



Course Match

User Manual v2.1

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Introduction

Course Match is a groundbreaking information exchange that employs complex, mathematical algorithms to optimize course selections based on student preferences and course section availability.

Course Match is built to maximize student satisfaction. It does so primarily in three ways. First, the system optimizes the allocation of seats, ensuring the best possible class schedule for each student. Second, Course Match eliminates the worry that others will gain an advantage through system manipulation – with Course Match your entire focus is on reporting your true preferences. Finally, with a single round per semester, Course Match makes effective use of the time you spend on the course selection process.

Overview

To understand how Course Match works, you must first familiarize yourself with the following terms:

Utilities: As a student, you have a relative utility (aka preference) for each of the 300+ course sections offered each semester. There are some course sections you strongly prefer, others less so and some not at all. Course Match asks that you state your true, relative utilities (preference) for as many of these sections as you like, and you will communicate your utilities using a **numerical expression**.

Clearing Prices: Each course section has a clearing price. The clearing price is determined by the number of available seats and the relative demand for those seats. Clearing prices are established by the system only AFTER all students have reported their utilities; they are calculated by Course Match based on the aggregate utilities reported by the entire Wharton MBA student population. Your individual utilities may not correlate with clearing prices. That is, your most preferred class may have a relatively low clearing price or Course Match may purchase a section with a relatively low utility for a high clearing price if sections with higher utilities cleared for relatively low prices.

Budgets: Each student has a set budget of course **tokens**. Course Match uses your course tokens to purchase your best possible schedule within your given budget, based on the established clearing prices.

At a high level, course selection within Course Match occurs in three steps:

1. **Utility reporting:** You report your relative utilities (preference) for as many sections as you like. To ensure a feasible schedule, you can only report utilities for sections of courses you are eligible to take (e.g., you are ineligible to take a course you have previously taken). Recommendation: we encourage you to assign utilities to twice the number of courses you are intending to take. For instance – if you plan on taking 5 classes in the fall semester, please report utilities for at least 10 course sections.
2. **Clearing prices are set and schedules are established:** Using the utility data from all Wharton MBA students, Course Match establishes a clearing price for each section and then builds a course schedule for each student. Again, recall the clearing price for each

section is based on the supply of available seats relative to overall demand. Each student's demand for a section depends on the strength of their utility for that section relative to other options. Using an extreme example to illustrate this point: a student assigns a utility of "100" to section 003 of the Negotiations course and a utility of only "1" or "2" to all other courses they wish to take in the fall semester. This communicates to Course Match that the student has a VERY strong preference (utility) for Negotiations, section 003 and only a slight preference for the other classes. Using this information, Course Match will do its best to produce a fall semester schedule for the student that maximizes their reported utilities given the clearing price and the student's budget of course tokens. In other words, **based on your reported utilities, you will receive the best schedule that you can afford.** And this is true for every student. You are assured your best schedule because Course Match knows the clearing prices – it never over or under pays for a course section, so your tokens are utilized to their fullest.

- 3. Drop/Add:** The Drop/Add period begins with a "buffer period" during which students may enter drop and add requests. At the end of the buffer period, the system closes again and **all drop requests are immediately processed. Add requests are sorted by class year, randomized, and then processed. All add requests from second-year students are given priority.** Students who add sections that are at or over capacity are added to a waitlist. Following the buffer-period, the automated Drop/Add system maintains a first come, first served waitlists for every section; it will automatically enroll students off the waitlist as seats become available.

Making it Work for You

1. Utility Reporting

Individual course sections:

During the period to report utilities, Course Match displays the full list of course sections available to you. You may use a 0 to 100 point scale to express your utility for that section. We suggest you assign a utility of 100 to your most preferred course section and then assign utilities to other course sections in order to express your preference for them relative to your most preferred section.

