**Overview**

This course, which follows on from Professor Stermole's Engineering Economics course (EBGN504), explores advanced discounted cash flow techniques and the emerging use of option pricing theory in the valuation and management of mineral and energy firms and properties. We first review traditional DCF and Monte Carlo DCF valuation techniques. Monte Carlo techniques are an attempt to more rigorously deal with the uncertainty in capital budgeting. Following this, the third section of the course delves into the more difficult use of option pricing theory in valuation and property operation. This “real options” section takes up a good portion of the course. The course ends with a capstone valuation case, based on an actual mine privatization in Peru. The presentation of this case will take place during the scheduled final exam period.

**Textbooks**

There is no one textbook that neatly covers all of the material in the course. I use John C. Hull's book, *Options, Futures, and Other Derivative Securities*, 6th edition, for the financial theory behind derivative asset valuation. There are newer editions available, but this one has all we need and can be found relatively cheaply used on the internet (it is also available in the bookstore). I will supplement this book by individual articles that I will either provide you with on Blackboard or in hardcopy, or that are available in *Real Options and Investment under Uncertainty: Classical Readings and Recent Contributions* (2004), edited by Eduardo Schwartz and Lenos Trigeorgis (available in the bookstore). I also recommend Avinash Dixit and Robert Pindyck, *Investment Under Uncertainty* (1994) as a more advanced text on real options, though we will not be using it in this class. For those who would like an NPV refresher text, I recommend Professor Stermole's book, which also deals nicely with the rules for taxing mineral rents in the United States.

To keep up with the latest in real options articles and ideas, visit the well-maintained real options web site [http://www.realoptions.org/](http://www.realoptions.org/). The site also has electronic copies of papers delivered at the past annual real options conferences. Two other sites, [http://www.real-options.com/resources_links.htm](http://www.real-options.com/resources_links.htm), and [http://www.puc-rio.br/marco.ind/](http://www.puc-rio.br/marco.ind/), have some resources on them, but it appear that they are no longer maintained and updated.
Course Tools

I will use Blackboard to post messages and certain additional items and papers. To get your Blackboard login set up, go to http://ccit.mines.edu/Blackboard_1 and click on “How do I access my Blackboard account for the first time?” Once you have a login name and password, go to http://blackboard.mines.edu and enroll in the course by selecting the course and then selecting the “Enroll” button. You do not need a special code to enroll. Blackboard will be the main means of communication that I will use, so please check Blackboard daily.

We will also be using Decisioeneering’s Crystal Ball Monte Carlo software, which is installed on the EB server and available in our computer labs. Finally, we will use Hull’s Derivagem option pricing software, available on the EB server.

Course Design and Requirements

Research has shown that lecturing is a poor method of instruction. Students typically “tune out” for about 50% of a lecture, and retain very little: three months after a course, students that have taken the course know only 8% more on the course topic than students that have not taken the course. I have therefore structured this course in a way that will improve learning and retention. Each week a project or question set will be assigned along with some suggested readings and several optional readings. I will always give you more work than is humanly possible to complete: always look carefully at any required readings, and then in the remaining readings continue with what interests you and fulfills your own particular needs. In the Wednesday lecture, I will lead a discussion of the week’s readings, bringing out the important points and clarifying any problem areas. In the Monday lecture a designated student or group of students will present the results of the assignment and field any questions. My job will be to help the student out if they get stuck, and to moderate if necessary. This will not only give you good practice at presenting financial analyses and leading discussions, but will also generate a true “seminar” environment. Since the class is small, you will each have at least one opportunity to present.

Each week the project or question set must be completed by the students not presenting. Weekly assignments tend to build on the previous week’s assignment. Every third week or so I will ask you to hand in that week’s assignment for grading. Since the assignments build on one another, you should have plenty of incentive to do the assignments each week even though you are not handing them in. The presenters for the week will be graded on their classroom presentation, and is not required to hand anything in. These graded assignments and presentations will be weighted equally, totaling 80% of the grade. The capstone case, in week 15, will be done in larger groups, and will be worth the remaining 20% of the grade.

I have assigned a healthy amount of work for each week. Note, however, that only a modest amount of work is required for a passing grade, and that students have done well without spending long hours on the assignments. What I am looking for in these assignments is clear presentation of the results, not necessarily fancy presentations and pages and pages of text. Handwritten work is fine (do not waste hours using MSWord’s Equation Editor or making your Powerpoint presentation fancy!). Another key to staying on top of things is to do some of the work each day and make use of my office hours. Do not attempt to do the entire assignment or read all of the required readings the night before class.
Grades

Excellent work is awarded an A (4.000 grade points), good work a B (3.000), marginal work a C (2.00), and failing work a D (1.000) or F (0.000 grade points). An A- is 3.700, a B+ is 3.300, and so on. The final grade for the course will be a weighted average of the grades on the individual exams and the paper, calculated just as a grade point average is calculated. Note that C- is the lowest passing grade in graduate study at CSM.

