CBEPS
CCEAG

The Canadian Board of Examiners for Professional Surveyors

Learning Outcomes

January 2007

Note: this booklet is current as of January 2007 but some sections are currently under review and may be revised. Users should periodically check the CBEPS website for updates.

CBEPS Exam Syllabus

SCHEDULE I

Item 1: Mathematics

- *Learning Outcomes*
- *Study Guide & Sample Questions*

Item 2: Least-Squares Estimation & Data Analysis

- *Learning Outcomes*
- *Study Guide & Sample Questions*

Item 3: Advanced Surveying (including Survey Astronomy)

- *Learning Outcomes*
- *Study Guide & Sample Questions*
- *Answers to Questions from Previous I-3 Examinations*

Item 4: Remote Sensing and Applied Photogrammetry

- *Learning Outcomes*

Item 5: Spatial Database Management Systems (Informatics)

Item 6: Map Projections and Cartography

Item 7: Cadastral Studies

- *Learning Outcomes*
- *Study Guide*

SCHEDULE II

Item 1: Geodetic Positioning

- *Learning Outcomes*

Item 2: Hydrographic Surveying and Oceanography

Item 3: Survey Law

- *Learning Outcomes*

Item 4: Land Use Planning and Environmental Management

- *Learning Outcomes*

Item 5: Land Information Systems and Management

- *Learning Outcomes*
- *Study Guide & Sample Questions*
- *Notes on Your Examination-Taking*

Item 6: Business: Law, Administration and Economics

- *Learning Outcomes*
- *Study Guide*

-- SCHEDULE I --

Schedule I - Item 1

Mathematics

Functions, continuity and limits, Differentiation and applications, Integration and applications, Numerical integration, Plane curves, tangency and curvature, Sequences and series, Series expansions, Partial differentiation, Multiple integrals and numerical approximations, Vector operations and analytical geometry, First and second order linear differential equations and solutions, Introduction to matrix algebra, linear equations and transformations, vector spaces and geometry, quadratic forms, rotation matrices.

Textbooks:

a. **Advanced Engineering Mathematics,** 8th Edition, Kreyszig, E. (1992) John Wiley & Sons, Toronto ISBN 0-471-55380-8

b. **Calculus with Analytic Geometry,** 5th Edition, Edwards, C.H. and Penney, D.E. (1998) Prentice Hall Inc. ISBN 0-13-736331-1

References:

a. **Single-Variable Calculus,** Stewart J., 4th Edition (1999), Brooks/Cole Publishing Co., Pacific Grove, CA ISBN 0-534-35562-5

b. **Calculus of a Single Variable, Early Transcendental Functions**, Larson R., Hostetler R. P., Edwards B.H., and Heyd, D. E., 2nd Edition, 1999, Houghton Mifflin Co. Boston
ISBN 0-395-93321-8

c. **Introduction to Applied Mathematics,** Strang, G. (1986) Wellesley-Cambridge Press
ISBN 0-961-40880-4

Note: programmable calculators may be used in this examination.

LEARNING OUTCOMES FOR SCHEDULE I – ITEM 1

Recommended Pre-examination Studies:

First-year University Mathematics
Calculus and Analytic Geometry
Linear and Matrix Algebra
Numerical Computations

Learning Outcomes:

1. Functions, continuity and limits.
   - Nature of mathematical functions
   - Nature of continuity of a function at one point
   - Nature of mathematical limits

2. Differentiation and applications.
   - Nature of differentiability of a function at one point
   - Differentiation of simple functions
   - Interpretations of derivatives of a function

3. Integration and applications. Numerical integration.
   - Meaning of integration of a function
   - Integration of simple functions
   - Nature of indefinite and definite integrals
   - Numerical evaluation of definite integrals

4. Plane curves, tangency and curvature.
   - Representations of plane curves
   - Direction of tangent to a curve at one point
   - Curvature of a curve at one point

5. Sequences and series. Series expansions.
   - Nature of sequences and series
   - Convergence of sequences and series
   - Tests of convergence for sequences and series
   - Taylor series expansions for simple functions

6. Partial differentiation.
   - Nature of partial differentiation
   - Partial differentiation of simple functions
   - Gradient and Laplacian operations

7. Multiple integrals and numerical approximations.

- Nature of multiple indefinite and definite integration
- Numerical approximation techniques for multiple integrals

8. Vector operations and analytical geometry.
   - Nature of real and complex vectors
   - Scalar and vector products of vectors
   - Analytical geometry in terms of vectors

9. First and second order linear differential equations and solutions.
   - Nature of linear ordinary differential equations
   - Nature of linear partial differential equations
   - Solution methods for simple ordinary differential equations
   - Solution methods for simple partial differential equations

10. Introduction to matrix algebra, linear equations and transformations.
    - Nature of matrices and simple matrix algebra
    - Matrix representation of linear algebraic equations and solutions
    - Matrix representation of linear transformations

11. Vector spaces and geometry.
    - Nature of vector real and complex spaces
    - Geometry in real and complex spaces

12. Quadratic forms, rotation matrices.
    - Nature of quadratic forms and applications
    - Rotation matrices in two and three dimensions

A STUDY GUIDE FOR SCHEDULE I – ITEM 1

1. Functions, continuity and limits.

- Nature of mathematical functions
- Nature of continuity of a function at one point
- Nature of mathematical limits

Sample Questions:

a) What is a mathematical function? Give examples.
b) Define the continuity of a function f(x) at some point $x = x_o$.
c) What is a discontinuity of a function f(x) at some point $x = x_o$?
d) Define the limit for a function f(x) as x approaches x_o (i.e. as $x \rightarrow x_o$)
e) Distinguish between the limit from the left and the limit from the right for a function f(x) as x approaches x_o on the real line.

2. Differentiation and applications.

- Nature of differentiability of a function at one point
- Differentiation of simple functions
- Interpretations of derivatives of a function

Sample Questions:

a) What is differentiability of function f(x) at some point $x = x_o$?
b) Distinguish between continuity and differentiability of f(x) at a point $x = x_o$.
c) Differentiate simple functions e.g. sin x, cosh x, e^x, $\log_e x$, $\log_{10} x$
d) What are the 2^{nd}, 3^{rd}, … derivatives of the previous functions?
e) For a function f(x), what is the interpretation of its derivatives f′(x), f″(x),…?

3. Integration and applications. Numerical integration.

- Meaning of integration of a function
- Integration of simple functions
- Nature of indefinite and definite integrals
- Numerical evaluation of definite integrals

Sample Questions:

a) What is the indefinite integral of a function f(x)? Give examples.
b) What are definite integrals of the same function f(x)? Give examples.
c) Evaluate the integral of f(x) = sin x between x = 0 and $x = \pi/2$.
d) What is the interpretation of the previous integral?
e) Approximate the previous integral with a discretization over $0 \leq x \leq \pi/2$.

4. Plane curves, tangency and curvature.

- Representations of plane curves
- Direction of tangent to a curve at one point
- Curvature of a curve at one point

Sample Questions:

a) What is a plane curve? Give examples.
b) What are implicit and parametric forms of a simple sinusoid?
c) What are arclength, slope and curvature for a simple sinusoid?
d) Given the function $f(x) = \sin x$, what is the direction of tangent at some $x = x_o$?
e) Given the function $f(x) = \sin x$, what is its curvature at some $x = x_o$?

5. Sequences and series. Series expansions.

- Nature of sequences and series
- Convergence of sequences and series
- Tests of convergence for sequences and series
- Taylor series expansions for simple functions

Sample Questions:

a) What is the difference between a sequence and a series? Give examples.
b) What is the limit of $1, 1/2, 1/3, \ldots, 1/n, \ldots$ as $n \rightarrow \infty$?
c) How do verify that $1 + 1/2 + 1/3 + \ldots + 1/n + \ldots$ diverges?
d) How do verify that $1 + 1/4 + 1/9 + \ldots + 1/n^2 + \ldots$ converges?
e) What is a Taylor expansion of a function $f(x) = \sin x$ at some point $x = \pi/2$?

6. Partial differentiation.

- Nature of partial differentiation
- Partial differentiation of simple functions
- Gradient and Laplacian operations

Sample Questions:

a) What is a partial differentiation of some function $f(x, y, z)$? Give examples.
b) Given $f(x, y, z) = e^x \sin(y+z)$, what are the corresponding partial derivatives?
c) What is the total derivative of the previous $f(x, y, z)$?
d) What is $\nabla f(x, y, z)$ for the previous $f(x, y, z)$?
e) What is $\Delta f(x, y, z) \equiv \nabla^2 f(x, y, z)$ for the previous $f(x, y, z)$?

7. Multiple integrals and numerical approximations.

- Nature of multiple indefinite and definite integration
- Numerical approximation techniques for multiple integrals

Sample Questions:

a) What are multiple indefinite and definite integrals of a function? Give examples.
b) What is the area of the surface $f(x, y) = \sin xy$ inside $0 \le x \le \pi/2$ and $0 \le y \le \pi/2$?
c) What is the volume under $f(x, y) = \sin xy$ inside $0 \le x \le \pi/2$ and $0 \le y \le \pi/2$?
d) What are some methods for approximating those integrals by summations?
e) What are quadrature methods? Give some simple examples.

8. Vector operations and analytical geometry.

- Nature of real and complex vectors
- Scalar and vector products of vectors
- Analytical geometry in terms of vectors

Sample Questions:

a) What are real and complex vectors? Give examples.
b) Express real and complex vectors in cartesian and polar coordinates.
c) What is the inner or scalar product of two arbitrary vectors? Give examples.
d) What is the cross or vector product of two arbitrary vectors? Give examples.
e) What is the length of a vector? What is the angle between two vectors?

9. First and second order linear differential equations and solutions.

- Nature of linear ordinary differential equations
- Nature of linear partial differential equations
- Solution methods for simple ordinary differential equations
- Solution methods for simple partial differential equations

Sample Questions:

a) What is the difference between ordinary and partial differential equations?
b) What are the orders in ordinary and partial differential equations? Give examples.
c) What are the differential equations for $f(x) = \sin x$? $g(x) = \sinh x$? $h(x) = e^x$?
d) What are the solution methods for the previous differential equations?
e) Solve the equations $\Delta U(x, y) = 0$ and $\Delta V(x, y, z) = 0$ for Cartesian x, y and z.

10. Introduction to matrix algebra, linear equations and transformations.

- Nature of matrices and simple matrix algebra
- Matrix representation of linear algebraic equations and solutions
- Matrix representation of linear transformations

Sample Questions:

a) What is a matrix? What is a column or row vector? Give examples.
b) Given two matrices A and B, are $A + B$, AB, $A^2 + B^2$, $(A + B)^2$ meaningful?
c) What is the determinant of a square matrix? What is the matrix inverse?
d) What are Cramer's rule and Gaussian elimination for linear algebraic systems?
e) What is the matrix algebra of linear systems of equations? Give examples.