Each section defaults to a utility of 0. **Course Match will never add a section with a 0 utility to your schedule.**

There is no limit to the number of utilities you can assign. You may report utilities for as many sections as you are willing and eligible to take. Utilities may be reported across multiple sections of the same course and/or sections that meet at the same time. Course Match knows you can take, at most, one section of the same course and only one course in a given timeslot. Course Match also knows that certain flexible core courses cannot be taken together so it will not generate a schedule with incompatible flexible core pairings (Ex. Course Match will never build a schedule that includes both ACCT 611-Fundamentals of Financial Accounting and ACCT 613-Fundamentals of Financial and Managerial Accounting).

Credit Unit (CU) limit:

You can report the maximum number of CUs you are willing to take in a given semester. Course Match will never generate a schedule that has more CUs than that limit. However, it is possible that Course Match will settle for a schedule with fewer credit units than your reported maximum. To give an example, suppose you report utilities for courses across only three time slots but tell Course Match that the maximum number of credit units you will enroll in for that particular semester is 5.0. In that case, given the utilities you reported, Course Match cannot generate a schedule with more than three courses.

Courses worth less than 1.0 CU:

Course Match maximizes the utility of your entire schedule, working toward your desired number of credit units. In doing so, the system exhibits a natural bias toward sections worth more CUs. Course Match essentially multiplies the utility you assign to a section by that section's credit unit value. For example, if you assign a utility of 100 to a section worth 1.0 credit unit, Course Match views that section as having a utility of 100. However, if you assign a utility of 100 to a section worth 0.5 credit unit, Course Match will treat that section as being worth a utility of 50. **Said another way, two 0.5 CU courses, each assigned 100 preference (utility) points, would be worth as much as single 1.0 CU course assigned 100 preference points.**

Adjustments

You have the option to express utilities for combinations of two course sections, either positively or negatively. In this way, you tell Course Match that two classes paired together are highly desirable, less desirable or not at all desirable.

Positive Adjustments:

Let us suppose you assign Course A with a utility of 100. Course B is also attractive to you but less so compared to Course A, thus you assign Course B with a utility of 60. However, if the combination of A & B together is highly desirable (perhaps because both courses deal with complementary topics or meet in consecutive timeslots), you can assign the pair an additional utility of 40 points. This means you are telling Course Match that Course A has a utility of 100, Course B has a utility of 60 and the pair combined have a utility of $100 + 60 + 40 = 200$. Without the adjustment, Course Match would believe that the pair has a utility of only $100 + 60 = 160$. The maximum adjustment you can enter for any pair is $100 \times (\text{sum of$

<i>Combinations</i>	
Section	Points
Course A	100
Course B	60
Combined	160
Adjustment	40
TOTAL	200

the CUs for the pair). For example, you can add an additional utility of up to 200 points for a pair of 1 credit unit courses and, at most, an added utility of 100 for a pair of 0.5 CU courses.

Negative Adjustments:

<i>Combinations</i>	
Section	Points
Course A	100
Course B	60
<i>Combined</i>	160
Adjustment	-50
TOTAL	110

While you are interested in Course A and Course B by themselves, you may be less interested in having both courses added to your schedule. In this case, you can report a **negative adjustment**. Again, let's assume you tell Course Match that Course A has a utility of 100, B has a utility of 60. By reporting a negative adjustment for the combination of the two courses you can tell Course Match that the two course sections together have a combined utility of less than 160. For the purposes of this example, Course Match will treat the combination as having a utility of $100+60-50=110$ instead of 160.

In essence, you can use negative adjustments to tell Course Match, "Give me one of these two sections but never both." Course Match has programmed into its interface an option that, when activated, will ensure the two course sections together are never added to your schedule.

2. **Clearing prices are set and schedules are established:**

Course Tokens:

Second-year students have more tokens than first-year students. During the fall semester, first-year students are granted additional tokens for each fixed core course they waive. However, even if a first-year student were to waive the entire fixed core, they will still have fewer tokens than a second-year student.

Note: Each semester, you will start with a new set of tokens; unspent tokens do not carry over to future semesters. This ensures Course Match will spend as many of your tokens as it can to get you the best schedule in any given semester.

