THE CREATION OF A NEW CONCERTO COMMUNICATING BETWEEN THE THAI INSTRUMENT AND ORCHESTRA BASED ON THE THAI TUNING SYSTEM

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THE CREATION OF A NEW CONCERTO COMMUNICATING BETWEEN THE THAI INSTRUMENT AND ORCHESTRA BASED ON THE THAI TUNING SYSTEM

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HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT
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This research investigates the traditional Thai tuning system. The disagreement has surrounded the tuning of Thai classical music. Focusing on Ranat Ek, we can analyze the sound cents of intervals and determine whether intervals are consonant using the existing mathematical formula by measuring the vibration frequency of each sound. Compared to the vibration data of Ranat Ek, with various school instruments, the tuning system of the Thai government was selected as the tuning standard for constructing the Ranat Ek concerto after data analysis. The researcher composed a Ranat Ek concerto after deciding to use the Thai government-issued tuning system. The researcher attempted to have the entire symphony orchestra use this tuning system to accompany Ranat Ek. Following the Western method of composing concertos, the selection of these three works as concertos was based on tempo. The music can incorporate Thai characteristics.

Keyword : Thai tuning system, Ranat Ek, Concerto

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ZHENG XILIN

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1
INTRODUCTION

Background

From the beginning of the research topic, "the creation of a new concerto communicating between Thai instruments with orchestra based on the Thai tuning system," let me introduce myself first. I have received Western music education since childhood. When I first heard Thai music, I had a strange feeling that the music was out of tune. Then I began to wonder why this was happening.

I collected information about the Thai tuning system on the Internet, and the most common one is seven tones equal temperament. In European music, an octave is divided into 12 notes, called the equal temperament. The ratio of the frequencies of any adjacent pair of notes is the same, giving an equivalent perceived step size as the pitch is roughly the logarithm of the frequency, and there are 100 cents between nearly two notes. Thai music divides an octave into seven equal parts. Between two relative notes are 171.4 cents. So, when a person used to Western music listens to Thai music for the first time, it feels out of tune. This tuning system was first proposed by Alexander J. Ellis, who introduced the idea that Thai tuning was a heptatonic equidistance scale and claimed this was an "ideal" tuning. Alexander J. Ellis was an English mathematician. He is a philologist and early phonetician who also influenced the field of musicology. Alexander J. Ellis was the first to measure Thai Musical Instruments' vibration frequency. Although his theory was a deviation from measurement, he attributed it to improper preservation or weather. I am going to show this tuning system in a table.

Table 1 Western tuning system (cents system by Alexander J. Ellis)

NOTES	C	#C	D	#D	E	F	#F	G	#G	A	#A	B	C
NO:	1	2	3	4	5	6	7	8	9	10	11	12	1
CENT TO NEXT NOTE	100	100	100	100	100	1000	100	100	100	100	100	100	100

Table 2 THAI tuning system (cents system by alexander J. Ellis)

NO:	1	2	3	4	5	6	7	8
CENT TO NEXT NOTE	171.4	171.4	171.4	171.4	171.4	171.4	171.4	171.4

After learning this knowledge, I tried to understand what causes the unique way of Thai music tuning.

The objective of the study

1. to study of tuning system of Thai instruments by using the existing formula of the Western tuning system.

2. to create a new concerto communicating between Thai musical instruments and orchestras based on the Thai tuning system.

Significant of the study

The analysis of the Thai tuning system concludes whether Thai musical instruments can play together with Western orchestras. The goal is not only to research music but also the study cultural inheritance. For a long time, my country China ultimately accepted the Western music system and ignored Chinese traditional music. Until the founding of New China in 1949, several outstanding composers and musicians emerged who blended their Chinese traditional music with Western music in a limited way, creating a thriving scene of Western and Chinese traditional music in China at the present stage. Through the research of this paper, I hope to discover the new direction of the inheritance and development of Thai music performed with Western music.

Scope of the Study

1. In this study, the researcher will study the tuning system by measuring the Thai musical instruments Ranat Ek at Srinakharinwirot University: Faculty of Fine Arts, Rambhai University, Prasarnmit Demonstration School, and study from published documents as follows: The tuning system released by the Thai government.

2. The formula used to calculate the intervals this time, The researcher used a formula invented by Liao Tianrui (繆天瑞).

3. This composition uses Thai musical instruments as follows: Thai xylophone (Ranat Ek Lek), Metal Thai xylophone (Ranat Ek Lek), Thai tenor flute, (Klui piang or), Thai soprano oboe (Pi Java)

4. The spelling of Thai Words will use phonetics.

5. The names of Thai musical instruments used this time refer to the writing style by David Morton

Definition of terms

Thai scale: The tuning system specification issued by the Thai government and the tuning system for civilian use.

Western tuning system: In the Western music system, the various systems of pitches are used to tune an instrument and its theoretical bases.

Concerto: A piece for one or more soloists and orchestra with three contrasting movements.

Music communication: The communication between two different musical styles is like the communication between two people with different languages. If communication is to be achieved, the language needs to be unified. The same is true in musical communication, which requires a unified musical system. Nowadays, our daily language is often mixed with foreign words. In the development of European music, there have also been composers and works of national music. They have added the characteristics and styles of folk music into the symphony, making the music widely spread. Therefore, music communication should be established to retain the national characteristics and limited integration.

Thai music ensemble: Thai classical music can be categorized into three genres according to their performing style and instrumentation: Pi phat, Khrueng Sai, and Mahori.

Thai musical instrument: Traditional Thai Musical Instruments are Krachappi (Thai: กระจับปี่), Chakhe (Thai: จะเข้),Saw sam sai (Thai: ซอสามสาย), Saw u (Thai: ซออู้), Saw duang (Thai: ซอด้วง), Khlui (Thai: ขลุ่ย),Pi (Thai: ปี่), Ching (Thai: ฉิ่ง), Chap (Thai: ฉาบ), Taphon (Thai: ตะโพน), Klong Song na (Thai:กลองสองหน้า), Klong that (Thai: กลองทัด), Ranat ek (Thai: ระนาดเอก), Ranat ek lek (Thai: ระนาดเอกเหล็ก). etc. It refers to the instruments used in traditional Thai music.

Thai hand position: In a symphony orchestra, the hand position needs to be changed to use the Thai tuning system when the string instrument part needs to play with the Thai instrument (Thai tuning system).

Research conceptual framework

Object 1

Use a tool to measure the vibration frequency of different instruments in the same school. The collected data is averaged to obtain reliable data.

Using the existing formula of the Western tuning system from *Liao Tianrui(廖天瑞)*, we can calculate whether the tuning system of Thai instruments is consonance in the interval.

Object 2

By interviewing Western and Thai instrument musicians to gain professional insights on tuning, the music needs to be played rather than just getting data on paper. Interviews were conducted to determine whether using the same tuning system was feasible.

Select one or several pieces of Thai music using the common Western form of performance - concerto. The same tuning system allows the two musical cultures to communicate.

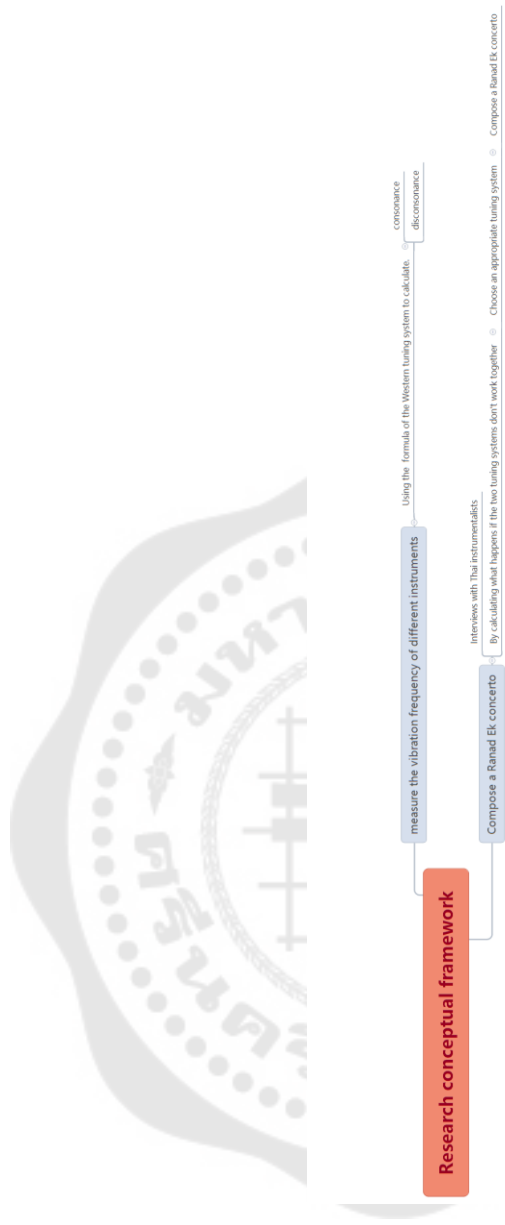


Figure 1 the research conceptual framework

Source: Lin, 2022

CHAPTER 2
LITERATURE REVIEW

In a research study on "THE CREATION OF A NEW CONCERTO COMMUNICATING BETWEEN THAI INSTRUMENTS WITH ORCHESTRA BASED ON THE THAI TUNING SYSTEM." The researcher has studied the document and research as a conceptual basis for this research. By dividing the categories of the documents studied into

1. The Documents relating to academic texts
    1.1 The tuning system in Western music
        1.1.1 International standard pitch
        1.1.2 Pythagorean tuning
        1.1.3 Just Intonation
        1.1.4 Equal temperament
        1.1.5 Consonance and dissonance
    1.2Thai tuning system
2. Relevant research

1. The Documents relating to academic texts.

1.1 The tuning system in Western music

Roughly speaking, temperament is a systematic and comprehensive study of sound. To be specific, temperament is a discipline that studies the relationships among the sounds that constitute the Tuning system by using mathematical methods according to the principles of acoustics, including local history and comparison temperament.

Because the Tuning system is closely related to the tuning scale, that is to say, the tuning system cannot exist without the tuning scale alone. In the study of traditional music in Asia, the tuning system and the tuning scale must be studied together because of the variety of the tuning scale.

Tuning system is based on acoustic principles and mathematical methods. It must be noted that the tuning system does not exist alone, and the tuning system is closely related to music itself. Therefore, the tuning system can not only be studied by mathematical methods but should be connected with practical research.

The classification of tone and the principle of producing sound

A sound is produced by the vibration of an object. If an object vibrates regularly and periodically for a certain period of time, the sound it produces has a certain pitch. This is called a musical sound. If an object vibrates erratically and produces a sound of no fixed pitch, it is called noise.

Sound is a traveling longitudinal wave which is an oscillation of pressure. Humans perceive frequency of sound waves as pitch. Each musical note corresponds to a particular frequency which can be measured in hertz. An infant's ear is able to perceive frequencies ranging from 20 Hz to 20000 Hz; the average adult human can hear sounds between 20 Hz and 16000 Hz. (Mifflin, 1992, pp.5)

Musical Instruments are divided into five categories according to the objects that vibrate (Sachs, 1881, pp.5).

Chordophone - Playing a stringed instrument, such as the violin erhu. Plucked instruments such as harps. Strike a stringed instrument like the piano.

Aerophone - Vibrating mouthpiece with sharp edges such as flute or bamboo flute. Reed vibration such as oboe, clarinet, suona, harmonica. Lip vibration such as trumpet, horn, tuba, trombone.

Membranophone - timpani, snare drum.

Idiophone - The object itself vibrates, such as a triangle, xylophone, tuning fork.

Electrophone - Electronic organ, electronic music synthesis.

There are similarities and differences between these vibrations, and I'll summarize them briefly.

If we hold the string of a stringed instrument with the same force, the shorter the string vibrates the faster it vibrates and the higher its pitch. Make the string ½ in length and hold the force constant, and the pitch goes up an octave. When a string starts to vibrate, not only does the whole string vibrate, but the sound produced at a length of ½ is an octave higher. When lengths are ⅓, the pitch is 12th higher (octave + Perfect 5th). This means that one sound is actually a compound of octaves, twelve (octave + Perfect 5th), seventeen (2 times octave + Perfect 3rd), and so on. We call the vibration of the whole string fundamental tone. The various sounds produced by segmentary vibration are called overtone or partial.

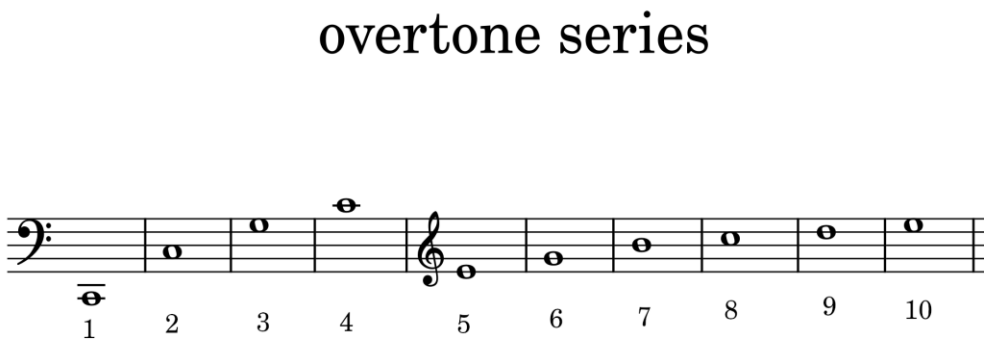


Figure 2 Overtone series

Source: Lin, 2022

In the picture, the first tone is fundamental tone. The second tone is 1st Overtone, the third tone is 2nd Overtone, and so on. In other words, overtones are all pitches higher than the lowest pitch within an individual sound; the fundamental is the lowest pitch. While the fundamental is usually heard most prominently, overtones are actually present in any pitch. (Joshua, 2000, pp.81–113)

Aerophone it means without the use of strings or membranes (which are respectively chordophones and membranophones), and without the vibration of the

instrument itself adding considerably to the sound (or idiophones). (Randel, 1999. pp.12)

Aerophone instrument vibrates in a manner similar to that of a string, but vibrates thing is not strings but air. The membranophone was different from the two vibration modes mentioned above, whose overtone was integer multiple. The overtone of the membranophone was non-integer multiple.

1.1.1 International standard pitch

The standard of pitch varies from place to place and from time to time, and in Europe since the 17th century the general trend has been higher and higher. In 1834, the Stuttgart Institute of Physicists decided a1=440Hz. In 1859, musicians and physicists in Paris, France decided A1 =435Hz. In 1939. The London International Conference decided to restore the results of the Stuttgart meeting, A1 =440Hz. From now on a1=440 is the international standard pitch. (Willi, 1969, pp.60)

1.1.2 Pythagorean tuning

Pythagorean Tuning was first proposed by the Ancient Greek philosopher Pythagoras in the 6th century. Pythagorean Tuning is composed of the sound of 2nd Overtone and 3rd Overtone to form a pure fifth, and then on this basis to form a pure fifth upward to form a scale. Pythagorean Tuning scales are shown below.

Scale step	1	2	3	4	5	6	7	8
Pitch name	c^1	d^1	e^1	f^1	g^1	a^1	b^1	c^2
Caculation method	1	$\frac{(\frac{3}{2})^2}{2}$	$\frac{(\frac{3}{2})^4}{2^2}$	$\frac{2}{3}\times 2$	$\frac{3}{2}$	$\frac{(\frac{3}{2})^3}{2}$	$\frac{(\frac{3}{2})^5}{2^2}$	2
Frequency ratio with tonic	1	$\frac{9}{8}$	$\frac{81}{64}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{27}{16}$	$\frac{243}{128}$	$\frac{2}{1}$
Cent value	0	204	408	498	702	906	1110	1200
Frequence	261.63	294.33	331.13	348.84	392.45	441.50	496.69	523.26

Figure 3 Pythagorean Tuning scales, calculation method and frequency ratio

Source: A Part of Lv Xue,by Liao tianrui

1.1.3 Just Intonation

Just Intonation is a major triad formed by adding the 5th Overtone on the basis of Pythagorean Tuning. Add the third notes to the tonic, dominant, and subordinate that make up the pure fifth. Take C major, for example. c-e-g, f-a-c, and g-b-d. These chords are Just Intonation scales.

Scale step	1	2	3	4	5	6	7	8
Pitch name	c^1	d^1	e^1	f^1	g^1	a^1	b^1	c^2
Calculation method	1	$\frac{(\frac{3}{2})^2}{2}$	$\frac{5}{4}$	$\frac{2}{3}\times 2$	$\frac{3}{2}$	$\frac{4}{3}\times\frac{5}{4}$	$\frac{3}{2}\times\frac{5}{4}$	$\frac{2}{1}$
Frequency ratio with tonic	1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	$\frac{2}{1}$
Cent value	0	204	386	498	702	884	1088	1200
Frcquence	261.63	294.33	327.04	348.84	392.45	436.05	490.56	523.26

Figure 4 Just Intonation scales, calculation method and frequency ratio

Source: A Part of Lv Xue,by Liao tianrui

The three tones constituted are lower than the Pythagorean Tuning scale (408-386=22cents). Compared with Pythagorean Tuning, levels 1, 2, 4 and 5 of scale step are the same. levels 3, 6, and 7 of scale step are characteristic of a pure tempered scale (22cents lower).

1.1.4 Equal temperament

Equal temperament, which divides an octave evenly into 12 semitones with the same distance between two adjacent notes, has been widely used in symphony orchestras and keyboard instruments. Equal temperament scales are shown below.

Scale step	1	2	3	4	5	6
Pitch name	c^1 ($\sharp b\,\flat\flat d^1$)	$\sharp c^1$ ($\times b,\ \flat d^1$)	d^1 ($\times c^1,\ \flat e^1$)	$\sharp d^1$ ($\flat e^1,\ \flat\flat f^1$)	e^1 ($\times d^1,\ \flat f^1$)	f^1 ($\sharp e^1,\ \flat\flat g^1$)
Calculation method	1.0000	1.05946	$(1.05946)^2$	$(1.05946)^3$	$(1.05946)^4$	$(1.05946)^5$
Calculation rusult	1.0000	1.0595	1.1225	1.1892	1.2599	1.3348
Frequency ratio With tonic	1	$\frac{89}{84}$	$\frac{449}{400}$	$\frac{44}{37}$	$\frac{63}{50}$	$\frac{303}{227}$
Cent value	0	100	200	300	400	500
Frequence	261.63	277.18	293.66	311.13	329.63	349.23

7	8	9	10	11	12	13
$\sharp f^1$ ($\times e^1,\ \flat g^1$)	g^1 ($\times f^1,\ \flat\flat a^1$)	$\sharp g^1$ ($\flat a^1$)	a^1 ($\times g^1,\ \flat\flat b^1$)	$\sharp a^1$ ($\flat\flat b^1,\ \flat c^2$)	b^1 ($\times a^1,\ \flat c^2$)	c^2
$(1.05946)^6$	$(1.05946)^7$	$(1.05946)^8$	$(1.05946)^9$	$(1.05946)^{10}$	$(1.05946)^{11}$	$(1.05946)^{12}$
1.4142	1.4983	1.5874	1.6817	1.7818	1.8877	2.0000
$\frac{140}{99}$	$\frac{433}{289}$	$\frac{100}{63}$	$\frac{37}{22}$	$\frac{98}{55}$	$\frac{168}{89}$	$\frac{2}{1}$
600	700	800	900	1000	1100	1200
370.00	392.00	415.31	440.00	466.17	493.89	523.26

Figure 5 Equal temperament scales, calculation method and frequency ratio

Source: A Part of Lv Xue,by Liao tianrui

When we understand the three tuning systems, we simply summarize them. Pythagorean Tuning, Just Intonation and Equal temperament each have their own characteristics and have relative contradictions. I will use the equal temperament as the standard to write a comparison table of major scales among the three tuning systems.

Table 3 comparison table of major scales: Pythagorean tuning

Tuning system	Scale step	1	2	3	4	5	6	7	1
Pythagorean tuning	Cent value between near pitch	0	204	204	90	204	204	204	90
	Cent value	0	204	408	498	702	906	1110	1200
	Cent value Different from equal temperament	0	4	8	-2	2	6	10	0

Table 4 comparison table of major scales: equal temperament

Tuning system	Scale step	1	2	3	4	5	6	7	1
equal temperament	Cent value between near pitch	0	200	200	100	200	200	200	100
	Cent value	0	200	400	500	700	900	1100	1200

Table 5 comparison table of major scales: Just Intonation

Tuning system	Scale step	1	2	3	4	5	6	7	1
Just Intonation	Cent value between near pitch	0	204	182	112	204	182	204	112
	Cent value	0	204	386	498	702	884	1088	1200
	Cent value Different from equal temperament	0	4	-14	-2	2	-16	-12	0
	Cent value Different from Pythagorean tuning	0	0	-22	0	-0	-22	-22	0

Normal adults are able to recognize pitch differences of as small as 25 cents very reliably. Adults with amusia, however, have trouble recognizing differences of less than 100 cents and sometimes have trouble with these or larger intervals. (Peretz and Hyde, 2003, pp.362-367)

Through the comparison of the three tuning systems mentioned above, in the case that the Tonic of the three tuning systems is completely the same, the following characteristics can be obtained:

Pythagorean Tuning Except that Scale step 4 is lower than two cents of equal temperament, Scale steps 2, 3, 4, 5, 6 and 7 are all higher than equal temperament. And Cent value Different is less than 10 cents. As we know, it is difficult

for ordinary people to perceive the difference below 25 cents. Pythagorean tuning and equal temperament are very similar, so it is okay to play slightly higher.

Compared with Pythagorean Tuning, Just Intonation has the same Cent value of other Scale steps except that Scale steps 3, 6 and 7 are lower than Pythagorean Tuning by 22 cents. Compared to equal temperament, Just Intonation also different of Scale step 3, 6, and 7. It is less than equal temperament, respectively, 14 cents,16 cents, and 12 cents.

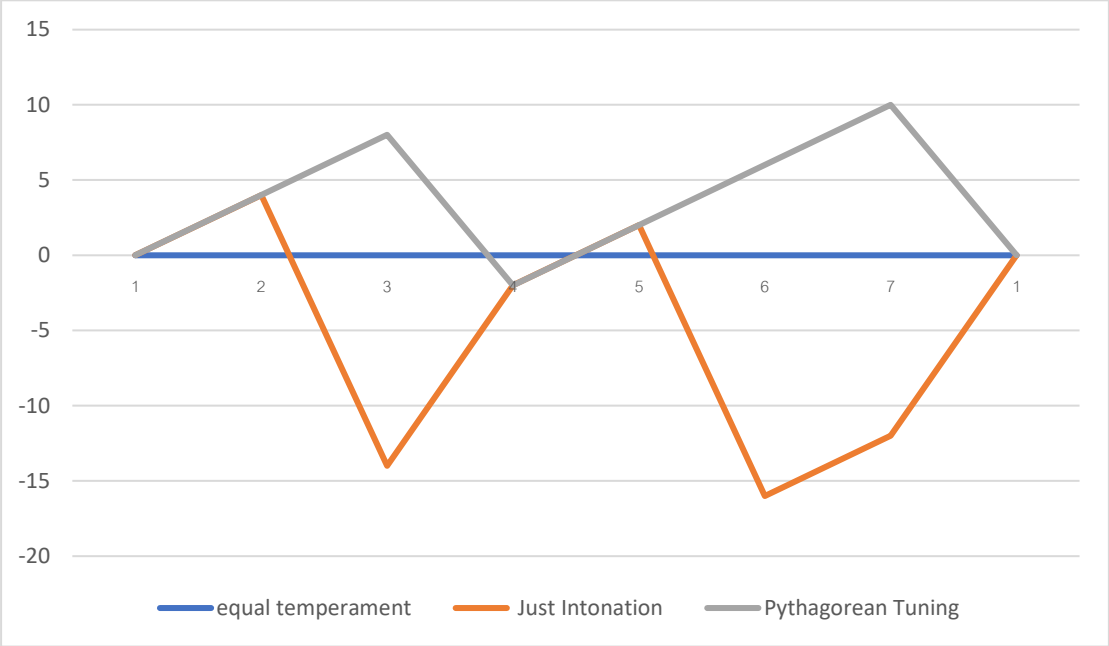


Figure 6 comparison figure of three western tuning system major scales

Source: Lin Zixiang, 2022

In the table above, we can obviously see that Just Intonation is more deviated from equal temperament than Pythagorean Tuning.

1.1.5 Consonance and dissonance

In music, consonance and dissonance are categorizations of simultaneous or successive sounds. Within the Western tradition, some listeners associate consonance with sweetness, pleasantness, and acceptability, and dissonance with harshness, unpleasantness, or unacceptability, although there is broad acknowledgement that this depends also on familiarity and musical expertise. (Lahdelma, and Eerola, 2020, pp.86-93)

Whether the two tones are consonance depends on whether the vibration frequencies of the two tones are proportional. As we mentioned before, vibration will produce overtones, and the more same overtones, the more the two tones will be in consonance. According to the principle of tuning System, Just Intonation is a major triad formed by adding the 5th Overtone on the basis of Pythagorean Tuning. Add the third notes to the tonic, dominant, and subordinate that make up the pure fifth. All the pitches are present in the tonic, so they are most consonant. Pythagorean Tuning is the second, and Equal temperament is the worst.

To judge whether the two intervals are consonance or not, we can use the consonance coefficient K.

K=1/nm

"n" represents the vibrational frequency of the upper pitch and "m" represents the vibrational frequency of the lower pitch. (Chen, 2008, pp.70)

We can calculate the consonance and dissonance of intervals. However, the "K" value obtained by this algorithm has a disadvantage, the distribution is not uniform. For example, the value of K at Perfect unison is 1, The octave K value is 0.5. The vibration frequency ratio of perfect fifth is $\frac{2}{3}$, K value is 0.16666.

In order to avoid the "K" value band by this algorithm has a disadvantage, the distribution is not uniform. We get Ip(dB) by calculating K as Logarithmic Function in mathematics.

$$Ip = 20\log_{10}(1000/nm)(dB)$$

(Chen, 2008, pp.72)

A new formula can be obtained by simplifying the formula.

$$Ip = 20lg(1000k)(dB)$$

The consonance of intervals is subjective to everyone. But it is also an objective thing (vibration frequency). So, there is objectivity. According to the calculated values, a classification table can be obtained by combining the musician's hearing.

Table 6 classification table whether the interval is a consonance.

consonance	dissonance
A:48-60 (dB) Perfect consonance	D:16-24 (dB) Imperfect dissonance
B:36-48 (dB) Median consonance	E:8-16 (dB) Median dissonance
C:24-36 (dB) Imperfect consonance	F: < 8 (dB) Perfect dissonance

Table 7 Common interval consonance coefficient K. table

	Vibration frequency ratio	Cents value	consonance coefficient K.		Ip(dB)
			Fractional form	decimal form	
Perfect unison	1/1	0	1/ (1×1)	1.00000	60 (A)
Just Intonation Minor second	16/15	112	1/ (16×15)	0.00416	12.40 (E)
Just Intonation Major second	10/9	182	1/ (10×9)	0.01111	20.92(D)
Major second	9/8	204	1/ (9×8)	0.01388	22.85(D)
	8/7	231	1/ (8×7)	0.01785	25.04(C)
	7/6	267	1/ (7×6)	0.02381	27.54(C)

Just Intonation Minor third	6/5	316	1/ (6×5)	0.03333	30.46(C)
Just Intonation Major third	5/4	386	1/ (5×4)	0.05000	33.98(C)
Perfect fourth	4/3	498	1/ (4×3)	0.08333	38.42(B)
Perfect fifth P5	3/2	702	1/ (3×2)	0.16666	44.44(B)
Just Intonation Minor sixth	8/5	814	1/ (8×5)	0.02500	27.96(C)
Just Intonation Major sixth	5/3	884	1/ (5×4)	0.06666	36.48(B)
	12/7	933	1/ (12×7)	0.01190	21.51(D)
	7/4	969	1/ (7×4)	0.03571	31.06(C)
Minor seventh	16/9	996	1/ (16×9)	0.00694	16.83(D)
Just Intonation Minor seventh	9/5	1018	1/ (9×5)	0.02222	26.94(C)
Just Intonation Major seventh	15/8	1088	1/ (15×8)	0.00833	18.42(D)
Perfect octave	2/1	1200	1/ (2×1)	0.50000	53,98(A)

When the vibration frequency of an interval cannot be expressed as a simple fraction (non-overtone vibration frequency), such as Equal temperament and the frequency ratio of each tone is irrational. The vibration and resonance phenomenon can also have an effect, but the effect is very limited. Using a relatively simple empirical formula calculation method. This method is suitable for the Equal temperament, as well as for the comparison of Thai Tuning system and Western Tuning system.

$I = Ip - \triangle I$

In Equal temperament, we can choose intervals with similar cents value (the ratio of vibration frequencies is the fraction) to calculate the $\triangle I$ value (Modified

index), and then calculate δ according to the absolute value of the difference cent value.

$$\triangle I=0.45(\delta-2)$$

The following table represents the consonance coefficient Ip of Equal temperament.

