Chapter 12: Mining Surveying
Sample Quiz

Multiple Choice Questions
Circle the most appropriate answers to the following questions.

1. In the transfer of orientation underground via an inclined shaft, which of the following methods will most likely provide the best result?
   a. optical method
   b. mechanical method
   c. combined optical and gyroscopic methods
   d. precise traverse method

2. Which of the following is true regarding orientation transfer with gyrotheodolites?
   a. gyrotheodolite is used to transfer coordinates down the shaft
   b. gyro azimuth and coordinates are simultaneously transferred by this method
   c. gyro azimuth and coordinates are independently transferred by different methods
   d. gyro method produces the same accuracy of orientation as in the case of mechanical method

3. Which of the following is false with regard to gyro equipment?
   a. gyrotheodolite is a combination of gyro unit and a theodolite
   b. gyrostation is a combination of gyro unit and a total station
   c. gyromat 3000 is capable of determining the direction of North to accuracy of ±3"
   d. gyromat 3000 is a manual type of precision gyrotheodolite

4. Which of the following is false with regard to gyro equipment?
   a. the spin axis of the gyro is always pointing in the direction of the North
   b. it consists of gyro motor that hangs on a thin tape
   c. its gyro motor oscillates as a result of the earth’s rotation
   d. the rotating axis of the gyro oscillates due to the effect of earth’s gravity

5. Which of the following gyro methods is significantly different from the rest?
   a. Reversal Point Method
   b. Turning Point Method
   c. Follow-up Method
   d. Transit Method

6. Which of the following gyro methods will require fixing the direction of gyrostation telescope during measurement process?
   a. Turning Point Method
   b. Transit Method
   c. Reversal Point Method
   d. Quarter Time Method
7. Which of the following indicates when the spin axis of the gyro and the optical axis of theodolite telescope are most likely parallel?
   a. when the gyro mark is at the turning point
   b. when the gyro mark is at the center of the gyro graduation scale
   c. when the gyro mark is at any point of the gyro graduation scale
   d. when the gyro mark is in the direction of the North

8. Which of the following gyro methods provides the most accurate orientation result?
   a. Two Turning Point Method
   b. Two Reversal Point Method
   c. Quarter Time Method
   d. Multiple Transit Method

9. Which of the following most accurately represents what happens if the gyrotheodolite is pre-oriented in the direction that is more than 30° away from the North direction?
   a. gyro mark accelerates towards the line joining the setup point and the North
   b. gyro mark slows down
   c. gyro mark accelerates away from the line joining the setup point and the North
   d. precise method of gyro orientation is done immediately

10. Which of the following most accurately describes the swing time in gyro orientation process?
    a. time taken by gyro mark to oscillate from one turning point to another
    b. time taken by gyro mark to oscillate from a turning point to the line joining the setup point to the North point
    c. time taken by gyro mark to oscillate from a turning point to the zero graduation point of the gyro scale
    d. time taken by gyro mark to oscillate to and from the zero graduation point of the gyro scale

11. Which of the following gyro orientation methods gives the least accurate result?
    a. Multiple Reversal Point Method
    b. Multiple Transit Point Method
    c. Quarter Time Method
    d. Two Turning Point Method

12. Which of the following is false with regard to when to use Multiple Transit Method?
    a. use when precise North direction must be determined
    b. use when the direction of gyrotheodolite telescope has been pre-oriented to less than 2° of the North direction
    c. use when a quick method of the gyro orientation has been successfully done
    d. use when the direction of gyrotheodolite telescope has been pre-oriented to around 30° of the North direction
13. In which of the following gyro orientation methods is Schuler’s mean most likely determined?
   a. Quarter Time Method
   b. Two Reversal Point Method
   c. Multiple Turning Point Method
   d. Multiple Transit Method

14. Which of the following gyro constant is not dependent on the latitude of gyro observation?
   a. gyro instrumental constant
   b. gyro calibration correction
   c. gyro’s proportionality factor
   d. gyro torque ratio constant

15. In which of the following gyro-observation methods is the torque’s ratio constant required?
   a. Two reversal points
   b. Turning point method
   c. Quarter time method
   d. Transit method