11. Vector spaces and geometry.

- Nature of vector real and complex spaces
- Geometry in real and complex spaces

Sample Questions:

a) What is a real vector space? What is a complex vector space? Give examples.
b) What are linear dependence and independence of a set of real or complex vectors?
c) What is a basis for a real or complex vector space? Give simple examples.
d) What is the dimension of a real or complex vector space? Give simple examples.
e) What is a subspace of a vector space? What is a projection onto a subspace?

12. Quadratic forms, rotation matrices.

- Nature of quadratic forms and applications
- Rotation matrices in two and three dimensions

Sample Questions:

a) What is a quadratic form? What is it used for? Give examples.
b) What are eigenvalues and eigenvectors for a square matrix?
c) What are singular values for an arbitrary matrix?
d) What is a singular value decomposition (SVD) for an arbitrary matrix?
e) What are rotation matrices in two and three dimensions? Examples?

Schedule I - Item 2

Least-Squares Estimation and Data Analysis

Mathematical modelling; Error propagation and linearization, Concept of adjustment, Least-squares adjustment, Variance-covariance propagation, Pre-analysis of survey measurements, Normal, Chi-square, t (Student) and F distributions, Confidence intervals, Statistical testing of estimates, residuals and variances, Error ellipses and ellipsoids, General least-squares adjustment, Conditions and combined cases, Constraints, Sequential adjustment techniques, Least-squares applications to plane and curvilinear coordinates, Network design, Statistical testing and analysis of estimates, residuals and variances, Error detection, Introduction to least-squares prediction and filtering.

Textbooks:

a. **Analysis and Adjustment of Survey Measurements,** Mikhail, E.M. and Gracie, G. (1981) Reprints available from the Dept. of Geomatics Engineering, University of Calgary, Calgary, Alberta, ($15.00)

b. **Observations and Least-Squares,** Mikhail, E.M. (1976). Reprints available from the Dept. of Geomatics Engineering, University of Calgary, Calgary, Alberta, ($30.00)

c. **Adjustment Computations: Statistics and Least Squares in Surveying and GIS**
Wolf, P. R. and Ghilani, C. D. (1997); John Wiley and Sons, Toronto
ISBN 0-471-16833-5

References:

a. **Geodesy: The Concepts, Part III (Methodology),** 2nd Edition, 1986, Vanicek, P. & Krakiwsky, E.J. North-Holland, New York. ISBN 0-444-87775-4
ISBN 0-444-87777-0

b. **Statistical and Data Analysis in Geology,** Davis, J.C., (1986), 2nd Edition, John Wiley & Sons, Toronto ISBN 0-471-08079-9

Note: programmable calculators may be used in this examination.

LEARNING OUTCOMES FOR SCHEDULE I – ITEM 2

Recommended Pre-examination Studies:

Introductory probability & statistics

Schedule 1 - Item 1 - Mathematics

Courses or extensive experience in plane surveying (horizontal and vertical relative positioning, topographic surveying, route design and setting out and quantity calculations, familiarity with commonly used surveying instruments, procedures, and recording.)

Learning Outcomes:

1. Apply knowledge of matrix theory, statistics and estimation.
   - Manipulation of matrix algebra involved in adjustment of observations
   - Concept of linear system and linearization
   - Fundamental of probability and statistics
   - Principle of least square estimation and properties
2. Analyze measurement errors and modeling, perform random error propagation and pre-analysis of survey measurements.
   - Types of errors and characteristics
   - Types of models and characteristics
   - Law of random error propagation, variance and covariance matrix
   - Pre-analysis of survey measurements
3. Formulate least squares adjustment problems (condition, parametric and combined cases).
   - Formulate parametric adjustment models (functional and stochastic)
   - Formulate condition adjustment models (functional and stochastic)
   - Formulate combined adjustment models (functional and stochastic)
4. Derive adjustment equations of difference cases and conduct least square adjustment to geomatics problems such as levelling, traverse, triangulation and trilateration networks.
   - Derive parametric adjustment equations
   - Derive condition adjustment equations
   - Derive combined adjustment equations
   - Application to geomatics problems such as levelling, traverse, triangulation and trilateration networks.

5. Assess the quality of the adjustment solutions (variance factor, variance-covariance matrix, error ellipse).
    - Estimation of variance factor
    - Determination of variance-covariance matrix of parameters obtained from least square adjustment
    - Concept of error ellipse and its determination

6. Perform statistical tests on mean and variance to detect and identify outliers in observations (normal, Chi-square, t Student and F distributions, statistical hypotheses, type I and II errors).
    - Perform statistical tests on mean and variance to detect and identify outliers in observations
    - Determine the confidence interval of adjusted parameters
    - Select appropriate testing methods (normal, Chi-square, t Student and F distributions)
    - Confidence level and error probability of statistical decisions (significance level, test power, type I and II errors)

STUDY GUIDE FOR SCHEDULE I – ITEM 2

1. Apply Knowledge of matrix theory, statistics and estimation.
   - Manipulation of matrix algebra involved in adjustment of observations
   - Concept of linear system and linearization
   - Fundamental of probability and statistics
   - Principle of least square estimation and properties

   Sample questions (e.g. see related chapters in "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

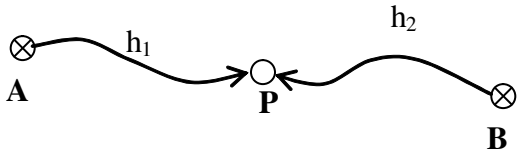
   Define and explain briefly the following terms:
   - Expectation
   - Variance
   - Unbiasedness of an estimator
   - Redundancy of a linear system
   - Root mean square error
   - Null hypothesis and alternative hypothesis
   - Type I error and Type II error
   - Accuracy and precision
   - Confidence interval

2. Analyze measurement errors and modeling, perform random error propagation and pre-analysis of survey measurements.
   - Types of errors and characteristics
   - Types of models and characteristics
   - Law of random error propagation, variance and covariance matrix
   - Pre-analysis of survey measurements

   Sample questions (e.g. see Chapter 2 and 6 of "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

   1) Given a leveling network below where A and B are two control points with known height, h_1 and h_2 are two height difference measurements with standard deviation of σ_1 and σ_2, respectively and $\sigma_1 = 2\ \sigma_2$. Determine the value of σ_1

and σ_2 so that the standard deviation of the height solution for point P using the least squares adjustment is equal to 2mm.



2) A surveyor's error (one sigma) due only to reading is determined to be $1.5''$ when making observations with a particular instrument. After repeatedly pointing on a distant target with the same instrument, the surveyor determines the combined error due to both reading and pointing to be $2.6''$. What is the surveyor's pointing error?

3) Given the variance-covariance matrix of the measurement vector $\ell = \begin{bmatrix} \ell_1 \\ \ell_2 \end{bmatrix}$:

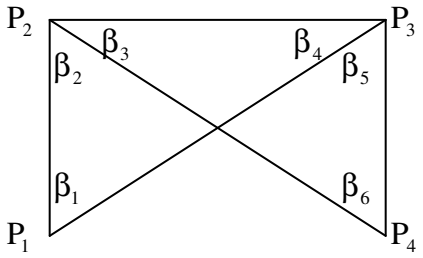
$$C_\ell = \begin{bmatrix} \frac{2}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

and two functions of ℓ: $x = \ell_1 + \ell_2$ and $y = 3\ell_1$, determine $C_{xy}, C_{x\ell}, C_{y\ell}$

7. Formulate least squares adjustment problems (condition, parametric and combined cases).
   - Formulate parametric adjustment models (functional and stochastic)
   - Formulate condition adjustment models (functional and stochastic)
   - Formulate combined adjustment models (functional and stochastic)

   Sample questions (e.g. see Chapter 3 and 4 of "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

1) The angles shown in the following figure are measured with a theodolite, and their observed values and standard deviations are listed in the table. Formulate the functional and stochastic models to determine the adjusted values for these angles using the condition approach.



Angle	Observed value	Standard Deviation
β_1	44°50'44"	3..0"
β_2	46°10'25"	1.5"
β_3	45°55'12"	1.5"
β_4	43°04'03"	1.5"
β_5	48°32'45"	1.5"
β_6	42°27'42"	3..0"

2) Assume that the points P1 and P2 in the problem 1) are two control points whose known coordinates are provided in the following table. Formulate the functional and stochastic models to determine the coordinates of the points P3 and P4 using parametric approach.

Control Points	X(m)	Y(m)
P1	0.00	**0.00**
P2	**1000.00**	**0.00**

8. Derive adjustment equations of different cases and conduct least square adjustment to geomatics problems such as levelling, traverse, triangulation and trilateration networks.
   - Derive parametric adjustment equations
   - Derive condition adjustment equations
   - Derive combined adjustment equations
   - Application to geomatics problems such as levelling, traverse, triangulation and trilateration networks.

Sample questions (e.g. see Chapter 3 and 4 of "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

1) Given the following mathematical models

$$f_1(\ell_1, x_1) = 0 \qquad C_{\ell_1}$$
$$f_2(\ell_2, x_1, x_2) = 0 \qquad C_{\ell_2} C_{x_2}$$

where f_i, x_i, ℓ_i and C_i represent mathematical model vectors, unknown parameter vectors, observation vectors and covariance matrices.

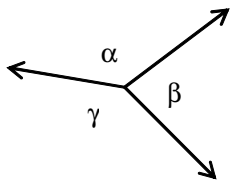
a) Linearize the mathematical models

b) Formulate the variation function

c) Derive the most expanded form of the least squares normal equation system.

2) Given the angle measurements at a station along with their standard deviations:

Angle	Measurement	Standard Deviation
□	134°38'56"	6.7"
□	83°17'35"	9.9"
□	142°03'14"	4.3"



Perform a least squares adjustment to the problem using

a) Conditional equations (condition adjustment)
b) Observation equations (parametric adjustment)

9. Assess the quality of the adjustment solutions (variance factor, variance-covariance matrix, error ellipse).
   - Estimation of variance factor
   - Determination of variance-covariance matrix of parameters obtained from least square adjustment
   - Concept of error ellipse and its determination

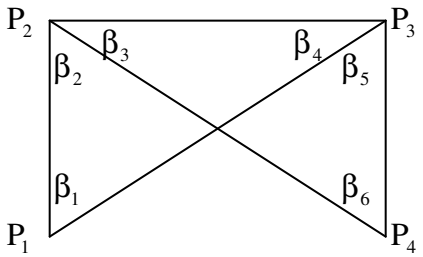
Sample questions (e.g. see Chapter 6 and 8 of "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

1) Given the variance-covariance matrix of the horizontal coordinates (x, y) of a survey station, determine the semi-major, semi-minor axis and the orientation of the standard error ellipse associated with this station.

$$C_x = \sigma_0^2 \begin{bmatrix} 0.380 & 0.025 \\ 0.025 & 0.510 \end{bmatrix}$$

where $\sigma_0 = 2\text{cm}$.