Table 8 consonance coefficient Ip of Equal temperament

Equal temperament cent value	Similar intervals vibrational ratios are fractional		δ	$\triangle$ I(dB)	I(dB)	classification
	cents	Ip(dB)				
0	0	60	0	0	60	A
100	112	12.40	12	4.5	7.9	F
200	204	22.85	4	0.9	21.95	D
300	316	30.46	16	6.3	24.16	C
400	386	33.98	14	5.4	28.58	C
500	498	38.42	2	0	38.42	B
600	702	$\delta > 25$			23.94	D

700	702	44.40	2	0	44.44	B
800	702	$\delta > 25$			25.86	C
900	884	36.48	16	6.3	30.18	C
1000	1018	26.94	18	7.2	19.74	D
1100	1088	18.42	12	4.5	13.92	E
1200	1200	53.98	0	0	53.98	A

音分值和频率对照表(一)

0—100 (c¹)				100—200 (♯c¹)			
0	261.630	50	269.296	100	277.187	150	285.310
1	261.781	51	269.452	101	277.347	151	285.474
2	261.932	52	269.608	102	277 508	152	285.639
3	262.084	53	269.763	103	277.668	153	285.804
4	262.235	54	269.919	104	277.829	154	285.970
5	262.387	55	270.075	105	277.989	155	286.135
6	262.538	56	270.231	106	278.150	156	286.300
7	262.690	57	270.387	107	278.310	157	286.465
8	262.842	58	270.544	108	278.471	158	286.631
9	262.994	59	270.700	109	278.632	159	286.797
10	263.146	60	270.856	110	278.793	160	286.962
11	263.298	61	271.013	111	278.954	161	287.128
12	263.450	62	271.169	112	279.115	162	287.294
13	263.602	63	271.326	113	279.277	163	287.460
14	263.754	64	271.483	114	279.438	164	287.626
15	263.907	65	271.640	115	279.560	165	287.792
16	264.059	66	271.797	116	279.761	166	287.959
17	264.212	67	271.954	117	279.923	167	288.125
18	264.364	68	272.111	118	280.084	168	288.291
19	264.517	69	272.268	119	280.246	169	288.458
20	264.670	70	272.425	120	280.408	170	288.625
21	264.823	71	272.583	121	280.570	171	288.791
22	264.976	72	272.740	122	280.732	172	288.958
23	265.129	73	272.898	123	280.894	173	289.125
24	265.282	74	273.056	124	281.057	174	289.292
25	265.435	75	273.213	125	281.220	175	289.459
26	265.589	76	273.371	126	281.382	176	289.627
27	265.742	77	273.529	127	281.544	177	289.794
28	265.896	78	273.687	128	281.707	178	289.961
29	266.049	79	273.845	129	281.870	179	290.129
30	266.203	80	274.004	130	282.032	180	290.297
31	266.357	81	274.162	131	282.195	181	290.464
32	266.511	82	274.320	132	282.358	182	290.632
33	266.665	83	274.479	133	282.522	183	290.800
34	266.819	84	274.637	134	282.685	184	290.968
35	266.973	85	274.796	135	282.848	185	291.136
36	267.127	86	274.955	136	283.012	186	291.304
37	267.282	87	275.114	137	283.175	187	291.473
38	267.436	88	275.273	138	283.339	188	291.641
39	267.590	89	275.432	139	283.502	189	291.810
40	267.745	90	275.591	140	283.666	190	291.978
41	267.900	91	275.750	141	283.830	191	292.147
42	268.055	92	275.909	142	283.994	192	292.316
43	268.210	93	276.069	143	284.158	193	292.485
44	268.365	94	276.228	144	284.322	194	292.654
45	268.520	95	276.388	145	284.487	195	292.823
46	268.675	96	276.548	146	284.651	196	292.992
47	268.830	97	276.707	147	284.816	197	293.161
48	268.985	98	276.867	148	284.980	198	293.331
49	269.141	99	277.027	149	285.145	199	293.500
50	269.296	100	277.187	150	285.310	200	293.670

• 302 •

Figure 7 Cent and vibration frequency comparison table (1)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

音分值和频率对照表(二)

200—300 (d¹)				300—400 (#d¹)			
200	293.670	250	302.275	300	311.132	350	320.249
201	293.840	251	302.450	301	311.312	351	320.434
202	294.009	252	302.624	302	311.492	352	320.619
203	294.179	253	302.799	303	311.672	353	320.805
204	294.349	254	302.974	304	311.852	354	320.990
205	294.519	255	303.149	305	312.032	355	321.175
206	294.689	256	303.324	306	312.212	356	321.361
207	294.860	257	303.450	307	312.393	357	321.547
208	295.030	258	303.675	308	312.573	358	321.732
209	295.200	259	303.850	309	312.754	359	321.918
210	295.371	260	304.026	310	312.935	360	322.104
211	295.542	261	304.201	311	313.115	361	322.290
212	295.712	262	304.377	312	313.296	362	322.477
213	295.883	263	304.553	313	313.477	363	322.663
214	296.054	264	304.729	314	313.658	364	322.849
215	296.225	265	304.905	315	313.840	365	323.036
216	296.396	266	305.081	316	314.021	366	323.223
217	296.568	267	305.258	317	314.202	367	323.409
218	296.739	268	305.434	318	314.384	368	323.596
219	296.910	269	305.611	319	314.566	369	323.783
220	297.082	270	305.787	320	314.747	370	323.970
221	297.257	271	305.964	321	314.929	371	324.157
222	297.425	272	306.141	322	315.111	372	324.345
223	297.597	273	306.318	323	315.293	373	324.532
224	297.769	274	306.495	324	315.476	374	324.720
225	297.941	275	306.672	325	315.658	375	324.907
226	298.113	276	306.849	326	315.840	376	325.095
227	298.286	277	307.026	327	316.023	377	325.283
228	298.458	278	307.203	328	316.205	378	325.471
229	298.630	279	307.381	329	316.388	379	325.659
230	298.803	280	307.559	330	316.571	380	325.847
231	298.976	281	307.736	331	316.754	381	326.035
232	299.148	282	307.914	332	316.937	382	326.224
233	299.321	283	308.092	333	317.120	383	326.412
234	299.494	284	308.270	334	317.303	384	326.601
235	299.667	285	308.448	335	317.486	385	326.789
236	299.840	286	308.626	336	317.670	386	326.978
237	300.014	287	308.805	337	317.853	387	327.167
238	300.187	288	308.983	338	318.037	388	327.356
239	300.360	289	309.162	339	318.221	389	327.545
240	300.534	290	309.340	340	318.405	390	327.735
241	300.708	291	309.519	341	318.589	391	327.924
242	300.881	292	309.698	342	318.773	392	328.113
243	301.055	293	309.877	343	318.957	393	328.303
244	301.229	294	310.056	344	319.141	394	328.493
245	301.403	295	310.235	345	319.326	395	328.683
246	301.577	296	310.414	346	319.510	396	328.872
247	301.752	297	310.594	347	319.695	397	329.062
248	301.926	298	310.773	348	319.879	398	329.253
249	302.100	299	310.953	349	320.064	399	329.443
250	302.275	300	311.132	350	320.249	400	329.633

Figure 8 Cent and vibration frequency comparison table (2)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

音分值和频率对照表(三)

400—500 (e¹)				500—600 (f¹)			
400	329.633	450	339.292	500	349.234	550	359.467
401	329.824	451	339.488	501	349.436	551	359.675
402	330.014	452	339.684	502	349.638	552	359.883
403	330.205	453	339.881	503	349.840	553	360.091
404	330.396	454	340.077	504	350.042	554	360.299
405	330.587	455	340.273	505	350.244	555	360.507
406	330.778	456	340.470	506	350.447	556	360.715
407	330.969	457	340.667	507	350.649	557	360.924
408	331.160	458	340.864	508	350.852	558	361.132
409	331.351	459	341.061	509	351.054	559	361.341
410	331.543	460	341.258	510	351.257	560	361.550
411	331.734	461	341.455	511	351.460	561	361.759
412	331.926	462	341.652	512	351.663	562	361.968
413	332.118	463	341.849	513	351.866	563	362.177
414	332.310	464	342.047	514	352.070	564	362.386
415	332.502	465	342.245	515	352.273	565	362.596
416	332.694	466	342.442	516	352.477	566	362.805
417	332.886	467	342.640	517	352.680	567	363.015
418	333.078	468	342.838	518	352.884	568	363.224
419	333.271	469	343.036	519	353.088	569	363.434
420	333.463	470	343.235	520	353.292	570	363.644
421	333.656	471	343.433	521	353.496	571	363.854
422	333.849	472	343.631	522	353.706	572	364.065
423	334.042	473	343.830	523	353.905	573	364.275
424	334.235	474	344.028	524	354.109	574	364.485
425	334.428	475	344.227	525	354.314	575	364.696
426	334.621	476	344.426	526	354.519	576	364.907
427	334.814	477	344.625	527	354.723	577	365.118
428	335.008	478	344.824	528	354.928	578	365.329
429	335.201	479	345.024	529	355.133	579	365.540
430	335.395	480	345.223	530	355.339	580	365.751
431	335.589	481	345.422	531	355.544	581	365.962
432	335.783	482	345.622	532	355.749	582	366.173
433	335.977	483	345.822	533	355.955	583	366.385
434	336.171	484	346.021	534	356.161	584	366.597
435	336.365	485	346.221	535	356.366	585	366.809
436	336.559	486	346.421	536	356.572	586	367.021
437	336.754	487	346.622	537	356.778	587	367.233
438	336.948	488	346.822	538	356.984	588	397.445
439	337.143	489	347.022	539	357.191	589	367.657
440	337.338	490	347.223	540	357.397	590	367.870
441	337.533	491	347.423	541	357.604	591	368.082
442	337.728	492	347.624	542	357.810	592	368.295
443	337.923	493	347.825	543	358.017	593	368.508
444	338.118	494	348.026	544	358.224	594	368.721
445	338.314	495	348.227	545	358.431	595	368.934
446	338.509	496	348.428	546	358.638	596	369.147
447	338.705	497	348.629	547	358.845	597	369.360
448	338.900	498	348.831	548	359.052	598	369.573
449	339.096	499	349.032	549	359.260	599	369.787
450	339.292	500	349.234	550	359.467	600	370.001

Figure 9 Cent and vibration frequency comparison table (3)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

音分值和频率对照表(四)

600—700 (#f¹)				700—800 (g¹)			
600	370.001	650	380.843	700	392.002	750	403.489
601	370.214	651	381.063	701	392.229	751	403.722
602	370.428	652	381.283	702	392.455	752	403.955
603	370.642	653	381.503	703	392.682	753	404.188
604	370.857	654	381.723	704	392.909	754	404.422
605	371.071	655	381.944	705	393.136	755	404.656
606	371.285	656	382.165	706	393.363	756	404.889
607	371.500	657	382.386	707	393.590	757	405.123
608	371.714	658	382.606	708	393.818	758	405.357
609	371.929	659	382.828	709	394.045	759	405.592
610	372.144	660	383.049	710	394.273	760	405.826
611	372.359	661	383.270	711	394.501	761	406.060
612	372.574	662	383.492	712	394.729	762	406.295
613	372.790	663	383.713	713	394.957	763	406.530
614	373.005	664	383.935	714	395.185	764	406.765
615	373.220	665	384.157	715	395.413	765	407.000
616	373.436	666	384.379	716	395.642	766	407.235
617	373.652	667	384.601	717	395.870	767	407.470
618	373.868	668	384.823	718	396.099	768	407.706
619	374.084	669	385.045	719	396.328	769	407.941
620	374.300	670	385.268	720	396.557	770	408.177
621	374.516	671	385.490	721	396.786	771	408.413
622	374.733	672	385.713	722	397.015	772	408.649
623	374.949	673	385.936	723	397.245	773	408.885
624	375.166	674	386.159	724	397.474	774	409.121
625	375.382	675	386.382	725	397.704	775	409.357
626	375.599	676	386.605	726	397.934	776	409.594
627	375.816	677	386.829	727	398.164	777	409.831
628	376.034	678	387.052	728	398.394	778	410.067
629	376.251	679	387.276	729	398.624	779	410.304
630	376.468	680	387.500	730	398.854	780	410.541
631	376.686	681	387.723	731	399.085	781	410.779
632	376.903	682	387.947	732	399.315	782	411.016
633	377.121	683	388.172	733	399.546	783	411.254
634	377.339	684	388.396	734	399.777	784	411.491
635	377.557	685	388.620	735	400.008	785	411.729
636	377.775	686	388.845	736	400.239	786	411.967
637	377.993	687	389.070	737	400.470	787	412.205
638	378.212	688	389.294	738	400.702	788	412.443
639	378.430	689	389.519	739	400.933	789	412.681
640	378.649	690	389.744	740	401.165	790	412.920
641	378.868	691	389.970	741	401.396	791	413.158
642	379.087	692	390.195	742	401.628	792	413.397
643	379.306	693	390.420	743	401.860	793	413.636
644	379.525	694	390.646	744	402.093	794	413.873
645	379.744	695	390.872	745	402.325	795	414.114
646	379.964	696	391.097	746	402.557	796	414.353
647	380.183	697	391.323	747	402.790	797	414.593
648	380.403	698	391.550	748	403.023	798	414.832
649	380.623	699	391.776	749	403.256	799	415.072
650	380.843	700	392.002	750	403.489	800	415.312

Figure 10 Cent and vibration frequency comparison table (4)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

音分值和频率对照表(五)

800—900 (#g¹)				900—1000 (a¹)			
800	415.321	850	427.481	900	440.007	950	452.901
801	415.552	851	427.728	901	440.262	951	453.162
802	415.792	852	427.975	902	440.516	952	453.424
803	416.032	853	428.223	903	440.771	953	453.686
804	416.272	854	428.470	904	441.025	954	453.948
805	416.513	855	428.718	905	441.280	955	454.211
806	416.754	856	428.965	906	441.535	956	454.473
807	416.994	857	429.213	907	441.790	957	454.736
808	417.235	858	429.461	908	442.045	958	454.998
809	417.476	859	429.709	909	442.301	959	455.261
810	417.718	860	429.958	910	442.556	960	455.524
811	417.959	861	430.206	911	442.812	961	455.787
812	418.200	862	430.455	912	443.068	962	456.051
813	418.442	863	430.703	913	443.324	963	456.314
814	418.684	864	430.952	914	443.580	964	456.578
815	418.926	865	431.201	915	443.836	965	456.842
816	419.168	866	431.450	916	444.093	966	457.106
817	419.410	867	431.700	917	444.349	967	457.370
818	419.652	868	431.949	918	444.606	968	457.634
819	419.895	869	432.199	919	444.863	969	457.899
820	420.138	870	432.448	920	445.120	970	458.163
821	420.380	871	432.698	921	445.377	971	458.428
822	420.623	872	432.948	922	445.635	972	458.693
823	420.866	873	433.198	923	445.892	973	458.958
824	421.109	874	433.449	924	446.150	974	459.223
825	421.353	875	433.699	925	446.406	975	459.488
826	421.596	876	433.950	926	446.665	976	459.754
827	421.840	877	434.200	927	446.924	977	460.019
828	422.083	878	434.451	928	447.182	978	460.285
829	422.327	879	434.702	929	447.440	979	460.551
830	422.571	880	434.954	930	447.699	980	460.817
831	422.815	881	435.205	931	447.957	981	461.083
832	423.060	882	435.456	932	448.216	982	461.350
833	423.304	883	435.708	933	448.475	983	461.616
834	423.549	884	435.960	934	448.734	984	461.883
835	423.793	885	436.212	935	448.994	985	462.150
836	424.038	886	436.464	936	449.253	986	462.417
837	424.283	887	436.716	937	449.513	987	462.684
838	424.528	888	436.968	938	449.772	988	462.952
839	424.774	889	437.221	939	450.032	989	463.219
840	425.019	890	437.473	940	450.292	990	463.487
841	425.265	891	437.726	941	450.552	991	463.755
842	425.510	892	437.979	942	450.813	992	464.022
843	425.756	893	438.232	943	451.073	993	464.291
844	426.002	894	438.485	944	451.334	994	464.559
845	426.248	895	438.739	945	451.595	995	464.827
846	426.495	896	438.992	946	451.855	996	465.096
847	426.741	897	439.246	947	452.117	997	465.365
848	426.988	898	439.499	948	452.378	998	465.633
849	427.234	899	439.753	949	452.639	999	465.902
850	427.481	900	440.007	950	452.901	1000	466.172

• 306 •

Figure 11 Cent and vibration frequency comparison table (5)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

音分值和频率对照表(六)

1000—1100 (#a¹)				1100—1200 (b¹)			
1000	466.172	1050	479.832	1100	493.892	1150	508.364
1001	466.441	1051	480.109	1101	494.177	1151	508.658
1002	466.711	1052	480.386	1102	494.463	1152	508.951
1003	466.982	1053	480.664	1103	494.748	1153	509.245
1004	467.250	1054	480.941	1104	495.034	1154	509.540
1005	467.520	1055	481.219	1105	495.320	1155	509.834
1006	467.790	1056	481.497	1106	495.606	1156	510.129
1007	468.060	1057	481.776	1107	495.893	1157	510.423
1008	468.331	1058	482.054	1108	496.179	1158	510.718
1009	468.601	1059	482.332	1109	496.466	1159	511.013
1010	468.872	1060	482.611	1110	496.753	1160	511.309
1011	469.143	1061	482.890	1111	497.040	1161	511.604
1012	469.414	1062	483.169	1112	497.327	1162	511.900
1013	469.685	1063	483.448	1113	497.614	1163	512.196
1014	469.957	1064	483.728	1114	497.902	1164	512.491
1015	470.228	1065	484.007	1115	498.190	1165	512.788
1016	470.500	1066	484.287	1116	498.477	1166	513.084
1017	470.772	1067	484.566	1117	498.765	1167	513.380
1018	471.044	1068	484.846	1118	499.054	1168	513.677
1019	471.316	1069	485.127	1119	499.342	1169	513.974
1020	471.588	1070	485.407	1120	499.630	1170	514.271
1021	471.861	1071	485.687	1121	499.919	1171	514.568
1022	472.133	1072	485.968	1122	500.208	1172	514.865
1023	472.406	1073	486.249	1123	500.497	1173	515.163
1024	472.679	1074	486.530	1124	500.786	1174	515.460
1025	472.952	1075	486.811	1125	501.075	1175	515.758
1026	473.226	1076	487.092	1126	501.365	1176	516.056
1027	473.499	1077	487.374	1127	501.655	1177	516.354
1028	473.773	1078	487.655	1128	501.945	1178	516.653
1029	474.046	1079	487.937	1129	502.235	1179	516.951
1030	474.320	1080	488.219	1130	502.525	1180	517.250
1031	474.594	1081	488.501	1131	502.815	1181	517.549
1032	474.868	1082	488.783	1132	503.106	1182	517.848
1033	475.143	1083	489.066	1133	503.396	1183	518.147
1034	475.417	1084	489.348	1134	503.687	1184	518.446
1035	475.692	1085	489.631	1135	503.978	1185	518.746
1036	475.967	1086	489.914	1136	504.269	1186	519.046
1037	476.242	1087	490.197	1137	504.561	1187	519.346
1038	476.517	1088	490.480	1138	504.852	1188	519.646
1039	476.792	1089	490.764	1139	505.144	1189	519.946
1040	477.068	1090	491.047	1140	505.436	1190	520.246
1041	477.344	1091	491.331	1141	505.728	1191	520.547
1042	477.619	1092	491.615	1142	506.020	1192	520.848
1043	477.895	1093	491.899	1143	506.312	1193	521.149
1044	478.171	1094	492.183	1144	506.605	1194	521.450
1045	478.448	1095	492.467	1145	506.898	1195	521.751
1046	478.724	1096	492.752	1146	507.191	1196	522.052
1047	479.001	1097	493.037	1147	507.484	1197	522.354
1048	479.278	1098	493.321	1148	507.777	1198	522.656
1049	479.554	1099	493.606	1149	508.070	1199	522.958
1050	479.832	1100	493.892	1150	508.364	1200	523.260

Figure 12 Cent and vibration frequency comparison table (6)

Source: A Part of Cent and vibration frequency comparison, Lv Xue, by Liao Tianrui

1.2Thai tuning system

Thailand, 7-TET has to be mentioned. This tuning system was proposed by Alexander J. Ellis in *On the Musical Scales of Various Nations*. Prince Prisdang carried three instruments in 1885: Ranat Ek, Ranat Ek Lek, Sor Sam Sai, "Tak 'hay" (Jakhe, Thai koto), and Alexander J. Ellis was allowed to test the tuning systems of these instruments when they traveled to London for an exhibition. (Ellis ,1885, pp.485-527)

They were advised by Prince Prisdang that “the intention was to make all the intervals from note to note identically the same”. Alexander J. Ellis then concluded, "Give the above division of the octave into seven equal intervals each containing 171.43 cents" (Ellis ,1885, pp.1105). Although Alexander J. Ellis found that some instruments were not tuned like his published theory of the 7-TET tuning system, but he interpreted the discrepancies as "artificial" and thought that "there is no harmonic interval but the Octave"(Helmholtz., 1895, pp.500) Alexander J. Ellis's mathematical interpretation of the Thai tuning system is a bit crude, dividing the European octave into seven intervals and ignoring indigenous cultural and historical factors in ethnomusicology.

The first policy that King Mongkut employed in coping with the Western threat was the introduction of Western education within the court, with the purpose of educating in the ways of the West the royal children who would become future leaders. Through this learning they would be able to negotiate with the Western powers on more equal and dignified terms and to maintain Siamese sovereignty. (Rutnin, 1996, pp.70). It was entrenched there by the middle of the twentieth century, by which time the Thai interval was routinely described as equidistant comprising 171.429 or 171.43 cents. (David, 1970, pp.10)

As mentioned in Assoc.Prof.Dr. Manop Wisuttipat work *The Theoretical Concepts on Thai Classical Music,* in 1913, when the grand master Luang Pradit Pai Roh began implementing numerals in Thai musical instruction, he used nine numbers, more to represent the fingerings of pitches for musical instruments than to represent the actual sounds. Even in the present time we still do not have assigned names for the pitches in Thai music. We only use meaningless syllables, such as "noi-noi-noi," etc.

Therefore, in the teaching of Thai music today, we favor the use of the note designations of the West, that is do re mi, etc. The assigning of the note names do re mi, etc. must be done in accordance with the basic concept in Thai music of tang - the actual pitch level of a scale. (Wisuttipat, 2002, pp.20)

Tang is explained in the Glossary of this book: A word literally meaning "way." The term has many different uses in Thai music. It can refer to the actual pitch level of a scale, as in tang nai. It can refer to the part played by an instrument in an ensemble, as in tang ranat. It can refer to a style of performance, as in tang peun. It can refer to individual versions of a song as composed by different masters. (Wisuttipat, 2002, pp.21)

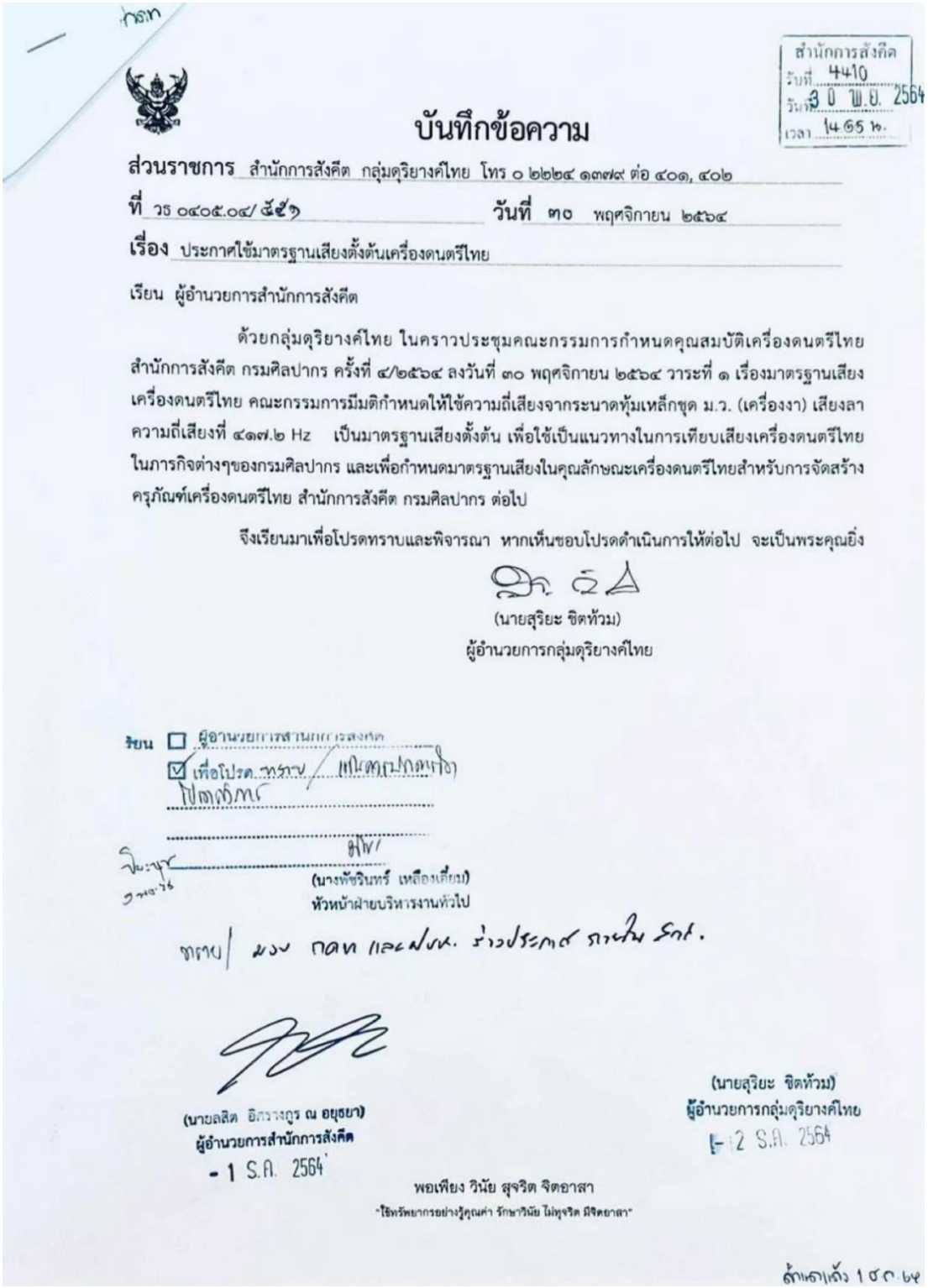
However, among the traditional Thai instruments, almost every school has its own tuning system.

In Buddhist calendar 2564, Ministry of Culture, Department of Fine Arts, Music Division, regulated Announcement about Tuning System. This document regulates the tuning system of Musical Instruments in Thailand and has legal effect. I will use this data.

In music instruction both theoretical and practical, it is of utmost importance to have technical terms such as scales, modes, etc., as references, including giving specific names to each musical pitch. Western music has adopted for the names of the pitches the syllables do, re mi, fa, sol, la, si; it also uses standard pitch designations with the letters A, B, C, D, E, F, G, according to the frequency of the pitches. The different steps of the scale, from the first through the seventh, are given still other names according to function: tonic, supertonic, mediant, subdominant, dominant, submediant, leading tone. No terms have arisen in Thai music which can be used in all situ ations and for every need, although in practice there is a need for these terms to designate various characteristics of Thai music. We do not even have standard names for the pitches which can be universally understood. Numerals are, therefore, most often used to indicate Thai notes. The sounds of music used to be represented by meaningless syllables, such as noi-noi noi, etc. Most musicians use the sounds ting-neng-neng to represent the melody of the kong wong yai part; they use the sounds teu-haw to

represent the tones of the pi nai. Other instruments are similarly represented by syllables which are imitations of their sounds. (Wisuttipat, 2002, pp.28)

When talking about the Melody Line and Harmony Line of Thai classical music, Assoc.Prof.Dr. Manop Wisuttipat concluded that, it can be said that harmony is not a governing fundamental in Thai music although some harmony notes do appear in the pieces. It can also be seen that some of the musical instruments can play multiple tones simultaneously (for example, the ranat, the kong wong, the jakay); when this occurs one tone will be the melody tone, and the other will be the harmony tone. When an ensemble performs, many tones are heard at the same time, i.e., there are many melody lines sounding together during which all the instruments create a combination of elaborative melody lines, each being individually characteristic. For this reason, Thai music is capable of having all kinds of intervals and more attention is paid on creating elaborative melody lines - variations - than on arranging harmonic intervals, whatever kind they are. Whenever harmonic intervals appear, however, it is by nature that there must be one melody line and one, two or three additional lines of harmony tones. MELODY LINES AND HARMONY LINES OF THE "TANG KONG" As discussed in the section above, some segments of the tang kong have harmony tones, both those that sound at the same time and those that are caused by broken 4th and octaves. This way two melody lines are observed. (Wisuttipat, 2002, pp.42-43)



สำนักการสังคีต
รับที่ 4410
วันที่ 30 พ.ย. 2564
เวลา 14.65 น.

บันทึกข้อความ

ส่วนราชการ สำนักการสังคีต กลุ่มดุริยางค์ไทย โทร ๐ ๒๒๒๔ ๑๓๗๙ ต่อ ๔๐๑, ๔๐๒

ที่ วธ ๐๔๐๕.๐๔/๕๕๑ **วันที่** ๓๐ พฤศจิกายน ๒๕๖๔

เรื่อง ประกาศใช้มาตรฐานเสียงตั้งต้นเครื่องดนตรีไทย

เรียน ผู้อำนวยการสำนักการสังคีต

ด้วยกลุ่มดุริยางค์ไทย ในคราวประชุมคณะกรรมการกำหนดคุณสมบัติเครื่องดนตรีไทย สำนักการสังคีต กรมศิลปากร ครั้งที่ ๔/๒๕๖๔ ลงวันที่ ๓๐ พฤศจิกายน ๒๕๖๔ วาระที่ ๑ เรื่องมาตรฐานเสียงเครื่องดนตรีไทย คณะกรรมการมีมติกำหนดให้ใช้ความถี่เสียงจากระนาดทุ้มเหล็กชุด ม.ว. (เครื่องงา) เสียงลาความถี่เสียงที่ ๔๑๗.๒ Hz เป็นมาตรฐานเสียงตั้งต้น เพื่อใช้เป็นแนวทางในการเทียบเสียงเครื่องดนตรีไทยในภารกิจต่างๆของกรมศิลปากร และเพื่อกำหนดมาตรฐานเสียงในคุณลักษณะเครื่องดนตรีไทยสำหรับการจัดสร้างครุภัณฑ์เครื่องดนตรีไทย สำนักการสังคีต กรมศิลปากร ต่อไป

จึงเรียนมาเพื่อโปรดทราบและพิจารณา หากเห็นชอบโปรดดำเนินการให้ต่อไป จะเป็นพระคุณยิ่ง

(นายสุริยะ ชิดท้วม)
ผู้อำนวยการกลุ่มดุริยางค์ไทย

เรียน ☐ ผู้อำนวยการสำนักการสังคีต
☑ เพื่อโปรดทราบ / แก้ไขตามที่เห็นสมควร

(นางพัชรินทร์ เหลืองเลี่ยม)
หัวหน้าฝ่ายบริหารงานทั่วไป

ทราบ / มอบ กลท และ ผอ.สน. ร่างประกาศ กรมฯ ลงนาม รก.

(นายลลิต อิศรางกูร ณ อยุธยา)
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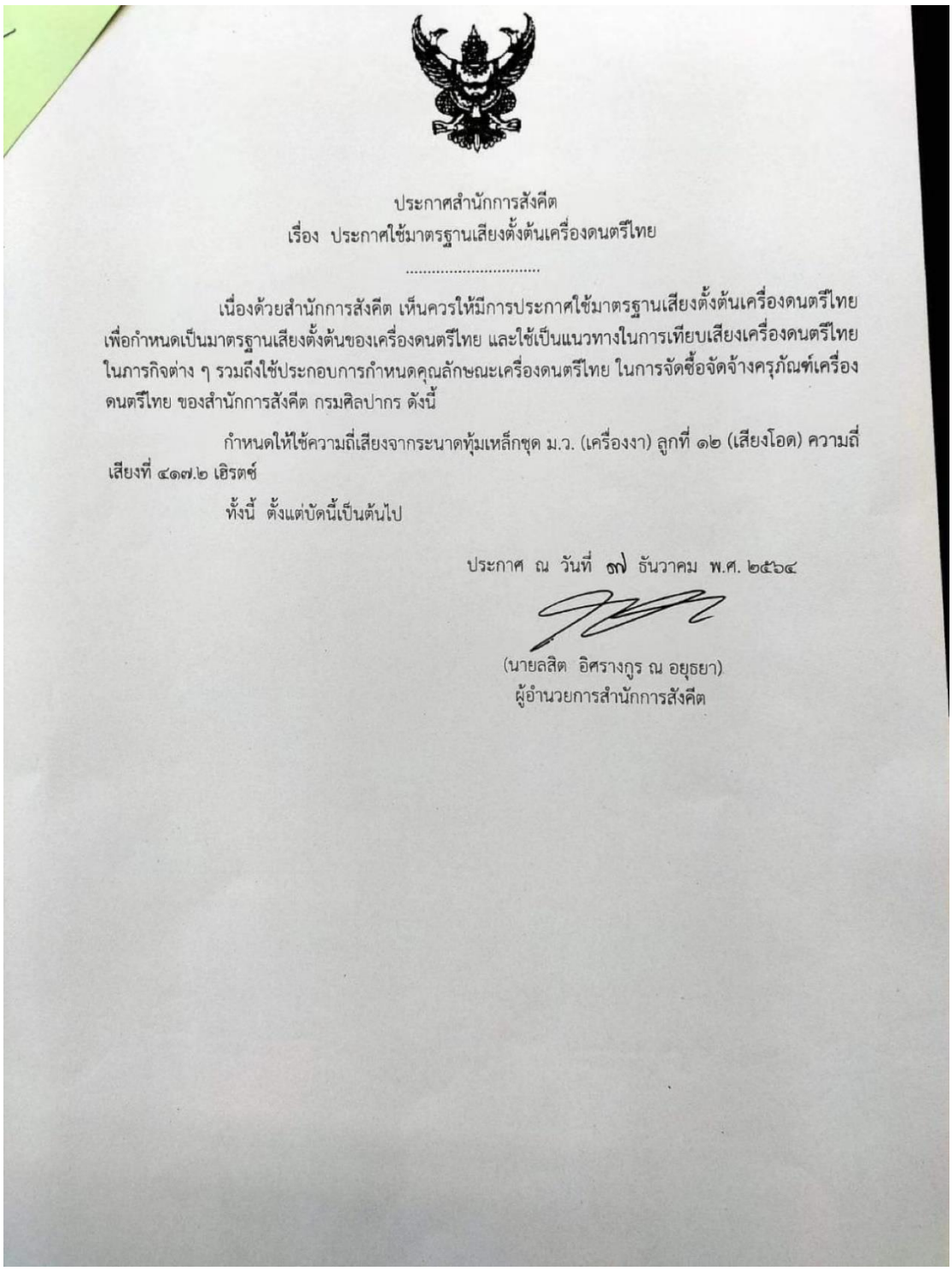
- 2 S.A. 2564

พอเพียง วินัย สุจริต จิตอาสา
"ใช้ทรัพยากรอย่างรู้คุณค่า รักษาวินัย ไม่ทุจริต มีจิตอาสา"

ส่งหลังเลิก ๑ ธ.ค. ๖๔

Figure 13 Document issued by the Thai Government on tuning system (1).

Source: Asst.Prof.Dr.Metee Punvaratorn, 2022



ประกาศสำนักการสังคีต
เรื่อง ประกาศใช้มาตรฐานเสียงตั้งต้นเครื่องดนตรีไทย

.....

