CERTIFIED ANALYTICS PROFESSIONAL

Candidate Handbook

CERTIFIED ANALYTICS PROFESSIONAL (CAP®) PROGRAM & EXAM

Candidate Handbook

INFORMS
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INTRODUCTION

About INFORMS

The Institute for Operations Research and the Management Sciences (INFORMS) is the leading international professional society of more than 12,500 operations research (O.R.) and analytics professionals and students. INFORMS promotes best practices and advances in O.R., the management sciences, and analytics to improve operational processes, decision making, and outcomes through an array of highly-cited publications, conferences, competitions, networking communities, and professional development services. INFORMS is committed to meeting the professional needs of those who develop, apply, research, and teach advanced analytics, O.R., and the management sciences.

About the INFORMS CAP Program

INFORMS is pleased to offer the Certified Analytics Professional (CAP®) program, the professional certification program that meets the needs of analytics professionals by: (1) validating analytics knowledge and ability; (2) differentiating analytics professionals from their peers; and (3) enhancing professionals' analytics knowledge and ability. The Certified Analytics Professional program was developed in 2011–2012. The first exam was administered on April 7, 2013, at the INFORMS Business Analytics Conference, April 7–9, in San Antonio, Texas.

The INFORMS CAP program advances the field of analytics by setting standards by which organizations can identify and develop qualified analytics professionals. Achieving the certification contributes to the career success and continued competence of analytics professionals. The CAP also reinforces the credibility and visibility of the analytics profession.

INFORMS defines "analytics" as the scientific process of transforming data into insight for making better decisions. Analytics begins with identifying the business problem and proceeds with evaluating it using statistical tools and methodologies to arrive at a solution, a process in which analytics professional are skilled.

INFORMS is the first professional nonprofit organization to develop a formal certification program for analytics professionals. Key components of the CAP program include:

1. Formal credentialing requirements, including a standardized exam and required renewal process;

2. Program content based on the findings of a job task analysis working group, whose members represent a broad background of analytics practitioners (see the section, "The Job Task Analysis");

3. Agreed-upon eligibility criteria consisting of academic preparation, work experience in analytics, and employer confirmation of adequate mastery of analytics soft skills;

4. Certification program content that is both software- and vendor-neutral; and

5. Successful completion of the certification process, confirming to both the certified professionals and their employers the set of core analytics skills they bring to a project team.

The CAP exam measures performance across the seven major areas, or domains, of analytics practice: business problem framing, analytics problem framing, data, methodology selection, model building, deployment, and model life cycle management. See the "The Job Task Analysis" section for more about the end-to-end process evaluated by the exam.

The CAP exam assesses a breadth of knowledge across the seven domains, and not a depth of knowledge in any one particular area. Those interested in taking the CAP exam should consider themselves to be analytics professionals or semi-professionals, and not analytics amateurs. They should be interested in adhering to the highest standards of analytics practice and pursuing continual professional development. See the "Eligibility Requirements" section for more on qualifying for the CAP exam.

CAP program development formally began in August 2011, when INFORMS established the INFORMS Certification Task Force to plan and develop this new analytics certification.

Members of the original INFORMS Certification Task Force included:

- Terry Harrison, CAP (Penn State University)
- Lisa Kart, CAP (Gartner)
- Bill Klimack (Chevron)
- David Leonhardi (Boeing)
- Jack Levis (UPS)
- Vijay Mehrotra (University of San Francisco)
- Paul Messinger, CAP (University of Alberta)
- Polly Mitchell-Guthrie (Kinaxis)
- Scott Nestler, CAP (University of Notre Dame)
- Michael Rappa (North Carolina State & Institute for Advanced Analytics)
- Barry Thomas (University of Iowa)

Following the first CAP exam in April 2013, an independent Analytics Certification Board (ACB) began overseeing the INFORMS analytics certification program. The ACB replaced the INFORMS Certification Task Force and became the official governing body. The ACB has independent authority to make all final decisions regarding program procedures, program content, approval of applicants, and granting of certification. The ACB functions independently of INFORMS. Visit certifedanalytics.org/analytics-certification-board for a current list of ACB members.

Vision and Mission Statement of the CAP Program

Vision: To advance the use of analytics to transform the world by setting agreed-upon standards of practice.

Mission: To advance the analytics profession by providing a high-quality program of certification and promoting continuing competence for practitioners.

Nondiscrimination Policy

INFORMS does not discriminate among candidates based on race, color, creed, gender, age, religion, national origin, ancestry, disability, military discharge status, sexual orientation, or marital status. INFORMS adheres to all applicable laws and regulations pertaining to nondiscrimination practices. INFORMS will arrange for reasonable accommodation for any individual requesting it.

Eligibility Requirements (Eligibility requirements for CAP certification include the following.)

Education and Experience

A candidate's number of years of analytics work experience determines the education requirement to be eligible for the CAP exam. Applicants must have one of the following combinations:

- At least two years of professional analytics work experience for individuals with an MA/MS degree or higher.

- At least four years of professional analytics work experience for individuals with a BA/BS degree.

- At least eight years of professional analytics work experience for individuals with any level of education or without a degree.

Applicants must provide proof of professional experience, including company/employer name; name, title, and contact information of immediate supervisor; and dates of employment. An applicant's degree must be obtained from a regionally accredited college or university recognized by the U.S. Department of Education or equivalent entity if from another country. Applicants with less than eight years of professional analytics work experience must provide proof of their degree by submitting a copy of their educational course transcript.

Degree Level	Degree Area	Experience
MS/MA or Higher	Analytics-related area	2 Years
BS/BA	Analytics-related area	4 Years
Any level of education/ BA or Higher	Non-analytics-related area	8 Years

Effectiveness

An important trait of a CAP is the demonstrated achievement of soft skills in addition to the knowledge, skills, and abilities covered by the CAP exam process. These "soft skills" include:

- The ability to communicate with a client/employer regarding the framing of an analytics problem;

- Understanding the client's/employer's organizational identity and industry focus; and

- The ability to convey a clear understanding of the findings of the analytics process to the client/employer.

The CAP program requires confirmation by a current or prior supervisor that the applicant has acceptable proficiency in the skills enumerated above. Such confirmation must be in documentation form and accompanied by the electronic signature of the supervisor. The supervisor may not be a relative of the candidate.

Candidates unable to obtain such confirmation who can demonstrate having put forth a reasonable effort to contact a past employer, client, or acceptable substitute may submit a summary of a recent analytics project describing in detail the soft skills applied in the successful completion of the project and in the implementation of its findings. Candidates choosing this option should contact INFORMS staff for additional instructions. Representatives of the ACB may additionally require a telephone interview with the candidate to assess the candidate's soft skills.

Ethics

Applicants must pledge to adhere to the Code of Ethics (see page 27) for analytics practitioners.

Exam

Applicants for CAP certification must pass an exam based on analytics practice. The practice parameters are detailed in the Job Task Analysis (JTA). All items in the exam are directly linked to the JTA.

The Job Task Analysis

The JTA defines the current knowledge, skills, and abilities (KSAs) needed to provide these services effectively. KSAs are validated by their frequency of use and importance. The JTA also serves as a blueprint for the content (performance domains) of the INFORMS CAP exam.

INFORMS upholds stringent guidelines for the development and administration of the exam. A panel of subject matter experts (SMEs) was selected to develop the first Job Task Analysis for the CAP credential.