Academic Integrity

Students and faculty at the Colorado School of Mines are expected to adhere the highest ethical standards. CSM students have adopted an honor code that reads (2011 CSM Student Graduate Bulletin, p. 28),

Mines students believe it is our responsibility to promote and maintain high ethical standards in order to ensure our safety, welfare, and enjoyment of a successful learning environment. Each of us, under this Code, shall assume responsibility for our behavior in the area of academic integrity. As a Mines student, I am expected to adhere to the highest ethical standards of academic excellence and personal integrity regarding my school work, exams, academic projects, and research endeavors. I will act honestly, responsibly, and above all, with honor and integrity in all aspects of my academic endeavors at Mines. I will not misrepresent the work of others as my own, not will I give or receive unauthorized assistance in the performance of academic coursework. I will conduct myself in an ethical manner in my use of the library, computing center, and all other school facilities and resources. By practicing these principles, I will strive to uphold the principles of integrity and academic excellence at Mines. I will not participate in or tolerate any for of discrimination or mistreatment of another individual.

The Bulletin goes on (p. 30) to note that if a student is found to have engaged in academic misconduct, sanctions ranging from a disciplinary change of grade to a loss of institutional privileges, suspension, or dismissal may be imposed.

I have adopted these guidelines for academic honesty in my courses. A student found committing any dishonest or unethical act will be penalized and potentially dismissed from the University in accordance with the University's general regulations on ethics and honesty.

Since there are no exams, and since I am to give you a grade that signals to the broader community your competence in this area, I must insist that the weekly projects or question sets that I am grading be done individually unless I have approved group work. Some discussion among yourselves is of course healthy and valuable, and I encourage this. I also encourage you to share data downloaded from public sources, and to learn from each other on the weeks that the assignments are not handed in. But complete the hand-in assignments individually. I do not want to see joint production. I cannot emphasize this enough. If I find that students are working together or copying from past years’ assignments, all parties involved will be awarded an F for the assignment and possibly the course.
Over the years I have found articles that I think are particularly good at discussing a given topic. These are listed here as a sort of bibliography. I will highlight each week in class the articles that are required reading.

I. Cost Approach, Comparable Sales Approach

Week 1            Cost Approach, Comparable Sales


II. Traditional DCF Valuation Techniques (Income Approach)

Week 2            Review of Basic DCF Concepts


Week 3

Incorporating Monte Carlo into DCF Analysis and Project Optimization


Week 4

Evaluating Flexibility via Dynamic Decision Making: Development Timing and Operating Policy


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Daniel R. Siegel, James L. Smith, and James L. Paddock, “Valuing Offshore Oil Properties with Option Pricing Models,” Midland Corporate Finance Journal Vol. 5, No. 1 (1987): 22-30. (NB: there is no Appendix A and B with this paper, even though the text refers to these)


Investment Under Uncertainty, Ch. 1, 2.

III. Modern Valuation Techniques (Income Approach)

Week 5 Futures Pricing

Hull, Ch. 1 (Introduction - Forward Contracts, Futures Contracts, Summary), Ch. 2 (Mechanics of Futures Markets - everything up to Delivery), Ch. 5 (Determination of Forward and Futures Prices - ignore Known Income, Futures prices of Stock Indices, Forward and Futures Contracts on Currencies, Delivery Options, Appendix).


Week 6 Differential Discounting


Week 7 An Introduction to Options and Option Valuation

Hull, Ch. 1 (Introduction - Options), Ch. 8 (Mechanics of Options Markets - everything up to Trading), Ch. 9 (Properties of Stock Options - all).

Michael Samis and Graham Davis, “Using Dynamic DCF and Real Options Methods to Value and Assess Flexible Mine Project Design,” in Mineral Resources/Reserves and


Investment Under Uncertainty, Ch. 1, 2.

Week 8 Stochastic Processes, The Black-Scholes Analysis of European Option Value

Hull, Ch. 12 (all, including Appendix), Ch. 13 (ignore Warrants, Appendix), Ch. 17 (Basic Numerical Procedures – section 17.6, pp. 410-12), Chapter 25 (Martingales and Measures – sections 25.1 to 25.3, Appendix ).


Investment Under Uncertainty, Ch. 3.

Week 9 An Example of Real Option Pricing: Valuing Undeveloped Oil Properties

Hull, Ch. 14 (Options on Stock Indices, section 14.1, 14.2), Ch. 22 (Exotics – Compound Options, section 22.4).


Investment Under Uncertainty, Ch. 12 (pp. 396-403).

Week 10 Option Valuation Using Binomial Lattices

Hull, Ch. 11 (Introduction to Binomial Trees - sections 11.1-11.5, 11.7-11.9, Summary), Ch. 17 (Basic Numerical Procedures - sections 17.1, pp. 391-96, 17.2).


Week 11 Valuing Operating Options, Part I

Hull, Ch 28 (Real Options).


Investment Under Uncertainty, Ch. 5, 6, 7 (Section 1).


Week 12 Valuing Operating Options, Part II


Week 13 The Brennan and Schwartz Classic Mine Valuation Paper


Investment Under Uncertainty Chapter 7 (Section 2).

IV. Valuing Political Risk

Week 14 Valuing Political Risk


V. Capstone Case

Week 15 Bidding for Antamina

Hull, Ch. 19 (More on Models and Numerical Procedures – 20.8 Options on Two Correlated Assets).