เนื่องด้วยสำนักการสังคีต เห็นควรให้มีการประกาศใช้มาตรฐานเสียงตั้งต้นเครื่องดนตรีไทย เพื่อกำหนดเป็นมาตรฐานเสียงตั้งต้นของเครื่องดนตรีไทย และใช้เป็นแนวทางในการเทียบเสียงเครื่องดนตรีไทย ในภารกิจต่าง ๆ รวมถึงใช้ประกอบการกำหนดคุณลักษณะเครื่องดนตรีไทย ในการจัดซื้อจัดจ้างครุภัณฑ์เครื่องดนตรีไทย ของสำนักการสังคีต กรมศิลปากร ดังนี้

กำหนดให้ใช้ความถี่เสียงจากระนาดทุ้มเหล็กชุด ม.ว. (เครื่องงา) ลูกที่ ๑๒ (เสียงโอด) ความถี่เสียงที่ ๔๑๗.๒ เฮิรตซ์

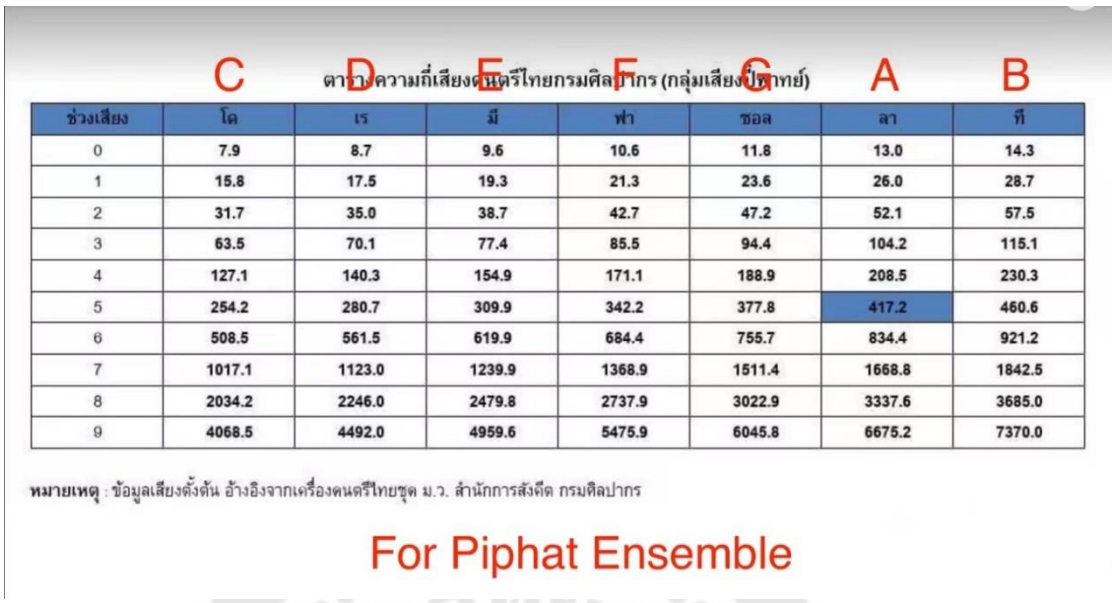
ทั้งนี้ ตั้งแต่บัดนี้เป็นต้นไป

ประกาศ ณ วันที่ ๑๗ ธันวาคม พ.ศ. ๒๕๖๔

(นายลสิต อิศรางกูร ณ อยุธยา)
ผู้อำนวยการสำนักการสังคีต

Figure 14 Document issued by the Thai Government on tuning system (2).

Source: Asst.Prof.Dr.Metee Punvaratorn, 2022



C D E F G A B

ตารางความถี่เสียงดนตรีไทยกรมศิลปากร (กลุ่มเสียงปี่พาทย์)

ช่วงเสียง	โด	เร	มี	ฟา	ซอล	ลา	ที
0	7.9	8.7	9.6	10.6	11.8	13.0	14.3
1	15.8	17.5	19.3	21.3	23.6	26.0	28.7
2	31.7	35.0	38.7	42.7	47.2	52.1	57.5
3	63.5	70.1	77.4	85.5	94.4	104.2	115.1
4	127.1	140.3	154.9	171.1	188.9	208.5	230.3
5	254.2	280.7	309.9	342.2	377.8	417.2	460.6
6	508.5	561.5	619.9	684.4	755.7	834.4	921.2
7	1017.1	1123.0	1239.9	1368.9	1511.4	1668.8	1842.5
8	2034.2	2246.0	2479.8	2737.9	3022.9	3337.6	3685.0
9	4068.5	4492.0	4959.6	5475.9	6045.8	6675.2	7370.0

หมายเหตุ : ข้อมูลเสียงตั้งต้น อ้างอิงจากเครื่องดนตรีไทยชุด ม.ว. สำนักการสังคีต กรมศิลปากร

For Piphat Ensemble

Figure 15 Tuning system issued by the Thai government for Piphat Ensemble

Source: Asst.Prof.Dr.Metee Punvaratorn, 2022

C D E F G A B

ตารางความถี่เสียงดนตรีไทยกรมศิลปากร (กลุ่มเสียงเครื่องสาย และมโหรี)

ช่วงเสียง	โด	เร	มี	ฟา	ซอล	ลา	ที
0	7.1	7.9	8.7	9.6	10.6	11.8	13.0
1	14.3	15.8	17.5	19.3	21.3	23.6	26.0
2	28.7	31.7	35.0	38.7	42.7	47.2	52.1
3	57.5	63.5	70.1	77.4	85.5	94.4	104.2
4	115.1	127.1	140.3	154.9	171.1	188.9	208.5
5	230.3	254.2	280.7	309.9	342.2	377.8	417.2
6	460.6	508.5	561.5	619.9	684.4	755.7	834.4
7	921.2	1017.1	1123.0	1239.9	1368.9	1511.4	1668.8
8	1842.5	2034.2	2246.0	2479.8	2737.9	3022.9	3337.6
9	3685.0	4068.5	4492.0	4959.6	5475.9	6045.8	6675.2

หมายเหตุ : ข้อมูลเสียงตั้งต้น อ้างอิงจากเครื่องดนตรีไทยชุด ม.ว. สำนักการสังคีต กรมศิลปากร

For Kruengsai and Mahori Ensemble

Figure 16 Tuning system issued by the Thai government for Kruengsai and Mahori Ensemble

Source: Asst.Prof.Dr.Metee Punvaratorn, 2022

2. Relevant research

John Garzoli, in his article The Myth of Equidistance in Thai Tuning, explicitly expressed dissatisfaction with Alexander J. Ellis' 7-tet theory. He compared the work of David Morton and Alexander J. Ellis and measured the vibration frequencies of instruments tuned by famous Thai tuners. Draw the following conclusions that, the theory of Thai equidistance is predicated on a harmonic octave Because it has been thought about to be true that the Thai octave has a ratio of 1:2, the theory of Thai equal distance is based on a harmonic octave. However, many tuners aim for a slightly larger interval rather than tune the octave to a 1:2 ratio. Nowadays, electronic tuners are also rarely used, although the tuner continues to adjust based on his or her own ears. Seven-tone equal temperament and the widely cited interval of 171.429 cents should be abandoned because they imply that Thai tuning can be meaningfully understood in terms of standardization and uniformity. This tuning system should be abandoned.

Tanarach Anukul used 1997 Dr. Sukree Charoensuk in his article *The Sustainability of Thai Traditional Music Tuning in Contemporary Trends*, related research report data. Dr. Sukree Charoensuk has very detailed vibration frequency measurements in the research report of Ranat Ek, Ranat Ek Lek, and singers with different singing intonations. Conclude that it is clear from the discovery of numerical facts that the Thai music modulation system's theory and practice are self-contradicting. Alexander J.Eliss's 1,200-cent interval is a component of putatively "ideal" heptatonic tuning, that is, in the sense that it should be prescribed as the only "correct" tuning.

Joint article by Pimpet Sratong-on,Warakom Nerdnoi and Pornchai Nivesrangsan, *An Analysis of Vibration Characteristic of Thai Traditional Xylophone (Ranad-Ek)*. The fundamental frequencies from the middle to highest tone of Ranad were very sensitive to the change of the small amount of lead. Nevertheless, the greater amount of lead contributed to the decreasing in the frequency value at the first time, then, the frequency became steady as the amount of lead increased. As a result, the geometry of Ranad pieces play a crucial role on their generated frequencies of Ranad.

CHAPTER 3
METHODOLOGY

The research on the Creation of a new concerto that communicates between Thai musical instruments and the orchestra on Thai tuning systems. The researcher studied the research documents and went to the field data collection area. There is the following process.

1. Data collection
2. Data preparation, study, and data analysis
3. Data processing and data analysis

1. Data collection

The researcher has planned the data collection. by collecting data from document surveys and related research, both appearing in printed form and characteristics of digital media, including fieldwork to collect data. By going to the area to collect data in the field, the data collection process was based on observations, interviews, and small group meetings. The researcher will obtain research-related information, movie data, still image information, and audio data. Once the information has been obtained, it will be organized into the system. Separate data groups and review the information. If it is found that the information collected is incomplete or defective, the investigator must arrange for additional data collection to be completed.

The tools used to collect data are as follows:

Macbook pro, Iphone 12 Pro max, Ipad Pro

Musical Application: Sibelius, Thai tuner, Sonic Tools

1. To collect and study relevant research papers The researcher has collected data from various sources, both in the publication books and digital media

1.1 Central Library Srinakharinwirot University

1.2 China National Knowledge Infrastructure

1.3 Online database system and information media

2. Data preparation, study, and data analysis

2.1 Data collection

The researchers measured the vibration frequency of Ranat Ek in each tone at Srinakharinwirot University: Faculty of Fine Arts. Rambhai Barni Rajabhat. Prasarnmit Demonstration School (Secondary). Using Musical Application: Sonic tools. The instrument was measured three times and averaged.

2.2 Interview

The researcher conducted a group interview with data subjects. Both formal and informal, in order to obtain information. The times by the data persons who have been interviewed are as follows.

Asst.Prof.Dr.Metee Punvaratorn (Thailand)

Assoc.Prof.Dr. Manop Wisuttipat (Thailand)

Asst.Prof.Dr. Chanick Wangphanich(Thailand)

Asst.Prof.Dr.Surasak Chamnongsan(Thailand)

Asst.Prof.Dr.Veera Pansuea (Thailand)

Lecturer Ratchanon Yimrayab (Thailand)

Lecturer Paritat Ruengyim (Thailand)

Supapol Saiwimarn (Thailand)

Qiu Ke (China)

Tang Ke (China)

Chen Han (China)

Qiu Shuopeng (China)

Guan Zhenyu (China)

Fang Jing (China)

2.3In-field data collection

The researcher has used the application tool to record the nitty-gritty information. Still, image information, movie data, and audio data, including field notes, cameras, mobile phones, video cameras, applications, sound recording, and sound level measurements.

3. Data processing and data analysis

When the data collection related to the research is completed, the researcher compiles and analyzes the data according to the anthropological methodology. (Ethnomusicology) as the following process.

3.1 Data processing

3.1.1 The researcher takes information from the collection and study of textbooks, including searched research, in order of content and categorization and arranges the content in order and continuity.

3.1.2 The researcher uses the data collected from observations and interviews. Let us transcribe, order, and categorize the content according to the relevant content. Furthermore, review the data with the data subject before taking it to the analytical stage.

3.2 Data analysis

In this research, the researcher studied the data according to the objectives of the research objectives.

1. to study of tuning system of Thai instruments by using the existing formula of the Western tuning system.

2. to create a new concerto communicating between Thai musical instruments and orchestras based on the Thai tuning system.

Which can be divided into the following issues of study and information:

To familiarize Western orchestra players with the Thai tuning system.

Create a playing method that enables string instruments to play the Thai tuning system. Researchers will use Ranat Ek as a solo instrument to create Ranat Ek concerto.

This paper mainly focuses on cultural integration, which refers to the process of national culture absorbing and digesting foreign culture based on its traditional culture in today's cultural exchange to promote its cultural development. National culture has the characteristics of epochal and nationality. National culture can only partially change into a foreign culture and can be rejected. Before I came to

Thailand to study, I had little access to Thai traditional music, which is also because Thailand's traditional music culture is relatively conservative. Before I did this research, many predecessors had done this kind of research on cultural integration. There are two main methods: 1. When two instruments with different tuning systems work together, the Thai instrument is adjusted to the Western tuning system. 2. Whether the intervals are in consonance or not, the two instruments are forced to play together, or the musical expression of dialogue is adopted (one by one). This is not to say that the presentation is terrible, but the disadvantages are obvious. For example, when a Thai musical instrument is adjusted to a Western tuning system, it will lose its original scale characteristics. It would be irresponsible for listeners familiar with the tuning of Western music to directly merge the Thai tuning system with the Western tuning system without considering the two tuning systems. This is also typical of all-Takenism. I suggest that when we are going to communicate and cooperate between two musical systems, we should respect both musical systems. Of course, we must choose one as the critical object of protection. For example, when we protect the Thai music system, we should keep the scale of the music system, the traditional performance method, the melody progression, and so on. At the same time, it integrates the orchestration, harmony, and movement system of the symphony in Western music for cooperation, which I think is the most meaningful thing for preserving and inheriting traditional culture.

When the study is complete, the results will be summarized. In conclusion, the research results will be written in order to be presented in Chapters 4 and chapter 5 as follows:

1. Present the study results descriptively and analytically.
2. Prepare a summary of the results obtained from the study.
3. Discussion and suggestions

CHAPTER 4
FINDINGS

In research on Creation of a new concerto that communicates between Thai musical instruments and the orchestra on Thai tuning systems. The researcher has studied the research documents and went to the field data collection area. to obtain results according to the objectives of the research The results of the study are as follows.

1. to study of tuning system of Thai instruments by using the existing formula of the Western tuning system. What the researcher discovered from studying the sound system of Thai musical instruments The study results are as follows.

1.1 The tunning system issued by the government.

First of all, we concentrate on the scale of Thailand. Thailand scales the formation significantly. It is for every school has its unique tuning system, which makes it challenging to study. The Thai government promulgated a tuning specification file and still needs to get all the instruments of the user response. Players tend to use more ears are tuning up. For the convenience of research, I defined the research direction of this time. I used the tuning standards issued by the government and the Musical Instruments of the Faculty of Fine Art at Srinakharinwirot University, Rambhai Barni Rajabhat University, Prasarnmit Demonstration School (Secondary), to collect data. First, let us look at the data issued by the Thai government, and we use the Concorde interval calculation formula mentioned above to calculate. In the Thai scale, โด เร มี ฟา ซอล ลา ที is usually used as the official expression. In daily communication, Pitch notes CDEFGAB, commonly used in Western music, are also used to express sound and facilitate communication with foreigners. In order to express the convenience and make it easier to understand, I will use two ways to express.

Table 9 classification K of Ranat Ek from tunning system issued by the government.

Pitch names	Relative cents	The vibration frequency (Hz)	Similar intervals vibrational ratios are fractional		δ	△ I(dB)	I(dB)	classification
			cents	Ip(dB)				
C โด	-46	254.2	0	60	0	0	60	A
D เร	121	280.7	182	20.92	15	7.2	13.72	E
E มี	293	309.9	316	30.46	23	9.45	21.01	D
F ฟา	465	342.2	498	38.42	13	4.95	33.47	C
G ซอล	636	377.8	702	44.44	20	8.1	36.34	B
A ลา	808	417.2	884	36.48	30	12.6	23.88	D
B ที	979	460.6	1018	26.94	7	2.25	24.69	C
C โด	1150	508.5	1200	53.98	6	1.8	52.18	A

Through an analysis of each interval in Thailand scales, we found a fascinating point, is that although the Thai tuning system is not calculated, ears to adjust, on the interval, Perfect unison, Perfect octave, Perfect fourth, and Perfect fifth can be consonance of definition, though not necessarily wholly consonance. This also explains the problem that in Piphat and Mahori, we hear melodic progressions but do not hear intervals or harmonic progressions at all. In traditional Thai ensembles, the most common interval is Perfect unison or Perfect octave. Although some intervals can reach consonance intervals, it is essential to understand that the Thai tuning system is independent of the Western tuning system. However, Western musicians once tried to define the Thai tuning system in terms of the European musical tuning system. In the earliest studies, it is yet to be known whether it was because of convenience or because Prince Prisdang made demands on Alexander J. Ellis, the tester. The Thai tuning system

is a cent of 171.4 for two adjacent notes. The above data are from the Thai government. According to the comparison of the relationship between vibration frequency and tone fraction, this specification of vibration frequency comes from the research results of Alexander J. Ellis.

1.2 Measurement of Tuning System for school Musical Instruments.

When I measured the Faculty of Fine Art in Srinakharinwirot University instruments, I got confusing results. The same instrument, for example, Ranat Ek, got two kinds of data, one is close to the government Tunning system document, and the other is entirely different from the government document. The following table shows the vibration frequency of Ranat Ek that I collected.

Table 10 Vibration data collected from the Faculty of Fine Art in Srinakharinwirot University

Scale series number	C โด	D เร	E ม	F ฟา	G ซอล	A ลา	B ท
1		156	196	208	234	248	278
2	312	331	371	417	468	496	556
3	625	662	743	834	936	1011	1113
4	1250	1365					

The above data is the conclusion from Ranat Ek, who tested the same type of tuned instruments. All the instruments were from the Faculty of Fine Art at Srinakharinwirot University. The data obtained are averaged without keeping decimals. (10F, Faculty of Fine Art in Srinakharinwirot University,02. Aug.2022) There is a significant discrepancy between the measured data above and the Tuning System files of the government. These differences in vibration frequencies can no longer be explained by the poor preservation of Musical Instruments and the sensory gap. I interviewed Asst.Prof.Dr.Metee Punvaratorn about this question. He told me, " We all

know that the tuning system in Thailand depends on the school you attend. Every school has its own habits in tuning system. They're more likely to use their ears for tuning." For this reason, Musical Instruments in Thailand, if they come from different schools, will have different tuning, even to the point that they cannot be played together. Asst.Prof.Dr.Metee Punvaratorn also mentioned an interesting thing in the interview, "I once adjusted some instruments to the official tuning system, and it was not long before the students asked Asst.Prof.Dr.Veera Pansuea, who is the Piphat ensemble master of the school, to adjust the instruments to the familiar tuning system". From the content of these interviews, we can draw some conclusions that traditional music in Thailand is adjusted according to the ears of the performers. There are many subjective factors in the adjustment of intonation. Players are also susceptible to intonation and will feel out of tune on adjusted instruments. I will use the calculation method mentioned before to analyze the Ranat Ek vibration frequency data collected in the Faculty of Fine Art at Srinakharinwirot University.

Table 11 classification K of Ranat Ek from Faculty of Fine Art in Srinakharinwirot University

Pitch names	The vibration frequency (Hz)	Relative cents	Similar intervals vibrational ratios are fractional		δ	$\triangle$ l(dB)	l(dB)	classification
			cents	lp(dB)				
C โด	312	305	0	60	0	0	60	A
D เร	331	408	112	12.40	9	3.15	9.25	E
E มี	371	605	316	30.46	16	6.3	24.16	C
F ฟา	417	808	498	38.42	5	1.35	37.07	B
G ซอล	468	1007	702	44.44	0	0	44.44	B
A ลา	496	1108	814	27.96	11	4.05	23.91	D
B ที	556	1332	1018	18.42	9	3.15	15.27	E
C โด	625	1507	1200	53.98	2	0	53.98	A

Asst.Prof.Dr.Metee Punvaratorn asked Ratchanon Yimrayab, a Rambhai Barni Rajabhat University Lecturer, to collect the frequency of Ranat Ek's vibration. After collecting data in the same way, the following data is obtained.

Table 12 Vibration data collected from Rambhai Barni Rajabhat University

Scale series number	C โด	D เร	E ม	F ฟา	G ซอล	A ลา	B ท
1		173	191	212	232	256	284
2	314	345	381	422	462	509	568
3	631	691	760	846	925	1020	1131
4	1260	1391					

The following conclusions can be calculated based on the Ranat Ek vibration data provided by Lecturer Ratchanon Yimrayab.

Table 13 classification K of Ranat Ek from Rambhai Barni Rajabhat University University

Pitch names	The vibration frequency (Hz)	Relative cents	Similar intervals vibrational ratios are fractional		δ	△ I(dB)	I(dB)	classification
			cents	lp(dB)				
C โด	314	320	0	60	0	0	60	A
D เร	345	481	182	20.92	21	8.55	12.37	E
E มี	381	653	316	30.46	17	6.75	23.71	D
F ฟา	422	830	498	38.42	12	4.5	33.92	C
G ซอล	462	987	702	44.44	35	14.85	29.59	C
A ลา	509	1154	702	44.44	32	13.5	30.94	C
Pitch names	The vibration frequency (Hz)	Relative cents	Similar intervals vibrational ratios are fractional		δ	△ I(dB)	I(dB)	classification
			cents	lp(dB)				
B ที	568	1368	1018	18.42	30	12.6	5.82	F
C โด	631	1546	1200	53.98	26	10.8	43.18	B

Asst.Prof.Dr.Metee Punvaratorn asked Prasarnmit Demonstration School (Secondary) Lecturer Paritat Ruengyim to help me collect The vibration frequency of Ranat Ek. After collecting data in the same way, I obtained the following data.

Table 14 Vibration data collected from Prasarnmit Demonstration school (Secondary)

Rnand Ek Vibration Frequency (Hz) collected from Prasarnmit Demonstration school (Secondary)						
C โด	D เร	E มี	F ฟา	G ซอล	A ลา	B ที
255.5	274.5	311	42	378	417	463

This data is very different from the data collected above. Many of the tones are very close to each other. Recently, the Prasarnmit Demonstration School started using the tuning system issued by the Thai government.

The following conclusions can be calculated based on the Ranat Ek vibration data provided by Lecturer Paritat Ruengyim.

Table 15 classification K of Ranat Ek from Prasarnmit Demonstration school (Secondary)

Pitch names	The vibration frequency (Hz)	Relative cents	Similar intervals vibrational ratios are fractional		δ	$\triangle$ l(dB)	l(dB)	classification
			cents	lp(dB)				
C โด	255.5	-43	0	60	0	0	60	A
D เร	274.5	83	112	12.40	14	5.4	7	F
E มี	311	300	316	30.46	27	11.25	19.21	D
F ฟา	342	468	498	38.42	13	6.05	32.37	C
G ซอล	378	636	702	44.44	23	9.45	34.99	C
A ลา	417	807	884	36.48	34	14.4	22.08	D
B ที	463	990	1018	18.42	15	5.85	12.57	E

In an interview with Assoc.Prof.Dr. Manop Wisuttipat, who demonstrated his tuning system, which is identical to the government-issued tuning system, the researchers will not double count here.

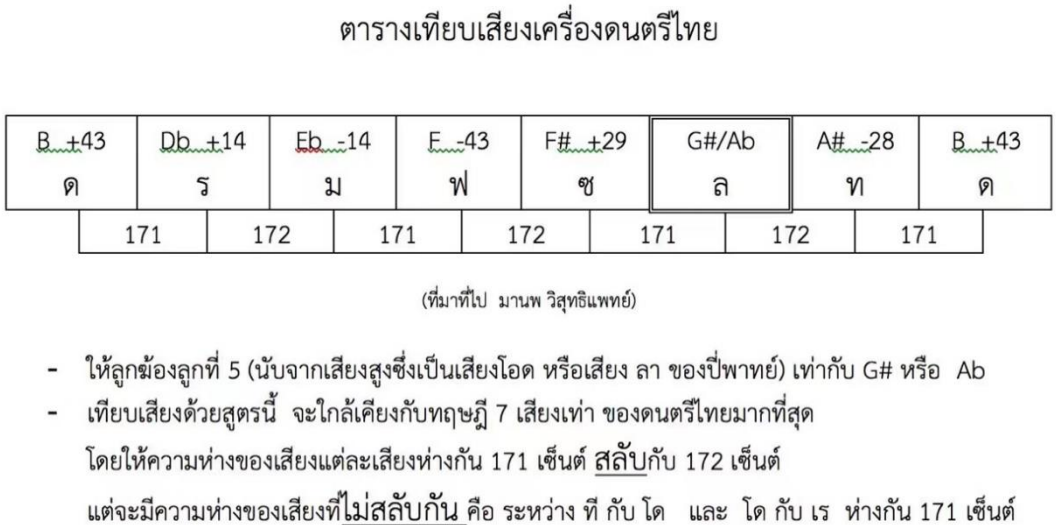


Figure 17 Assoc.Prof.Dr. Manop Wisuttipat uses the tuning system.

Source: Asst.Prof.Dr.Metee Punvaratorn, Assoc.Prof.Dr. Manop Wisuttipat, 2023

With contact from.Prof.Dr.Metee Asst Punvaratorn, the researcher got the tuning system he used from Supapol Saiwimarn. He is a Thai Instruments maker. Many universities invited him to tune the sound of the instrument. From the interview data (May 21, 2023), Mr. Supapol Saiwimarn mentioned the tuning system. Has studied from the research documents of A.Boonchuay Sowat. When considered, it is consistent with the sound system of the Fine Arts Department as shown in the announcement document. This sound calibration formula has been used in many educational institutions such as the Faculty of Education, at Chulalongkorn University. Suankularb Wittayalai School and others.

บันไดเสียงระนาดเอก แนวเสียงกรมศิลป์	
ลูกที่ 1 เริ่มจากซ้าย	เสียง ซอล = 171.1 Hz, F-35 Cents
ลูกที่ 2	เสียง ลา = 188.9 Hz, F#+36 Cents
ลูกที่ 3	เสียง ที = 208.5 Hz, G#+8 Cents
ลูกที่ 4	เสียง โด = 230.3 Hz, A#-21 Cents
ลูกที่ 5	เสียง เร = 254.2 Hz, C-50 Cents
ลูกที่ 6	เสียง มี = 280.7 Hz, C#+22 Cents
ลูกที่ 7	เสียง ฟา = 309.9 Hz, D#-7 Cents
ลูกที่ 8	เสียง ซอล = 342.2 Hz, F-35 Cents
ลูกที่ 9	เสียง ลา = 377.8 Hz, F#+36 Cents
ลูกที่ 10	เสียง ที = 417.2 Hz, G#+8 Cents
ลูกที่ 11	เสียง โด = 460.6 Hz, A#-21 Cents
ลูกที่ 12	เสียง เร = 508.5 Hz, C-50 Cents
ลูกที่ 13	เสียง มี = 561.5 Hz, C#+22 Cents
ลูกที่ 14	เสียง ฟา = 619.9 Hz, D#-7 Cents
ลูกที่ 15	เสียง ซอล = 684.4 Hz, F-35 Cents
ลูกที่ 16	เสียง ลา = 755.7 Hz, F#+36 Cents
ลูกที่ 17	เสียง ที = 834.4 Hz, G#+8 Cents
ลูกที่ 18	เสียง โด = 921.2 Hz, A#-21 Cents
ลูกที่ 19	เสียง เร = 1017.1 Hz, C-50 Cents
ลูกที่ 20	เสียง มี = 1123.0 Hz, C#+22 Cents
ลูกที่ 21	เสียง ฟา = 1239.9 Hz, D#-7 Cents
ลูกที่ 22	เสียง ซอล = 1368.9 Hz, F-35 Cents

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Figure 18 Tuning system from Supapol Saiwimarn

Source: Asst.Prof.Dr.Metee Punvaratorn, Supapol Saiwimarn, 2023

You can see that Mr. Saiwimarn's tuning system is precisely the same as the tuning system that the government has issued. From the above calculation results, we can find that Ranat Ek of the Faculty of Fine Art in Srinakharinwirot University, in Major Third, Perfect Fourth, Perfect Fifth, and Perfect octave, those intervals are a significant improvement in the interval consonance. There are, or almost all, more consonance intervals than those in the official document. It is also indirect evidence that Thai musicians are more inclined to use naturally vibrating frequency multiples notes as their tuning system. I prefer to refer to the disunity in the pitch of fixed-pitch percussion instruments as the diversity of musical tuning systems. Morton David wrote in his paper "rough and ready approach to precise tuning". He understood the diversity of tuning as a series of factors, including poor technique, mistakes made by tuners, poor instrument preservation, Etc. Ranat Ek can adjust the vibration frequency by heating or attaching waxy. Heating increases the vibration frequency, and the attachment of waxy (mixed lead scrap) decreases the vibration frequency. Every traditional Thai musician has his or her tuning system. Hence, the diversity of tuning systems in Thailand is not due to poor preservation of instruments or differences in the ears of each person. In Thailand, an instrument is tuned by experienced musicians who tune it by ear. Although it is common for instruments to be tuned by government tuning methods, the fact that tuners tune them by ear leads to instruments that do not precisely resemble the government tuning system. Because of these minor adjustments, Thai music's tuning system is diverse. Asst.Prof.Dr.Metee Punvaratorn said Thai primarily traditional musical instruments would be tuned before the big event like a Waikhru ceremony (Teacher Hommage), a play for Khone, a competition, or a special occasion. Because of the Thai tuning system, each school has significant differences. I will use the tuning standards issued by the Thai government for the next music creation.

2.The instruments in a symphony orchestra, the changes that need to be made to use the Thai tuning system.

The instruments used in Western orchestras are designed based on the unified tuning system. Most of the instruments use pure temperament. When these instruments, such as the violin, viola, cello, and double bass, are played in the Thai tuning system, they must adjust their playing methods. The following study will call this playing method the Thai hand position.

2.1Violin

My music creation aims to make Thai and Western music have limited integration and exchange so that more people can hear, understand, and Thai love music. This meant that to use the Thai tuning system in my compositions. We had to invent a new way of playing. String instruments must use a new hand position when playing in an ensemble. I temporarily name this hand position the Thai hand position. After I interviewed the string instrument players, they all expressed their novelty and willingness to try and also put forward suggestions for my creation. The first thing we will talk about is how the violin is played. The violin is an essential member of the stringed instrument family and the template for all stringed instruments to undergo the Thai hand position transformation. I interviewed the violinist Qiu Ke of the Xiamen Philharmonic Orchestra. Although young, she has deep played experience and excellent insight into intonation. I adopted the method of listening to Thai intonation, asked her to play the same intonation on the violin, and recorded the Thai hand position. The Tuner used is the Thai Tuner Application from the APP STORE.

The violin typically has four strings, and it is usually played by brushing a bow across its strings. The violin typically has four strings which are tuned in perfect fifths with notes G3, D4, A4, and E5.

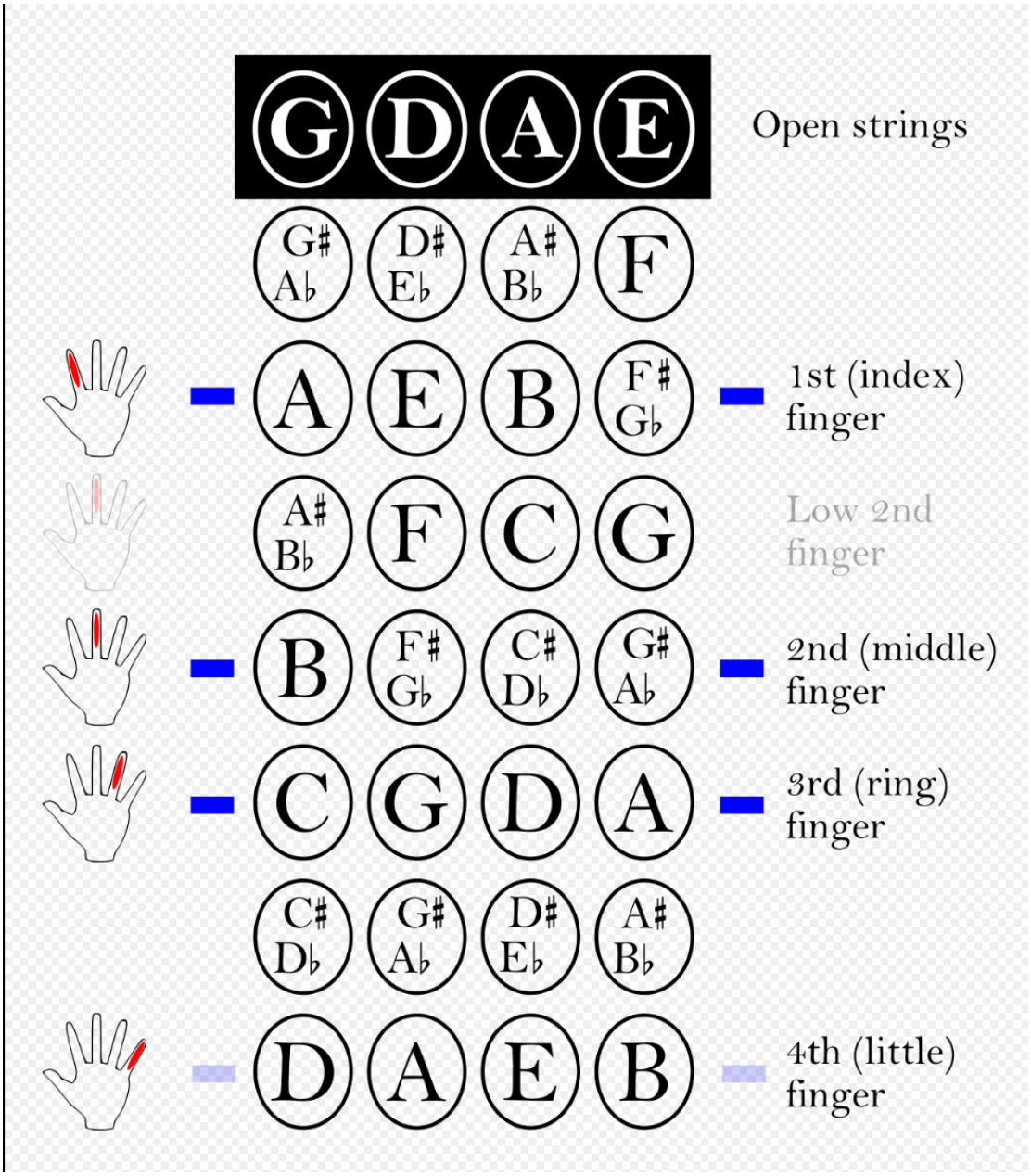

Figure 19 The method of playing the violin in just intonation.