2) Calculate the variance-covariance matrix and the standard deviations of the adjusted angles in the following network. Assume all angles are measured with the same precision ($\sigma_\beta = 1.0''$).



10. Perform statistical tests on mean and variance to detect and identify outliers in observations (normal, Chi-square, t Student and F distributions, statistical hypotheses, type I and II errors).
    - Perform statistical tests on mean and variance to detect and identify outliers in observations
    - Determine the confidence interval of adjusted parameters
    - Select appropriate testing methods (normal, Chi-square, t Student and F distributions)
    - Confidence level and error probability of statistical decisions (significance level, test power, type I and II errors)

Sample questions (e.g. see Chapter 8 of "Analysis and Adjustment of Survey Measurements" by Mikhail and Gracie (1981))

1) An angle is measured 10 times. Each measurement is independent and made with the same precision. The sample standard deviation is s = 3.7". Test at a significance level of 5% the hypothesis that the population standard deviation □ of the measurements is 2.0" against the alternative that □ is not 2.0".

2) A baseline of calibrated length (μ) 1153.00m is measured 5 times. Each measurement is independent and made with the same precision. The sample mean ($\bar{x}$) and sample standard deviation(s) are calculated from the measurements:

   $\bar{x}$ =1153.39m s = 0.06m

   a) Describe the major steps to test the mean value.

   b) Test at the 10% level of confidence if the measured distance is significantly different from the calibrated distance.

Schedule I - Item 3

Advanced Surveying (including Survey Astronomy)

Precision horizontal and vertical control; simulation [pre-analysis] and design of surveys; error analysis of resultant data; application of optical and electromagnetic measuring principles and techniques; calibration of surveying instruments; utilization of surveying instruments; engineering surveys [including high precision, deformation, and mining surveys].

The celestial sphere and its coordinate system; altitude and azimuth; declination, hour angle, right ascension; celestial latitude and longitude; time (sidereal, apparent, universal); equation of time; determination of azimuth; use of ephemerides, almanacs and star catalogues.

Textbooks:

a. **Surveying: Theory and Practice,** Anderson, J. M. and Mikhail, E. M. 7th Edition, 1998 McGraw-Hill, New York ISBN 0-07-015914-9

b. Chapter 33 (“Modern Surveying Techniques for Mining and Civil Engineering.” by A.Chrzanowski) in J.A. Hudson [edit] **Comprehensive Rock Engineering, v.3 Rock Testing and Site Characterization**. 1993, Pergammon Press, ISBN 0-08-042066-4

c. Chapter 16 (“Engineering and Mining Surveys.” by A. Chrzanowski) in G. McGrath and L.M. Sebert [edit] **Mapping a Northern Land, 1947 -1994**. 1999, McGill-Queen’s University Press, ISBN 0-7735-1689-1

d. Chapter 20 (“Mining Surveys” by A. Chrzanowski and A.J. Robinson) in Davis, R.E., Foote, F.S., Anderson, J.M., and Mikhail, E.M. **Surveying: Theory and Practice**, 6th, 1981, McGraw-Hill, ISBN 0-07-015790-1 [out of print, replaced by 7th edition by Anderson and Mikhail, which no longer includes this chapter].

e. **Introduction to Geodetic Astronomy,** Thomson, D. B., Lecture Notes 49, 1981, University of New Brunswick, Department of Geodesy and Geomatics Engineering, (ordering particulars through <http://gge.unb.ca/Pubs/Pubs.html>)

f. **The Star Almanac for Land Surveyors**, (current year), Her Majesty's Nautical Almanac Office, London, England, available through <http://www.nao.rl.ac.uk>

Copies of textbook items b., c. and d. can be obtained as a package entitled “Joint Boards Item I-3, Selected Textbook Material”, prepaid by cheque or postal money order for $ 10.00, [includes shipping by regular post and GST], payable to “Geodesy and Geomatics Engineering”. Contact: Publications, Department of Geodesy and Geomatics Engineering, University of New Brunswick, P.O. Box 4400, Fredericton, NB, E3B 5A3 or via <delorey@unb.ca>.

References:

a. **Elementary Surveying,** Wolf, P.R. and Ghilani, C.D., 10th Edition, 2002, Prentice Hall Canada Inc. ISBN 0-321-01461-8
b. **The Astronomical Almanac**, (current year), U.S. Naval Observatory, Nautical Almanac Office, Washington, D.C. available through <http://www.nao.rl.ac.uk> or <http://aa.usno.navy.mil>

Note: programmable calculators may be used in this examination.

LEARNING OUTCOMES FOR SCHEDULE I – ITEM 3

Recommended Pre-examination Studies:

Schedule I - Item 1 - Mathematics

Schedule I - Item 2 – Least-Squares Estimation and Data Analysis

Courses or extensive experience in plane surveying (horizontal and vertical relative positioning, topographic surveying, route design and setting out and quantity calculations, familiarity with commonly used surveying instruments, procedures, and recording.)

Learning Outcomes:

Design the appropriate combination of equipment and procedures for a data gathering task that will ensure that the gathered data meets the quality requirements of relative positioning (horizontally or vertically or in three dimensions simultaneously)

Assess data gathered for the calibration of surveying instruments, for measurements of high precision, or for mining surveying.

Gather, process, and assess astronomic observations for azimuth.

Student should have an ability to:

Discuss the concept of precision as it relates to surveying processes including the sources and types of errors.

Translate specifications such as maximum misclosures into a choice of equipment and procedures.

Compose specifications and requirements for gathering survey related data.

Differentiate between the process that results in position information and the process that requires repeated positioning for local deformation monitoring.

STUDY GUIDE FOR SCHEDULE I – ITEM 3

Questions and Answers

Textbook a: Surveying: Theory and Practice, Anderson and Mikhail, 1998: answers to suggested questions:
[refer to whole chapter with emphasis on "Part B Advanced Topics" if it exists]

Chapter 2. Survey Measurements and Adjustments
2.17 a: ±11.18"; b: mean = 33°42'15" ±13.9" at 95%, single = 33°42'10" ±70.5" at 95%
2.18: diag [225, 900, 1125]
2.19: $\sigma_s^2 = a^2 + b^2 s^2$ [Chrzanowski, 1993, eq. 4] making cov = diag [0.0058^2, 0.3010^2, 0.0255^2] and weight = diag [29726.52, 11.04, 1537.87]
2.20: -0.707
2.21: 66°05'55" ±52"
2.22: 7071.07 m^2 ±2.7 m^2
2.23: ±0.107 m
2.24: 5636.40 m^2 ±9.98 m^2
2.25: $\sigma_{mean} = \pm\sigma/[n^{1/2}]$
2.26 a: b = 151.681 m, c = 87.001 m, $\sigma_b^2 = 0.00823$ m^2, $\sigma_c^2 = 0.01306$ m^2, $\sigma_{bc} = 0.00919$ m^2; b: 55°00' ±2.8'; c: area = 5404.9 m^2 ±2.7 m^2
2.27: $16 = [0.25"]^{-2}$
2.28 to 2.33: see text

Chapter 4. Distance Measurement
4.29, 30: see text sec 4.28 to 4.30
4.31: $\lambda_{field} = 9.990458$ m, $\lambda_{standard} = 9.990154$ m, difference = 30.43 ppm
4.32: 12.19235 m
4.33: 299710.8 km/s
4.34: 11.98813 m
4.35: 39.96031 m
4.36: +34.9 ppm
4.37: +13.8 ppm
4.38: 2356.863 m
4.39: 1555.488 m
4.40: additive constant = -0.032 m
4.41: see text sec 4.39
4.42: 327.379 m
4.43: 519.903 m
4.44: 709.434 m
4.45: ±0.036 m

4.46: ±38”
4.47 a: ±0.056 m; b: ±0.354 m
4.48: 17691.256 m
4.49: 25428.309 m
4.50: horizontal = 60079.101 ft, ellipsoidal = 60071.915 ft
4.51: 20377.582 m
4.52: ±0.227 ft

Chapter 5. Vertical Distance Measurement: Leveling
5.10: 624.89 ft, +26.94 ft
5.11: 280.99 m
5.47 a: 5247.695 m; b: 832.919 m
5.48 a: 4578.053 m; b: 572.015 m
5.49: ±0.029 ft
5.50: ±0.0179 m
5.51 a: ±0.052 m; b: ±0.031 m
5.52: 90.982 m
5.53: 625.86 m
5.55: +0.111 m, 1.499 at B, 1.610 at A, -0.034 m, corrected rod readings yield ΔH = 0.111 m

Chapter 6. Angle and Direction Measurement
6.31 a: ±51”; b: ±33”; c: ±18”
6.32: at A from C to D: 44°32’00.8”, at A from D to E: 47°53’22.5”; $\sigma^2_{aAfCtD} = 32$, $\sigma^2_{aAfDtE} = 20$, $\sigma_{CD/DE} = -16$, all in arcseconds squared
6.33: solution of binomial yields 6.4 or -0.8, so use 8 repetitions [rounded up to next even number]
6.34: see text, ex. 6.5 to 6.7
6.35 a: ±9.4”; b: ±2.8”
6.36 a: ±51.1”; b: ±33.2”; c: ±18.3”

Chapter 9. Other Methods of Horizontal Positioning
9.8 to 9.10: see text
9.11: 21499.865 m
9.12: see section 4.45 and figure 4.24, 19153.462 m

Chapter 10. Introduction to Astronomy
10.1 to 10.4: see text, sec 10.2,3,4,5,10
10.5: 21h06m50s on previous day
10.6: 15h35m12s
10.7: 17h20m
10.8: 80°13’45” W
10.9: 15h54m46s
NOTE that the “current year” is 1997 in the following.
10.10: EqT = 00m29.75s; LCT = 14h24m07s on 1997 06 10; LAT = 14h23m37s
10.11: EqT = 03m13.98s; LCT = 15h06m16s
10.12: LST = 9h07m31s
10.13: 8.8”; 8.0”
10.14: 0°01’44.4”; 26°08’46”
10.15: 8.63”; 0°03’46”; 15°06’46”
10.16: 6°15’56.68”
10.17: 19°00’53.82”
10.18: 15°03’51”
10.19: 66°46’45”
10.20: 312°32’53”
10.21: A_{Sun} = 237°51’58.0”; A_{24to49} = 195°17’53.5”
10.23: A_{Sun} = 238°11’59.1”; A_{16to38} = 15°16’03.7”
10.25: A_{Sun} = 224°55’42.4”; A_{AtoA9} = 168°09’51”
10.26: A_{Sun} = 90°16’16.9”; A_{toRO} = 0°37’02”
10.27 a: 130°36’55”; b: 101°47’29.3” W
10.28: 53°32’33.9” N
10.29: 100°59’12” W
10.30: $A_{Polaris}$ = -0°25’49.8”; $A_{Patio\ to\ Kani}$ = 6°40’19.2”
10.32: 6°39’59.6”
10.33: 45°14’34” N
10.34: 49°21’06” N
10.35: PST = 11h11m21s
10.36: EST = 2h36m50s
10.37: PST = 20h23m25s
10.38: Z = 1°02’55.7”; t = 89°16’40”
10.39: 0°56’40”
10.40: t = 92°30’00”; Z = 1°07’30”

