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Research Article

Super-Spreading is Possible by the Day the First Patients are Discovered in the Community

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ABSTRACT

I proposed a discrete mathematical SEPIR model for seasonal influenza. In this study, by examining affection by pre-infectious students in real data, I found that the first patients were discovered four days after the consecutive holidays, namely the incubation period passing at our academy. I show that students are likely to super-spread seasonal influenza by the day the first patients are discovered. Then, it is effective to strengthen for seasonal influenza measures within the community especially four days after the consecutive holidays.

1. Introduction

An epidemic of Flu: seasonal influenza occurred at JCGA: Japan Coast Guard Academy in January, 2017. After three consecutive holidays from January 7th to 9th, students returned to the dormitory and started taking classes. On Friday January 13th, two students developed Flu. At that time, there were 150 undergraduate students. Finally, 37 students, 20 freshmen, 13 sophomores and 4 juniors developed the Flu [1]. Of the 60 teachers not one developed Flu. According to our medical doctor at that time, usually about five students develop Flu at the dormitory in a usual epidemic wave.

An epidemic of SARS: Severe Acute Respiratory Syndrome occurred in Singapore in 2003[2]. Five people were categorized as super spreaders of SARS who directly affected more than ten people. At JCGA, I also found the super-spreading of Flu. In this paper, I show super-spreading by the day that first patients are discovered.

2. Mathematical Model

Kermack et.al proposed SIR model for epidemics[3]. The state transition diagram of an individual is shown in Fig. 1(a). “S”, “I” and “R” means susceptible state, infectious state and recovered state. An individual of “S” can transit to “I” by contact with individual of “I”. Then, an individual moves state from “I” to "R" depending on how long it has been in “I”.

Keeling et.al [4] introduced the incubation period, that is exposed “E” state into SIR model and proposed mathematical SEIR model, which many childhood infectious diseases follow. Individual of “E” is affected but not yet infectious. Only individual of “I” can affect individual of “S”. The state transition diagram of an individual is shown in Fig. 1(b).

At JCGA, students are not affected by students of “I” because patients are isolated in sick rooms. Then, I introduced pre-infectious state “P” into SEIR model and

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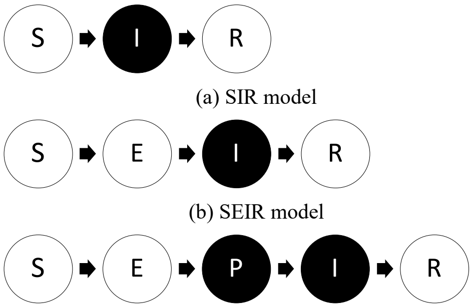
proposed the discrete mathematical SEPIR model for Flu[1]. The incubation period is divided into two periods, the exposed period and the infectious period, but neither have any symptoms. I set the former as exposed state "E" and the latter as pre-infectious state "P". The state transition diagram of an individual is shown in Fig. 1(c).



(a) SIR model

(b) SEIR model

(c) SEPIR model

Fig. 1. The state transition diagram of an individual: circle shows state of individual. S: Susceptible state, E: Exposed state, P: Pre-infectious state, I: Infectious state and R: Recovered state. Black circle means that it can affect others.

$$\Delta S = S(t+1) - S(t) = -\alpha S(t)P(t) - \beta S(t)I(t) \quad (1)$$

$$\Delta E = E(t+1) - E(t) = \alpha S(t)P(t) + \beta S(t)I(t) - \sigma E(t) \quad (2)$$

$$\Delta P = P(t+1) - P(t) = \sigma E(t) - \tau P(t) \quad (3)$$

$$\Delta I = I(t+1) - I(t) = \tau P(t) - \gamma I(t) \quad (4)$$

$$\Delta R = R(t+1) - R(t) = \gamma I(t) \quad (5)$$

Individual of "I" or "P" can affect individual of "S". There is some contact between individual of "S" and that of "I". The probability of the contact is determined by the respective numbers of "S" and "I". Considering a mean infectivity rate β, individual of "S" moves "E" as given in Eq (1)[3]. There is also some contact between individual of "S" and that of "P". The probability of the contact is determined by the respective numbers of "S" and "P". By introducing infectivity rate α, individual of "S" moves "E" as given in Eq (1)[1]. By introducing transmission rate σ, individual of "E" moves "P" as given in Eq (2)[1]. By introducing transmission rate τ, individual of "P" moves "I" as given in Eq (3)[1]. By introducing the recovery rate γ which is the inverse of the infectious "I" period, this leads to a far more straightforward equation as shown in Eq (4)[3]. Here, S(t), E(t), P(t), I(t) and R(t) is the number of individuals of "S", "E", "P", "I" and "R". I set a base time as 08:30 and t represent days since January 9.

