Key Concepts in Richard Woodward’s Dyn. Optimization Course

The grade you receive in the course is related to your ability to master basic, intermediate and advanced skills.

I. General issues in dynamic optimization

A. Basic skills
   1. Identify the key variables and functions in a problem: state, control & intermediate in a general problem statement. (PS1.1)
   2. Define the key functions: Benefit function, state equation, objective function, and salvage value in a general problem statement. (PS1.2)
   3. Be able to write a computer program that would carry out the tasks indicated on the Quiz included in the VB tutorial. (VB Tutorial)

B. Intermediate skills
   1. Explain the commonalities and differences between optimal control and dynamic programming.

C. Advanced skills
   1. Independently develop a well-defined dynamic optimization problem with reasonable sets of key variables and functions.
   2. Clearly convert a problem from a DP to OC specification and vice versa and explain the commonalities and differences.

II. Optimal control (continuous time & analytical solutions)

A. Basic skills
   1. Solve a very simple (constant or single variable) first-order differential equation. (PS1.3)
   2. Explain in words what a differential equation means (of any order). (PS1)
   3. Solve differential equations using a symbolic algebra program. (PS1.3)
   4. Take a clearly defined dyn. opt. problem and write down the Hamiltonian and FOCs. (PS2)
   5. Derive the transversality condition for a vertical end-point problem. (PS2)
   6. Reformulate a present-value OC problem to a current-value specification and vice versa. (PS2.4)

B. Intermediate skills
   1. Solve a linear first-order differential equation. (PS1.3)
   2. Correctly develop a phase diagram given the appropriate differential equations, including identifying the equilibrium. (PS1.4)
   3. Describe a phase diagram or set of differential equations in terms of stability and trajectories. (PS2)
   4. Take a general problem and write down the Hamiltonian and FOCs. (PS2)
   5. Given a general problem statement, identify the type of end-point problem that it is and correctly state the transversality condition. (PS2)
   6. Provide economic interpretation of the FOC w.r.t. the control variable (present & current value). (PS2)
   7. Set up a constrained dyn. optimization problem and derive the FOCs. (Lecture 14)
C. Advanced skills
1. Correctly solve a system of equations to reach a set of differential equations, present them in a graph, and interpret the graph. (Lecture 2)
2. Solve a relatively simple constrained optimal control problem. (Lecture 14)
3. Evaluate analytically and/or numerically the stability of a system of nonlinear differential equations. (PS1.4)
4. Given a general problem statement, provide the correct formal statement of the problem, solve the problem (to the extent that a solution is possible), and use appropriate mathematical and graphical skills to describe the solution to the problem. (PS2)
5. Provide strong economic intuition for optimal trajectories using the FOCs. (PS2)
6. Derive the correct transversality condition for any general problem using both a present- and current-value specification, including problems with salvage value and infinite-horizon problems. (PS2)
7. Provide economic interpretation of the FOC w.r.t. the state variable for both present & current value specifications. (PS2)
8. Provide intuitive economic interpretation of a Hamiltonian. (PS2)
9. Solve a constrained dynamic optimization problem including MRAP and bang-bang type problems. (Lecture 14)
10. Set up and solve a relatively simple stochastic control problem. (Lecture 14)

III. Numerical dynamic programming (discrete time & numerical solutions)

A. Basic skills
1. Set up and solve a well-defined deterministic DD-DP problem using a circle-and-arrow approach. (PS3.2)
2. Write down the Bellman’s equation for a well-specified dynamic optimization problem. (PS3.2)
3. Write down pseudo code that would be used to solve a finite-horizon one-dimensional DD-DP problem. (PS3.2)
4. Write a computer program to numerically solve a deterministic finite-horizon one-dimensional DD-DP problem. (PS3.3)
5. Write computer code that generates the optimal path that follows from the solution to a deterministic finite-horizon one-dimensional DD-DP problem and explain the path. (PS3.3)
6. Set up a Markov transition matrix, and find the transition probabilities over $n$ periods and as $n \to \infty$. (Lecture 9)

B. Intermediate skills
1. Set up and solve a well-defined stochastic DD-DP problem using a circle-and-arrow approach. (Lecture 7)
2. Write down the Bellman’s equation for a general problem statement for a DD problem. (PS3)
3. Present graphically and economically interpret the policy function and value function that results from any DP problem. (PS3)
5. Write a computer program that solves a deterministic infinite horizon DD-DP. (PS3.4)
6. Write computer code that generates the optimal path that follows from the solution to a deterministic infinite-horizon DD-DP problem and explain the path. (PS3.3)
7. Write a computer program that solves a deterministic CD-DP problems using rounding or linear interpolation. (PS3.4)
8. Write a computer program that solves a stochastic DD-DP problems (PS3.5)
9. Calculate and economically interpret the probabilistic outcomes of a stochastic DP problem (PS3.5)
10. Write computer code that generates the optimal paths that follows from the solution to a stochastic DD-DP problem and explain and analyze the paths and the solution to the problem. (PS3.5)
11. Solve analytically a simple DP problem with a continuous choice variable. (PS3.1)

C. Advanced skills
1. Write a computer program that solves a stochastic infinite horizon DD-DP. (PS3.5)
2. Write a computer program that solves a deterministic CC-DP problems using hill-climbing algorithms. (Lecture 11)
3. Write a computer program that solves a problems with multiple state variables.
4. Demonstrate the ability to use policy iteration and another acceleration technique for the solution of $\infty$-horizon problems. (PS3.5)
5. Demonstrate the ability to use nonlinear interpolation and spline methods for problems with continuous state variables. (Lecture 11)
6. Describe in general terms how Rust’s nested fixed point algorithm would be used to estimate the parameters of a dynamic decision problem. (Lecture 13)