Source: wikipidia,2022

From the figure above, we can see the sound played by each string and the fingers used in the First position fingerings of a regular violin. While the violin plays the Thai tuning system, the position of each note and the corresponding string changes significantly.

I recorded the position of the hand on the violin playing an octave, from C โด with a vibration frequency of 254.2Hz to high C โด with a vibration frequency of 508.5Hz.

Figure 20 Thai hand position of violin

Source: Lin Zixiang, 2022

We can see the position of each note when Qiu Ke tries to play a Thai scale that is different from normal violin playing.

Table 16 Thai hand position of violin

G3	D4	A4	E5
C โด	F ฟา	B ที	C โด
D เร	G ซอล	C โด	
E ม	A ลา		

After my interview, I learned from Qiu Ke that the violin is designed to have a tuning principle. The pitch of each string is G3, D4, A4, and E5, which is a pure fifth to the following string. For example, when a violin plays with a specific Thai instrument, it is ok to let it adjust its Hand position and play. Players must be familiar with the Thai tuning system and have an individual playing basis. There is no fixed fingering position for each note. The above is shown by following the First position fingerings of the violin. For example, in the high C of the Thai tuning system, she can use an E5 string to play or an A4 string to play. This is just an attempt at musical innovation.

2.2Viola

The viola is also a member of the string family. It is slightly larger and more profound than the violin. The strings from low to high are typically tuned to C3, G3, D4, and A4. The picture below will show the First position of viola fingerings. The picture below will show the First position of viola fingerings.

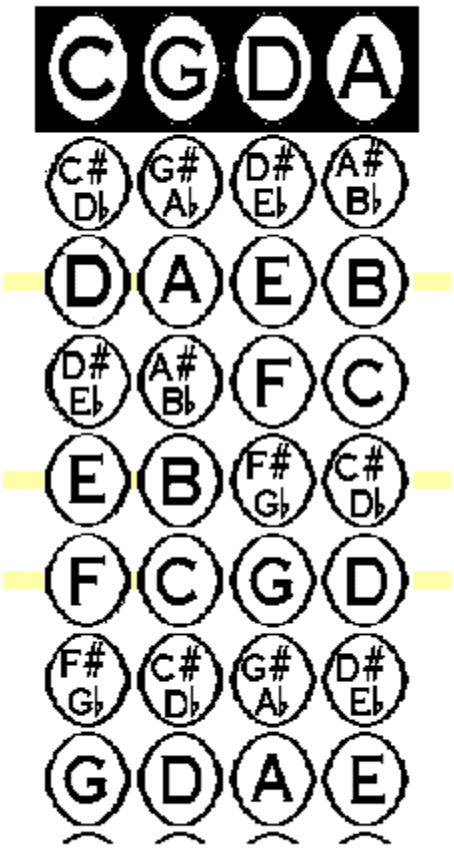

Figure 21 The method of playing the viola in just intonation.

Source: wikipidia,2022

When the Viola plays the Thai tuning system, the position of the fingers also needs to be adjusted, and multiple positions play the same pitch. I recorded the position of the hand on the Viola playing an octave, from C โด with a vibration frequency of 254.2Hz to high C โด with a vibration frequency of 508.5Hz.

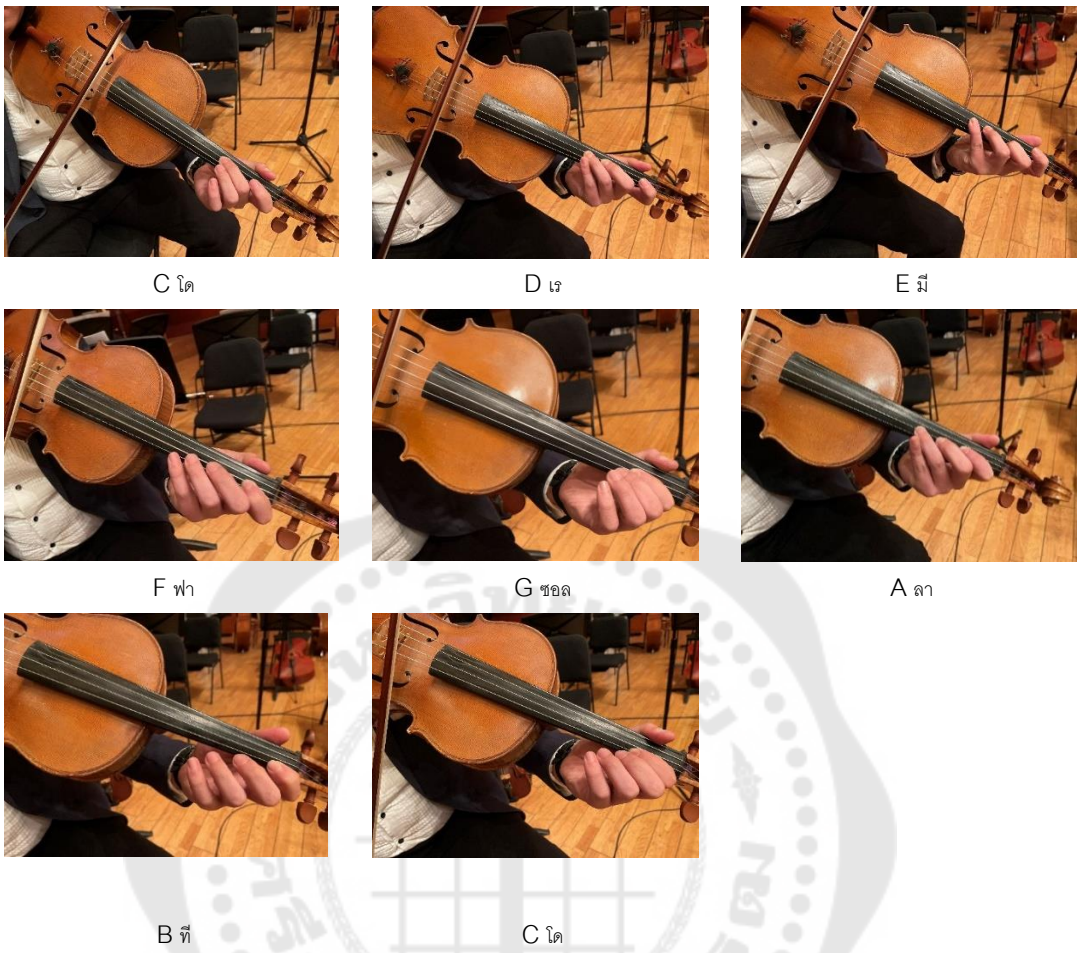

Figure 22 Thai hand position of viola

Source: Lin, 2022

I interviewed Tang Ke, the viola principal of the Xiamen Philharmonic Orchestra, about how the viola plays the Thai tuning system. Tang Ke is an excellent and experienced viola player. He believes that good players familiar with the Thai tuning system will have an easier time playing the viola using the Thai tuning system.

2.3 Cello

We also need to adjust the cello to accomplish the purpose of playing with Ranat Ek. The cellist I interviewed is Chen Han, the Principal cellist of the Xiamen Philharmonic Orchestra. He is also very interested in playing the Thai Tuning system for the cello and tried it in the interview. Moreover, gave me some advice on how to

compose music. Viola is a string instrument of the violin family. Its four strings are usually tuned in perfect fifths: low to high, C2, G2, D3, and A3. Each string on the viola is an octave higher than the cello.

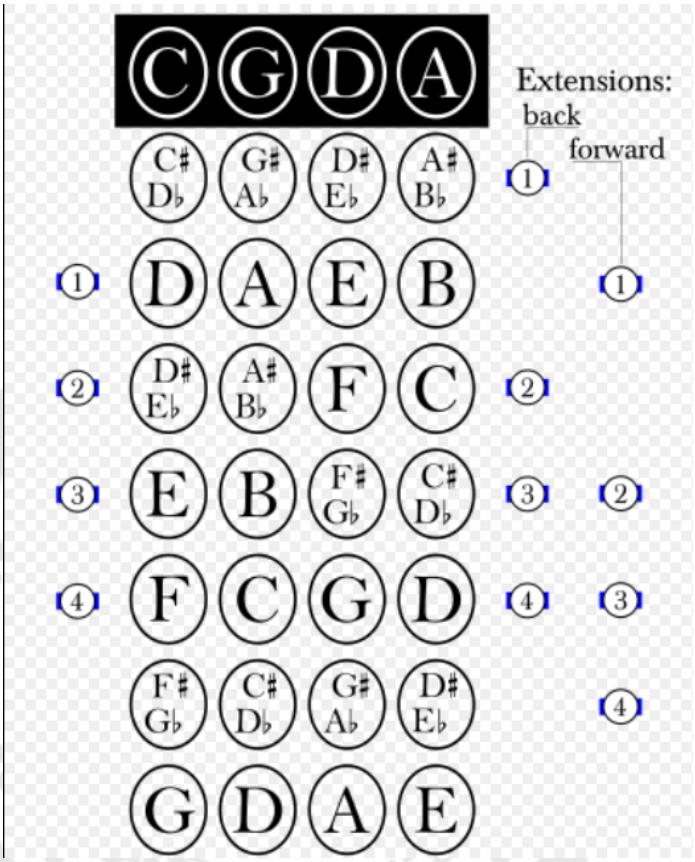

Figure 23 The method of playing the cello in just intonation.

Source: wikipidia, 2022

When the Cello plays the Thai tuning system, the position of the fingers also needs to be adjusted, and multiple positions play the same pitch. I recorded the position of the hand on the Cello playing an octave, from C โด with a vibration frequency of 127.1Hz to high C โด with a vibration frequency of 254.2Hz.

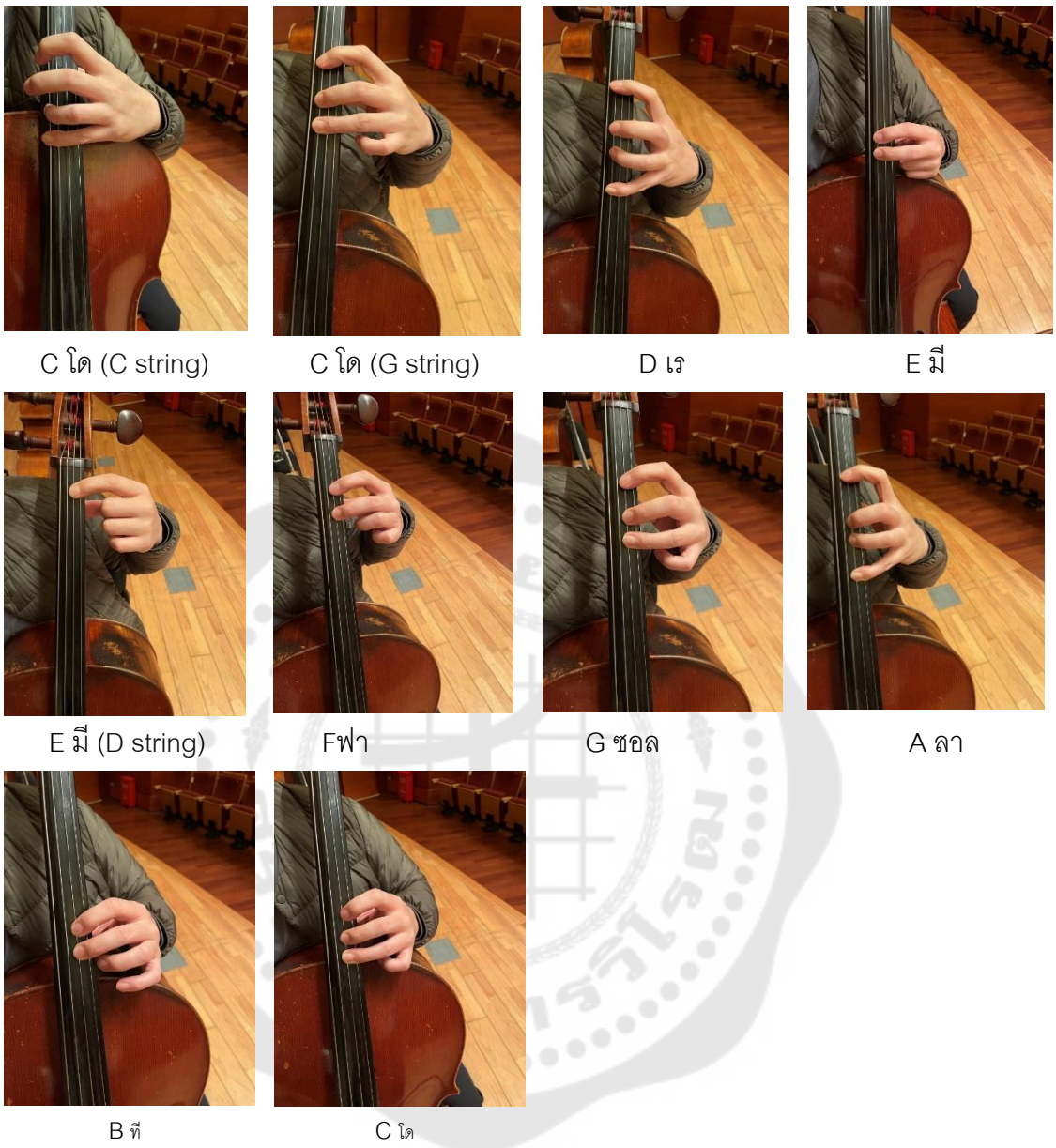

Figure 24 Thai hand position of cello

Source: Lin, 2022

2.4Double bass

The double bass is the orchestra's largest stringed instrument and the lowest note. The instrument's structure is also similar to that of the cello, which is commonly made up of four strings. The double bass is the only modern bowed string instrument tuned in fourths rather than fifths, with strings usually tuned to E1, A1, D2, and G2. The sound is heard an octave lower than what is written on the score. I collected finger position with vibration frequencies ranging from 63.5Hz to 115.1Hz. The performer is Qiu Shuopeng, the principal double bass of the Xiamen Philharmonic Orchestra.

Figure 25 Thai hand position of double bass

Source: Lin, 2023

For data collection, this performer is using a German Bow, which is commonly known as the German style. There are some differences between the German double bass bow and the French double bass bow. The German double bass bow is more significant, and the bow is held differently.

Figure 26 German double bass bow

Source: Lin, 2023

2.5 Wind instrument

The Wind instrument is divided into woodwind and brass parts in Western symphony orchestras. Brass instruments include the French horn, trumpet, trombone, tuba, and other instruments. Woodwind instruments include flute, oboe, clarinet, bassoon, and other instruments. In brass instruments, the player's lips vibrate, causing the air within the instrument to vibrate. In woodwind instruments, the player either: causes a reed to vibrate, which agitates the column of air (as in a saxophone, clarinet, or oboe). Blows across the edge of an open hole (as in a flute). In Chapter 2, I mentioned the different classifications of vibrations. All of these vibrations produce overtone vibrations. That means tuning them is impossible if I need to use these

instruments. For example, if I adjust the main tone tube of the horn, I change the standard tone (A=440) to A=417.2. This means that the pitch of each note will be proportionally adjusted. So, most wind instruments are not suitable for pitch adjustment. As with all brass instruments, the sound is produced when the player's vibrating lips cause the air column inside the instrument to vibrate. Nearly all trombones use a telescoping slide mechanism to alter the pitch instead of the valves used by other brass instruments. This means that the trombone can telescoping slide mechanism to alter the pitch. Makes tuning a single pitch possible. However, it takes much practice to do that. Although almost all wind parts are unlikely to use the Thai tuning system, wind parts can also be used in music creation. For example, the French horn often plays a glissando to represent the sound of an elephant or a train or ship, the flute or piccolo often plays a diligent high note to represent the sound of a bird, and the oboe plays a specific pitch much like a duck. We can intersperse these instruments in certain pieces, which can be a finishing touch to our creation.

2.6 Percussion

Percussion is a broad name for a group of musical instruments that generate sound by tapping and scraping. The percussion section of an orchestra usually consists of membranophones such as timpani, snare drum, bass drum, and tambourine, in addition to idiophones such as cymbals and triangle.

This means we cannot measure the number of precise types of instruments. Percussion instruments commonly used in symphony orchestras have been mentioned above. In short, percussion is a large category with hundreds of different instruments. Percussion instruments are divided into pitched percussion and unpitched percussion. For example, the Marimba, an instrument with a piano-like keyboard distribution, can hit different pieces of wood and produce different pitches of sound, a pitched percussion. However, the Marimba cannot be turned into Thai mode, and neither can the Celesta. I will refrain from using such instruments in my composition or Thai percussion instruments instead because Thai instruments do not need to be tuned again. Ranat Ek Lek, for example, would be an excellent alternative to Celesta, made of metal and with

similar acoustics. I also want to mention a single instrument, the timpani, which adjusts the pitch of each drum by adjusting the pedals. The player's ear usually adjusts the timpani adjustment pitch due to how the drumhead vibrates. The timpani player had better mark the pedals before playing. An unpitched percussion instrument is a percussion instrument played in such a way as to produce sounds of indeterminate pitch or an instrument usually played in this fashion. Unpitched percussion is typically used to maintain a rhythm or to provide accents, and its sounds are unrelated to the melody and harmony of the music. It can be used directly when composing music without special adjustments to play the Thai tuning system.

To sum up, I chose violin, viola, cello, double bass, Timpani, Gong, Manbo bell, Triangle, French horn, Trumpet, Trombone, Thai xylophone (Ranat Ek Lek), Metal Thai xylophone (Ranat Ek Lek), Thai tenor flute, (Klui piang or), Thai soprano oboe (Pi Java) for the following concerto creation.

3. Compose a concerto

In my works, I choose three pieces of Thai music as the basis for my creation, in which I use the Thai tuning system and Western symphonic instruments. It comprises three movements, Khaeg Sai, Sukhotai Dance, and Elephant.

3.1 The first movement "KHAEG SAI"

The piece I chose for the first movement was KHAEG SAI by Prince Paribatra, the son of King Chulalongkorn (Rama V), Prince Paribatra is also a very important figure in Thai history. I found this song in the music sheet that Assoc.Prof.Dr. Manop Wisuttipat gave me. It only has two pages, but it is very Thai music style. So, I chose this piece of music as the foundation of my first movement.

The first movement of the Ranat Ek Concerto I composed consists of five parts. This creation is due to the peculiarity of Thai music, which has no apparent musical form. In the creation of this piece, I chose conventional strings and percussion arrangements, including the first violin part, the second violin part, the viola part, the cello part, the double bass part, the timpani, and a traditional Thai percussion Ranat Ek Lek. The tempo of this piece is based on Andante, and the time signature is 2|4. Some

fermata and ritardando are used where phrases transition. This allows Ranat Ek, the solo instrument, to perform the instrument's characteristics more freely and allows the audience to enjoy the music while waiting.

In the first part of the piece, the introduction, the first violin and the second violin parts play a Sixteenth note rhythm at piano pianissimo (ppp)(Picture Example 1). The Ranat Ek Lek, a traditional Thai percussion instrument, is added to the second bar to play the Chord-tone (Picture Example 2). This is because Ranat Ek Lek, also a Thai instrument, does not need to adjust the tuning system, and Ranat Ek Lek is a metal instrument, which adds layers and gives the music more fullness. Then the viola part, the timpani part, the cello, and the double bass were added one by one to make the music more layered (Picture Example 3).

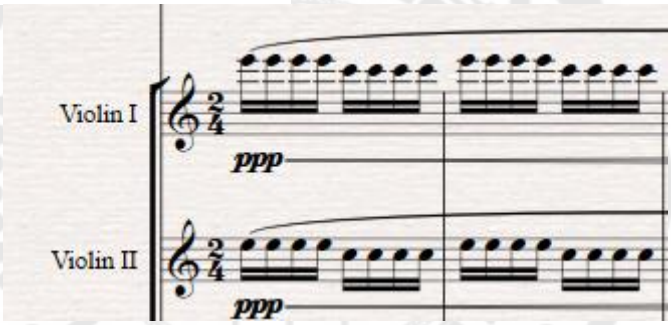

Figure 27 Picture Example 1

Source: Lin, 2022

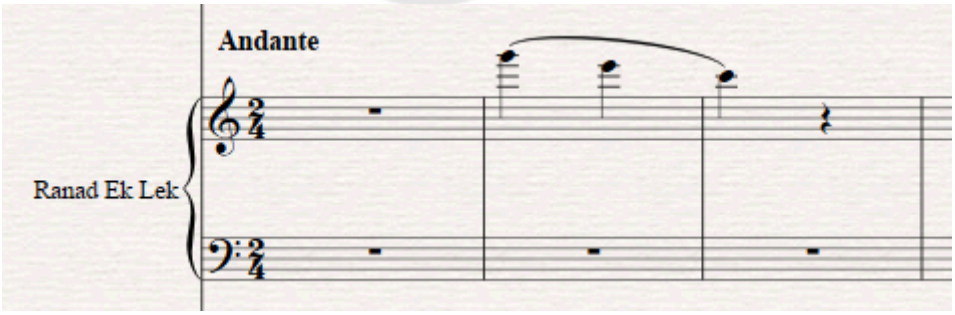

Figure 28 Picture Example 2

Source: Lin, 2022

Figure 29 Picture Example 3

Source: Lin, 2022

Gradually crescendo in the performance, reach forte fortissimo in bar 26. All the parts are fermata here, and then the cello diminuendo uses the Pizz playing method and quietly ends the first part of the piece, the introduction (Picture Example 4). In the Western harmonic principle, we use the tonic chord, the subdominant chord. The dominant chord. Furthermore, we used tonicisation to add variation to the music. The introduction ends with the tonic chord.

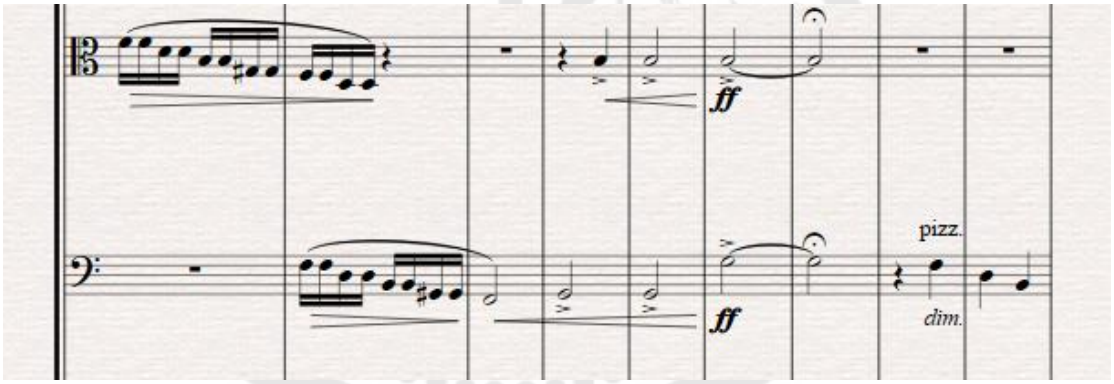

Figure 30 Picture Example 4

Source: Lin, 2022

After the introduction is the first part, I have divided. This part begins at bar 30 and ends at bar 49. In this part, the string part uses the Pizz playing technique, close to the timbre of Asian instruments. In terms of the intensity of the sound, the intensity of the accompaniment part is lower than that of Ranat Ek. This will highlight the performance of the solo instrument. The string instrument accompaniment is appropriately given a rest between notes (Picture Example 5).

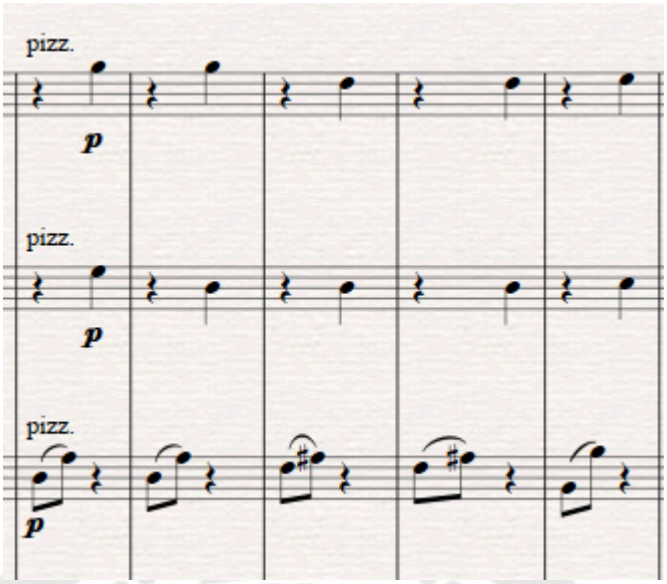

Figure 31 Picture Example 5

Source: Lin, 2022

At bar 38, the string instruments were switched to the bow to perform. As before, the string instrument accompaniment appropriately rests between notes. In this part, only string instruments were used for accompaniment, and no double bass was used for accompaniment in order to avoid complex vocal parts and more intensity than Ranat Ek. In the Western harmonic principle, we use the tonic chord, the subdominant chord. The dominant chord. In order to make a difference from the introduction part, changes are made in the harmonic connection. The first part is followed by the second part, which begins with bars 50 and ends with bars 64. The solo instrument Ranat Ek starts the a cappella performance so Ranat Ek players can play more relaxedly. The stringed accompaniment appears in bar 53. The double bass appears in the accompaniment. The double bass uses Pizz playing to add color to the music. The overtone of the Pizz on the double bass is the same as the first note of this measure on the cello. While enhancing the color of the music also makes the music light up (Picture Example 6). In this sentence, the cello uses the walking bass, increasing the line of the bass part.

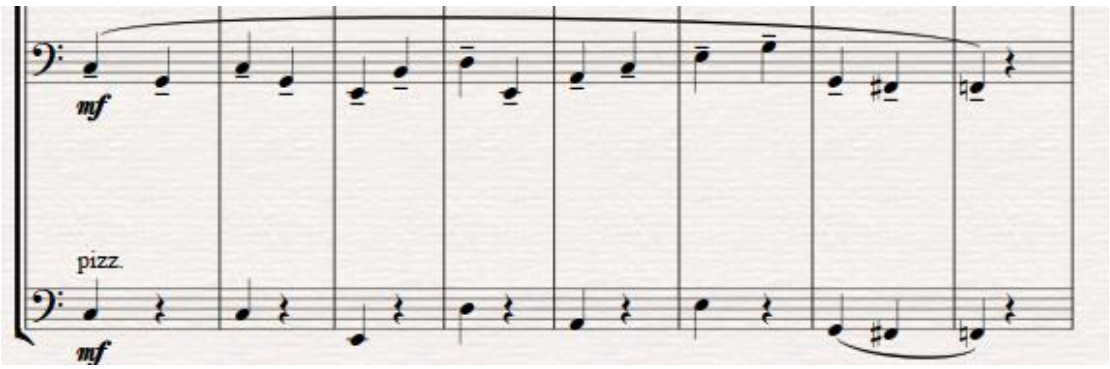

Figure 32 Picture Example 6

Source: Lin, 2022

The third part begins with measure 65 and ends with measure 75. The third and second parts are composed with similar ideas, but they are quite different. Ranat Ek Lek and the solo instrument Ranat Ek are played in Canon style. Both Ranat Ek Lek and Ranat Ek use the Thai tuning system. Ranat Ek Lek plays an octave higher. The addition of Ranat Ek Lek in the performance will surprise the audience (Picture Example 7).

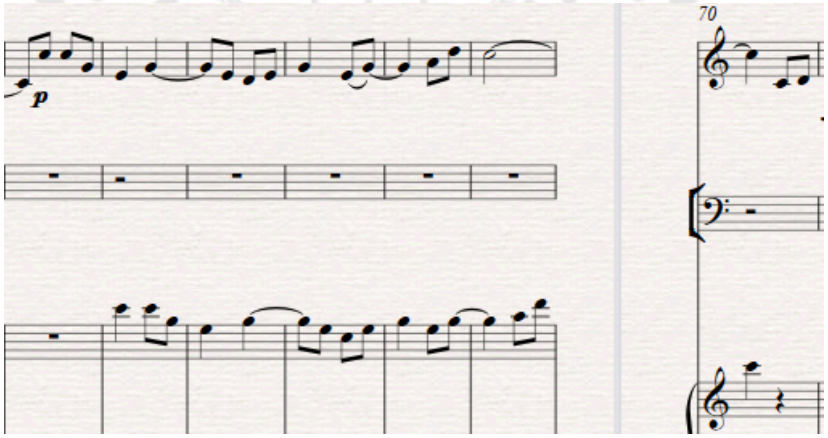

Figure 33 Picture Example 7

Source: Lin, 2022

In the Western harmonic principle, we use the tonic chord, the subdominant chord. the dominant chord. Harmonic variation is added to the piece and a half-tone descending is adopted in the bass (Picture Example 8). It conforms to the principle of proximity of harmony arrangement.

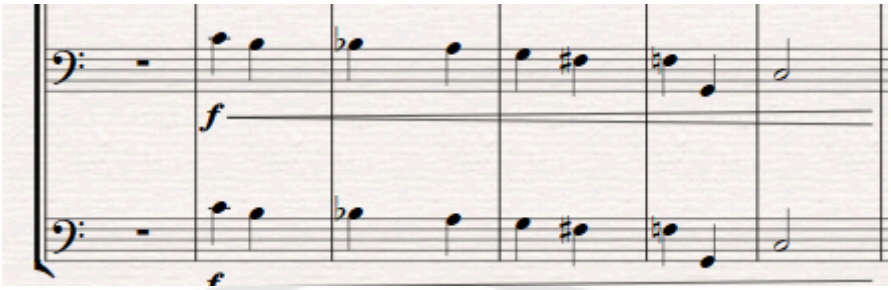

Figure 34 Picture Example 8

Source: Lin, 2022

The coda section of this piece is 76 bars to the end. In the coda part of this movement, the melody that appears in the introduction is chosen. The violin, viola, and cello descending one by one, and the timpani play an important role in the performance (Picture Example 9). The timpani joined the instruments and added strength to the string accompaniment. Beat by beat, the musical intensity become forte fortissimo. When all instruments play forte fortissimo, Ranat Ek Lek joins in. The unique timbre of Ranat Ek Lek makes Ranat Ek Lek stand out among other instruments. Ranat Ek Lek very unexpectedly played Twelve Variations on the melody of "Ah vous dirai-je, Maman", K. 265/300e.This piece is a piano composition by Wolfgang Amadeus Mozart, composed when he was around 25 years old. Be well known version of this piece of music is "Twinkle, Twinkle, Little Star," which has been changed into a children's song (Picture Example 10). This arrangement gives a kind of unexpected surprise, but it makes sense when audiences think about it. When Ranat Ek Lek joined the perform, the intensity of the music diminished. The string part is played very quietly.

