200,000 m). The rover receives the following correction values from the base station: (ΔX: -2.5 m, ΔY: 3.0 m, ΔZ: -1.5 m). Calculate the corrected coordinates for the rover. **(5 marks)**

4. You are conducting a topographic survey using a Total Station. Describe the process of measuring distances and angles using a Total Station and explain how to correct the measured horizontal distance to account for slope distance. Given the measured slope distance is 500 meters, the vertical angle is 5 degrees, and the instrument and target heights are equal, calculate the corrected horizontal distance. **(5 marks)**

5. You are tasked with determining the elevation of a new point using the differential leveling. Explain what differential leveling is and its advantages over conventional leveling. Describe the process of differential leveling and explain how to apply corrections for instrument and target heights. Given the following data:
    - Back sight (BS) on a benchmark (BM) with known elevation of 100 meters: 2.50 meters
    - Fore sight (FS) on the new point: 1.75 meters

    Calculate the elevation of the new point. **(5 marks)**

6. In geodetic surveying, you are required to determine the true ground distance between two points using the scale factor and grid distance. Explain what a scale factor is and its significance in surveying. Describe the process of converting a grid distance to a ground distance and explain the concept of geoid separation. Given the following data:
    - Grid distance between two points: 1200 meters
    - Scale factor: 0.9996
    - Geoid separation: -25 meters

    Calculate the true ground distance between the two points and the elevation difference due to geoid separation. **(5 marks)**

SECTION B: Case Study [50 marks]

This section consists of THREE Case study. <u>ATTEMPT ANY TWO CASES</u>. Each case study carries 25 marks.

1. You are entrusted to play a lead role for surveying and mapping in Topographical Division of NLCS. The government has an urgent requirement to obtain comprehensive geospatial data and information necessary for the development of the Gelephu Mindfulness City (GMC), which spans 2000 square kilometers, which would be a unique city in the world. The following details encompass the required information and key deliverables:
    - Detailed topographic data and information at a scale of 1:1000.
    - Land use and land cover detial
    - Vertical and horizontal accuracy of 0.5 meters.
    - Contour interval of 1 meter.
    - The designated Area of Interest (AOI) includes urban areas, agricultural land, dense vegetation and hilly terrain.
    - The project must be completed within a two-month timeline.

Your task is to formulate a comprehensive project proposal that addresses these stipulated tasks, shedding light on your chosen methodology, technical approach, and strategic considerations, required resource inputs and project deliverables. The proposal should aptly demonstrate your proficiency in survey engineering, adeptness in project management, and adept problem-solving abilities. **(25 marks)**

2. Imagine you are leading a geodetic team tasked with establishing a high-precision geodetic network for new urban center that will undergo rapid development. The city requires a geodetic network to

support various infrastructure projects, including new transportation routes, utility installations, and high-rise buildings. The project requirements are:

- A geodetic control network with a horizontal accuracy of ±2 cm and vertical accuracy of ±1 cm.
- The network must cover an area of 20 square kilometers.
- Integration with existing national geodetic frameworks.
- The project must be completed within 10 months.

Formulate a comprehensive project proposal for establishing the high-precision geodetic network. Your proposal should include:

- Surveying methods, techniques and instruments to achieve the required accuracy.
- Methods for integrating the new geodetic network with existing national frameworks.
- Project timeline and management plan.
- Potential challenges and mitigation strategies.

The proposal should aptly demonstrate your surveying proficiency, adeptness in project management, and adept problem-solving abilities. **(25 marks)**

3. Accurate and updated road network data is essential for applications such as transportation planning, disaster management, and suitability analysis. Bhutan currently lacks precise and up-to-date spatial road data. As a surveying professional, you are tasked with formulating a project proposal to map roads across the entire country. The project details are as follows:
    - Area of Interest: Whole country
    - Estimated Length of the Road: 12,000 km
    - Different Road Categories: Based on material, use, and location
    - Given Timeline: 6 months
    - Required Accuracy: 10 cm horizontal and 1 m vertical

    Your proposal should clearly include:

    - Data Acquisition and Processing: Outline the appropriate and efficient methods and techniques for acquiring and processing road data
    - Quality Control and Checks: Describe the mechanisms for ensuring data accuracy and reliability through quality control procedures.

- Geodatabase Development: Explain how you will build a reliable geodatabase to store and manage the road network data.
- Utilization of Existing Data: Develop a strategy for effectively integrating and using existing road data to enhance the project.
- Sustainability Plan: Provide a framework for the long-term maintenance and updating of the road network data.

Based on these requirements, provide a comprehensive project proposal demonstrating your surveying proficiency for the successful execution of the National Road Infrastructure Mapping Project. **(25 Marks)**

TASHI DELEK