Clearing Prices and Schedules:

Course Match uses a considerable amount of cloud computing power and mathematical algorithms to analyze the set of utilities reported by all Wharton MBA students and establish clearing prices for courses. Roughly speaking, the clearing price of each section balances supply with demand – if demand exceeds available seats, Course Match increases the price. If demand is less than supply, it decreases the price. Since Course Match knows the clearing price of each course before it begins to build your schedule, it will purchase the best possible schedule you can afford given your preferences.

Weighted Totals				
Section	CUs	Points	Weight	Weighted Total
A	1.0CU	100	1	100
B + C	1.5CU	200	1.5	300
Schedule Value =				400

To be more specific, Course Match finds the schedule that maximizes the weighted sum of utilities assigned to the schedule. For example, you receive a schedule that includes Courses A, B and C. Both A and B are 1 credit unit courses and Course C is 0.5 credit units. Let's say you reported the following utilities: Course A = 100, Course B = 80, Course C = 60, and B & C = 200. Course Match "values" this schedule at $100 + (1.5 \times 200) = 400$ points. To explain, Course A has a weight of "1" because it is 1 CU, while a weighting of 1.5 is applied to the value of the B & C pair because that pair has 1.5 CUs.

In assembling a schedule, Course Match makes intelligent decisions on your behalf based on the utilities you report. If your first choice section is very expensive, it may be better for you to receive your 2nd, 3rd, 4th, and 5th choices, rather than your 1st, 12th, 13th, and 14th. That said, if your first choice is inexpensive, Course Match will add it to your schedule and use your residual tokens on your remaining choices. Even if your first choice is relatively expensive, Course Match may still be able to add it your schedule if your other high-ranking courses are not very expensive. Course Match uses its computational horsepower to find the best combination for you.

Ties

In the process of establishing course prices, it is possible that students may have an equally strong utility for the same section. If only one student can be

enrolled in the section (i.e., there is one remaining seat), then a "tie" needs to be broken. Course Match breaks ties by randomly allocating to students a small number of course tokens. When a "tie" arises, the student with slightly more tokens will be assigned the seat. This is akin to flipping a coin.

3. Drop/Add

You will see your schedule for the first time a few weeks before the start of classes. When schedules are released, an automated Drop/Add period begins. You can drop, without penalty up to the drop/add deadline, a seat in a course section you "own." Up until the drop/add deadline, you can add to your schedule a class that has open seats assuming you are eligible to take the course and provided that enrolling in the course does not create an incompatible flex core pairing (to refer back to our earlier example about ACCT 611 and ACCT 613).

Waitlists

During the drop/add period you can add your name to waitlists for course sections that are "closed" (i.e., there are no open seats). You will be able to see the length of each waitlist and your position on the list. You can remove yourself from a waitlist at any time. You can also add yourself to as many waitlists as you like provided you are eligible to take the course.

When you attempt to add yourself to a waitlist, you will be prompted if the section you are adding conflicts with another waitlist you are on or conflicts with a section for which you are currently enrolled. In either scenario, to be added to the waitlist, you must first certify that, if granted a seat in the waitlisted section, you give permission for Course Match to resolve all other course conflicts. More specifically, Course Match will automatically drop you from sections that create a time or procedural conflict. Before approving your addition to a waitlist, the drop/add system will generate a warning message informing you of the consequences.

<i>Automated Waitlists</i>	
MW Schedule	
	9:00am – 10:30am 10:30am-12:00pm
Own	A1 B2
Waitlist	B1
MW Schedule (waitlist seat granted)	
	9:00am – 10:30am 10:30am-12:00pm
Drop	A1 B2
Own	B1

Let's say you own Course A1 & Course B2, meeting M/W from 9-10:30am & M/W from 10:30am-12:00pm, respectively. During the drop/add period, you add yourself to the waitlist for B1 (meets M/W from 9-10:30am). B1 is a different section of B2. It meets at the same time as A1. If granted a seat off the waitlist for B1, you will be automatically dropped from both A1 and B2 because you can't be registered in two sections that meet at the same time or two sections of the same course.