3. Former Results[1]

I have the JCGA data of developed students as shown by "I" in Table 1 (Case A). First column ID shows student identification number and next 18 columns show the daily state of the student. The date with underline means day off. The average of infectious "I" period is 3.86 days.

I found that student 1 and 2 brought Flu to the JCGA, which is called the source of the infection. I supposed that a student is affected in their room, which is a closed space and follows the SEPIR model. By retrospective investigation of activities in closed spaces according to the schedule of students, I found that it was on campus transmission. As for infection channels, I found I just had to deal with bedrooms and classrooms as closed spaces. As for the incubation period, focusing on student of "E", I found the period of "E" is one day and the period of "P" is two days. Then, I filled in the state of the students, such as "S"," E", "P" and "R", in Table 1, as well.

Table 1. Epidemic of Flu at JCGA in January, 2017 (Case A).

ID	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	F	C	B	Y
1	S	E	P	P	**I**	I	I	I	R	R	R	R	R	R	R	R	R	R	16	16	0	O
2	S	E	P	P	**I**	I	I	I	R	R	R	R	R	R	R	R	R	R	11	9	2	O
3	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R	7	6	1	U
4	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R	6	6	0	U
5	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R	6	6	0	U
6	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	R	6	6	0	U
7	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	R	R	8	6	2	U
8	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	0	0	0	XC
9	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	1	0	1	XC
10	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
11	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	2	0	2	XC
12	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
13	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	1	0	1	XC
14	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
15	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
16	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
17	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	U
18	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	1	0	1	X2
19	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	R	1	0	1	X2

20	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	R	0	0	0	XC
21	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	R	0	0	0	XC
22	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	0	0	0	X2
23	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	0	0	0	X2
24	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	0	0	0	XC
25	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	0	0	0	X2
26	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	R	0	0	0	XC
27	S	S	S	S	E	P	P	I	I	R	R	R	R	R	R	R	R	R	0	0	0	XC
28	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	0	0	0	XB
29	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	1	1	0	XB
30	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	1	1	0	XB
31	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	1	1	0	O
32	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	0	0	0	XB
33	S	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	1	1	0	XB
34	S	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	0	0	0	O
35	S	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	1	1	0	O
36	S	S	S	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	0	0	0	XC
37	S	S	S	S	S	S	S	S	S	E	P	P	I	I	I	I	I	R	0	0	0	XC
I	0	0	0	0	2	7	21	27	25	27	12	9	7	3	1	1	1	0				
P	0	2	7	21	25	21	13	8	8	3	2	1	0	0	0	0	0	0				
G	-	-	13	6	1	4	0	1	1	0	0	0	-	-	-	-	-	-				
CG	-	-	13	6	0	0	0	0	0	0	0	0	-	-	-	-	-	-				
BG	-	-	2	3	1	4	0	0	0	0	0	0	-	-	-	-	-	-				

4. JCGA 2017 Case

I reconfirmed to focus on the affected students by student of "P". In Table 1, F, C and B columns refer to the number of affected students by student of "P" at JCGA, in classrooms and in bedrooms. F and C of students 1 or 2 are very high. And C is more than B because students in classrooms are more than that of bedrooms. Here, F is not equal to the sum of C and B because students can affect the same student in both rooms.

I and P rows refer to the number of students of "I" and "P". I on January 16th or 18th is the most and P on January 13th is the most. G, CG and BG rows refer to the number of affected students by student of "P" at JCGA, in classrooms and in bedrooms on that day. G on January 11th or 12th is very high. CG is more than BG because students in classrooms are more than that of bedrooms. Here, G is not equal to the sum of CG and BG because students can be affected in both rooms on that day. Y means infection channel. "O" refers to outside of JCGA on weekends. "X-" refers to campus transmission and 26 students of "X" derived from student 1 and 2. "XC" refers to infection in classroom, "XB" refers to infection in bedroom and "X2" refers to infection in both rooms. "U" refers to unknown.