Chapter 15. Control and Topographic Surveying
see text

Textbook b: Chapter 33: "Modern Surveying Techniques for Mining and Civil Engineering" by Chrzanowski, in Comprehensive Rock Engineering, v.3 Rock Testing and Site Characterization, Hudson [edit], 1993

Q1: The effects of lateral refraction can be quantified, more to recognize when conditions should be avoided rather than to apply as a correction. Along the south face of a block of buildings, temperature readings were taken at the wall surface and 1 m away. The average values were 35 C and 30 C, respectively. A traverse around the block had to be run with the lines offset by 0.5 m from the building faces. The block is 300 m square. By how much is the effect of refraction along this one side likely to contaminate the misclosure of the block, assuming standard pressure?
[2'20" = 260" (130" smaller at each corner)]

Q2: EODMI are designed to be used at an average temperature, pressure, and relative humidity [e.g., 12 C, 1013.25 mb, 60%].

a: If the accuracy is to be maintained to within 2 ppm, what would be the limits on the variation of i: temperature or ii: pressure from the design values?
[i: 10.0 C $\leq$ t $\leq$ 14.0 C, or ii: 1007.3 $\leq$ p $\leq$ 1019.2 mb]

b: If the accuracy is to be maintained to within 2 ppm, what would be the limits on the variation of temperature and pressure, simultaneously, from the design values?
[10.6 C $\leq$ t $\leq$ 13.4 C and 1009.0 $\leq$ p $\leq$ 1017.5 mb]

Q3: Geodetic measurements are usually made to determine "absolute" position. They can be repeated at a later time to determine change in position over that period. Geotechnical instrumentation provides relative changes. Explain how geodetic and geotechnical observations can complement each other in the monitoring of a sensitive structure for horizontal or planimetric deformation, for vertical deformation, and for three dimensional deformation.

Q4: The azimuth of a reference line can be determined using a gyrotheodolite or a gyro attachment. Commonly underground activity, such as in mining, is described in a local coordinate system. Explain what corrections need to be applied to a gyro azimuth, and under what circumstances, in order to for it to be used in the coordinate system of the activity.

Q5: Most typical land surveying activity employs plane surveying. Explain the circumstances under which it is necessary to be concerned about the geodetic aspects of surveying.

Q6: Suggest, with examples, the achievable limits on the precision and on the accuracy of geodetic surveys for deformation monitoring.

Textbook c: Chapter 16: "Engineering and Mining Surveying" by Chrzanowski, in Mapping a Northern Land, 1947 – 1994, McGrath & Sebert [edit], 1999
Q1: This chapter presents a number of surveying efforts either in Canada or involving Canadians. Explain a couple of examples of efforts that are beyond the usual demands of land surveying and what cautions were exercised. Approach this as if you were presented with the opportunity to be involved and had to consider the demands on equipment and expertise.
Q2: The references for this chapter span a period of about 45 years with the most recent being 1994. In what way would current surveying technology provide an advantage, on the surface or underground or both, if any of these projects were to be done today?

Textbook d: Chapter 20: "Mining Surveys" by Chrzanowski & Robinson, in Surveying: Theory and Practice, Davis, Foote, Anderson & Mikhail, 1981
20.1: ±0.218 m
20.2: ±0.322 m
20.3 a: d = 1.128 mm [assumed available in reminder of problem], P = 100 kg; b: ΔH = 1.429 m, between platforms; c: T = 34.8 seconds; d: $e_{\text{air current}}$ = 0.51 mm, $e_{\text{spiral shape}}$ = 0.222 mm, e_{scale} = 0.2 mm, total: ε_A = 28" over b = 4.000 m
20.4: X_C = 532.888 m, Y_C = 369.878m; A_{CD} = 328°32'18" ±32"
20.5: A_{CD} = 71°21'54"

Answers to questions on Previous I-3 Examinations:

September 2002:

1. see Anderson & Mikhail (1998) ch.2
2. a: -0.0037 m, -0.0204 m, -0.0067 m; b: ±0.200 m, ±0.0606 m, ±0.1501 m; c: ±41.6' to P1, ±20.8" to P2
3. 309°52'24.04"
4. see I-2 textbooks
5. a: ±2.4 C, ±7.6 mb
6. see Chrzanowski (1993)
7. b: ±0.0052 m

March 2003:

1. see Anderson & Mikhail (1998) ch.2
2. c: ±0.0063 m; d: ±0.0045 m
3. 314°17'01"
4. see I-2 textbooks
5. a: ±1.7 C, ±5.4 mb
6. see Chrzanowski (1993)
7. b: ±0.0052 m

October 2004:

1. see Anderson & Mikhail (1998)
2. c: ±0.0055 m; d: ±0.0039 m
3. 44°41'04.7", note Daylight time
4. see I-2 textbooks
5. a: ±1.7 C, ±5.4 mb
6. a: ±3.1"; b: $2^{1/2}\sigma_\delta/[n_s^{1/2}]$
7. b: ±0.0035 m; c: ±0.0040 m

March 2005:

1. see Anderson & Mikhail (1998) and I-2 textbooks
2. see Chrzanowski & Robinson (1981)
3. 46°30'06.13", note Daylight time
4. ±1.4 m
5. a: ±2.3 C, ±7.7 mb
6. a: ±3.15"; b: $2^{1/2}\sigma_\delta/[n_s^{1/2}]$; c: $2\sigma_\delta$
7. b: ±0.0035 m; c: ±0.0040 m
8. see Anderson & Mikhail (1998)

Schedule I – Item 4

Remote Sensing and Applied Photogrammetry

A survey of the physical principles of modern quantitative remote sensing using optical, infrared and microwave radiation. These principles include: the basic characteristics of electromagnetic radiation; radiometry; the interactions between radiation and terrestrial materials and atmospheric constituents; and characteristics of sensor systems and their measurements. Sensor Models (resolution, spectral and spatial response). Spectral transom (multispectral ratios, principal components, contrast enhancement), spatial transform (convolution, Fourier and scale-space transform), corrections and calibration (noise reduction, radiometric calibration , geometric corrections), thematic classification (parametric and non-parametric classification, sub-pixel classification). Overview of current applications, including mapping, change detection.

Data acquisition systems employed in aerial and close-range photogrammetry: metric and non-metric cameras, and non-conventional imagery. Mathematical relationships between image and object space. Direct and inverse problems of projective and similarity coordinate transformations. Conditions of collinearity and coplanarity. Orientation procedures (Interior, Exterior, Relative and Absolute). Measurement and correction of image coordinates. Stereo model formation and error analysis. Various mathematical models for analog, analytical, independent model, strip and block adjustments. Project planning.

Textbooks:

a. **Remote Sensing : Models and Methods for Image Processing**, 2nd Edition, 1997, Robert A. Schowengerdt, Academic Press. ISBN 0-12-628981-6

b. **Introductory Digital Image Processing: A Remote Sensing Perspective**, 2nd Edition, 1995, John R. Jensen, Prentice Hall. ISBN 0-13-205840-5

c. **Elements of Photogrammetry (with Applications in GIS)** 3rd Edition, 2000, Wolf, P. R. and Dewitt B. A., McGraw-Hill. ISBN 0-07-292454-3

References:

a. **Remote Sensing Digital Image Analysis : An Introduction,** Jia X., Richards J., 3rd edition, 1999, Springer Verlag. ISBN 3-540-64860-7

b. **Assessing the Accuracy of Remotely Sensed Data : Principles and Practices**, Congalton R., Green K, 1998, CRC Press ISBN 0-87-371986-7

c. **Analytical Photogrammetry,** El-Sheimy, Dr. Naser, 2001: Lecture Notes for "ENGO431". Available from the Canadian Board of Examiners for Professional Surveyors. Please call 613-274-7115 to order. 15$

d. **Close range photogrammetry and machine vision,** Atkinson K.B., 1996. Whittles Publishing. ISBN 1-87-032546-X

e. **Manual of Photogrammetry,** Slama, C. S. (Editor), 1980. 4th Edition. American Society of Photogrammetry and Remote Sensing, Falls Church, VA

Note: programmable calculators may be used in this examination.

LEARNING OUTCOMES FOR SCHEDULE I – ITEM 4

Recommended Pre-examination Studies:

Schedule 1 - Item 1 - Mathematics

Schedule I - Item 2 – Least-Squares Estimation and Data Analysis

Introductory Physics (specifically geometric optics)

Learning Outcomes:

- Deeper understanding of the role of remote sensing and photogrammetry in mapping applications (Image acquisition and Image measurement)
- Ability to work in a basic fashion with remote sensing imagery (optical, infrared and microwave radiation) and to apply spectral transom (multispectral ratios, principal components, contrast enhancement), spatial transform (convolution, Fourier and scale-space transform), corrections and calibration (noise reduction, radiometric calibration , geometric corrections), and thematic classification (parametric and non-parametric classification, sub-pixel classification) to these imagery.
- Ability to apply concepts and principles of determining spatial positions using photogrammetric techniques (e.g. aerial photographs coordinate transformation, space intersection, and space resection).
- Expansion of skills in photogrammetric measurement techniques and their applications in mapping and other Geomatics disciplines
- Assessment of auxiliary information (e.g. GPS and INS) and control requirements in photogrammetric networks, and
- Photogrammetric mission planning.

Student should have an ability to:

- Discuss the concept of electromagnetic radiation and how it interacts with matter, particularly the land surface, the oceans and the atmosphere.
- How to infer valid information from remote observations (e.g., of electromagnetic spectra).
- Apply the principles, techniques and practice of the quantitative analysis of digital imagery.
- Apply remote sensing technologies and their spatial and temporal sampling characteristics.
- Capacity to relate observations to models (mathematical, computational and conceptual) of photogrammetric data.
- Apply the concepts and principles of determining spatial positions using photogrammetric techniques.

Schedule I - Item 5

Spatial Database Management Systems (Informatics)

Computer Systems; World Wide Web, spatial databases, Database Management Systems (DBMS) and universal servers; web servers; data warehouses, datamarts, On-Line Analytical Processing (OLAP) and Data Mining; relational, object-relational, object-oriented and multidimensional systems; application of Database Management to Geographical Information Systems (GIS); spatially-extended SQL; database design (system development methods and database modeling), UML, Entity-Relationship and relational database modeling; visual modeling tools (or CASE tools, Computer-Assisted Software Engineering); integrity constraints; database normalization and optimization; spatial and non-spatial access methods; data fusion.