The findings of this panel were then distributed to practicing analytics professionals, whose feedback informed adjustments to the performance domains, tasks, and knowledge comprising the blueprint used for determining the content of the CAP exam.

The table below lists the domains derived from the JTA and their approximate weight in the certification exam. The final weights are determined by the percentage of questions included from each domain in the actual exam.

Domain	Approximate Weight
I. Business Problem (Question) Framing	14%
II. Analytics Problem Framing	17%
III. Data	23%
IV. Methodology (Approach) Selection	14%
V. Model Building	16%
VI. Deployment	10%
VII. Model Life Cycle Management	6%

The JTA and its resulting blueprint are reviewed periodically and updated as needed to reflect current practices in analytics. The following list of domains also includes the key tasks associated with each domain.

(14%)   Domain I: Business Problem (Question) Framing

The ability to understand a business problem and determine whether the problem is amenable to an analytics solution.

- **T-1**   Identify initial problem statement and desired outcomes
- **T-2**   Identify stakeholders and their perspectives
- **T-3**   Determine if the problem can be effectively addressed by analytics
- **T-4**   Refine the problem statement and identify business constraints
- **T-5**   Define an initial set of business costs and benefits
- **T-6**   Obtain stakeholder agreement on the business problem framing

(17%)   Domain II: Analytics Problem Framing

The ability to reformulate a business problem into an analytics problem with a potential analytics solution.

- **T-1**   Reformulate problem statement as an analytics problem
- **T-2**   Develop a proposed set of drivers and relationships to outputs
- **T-3**   State the set of assumptions related to the problem
- **T-4**   Define key metrics of success
- **T-5**   Obtain stakeholder agreement on the analytics problem framing

(23%)   Domain III: Data

The ability to effectively work with data to help identify potential relationships that will lead to refinement of the business and analytics problem.

- **T-1**   Identify and prioritize data needs and sources
- **T-2**   Acquire data
- **T-3**   Clean, transform, and validate the data
- **T-4**   Identify relationships in the data
- **T-5**   Document and report findings (e.g., insights, results, business performance)
- **T-6**   Refine the business and analytics problem framing

(14%)   Domain IV: Methodology (Approach) Selection

The ability to identify and select potential approaches for solving the business problem.

- **T-1**   Identify available problem solving methodologies (approaches)
- **T-2**   Evaluate methodologies (approaches)[1]
- **T-3**   Select approaches (methods)[1]

(16%)   Domain V: Model Building

The ability to identify and build effective model structures to help solve the business problem.

- **T-1**   Identify model structures[1]
- **T-1a** Build and verify the models
- **T-2**   Run and evaluate the models

[1] Tasks that are beyond the scope of the certification exam and that will not be tested.

(16%) Domain V: Model Building (Continued)

- **T-3**   Calibrate models and data[1]

- **T-4**   Integrate the models[1]

- **T-5**   Document and communicate findings (including assumptions, limitations, and constraints)

(10%) Domain VI: Deployment

The ability to deploy the selected model to help solve the business problem.

- **T-1**   Perform business validation of the model

- **T-2**   Deliver report with findings; and/or

- **T-3**   Create model, usability, and system requirements for production

- **T-4**   Deliver production model/system[1]

- **T-5**   Support deployment

(6%)   Domain VII: Model Life Cycle Management

The ability to manage the model life cycle to evaluate business benefit of the model over time.

- **T-1**   Create document

- **T-2**   Track model performance

- **T-3**   Recalibrate and maintain the model[1]

- **T-4**   Support training activities

- **T-5**   Evaluate the business benefit of the model over time

[1] Tasks that are beyond the scope of the certification exam and that will not be tested.

EXAM APPLICATION & SCHEDULING

Steps in the CAP Certification Process

1. The potential applicant determines whether they meet the eligibility requirements detailed in the Eligibility Requirements section.

2. The applicant signs in or creates a profile at https://app.prolydian.com/organizations/INFORMS. It is recommended that candidates use a personal email address instead of a work email address when creating their profile. This allows for continuous communication in case of a job change.

3. The applicant provides contact information for a current or recent supervisor of analytics in the workplace.

4. Applicant provides an electronic version of unofficial transcripts (in English). This is not a copy of the diploma and must document the required academic preparation for the CAP credential.

5. Applicant completes, submits payment of the application fee, and submits the online application.

6. INFORMS staff reviews the application to confirm the applicant's eligibility. When an application is approved, the candidate is eligible to sit for the exam within 12 months from their application approval date..

7. Once a candidate's application is approved, they will receive instructions to pay for their exam. Upon payment, the candidate will be set up as a test taker with the CAP exam provider Kryterion Webassessor. Exams are offered both remotely and at test centers. Exam sites are listed at https://www.kryterion.com/locate-test-center/.

8. The candidate takes the exam at the selected exam site.

9. The candidate receives an official score report noting pass/fail immediately following completion of the exam. No other score report will be issued.

10. Eligible candidates who pass the exam will receive an email with a link to the candidate's credential within two weeks of successful exam completion. Candidates who fail the exam should begin a process of targeted professional development to address the areas of weak performance cited in the score report.

11. All CAP certification holders must renew their certification every three years. See the "Certification Renewal Process" section for more information. *Note: Certification is granted only to individuals who meet all eligibility requirements and achieve a passing score on the exam. Special exceptions of certification status are not permitted for any candidates failing to meet these requirements.*

Application and Payment Process

www.certifiedanalytics.org

To apply for the CAP certification exam, please follow these steps:

1. Complete and submit to INFORMS the "CAP/aCAP Certification Application and Agreement" form online at app.prolydian.com/organizations/INFORMS.
2. Submit an electronic version of unofficial transcripts (in English). This is not a copy of the diploma and must document the required academic preparation for the CAP credential.
3. Provide contact information for a current or recent supervisor who will complete the "Confirmation Statement on Analytics Soft Skills" form online.
4. Agree to the Code of Ethics.
5. Submit Application Fee, and electronically sign and submit the Application Agreement.
6. Once an application has been accepted, pay the exam fee to INFORMS.

INFORMS processes applications within seven business days of receipt of application, payment, and accompanying documents. Payment of the certification fees may be made by: credit card from a U.S. issuing bank (Mastercard, Visa, American Express or Discover), check made payable to INFORMS in U.S. dollars drawn on a U.S. bank, or wire transfer from a U.S. bank (contact INFORMS for details).

Fees and Refunds

Fees are subject to change. INFORMS offers discounts on certification fees to current INFORMS members. INFORMS may offer discounts to other certification partners. If your organization is interested in becoming a certification partner, please contact INFORMS. Refunds may be provided in some circumstances, but not after a candidate has begun an exam. INFORMS reserves the right to impose a processing fee on certification exam refunds. Application fees are nonrefundable. Exam fees are nonrefundable after a candidate's eligibility expires or 90 days after payment., whichever date comes first.

The following fees are currently approved for the CAP program:

Application Fee (Nonrefundable)	$55	Recertification/Reinstatement Fee	$120
Regular Exam Fee	$640	INFORMS Member[a] Recertification Fee (Before CAP expiration)	$40
INFORMS Member[a] Exam Fee	$440	INFORMS Member[a] Reinstatement Fee (Within 6 months after CAP expiration)	$80
INFORMS Member from Developing Countries[b] Exam Fee	$220	INFORMS Member from Developing Countries[b] Recertification Fee (Before CAP expiration)	$20
Reexamination Fee[c]	$400	INFORMS Member from Developing Countries[b] Reinstatement Fee (Within 6 months after CAP expiration)	$40
INFORMS Member Reexamination Fee[c]	$300	Approved Refunds Processing Fee	$100
Rescheduling Fee[d]	$100	Appeals Processing Fee	$350

Contact INFORMS to inquire about group rates.