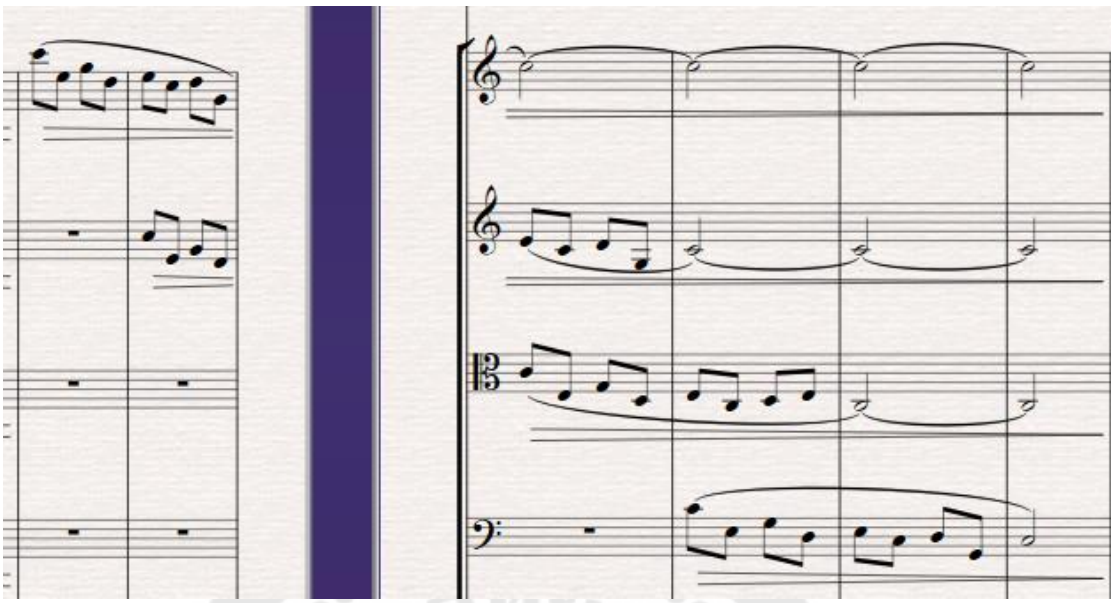

Figure 35 Picture Example 9

Source: Lin, 2022

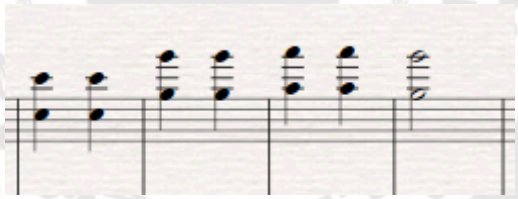

Figure 36 Picture Example 10

Source: Lin, 2022

After the fermata, the sixteenths of the timpani are paired with the dynamic mark Sforzando, indicating that the piece is coming to an end. For the last note, the dynamic mark of the string part is Forte, but because of the Pizz method of playing, it is just right in the audience's sense. In harmony, similar to the method adopted in the introduction, it will not be repeated here.

3.2 The second movement "Sukhotai Dance"

The second piece that I've adapted is a traditional Thai piece called the Sukhotai Dance. I adapted it from a work by YouTuber: Fino the Ranad(https://www.youtube.com/channel/UCvXQOeWsgWFAq5LXQ72in8A). The tuning system he created was based on the Western tuning system, and the instrument was in F major. I did a symphonic adaptation of this piece on the Thai tuning system. This piece is characteristic of Nationalism in music, unlike the one-part form in the first movement, which is similar to binary form. It may seem like each part has a long phrase, but in fact, the solo develops from almost the same melody. common meter was used in the whole music. In the first part, Largo's tempo was used, and orchestration method was used to create an atmosphere of watching dance performances on shore in Thailand by boat, with the moon reflected on the water surface. Although the melody of the solo instrument in the second part is almost similar to that in the first part, Tempo becomes Adagio, full of cheerful atmosphere, so as not to bore the listener. I, on the second movement of adaptation using orchestration method, choose accompaniment instrument has the Timpani, Gong, Mambo bell, Triangle, violin I, II violin, Viola, Violoncello, Contrabass. Consider Ranat Ek's smaller playing voice and the difficulty of adjusting Western symphony orchestra wind instruments to the Thai tuning system. So, I still use a small band of strings and percussion combination for accompaniment. In this piece, the melody of the solo instrument is very Asian, and there is commonality due to the history of Asian nationalism music interacting with each other. I think it can be seen as a distortion of the Chinese pentatonic mode. The instrument of the original recording has been tuned, which can be understood as F major (Chinese pentatonic, gong F). In the re-creation, I will still use the Thai tuning system, so I will use no key for the key sign. It adopts the creation style of Chinese art songs, integrates the rich timbre of western music, and retains the unique charm of Thai music.

The first verse of the second movement is the beginning to bar 37. At the beginning of the piece, the first violin vibrates, and the sound gradually crescendos over three bars (Picture Example 11). In the third bar, the gong joins in, which is my specially

arranged accompaniment instrument. The gong is a particularly Asian instrument. Asian countries have a lot of gong Musical Instruments. in my adaptation of this song, I recommend 3 bossed gongs in stall of Thailand (Picture Example 12). When playing this piece using 3 bossed gongs in stall of Thailand, the gong at the bottom will have a very good tone.

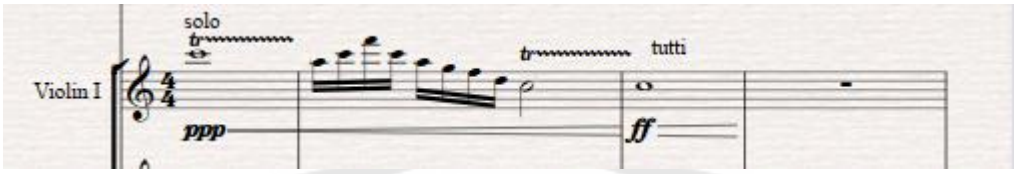

Figure 37 Picture Example 11

Source: Lin, 2023

Figure 38 Picture Example 12

Source: Lin, 2023

In the fifth bar, the orchestra accompaniment changes from fortissimo to piano, and Ranat Ek plays from piano in the solo part, a loud and Whisper sound change that highlights the dexterity of the solo instrument (Picture Example 13).

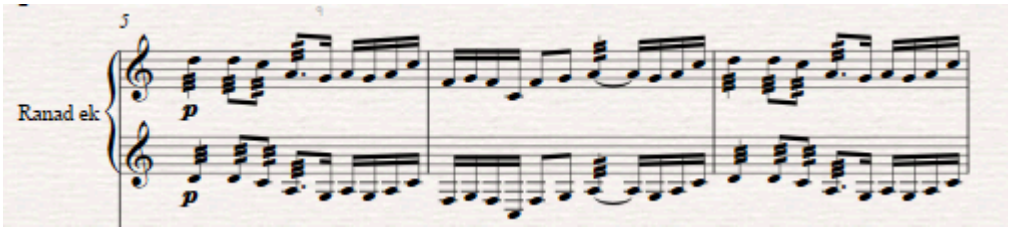

Figure 39 Picture Example 13

Source: Lin, 2023

When the solo instrument plays a long note, the accompanying instrument follows the melody played by the solo instrument, a compositional technique called Fill-in. It appears many times in this piece of music that I have adapted.

The percussion instruments play a major role in enhancing the accent in this piece. Where percussion is added, the gong instrument is added to the accompaniment, which sounds more characteristic of Southeast Asia in the whole melody (Picture Example 14).

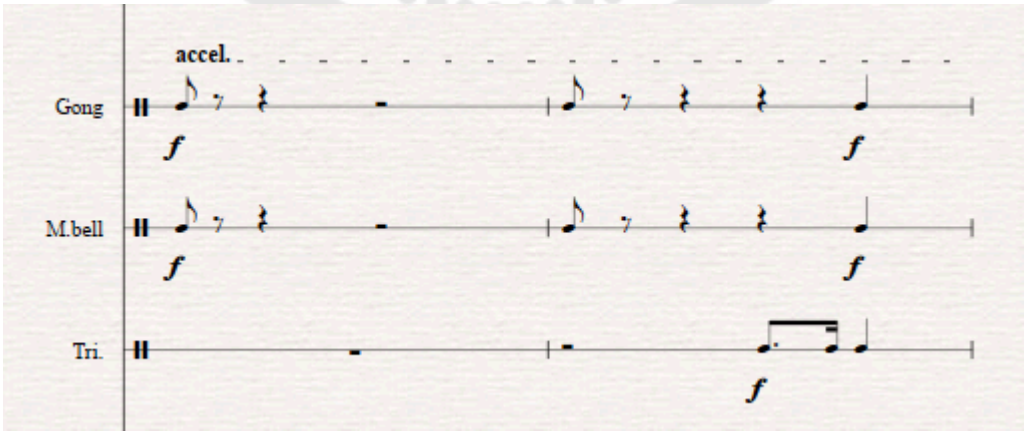

Figure 40 Picture Example 14

Source: Lin, 2023

Although the first part is quite large, the idea is to make the piece sound less boring. From bar 35, there appears the speed marked accel, which is short for Italian accelerando, which means speed up.

And then the second part of the piece, the speed changes from Largo to Adagio, At the beginning of the music, mambo bell plays an important accompaniment. The speed becomes faster and brings people a feeling of joy, which is in sharp contrast to the previous solemn feeling. At first, I wanted to use wooden clapper (กรับเสภา) from Thailand to replace the voice of mambo bell, but after much hesitation, I decided to use mambo bell. The sound of mambo bell is not as high as the vibration frequency of wooden clapper, so it sounds more dynamic (Picture Example 15).

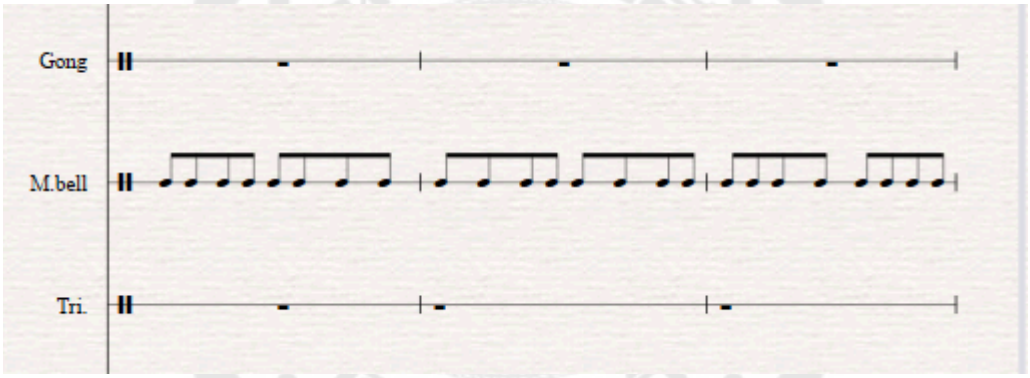

Figure 41 Picture Example 15

Source: Lin, 2023

In bar 44, the timpani are added, and the timpani plays the note within the chord in this position. The change of the fifth interval is easier to play for the timpani. Instead of simply playing the fundamental notes, the timpani can better highlight the bass lines (Picture Example 16).

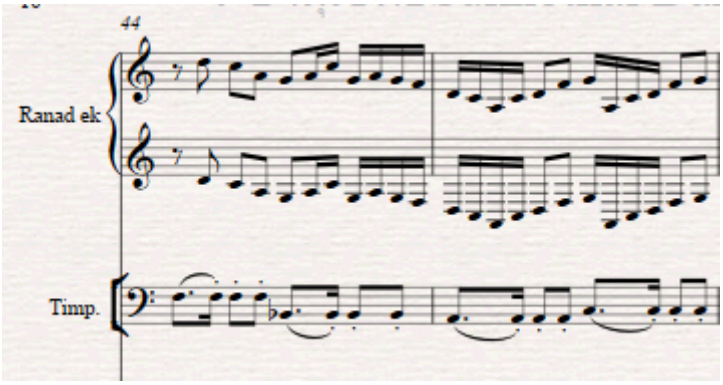

Figure 42 Picture Example 16

Source: Lin, 2023

It can be said that my creative ideas in the second part are basically the same as those in the first part, which increases the rhythm and connectivity of the music.

3.3 The third movement "The Elephant"

the third movement I adapted again from the music of YouTuber Fino the Ranad (https://www.youtube.com/channel/UCvXQOeWsgWFAq5LXQ72in8A), This is a widely sung by Thailand a children's song "Chang Chang Chang Chang", the original song is also adapted from an old Thai song, this old song with Myanmar style. The original song is a very clear style of Oriental music. Similar to China's C Gong mode, the selected instruments include woodwind group, brass group, percussion group and string group. The string part is still the standard symphony orchestra configuration, consisting of the first violin, second violin, viola, cello, and double bass. The brass parts, which cannot be tuned to the Thai tuning system, are used in this piece, but only to mimic animal sounds. The woodwind part will be very distinctive. I will use Thai Musical Instruments, such as Thai tenor flute (Klui piang or) (Picture Example 17) and Thai soprano oboe (Pi Java) (Picture Example 18), for woodwind part.

Figure 43 Picture Example 17

Source: Lin, 2023

Figure 44 Picture Example 18

Source: Lin, 2023

Percussion parts include timpani, snare drum, Thai Gong and Triangle. In this creation, I respect the original style of the music and try not to make too many adaptations on the original folk music mode. As the third movement of Ranat Ek Concerto I created, the solo music basically followed the tempo principle of each movement. The third movement is more cheerful, the tempo is vivace. Since the melody of the original song is repeated many times, in general, the musical form of this song is similar to that of a rondo form. At the beginning of the piece, we use the double bass to imitate the footsteps of the elephant, and at the beginning of the third bar, we use the

sound of the melodic motive as the introduction (Picture Example 19). In the timpani roll and the triangle, we enter into a formal melodic motive.

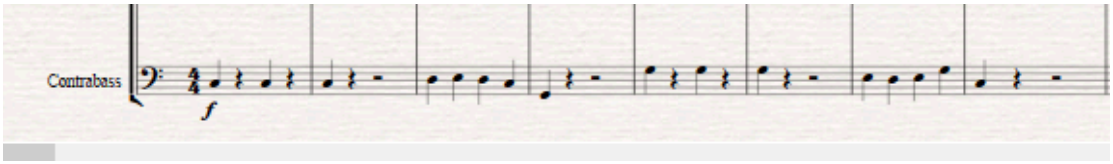

Figure 45 Picture Example 19

Source: Lin, 2023

In bars 9 to 12, snare drum will be performed in a special way. Without changing the time signature, metatony method will be adopted to make the beat of the music more flexible, so as to change the calm style of the music and make the audience feel fresh (Picture Example 20). This kind of motivation comes up a lot in the music.

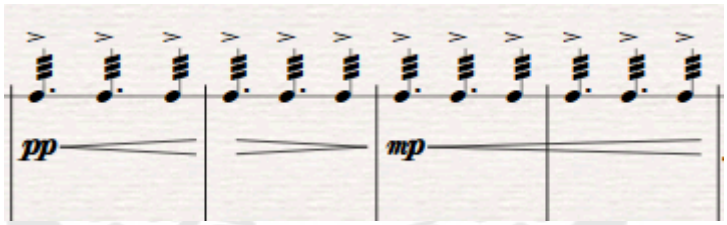

Figure 46 Picture Example 20

Source: Lin, 2023

Brass instruments, such as the French horn, trumpet, and trombone in bars 13 to 15, are also played in a unique way. We have analyzed before that due to the particularity of design, brass instruments cannot be adjusted to the Thai tuning system, so they cannot be added to the performance in a normal way. However, this piece of music is an exception.

The title of this movement is elephant, and the version of lyrics for teenagers is full of children's longing for the unknown. After I adapted the music, it was very cheerful. In my music, the brass instrument used the glissando method to play again

and again, imitating the cries of elephants. Here I borrowed the creative ideas of other composers and added the performance of brass instruments that should have been inappropriate. In the brass part, the pitch and timbre of the instruments are different, which can well simulate the cries of elephants in different situations and at different ages (Picture Example 21).

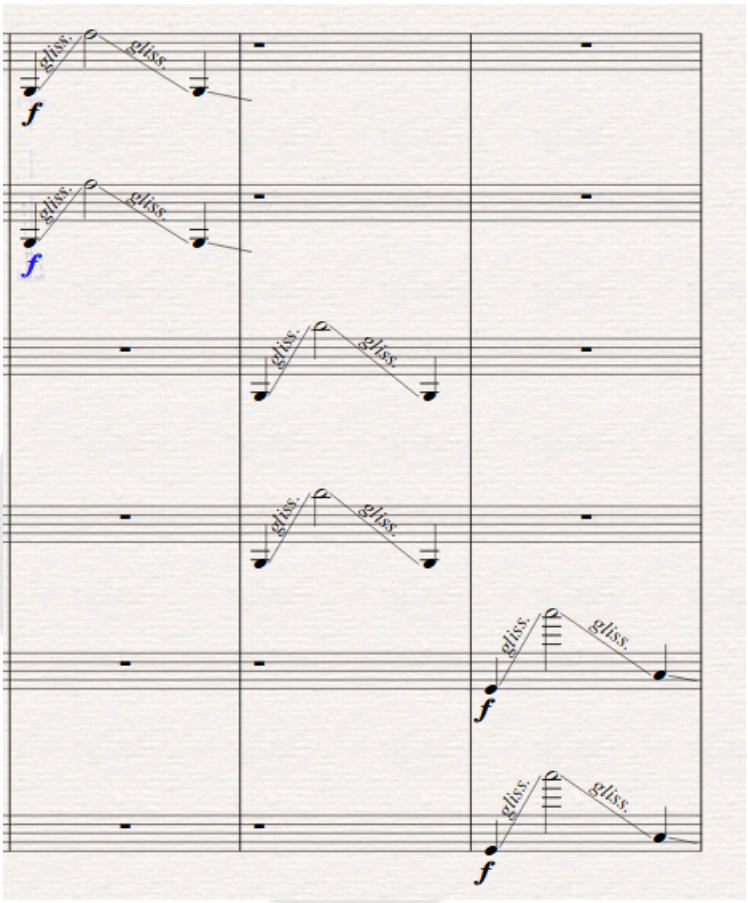

Figure 47 Picture Example 21

Source: Lin, 2023

After all instruments are present and played, the solo Ranat Ek is played with Thai tenor flute and Thai soprano oboe in alternating measure by measure. The solo instrument enters the performance in a casual manner, also to reduce the seriousness of the piece (Picture Example 22).

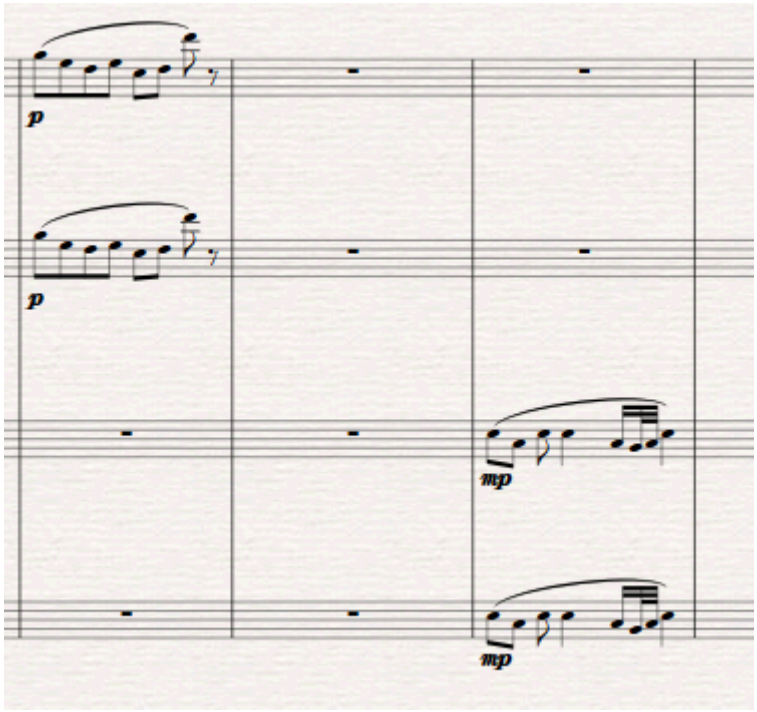

Figure 48 Picture Example 22

Source: Lin, 2023

The melody of the solo instrument after it starts, it sounds very similar to the intro, but in the orchestration, I've made a lot of changes. The violin is in bar 47, playing the same melody with the solo instrument. In terms of composition, we call doubling. In bar 48, you switch back to the accompaniment immediately. The reason for this is that the solos may be rhythmically free, and also to avoid the melody being too noisy (Picture Example 23).

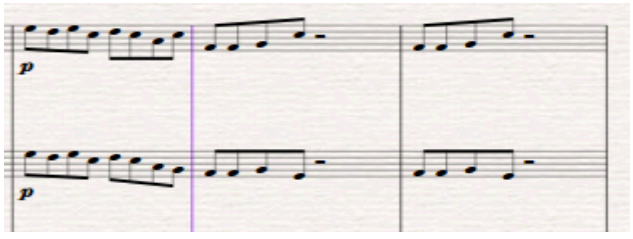

Figure 49 Picture Example 23

Source: Lin, 2023

In the later performance of the Thai tenor flute, trill method appeared many times, imitating the birdsong in the jungle, showing the diversity of the jungle (Picture Example 24).

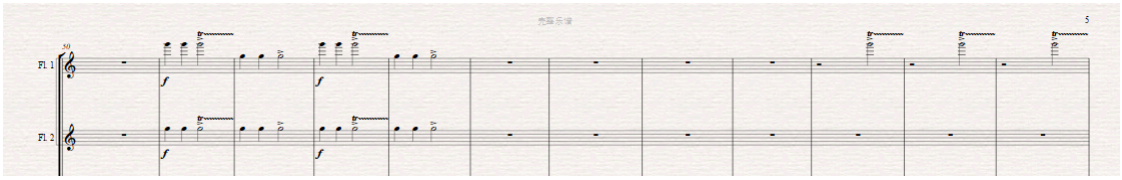

Figure 50 Picture Example 24

Source: Lin, 2023

The triangle also plays a very important role in the music. As the background of the whole music, it shows the solo instrument well. In bar 90, the meter changes, and then in bar 91, it changes back to the original meter. I define the next 6 bars as Cadenza, only the triangle and the solo instrument play, the triangle keeps the original rhythm (Picture Example 25). The musical form of this movement is the rondo form, so the melody repeats this theme a lot, and I won't go into it too much here.

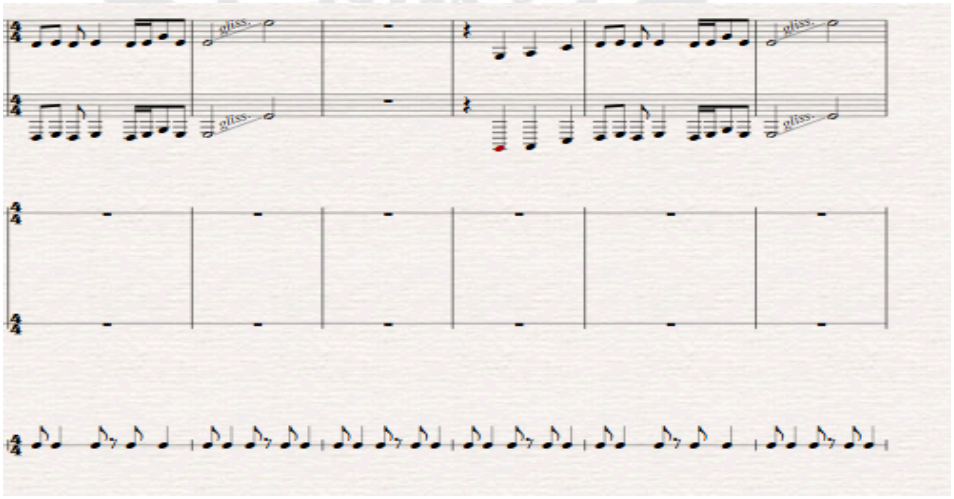

Figure 51 Picture Example 25

Source: Lin, 2023

At the end of the piece, I used to want to have a long ending, but the previous piece was already long enough, and adding another long piece would be very cumbersome. So, I chose the motive of the theme, this is a common way to end a piece of Western music. In the previous music, I chose to imitate the elephant sound with a brass instrument but play it one after another. In the last bar of this movement, all the brass instruments will come together to imitate the sound of an elephant in the glissando method, thus ending this Ranat Ek concerto (Picture Example 26).

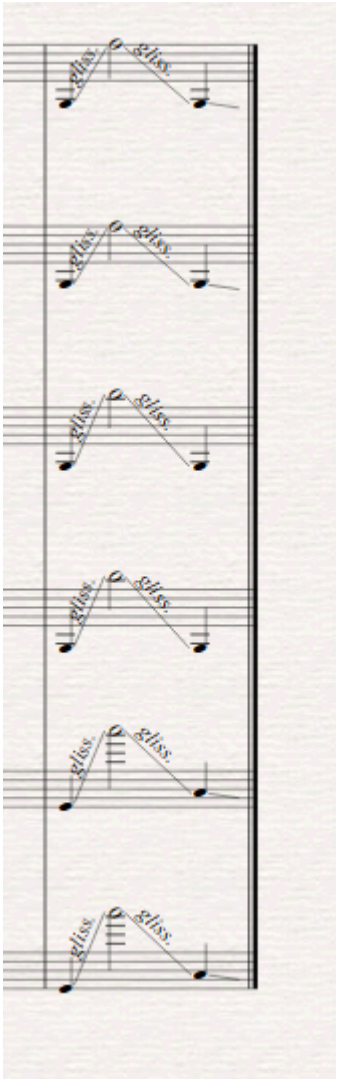

Figure 52 Picture Example 26

Source: Lin, 2023

After studying the tuning system of several Thai schools in Thailand, the researchers finally decided to use the tuning system issued by the Thai government as the tuning system standard for concerto composition. Three Thai pieces were chosen, namely Khaeg Sai, Sukhotai Dance and Elephant. The researchers retained the characteristics of Thai Musical Instruments and used symphony orchestra for accompaniment.

CHAPTER 5
CONCLUSION AND DISCUSSION

The main research direction of this paper is to make it possible for traditional Thai instruments and Western symphony orchestras to play with the Thai tuning system. A musical tone is a sound with a distinct pattern of vibration pronunciation that can distinguish distinct pitches and imitate them. For example, the sound of an instrument being played and the music on the radio are musical sounds. The overtone series of music is regular. Therefore, when two or more sounds are played simultaneously, people will subjectively distinguish whether it sounds good or not. Western music describes their interval as minor, major, perfect, augmented, diminished, double-augmented, and double-diminished. Here I use Professor Chen Qixiang's calculation formula to show whether the two intervals are consonant more visually. According to this theory, two sounds that vibrate at the same frequency will sound perfect to the listener. However, whether it is Thai or Western music, they usually do not play the same note together. More often, it is playing different notes at the same time. In more specific cases, I have heard fugue music in traditional Thai music, similar to Western fugue music. So, a visual way to describe the interval is easier. There are many different schools of Thai tuning systems. According to the professors, each school has its tuning system. The players in each school will adjust the instrument's pitch themselves, rely on the ears to adjust the pitch, and the specific pitch will depend on the teacher. When I tested Srinakharinwirot's instruments, the frequencies of each note vibrated, and there was little difference in pitch. The instrument was not out of tune. It was deliberately tuned to be in tune. Using Professor Chen Qixiang's vibration frequency calculation formula, it is easy to find that Srinakharinwirot's instrument calculates more in tune than that published by the Thai government. For the applicability of the study, I still adopted the tuning system issued by the Thai government.

CONCLUSTION

One of the most critical attempts in this study was to use the Thai tuning system to play traditional Thai instruments with a symphony orchestra. This study's difficulty is adapting the Musical Instruments in the symphony orchestra to the Thai tuning system without adjusting the structure of the original Musical Instruments. I interviewed one of the best orchestras in China, the Xiamen Philharmonic Orchestra, for which I work. The players in the orchestra showed me how the notes in the Thai tuning systems could be played without adjusting the instrument's structure. I interviewed one of the best orchestras in China, the Xiamen Philharmonic Orchestra, for which I work. The players in the orchestra showed me how the notes in the various Thai tuning systems could be played without adjusting the instrument's structure. One of the most challenging points is the wind music; changing pitch is done by pistons, pressing buttons, and pulling pipes. Because the design did not consider the convenience of playing different tuning systems, adjusting the wind instruments in a symphony orchestra to the Thai tuning system is only possible if the instruments are remanufactured. Therefore, when composing music, I use alternative methods to add traditional Thai instruments to the wind part of the symphony orchestra. For example, I use the Thai tenor flute (Klui piang or) for the flute and the Thai soprano oboe (Pi Java) for the oboe. The brass cannot be tuned to the Thai tuning system in my composition, so I let the brass play the musical effect. For example, the brass part mimics the elephant voice in the third movement. The percussion part is the part I focus on. Since there are thousands of instruments in the symphony orchestra, choosing which instruments to join the performance takes much work. On the principle of percussion, I prefer to use Thai instruments. Percussion instruments, such as marimba and celesta, which are in tune, are unsuitable for accompaniment. In the first movement, I chose to use another Ranat Ek instead. Therefore, I completed the research in the way of composition. Based on the calculated data, I concluded that Thai Musical Instruments and symphony orchestras could perform together only with the same tuning system. For the spread of Thai music in the world, it is very positive. It is a bold attempt to let the symphony orchestra use the Thai

tuning system for accompaniment. Of course, this study also has some things that could be improved. First of all, when testing the vibration frequency of the tuning system of Musical Instruments in Thailand, due to COVID-19, enough musical instrument data could not be collected. Second, for Western instrumentalists playing in the Thai tuning system, String instruments can play the same note using more than one finger position. Since there is no way to form a system of playing methods, unexpected situations may occur during performances or rehearsals. I compose music that, in theory, and calculation, will be performed. However, this performance may be challenging to achieve in reality, as it requires symphony orchestra players to be familiar with the Thai tuning system and much practice. Therefore, I took some consideration in the creation. Ranat Ek adjusted to 12 equal temperaments, and the symphony orchestra could achieve the performance. Symphony orchestra accompaniment only needs to replace the corresponding instrument.

SUGGESTION

I have several research directions in the follow-up research, and I will share my thoughts.

1.Study the tuning system of various schools in Thailand and try to summarize the rules and differences. The 7-TET was created by Alexander J. Ellis and is based on the Western tuning system, which is very different from the folk tuning system but is still officially recognized. It will be widely used if we can sum up a common folk tuning system.

2.Because of the unique nature of the Thai tuning system, it is very difficult for symphony orchestra players to play the Thai tuning system directly. After a period of practice, string instruments may be able to perform. This greatly increased the difficulty of playing. If the performing method can be summarized and string instruments can be played in a unified way, it will be easier for this form of music to spread around the world.

3.In Thai forms of performance, whether Piphat, Khrueng sai, or Mahori, the instruments are mainly high-pitch instruments with few or no bass instruments. In

Modern Chinese orchestras, there is also a lack of bass instruments. Western instruments, such as the cello and the double bass, were added to overcome the lack of bass instruments. This is to make the music more colorful. Of course, Modern Chinese orchestras use traditional Chinese bass instruments, gehu, and bass gehu, instead of the double bass and cello. Nevertheless, it is rare.

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APPENDIX

1. Interview Transcripts

1.1 Interviewee: Asst.Prof. Metee Punvaratorn

Interviewer: Lin Zixiang

Address:12F, Faculty of Fine Art in Srinakharinwirot University

(M＝Asst. Prof. Metee Punvaratorn,I＝Interviewer)

I: I am very glad to interview you. I'm going to ask you some questions, and I hope you can answer my questions.

M: yes, please.

I: Why does every school or ensemble in Thailand, like Piphat, have their own tuning system？

M: It's an interesting question, because I was raised, my teachers taught me to tune this way, and I developed this habit.

I: This means that each teacher uses their own tuning system when they tune, and they tune by ear instead of using a tuning machine.

M: exactly!

I: I found out that the government has issued the tuning system to the musical instrument factory, but I used the software to test the school's musical instrument tuning system, which is quite different from the documents issued by the government. What is the reason for this? Is it the problem of instrument maintenance?

M: In fact, there are two possibilities. The factory can produce Musical Instruments with the tuning system issued by the government, or it can manufacture Musical Instruments with the tuning system required by the customer. I can tell you an interesting story. I once adjusted the Musical Instruments in our school to the tuning system required by the government. The next day, Prof. Veera, master of Piphat of our university, found that the intonation had changed, and he adjusted the intonation back to his favorite. So, I don't think it was a poor preservation of the instrument.