Textbooks:

a. **Database Systems: A Practical Approach to Design, Implementation and Management,** Connolly, Thomas and Begg, Carolyn, 4th Edition, 2004 Addison-Wesley, Boston ISBN-10: 0321294017 ISBN-13:9780321294012 (complete description available at Pearson Education Canada at http://vig.pearsoned.ca/catalog/academic/product/0,1144,0321294017,00.html)

b. **An Introduction to Database Systems**, Date, C. J., 8th Edition, 2004, Addison-Wesley Publishing Company, Boston ISBN-10 0321197844 ISBN-13:9780321197849 (complete description available at Pearson Education Canada at http://vig.pearsoned.ca/catalog/academic/product/0,1144,0321197844,00.html)

c. **UML Principes de modélisation,** Fannader, R. et Leroux H. 1999. Dunod, Paris ISBN 2-10-004650-0

d. **UML Distilled - A Brief Guide to the Standard Object Modelling Language**, Fowler, M. and Kendall, S. 3rd Edition, 2004, Addison-Wesley, Boston ISBN-10 0321193687 ISBN-13: 9780321193681 (complete description available at Pearson Education Canada at http://vig.pearsoned.ca/catalog/academic/product/0,1144,0321193687,00.html)

e. **Spatial Database Systems: Design, Implementation and Project Management**, Yeung, Albert K.W., Hall, G. Brent, 2007, Springer ISBN-10: 1-4020-5391-6 ISBN-13: 978-1-4020-5391-7. (complete description available at Springer at http://www.springer.com/east/home/generic/search/results?SGWID=5-40109-22-173674015-0)

References:

a. **Modeling Geospatial Databases with Plug-Ins for Visual Languages: A Pragmatic Approach and the Impacts of 16 Years of Research and Experimentations on Perceptory**, Bédard, Y., Larrivée, S., Proulx M.-J. & Nadeau, M. in **Conceptual Modeling for Advanced Application Domains** Workshop ER2004 workshp COMOGIS, S. Wang et al. (Eds.): , LNCS 3289, pp. 17–30, 2004 (complete description available at Springer at http://www.springer.com/east/home/generic/search/results?SGWID=5-40109-22-35890088-0)

Note: programmable calculators may be used in this examination.

Schedule I - Item 6

Map Projections and Cartography

Principles of map projections: plane, conical and cylindrical; azimuthal, equidistant, conformal and equal-area; distortions in map projections.

The Universal Transverse Mercator Projection (3 degree and 6 degree); geographic to grid and grid to geographic transformations, scale factors, convergence, grid cells.

The Mercator Projection: Geographic to grid and grid to geographic transformations, loxodrome line and distance calculations.

The presentation of map information on various types of maps: planimetric, topographic, photo-base maps, special and thematic maps, shaded relief maps.

Map construction: artwork, materials, equipment, software (CAD, GIS), data integration, spatial databases vs. CAD drawing.

Reproduction: screening and printing, monochrome and multi-coloured maps.

Cartographic design systems: cartographic principles of design, automatic plotters.

Thematic mapping and graphic semiology: visual variables (weight, colour, orientation, size, shape, etc.), measurement scales (nominal, ordinal, interval, ratio)

Web mapping

Map generalization

Textbooks:

a. **Elements of Cartography,** Robinson, A.H. et al, 6th Edition, 1995 John Wiley & Sons, Etobicoke ON ISBN 0-471-55579-7

b. **Proceedings of the 19th International Cartographic Conference,** Ottawa, Ont. August 1999, CD-ROM, Canadian Institute of Geomatics, 1390 Prince of Wales Drive, Suite 400, Ottawa ON K2C 3N6, $35.00 + S&H

c. **Thematic Cartography and Visualization,** Slocum, T., 1999, Prentice Hall ISBN 0-13-209776-1

d. **Geographic Information Systems and Science.** Longley, P.A., Goodchild, M.F., Maguire, D. J. and Rhind, D.W., 2001, John Wiley and Sons, Etobicoke ON. **Chapters 1, 3, 4, 5, 6, 7 and 8** ISBN 0-471-49521-2

References:

a. **Flattening the Earth,** Snyder, J. P., 1993, University of Chicago Press ISBN 0-226-76746-9 (cloth),ISBN 0-226-76747-7 (paper)

b. **Interactive and Animated Cartography,** Peterson, M., 1995, Prentice Hall, New Jersey, ISBN 0-13-079104-0

c. http://maps.nrcan.gc.ca/ and http://maps.nrcan.gc.ca/maps101

d. http://atlas.gc.ca/site/english/learning_resources/carto/index.html

e. http://geonames.nrcan.gc.ca/index_e.php

Schedule I - Item 7

Cadastral Studies

Cadastral surveys and land registration systems. The cadastre. Common Law and Civil Law concepts of land and property in Canada. The link between the land surveyor and the law - professional ethics, discipline, liability. Interests in land. Doctrines of tenure and estates. How rights in land are held and transferred by people. Survey systems and nature of boundaries. Recording rights in land - registrations of deeds and of titles. Common property. Canada Lands. Indian lands. FIG Statements on the Cadastre. Links with boundary law and with land use planning. Case law as represented in the textbooks and references.

Textbooks:

a. *Chapters 1-4 and 9-12,* **Survey Law in Canada,** 1989. Reprints available from the Dept. of Geomatics Engineering, University of Calgary, Calgary, Alberta.

b. *Chapter 4,* **Cadastral Studies Lecture Notes,** 2000, Teskey, W.F. et al, Publication No. 10008, Dept. Geomatics Engineering, The University of Calgary.

c. International Federation of Surveyors (FIG) web-site and links:
www.fig7.org.uk/publications/cadastre/statement_on_cadaste.html
www.fig7.org.uk/events/sing97/sing971.htm
www.fig7.org.uk/publications/Bogor/BogorDeclaration.html

d. **Land Administration,** Dale, P.F. and McLaughlin, J.D. Oxford University Press Canada, Don Mills, Ont. 1999. ISBN 0198233906

LEARNING OUTCOMES FOR SCHEDULE I – ITEM 7

Learning outcomes:

1. To find and apply the principles of case law, by researching, finding and analyzing relevant decisions of the courts using CanLII, provincial and federal government web-sites, and law library electronic portals(or hard-copy sources).

2. To find and apply the principles of statute law, by researching, finding and analyzing relevant pieces of legislation using CanLII, provincial government web-sites, and law library electronic portals (or hard-copy sources).

3. To understand the nexus between cadastral surveying, the law and the land:

   - the parcel is that to which title applies;
   - title refers to legal rights in land, and includes freehold (fee simple), leasehold, easements, rights of use, and any combination thereof;
   - a boundary is the two-dimensional line (having length and depth, but no width) that defines the spatial extent of the parcel;
   - a cadastral surveyor marks boundaries on the ground and draws boundaries on paper (or in digital files) but does not make boundaries;
   - land registration refers not to registering land per se, but to recording rights in land (parcels).

4. To appreciate that cadastral surveyors are sometimes considered quasi-judicial officials who enjoy the exclusive right to establish and re-establish boundaries, a right that is tempered by obligations pursuant to:

   - the law of negligence;
   - agreements with clients;
   - standards set by provincial land surveying associations;
   - requirements of regulatory agencies, such as municipalities and provinces.

STUDY GUIDE FOR SCHEDULE I – ITEM 7

What follows assumes that you have read chapters 1 – 4 and 9 – 12 of *Survey Law in Canada.*

A. Finding study resources:

1. The Canadian Legal Information Institute (CanLII) is a non-profit society owned and funded by the 14 member law societies comprising the Federation of Law Societies of Canada.[1] There is free public on-line access to over 325,000 decisions of the courts, and to over 1.7 million statutes and regulations: www.canlii.org.

2. If you have access to a law library run by a law society or a university, use hard-copy (paper) sources, and search the boundaries section of the *Canadian Encyclopedic Digest* and the *Canadian Abridgement*.

3. Another paper source is publications of the Canadian Institute of Geomatics (such as *Geomatica*), and of the provincial surveying associations (such as *The Link*, *ALS News*, and the *AOLS Quarterly*, to name but few). The former has regular *Surveyor and the Law* articles and infrequent research articles on cadastral surveying; the latter often reviews cadastral surveying issues that emphasise legal rights in land

4. University law libraries provide excellent electronic portals for finding legislation and decisions. For example, the web-site for the law library at the University of Calgary directs you efficiently to 14 categories of legal information: http://library.ucalgary.ca/branches/lawlibrary/

5. Of course, there is much available on-line through search engines such as Google. The key is to differentiate the valuable form the dross. Examples of the former include the web-sites of the various provincial land surveying associations (such as the Ordere des Arpenteurs-Geometres du Quebec: www.oagq.qc.ca) and the Canadian Council of Land Surveyors (CCLS).

6. Finally, subscription services such as WestlaweCarswell, LexisNexis and Quiklaw are useful sources. However, I do not expect you to have such access; the five sources already described are sufficient for your purposes.

1 Douglas Mah. CanLII looks to the future. *The Advisory.* The Law Society of Alberta. v4 – n4. July 2006. p.3.

B. Understanding study material:

1. *Cadastre 2014,* published by the International Federation of Surveyors (FIG):
   - What are the characteristics of a cadastre?
   - What are four principles of land registration?
   - What is the relationship between surveyors and the cadastre?

2. *Agenda 21* and the *Johannesburg Declaration on Sustainable Development:* How might cadastral surveying in Canada contribute to three principles of sustainability?

3. Justice Cooley's 19th century essay on the judicial functions of surveyors:
   - Given your knowledge of cadastral surveying (gleaned through courses and the workplace), to what extent are Cooley's observations relevant to your provincial jurisdiction today?
   - What distinction does Cooley make between establishing boundaries on the ground, and re-establishing such boundaries?
   - Have changes in technology, training, and regulation affected Cooley's critique?

4. How are boundary, parcel, survey, surveyor, freehold, leasehold, deed, title, registration and description defined in any three of the seven legal dictionaries that are available on-line through the University of Calgary law library?

5. Use CanLII to peruse (ideally, for your home province or territory):
   - a statute (piece of primary legislation) that deals with land registration;
   - a regulation (a piece of subordinate legislation) that deals with land surveyors;
   - a decision of the courts that deals with land surveying, land surveyors, or land registration.

6. The exclusive right to practice cadastral surveying:
   - *BC v. Infomap Services*, (1990) 68 DLR(4th) - BC Court of Appeal;
   - *AOLS v. van Loon* - Ontario Court of Appeal (January 29, 2004).

7. Role of a cadastral surveyor (consultant vs. employee): *Johnson v. Alberta* - Alberta Court of Queen's Bench (December 6, 2002).
   - What complaint did the landowners have of the Crown?
   - What is the test to determine whether a cadastral surveyor is an employee?
   - What procedure is to be followed by a surveyor in re-establishing a natural boundary?

8. The duty of care owed by a cadastral surveyor:
   MacLaren-Elgin v. Gooch (1972), 1 OR 474.

9. Utility of a cadastral survey in a real estate transaction:
   Ontario decision involving a plan of survey in Bancroft, a real estate agent, a reluctant purchaser and a frustrated vendor (June 2006).