[a] Applicants must be members of INFORMS in good standing at the time of application to receive the member discount. No refunds will be granted for applicants joining INFORMS after submission of certification application materials.

[b] Applicants must be members of INFORMS, from an INFORMS-designated developing country, in good standing at the time of application to receive the member from a developing country discount. No refunds will be granted for applicants joining INFORMS after submission of certification application materials.

[c] Reexamination fees apply to second and third CAP exam attempts within a candidate's 12 months of eligibility. Exams scheduled past a candidate's eligibility period will be canceled and exam fees will be forfeited.

[d] Exams may be rescheduled free of charge if done at least 72 hours in advance of the scheduled exam date. Otherwise a rescheduling fee will be incurred.

Scheduling an Exam

After an application is approved and the exam fee paid, candidates will receive an email from the exam provider in 3-5 business days with instructions for scheduling the exam. Exams may only be scheduled and taken within a candidate's eligibility period (12 months from their application approval date, not the date the exam fee was paid). Exams scheduled past a candidate's eligibility period will be canceled and exam fees will be forfeited.

Modifying/Missing a Scheduled Exam Date

Should the need arise to reschedule a CAP exam, candidates must do so through the exam vendor's site at least three business days prior to the scheduled exam date, except in cases of emergency (see below). Candidates doing so will have their exam rescheduled at no additional cost.

Candidates wishing to cancel the exam may receive a refund of the exam fee less a $100 processing fee if their refund request is submitted within 90-days of exam payment and before their exam eligibility has expired. Candidates requesting to cancel their exams less than three business days before their scheduled exam date will not receive a refund and will be required to pay a rescheduling fee to reschedule their exams.

Candidates who arrive more than 15 minutes late or fail to arrive for a scheduled exam forfeit their exam fees.

INFORMS understands that there may be situations when cancellations are required by circumstances beyond the candidate's control, including:

- Natural disasters;
- Medical emergencies;
- Travel cancellations;
- Death or illness of an immediate family member;
- Inclement weather; and
- Exam facility power failure.

INFORMS staff will handle these situations on a case-by-case basis. Candidates will be expected to submit written and possible supporting documentation to avoid a cancellation penalty. In the event of exam cancellation due to inclement weather, power failure, or other unforeseen circumstances that make holding the exam untenable, affected candidates will be able to reschedule at no additional cost.

Special Exam Arrangements

Candidates with Disabilities

INFORMS complies with the Americans with Disabilities Act (ADA). INFORMS strives to ensure that no individual with a documented disability is deprived of the opportunity to take the certification exam solely by reason of that disability provided that reasonable special accommodations can be made.

To request special accommodations, candidates must complete the INFORMS Certification Exam Special Accommodations form at https://share.hsforms.com/1xmnAGWH7Q6KCkpYjnKIVBQ21xem?utm_referrer=https%3A%2F%2Fwww.certifiedanalytics.org%2F. The form includes a statement of the disability and a space for verification by a medical or mental health professional. Candidates must provide all documentation with their application and fees at least 45 days prior to a desired exam date. INFORMS also requires that applicants notify INFORMS of any requests for special accommodations prior to scheduling the exam.

◖ PREPARING FOR THE EXAM

The CAP exam is a written exam composed of 100 multiple-choice questions, each with four possible answers. There is only one correct answer for each question. Candidates are given three hours to complete the exam.

Sample Exam Questions

The following sample exam questions were developed by SMEs in the analytics field. At the end of this list of questions is the answer key. These sample questions will never appear in an actual CAP exam.

The 23 questions published here are intended to familiarize certification candidates and potential certification candidates with the format of the questions that appear on the exam. They are also intended to provide a sample of the content (knowledge and skill) assessed by the certification exam. These questions are not intended as a self-assessment instrument, nor should they be used to predict success or failure on the exam. Candidates should bear in mind that the exam is a pass/fail assessment, and that passing does not require all questions to be answered correctly.

The rationale for correct answers is provided at the end of this section. The rationales for both the correct and incorrect responses can be found in the Candidate Handbook and at certifiedanalytics.org/sample-test.

1. A box and whisker plot for a dataset will MOST clearly show:

   a. The difference between the second quartile and the median.
   b. The 90% confidence interval around the mean.
   c. Where the [actual-predicted] error value is not zero.
   d. If the data is skewed and, if so, in which direction.

2. Which of the following BEST describes the data and information flow within an organization?

   a. Information assurance
   b. Information strategy
   c. Information mapping
   d. Information architecture

3. A clothing company wants to use analytics to decide which customers to send a promotional catalog in order to attain a targeted response rate. Which of the following techniques would be the MOST appropriate to use for making this decision?

   a. Integer programming
   b. Logistic regression
   c. Analysis of variance
   d. Linear regression

4. Which of the following is an effective optimization method?

   a. Analysis of variance (ANOVA)
   b. Generalized linear regression model (GLM)
   c. Box-Jenkins Method (ARIMA)
   d. Mixed-integer programming (MIP)

5. After building a predictive model and testing it on new data, an under-prediction by a forecasting system can be detected by its:

   a. Negative-squared
   b. Bias
   c. Mean absolute deviation
   d. Mean squared error

6. A furniture maker would like to determine the most profitable mix of items to produce. There are well-known budgetary constraints. Each piece of furniture is made of a predetermined amount of material with known costs, and demand is known. Which of the following analytical techniques is the MOST appropriate to solve this problem?

    a. Optimization
    b. Multiple regression
    c. Data mining
    d. Forecasting

7. In the initial project meeting with a client, which is the MOST important information to obtain?

    a. Timeline and implementation plan
    b. Analytical model to use
    c. Business issue and project goal
    d. Available budget

8. Which of the following statements is true of modeling a multi-server checkout line?

    a. A queuing model can be used to estimate service rates.
    b. A queuing model can be used to estimate average arrivals.
    c. Variability in arrival and service times will tend to play a critical role in congestion.
    d. Poisson distributions are not relevant.

9. A preferred method or best practice for organizing data in a data warehouse for reporting and analysis is:

    a. Transactional-based modeling
    b. Multidimensional modeling
    c. Relation-based modeling
    d. Tuple-based modeling

10. The monthly profit made by a clothing manufacturer is proportional to the monthly demand, up to a maximum demand of 1,000 units, which corresponds to the plant producing at full capacity. (Any excess demand over 1,000 units will be satisfied by some other manufacturer, and hence yield no additional profit.) The monthly demand is uncertain, but the average demand is reliably estimated at 1,000 units. At this level of demand the monthly profit is $3,000,000. Which of the following statements must be true of the expected monthly profit, P?

    a. P can have any positive value.
    b. P is possibly greater than $3,000,000.
    c. P is equal to $3,000,000.
    d. P is less than $3,000,000.

11. One of the main advantages of tree-based models and neural networks is that they:

    a. are easy to interpret, use, and explain.
    b. build models with higher R-squared than other regression techniques.
    c. reveal interactions without having to explicitly build them into the model.
    d. can be modeled even when there is a significant amount of missing data.