5. JCGA 2019a Case

In January 2019, an epidemic of Flu also occurred on JCGA training ship. Here, I define epidemic as the case that patients are more than first patients. After winter vacation until January 3rd, students returned to the dormitory and started embarkation training. At that time, there were 56 freshmen on the JCGA training ship. On Friday January 10, a student, the source of infection developed Flu. Finally, 18 students were affected.

Table 2. Epidemic of Flu on JCGA embarkation training ship in January, 2019 (Case B).

SN	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	F	C	B	Y
1	S	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	6	6	4	O
2	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	12	12	7	U
3	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	R	R	7	7	4	X2
4	S	S	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	2	2	2	XC
5	S	S	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	2	2	2	XC
6	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	2	2	2	X2
7	S	S	S	S	S	E	P	P	I	I	I	I	I	I	R	R	R	R	2	2	2	X2
8	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	R	R	R	2	2	2	X2
9	S	S	S	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	2	2	2	X2
10	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	2	2	2	X2
11	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	2	2	2	X2
12	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	2	2	2	X2
13	S	S	S	S	S	S	E	P	P	I	I	I	I	I	R	R	R	R	2	2	2	XC
14	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	2	2	2	XC
15	S	S	S	S	S	S	E	P	P	I	I	I	I	R	R	R	R	R	2	2	2	XC
16	S	S	S	S	S	S	S	S	E	P	P	I	I	I	R	R	R	R	0	0	0	X2
17	S	S	S	S	S	S	S	S	E	P	P	I	I	R	R	R	R	R	0	0	0	X2
18	S	S	S	S	S	S	S	S	S	S	S	S	S	S	E	P	P	I	0	0	0	U
I	0	0	0	0	0	1	2	3	8	15	15	12	12	4	0	0	0	1				
P	0	0	0	1	2	2	6	12	7	2	2	0	0	0	0	1	1	0				
G	-	-	-	1	5	7	0	2	0	0	0	-	-	-	-	0	0	-				
CG	-	-	-	1	5	7	0	2	0	0	0	-	-	-	-	0	0	-				
BG	-	-	-	1	3	4	0	2	0	0	0	-	-	-	-	0	0	-				

Developed students are shown by "I" in Table 2 (Case B). According to former study[1], I filled in the state of students such as “S”,” E”, “P” and “R”, as well. F, C, B, Y, I, P, G, CG and BG are the same as in Table 1. Here, base time is 10:00. First column SD shows serial number. I found that F and C of student 1 or 2 is very high and G and CG on January 9th or 10th are very high. C is more than B and CG is more than BG. And G on January 12th is small though P is most. The data is shown in appendix (Table5 and Table 6). The working hours is from 08:30 to 17:15 on the training ship.

6. Super Spreading

In the two cases, it seems that the source students developed Flu at the very beginning and super-spread the virus. Here, I define super-spreading as that of more than some ratio of students directly affected at JCGA. And I found that the source students affected many students by the day of the first patients being discovered, hereinafter referred to D-day. After D-day, even though P is large, G is small, few students were affected. At that time, the preventative measures against epidemic students were adapted after D-day, such as wearing medical masks, hand washing and ventilation. The measures seemed to be effective. Moreover, I found that about four days after the consecutive holidays, namely the incubation period passing, the first patients were discovered. Then, I focus on the day not people as for super spreading.

In the Singapore case, super spreader infected more than ten people not in whole Singapore, but in their community. As for community size, Dumber showed that the average number of people in community is about 150[5]. I define the super-spreading that people directly affected more than 6.7% (=10/150) of their community in the day. In case A, G on January 11th, that is by D-day, students affected 13 students at JCGA. It is categorized as super-spreading. In case B, G on January 9th and 10th, that is by D-day, students affected 15 or 7 students on JCGA training ship. It is categorized as super-spreading.

