

## PROPOSED CURRICULUM FOR A MASTER OF SCIENCE DEGREE IN COST ENGINEERING

TCM Framework: General Reference

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### INTRODUCTION

This educational practice represents a proposed curriculum for a master of science degree program with an emphasis on cost engineering. The purpose of this document is to support post-graduate education in cost engineering, by providing the following:

- Guidance to faculty and students in the formulation of master's degree programs that will concentrate on cost engineering, while maximizing the opportunity for cross-disciplinary coursework.
- A basis for course selection or self-study where no such degree program exists.

The curriculum for this course of study is based upon the content of *The Total Cost Management (TCM) Framework*, and AACE recommended practice 11R-88, *Required Skills and Knowledge of Cost Engineering*. It also references coursework that is typical in Construction, Project, and Engineering Management degree programs.

A master's-level curriculum in cost engineering should specify prerequisite undergraduate courses, as identified in this EP. The institution may allow professional experience to serve as a substitute for formal course work, or supplementary coursework to be undertaken concurrently with the master's-level curriculum. This proposed curriculum provides course descriptions and outlines components of each subject.

The proposed curriculum focuses on cost engineering, and is in alignment with project Engineering, Procurement, Construction, and Management (EPCM), as well as Manufacturing and Information Technology. This recommended program of study offers a logical progression in formal education. Most bachelor's degree and master's degree Construction, Project, and Engineering programs offer, as a part of their scope a study, a brief overview of project controls. In many cases these programs are accredited in North America and internationally by the American Council for Construction Educators (ACCE).

The objective of this EP is to present to Universities that already offer higher education in Construction, Project, or Engineering Management a proposed degree program that is in line with industry and offers more extensive and deep coursework in project controls, cost engineering, and quantity surveying.

### PROPOSED CURRICULUM

#### A. Undergraduate Prerequisite Subjects

- Engineering or Business Economics
- Financial or Project Accounting
- Business Writing
- Mathematics

Preferably, the incoming student will have an undergraduate degree in engineering, business, finance, or mathematics, with a minimum GPA of 3.0.

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B. Cost Engineering Required / Core Courses  
(8 courses / 24 credits from this list)

- Cost Estimating
- Planning and Scheduling
- Procurement and Contracting
- Project and Contract Administration
- Fundamentals of Project Management
- Project Controls Ethics
- Decision and Risk Analysis
- Performance Measurement and Data Analytics

C. Cost Engineering Elective Subjects  
(3 courses / 9 credits from this list)

- Advanced Economic Analysis
- Appraisal and Valuation
- Communications in Technical Organizations
- Organizational Theory
- Contract and Commercial Law
- Project Finance
- Special Topics in Cost Engineering

D. General Electives

- Interdisciplinary subjects as approved by the University to support the degree program or dual degree
  - Engineering
  - Construction Management
  - Manufacturing
  - Real Estate
  - Project Management
  - Engineering Management
  - Information Systems
  - Law
  - Finance
  - Business

E. Capstone Project (3 credits)

- Thesis on a cost engineering subject

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**COURSE CONTENT****A. Undergraduate Prerequisite Subjects**

Preferably, the incoming student will have an undergraduate degree in engineering, business, finance, or mathematics, with a minimum GPA of 3.0. An incoming candidate for a master's program who does not have college credit for any of these subjects should either add them to his/her total degree program or demonstrate proficiency in them to the satisfaction of the university. The institution may allow professional experience or certification to serve as a substitute for formal course work.

1. Engineering or Business Economics
  - a. Fundamentals of economics, including :
    - i. Micro- and macro- economics
    - ii. Demand and supply
    - iii. Price determination
    - iv. Market structures
    - v. Labor markets and wages
2. Financial or Project Accounting
  - a. Basic financial accounting, including :
    - i. Bookkeeping
    - ii. Debit and credit
    - iii. Depreciation
    - iv. Ledgers
    - v. Generally Accepted Accounting Principles
    - vi. Cash and accrual basis
    - vii. Financial reports
3. Business Writing
  - a. Demonstrated competency in written communication gained through prior formal instruction or experience
4. Mathematics
  - a. Demonstrated competency in mathematics, including :
    - i. Analytical geometry
    - ii. Algebra
    - iii. Calculus
    - iv. Basic probability and statistics

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## B. Cost Engineering Required Subjects.

Subjects in this category are intended to provide a basic background in business or project management and are considered essential for the professional cost engineer. 8 courses / 24 credits of the degree program will be devoted to pursuing these subjects.