12. A company is considering designing a new automobile. Their options are a design based on current gasoline engine technology or a government proposed "Green" technology. You are a government official whose job is to encourage automakers to adopt the "Green" technology. You cannot provide funding for development or production costs, but you can provide a subsidy for every car sold. The development costs and the wholesale price, in USD ($), of the cars are shown in the following table:

	Gasoline Technology	"Green" Technology
Production Wholesale Price/Vehicle	25,000	40,000
Variable Cost/Vehicle	15,000	35,000
Fixed Development Cost	100,000,000	200,000,000

How large a subsidy per vehicle sold will be required, assuming there will be enough demand to motivate the switch?

    a. Greater than $5,000
    b. Less than $5,000
    c. Cannot be determined
    d. Equal to $5,000

14. A project seeks to build a predictive data-mining model of customer profitability based upon a series of independent variables including customer transaction history, demographics, and externally purchased credit-scoring information. There are currently 100,000 unique customers available for use in building the predictive model. Which of the following strategies would reflect the BEST allocation of these 100,000 customer data points?

    a. Use 70,000 randomly selected data points when building the model and hold the remaining 30,000 as a test dataset.
    b. Build the model using all 100,000 data points.
    c. Randomly partition the data into four datasets of equal size, build four models and take their average.
    d. Use 1,000 randomly selected data points when building the model.

15. You have simulated the net present value (NPV) of a decision. It ranges between -$10 million and +$10 million. To BEST present the likelihood of possible outcomes, you should:

    a. Present a single NPV estimate to avoid confusion.

    b. Present a histogram to show the distribution of various NPV estimates.

    c. Trim all outliers to present the most balanced diagram.

    d. Relax constraints associated with extreme points in the simulation.

16. Two investors who have the same information about the stock market buy an equal number of shares of a stock. Which of the following statements MUST be true?

    a. The risks for the two investors are statistically independent.

    b. Both investors are subject to the same risks.

    c. Both investors are subject to the same uncertainty.

    d. If the investors are optimistic, they should have borrowed, rather than bought the shares.

17. A segmentation of customers who shop at a retail store may be performed using which of the following methods?

    a. Markov chain Monte Carlo and ANOVA

    b. Clustering, factor, and control charts

    c. Decision tree and recursive function analyses

    d. Clustering and decision tree

18. A company ships products from a single dock at their warehouse. The time to load shipments depends on the experience of the crew, products being shipped, and weather. The company thinks there is significant unmet demand for their products and would like to build another dock in order to meet this demand. They ask you to build a model and determine if the revenue from the additional products sold will cover the cost of the second dock within two years of it becoming operational. Which of the following is the MOST appropriate modeling approach?

    a. Optimization, because it is a transportation problem.

    b. Optimization, because the company's objective to maximize profit and capacity at the dock is a limited resource.

    c. Forecasting, because you can determine the throughput at the dock, calculate the net revenue, and compare this with the cost of the new dock.

    d. Discrete-event simulation, because there is a sequence of discrete random events through time.

19. An analytics professional is responsible for maintaining a simulation model that is used to determine the staffing levels required for a specific operational business process. Assuming that the operational team always uses the number of staff determined by the model, which of the following is the MOST important maintenance activity?

    a. Ensure that all the model input data items are available when needed.

    b. Determine if there has been a change in model accuracy over time.

    c. Ensure that all users are reviewing the model results in a timely fashion.

    d. Determine that the model's reports are understood by the users.

20. In the following diagram, what is true of Strategy B compared to Strategy A?

Cumulative Probability Curves: NPV - Millions US$
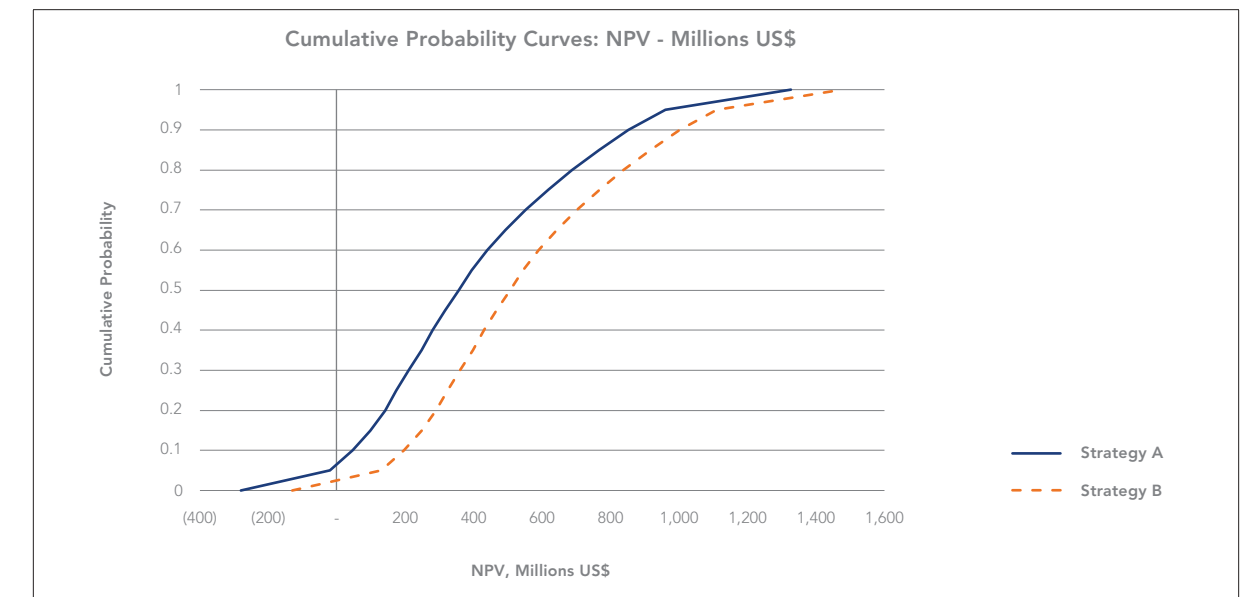
    a. Strategy B exhibits stochastic (probabilistic) dominance over Strategy A.

    b. Strategy B has the same downside risk as Strategy A since the curves have the same shape.

    c. Strategy A exhibits stochastic (probabilistic) dominance over Strategy B.

    d. Strategy B must have the same uncertainties impacting it as Strategy A because the curves are so similar in shape.

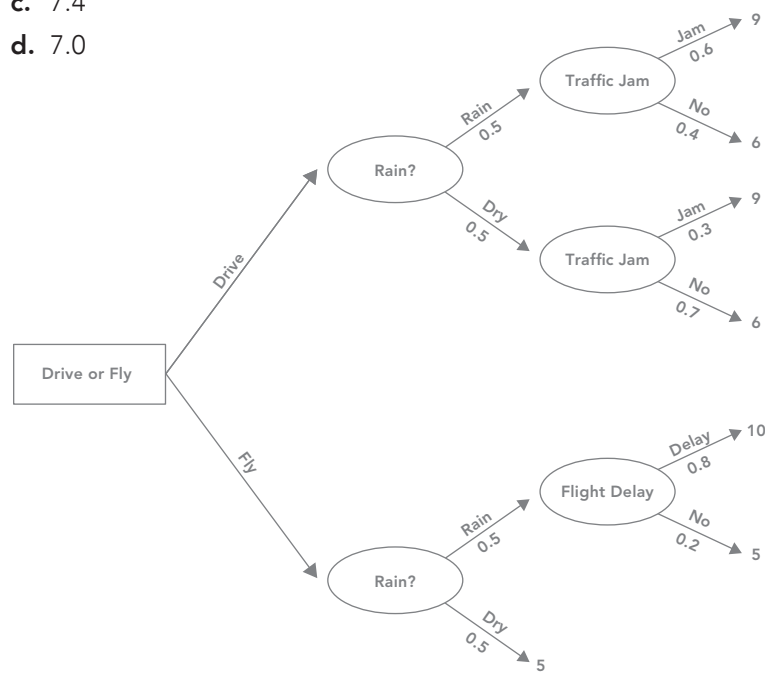**21.** Each month you generate a list of marketing leads for direct mail campaigns. Which of the following should you do before the list is used?

    a. Exclude people who were on the list the previous month.

    b. Retain x% of the leads as control for performance measurement.

    c. Remove opt-outs.

    d. Exclude people who were never on the list.