7. JCGA 2019b Case

In January 2019, an epidemic of Flu also occurred at JCGA. After winter vacation, students returned to the dormitory and started taking classes. At that time, there were 109 undergraduate students. On Thursday January 9, six students developed Flu. Finally, 13 students, 11 sophomores and 2 juniors developed Flu. Developed students are shown by “I” in Table 3 (Case C). According to a former study[1], I filled in the state of students such as “S”,” E”, “P” and “R”, as well. F, C, B, Y, I, P, G, CG and BG are the same as in Table 1. Here, the base time is 10:00. The data is shown in appendix (Table 7, Table 8, Table 9 and Table 10).

Though six students were the source of the infection bringing Flu, super-spreading didn’t occur. This case is similar to after D-day in Case A and B. Compared to Case A, I found that some factors were effective.

- No big lecture for all students: students cannot contact many students.
- No martial arts: students cannot contact physically.
- Small number of students at JCGA: students can distance from each other.

Table 3. Epidemic of Flu at JCGA in January, 2019 (Case C).

SN	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	F	C	B	Y
1	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	2	1	1	O
2	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	1	1	0	O
3	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	1	1	0	O
4	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	1	1	0	O
5	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	1	1	0	O
6	S	E	P	P	**I**	I	I	I	I	I	R	R	R	R	R	R	R	R	1	1	0	O
7	S	S	E	P	P	I	I	I	I	I	I	R	R	R	R	R	R	R	0	0	0	O
8	S	S	E	P	P	I	I	I	I	I	I	R	R	R	R	R	R	R	0	0	0	O
9	S	S	E	P	P	I	I	I	I	I	R	R	R	R	R	R	R	R	0	0	0	O
10	S	S	S	E	P	P	I	I	I	I	I	I	R	R	R	R	R	R	0	0	0	XC
11	S	S	S	E	P	P	I	I	I	I	I	I	R	R	R	R	R	R	0	0	0	XB
12	S	S	S	S	S	S	S	E	P	P	I	I	I	I	I	I	R	R	0	0	0	U
13	S	S	S	S	S	S	S	S	E	P	P	I	I	I	I	I	I	R	0	0	0	O
I	0	0	0	0	6	9	11	11	11	11	5	4	2	2	2	2	1	0				
P	0	0	6	9	5	2	0	0	1	2	1	0	0	0	0	0	0	0				
G	-	-	2	0	0	0	-	-	0	0	0	-	-	-	-	-	-	-				
CG	-	-	1	0	0	0	-	-	0	0	0	-	-	-	-	-	-	-				
BG	-	-	1	0	0	0	-	-	0	0	0	-	-	-	-	-	-	-				

8. Infectivity Rate

At JCGA, infectivity rate β by “I” is 0 because patients are isolated in a sick room. Then, I calculated infectivity rate α by “P” in classroom and bedroom, as for by D-day (α_{bC} and α_{bB}) and after D-day (α_{aC} and α_{aB})(Table 4). I found that the average infectivity rate after D-day is smaller than that of D-day. Especially the average infectivity rate in the classroom after D-day (α_{aC}) is one twentieth of that of D-day (α_{bC}). Considering that most students are affected in classrooms, that is a significant impact on the epidemic. The measures against Flu seem to be effective after D-day. It seems that Flu has finished super-spreading by D-day.

I show the average infectivity rate in the former study in Table 4, as well[1]. The standard deviation of the infectivity rate after D-day (α_aC and α_aB) is smaller than that of the former study. They approach real data more than the former study after D-day. While, those by D-day (α_bC and α_bB) have a very wide range, it is possible to provoke a pandemic by D-day. That is, students likely to super-spread seasonal influenza by D-day.

Table 4. Infectivity rate by “P” of JCGA 2017 Case .

Infectivity rate	Classrooms		Bedrooms	
This study	by D-day	after D-day	by D-day	after D-day
	α_bC	α_aC	α_bB	α_aB
Range	0 – 0.32	0 – 0.0185	0 - 0.286	0 - 0.167
The Average	0.0423	0.00190	0.0391	0.0152
Standard Deviation	0.0886	0.00489	0.0853	0.0430
Former study[1]	α_C		α_B	
The Average	0.0206		0.0259	
Standard Deviation	0.0637		0.0660	

9. Conclusion

By examining affection by pre-infectious students in real data, I found that the first patients were discovered four days after the consecutive holidays, namely the incubation period passing at our academy. I show that students are likely to super-spread seasonal influenza by the day the first patients are discovered. Then, it is effective to strengthen for seasonal influenza measures within the community especially four days after the consecutive holidays.