As there may be an initial rush to access open seats and waitlists, at the beginning of the Drop/Add period there will be a “buffer period” in which the sequence of requests will be randomized across students. Second-year students will be prioritized such that their add requests will be processed before first-year students’. There is no need to be the first to click “submit” as soon as the drop/add period begins. It is only after the buffer period that the Drop/Add system operates on a first come first served basis.






Swaps

No student is allowed to “swap” a course section with another student. If a student wishes to change their section, they must do so through the standard add/drop process.

Course Match: An Example

To further illustrate how Course Match works, let us walk you through an example. Let us take a look at an actual sample schedule created by Course Match for Lisa, one of the Wharton MBA students who helped put Course Match to the test.

Fig. 1

Course	Title	Instructor	Day	Start	Stop	Prefs	Price	Sched
LGST813	LEG ASP ENTREPRENRSH	FRANKLIN B	M	300 PM	600 PM	100	 c1	
LGST806-409	NEGOTIATIONS	NASH J	R	300 PM	600 PM	91	 c2	
LGST806-407	NEGOTIATIONS	MAGUIRE J	W	300 PM	600 PM	90	 c2	
MGMT691	NEGOTIATIONS	SAWYER T	TR	1030 AM	1200 PM	90	 c2	
MKTG776	APPL PROB MODELS MKTG	GAUSS C	W	300 PM	600 PM	74		
REAL721-405	REAL ESTATE INVESTMENTS	CHATEAU T	MW	130 PM	300 PM	71		
MKTG773	CUSTOMER BEHAVIOR	WALTON S	TR	1030 AM	1200 PM	65		
REAL721-407	REAL ESTATE INVESTMENTS	MAHAL T	TR	130 PM	300 PM	62		
FNCE750	VENT CAP & FNCE INNOVAT	SCHOLES M	MW	130 PM	300 PM	61		
MKTG778	STRATEGIC BRAND MGMT	KRAFT F	TR	130 PM	300 PM	49	 c3	

In Course Match you assign utilities by section. Fig. 1 shows a list of Lisa’s top selections. As you can see, Lisa’s most preferred course is Legal Aspects of Entrepreneurship – she assigned a utility of 100 to that section of the course (c1). Lisa then assigned utilities to the other sections to indicate her relative interest. For example, at 91 and 90 points, Lisa has a strong interest in Negotiations (c2), and her interest in Strategic Brand Management (c3) is about half as strong as her most preferred section.

Fig. 2

Course	Title	Instructor	Day	Start	Stop	Prefs	Price	Sched
LGST813	LEG ASP ENTREPRENRSH	FRANKLIN B	M	300 PM	600 PM	100		
LGST806-409	NEGOTIATIONS	NASH J	R	300 PM	600 PM	91	← c1	
LGST806-407	NEGOTIATIONS	MAGUIRE J	W	300 PM	600 PM	90	← c1	
MGMT691	NEGOTIATIONS	SAWYER T	TR	1030 AM	1200 PM	90	← c1	
MKTG776	APPL PROB MODELS MKTG	GAUSS C	W	300 PM	600 PM	74		
REAL721-405	REAL ESTATE INVESTMENTS	CHATEAU T	MW	130 PM	300 PM	71	← c2	
MKTG773	CUSTOMER BEHAVIOR	WALTON S	TR	1030 AM	1200 PM	65		
REAL721-407	REAL ESTATE INVESTMENTS	MAHAL T	TR	130 PM	300 PM	62		
FNCE750	VENT CAP & FNCE INNOVAT	SCHOLES M	MW	130 PM	300 PM	61	← c2	
MKTG778	STRATEGIC BRAND MGMT	KRAFT F	TR	130 PM	300 PM	49		

Fig. 2: Lisa assigned utilities across multiple sections of the same course (Negotiations). She is letting the system know that she is open to taking the course on Wednesdays, Thursdays, or Tuesday/Thursday. However, Course Match knows to give her a maximum of one section of a course. Lisa also expressed utilities for sections offered at the same time (c2). Again, Course Match knows to give her only one course in a specific timeslot.