10. Standards set by a provincial land surveying association:
    Compare three topics (of your choosing) between Newfoundland's *Manual of Practice* and Alberta's *Manual of Standard Practice*.

11. Interpret any metes and bounds description of land ceded by aboriginal peoples in Canada pursuant to any one of the numbered treaties entered into with the federal government in the late 19th and early 20th centuries. The full text of each treaty is found on the DIAND web-site.

12. Descriptions – There are at least five excellent publications on describing parcels of land using words (metes and bounds) or plans, on the web-sites of the Association of British Columbia Land Surveyors, the Association of Ontario Land Surveyors, and the Association of Nova Scotia Land Surveyors. Familiarize yourself with the principles:
    - *Descriptions for deeds*. Klotz et al . 1909 40pp
    - *Descriptions of land*. Cautley. 1913. 49pp.
    - *Examples of descriptions*. Peters. 1930. 19pp.
    - *Legal descriptions*. Mucklestone. 1969. 17pp.
    - *The deed description*. Hutchinson.

13. Critique the CCLS *Model Code of Ethics*.

14. Review any provincial statute that deals with trespassing, such as the *Trespass to Premises Act* (Alberta) or the *Trespass to Property Act* (Ontario).

-- SCHEDULE II --

Schedule II - Item 1

Geodetic Positioning

Natural, celestial inertial and dynamic coordinate systems, Coordinate system transformations, Canadian Spatial Reference Systems (CSRS), NAD27, NAD83, CGVD28, NAVD 88. Definition of horizontal and vertical datums. Effects of the gravity field on positioning. Propagation and properties of EM waves. Principles of electromagnetic distance measurement. EDM instrument calibration. Classification of EDM systems operating at various EM frequencies. Precise static positioning using conventional geodetic and satellite methods. Satellite and shore-based kinetic, kinematic and static positioning methods. Underwater acoustic positioning and offshore monumentation. Fundamentals of geodetic space methods for deformation studies.

Textbooks:

a. **Fundamentals of Geodesy,** ENGO 421 Lecture Notes, Report no. 10014, Schwarz, K.P. (1994) Department of Geomatics Engineering, The University of Calgary

b. **Geodesy,** Torge, W., Walter de Gruyter, N.Y., 1991 2nd Edition (paperback) *(listed at amazon.com)* ISBN 3-110-07232-7

c. **GPS Theory and Practice,** Hofmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (1997) 4th Edition, paperback, Springer-Verlag, New York ISBN 3-211-82839-7

d. **Surveying Offshore Canada Lands for Mineral Resource Development** (1982), 3rd Edition, reprints available from Association of Canada Lands Surveyors, 900 Prince of Wales Drive, Suite 100E, Ottawa ON K2C 3L6. Tel 613-723-9200, email info@acls-aatc.ca

References:

a. **Online Tutorial in Geodesy** by P. Vanicek, University of New Brunswick, Available at http://gge.unb.ca/Research/GeodesyGroup/tutorial/tutorial.htm.

b. **Geodesy: The Concepts,** 2nd Edition (Paperback available), Vanicek, P. and Krakiwsky, E.J., North-Holland, New York, 1986 ISBN 0-444-87777-0

c. **Physical Geodesy,** Moritz, H., Freeman Publisher and Co., San Francisco. 1967, (Reprints available from the bookstore, The University of Calgary)

d. **GPS Satellite Surveying,** Leick, A., 1995, 2nd Edition, John Wiley & Sons, Toronto, Ontario ISBN 0-471-30626-6

Note: programmable calculators may be used in this examination.

LEARNING OUTCOMES FOR SCHEDULE II – ITEM 1

Recommended Pre-examination Studies:

Schedule I - Item 1 - Mathematics

Schedule I - Item 2 – Least-Squares Estimation and Data Analysis

Schedule I - Item 3 – Advanced Surveying (including Survey Astronomy)

Schedule I - Item 6 – Map Projections and Cartography

Courses or extensive experience in geodetic positioning (horizontal, vertical and 3D), geodetic computations in 3D space, on the ellipsoid and with respect to vertical datums, fluency in handling coordinate transformations among the 3D, horizontal and vertical coordinate systems used in Canada and North America, knowledge of the most commonly used geodetic instruments, procedures, recording and applications, and familiarity with the characteristics and use of conformal map projections.

Learning Outcomes:

- Identify and select the appropriate coordinate system and coordinate system transformations (either on a 3D space, on the ellipsoid, on the conformal mapping plane or with respect to vertical datums) to be used in the support of geodetic applications.
- Reduce terrestrial observations collected on the Earth's surface down to the reference ellipsoid.
- Relate 2D coordinates and observations between the ellipsoid and the conformal mapping plane.
- Explain how terrestrial observations relate to the gravity field.
- Perform computations (horizontal coordinates and azimuth) on the reference ellipsoid.
- Perform computations (3D coordinates, elevation and azimuth) on the 3D space using terrestrial observations.
- Perform computations (horizontal coordinates and azimuth) on the conformal mapping plane.
- Relate Cartesian and curvilinear coordinates.
- Analyse the quality of results obtained from GNSS processing packages.
- State the characteristics of space positioning techniques, including, observables, mathematical models, observation methods and uncertainty associated with them.
- State the characteristics of conformal mapping projections (UTM, LTM and Double Stereographic)
- Define the various vertical surfaces used as datum in geodesy.
- Relate the various vertical datums among themselves.
- Define the different systems of height.
- Relate the systems of height.
- Explain how heights relate to the gravity field
- Perform height computations.

Schedule II - Item 2

Hydrographic Surveying and Oceanography

Composition and properties of water, speed of sound in water, Ocean characteristics: salinity, temperature, circulation, Oceanographic instruments and techniques, Ocean resources, Waves, ocean currents, tides and tidal currents, Water levels, tide gauges and vertical datums used in hydrography, Shore and satellite-based marine positioning systems, Horizontal positioning and depth measurement requirements for charting, Elements of underwater acoustics, Sonar parameters and equations, Echo sounder operations and design considerations, Narrow and multibeam sweep and swath systems, Side scan sonars, Echo sounding measurement corrections, Non-acoustic methods: EM, laser and mechanical methods, Calibration of instruments, IHO standards for hydrographic surveys, equipment requirements, logistics and procedures, Field sheet preparation and presentation.

Textbooks:

a. **Hydrography,** De Jong C.D., Lachapelle G., Skone S., Elema, I.A., (2002), Delft University Press, 353 p. ISBN 90-407-2359-1. Available from Booksurge.com.US$32.50. Note: Chapter 11 of this book (Sounding Methods) is available in PDF at http://mail.vssd.nl/hlf/a033Ch11.pdf

b. **IHO Standards for Hydrographic Surveying**, (1999) International Hydrographic Organization, Special Publication S-44, 4th Edition, IHO, Monaco. Available as a free download in Adobe PDF format at http://iho.shom.fr/publicat/free/files/S-44-eng.pdf

c. **Hydrography for the Surveyor and Engineer,** Ingham, A.E., 3nd Edition, 1992. Blackwell Scientific Publications, Oxford ISBN 0-632-02943-9

d. **Introduction to Oceanography,** Ross, D.A., (1988) 4th Edition, Prentice-Hall Inc., ISBN 0-13-491408-2

e. **Surveying Offshore Canada Lands for Mineral Resource Development** (1982), 3rd Edition, reprints available from Association of Canada Lands Surveyors, 900 Dynes Road, Suite 100E, Ottawa ON K2C 3L6. Tel 613-723-9200, Fax 613-224-9571, email info@cbeps-cceag.ca

f. **Hydrographic Dictionary,** (1994), International Hydrographic Organization Special Publication No. 32, 5th Edition, IHO, Monaco. May be ordered from the Association of Canada Lands Surveyors, 900 Dynes Road, Suite 100E, Ottawa ON K2C 3L6. Tel 613-723-9200, email info@ cbeps-cceag.ca $70.00

References:

a. **Descriptive Physical Oceanography: An Introduction**. Pickard, G.L. and Emery, W.J., 5th Edition, 1990, Pergamon Press ISBN 0-08-026279-1

b. **Principles of Underwater Sound,** Urick, R.J., (1983) 3rd Edition, McGraw-Hill Book Company, Toronto ISBN 0-07-066087-5

c. **Canadian Tidal Manual,** Forrester, W.D., Hydrographic Chart Distribution Office, DFO, 1675 Russell Road, Ottawa, ON. K1G 3H6 ISBN 0-66—11341-4

Note: programmable calculators may be used in this examination.

Schedule II - Item 3

Survey Law

The Canadian Legal System: Case law and precedent; Common Law; Civil Law in Quebec; Expert Witness

Real Property Law: Land use controls; Easements and rights of ways; Reservation; Prescription; Adverse Possession; Limitation of actions

Boundary Law: Creation of boundaries; Principles of evidence; Creation of evidence; Retracement; Artificial boundaries; Natural boundaries; Riparian/Littoral rights; Boundaries; High and low water mark; Erosion and accretion; Dedication and acceptance; Navigable waters; Descriptions of land; Offshore boundaries; Leases at sea.

Case Law: A study of selected cases.

Textbooks:

a. **Survey Law in Canada, A Collection of Essays on the Laws Governing the Surveying of Land in Canada,** Reprints available from the Dept. of Geomatics Engineering, University of Calgary, Calgary, Alberta.

b. **Registration of Title to Land,** Di Castrie R., Carswell, Toronto, ISBN 0-459-35440-X

c. **Cadastral Studies Lecture Notes,** 2000, Cadastral Studies Lecture Notes, 2000, Teskey, W.F. et al, Publication No. 10008, Dept. Geomatics Engineering, The University of Calgary.

References:

a. **Boundary Control and Legal Principles,** 2nd Ed., Brown, Curtis, M., Wiley, 1969. ISBN 0-471-10660-7

b. **Précis de droit de l'arpentage au Québec,** Raymond, G., Girard, G., Laferrière; Ordre des arpenteurs-géometrès du Québec, Québec, QC. 35,00 $ + GST

LEARNING OUTCOMES FOR SCHEDULE II – ITEM 3

1. Understand the basis of the Canadian legal system and how our legal system is affected by case law and precedent.

2. Develop a clear understanding of Federal and Provincial statutes, the Common Law and the Civil Law in Québec as they affect property rights and cadastral surveys.

3. Understand limitations of actions and estoppel.

4. Understand the principles and admissibility of evidence including the role of an expert witness and how an expert witness differs from any other witness.

5. Have a clear understanding of road dedication, easements, rights of way, statutory rights of way and the various means through which they are created.

6. Understand adverse possession, prescription and be able to clearly articulate the differences and similarities.

7. Understand grants, reservations, transfers through deeds and other land related documents.

8. Develop a knowledge of land use controls and how they affect property rights.

9. Have a clear understanding of water boundaries and their definition, the common law doctrines of accretion and erosion and the principles of apportionment, how property rights are affected by the ambulatory nature of water bodies and related case law.