16. Given the mean horizontal reading to RO as HCR, gyro north measurement as N', gyro-
    theodolite calibration correction as A and the convergence of meridian as γ, which of the
    following expressions is true for the uncorrected gyro azimuth of RO?
   a. N'
   b. HCR - N'
   c. HCR – N’ - A
   d. HCR – N’ - A - γ

17. Given the mean horizontal reading to RO as HCR, gyro north measurement as N', gyro-
    theodolite calibration correction as A and the convergence of meridian as γ, which of the
    following expressions is true for the grid azimuth of RO?
   a. N'
   b. HCR - N'
   c. HCR – N’ - A
   d. HCR – N’ - A - γ

18. Given the mean horizontal reading to RO as HCR, gyro north measurement as N', gyro-
    theodolite calibration correction as A and the convergence of meridian as γ, which of the
    following expressions is true for the true azimuth of RO?
   a. N'
   b. HCR - N'
   c. HCR – N’ - A
   d. HCR – N’ - A - γ
19. Which of the following mining orientation techniques will not be considered as mechanical?
   a. Coplanning  
   b. Weisbach triangulation  
   c. Weiss quadrilateral  
   d. Gyro-theodolite traversing

20. Which of the following does not form part of the skills expected of a mine surveyor?
   a. geodetic and topographic surveying skills  
   b. geological exploration skill  
   c. cadastral skill  
   d. cartographic and GIS skills

21. Which of the following activities is not engaged in by the mine surveyors?
   a. investigation and negotiation of mineral mining rights  
   b. prediction of the effects of mine working on the surface  
   c. documentation of information about mining activities  
   d. determination of qualities of mineral deposits

22. Which of the following represents a drift in mining terminology?
   a. a horizontal underground passage that ends at the vein  
   b. a nearly horizontal passage from the surface by which a mine is entered, having no opening at the other end  
   c. a horizontal underground passage that is open to the surface at both ends  
   d. a horizontal underground passage through the vein or ore body

23. Which of the following represents a crosscut in mining terminology?
   a. a horizontal underground passage that ends at the vein  
   b. a nearly horizontal passage from the surface by which a mine is entered, having no opening at the other end  
   c. a horizontal underground passage that is open to the surface at both ends  
   d. a horizontal underground passage through the vein or ore body

24. Which of the following represents an adit in mining terminology?
   a. a horizontal underground passage that ends at the vein  
   b. a nearly horizontal passage from the surface by which a mine is entered, having no opening at the other end  
   c. a horizontal underground passage that is open to the surface at both ends  
   d. a horizontal underground passage through the vein or ore body
25. Which of the following represents a vertical opening or hole from the surface to an underground mine?
   a. Raise
   b. Winze
   c. Vein
   d. Shaft

26. Which of the following represents the part of the underground mine where water is usually collected?
   a. Stope
   b. Sump
   c. Winze
   d. Drift

27. Which of the following is not a common type of mine?
   a. Underground mine
   b. Open-pit mine
   c. Strip mine
   d. oil and gas mine

28. Which of the following is not one of the work elements that differentiate mining surveying from “normal” surveying on land?
   a. dangers to life may be due to rock movements
   b. control transfer underground is more difficult
   c. centering of survey instruments underground may be more difficult
   d. short traverses involved provides an advantage with regard to error propagation

29. Which of the following is false concerning direct traversing technique in underground mines?
   a. it should be done through an adit
   b. if steep sights are involved, the number of traverse points will increase
   c. if steep sights are involved, centering error will not be reduced by forced-centering
   d. if steep sights are involved, centering and levelling errors will become more serious

30. Which of the following is false with regard to shaft plumbing?
   a. rock masses cannot cause vertical wire to change its position in shaft plumbing
   b. piano wire is to define a vertical reference line in shaft plumbing
   c. diameters of shafts are usually from 4 m to 8 m
   d. the deeper the shaft, the more difficult it is to make accurate pointing on the vertical wire in the shaft
31. Which of the following is false with regard to a weight hanged on a wire in shaft plumbing?
   a. the heavier the weight is the thicker the wire
   b. the weight should be immersed in liquid in order to reduce excessive swinging of the wire
   c. when the weight on the hanging wire is immersed in water, the swinging of the wire immediately stops
   d. the deeper the shaft, the heavier the weight used on the shaft wire