I: I think so too, but why is it that in the lower register, pitch is generally lower than the government-issued tuning system?

M: I think they wanted to make one octave wider, which would make the music more expressive. Besides, the Thai ensemble lacked a bass instrument, so it was pitched lower in the bass register.

I: When I'm doing research or composing music, which data do you think I need to use, the government data or the school data, because the vibration frequencies of the two data are very different.

M: The vibration frequency issued by the government. Because it's more reliable. Imagine playing with instruments from different schools or ensembles, all with different tuning systems. It would be very scary.

I: I agree with you, but this tuning system issued by the government is actually the same as Alexander J. Elils' original 7-TEN tuning system, with 1200 cents divided equally. As a Thai, would you be unhappy about that?

M: For example, it's the Equal temperament. It's not the best tuning system, but it's the most versatile one.

I: In the case of the Thai instrument, Ranat Ek, is there only intervals and no harmonies? Whether a common interval is the fourth or the fifth or the octave?

M: In fact, the Thai Ensemble doesn't harmonize in any of the pieces that I know. The interval all can be perform, the more common interval is the fourth or the fifth or the octave. Ranat Ek also doesn't use two sticks in traditional playing.

I: If I wanted to compose a piece with Thai melody, Thai instruments, symphony accompaniment, and Thai tuning system, what composition advice would you give me?

M: It's your work. It's up to you. But if you can, you can use some Thai percussion instruments.

I: Thank you, Asst. Prof. Metee Punvaratorn, I will accept your suggestion. It is a great honor that you can accept my interview today. I will continue to finish my thesis. Hope you have a nice day.

M: You too.

1.2 Interviewee: Asst.Prof. Chanik Wangpanich

Interviewer: Lin Zixiang

Address: Online interview

(C＝Asst. Prof. Chanik WangpanichI＝Interviewer)

I: Asst.Prof. Chanik Wangpanich, I'm sorry to come to interview you so late. As my assistant supervisor, I would like to ask you what you think about my thesis?

C: I think it's very interesting, the conventional research is to take a Thai instrument and adjust it to a Western tuning system, or just play it regardless of the tuning system, but I think you're going to have trouble tuning a Western tuning system.

I: Yes, if I need to take an entire Western symphony orchestra and turn it into a Thai tuning system, I don't think it's realistic and it doesn't make sense. So, I'm going to use some tricks to get these two tuning systems to communicate to each other. It's not so much a technique as a musical representation of the picture. For example, I will write a concerto, and the beginning of a concerto is usually played by a symphony orchestra. Then the solo instrument comes in. This is when conflicts occur on the tuning system. Then solo instruments begin to play, accompanied by strings and percussion by adjusting the hand position to adjust the tuning system (becoming the Thai tuning system). Then wind music is added, repeated tuning system conflicts, and finally the string and Thai instruments complete the final ending. This is my idea of composition.

C: It's a very good idea. I think you don't want to tune wind instruments and brass instruments, not only to enhance the conflict in communication, but also because wind instruments and brass instruments are very difficult to tune.

I: Yes, as a horn player myself, I understand tuning a wind instruments and brass instruments is equivalent to recreating it. Percussion instruments I'm also going to use some Thai percussion instruments.

C: I think it works, so who do you think is going to play this piece for you.

I: This is a kind of musical exploration for me. I create music by understanding the tuning system of Thailand, which is not necessary to play, after all, it is very difficult for the performers. I think it is a kind of protection for the traditional music

of Thailand. Protecting traditional music culture in the process of development. What I'm confused about now is which tuning method should I use, the tuning system issued by the government or the tuning system of a certain school?

C: As Prof.Metee pointed out, musical instrument factories in Thailand are all made according to the tuning regulations issued by the government, but there are also customers who require a specific tuning system, such as a Western tuning system. This is a whole new direction of research that I don't think anyone has tried before, and I'm looking forward to seeing what you do.

I: Thank you, Professor. I have a clearer understanding of the research scope. I will finish my work as soon as possible. Thank you so much for accepting my interview request.

1.3 Interviewee: violinist Qiu Ke of Xiamen Philharmonic Orchestra

Interviewer: Lin Zixiang

Address: Xiamen Philharmonic Orchestra

(Q＝Qiu Ke，I＝Interviewer)

I: I am very glad to interview you. I am researching and creating the Thai tuning system. Do you know anything about Thai music?

Q: I've only heard melodies from Thai movies and TV dramas, but I don't know much about it.

I: I'm going to play you the tuning system issued by the Thai government. Do you think you can do that on a violin?

Q: I think it is OK to use the Thai tuning system on the violin and make some changes in the hand position. A professional violin player or even an amateur can play it after practice.

I: Do you think it is possible to develop an educational approach for people to use the violin to play the Thai tuning system?

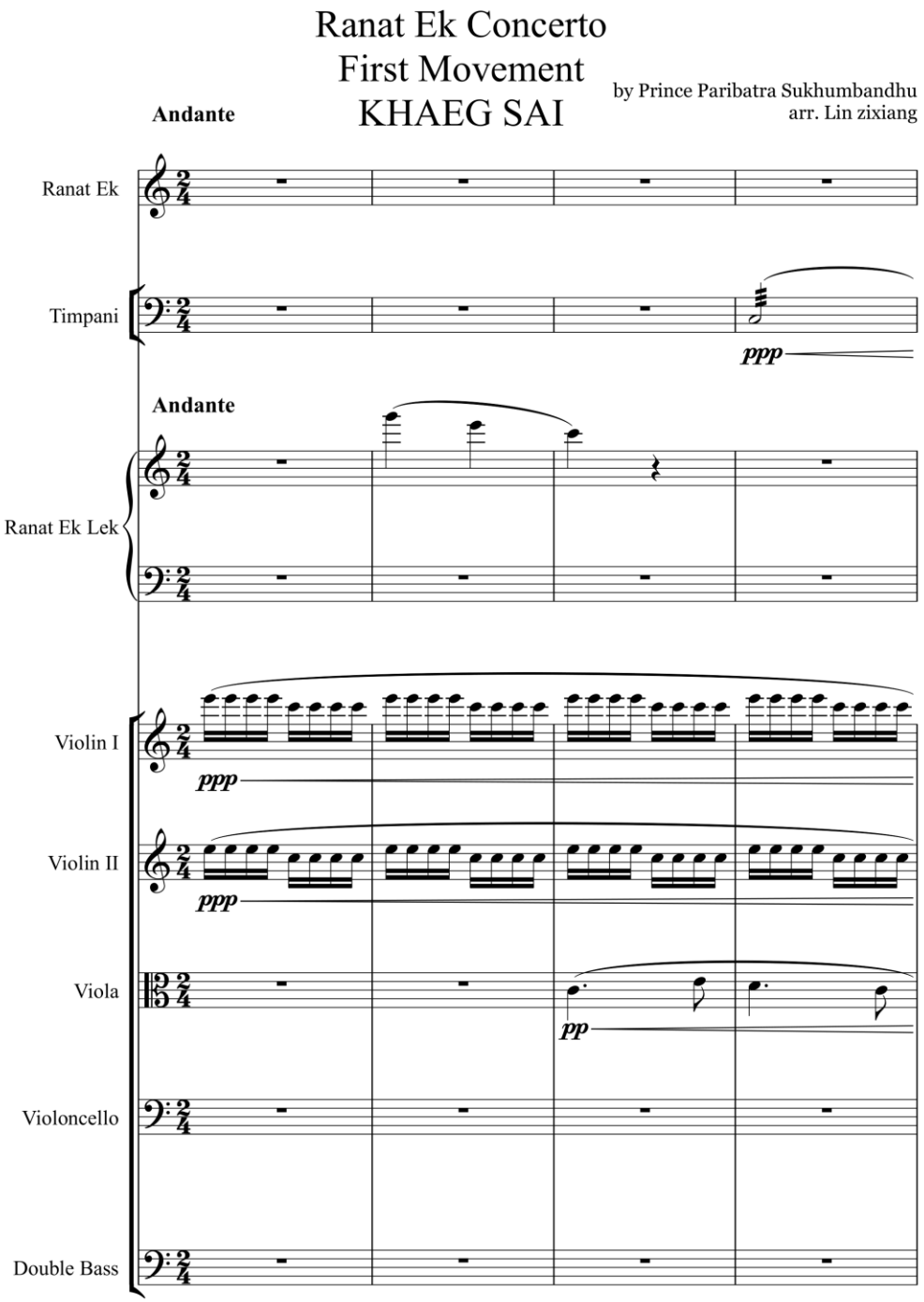
Q: I don't agree with this. The violin is designed to have tuning principle in it. The pitch of each string is G3, D4, A4 and E5, which is a pure fifth to next string. For

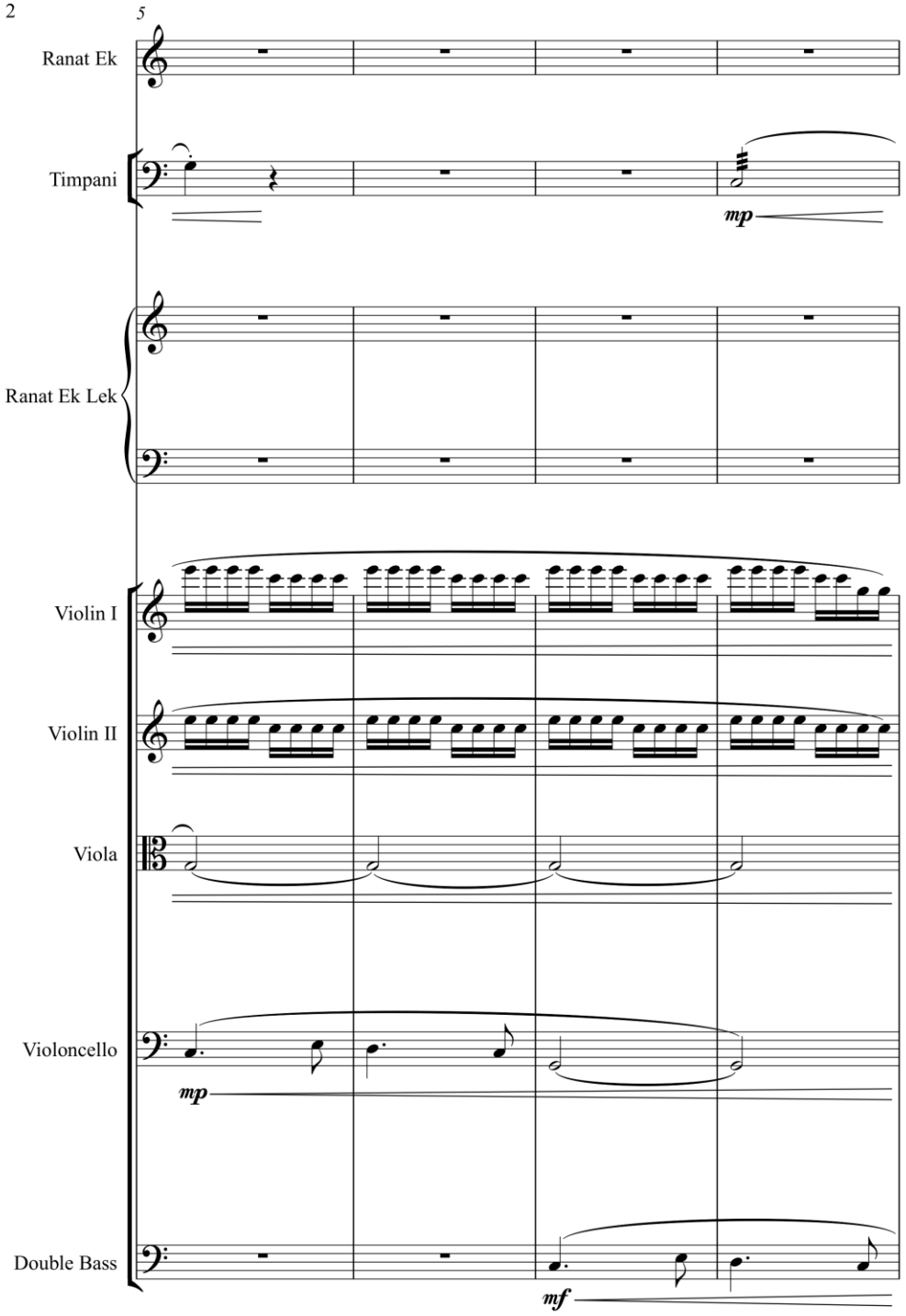
example, when a violin plays with a certain Thai instrument, it is ok to let the violin adjust its Hand position and simply play. Players need to be familiar with Thai tuning system and have a certain playing basis. Violins are not designed for the Thai tuning system, there is no way to play two notes using Thai tuning, it's illogical.

I: I agree with you that players need to get used to the tuning system of Thai instruments rather than another education.

Q: For example, in the high C of the Thai tuning system, I can use E5 string to play, or A4 string to play. Therefore, the best way to make the violin play the music of the Thai tuning system is that the player can be familiar with the Thai tuning system and have a good knowledge of western music.

2 The score of Ranat Ek concerto

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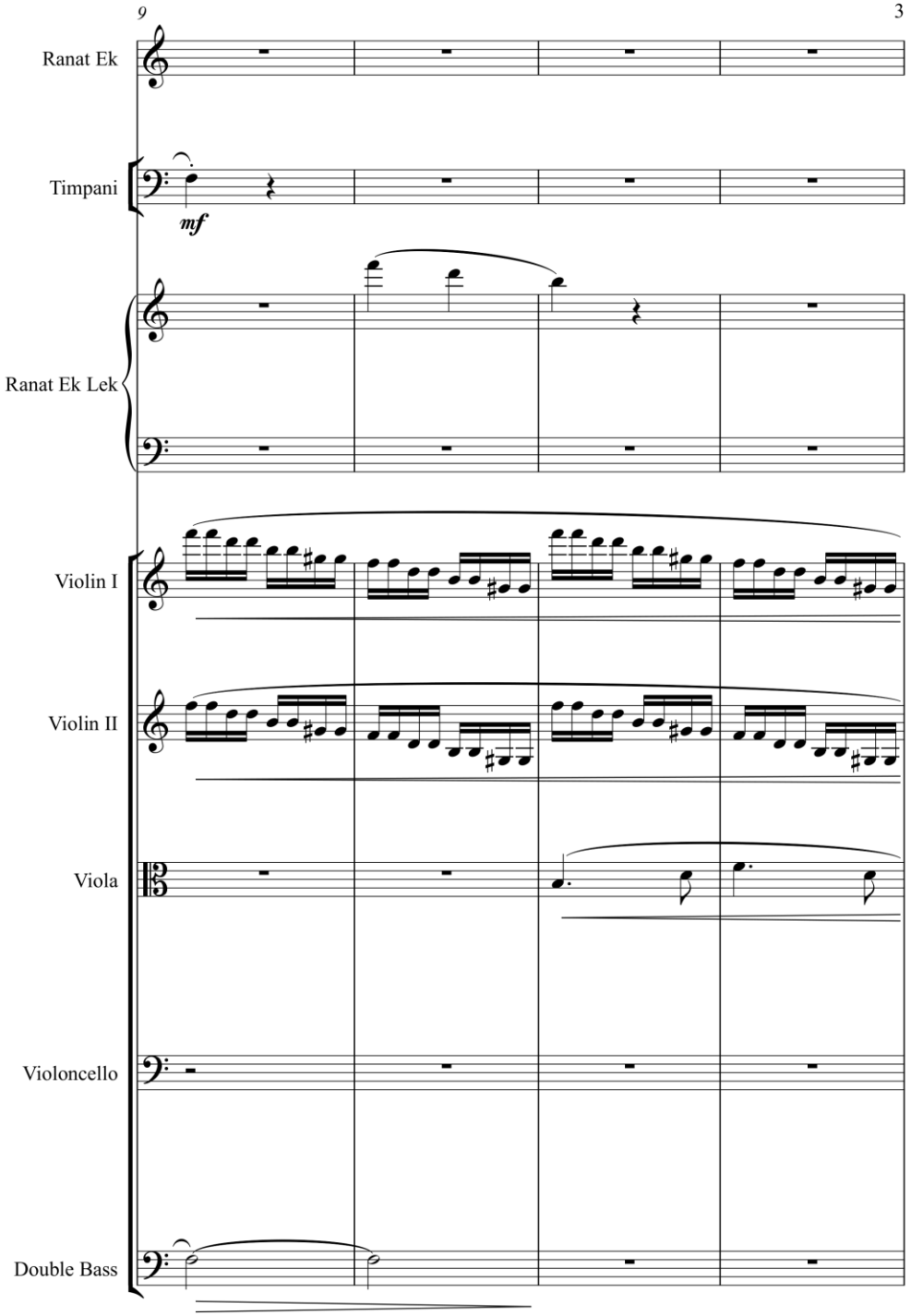
Timpani
mp
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
mp
Double Bass
mf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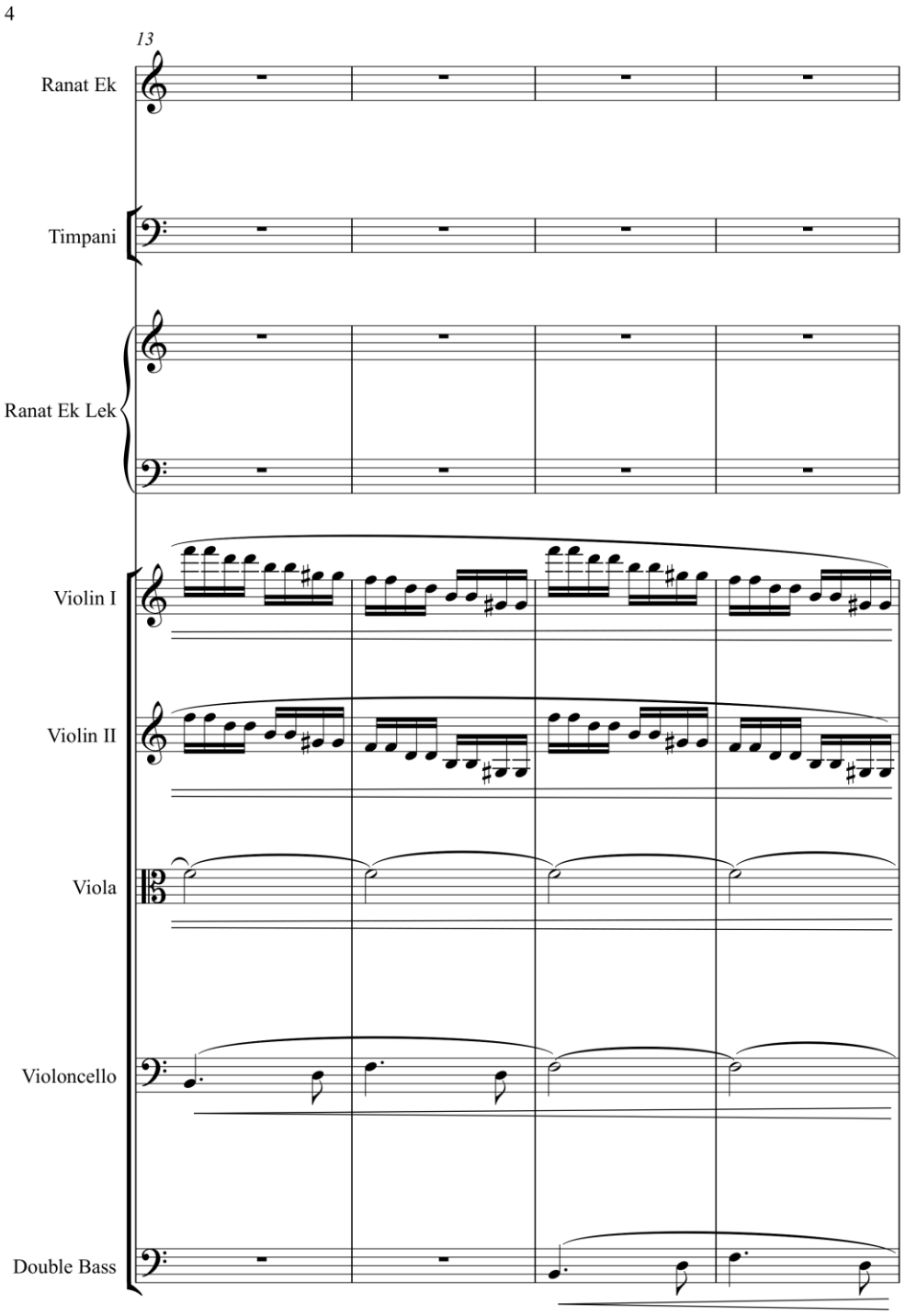
mf
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
Double Bass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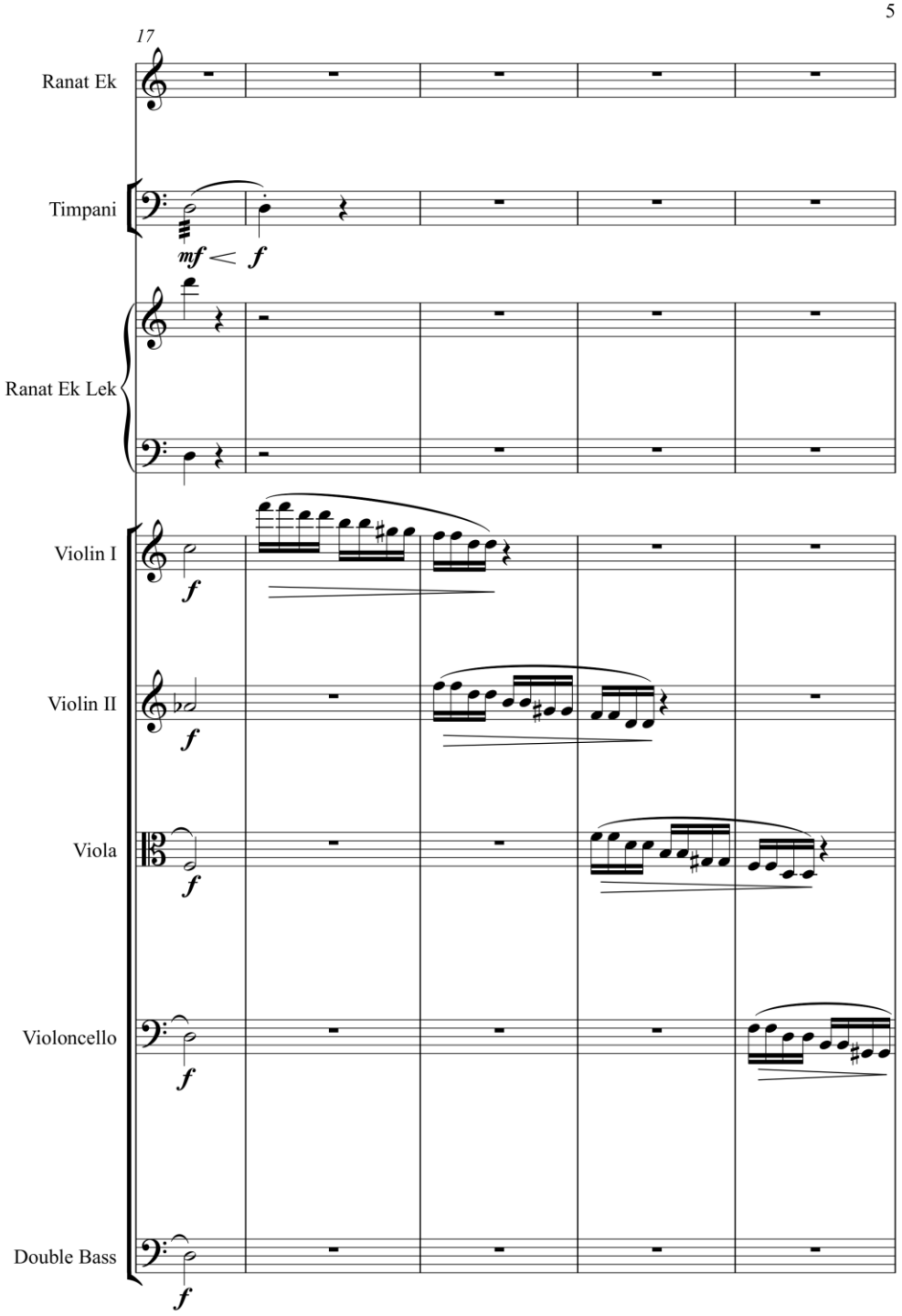
Timpani
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
Double Bass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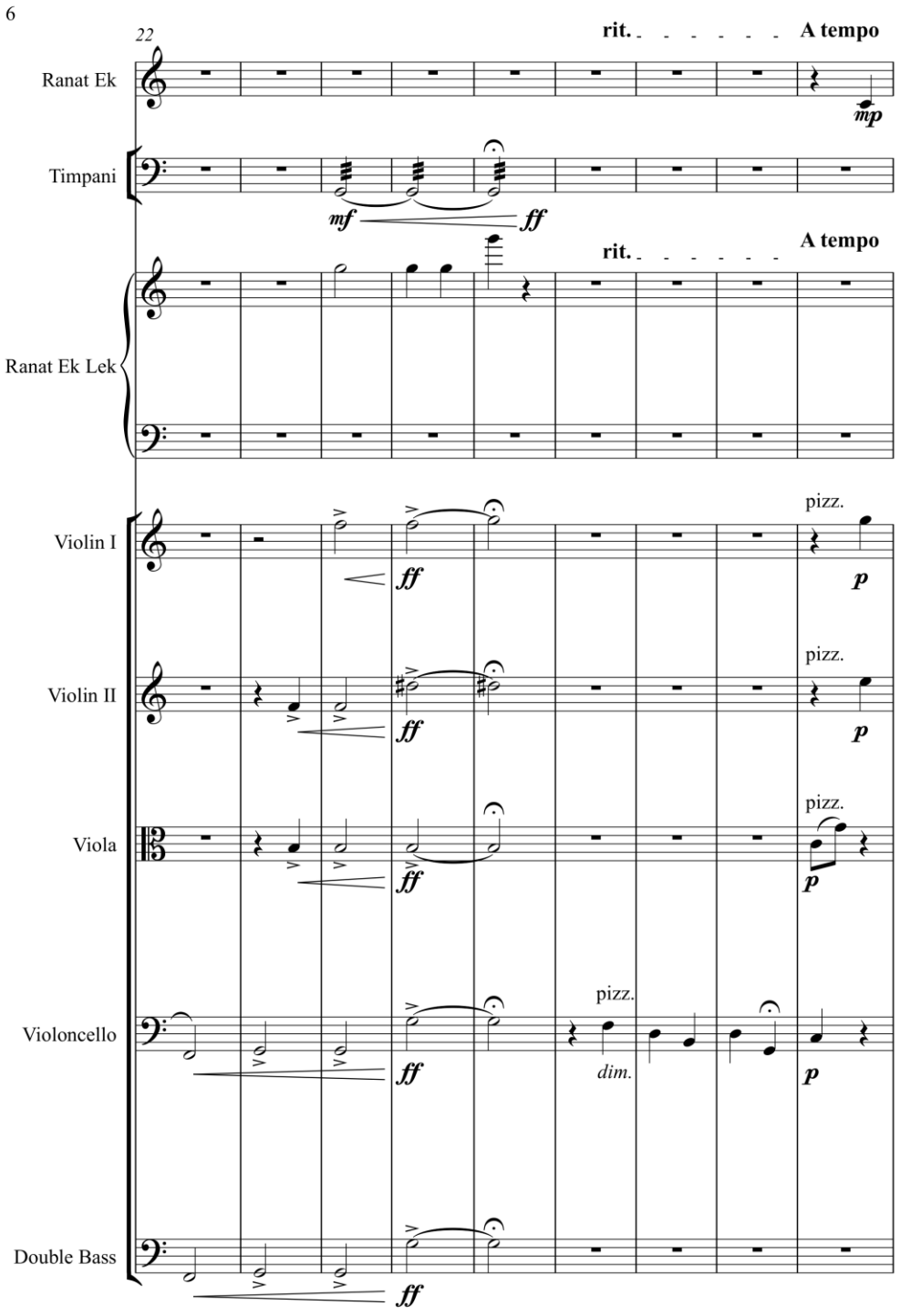
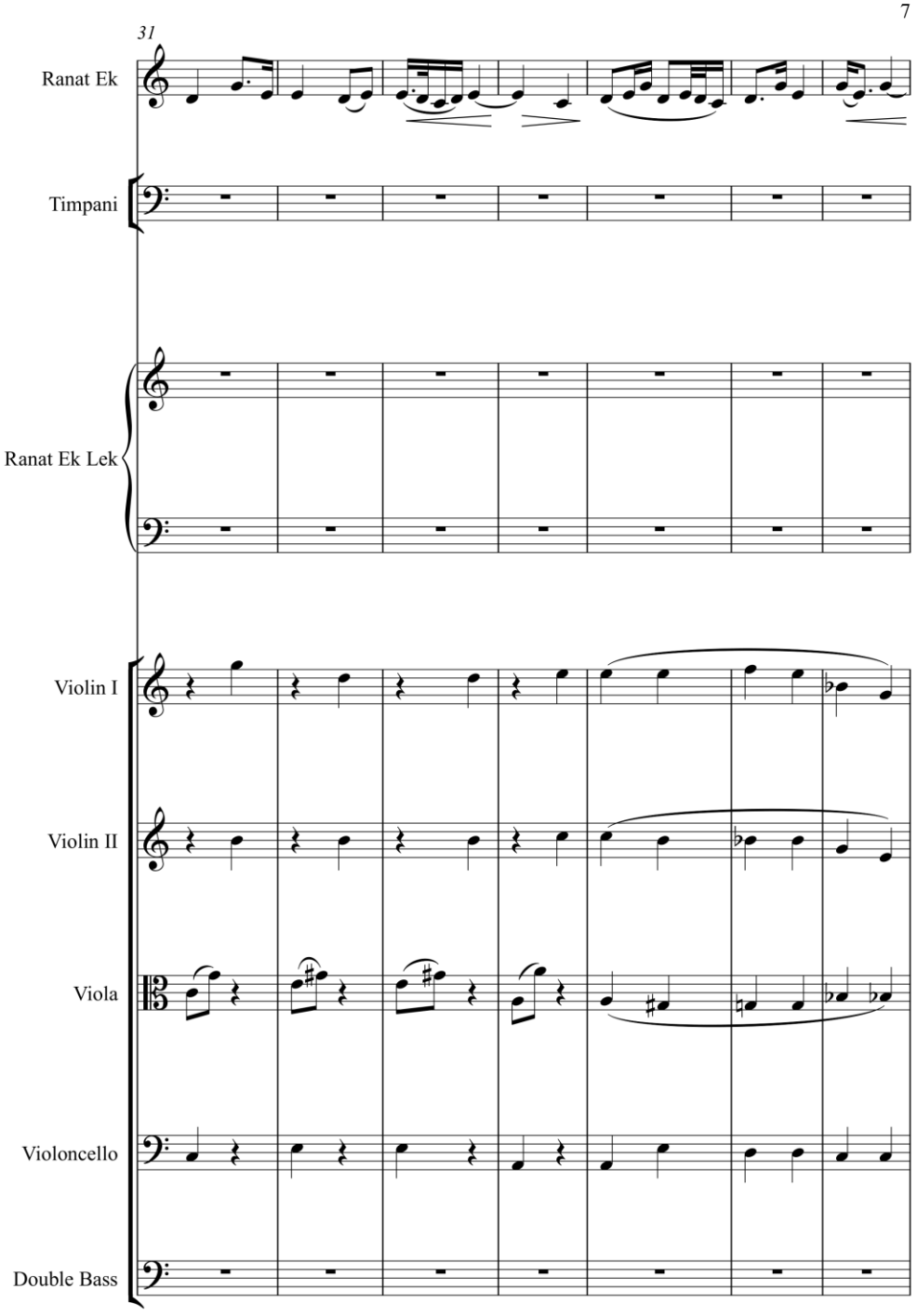
Timpani
mf
f
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
Double Bass