22. Conjoint analysis in market research applications can:

    a. give its best estimates of customer preference structure based on in-depth interviews with a small number of carefully chosen subjects.

    b. only trade off relative importance to customers of features with similar scales.

    c. allow calculation of relative importance of varying features and attributes to customers.

    d. only trade off among a limited number of attributes and levels.

23. When analyzing responses of a survey of why people like a certain restaurant, factor analysis could reduce the dimension in which of the following ways?

    a. Collapse several survey questions regarding food taste, health value, ingredients, and consistency into one general unobserved "food quality" variable.

    b. Condense similar survey respondent answers into clusters of like-minded customers for market segment analysis.

    c. Reduce the variability of individual subject ratings by centering each respondent's ratings around his or her average rating.

    d. Decrease variability by analyzing inter-rater reliability on the question items before offering the survey to a wide number of respondents.

24. All times in the decision tree below are given in hours. What is the expected travel time (in hours) of the optimal (minimum travel time) decision?

    a. 7.8
    b. 6.9
    c. 7.4
    d. 7.0

Correct Answers

Question #	Answer	Question #	Answer	Question #	Answer
1.	d	9.	b	17.	d
2.	d	10.	d	18.	b
3.	b	11.	c	19	a
4.	d	12.	a	20.	c
5.	b	13.	a	21.	c
6.	a	14.	b	22.	a
7.	c	15.	c	23.	d
8.	c	16.	d		

Distribution of Sample Questions per Domain

Domain	Questions
Domain I: Business Problem Framing	Questions 7, 12, 14, 15
Domain II: Analytics Problem Framing	Questions 8, 10, 16, 21
Domain III: Data	Questions 1, 2, 9, 22
Domain IV: Methodology (Approach) Selection	Questions 3, 4, 6, 17
Domain V: Model Building	Questions 11, 13, 19, 23
Domain VI: Deployment	Questions 5, 20
Domain VII: Model Life Cycle Management	Question 18

Rationale for Correct Answers

1. **d) If the data is skewed and, if so, in which direction.**

    A box and whisker plot, sometimes just called a "box plot," was invented by John Tukey as a way to graphically display the distribution of data. The ends of the box are at the first and third quartiles, and there is a line somewhere in the box representing the median value. The whiskers extend either to the minimum and maximum values in the dataset, or possibly less if they do not include points identified as outliers.

2. **d) Information architecture**

    Information architecture refers to the analysis and design of the data stored by information systems, concentrating on entities, their attributes, and their interrelationships. It refers to the modeling of data for an individual database and to the corporate data models that an enterprise uses to coordinate the definition of data in several (perhaps scores or hundreds) distinct databases.

3. **b) Logistic regression**

    This type of classification model is often used to predict the outcome of a categorical dependent variable (response vs. no response) based on one or more predictor variables, so this is the most appropriate answer. The goal of the analytics in the stated problem is to determine who is most likely to respond, and the binary nature of this predicted outcome is provided by logistic regression.

4. **d) Mixed integer programming (MIP)**

    This is a mathematical optimization technique used when one or more of the variables are restricted to be integers. It is an effective optimization model.

5. **b) Bias**

    The bias measures the difference, including the direction of the estimate and the right answer. Depending on whether it's positive or negative, it will show whether there is an over or under estimate.

6. **a) Optimization**

    The problem statement describes an optimization problem: the furniture maker's objective function is to maximize his profit. The decision variables are the amount of each item to produce, and the constraints are that he must meet demand and stay within his budget. Optimization is the most appropriate technique to solve this problem.

7. **c) Business issue and project goal**

    Understanding the business issue and project goal provides a sound foundation on which to base the project.

8. **c) Variability in arrival and service times will tend to play a critical role in congestion.**

    Arrival and service time distributions are inputs to a queuing model that would be used to modela checkout line and directly influence congestion.

9. **b) Multidimensional modeling**

    Multidimensional modeling is the optimum way to organize data in a data warehouse for analysis. It is associated with OLAP (Online Analytical Processing). OLAP data is organized in cubes that can be taken directly from the data warehouse for analysis.

10. **d) P is less than $3,000,000.**

    When the demand is 1,000 or greater, the profit is $3,000,000. But when the demand is less than 1,000, the profit is less than $3,000,000. Given this and that the average demand is 1,000 units, the expected monthly profit must be less than $3,000,000.

11. **c) Reveal interactions without having to explicitly build them into the model.**

    Tree-based models and neural networks are employed to find patterns in the data that were not previously identified (or input into the model building process).

12. **a) Greater than $5,000**

    If we consider the profit from an individual vehicle to be the wholesale price minus the variable cost, we see that the profit from a Gasoline Technology vehicle is $25K - $15K = $10K. Similarly, the profit from a "Green" Technology vehicle is $40K - $35K = $5K. To make up for this difference in lost profit, the subsidy provided to the automaker would have to be at least $5K (the difference between $10K and $5K). In addition, the subsidy would need to be greater than $5,000 so that the automakers would be able to recover their increased fixed costs at a reasonable level of demand.

13. **a) Use 70,000 randomly selected data points when building the model and hold the remaining 30,000 out as a test dataset.**

    This split provides sufficient data to build the model and sufficient data to test the model. This is the best allocation of the customer data points. (A common 'rule of thumb' is to use about two-thirds of the data to build the model and one-third to test it.)

14. **b) Present a histogram to show the distribution of various NPV estimates.**

    Net present value (NPV) takes as input a time series of cash flow (both incoming and outgoing) and a discount rate and outputs a price. By showing a histogram (a graphical representation of the distribution of data), it is possible to see how likely various NPVs (beyond the given minimum and maximum) are to occur. This would be useful information when considering a decision, especially since the range of outcomes includes $0, meaning the decision could result in a profit or a loss.

15. **c) Both investors are subject to the same uncertainty.**

    Both investors are subject to the same uncertainty regarding the stock market.`

16. **d) Clustering and decision trees**

    Customer segmentation consists of dividing a customer base into groups that are similar in specific ways relevant to marketing, e.g., age, gender, interests, spending habits, etc. Customer segmentation allows a company to target specific groups of customers effectively and best allocate marketing resources. Two ways to do this segmentation are clustering and decision trees.

17. **d) Discrete-event simulation, because there is a sequence of random events through time.**

The time to load shipments depends on the experience of the crew, products being shipped, and weather. Given that there is a sequence of random events through time, discrete-event simulation is the most appropriate modeling approach.

18. **b) Determine if there has been a change in model accuracy over time.**

The most important maintenance activity for the analytics professional responsible for maintaining the simulation model is to monitor the accuracy of the model over time. If there has been a change in accuracy, the analytics professional may need to revisit the assumptions of the model.