Fig. 3

Course	Title	Instructor	Day	Start	Stop	Prefs	Price	Sched
LGST813	LEG ASP ENTREPRENRSH	FRANKLIN B	M	300 PM	600 PM	100		
FNCE750	VENT CAP & FNCE INNOVAT	SCHOLES M	MW	130 PM	300 PM	61		

LGST813 = 100 points Max. Positive Adjustment Max. Negative Adjustment
 FNCE750 = 61 points # of CU x 100 = 200 Course 1 pts + Course 2 pts = 161

Positive Adjustment Negative Adjustment
 $100 + 61 + 200 = 361$ $100 + 61 - 161 = 0$

Fig. 3: My Adjustments - Course Match also allows you to express utilities, positive or negative, for combinations of courses. You can do this by using the "My Adjustments" tool in Course Match.

Positive Adjustment – For simplicity's sake, let us continue with the above example to illustrate a positive adjustment. Lisa's course with the highest utility (100) is Legal Aspects of Entrepreneurship. She also has a sizable interest in the Venture Capital course (utility of 61). If it is a high priority for Lisa to have both of these courses in her schedule, without actually adjusting her utility for the Venture Capital course, she can utilize the Positive Adjustment feature in Course Match to report that the combination of Legal Aspects of Entrepreneurship AND Venture Capital has a utility of as much as 361 points instead of 161 (100 + 61).

Negative Adjustment – What if the opposite is true? That is - what if Lisa only wants ONE of the two courses and never both? In this case, she can use the Negative Adjustment tool in Course Match. Take a look at Fig. 4 below.

Fig. 4

Course	Detail	Credit	Qtr	Utility	
LGST813	LEGAL AND TRANSACTIONAL ASPECTS OF ENTREPRENEURSHIP FRANKLIN B M 3:00 PM - 6:00 PM	1.00	Full	100	<input checked="" type="checkbox"/>
FNCE750	VENTURE CAPITAL AND THE FINANCE OF INNOVATION SCHOLES M MW 1:30 PM - 3:00 PM	1.00	Full	61	<input checked="" type="checkbox"/>

☒ Never give me this combination

Fig. 4 - Lisa has selected FNCE 750 (Venture Capital) and LGST 813 (Legal Aspects of Entrepreneurship) then checked off "Never give me this combination". When creating a schedule for Lisa, Course Match now knows never to give her both of these courses, only one.

Fig. 5: Let's check what Course Match bought for Lisa based on her utilities and a budget of 5000 tokens. The last two columns show the clearing price for each section and the classes that were added to her schedule (denoted by the check marks).

Fig. 5

Course	Title	Instructor	Day	Start	Stop	Prefs	Price	Sched	
LGST813	LEG ASP ENTREPRENRSH	FRANKLIN B	M	300 PM	600 PM	100	470	✓	← c1
LGST806-409	NEGOTIATIONS	NASH J	R	300 PM	600 PM	91	4900		← c2
LGST806-407	NEGOTIATIONS	MAGUIRE J	W	300 PM	600 PM	90	460		
MGMT691	NEGOTIATIONS	SAWYER T	TR	1030 AM	1200 PM	90	0	✓	← c2
MKTG776	APPL PROB MODELS MKTG	GAUSS C	W	300 PM	600 PM	74	0	✓	
REAL721-405	REAL ESTATE INVESTMENTS	CHATEAU T	MW	130 PM	300 PM	71	0		
MKTG773	CUSTOMER BEHAVIOR	WALTON S	TR	1030 AM	1200 PM	65	1782		
REAL721-407	REAL ESTATE INVESTMENTS	MAHAL T	TR	130 PM	300 PM	62	0	✓	
FNCE750	VENT CAP & FNCE INNOVAT	SCHOLES M	MW	130 PM	300 PM	61	3220	✓	
MKTG778	STRATEGIC BRAND MGMT	KRAFT F	TR	130 PM	300 PM	49	0		

Fig. 5 (continued): Lisa's most desired course (LGST 813 with a preference/utility of 100) had a relatively low clearing price and was added to her schedule (c1). The section of Negotiations for which Lisa assigned the highest utility was expensive (LGST 806-409 cleared for a whopping price of 4900). But she reported that she likes another section of Negotiations nearly as much and it was significantly less expensive so Course Match added it to her schedule (MGMT 691).