6
22
rit.
A tempo
Ranat Ek
mp
Timpani
mf
ff
rit.
A tempo
Ranat Ek Lek
Violin I
ff
pizz.
p
Violin II
ff
pizz.
p
Viola
ff
pizz.
p
Violoncello
ff
pizz.
dim.
p
Double Bass
ff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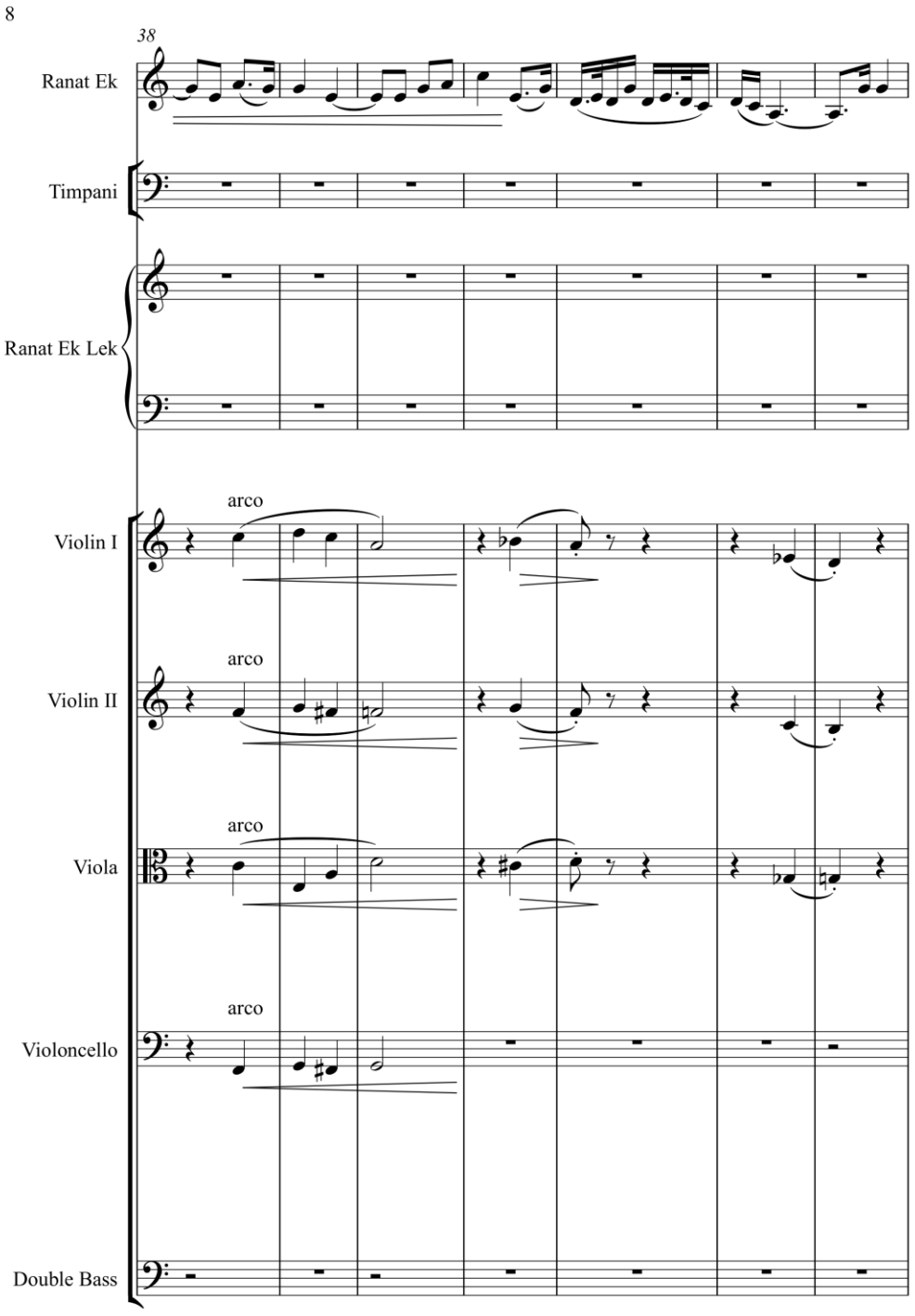
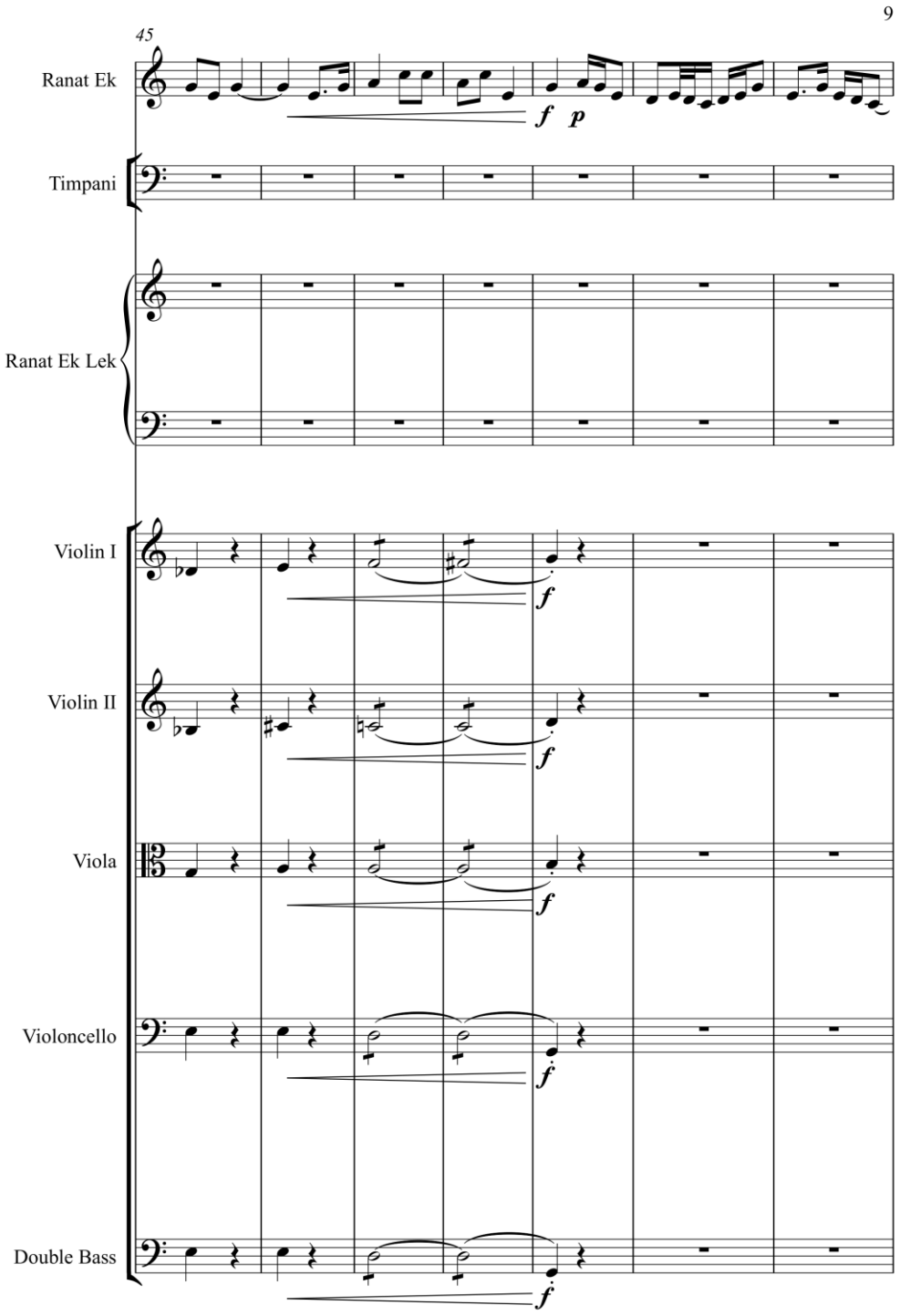
Ranat Ek
Timpani
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
Double Bass


8
38
Ranat Ek
Timpani
Ranat Ek Lek
arco
Violin I
arco
Violin II
arco
Viola
arco
Violoncello
Double Bass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Ranat Ek
Timpani
Ranat Ek Lek
Violin I
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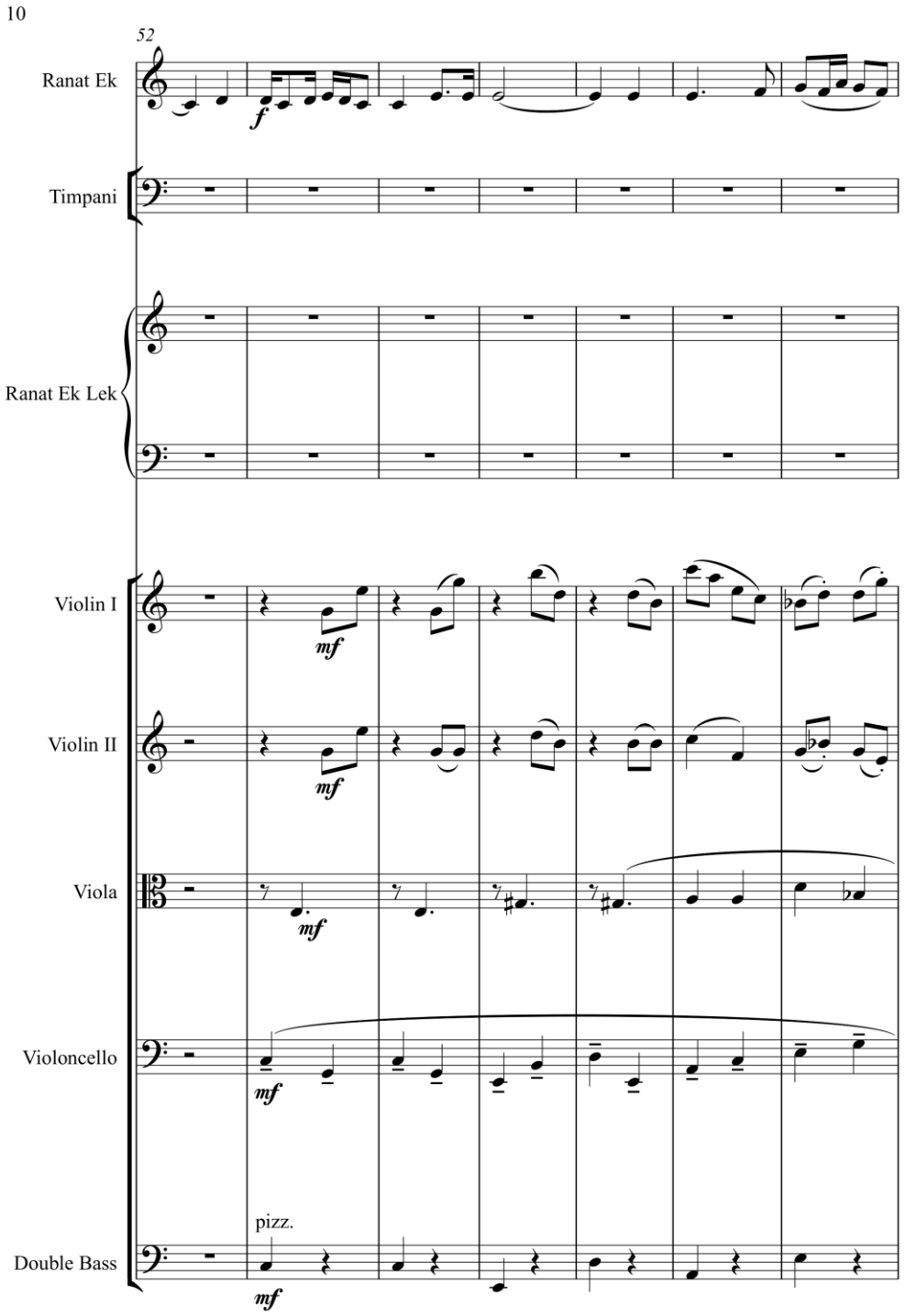
Viola
Violoncello
Double Bass
f
p
f
f
f
f
f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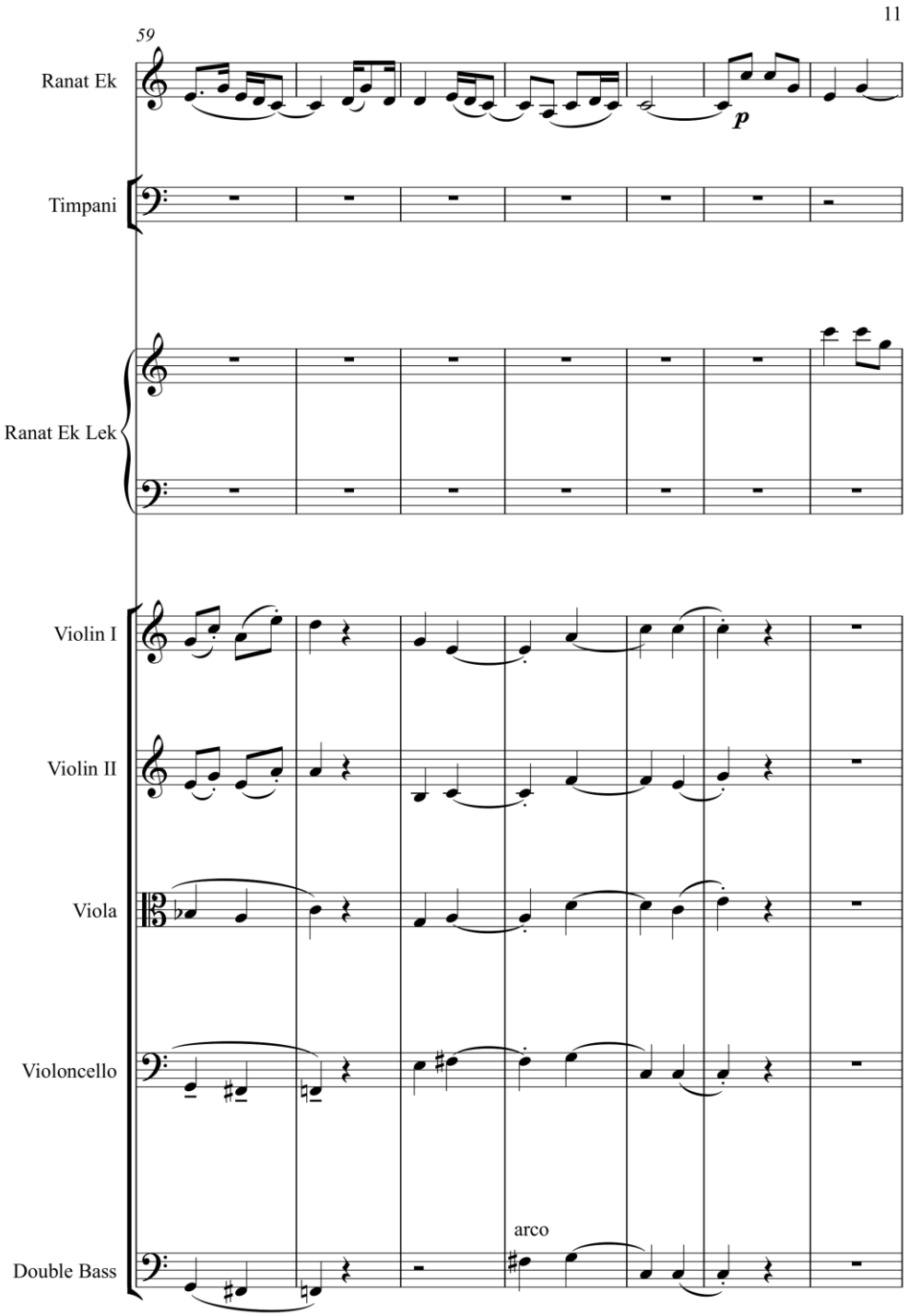
Timpani
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
Double Bass
pizz.
f
mf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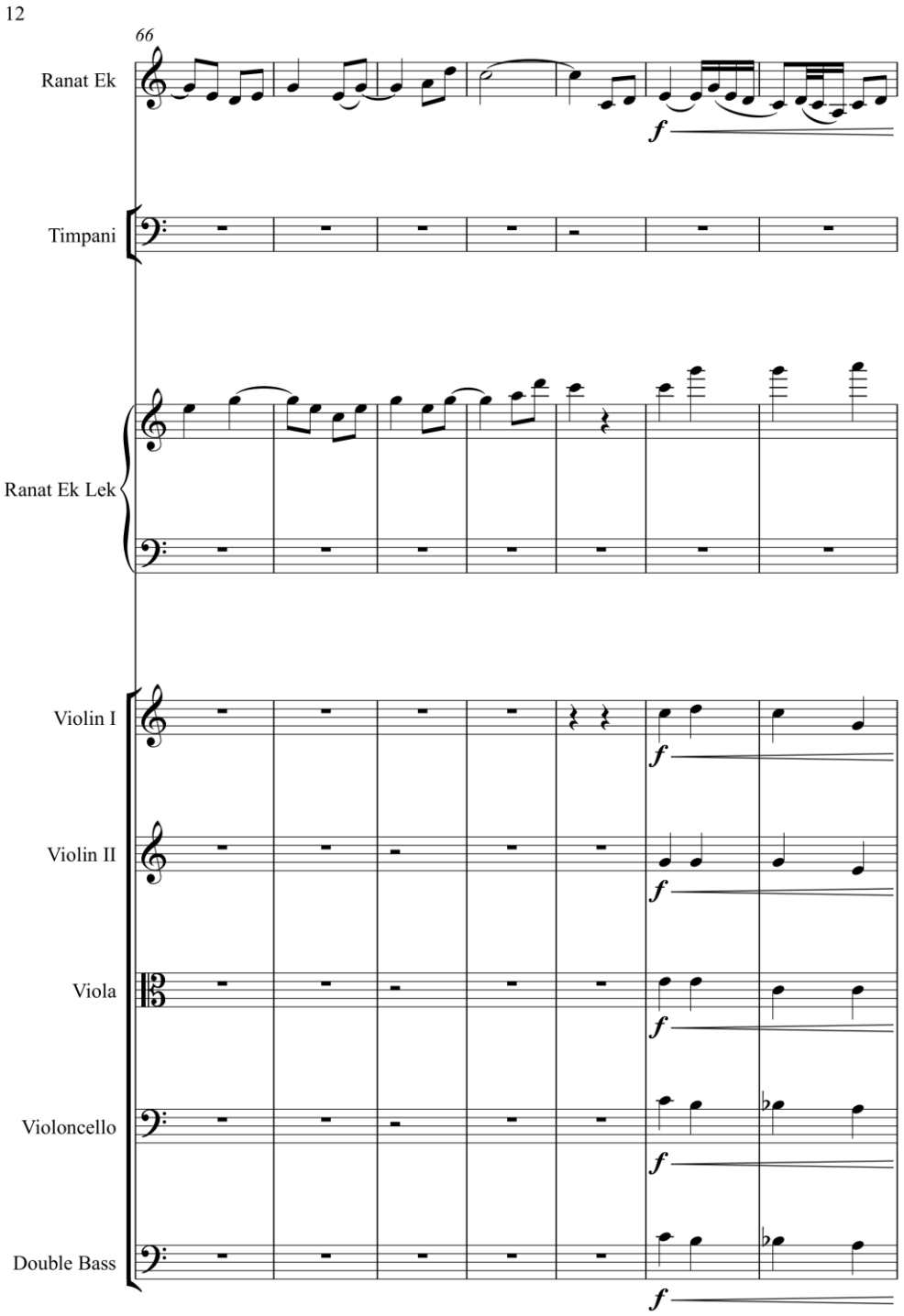
p
Timpani
Ranat Ek Lek
Violin I
Violin II
Viola
Violoncello
arco
Double Bass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Double Bass
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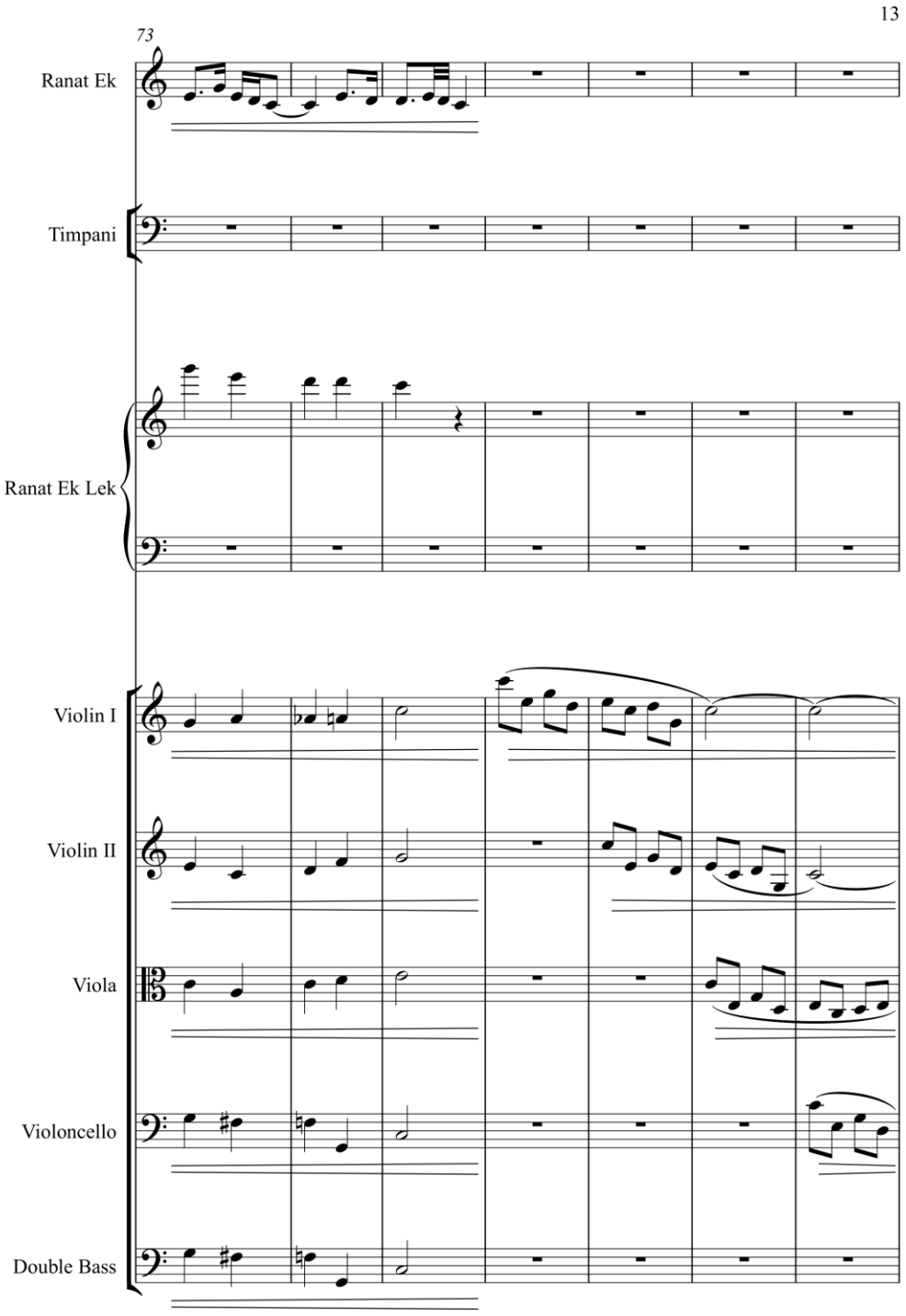
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Ranat Ek Lek
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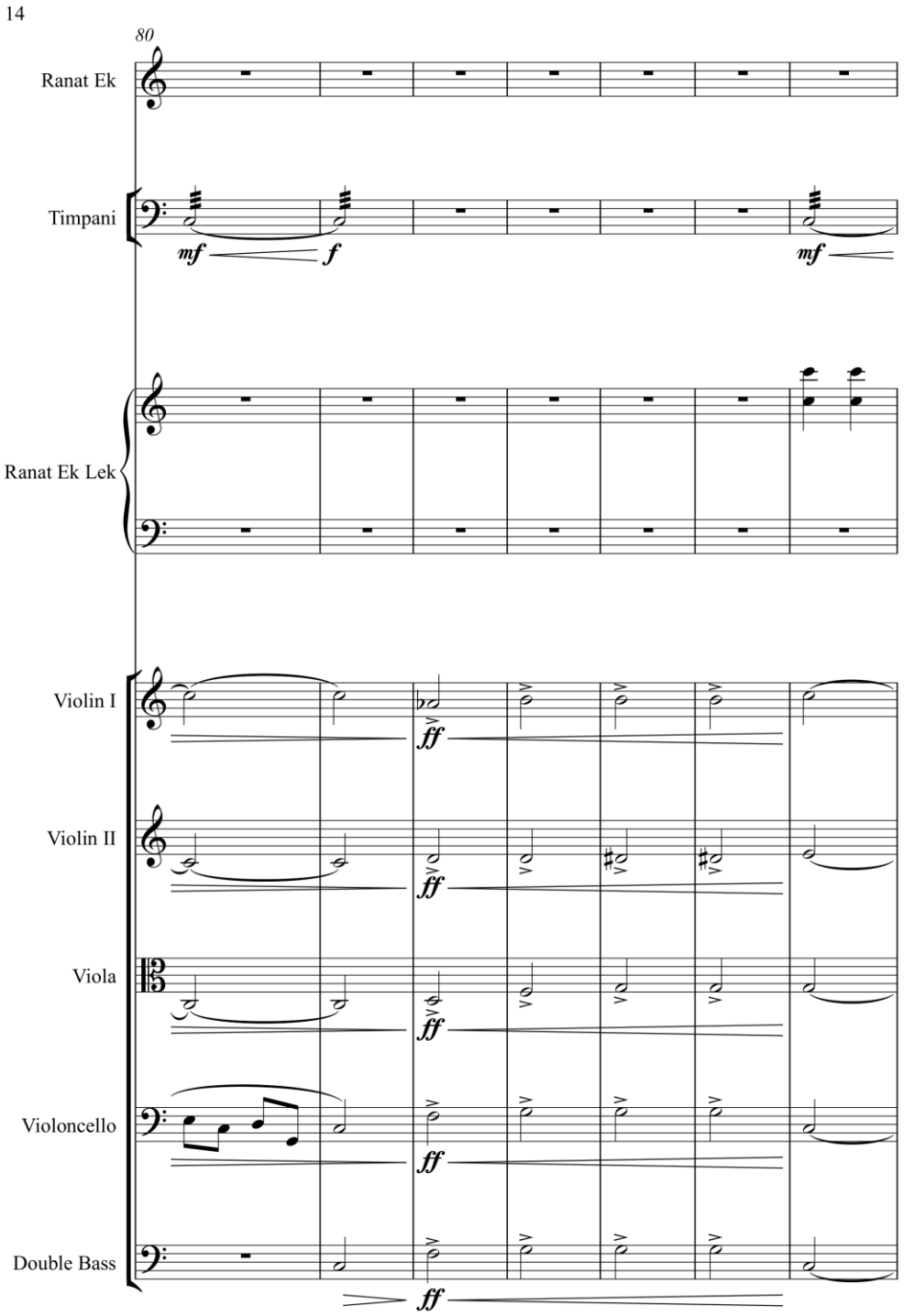
Viola
Violoncello
Double Bass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80
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Timpani
mf
f
mf
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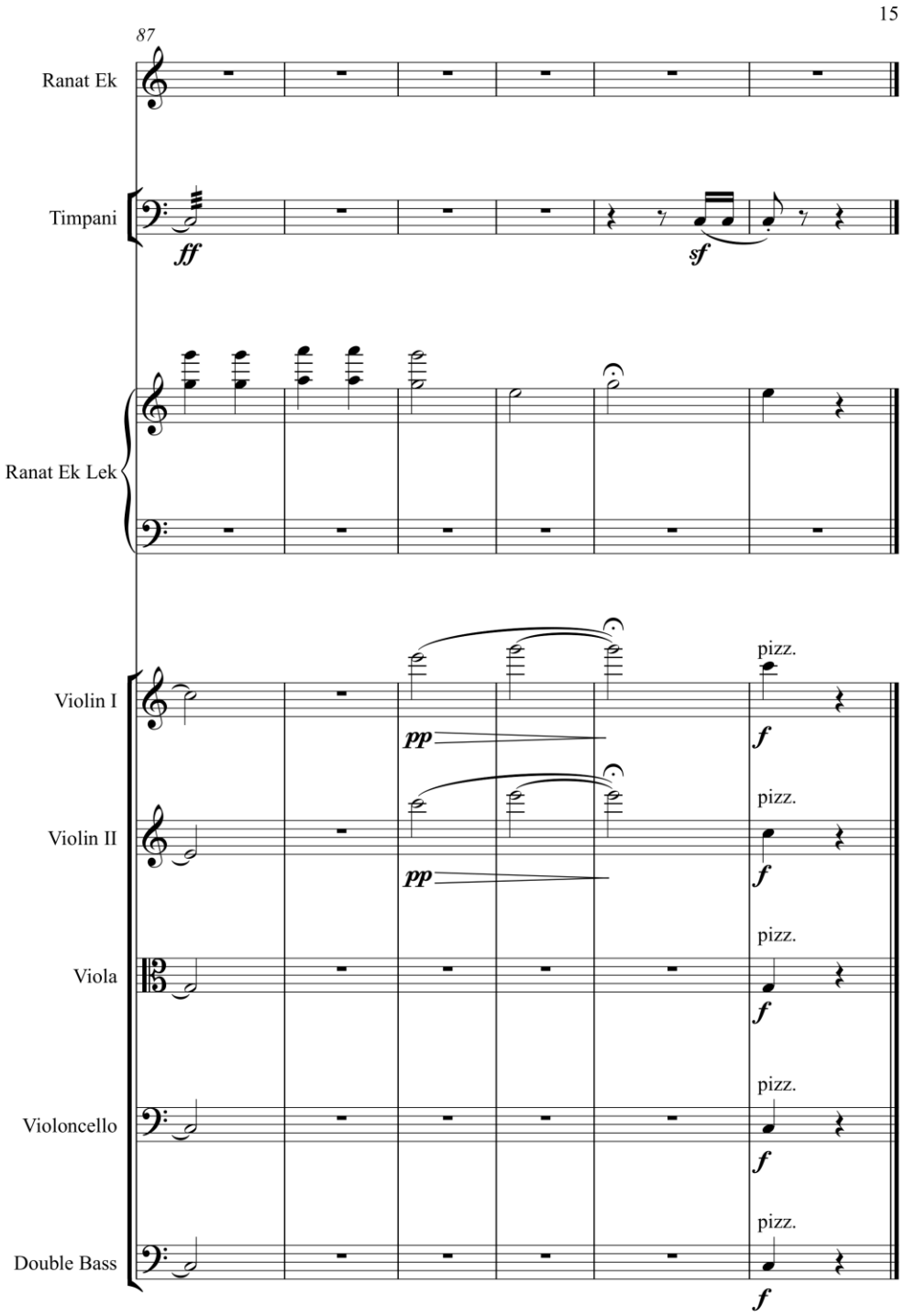
Viola
ff
Violoncello
ff
Double Bass
ff