19. **a) Strategy B exhibits stochastic (probabilistic) dominance over Strategy A.**

Because the cumulative probability curve for Strategy B is below (or to the right) of the corresponding curve for Strategy A, it can be said that Strategy B exhibits stochastic dominance (SD) over Strategy A. B stochastically dominates A when, for any good outcome x, B gives at least as high a probability of receiving at least x as does A, and for some x, B gives a higher probability of receiving at least x. Since the curves do not cross, B stochastically dominates A.

20. **c) Remove opt-outs.**

The list of marketing leads should not include people or organizations that have opted out.

21. **c) Allow calculation of relative importance of varying features and attributes to customers.**

Conjoint analysis by definition maps consumer preference structures into mathematical tradeoffs and was designed to allow a marketer to compare the relative utility of varying features and attributes.

22. **a) Collapse several survey questions regarding food taste, health value, ingredients, and consistency into one general unobserved "food quality" variable.**

Factor analysis is a statistical method used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors. The information gained about the interdependencies between observed variables can be used later to reduce the set of variables in a dataset.

23. **d) 7.0**

To get this answer, solve the decision tree using the "roll back" technique. Continuing back the bottom branch of the tree, the expected time if you fly is (0.5)(9.0) + (0.5)(5) = 7.0 hours. When faced with the "drive or fly" decision, choose to fly (since 7.0 hours is less than 7.35 hours). Thus, answer d) 7.0 hours is the expected travel time of the optimal (or minimal travel time) decision.

References

The following references may help you prepare for the CAP exam. A committee of select SMEs who have earned the CAP credential have developed a study guide to help candidates prepare for the exam. It is available on certifiedanalytics.org and has information relating to each of the domains listed below.

Domain I: Business Problem (Question) Framing

Kirkwood CW (1997) *Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets* (Duxbury Press, Pacific Grove, CA).

https://www.statisticshowto.com/false-positive-definition-and-examples/

Domain II: Analytics Problem Framing

Albright SC & Winston WL (2017) Business Analytics: Data Analytics and Decision Making, 6th ed. (Cengage Learning, Australia).

Skinner D (2009) Introduction to Decision Analysis, Third Ed. (Probablistic Publishing).

Domain III: Data

lbright SC & Winston WL (2017) Business Analytics: Data Analytics and Decision Making, 6th ed. (Cengage Learning, Australia).

Negnevitsky, Michael (2011) *Artificial Intelligence, A Guide to Intelligent Systems*, Third Ed. (Pearson), p 34.

Booz Allen Hamilton Field Guide to Data Science, page 35.

Buhlmann P, Drineas P, Kane M, & van der Laan M, Eds. (2016) *Handbook of Big Data* (CRC Press, Florida), pp. 61-64. http://datashader.org/user_guide/1_Plotting_Pitfalls.html.

Fryman L, Lampshire G, & Meers D (2017) *The Data and Analytics Playbook: Proven Methods for Governed Data and Analytic Quality* (Morgan Kaufmann Publishers), pp. 10-21.

Han J, Pei J, & Kamber M (2011) *Data Mining: Concepts and Techniques* (Elsevier).

Hillier F, Hillier M (2014) *Introduction to Management Science: A Modeling and Case Study Approach*, 12th ed. (McGraw-Hill Higher Education, New York, NY).

https://www.public.asu.edu/~kirkwood/DAStuff/refs/decisiontrees/index.html. Definition 2.3 for Utility function and 2.1 for Certainty equivalent and p. 258 (6th edition).

Domain IV: Methodology (Approach) Selection

Albright SC & Winston WL (2017) *Business Analytics: Data Analytics and Decision Making*, 6th ed. (Cengage Learning, Australia), pp. 367-368.

Cochran JJ, Ed. (2019) *INFORMS Analytics Body of Knowledge* (John Wiley & Sons, Hoboken, NJ), p. 13, Table 1.3.

Hiller FS & Lieberman GJ (1990) *Introduction to Operations Research*, 5th ed. (McGraw-Hill, New York).

Kantardzic M (2011) *Data Mining: Concepts, Models, Methods, and Algorithms*, 2nd ed. (John Wiley & Sons, Hoboken, NJ), pp. 17-21 and pp. 105-118.

Kirkwood CW (1997) *Strategic Decision Making* (Duxbury Press, Pacific Grove, CA), Chapter 2.

McClave JT, Benson PG, & Sincich T (2008) *Statistics for Business and Economics (Pearson),*10th ed., p. 423.

Domain V: Model Building & Domain VII: Model Life Cycle Management

Albright SC & Winston WL (2017) *Business Analytics: Data Analytics and Decision Making*, 6th ed. (Cengage Learning, Australia), pp. 447, 497-499.

Cochran JJ, Ed. (2019) *INFORMS Analytics Body of Knowledge* (John Wiley & Sons, Hoboken, NJ), pp. 249-252.

Hillier FS & Lieberman GJ (2014) *Introduction to Operations Research*, 10th ed. (McGraw-Hill, New York).

Law AM & Kelton DW (2013) *Simulation Modeling and Analysis*, 5th ed. (McGraw-Hill, New York).

Ross SM (2017) *Introductory Statistics*, 4th ed. (Academic Press, Burlington, MA).

Skinner D (2009) *Introduction to Decision Analysis* , Third Ed. (Probablistic Publishing), pp. 137-141.

Domain VI: Deployment

Laursen GHN & Thorlund J (2016) *Business Analytics for Managers: Taking Business Intelligence Beyond Reporting*, 2nd ed. (John Wiley & Sons, Hoboken, NJ).

Continuing Education/Training Courses

Along with the above-mentioned references, there are also many analytics-related continuing education and training courses offered by INFORMS and others. Opportunities for professional development are listed on the INFORMS website: informs.org/Professional-Development/Continuing-Education.

Note: Completion of preparatory courses is not a requirement for eligibility to sit for the CAP exam.

◖ TAKING THE EXAM

Exam Site Requirements and Instructions

Check-in Procedure

Candidates should arrive at the exam site at least 30 minutes before the scheduled exam time. To gain admission to the exam center, you must present two forms of identification. The primary form must be government-issued, and include your name, signature, and photograph. No form of provisional ID will be accepted. You will also be required to sign a roster for verification of identity.

- Examples of valid primary forms of identification are current: driver's license, state identification card, passport, or military identification card.

- The secondary form of identification must display your preprinted legal name and signature for signature verification (e.g., credit card, social security card, or employment or student ID card, all with signature).

- If the name on your registration is different than it appears on your identification, you must bring proof of your name change (e.g., marriage license, divorce decree, or court order).

- You must have proper identification to gain admission to the exam center. Failure to provide appropriate identification at the time of the exam will be considered a missed appointment, and no refund of your exam fee will be provided.

Prohibited Items in the Exam Room

Candidates can bring in and use any nonprogrammable, battery-operated calculator. Candidates may not bring any of the following items into the exam center: cell phones/smartphones, laptops, iPads or tablets, tape recorders, book bags, pagers, notes of any kind, books, newspapers, or any such item deemed inappropriate by the exam center. *Note: If there is no designated secure storage, candidates may bring the items into the exam room to be placed in an inaccessible location within the room during the exam.*

Exam Aids

Candidates taking the exam will have a calculator embedded in the exam platform.