Fig. 6: Lisa's most preferred Real Estate course (c1) conflicts with the Venture Capital course (c2). Course Match recognizes that the other section of Real Estate Investments (c3) and the Venture Capital section together are worth more to Lisa combined than the first section of Real Estate alone, and therefore picks that combination.

Fig. 6

Course	Title	Instructor	Day	Start	Stop	Prefs	Price	Sched
LGST813	LEG ASP ENTREPRENRSH	FRANKLIN B	M	300PM	600PM	100	470	✓
LGST806-409	NEGOTIATIONS	NASH J	R	300PM	600PM	91	4900	
LGST806-407	NEGOTIATIONS	MAGUIRE J	W	300PM	600PM	90	460	
MGMT691	NEGOTIATIONS	SAWYER T	TR	1030AM	1200PM	90	0	✓
MKTG776	APPL PROB MODELS MKTG	GAUSS C	W	300PM	600PM	74	0	✓
REAL721-405	REAL ESTATE INVESTMENTS	CHATEAU T	MW	130PM	300PM	71	0	← c1
MKTG773	CUSTOMER BEHAVIOR	WALTON S	TR	1030AM	1200PM	65	1782	
REAL721-407	REAL ESTATE INVESTMENTS	MAHAL T	TR	130PM	300PM	62	0	✓ ← c3
FNCE750	VENT CAP & FNCE INNOVAT	SCHOLES M	MW	130PM	300PM	61	3220	✓ ← c2
MKTG778	STRATEGIC BRAND MGMT	KRAFT F	TR	130PM	300PM	49	0	

Course Match Theory

Course Match is built upon breakthroughs in the area of competitive equilibrium, namely those explored by Eric Budish in his paper titled, "The Combinatorial Assignment Problem: Approximate Competitive Equilibrium from Equal Incomes"¹ and Abraham Othman, Tuomas Sandholm and Eric Budish in their paper, "Finding Approximate Competitive Equilibria: Efficient and Fair Course Allocation"². Their theory has been thoroughly vetted by the top minds in the field, but Course Match is the first system to make the theory a reality.

Course Match Testing

In Fall of 2011, Wharton faculty and staff joined with 132 MBA students to put Course Match theories to the test. In 8 separate sessions students were presented with a list of 25 classes and given an overview to Course Match. Each student then built two schedules, one using Wharton Auctions (previous system for course selection) and another using Course Match. With their two schedules, students answered a series of questions based on their results and those of their peers. Results were clear: students were more satisfied with their Course Match schedules than those generated by Auction. They were less envious of their peers' schedules and found Course Match easier to use even though they received only minimal training on the new system.

Course Match Development

Course Match was developed through the considerable efforts of students, staff & faculty. In particular, the following individuals participated in the Course Match Design Team.

Students: Class of '12: Paul Nolen, Katie Scarborough Class of '13: Pardon Makumbe, Jessica Stoller

WCIT: Alec Lamon, Jason Lehman, Hugh MacMullan, John Piotrowski, Courtney Wilburn

Faculty: Gerard Cachon (Course Match Committee Chair), Sigal Barsade, Dean Foster, Robert Holthausen, Judd Kessler, Jagmohan Singh Raju.

MBA Program Office: Peggy Bishop Lane, Frank DeVecchis, Howie Kaufold, Naomi Tschoegl

Theory and Systems Development: Eric Budish, Abraham Othman

¹ Budish, E. (2011). The Combinatorial Assignment Problem: Approximate Competitive Equilibrium from Equal Incomes. *Journal of Political Economy*, 119(6)

² Othman, A., Sandholm, T., Budish E. (2010). Finding Approximate Competitive Equilibria: Efficient and Fair Course Allocation. *AAMAS '10 Proceedings of the 9th International Conference on Autonomous Agents in Multi-agent Systems*, 1(1)