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Appendix

Table 5. Epidemic Data of seasonal influenza, in January, 2019 (Case B). SN: Serial number, ID: identification number, I: Infected state and Date with under bar refers to holiday

SN	ID	Date																			
		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	36		I	I	I	I	I	I													
2	40			I	I	I	I	I													
3	1				I	I	I	I													
4	31					I	I	I	I	I											
5	44					I	I	I	I	I											
6	23					I	I	I													
7	37					I	I	I	I	I	I										
8	32					I	I	I													
9	10						I	I	I	I	I										
10	9						I	I	I	I											
11	22						I	I	I	I											
12	39						I	I	I	I											
13	42						I	I	I	I	I										
14	35						I	I	I	I											
15	50						I	I	I	I											
16	45								I	I	I										
17	29								I	I											
18	7														I	I	I	I	I	I	

Table 6. Properties of students in Case B. SN: Serial number, ID: identification number and BA: bedroom area. M refers to men area and F refers to female area. I deal with separate areas for men and women instead of bedroom numbers because I don’t have information about bedrooms. As for training, I assumed that all students had the same practice

ID	BA	ID	BA	ID	BA	ID	BA	ID	BA	ID	BA
1	M	11	M	21	M	31	M	41	M	51	M
2	M	12	F	22	M	32	F	42	F	52	F
3	M	13	M	23	M	33	M	43	M	53	M
4	M	14	M	24	F	34	M	44	M	54	M

5	F	15	F	25	M	35	F	45	M	55	M
6	M	16	M	26	M	36	M	46	F	56	M
7	F	17	M	27	M	37	F	47	M		
8	M	18	F	28	M	38	M	48	M		
9	M	19	M	29	M	39	M	49	F		
10	M	20	M	30	M	40	M	50	F		

Table 7. Schedule of students on weekdays

Time	Activity
00:00-06:30	sleep
07:10-07:40	breakfast
08:45-10:15	class: first period
10:30-12:00	class: second period
12:00-13:00	lunch
13:00-14:30	class: third period
14:45-16:15	class: fourth period
16:15-17:15	sports activities
17:15-18:15	dinner
19:00-22:15	study
22:30-24:00	sleep

Table 8. Epidemic Data of seasonal influenza, in January, 2019 (Case C). SN: Serial number, ID: identification number, I: Infected state and Date with under bar refers to holiday

SN	ID	Date																	
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	58					I	I	I	I	I	I								
2	62					I	I	I	I	I	I								
3	63					I	I	I	I	I	I								
4	74					I	I	I	I	I	I								
5	107					I	I	I	I	I	I								
6	108					I	I	I	I	I	I								
7	86						I	I	I	I	I	I							
8	104						I	I	I	I	I	I							
9	70						I	I	I	I	I								
10	68							I	I	I	I	I	I						
11	114							I	I	I	I	I	I						
12	64											I	I	I	I	I	I		
13	118												I	I	I	I	I	I	

Table 9. Properties of students in Case C.SN: Serial number, ID: identification number, SR: Room number of study room, BR: bedroom and CR: classrooms of all students.