32. Which of the following is not likely to be true about the process of orienting underground survey?
   a. it gives horizontal position of at least a point underground in the surface system
   b. it gives the elevation of at least a point underground in the surface system
   c. it gives the azimuth of at least a line underground
   d. it gives the positions of the underground points relative to one another

33. Which of the following is false about mine orientation survey?
   a. it provides coordinates of at least one point of the underground network, putting the underground network in the same system as the surface network
   b. it provides the bearing of one line in the underground network
   c. it is also known as correlation
   d. it is always carried out through the mine adit

34. Which of the following mining orientation techniques is most likely done through the mine adit?
   a. Mechanical plumbing
   b. Direct traversing
   c. Gyro-theodolite traversing
   d. Optical transfer

35. Which of the following is false about mechanical technique of mining orientation?
   a. weight of plumb bob used must be less than 50% of the breaking strength of the plumb line
   b. thicker wire is used in deeper shafts
   c. constant movement of plumb wires is the most dangerous cause of errors
   d. pointing errors on thicker wires are usually less than those on thin wires

36. Which of the following is false about the method of orientation transfer with two wires in a single shaft?
   a. the method is simpler than other methods
   b. deflection of the wires relative to each other may cause large orientation error
   c. installing the plumb lines in the shaft is easily done without much experience
   d. data collection by the method can be automated
37. In which of the following mining orientation techniques is the theodolite setup point expected to be exactly aligned with the plane containing two plumb-lines?
   a. Weisbach triangulation method
   b. Co-planning method
   c. Quadrilateral method
   d. Hause method

38. Which of the following is true about underground mining surveying?
   a. azimuth determination by astronomic method is possible
   b. control points are commonly located on the floor
   c. centering errors are usually of the same magnitude as those relating to surface surveys
   d. targets are usually poorly lighted

39. Which of the following is false about direct traversing technique of mine orientation?
   a. x, y z coordinates are usually determined
   b. steep sights may be involved
   c. increased number of setup points is possible
   d. it is commonly run through shafts of any type

40. Which of the following is false with regard to co-planning method of mine orientation?
   a. azimuth determined on the ground surface is transferred directly underground
   b. two wires in a single vertical shaft are used
   c. surface and underground alignment operations must be done at the same time
   d. the method is not affected by the swinging of wires used

**Discussion and Calculation Questions**

Answer the following.

1. Explain in your own words how you will precisely transfer elevation down an 80m-deep shaft to underground mine using total station, zenith plummet, Taylor Hobson sphere, level equipment, etc. Give your explanation in step-by-step point form that is logical.

2. The transfer of elevation from the surface benchmarks via a single shaft to underground stations can be done using total station equipment or steel tape.
   i) Briefly explain three important limitations of using tape and three important limitations of using total station.
   ii) Explain 5 important corrections that must be applied to steel tape measurements in the elevation transfer.
   iii) Explain with reasons the important corrections that are applied to tape in elevation transfer that are normally not applied when tape is used to determine horizontal distances.
3. The transfer of orientation (i.e., azimuth, from the surface to a level underground) (e.g., to a
tunnel or an adit) can be done down a single shaft using a pair of plumblines, P₁ and P₂. Two
ways in which this can be done are the Weisbach or pair of adjacent triangles method and the
Hause or quadrilateral method. The surface connections to P₁ and P₂ are the same but the
underground connections differ between the two methods. Compare the two methods with
respect to their advantages and limitations.

4. The center line of a tunnel AB shown in the figure below is to be set out to a given bearing.
A short section of the main tunnel has been constructed along the approximate line and
access is gained to it by means of adit connected to a shaft. Two wires P₁ and P₂ are
plumbed down the shaft and readings are taken on to them by a theodolite set up at station E
slightly off the line P₁-P₂ produced. A point F is located in the tunnel and sighting is taken
on to this from station E. Finally a further point G is located in the tunnel and the angle EFG
measured. From the surface survey initially carried out, the coordinates of P₁ (N 1119.32 m,
E 375.78 m) and P₂ (N 1115.70 m, E 375.37 m) have been determined.

