

**Hong Kong Baptist University**  
**Faculty of Science**  
**Department of Mathematics**

**Title (Units): MATH 1690 Mathematics of Fairness**

**Course Aims:** This course is intended to teach students how mathematics can help in searching for procedures that can ensure a fair and suitable resolution of conflicts. It also aims to provide students with skills and concepts to identify, model and solve social problems.

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**Learning Outcomes (LOs):**

Upon successful completion of this course, students should be able to:

No.	Learning Outcomes (LOs)
	<b>Knowledge</b>
1	Identify the principles of mathematical methodology / reasoning
2	Demonstrate appropriate analytic skills to manipulate quantitative procedures
	<b>Skills</b>
3	Solve everyday problems of both equal or unequal weighted voting systems
4	Analyze and compare the division and apportionment methods mathematically
5	Raise and criticize mathematical models in daily fairness aspects in Hong Kong and other places.
	<b>Attitudes</b>
6	Solve problems independently and collaboratively as part of a team

## Teaching & Learning Activities (TLAs)

CILO No.	TLAs
CILO 1, 2, 3	<b>Lecture</b> Related daily life situations will be introduced to the class. After demonstrating the basic concepts and techniques, the instructor will discuss complicated circumstances in order to strengthen their knowledge bases.
CILO 2, 3, 4	<b>In-class activities</b> Case scenarios related to the topics will be presented to students in which they will negotiate approaches in term of the concepts of fairness in mathematical sense. The instructor will initiate discussions and give feedbacks to consolidate their knowledge throughout the practice.
CILO 4, 5, 6	<b>Project</b> Students will be asked to look into their surroundings, formulate questions, properly model, and solve on a related topic. Instructor will evaluate the rationale for the methodology adopted. This helps students distinguish and recognize characteristics of different methodologies.

## Assessment:

No.	Assessment Methods	Weighting	CILO Addressed	Remarks
1	Continuous Assessment	40%	CILO 3, 4, 5	An in-class <b>quiz</b> will be given regularly in order to determine whether they can get a grip of the course materials. A <b>project</b> requires student to investigate a topic in depth, which is selected on their own. The instructor will then evaluate their proficiency analyzing the real-life situations and how well they demonstrate the knowledge acquired.
2	Mid-term test	20%	CILO 1, 2, 3	A <b>mid-term</b> test will be designed to assess their ability to master the knowledge and skills of the course.
3	Final Exam	40%	CILO 1, 2, 3	<b>Final examination</b> questions are designed to check whether they can achieve their intended learning outcomes. Questions will be related to everyday situations and to students' projects in order to examine whether students can apply the mathematics of fairness to solve problems appropriately.

**Learning Outcomes and Weighting:**

<b>Content</b>	<b>LO No.</b>	<b>Teaching (in hours)</b>
1. Politicians Go Extreme	1, 2, 5	6
2. Ideal Voting System	1, 2	6
3. Strategic Voting	1, 2, 3, 5	6
4. Weighted Voting System	1, 2, 3, 5	9
5. Geographical Seats in LegCo	1, 2, 4	6
6. Fair division	1, 2, 4	6

**Textbook:** Chiu, S. N., Ling, L. (2010) Mathematics of Fairness, HKMS

**References:**

1. COMAP. (2007). *For All Practical Purposes: Mathematical Literacy in Today's World* (7<sup>th</sup> Edition). W. H. Freeman.
2. Tannenbaum, P. (2009). *Excursions in Modern Mathematics* (7<sup>th</sup> Edition). Prentice Hall.
3. Bennelt J. & Briggs W. (2008). *Using and Understanding Mathematics: A Quantitative Reasoning Approach* (4<sup>th</sup> Edition). Pearson Education.
4. .L. Pirnot (2001). *Mathematics All Around*. Addison Wesley Longman, Inc.
5. <http://www.elections.gov.hk/>

**Course Content in Outline:**

	<b><u>Topic</u></b>	<b><u>Hours</u></b>
I.	Politicians Go Extreme	6
	a. Two-candidate spatial model	
	b. Multi-candidate spatial model	
	c. Expected votes	
II.	Ideal Voting	6
	a. Ideal voting criteria	
	b. Voting systems with single-tick ballots	
	c. Voting systems with rank ballots	
	d. Voting systems with multi-tick ballots	
	e. Multiple-winner voting systems	
III.	Strategic Voting	6
	a. Manipulating voting systems	
	b. Manipulable or not?	
	c. Group manipulation	
IV.	Weighted Voting System	9
	a. Weighted voting systems in LegCo	
	b. The Shapley-Shubik power index	
	c. The Banzhaf power index	
	d. Comparing voting systems	
	f. Multiple-winner voting systems	
V.	Geographical Seats in LegCo	6
	a. Apportionment	
	b. The Hamilton method	
	c. Divisor methods	
	d. LegCo election 2008	
VI.	Fair Division	6
	a. Sharing discrete objects	
	b. Continuous fair division	
	c. Envy-free procedure for three	