ID	SR	BR	CR	CR	CR	CR	CR	CR
57	203	23	200	210	2EB	22C	2MB	2PA
58	411	44	200	220	2EA	22C	2MB	2PA
59	206	24	200	220	2EB	22K	2MA	2PA
60	314	35	200	210	2EA	22K	2MA	2PA
61	401	41	200	210	2EA	22K	2MA	2PB
62	202	15	200	220	2EB	22K	2MB	2PA
63	409	43	200	220	2EB	22K	2MB	2PA
64	304	12	200	210	2EA	22K	2MA	2PB
65	412	44	200	210	2EB	22C	2MB	2PA
66	416	13	200	230	2EB	22K	2MA	2PB
67	303	14	200	210	2EA	22K	2MB	2PA
68	303	2	200	210	2EB	22K	2MB	2PB
69	313	34	200	230	2EB	22R	2MA	2PA
70	308	32	200	220	2EA	22K	2MA	2PA
71	201	11	200	230	2EA	22K	2MA	2PA
72	212	26	200	210	2EB	22C	2MA	2PA
73	402	41	200	220	2EA	22C	2MA	2PA
74	308	32	200	220	2EA	22K	2MA	2PA
75	417	45	200	210	2EB	22C	2MA	2PA
76	208	24	200	220	2EA	22C	2MB	2PA
77	209	25	200	220	2EB	22K	2MB	2PA
78	204	23	200	210	2EB	22R	2MB	2PA
79	407	42	200	220	2EB	22R	2MB	2PA
80	315	13	200	210	2EA	22R	2MA	2PA
81	212	26	200	210	2EB	22C	2MB	2PA
82	207	24	200	220	2EA	22R	2MB	2PA
83	210	25	200	210	2EA	22C	2MB	2PA
84	211	25	200	230	2EA	22C	2MA	2PA
85	306	32	200	210	2EA	22C	2MB	2PA
86	207	24	200	220	2EA	22K	2MB	2PA
87	305	31	200	210	2EB	22K	2MA	2PA
88	310	33	200	210	2EB	22C	2MA	2PA
89	213	26	200	210	2EA	22C	2MB	2PA
90	415	1	200	220	2EB	22C	2MB	2PB
91	404	16	200	210	2EA	22K	2MB	2PA
92	214	11	200	210	2EB	22C	2MB	2PA
93	417	45	200	210	2EA	22K	2MA	2PA

94	311	33	200	220	2EB	22K	2MA	2PA
95	312	34	200	230	2EA	22K	2MA	2PA
96	317	35	200	220	2EB	22C	2MB	2PA
97	301	31	200	210	2EB	22K	2MA	2PA
98	215	1	200	210	2EB	22C	2MA	2PA
99	413	45	200	210	2EB	22K	2MA	2PB
100	211	25	200	220	2EA	22C	2MA	2PA
101	405	42	200	210	2EB	22K	2MB	2PA
102	401	41	200	230	2EA	22C	2MA	2PA
103	307	32	200	220	2EA	22R	2MA	2PA
104	408	43	200	210	2EB	22K	2MA	2PA
105	205	23	200	210	2EB	22K	2MB	2PA
106	403	41	200	220	2EA	22C	2MA	2PA
107	410	43	200	220	2EB	22R	2MA	2PA
108	312	34	200	220	2EA	22C	2MA	2PB
109	316	35	200	210	2EA	—	2MA	2PA
110	216	26	200	210	2EB	22K	2MA	2PA
111	409	43	300	310	3EA	3SA		
112	202	2	300	310	3EA	3PO		
113	403	41	300	310	3EB	3SA		
114	411	44	300	310	3EB	3SA		
115	211	25	300	310	3EA	3PO		
116	206	23	300	310	3EA	3SA		
117	408	43	300	310	3EA	3SA		
118	405	42	300	310	3EA	3SA		
119	414	45	300	310	3EA	3PO		
120	308	33	300	310	3EB	3SA		
121	208	24	300	310	3EB	3SA		
122	413	45	300	310	3EA	3PO		
123	307	32	300	310	3EB	3SA		
124	205	23	300	310	3EB	3PO		
125	412	44	300	310	3EA	3PO		
126	301	31	300	310	3EB	3PO		
127	408	43	300	310	3EB	3SA		
128	306	32	300	310	3EA	3SA		
129	209	25	300	310	3EA	3SA		
130	212	26	300	310	3EA	3SA		
131	311	34	300	310	3EB	3SA		
132	302	31	300	310	3EB	3SA		
133	313	34	300	310	3EA	3SA		
134	406	42	300	310	3EB	3PO		
135	410	44	300	310	3EA	3PO		
136	213	26	300	310	3EB	3SA		
137	312	34	300	310	3EB	3SA		
138	417	45	300	310	3EA	3SA		
139	305	31	300	320	3EB	3SA		
140	210	25	300	320	3EA	3PO		
141	209	25	300	320	3EB	3SA		
142	412	44	300	320	3EB	3SA		
143	216	26	300	320	3EA	3SA		
144	416	15	300	320	3EA	3SA		
145	407	42	300	320	3EA	3SA		
146	307	32	300	320	3EA	3SA		
147	304	17	300	320	3EB	3PO		
148	208	24	300	320	3EB	3SA		
149	317	35	300	320	3EB	3SA		
150	309	33	300	320	3EB	3SA		
151	203	23	300	320	3EB	3SA		
152	310	33	300	320	3EB	3PO		
153	201	13	300	320	3EA	3SA		
154	401	41	300	320	3EA	3SA		
155	207	24	300	320	3EA	3SA		
156	204	23	300	320	3EB	3SA		
157	402	41	300	330	3EA	3SA		
158	314	34	300	330	3EB	3SA		
159	316	35	300	330	3EA	3PO		
160	311	34	300	330	3EA	3SA		
161	214	14	300	330	3EA	3SA		
162	216	26	400	430	4EB	4SA		
163	215	16	400	430	4EA	4PO		
164	414	45	400	430	4EB	4SA		
165	312	34	400	430	4EA	4PO		