The measured horizontal distances are given as P₁-P₂ = 3.64 m, P₂-E = 4.46 m, E-P₁ = 8.09
m, EF = 13.12 m, and FG = 57.50 m, and the measured horizontal angles as \( \alpha = 9'' \), \( \delta =
167°10'49'' \), \( \theta = 87°23'41'' \). Answer the following:

a. Calculate the coordinates of stations E and F (using sine law involving angle \( \beta \)).
b. Given the standard deviation of distance P₁-P₂ as 10 mm, that of E-P₁ as 15 mm and the
standard deviations of angle \( \alpha \) as 3'' respectively, determine the standard deviation of
angle \( \beta \) using sine law and Equation (12.9) of your Lecture Notes.
c. If the errors due to the distance measurements are only considered in Question (b), what
is their combined contribution to the standard deviation of angle \( \beta \) (i.e. assuming \( \sigma_\alpha = 0 \))?
5. Referring to Figure 1 in Question 1 above and assuming the same measurements except that now \( P2-E = 4.70 \, \text{m} \), \( \alpha = 12^\circ 06'48" \) and \( \delta = 155^\circ 10'49" \). The angle \( \beta = 152^\circ 12'00" \) (calculated using sine law). Answer the following:
   a. Calculate the standard deviation of the calculated \( \beta \), assuming the standard deviation of distance \( P1-P2 \) is 10 mm, that of \( E-P1 \) is 15 mm and the standard deviation of angle \( \alpha \) is 3" respectively. [You must use the error propagation Equation (12.9) from the reference book.]
   b. If the errors due to the distance measurements are only considered in Question (a), what is their combined contribution to the standard deviation of angle \( \beta \) (i.e. assuming \( \sigma_\alpha = 0 \))?
   c. Compare the results in Questions 1 and 2 and comment on the statements that “Weisbach method should not be applied if \( \alpha \) is greater than 10"” and “\( \alpha \) must be measured with high precision in order to use Weisbach method”.

6. A local plane coordinate system was established at the collar of a shaft at latitude of 59°30'N. At a depth of 2km, an adit runs approximately in a westerly direction from the shaft. A flat traverse follows the adit with stations along one side. Gyro-azimuths, following the transit (time) method, have been observed with a well-calibrated SOKKIA GP3X gyrostation at regular intervals in order to “control” the orientation of the adit. The transit method results in angle, \( A_g \), describing the direction of the gyro zero with respect to North. The equipment and procedures suggest that \( \sigma_{A_g} = \pm \, 20" \) and the average deflection of the vertical along the adit is -5". Answer the following using the above information:
   a. Apart from the internal corrections that are automatically done by the gyrostation to the gyro measurements, explain 3 other important systematic corrections, with suggestions of their numerical values, that should be applied to an \( A_g \), observed at 4 km (westerly) from the shaft in order to convert it to a grid azimuth in the surface coordinate system. If you are not able to calculate a value for a correction, explain what other information (with formulas) would be needed to do so and how it would be obtained.
   b. Explain how you would apply the 5 corrections (2 internal corrections and your 3 corrections) in question (a) above in order to determine the grid bearing of a reference object (RO) from the setup point if the mean horizontal direction reading to RO is \( H \), and provide a typical expression relating the grid azimuth to all the necessary correction(s) to be applied (paying particular attention to signs and symbols already given above and clearly showing the necessary corrections in the expression). If any of the corrections cannot be included in the expression, explain how it can be corrected for. You must define every symbol in your expression in order to earn full marks.
   c. The SOKKIA GP3X gyrostation is integrated with SET3X total station that has angular accuracy of 3” according to ISO 17123-3 Standards. What procedures (stating types of errors minimized) would you recommend to achieve a standard deviation of azimuth of RO close to \( \pm \, 20" \) in a setup?