Disciplinary Policy and Procedures

Candidates are to conduct themselves in a professional manner in the exam center. Any violation may be subject to disciplinary action up to and including dismissal from the exam center and loss of exam fee. Grounds for termination of the exam and dismissal from the exam center include the following:

- Having or attempting to have another individual take the exam.

- Failing to provide the proper identification.

- Using any prohibited exam aids/materials.

- Communicating in any manner with other candidates during the administration of the exam.

- Leaving the exam room or center without permission.

- Engaging in cheating or any other dishonest or unethical conduct.

- Failing to follow any of the exam administration rules as stipulated by INFORMS.

◖ AFTER THE EXAM

Exam Score Reports and the Scoring Process

INFORMS uses a criterion-referenced methodology for determining the passing score for its exams. There is no grading on a curve, and candidates are not competing with each other. The specific methodology used is the modified Angoff technique, which relies on the judgments of SMEs to determine an acceptable level of knowledge, skill, and ability in analytics.

INFORMS may, at times, include pre-exam items in some exams. These items are used for developing future exams and, accordingly, are not scored and have no impact on a candidate's pass/fail status.

Each candidate will receive an official digital score report immediately after completing the exam. This will be the only official score report provided. The score report for failing candidates will include additional information on performance by domain. Pass/fail reports will not include raw scores.

Raw exam scores are confidential. INFORMS will not disclose exam scores to anyone unless INFORMS is required to do so by court order or subpoena. Unless otherwise requested in writing, INFORMS will publish the names of all individuals who have passed the exam and who maintain current certification status in our registry: certifiedanalytics.org/current-certificants.

Reexamination

Candidates who do not pass their initial exam have the option of retaking this exam up to two times during the first 12 months following the approval of their application. Candidates who take the exam a second or third time will be expected to pay the reexamination fee cited in the "Fees and Refunds" section, each time.

Candidates who fail the exam three times will be required to wait one year from the date of their last attempt to reapply for certification. Reapplying under these circumstances requires a new submission of all application materials. Candidates who fail the exam three times are encouraged to pursue a program of education/training prior to reapplying for certification.

Security and Confidentiality

All exam-related materials – exam form, exam questions and graphics, and worksheets – are the exclusive intellectual property of INFORMS. Accordingly, none of these proprietary materials are available for review by any persons other than the INFORMS certification staff and INFORMS Analytics Certification Board.

All certification candidates sign an application agreement stating they will not discuss or share the specific content of any INFORMS certification exams with anyone. Any violation of this provision could result in sanctions up to and including revocation of certification status.

◖ APPEALS OF CERTIFICATION DECISIONS

Appeals Eligibility (Appealable decisions include the following.)

- Denial of eligibility for certification
- Denial of certification
- Denial of renewal
- Revocation of certification

Appeals Process

Applicants, candidates, or certificate holders wishing to appeal a decision must submit written documentation within 30 days of the receipt of the written decision by INFORMS. The written documentation should specify the grounds on which the appeal is based. A nonrefundable fee of $350 drawn on a U.S. bank in U.S. dollars must be submitted with the letter of appeal.

Appeals Panel

INFORMS will appoint an appeals panel consisting of one current member of the INFORMS Board of Directors and one current or former member of the INFORMS ACB. None of these individuals shall have had any affiliation (business, professional, or personal) with the individual filing the appeal. The appeals panel members will conduct their work and render a written decision within 60 business days of their appointment.

Appeals Decisions

The appeals panel shall render a decision on any allegations of procedural error or in the making of a decision with insufficient evidence to support it. Appeals regarding required compliance with existing and published testing standards or program requirements are not accepted.

The appeals panel may render a decision to uphold the INFORMS decision, grant the appeal requested by the appellant, or refer the matter back to the INFORMS ACB for reconsideration. A written copy of the appeals panel decision shall be sent to the INFORMS ACB and the appellant.

DISCIPLINARY PROCESS

Certificate holders are required to comply with all existing and future rules, regulations, and administrative ethical standards for certification established by INFORMS. Certificate holders are responsible for demonstrating compliance. Failure to do so may lead to disciplinary action, including but not limited to the denial of eligibility, nonrenewal of a certification, revocation of certification, probation or suspension, issuance of a letter of censure, or issuance of a written reprimand.

Individuals may report alleged violations of INFORMS rules or regulations in writing to INFORMS. Written documentation should include the identity of the individual involved in the alleged misconduct and the nature of the misconduct described in as much detail as possible, and the signature of the individual filing the complaint.

INFORMS has the authority to initiate a disciplinary action without receiving a complaint or notification of inappropriate conduct. INFORMS reserves the right to pursue any and all civil and legal remedies available under the law.

Grounds for disciplinary action include:

1. Conviction of a felony involving moral turpitude.

2. Conviction of any other criminal offense that reasonably calls into question the certificate holder's ability to provide professional analytics services.

3. Engaging in, authorizing, or aiding or abetting fraud, deceit, misrepresentation of materials/facts, provision of false or forged evidence, or bribery in connection with any application for a certificate or registration.

4. False statements made in any initial or renewal application materials.

5. Obtaining or attempting to obtain certification or renewal by any fraudulent means.

6. Failure to meet renewal requirements.

7. Use of expired credentials or false or unauthorized use of any INFORMS credentials.

8. Unauthorized possession or distribution of an INFORMS exam or exam materials.

9. Unauthorized use of any registered trademark of INFORMS.

INFORMS shall have the authority to establish procedures for hearings and potential reinstatement upon satisfactory assurance of proper conduct.

Individuals who wish to report a possible certification violation may send a written letter of complaint to:

INFORMS
Attn: Certification Manager
5521 Research Park Drive, Suite 200, Catonsville, MD 21228
email: info@certifiedanalytics.org

CODE OF ETHICS

Prepared by the INFORMS Certification Task Force

INFORMS has developed the Code of Ethics for Certified Analytic Professionals. All candidates and certificate holders participating in the certification process are required to comply with the current and future provisions of this code.

Applicability: This Code of Ethics applies specifically to those seeking to maintain the CAP certification but may be useful to other practitioners who use analytics. Clients, employers, researchers, policymakers, journalists, students, and the public should expect analytical practice by CAP-certified individuals to be conducted in accordance with these guidelines. Application of these or any other ethical guidelines generally requires good judgment and common sense.

Purpose: This Code aims to clarify important ethical requirements; to establish rules and standards; to hold the profession accountable; to aid analytics professionals in making and communicating ethical decisions; to help deter unethical behavior and promote self-regulation; and to list possible violations, sanctions, and enforcement procedures.

General: Analytics professionals aid decision makers in business, industry, academia, government, and military, that is to say, in all facets of society. It is therefore imperative to establish and project an ethical basis to serve as the foundation for their work. Furthermore, practitioners are encouraged to exercise good professional citizenship to improve the public climate for, understanding of, and respect for the use of analytics across its range of applications. Analytics professionals are obliged to responsibly conduct their professional activities, paying particular attention to the values of consistency, respect for individuals, autonomy for all, integrity, justice, utility, and competence.

Responsibilities: This Code recognizes that analytics professionals have obligations to a variety of parties, including society, employers and clients, colleagues, research subjects, INFORMS, and the profession. Responsibilities regarding each of these parties are further described next.

Society: All professionals have societal obligations to perform their work in a professional, competent, and ethical manner. Professionals should adhere to all applicable laws, regulations, and international covenants.