### 1. Cost Estimating

- a. The equivalent of a 3-credit course built around construction or manufacturing cost estimating which provides an introduction to definitive estimating. It should include these subjects:
  - i. Types of estimates, techniques, and accuracy
  - ii. Cost data sources
  - iii. Interpreting drawings and specifications
  - iv. Labor costs
  - v. Materials costs
  - vi. Equipment costs
  - vii. Overhead, indirect, and distributable costs
  - viii. Basic contingency
  - ix. Inflation/Escalation
  - x. Cost indices
  - xi. Profit
  - xii. Introduction to cost estimating software
  - xiii. Practical exercise in pricing a project or product
  - xiv. Proposals
  - xv. Contractual, managerial, and legal aspects of estimating and budgeting

### 2. Planning and Scheduling

- a. The equivalent of 3-credit course designed to provide basic proficiency in common scheduling techniques and theory. These subjects should be included :
  - i. History of scheduling
  - ii. Resource planning
  - iii. Bar chart (Gantt) scheduling
  - iv. CPM Scheduling
  - v. Time-scaled networks
  - vi. Linear Scheduling
  - vii. Schedule baselines
  - viii. Contractual, managerial, and legal aspects of scheduling
  - ix. Schedule delay
  - x. Introduction to Planning and Scheduling Software

### 3. Procurement and Contracting

- a. This is a detailed study of standard (AIA, AGC, U.S. Government, FIDIC etc.) and selected user-prepared contract forms. Topics include :
  - i. Procurement strategies and delivery methods
  - ii. Value for money analysis
  - iii. Contract forms
  - iv. Purchase orders
  - v. Consulting contracts
  - vi. Liabilities and risk allocation
  - vii. General conditions
  - viii. Special or supplementary conditions
  - ix. General requirements

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- x. Contract documents
  - xi. Subconsultants
  - xii. Change orders and variations
  - xiii. Legal principles
  - xiv. Ethics principles
4. Project and Contract Administration
- a. This subject area provides an understanding of the administration of contracts and purchase orders. Topics include :
    - i. Contractor and vendor qualification
    - ii. Procurement strategies and delivery methods
    - iii. Proposals
    - iv. Bidding and evaluation
    - v. Payment
    - vi. Financial management
    - vii. Change processing
    - viii. Document control
    - ix. Claims and disputes
    - x. Contract closeout
    - xi. Legal principles
    - xii. Ethics principles
5. Fundamentals of Project Management
- a. This course provides a systematic look at project planning, by defining essential elements. Topics in this group apply the principles learned in earlier coursework. Topics include:
    - i. Project stakeholders and interests
    - ii. Organizational structures for project management
    - iii. Insurance and bonding
    - iv. Budget
    - v. Work breakdown structures and charts of accounts
    - vi. Project management plans
    - vii. Project initiation
    - viii. Subcontracting
    - ix. Document control
    - x. Change control
    - xi. Contingency management
    - xii. Project handover
    - xiii. Historical data files
    - xiv. Project closeout
    - xv. Introduction to project management software
6. Project Controls Ethics
- a. This course introduces students to ethical methodologies, principles, values, and frameworks, then uses that foundation to study discipline- and field-specific codes of ethics within the profession. The course explores the ethical responsibilities of project management professionals to themselves, corporations, the government, and the public.
    - i. Human nature
    - ii. Ethics concepts
    - iii. Codes of ethics
    - iv. Compliance
    - v. Interdependencies

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- vi. Intelligent disobedience
  - vii. Culture and values
  - viii. Integrity
  - ix. Legal concepts
7. Decision and Risk Analysis
- a. This course includes a review of the basic components of risk: the probability of an event and the consequences of the event. The core elements of probability theory are reviewed, and applied to the basic components of estimating and scheduling theory. Risk management is assessed from its basic steps: risk identification, risk impact analysis, risk response planning, risk monitoring and control, and recovery. Topics include :
    - i. Probability
    - ii. Descriptive statistics
    - iii. Sampling theory
    - iv. Hypothesis testing
    - v. Decision theory
    - vi. Correlation and regression
    - vii. Types of risk
    - viii. Risk tolerance
    - ix. Risk modeling, using Monte Carlo simulation
    - x. Risk management
    - xi. Insurance
    - xii. Risk transfer
    - xiii. Introduction to risk modeling software
8. Performance Measurement and Data Analytics
- a. This course is designed to demonstrate and apply principles of economic analysis to a variety of business situations and case studies. Typical of included subjects are:
    - i. Data collection and sampling
    - ii. Audit techniques
    - iii. Variance analysis
    - iv. Earned value analysis
    - v. Value engineering
    - vi. Forecasting and trending
    - vii. Project evaluation
    - viii. Project monitoring
    - ix. Key performance indicators
    - x. Reporting, graphs, and charts
- C. Cost Engineering Elective Subjects
- Students will select a minimum of 3 courses / 9 credits from this group of subjects.
1. Advanced Economic Analysis
- a. This course is designed to demonstrate and apply principles of economic analysis and finance in a variety of business situations and case studies. Topics include :
    - i. Life-cycle cost analysis
    - ii. Time value of money
    - iii. Evaluation of purchase, lease, and rental options
    - iv. Profitability studies
    - v. Cost-Benefit studies