10. Understand clearly riparian and littoral rights and how they have been affected by modern statutes.

11. Understand the classification of waters, offshore boundaries and zones, tenures over bodies of water and at sea, jurisdiction over the offshore, navigability

12. Have a clear understanding of all types of boundaries, their creation and demarcation, descriptions, retracement and reposting, the hierarchy of evidence, etc.

13. Have a good knowledge of historical and modern case law relating to all of the above. Sources include the prescribed and other textbooks, reviews in readily available periodicals such as provincial association publications and Geomatica, the various court system websites, law libraries, public and institutional libraries.

Schedule II - Item 4

Land Use Planning and Environmental Management

The candidates are expected to have a general understanding of how urban planning has evolved in Canada and its present institutional, administrative and legal arrangements as covered in the text. Candidates should be able to relate this knowledge to the jurisdiction in which they work. Candidates are expected to have specific knowledge covered in the texts on (a) how to do a site analysis prior to planning and design, and (b) the criteria that are applicable to the design of residential site and subdivision plans.

The candidates are expected to have a general understanding of the basic concepts in resource management including environmental and ecological concerns that relate to resource development especially in remote areas of Canada.

Textbooks:

a. **The Costs and Benefits of Environmentally Sound Planning Practices.** Ted Martin,1979. Available at CMHC Library, Ottawa. Free. Order by email to chic@cmhc-schl.gc.ca

b. **Site Planning,** Lynch K., 3rd Edition, 1984, M.I.T. Press, Cambridge Mass. ISBN 0-262-12106-9

c. **Environmental Planning Resourcebook,** Reg Lang and Audrey Armour. Published by Lands Directorate, Environment Canada and Supply and Services Canada, Montréal. 1980. Available on loan from Environment Canada Library. ISBN 0-919-86808-8

d. **Planning Canadian Communities:** An Introduction to the Principles, Practice and Participants, Hodge, G.H., 3rd Edition, 1997, Nelson Canada ISBN 0-176-07379-5

References:

a. **Your Guide to who Manages Crown Land in the Northwest Territories,** Indian and Northern Affairs Canada. Available at http://nwt-tno.inac-ainc.gc.ca/pdf/Lands_Guide_English.pdf

b. **An Introduction to Environmental Site Assessments,** 1995, Canada Mortgage and Housing Corporation, Ottawa, NHA 6787E, available free in English and French at CMHC, Tel. 1-800-668-2642. To download: http://www.cmhc-schl.gc.ca/. Click on 'Library', enter publication name in Search box, select 'Entire CMHC Website'.

c. **Environmental Site Assessment Interpretation Guidelines, Research Report, Phase 1,** Canada Mortgage and Housing Corporation, Ottawa, June 1994, available free in English and French at CMHC, Tel. 1-800-668-2642. To download: http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/95-204.pdf

d. **Précis de droit de l'arpentage au Québec,** Raymond, G., Girard, G., Laferrière, A; Ordre des arpenteurs-géomètres du Québec, Québec, QC. 1993 http://www.oagq.qc.ca/PDF/precis.pdf 35,00 $ + TPS

e. **Aménager le territoire. Critères, méthodes et applications; un guide de planification et d'aménagement urbain,** Aubé, P., mai 2000; Ordre des arpenteurs-géomètres du Québec, Québec, QC. *This publication (361 pages) will be of particular interest to candidates who expect to gain specific knowledge related to site analysis prior to planning and design, and to the criteria applicable to the design of residential site and subdivision plans.* http://www.oagq.qc.ca/PDF/amenager.pdf 75,00$ + TPS

f. **The Integrated Community: A Study of Alternative Land Development Standards**
A Report by Central Mortgage and Housing (CMHC), Ottawa, prepared by BLGDG Ltd. and Associates, June 1996, No PE 0207, 106 pages.
http://www.cmhc-schl.gc.ca/publications/en/rh-pr/socio/socio030.pdf

i. **Sustainable Residential Developments: Planning, Design and Construction Principles** A Report by Central Mortgage and Housing (CMHC), Ottawa, prepared by the School of Architecture, McGill University, Montreal, September 1993, No. 6781E, 186 pages.
http://www.cmhc-schl.gc.ca/publications/en/rh-pr/socio/socio015.pdf

LEARNING OUTCOMES FOR SCHEDULE II – ITEM 4

For *Land Use Planning*, the student should be able to demonstrate a general knowledge of land use planning and utilization and be able to describe and explain:

- evolution of land settlement patterns in Canada
- the legal and policy environments for regional, municipal and site-specific planning
- the purpose of regional plans, official community plans and zoning legislation
- the role of the public and other stakeholders in the planning processes
- the process and factors to be considered for conducting a site analysis for planning and design of neighbourhoods and specific site developments. These factors include terrain evaluation, drainage, slope, aspect, landform and geology, vegetation, air quality, climate, noise, local and arterial access and environmental hazards.
- unit densities for land development, site coverage, floor space ratios, building setbacks and other factors
- the use of special site and building restrictions
- special considerations for cold climate design

For *Environmental Management*, the student should be able to demonstrate a general knowledge of sound environmental management practices as they apply to the development of land for residential, commercial, recreational and industrial purposes. The student should be able to identify and explain appropriate processes or measures for:

- appropriate public and stakeholder consultation for proposed land use activities
- access road and trail construction
- evaluating access requirements, impacts and costs
- addressing stream crossing and drainage requirements
- avoiding critical habitat for wildlife species
- identifying potential archaeological sensitivities
- protection of legal survey and control survey monuments
- excavations, quarries and slope stabilization
- fuel handling and storage
- reclamation, including erosion control devices and revegetation

Schedule II - Item 5

Land Information Systems and Management

Geographical Information Systems; the communication paradigm of GIS; data and metadata; data quality; data fusion; representation of spatial data; georeferencing; spatial analysis; digital mapping; spatial representations of the land and GIS data structures; topology and spatial analysis; raster, network and 3-D analysis; information system development strategies; land information systems (LIS), including parcel-based LIS; institutional and organizational issues affecting LIS and the application of GIS technologies, such as: data pricing strategies, access to information, privacy, security, and organizational structures.

Textbooks:

a. **Concepts and Techniques of Geographic Information Systems,** Lo, C. P. and Yeung, Albert K. W., Prentice-Hall, 2002, ISBN 0-130-80427-4

b. **Land Administration,** Dale, P.F. and McLaughlin, J.D. Oxford University Press Canada, Don Mills, Ont. 1999. ISBN 0-198-23390-6

References:

a. **GIS: A Computing Perspective.** Worboys, M.F. and Duckham, M. (2004), Second Edition, CRC Press, ISBN 0415283752

b. **A Study of the Nature of Data Using a Communication-Based Conceptual Framework of Land Information Systems**. Bédard, Y., The Canadian Surveyor, Vol. 40, No. 4, 1986, pp. 449-460.

c. **The Data Warehouse Challenge: Taming Data Chaos**, Brackett, M.H., John Wiley and Sons, 1996 ISBN 0-471-12744-2

d. **Geographic Information Systems: A Management Perspective,** 2nd Edition, 1991, Aronoff, S., WDL Publications, Ottawa, ISBN 0-921-80400-8

LEARNING OUTCOMES FOR SCHEDULE II – ITEM 5

Recommended Pre-examination Studies:

Schedule I – Item 5: Spatial Database Management Systems (Informatics)
Schedule I – Item 6: Map Projections and Cartography

Learning Outcomes:

1. Synthesize and integrate fundamental concepts of GIS theory, methodology and technique, including data models, data structures, topology, spatial data representation, georeferecing, spatial analysis, network and 3-D analysis.

    - Explain basic concepts and terms associated with geographical / land information management and systems.
    - Appreciate the range and diversity of GIS applications in land information management.
    - Describe the functional basis of a LIS/GIS (i.e., how it works), including how it differs from other computerized systems, and why.
    - Identify the different levels of data abstraction and data models and their features.
    - Differentiate the vector and raster methods of geographic data representation, including the representation of spatial relationships, and data processing process.
    - Demonstrate basic GIS software and spatial analysis skills provided by most commercial LIS/GIS systems, as well as basic scientific computing skills.
    - Explain the concepts and methods of GIS modeling.

2. Evaluate different LIS/GIS data collection approaches and data sources that requires the knowledge of data quality, data fusion, metadata management, and other issues such as data pricing, data access policies, privacy, security, and organizational influences.

    - Describe major LIS/GIS data collection approaches and data sources
    - Outline the key data quality issues involved in using LIS/GIS
    - Discuss the importance, possible usage, and components of spatial metadata as related to land information management.

3. Design appropriate implementation procedures and LIS/GIS system development strategies that follow the general software engineering paradigm

- Consider the benefits and shortcomings of using LIS/GIS for a variety of land information management applications.
- Develop a strategy to implement an effective LIS/GIS system.
- Identify the issues of implementing GIS with special reference to: data, people, technology and application.
- Explain the principles and methods of software engineering as applied to LIS/GIS.
- Demonstrate the basic understanding of the implications of some emerging technologies such as Internet/Web technologies.

STUDY GUIDE FOR SCHEDULE II – ITEM 5

Study Guide:

Suggested Readings from Textbooks:

Concepts and Techniques of Geographic Information Systems, Lo, C.P. and Yeung, Albert K.W., Prentice-Hall, 2002: Chapter 1, Chapter 3-7 and Chapter 9-12.

Land Administration, Dale, P.F. and McLaughlin, J.D., Oxford University Press, 1999: Chapter 1, Chapter 5, Chapter 8, and Chapter 9.

Sample Questions:

1. What are the applications of GIS?
2. Why is it difficult to label if a piece of software is a GIS or not?
3. What are the differences between a CAD system and a GIS?
4. What are the similarities and differences between a GIS and an LIS?
5. Describe the way(s) the following three classes of GIS users interact with GIS: (1) Viewers, (2) General users and (3) GIS Specialists.
6. What is a classification scheme and feature code?
7. Describe the concept of layers in a geographic/land information system. Explain why we organize data in layers in LIS/GIS? Compile a list of layers and attributes that would likely be included in a LIS.
8. What are the factors that must be considered when developing a classification scheme?
9. Why is it necessary for GIS software to support both raster and vector formats?
10. List characteristics of vector and raster data model.
11. What are the relative merits and limitations of using raster and vector representations (in terms of data storage, data retrieval, data analysis, etc.)?
12. Give reasons why raster-to-vector conversion is difficult.
13. What is "topology"? Why is the concept of topology important for representing geographic information?
14. Using a simple diagram, explain the three types of topological relationship in geographic data representation.
15. Explain the use of topological relationship in geographic data processing.