Employers and Clients: It is the practitioner's responsibility to assure employers and clients that an analytical approach is suitable to their needs and resources, and communicate the capabilities and limitations of analytical methods in addressing their problem. Analytics professionals should clearly state their qualifications and relevant experience. It is imperative to fulfill all commitments to employers and clients, guard any privileged information they provide unless required to disclose (e.g., by court order), and accept full responsibility for their performance.

Where appropriate, present a client or employer with choices among valid alternative approaches that may vary in scope, cost, or precision. Apply analytical methods and procedures scientifically, without predetermining the outcome. Resist any pressure from employers and clients to produce a particular result, regardless of its validity.

Colleagues: Analytics professionals have a responsibility to promote the effective and efficient use of analytical methods by all members of research teams and to respect the ethical obligations of members of other disciplines. When possible, professionals share nonproprietary data and methods with others to participate in peer review, focusing on the assessment of methods, not individuals. Respect differing professional opinions while acknowledging the contributions and intellectual property of others. Those professionals involved in teaching or training students or junior analysts have a responsibility to instill in those they teach or train an appreciation for the practical value of the concepts and methods being taught.

Those in leadership and decision-making roles should use professional qualifications with regard to analytic professionals' hiring, firing, promotion, work assignments, and other professional matters. Avoid harassment of or discrimination based on professionally irrelevant bases such as race, color, ethnicity, gender, sexual orientation, national origin, age, religion, nationality, or disability.

Research Subjects: If a project involves research subjects, including census or survey respondents, an analytics professional will know and adhere to the appropriate rules for the protection of those human subjects. Be particularly aware of situations involving vulnerable populations that may be subject to special risks and may not be able to protect their own interests. This responsibility includes protecting the privacy and confidentiality of research subjects and data concerning them.

INFORMS and the Profession: Analytics professionals will strive for relevance in all analyses. Each study or project should be based on a competent understanding of the subject-matter issues, appropriate analytical methods, and technical criteria to justify both the practical relevance of the study and the data to be used. Guard against the possibility that a predisposition by investigators or data providers might predetermine the analytic result. Remain current in constantly changing analytical methodology, as preferred methods from yesterday may be less acceptable today and totally obsolete tomorrow. Disclose conflicts of interest, financial and otherwise, and resolve them. Provide only such expert testimony as you would be willing to have peer reviewed. Maintain personal responsibility for all work bearing your name; avoid undertaking work or coauthoring publications for which you would not want to acknowledge responsibility.

Alleged Misconduct: CAPs will strive to avoid condoning or appearing to condone careless, incompetent, or unethical practices. Misconduct broadly includes all professional dishonesty, by

commission or omission, and, within the realm of professional activities and expression, all harmful disrespect for people, unauthorized or illegal use of their intellectual and physical property, and unjustified detraction from the reputation of others. Recognize that differences of opinion and honest error do not constitute misconduct; they warrant discussion, but not accusation. Questionable scientific practices may or may not constitute misconduct, depending on their nature and the definition of misconduct used. Do not condone retaliation against or damage to the employability of those who responsibly call attention to possible scientific error or misconduct.

References

Saul I. Gass (2009) *Ethical Guidelines and Codes in Operations Research*, pp. 1044–1050.

American Statistical Association, *Ethical Guidelines for Statistical Practice*, August 7, 1999.

U.S. federal regulations regarding the protection of human subjects are contained in Title 45 of the Code of Federal Regulations, Chapter 46 (45 CFR 46).

RECERTIFICATION PROCESS

One of the hallmarks of a strong professional certification program is a process for ensuring the continuing competence of certificate holders in the discipline. INFORMS will use a Professional Development Unit (PDU) system similar to those used in other professional certifications. All certificate holders must participate in an ongoing formal renewal process to maintain their certification status. Certification holders must demonstrate compliance with renewal requirements during their three-year certification cycles.

Professional Development Unit (PDU) Requirements

All certification holders will be required to achieve a minimum of 30 PDUs in a three-year renewal period. PDUs must be in at least three of the five PDU categories. The following table describes options for achieving the required PDUs along with any required minimum or maximum PDUs specified in each category. Certificate holders may earn a maximum of 10 PDUs per PDU category unless stated otherwise.

PDU Category	Description of Policy	PDU Points Allowed
Participation as a student in formal education/training programs provided on analytics topics	This option includes courses, seminars, and workshops on analytics-related issues.	One (1) PDU per hour of instruction. Certificate holders must achieve at least eight (8) PDUs in this category during the three-year renewal period. Maximum of ten (10) PDUs allowed towards recertification.

PDU Category	Description of Policy	PDU Points Allowed
Self-directed learning	This category includes reading articles and books or watching instructional videos on analytics issues.	One (1) PDU per each hour of self-directed learning. Maximum of ten (10) PDUs allowed towards recertification.
Creating new analytics knowledge or content, including serving as faculty at learning events	Examples include authoring articles, books, etc. PDUs are also awarded for serving as faculty at learning events.	One (1) PDU is awarded per hour of activity spent in these activities. Maximum of ten (10) PDUs allowed towards recertification.
Volunteer service	Examples include serving as a volunteer for INFORMS or its regional chapters, working on analytics meetings, and assisting the certification process.	One (1) PDU is awarded per hour of volunteer service. Maximum of ten (10) PDUs allowed towards recertification.
Analytics professional work experience	Full-time employment as an analytics professional for a minimum of one year.	Five (5) PDUs are awarded for each full year of employment as an analytics professional. Certification holders may earn a maximum of 15 PDUs in this category in a three-year period.

All claimed PDUs must be submitted to and verified by INFORMS prior to the conclusion of a certificate holder's three-year renewal cycle. Certification holders are reminded that they will not be able to claim more than the maximum PDUs allowed in any specific category.

Recording PDUs and the Audit Process

Certification holders are required to keep accurate records of all professional development activities including all certificates or letters confirming attendance or participation in approved education or training programs. Certification holders must present all required PDU records to INFORMS before certification renewal will be granted. Certification holders can input their PDUs as they are earned in the CAP website. INFORMS will periodically audit a sample of certificate holders to verify the PDUs they have claimed in their renewal application.

Changes to Name and Address of Certification Holders

All candidates and certification holders must notify INFORMS immediately of any change in their name or address used for purposes of communication regarding certification matters.

Notify INFORMS by one of the following methods:

1. Entering changes to your record online.

2. Emailing the changes to info@certifiedanalytics.org.

3. Calling INFORMS certification staff with the changes at 443-757-3500 or 1-800-446-3676.

Note: Individuals who are changing their names must contact INFORMS certification staff to review the necessary legal documentation required to verify such changes.

◖ USE OF THE CAP CREDENTIAL

Once certification holders receive written confirmation from INFORMS regarding their new certification status, they may use the CAP mark after their names. Always list the designation in block (capital) letters. The CAP designation may be used only in conjunction with a certificate holder's name. The CAP designation may not be used in reference to a company or organization. The CAP logo may also be used on letterhead and personal websites, business cards, LinkedIn, and email signatures with written approval from INFORMS.

INFORMS will send new certification holders their electronic certificate via a unique URL.

CAP logo lapel pins are also available to new certification holders. They are distributed at all INFORMS conferences and meetings or can be requested by contacting the INFORMS certification manager at info@certifiedanalytics.org.

Unless otherwise requested in writing, INFORMS will publish the names of all current CAPs in an official list/registry on its website at certifiedanalytics.org/current-certificants.