Table 10. Class schedules and class rooms in Case C. D: Identification number, D: Date of January 2017, P: Class Period, G: Grade, CRID: Classroom ID

ID	D	P	G	CRID	ID	D	P	G	CRID
1	07	1	2	210	71	16	3	2	210
2	07	1	2	220	72	16	3	2	220
3	07	1	2	230	73	16	3	2	230
4	07	1	3	3PO	74	16	3	3	310
5	07	1	3	3SA	75	16	3	3	320
6	07	2	2	200	76	16	3	3	330

7	07	2	3	300	77	17	1	2	220
8	07	4	3	310	78	17	2	2	210
9	07	4	3	320	79	17	2	2	230
10	07	4	3	330	80	18	1	2	200
11	08	1	3	310	81	18	1	3	300
12	08	1	3	320	82	18	2	2	220
13	08	1	3	330	83	18	2	2	230
14	08	2	2	210	84	18	2	3	300
15	08	2	3	310	85	18	3	2	210
16	08	2	3	320	86	18	3	2	220
17	08	2	3	330	87	18	3	2	230
18	08	3	2	200	88	18	4	3	300
19	08	3	3	310	89	19	1	2	210
20	08	3	3	330	90	19	1	2	220
21	09	1	2	200	91	19	1	2	230
22	09	1	3	310	92	19	1	3	300
23	09	1	3	320	93	19	2	2	210
24	09	1	3	330	94	19	2	2	220
25	09	2	2	22C	95	19	2	3	300
26	09	2	2	22K	96	19	3	2	220
27	09	2	2	22R	97	19	3	3	310
28	09	2	3	310	98	19	3	3	320
29	09	2	3	320	99	21	1	2	200
30	09	2	3	330	100	21	1	3	3PO
31	09	3	2	210	101	21	1	3	3SA
32	09	3	2	230	102	21	2	2	210
33	09	3	3	310	103	21	2	2	220
34	09	3	3	330	104	21	2	2	230
35	10	1	2	2EA	105	21	2	3	300
36	10	1	2	2EB	106	21	3	2	210
37	10	2	2	2EA	107	21	3	3	300
38	10	2	2	2EB	108	21	4	3	300
39	10	3	2	210	109	22	1	2	200
40	10	3	2	230	110	22	1	3	310
41	10	3	3	300	111	22	1	3	320
42	11	1	2	200	112	22	1	3	330
43	11	1	3	300	113	22	2	2	210
44	11	2	2	200	114	22	2	2	220
45	11	2	3	300	115	22	2	2	230
46	11	3	2	210	116	22	2	3	3PO
47	11	3	2	230	117	22	2	3	3SA

48	11	3	3	310	118	22	3	2	210
49	11	3	3	320	119	22	3	2	230
50	11	3	3	330	120	22	3	3	310
51	11	4	2	210	121	22	3	3	320
52	11	4	3	310	122	22	3	3	330
53	15	1	2	200	123	22	4	3	310
54	15	1	3	310	124	22	4	3	320
55	15	1	3	320	125	22	4	3	330
56	15	1	3	330					
57	15	2	2	210					
58	15	2	2	230					
59	15	2	3	320					
60	15	2	3	330					
61	15	3	3	310					
62	15	3	3	330					
63	16	1	2	200					
64	16	1	3	3EA					
65	16	1	3	3EB					
66	16	2	2	22C					
67	16	2	2	22K					
68	16	2	2	22R					
69	16	2	3	3EA					
70	16	2	3	3EB					

Authors Introduction

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