16. Give examples of redundant data in a database.
17. What are the advantages and disadvantages of redundant data?
18. Why we need explicit topological data in a GIS database?
19. What is topology building?
20. Describe the map digitizing procedures of converting a paper map into a LIS/GIS database with topological data structure (topology building process).
21. What is the difference between spaghetti digitising and arc digitising?
22. Explain the procedure of creating a topological database starting from map digitising.
23. How is data retrieval different from data analysis?
24. What is the overlay operation and how it can be used to support geographic decision-making?
25. Explain the use of buffer zone generation and overlay in spatial analysis with an example.
26. What is spatial modelling?
27. Why is spatial modelling a difficult task?
28. Why do we say that a buffer zone is the simplest spatial model?
29. Why is it not feasible for commercial GIS software to include too many spatial modelling modules?
30. With the aid of a simple diagram, explain the components of a database management system (DBMS).
31. What are the advantages and disadvantages of storing geographic data in a DBMS?
32. Explain the limitations of conventional DBMS for geographic data management.
33. What is SQL? Give an example of using SQL to retrieve data from a relational table.
34. Given a GIS with two databases, one for spatial attributes and another one for non-spatial attributes, describe what the GIS software would have to do in order to retrieve the non-spatial attributes of a polygon identified by the user by pointing to it on the screen.
35. Similar to the previous questions, describe what the GIS software would have to do in order to draw the outline of the property identified by the user through a query using its non-spatial attributes.
36. With the aid of one or more diagrams, explain the concept and process of geocoding by address matching.
37. Explain the concept and application of network analysis.
38. What is the difference between a 2.5D and 3D model?

39. Are there any differences between a "digital terrain model" (DTM) and (i) "digital elevation model" (DEM) and (ii) "digital terrain elevation data" (DTED)?
40. Describe in detail some commonly-used methods for collecting terrain data.
41. What are the advantages of storing digital terrain in TIN rather than in DEM?
42. What is conceptual data modeling?
43. Define the following terms in conceptual modeling using the entity-relationship (E-R) model: entities, entity types, relations, attributes, and cardinalities of relationships.
44. What is logical data modeling? What is the end product of logical data modeling?
45. What is physical data modeling? What is the end product of physical data modeling?
46. What are the advantages of using the software engineering approach in LIS/GIS implementation?
47. List the activities of systems planning, starting from the forming of the systems planning team to the production of the application development plan.
48. Briefly explain the steps of evaluating and selecting LIS/GIS software
49. Briefly explain the steps of evaluating and selecting hardware for LIS/GIS implementation.
50. Describe the objectives and process of the following tasks in LIS/GIS implementation: populating the geographic database, application software development, software testing, and technology roll-out.
51. Explain why the increasing availability of digital geographic data has not been translated into increasing use of geographic data?
52. Explain the relationship between data ownership, copyright and cost recovery in the use of geographic data.
53. What is metadata? Why is the metadata important to LIS?
54. Describe at least four of the data elements for metadata. What are spatial metadata? What are the benefits of using metadata from both the user and producer perspectives? What are the major uses of metadata?
55. Why is data quality information difficult to obtain?
56. Explain the differences between "accuracy", "precision", "error" and "uncertainly".
57. What are "inherent" sources of data errors? What are "operational" sources of data errors?
58. Explain the following terms with special reference to geographic data: *de facto* standard, *de jure* standard, application standard, data standard, technology standard, and professional standard.
59. What are data transfer standards and interchange formats?

60. How does "data transfer without a common transfer format" differ from "data transfer with a common transfer format"? Why is it so difficult to develop a universally acceptable standard for data interchange?
61. Briefly describe the geographic data standards used in the United States or Canada.
62. Explain why data standard is important for "interoperability of GIS".
63. "The technology issues of GIS today have not very much to do with the lack of inadequacy of technology per se. Instead, they are concerned mainly with the ability of GIS users to evaluate and manage technology". Explain why.
64. The collection of geographic data depends heavily on the use of new technology. Explain the data-related technology issues in LIS/GIS.
65. Explain the three major GIS application issues: breadth and depth of application development; approach to application development; and integration with other types of technology.
66. Why is it necessary to develop custom applications by programming?
67. What is component software? Explain the impacts of using component software in GIS application program.
68. What is a "graphical user interface"?
69. Explain the importance of graphical user interface in the use of GIS.
70. How have concepts and methods of "enterprise computing" affected LIS/GIS development in recent years?
71. Explain the concepts, characteristics and application of a spatial data warehouse.
72. What is "interoperability"? What are the advantages of interoperability in LIS/GIS? What has the GIS industry done to address the issues of interoperability?
73. What is client/server computing?
74. With the aid of a diagram, describe the client/server architecture of GIS.
75. Explain the impacts of the Internet and Web on LIS and GIS developments.

Notes on Your Examination Taking:

1. The correct approach to answering an examination question is to explain with ample illustrations and examples instead of just listing the facts. Wherever appropriate, the examiner(s) welcome answers in point form and in pictures. When you answer in point form, make sure that the list follows a logical flow and not just a random collection of points. When you answer in pictures, make sure that it is adequately annotated.
2. The challenge is to collect the facts, set the priorities, and organize your answer in the allocated time. Your mark is an indication on how well you work under pressure. The “perfect” answer, of course, is one that would make anybody understand regardless of his or her background. This is not achievable in an examination setting. What the examiner(s) need to know is how good you can approximate the impossible “perfect” answer in the time available. The best approach is a top-down one, which is to identify the essential points and expand from there. In other words, always spend a minute or two to plan your answer before you start writing.

Schedule II - Item 6

Business: Law, Administration and Economics

Nature of economics; the price system, production and cost; Government and business, Macroeconomics.

Sources of law; Court systems in Canada; Conditions of contract; Principal and agent; Real property law.

Forms of business organization; Proprietorship, partnership, corporation, joint venture/consortium; Responsibilities of partners and directors; Protection of shareholders, employees and creditors;

The business plan; Capitalization; Banking practices; Cash flow projections; Securing credit; Loans and chattel mortgages, collateral security; Assignment of book debts; Bankruptcy; Securities legislation; Flow-through share issuance; income distribution options; Taxation as it applies to professionals in proprietorships, partnerships and corporations; statutory employer assessments and obligations.

Textbooks:

a. **The Law and Business Administration in Canada**, Smyth, J.E., Soberman, D.A. and Easson, A.J., 11th Edition, Pearson Prentice Hall Canada, Toronto, 2007. ISBN 0-13-196978-1

b. **Introduction to Economics, Stephen D. Casler**, paperback 480 pages, Harper-Collins Canada Limited. ISBN-0064671135

c. **CCLS PLIC – Loss Prevention Practice Management Guide**, pdf format available on CCLS website at www.ccls-ccag.ca

d. **See additional web links** listed under Study Guide for Schedule II – Item 6

References:

a. **Law for Professional Engineers,** Marston, Donald L. 3rd Edition, 1996, McGraw-Hill Ryerson, Toronto. ISBN: 0-07-552628-X

LEARNING OUTCOMES FOR SCHEDULE II – ITEM 6

Recommended pre-examination Studies:

None

Learning Outcomes:

Ability to demonstrate familiarity with a broad range of topics related to business law, administration and economics. Able to:

1. Describe the legal system in Canada in terms of:
   - Sources of law
   - Law making process
   - Types of law – public, private, administrative, contract, torts, criminal, commercial, tax, etc.
   - Courts system - federal and provincial

2. List and explain:
   - Contract components and requirements – major elements of a contract; who can legally enter into a contract; how a contract can be discharged;
   - Agency principles – relationship between an agent and a principal; obligations and rights of each party; limitations of agency
   - Real property law principles – what is real property; division of powers between federal and provincial governments; different types of real property ownership
   - Rights and interests in land – public, private, aboriginal; types of estates; encumbrances, caveats and liens; easements and covenants
   - Land registration systems – types in use in Canada and their differences; advantages and disadvantages of each type
   - Land survey systems – what are they; how do they fit in with land registration systems; what are the principal components

3. Describe and differentiate a variety of business law basics such as:
   - Forms of business organization – private and public corporations; sole proprietorship; partnership; corporation
   - Income distribution in the various forms of business organizations
   - Roles, duties and responsibilities of partners, directors, shareholders, creditors and employers; protection afforded to each

- Professional liability issues and contracts – professional liability insurance; class action; contractual liability
- Construction and mechanics liens – what are they and how to use them
- Business financing – debt and equity; bank loans; flow-through shares; private placement

4. Describe the nature of economics:
   - Differences between macroeconomics and microeconomics
   - Role of pricing system, production and cost in the Canadian economy
   - Role of government and business in shaping the Canadian economy – fiscal policy; monetary policy; interest rate; productivity; employment; demand and supply
   - Impact of global economy on the Canadian economy

STUDY GUIDE FOR SCHEDULE II – ITEM 6

1. Legal system in Canada –

Chapter 2 - The Law and Business Administration in Canada, Smyth, J.E., Soberman, D.A. and Easson, A.J., 11th Edition, Pearson Prentice Hall Canada, Toronto, 2007. ISBN 0-13-196978-1

The Canadian Legal System, 5th ed., Gerald L. Gall
Thomson Carswell, July 2004

http://canada.justice.gc.ca/en/dept/pub/just/index.html - The judicial structure

http://www.justice.gc.ca/en/jl/index.html - Canada's court system

http://www.mta.ca/faculty/arts/canadian_studies/english/about/law/ - The law making process and sources of law

2. Contracts, agency, real property, land rights and interests; land registration and land survey systems

Part 3 & 4; Part 5, Chapters 23, 25 - The Law and Business Administration in Canada, Smyth, J.E., Soberman, D.A. and Easson, A.J., 11th Edition, Pearson Prentice Hall Canada, Toronto, 2007. ISBN 0-13-196978-1

http://www.duhaime.org/contract/ - Contract law, agency, real property

www.caplacanada.org/download_file.php?id=4 – glossary of land terms

http://www.tbs-sct.gc.ca/pubs_pol/dcgpubs/realproperty/rpg-gbi_e.asp - real estate glossary

http://www.srd.gov.ab.ca/fw/fishing/surveysystem.html - land survey system

http://ess.nrcan.gc.ca/2002_2006/pri/serv_e.php - land survey system

3. Business law basics

Part 2, Chapter 4; Part 6; Part 7; - The Law and Business Administration in Canada, Smyth, J.E., Soberman, D.A. and Easson, A.J., 11th Edition, Pearson Prentice Hall Canada, Toronto, 2007. ISBN 0-13-196978-1

CCLS PLIC – Loss Prevention Practice Management Guide, pdf format available on www.ccls-ccag.ca

4. Economics

Macroeconomics and microeconomics
http://www.investopedia.com/ask/answers/110.asp

General
http://www.investopedia.com/university/economics/

Fiscal policy
http://www.finpipe.com/fiscpol.htm

Monetary policy
http://www.finpipe.com/monpol.htm
http://www.bankofcanada.ca/en/monetary/monetary_main.html
http://www.canadianencyclopedia.ca/index.cfm?PgNm=TCE&Params=A1ARTA0005380

Global economy and Canada
http://www.dfait-maeci.gc.ca/ciw-cdm/economy/economy-en.asp?menu=4&submenu=1