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- vi. Budgeting and cash flow analysis
  - vii. Inflation/Escalation
  - viii. Time value of money
  - ix. Equivalence
  - x. Methods for comparison of economic alternatives
  - xi. Break-even analysis
2. Appraisal and Valuation
- a. This course aims to establish the economic context for the creation of value, introduce the principles for the assessment of value in property and product markets, develop a clear understanding of the valuation process and appropriately apply the principal valuation methods to a range of property / product types and interests. Topics include :
    - i. Basic economics and structure of markets
    - ii. Legal rights
    - iii. Investment characteristics
    - iv. Principles of valuation
    - v. Ethical considerations
    - vi. Price, value, and worth
    - vii. Data sources
3. Communications in Technical Organizations
- a. This course teaches students essential communication skills utilized by successful managers in technical organizations, including subjects such as:
    - i. Types of communication
    - ii. Conveying a brand and culture
    - iii. Audiences and stakeholders
    - iv. Personality traits
    - v. Presentations
    - vi. Proposal writing
    - vii. Meeting management
    - viii. Social media
    - ix. Cultural challenges
4. Organizational Theory
- a. This subject area deals with practical applications of the organization including management theories, organizational principles, and processes of organizational behavior. Topics include :
    - i. Management concepts
    - ii. Leadership/management styles
    - iii. Personnel management
    - iv. Organizational management
    - v. Conflict management
    - vi. The project office
    - vii. Strategy and objectives
    - viii. Global projects
5. Contract and Commercial Law
- a. This overview of the body of law is included to equip students with the skills to formulate and implement strategies and policies to minimize potential legal pitfalls. Topics include :
    - i. General principles of tort and contract law
    - ii. Contracts and terms
    - iii. Contract negotiations

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- iv. Insurance and bonding
- v. Liability / negligence
- vi. Breach and damages
- vii. Intellectual property rights
- viii. Licensing and technology transfer
- ix. Confidential and proprietary business information
- x. Constructive changes
- xi. Defective work
- xii. Warranties
- xiii. Termination
- xiv. Bankruptcies
- xv. Claims
- xvi. Alternative dispute procedures

#### 6. Project Finance

- a. This course teaches students to understand finance in the context of project organizations.
  - i. Funding sources
  - ii. Financial markets, stocks, and portfolios
  - iii. Entrepreneurial finance
  - iv. Corporate finance
  - v. Personal finance
  - vi. Corporate financial statements
  - vii. Organizational finance theory
  - viii. Debt and equity financing
  - ix. Crowdfunding

#### 7. Special Topics in Cost Engineering

- a. Universities normally have a "Special Topics" course category which enables a student to pursue one or more credits of study in a subject area agreed to between the student and the advisor. Those involving a cost engineering topic may be credited to the electives group.

#### D. Capstone Project (3 credits)

- 1. The Capstone Project is to be completed in the final term of the masters program, and provides an opportunity for students to apply what they have learned by producing a substantial piece of research under the tutelage of an industry advisor and program faculty. The project is expected to be aligned with students' chosen areas of interest. The project product will be a thesis or graduate report on a cost engineering subject.

#### E. General Electives

- 1. Other elective courses may draw from those offered in Masters of Business Administration (MBA), Masters of Engineering Management, or Master of Science in Project Management degree programs, with an emphasis on project-related industry specifics and applications. Interdisciplinary subjects are acceptable as approved by the University to support the degree program or dual degree.
  - a. Engineering
  - b. Construction Management
  - c. Manufacturing
  - d. Real Estate
  - e. Project Management
  - f. Engineering Management



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- g. Law
- h. Finance
- i. Business

## REFERENCES

- Stephenson, H. Lance., Editor, *Total Management Framework: An integrated Approach to Portfolio Program and Project Management, 2nd Edition, Revised*, AACE International, Morgantown, WV, 2016.
- AACE International, Recommended Practice No. 11R-88 *Required Skills and Knowledge of Cost Engineering*, AACE International, Morgantown, WV, (latest revision).

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