15
87
Ranat Ek
Timpani
ff
sf
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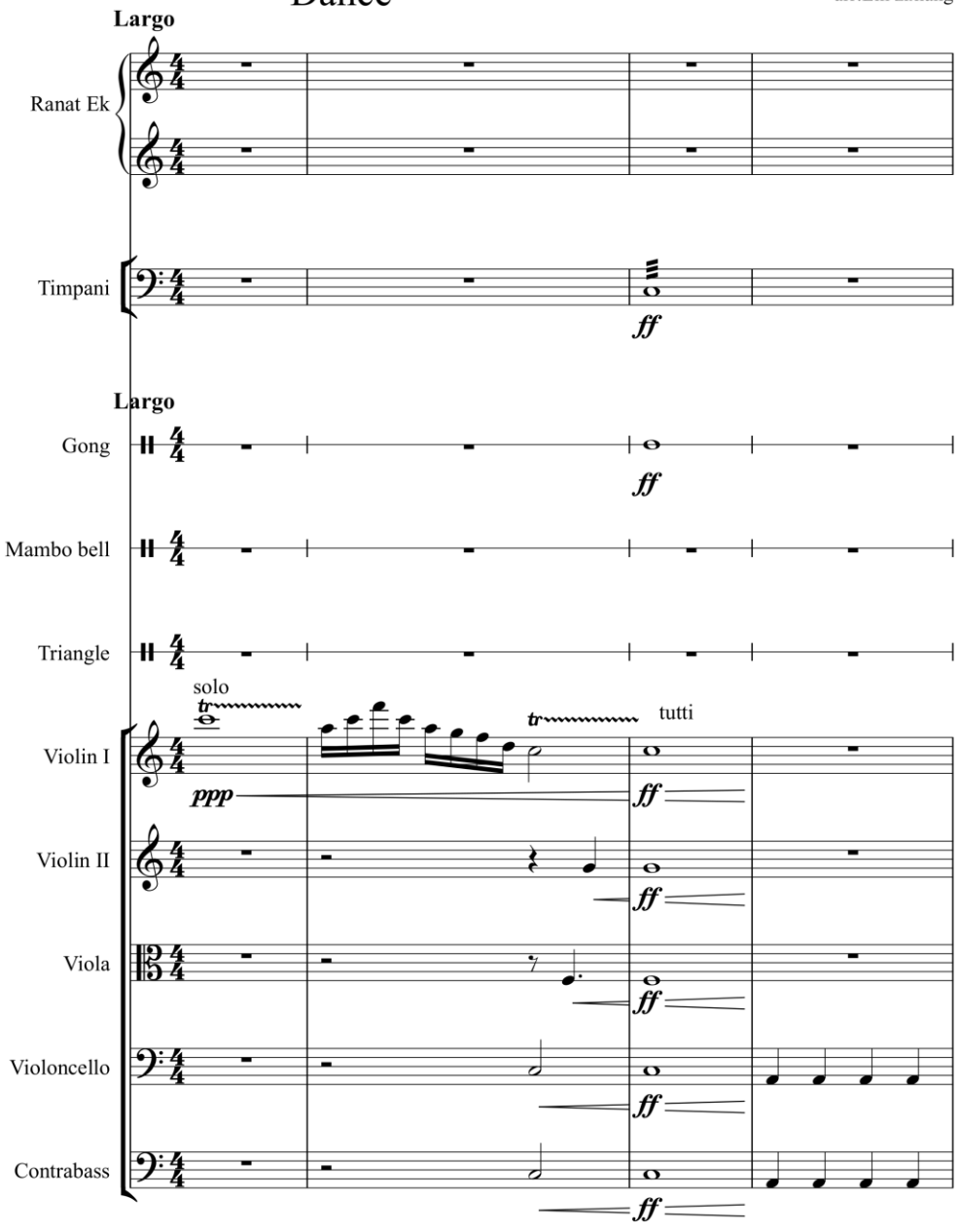
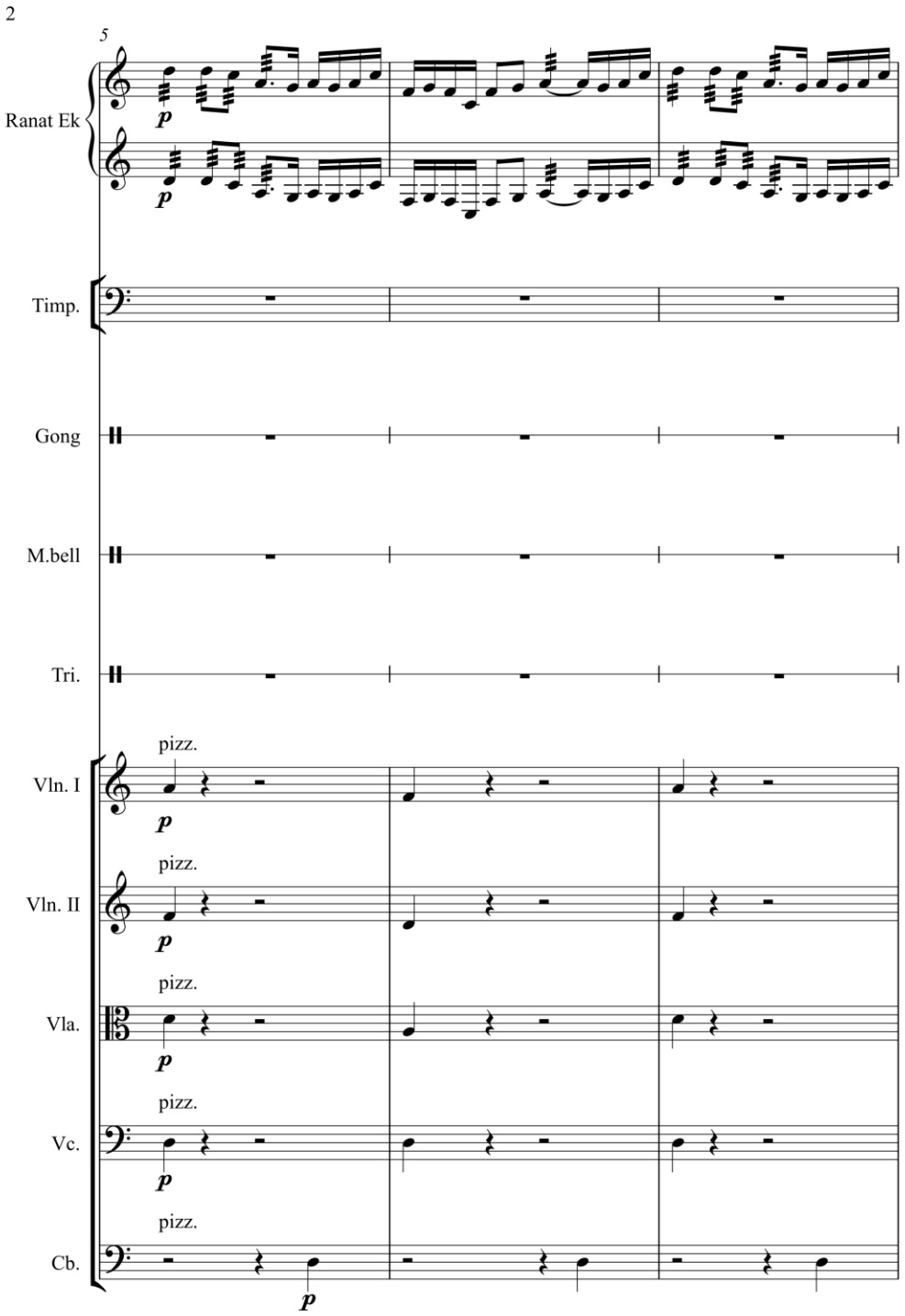
Violin I
Violin II
Viola
Violoncello
Double Bass
pp
pizz.
f

Ranat Ek Concerto
Second Movement
ระบำสุโขทัย Sukhothai Dance

Thai traditional music
arr:Lin zixiang




2
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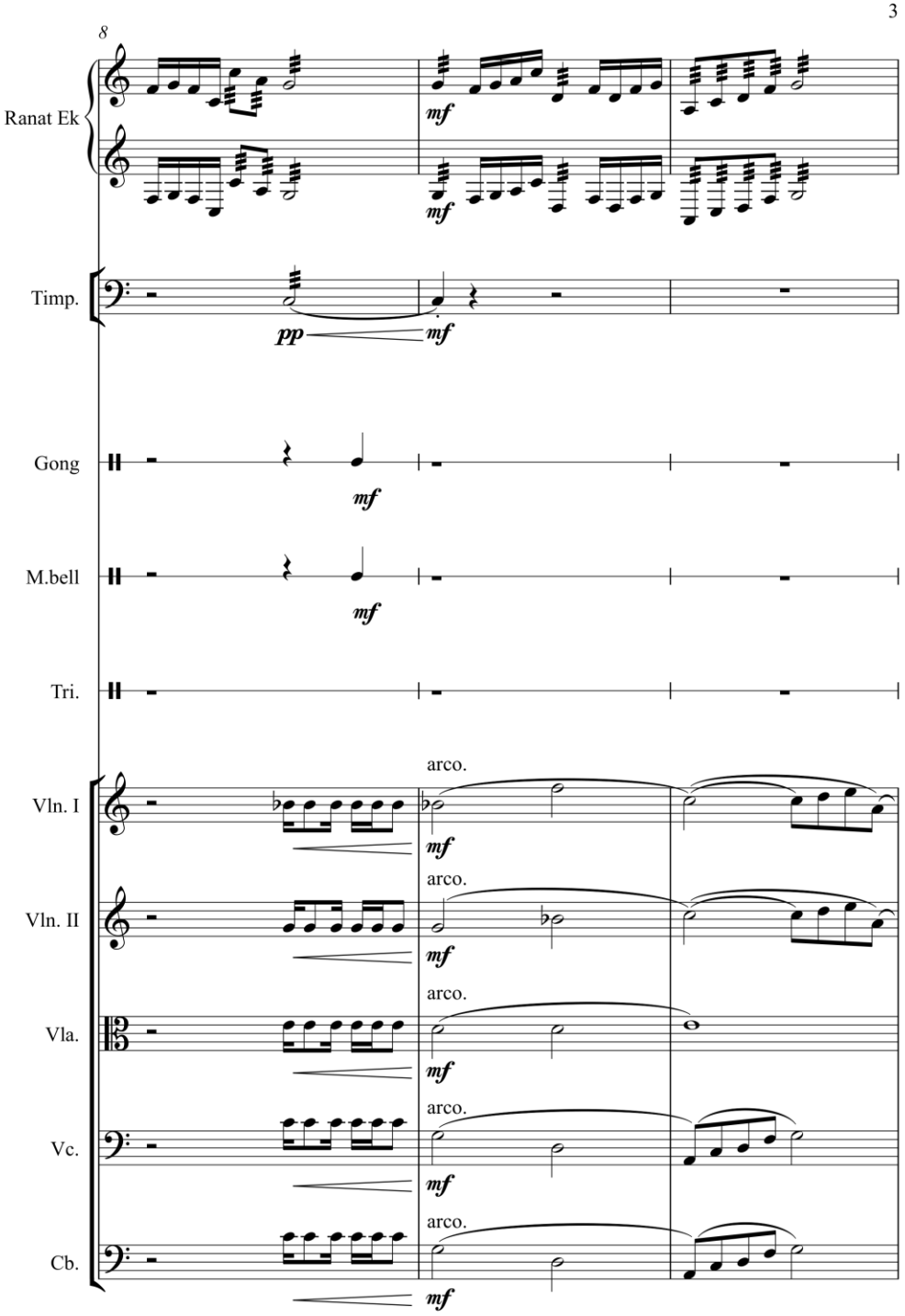
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
pizz.
p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8
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mf
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Timp.
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M.bell
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Tri.
Vln. I
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Vln. II
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arco.
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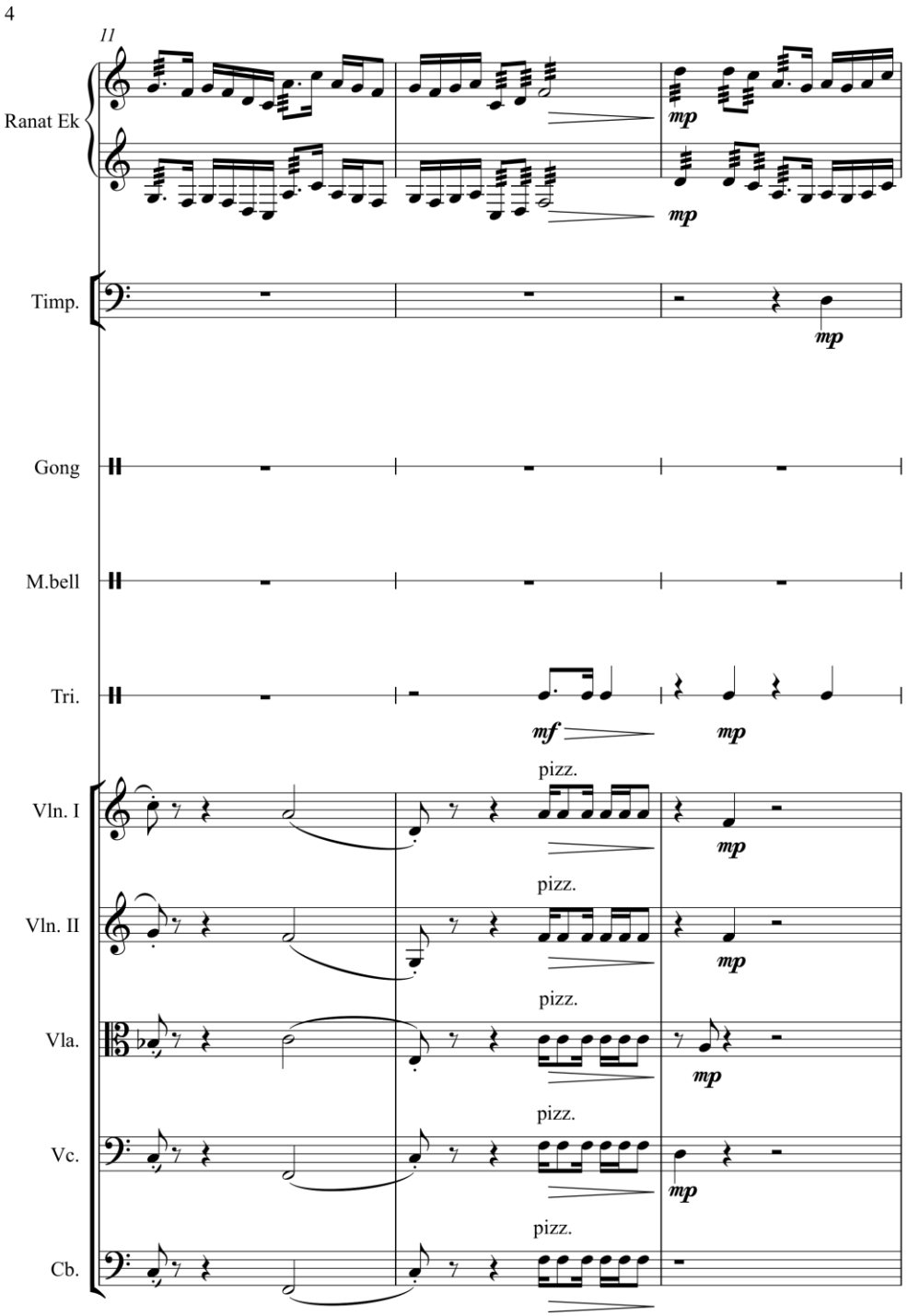
Cb.
arco.
mf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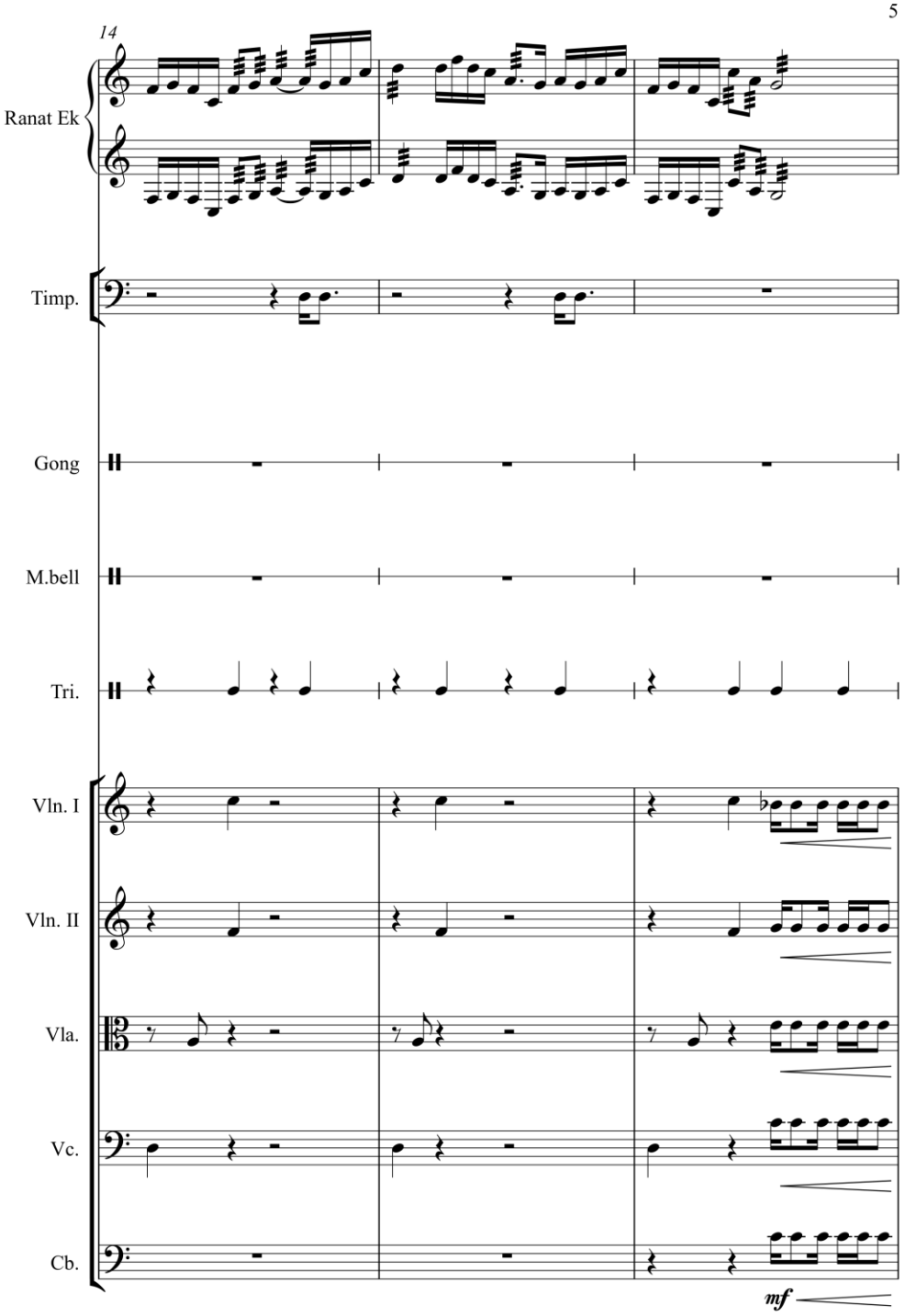
pizz.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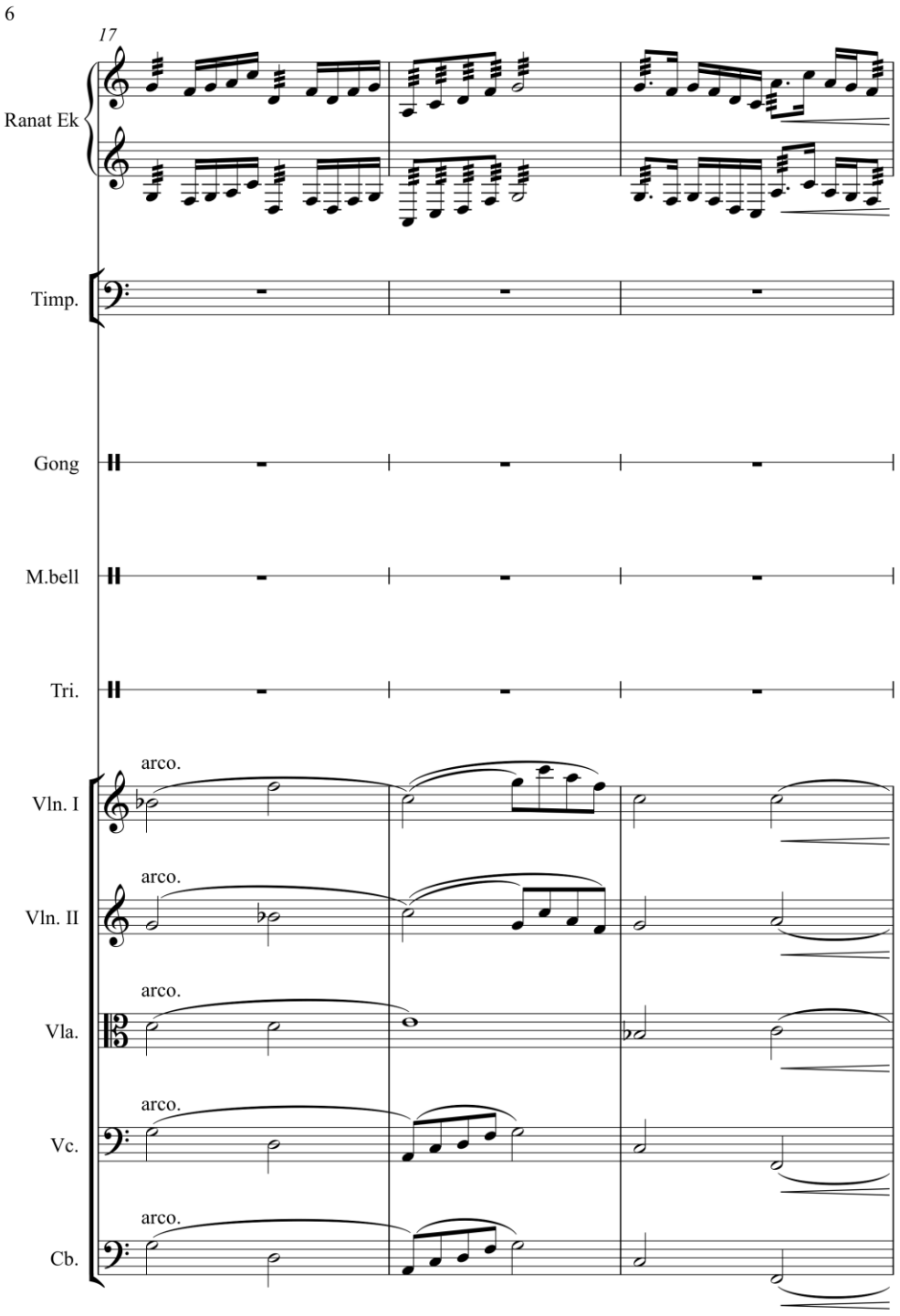
6
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Gong
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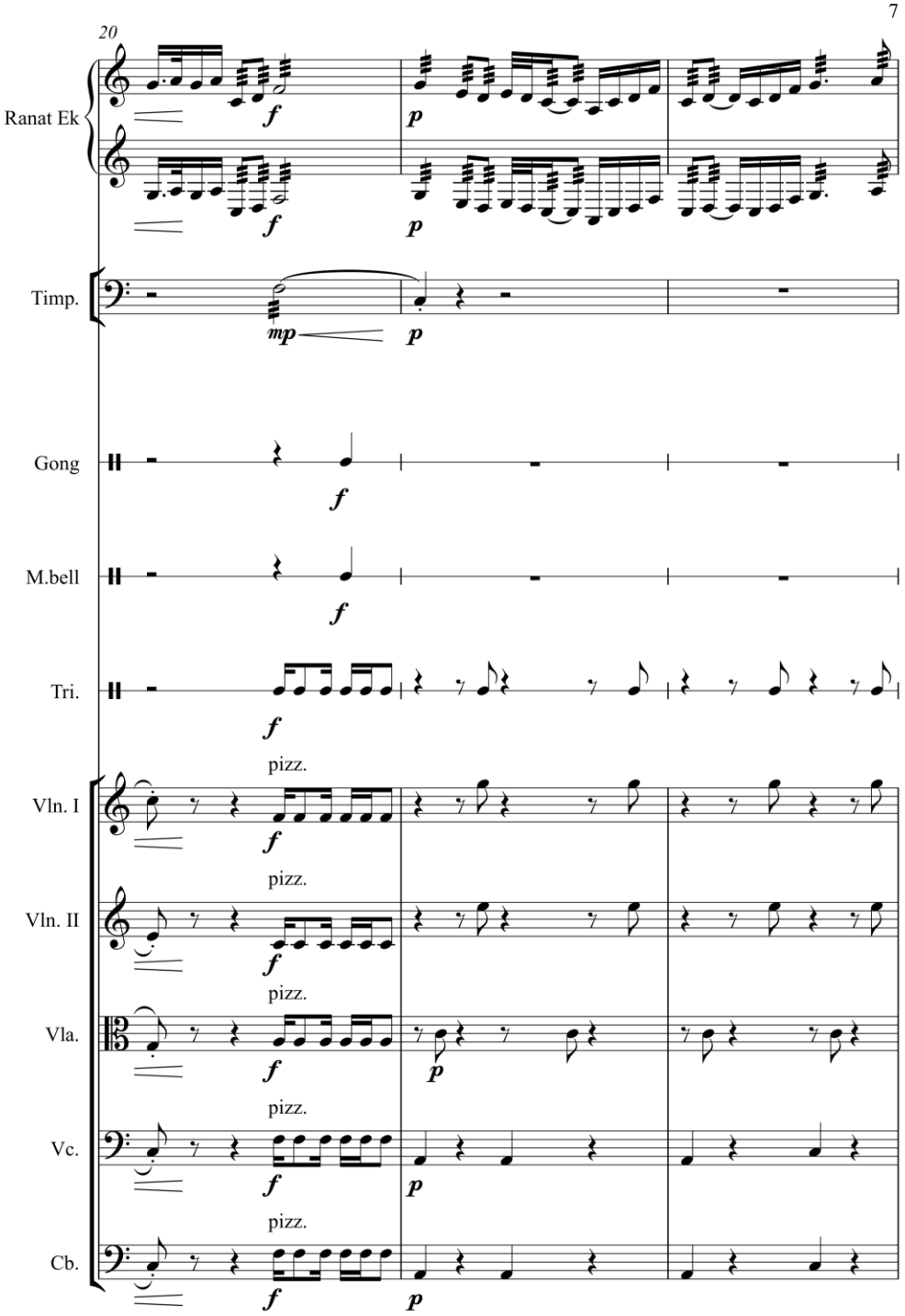
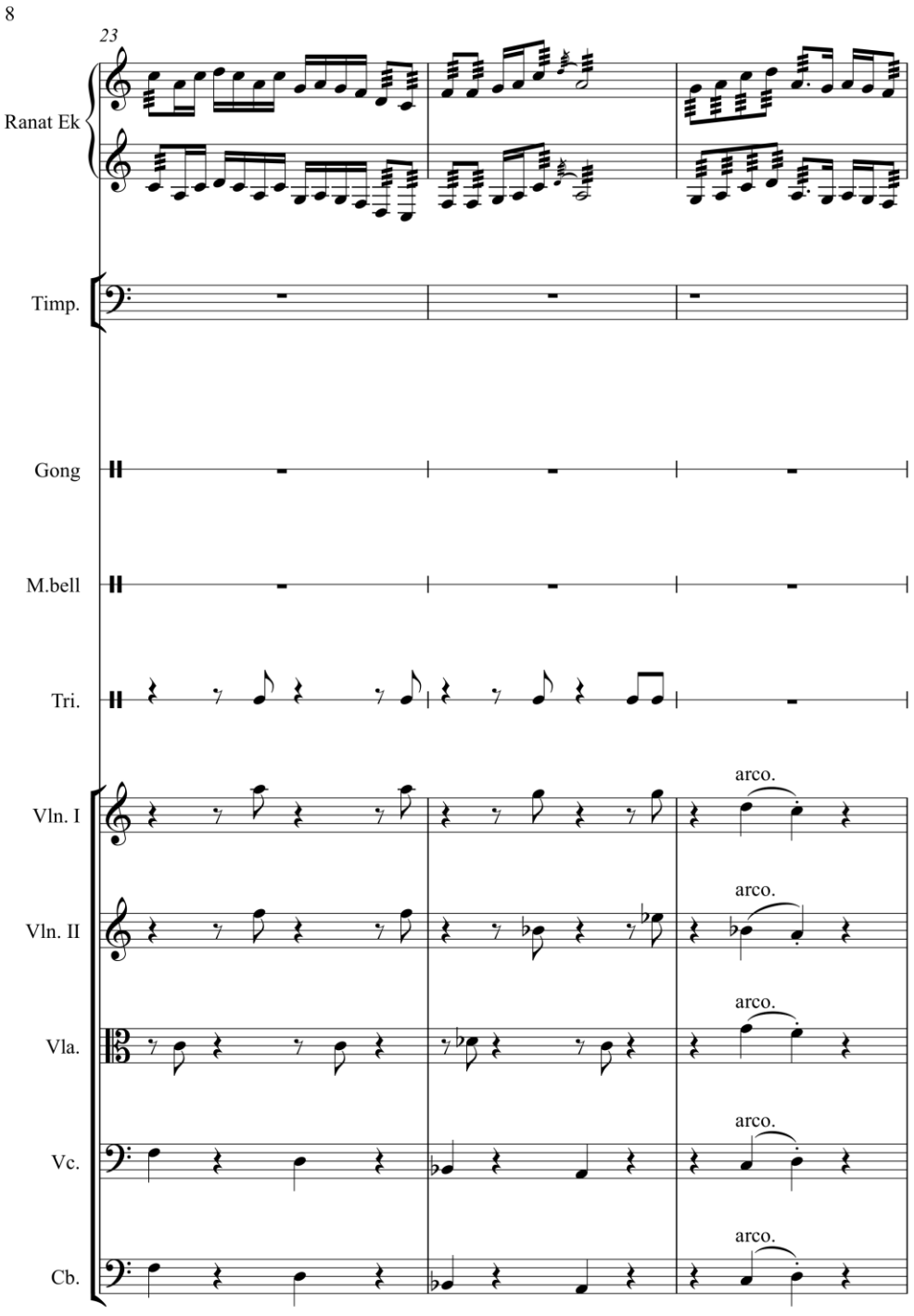
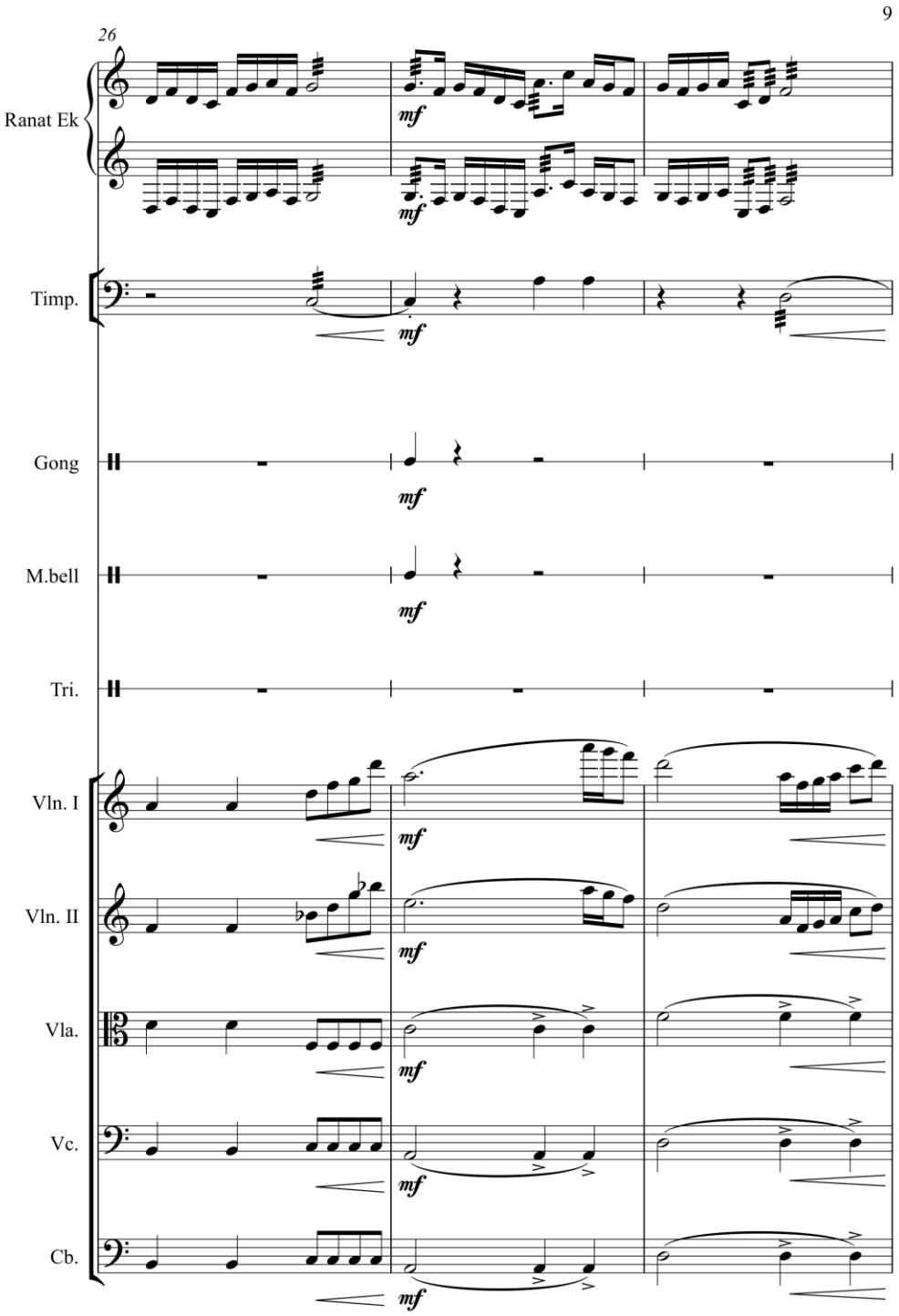
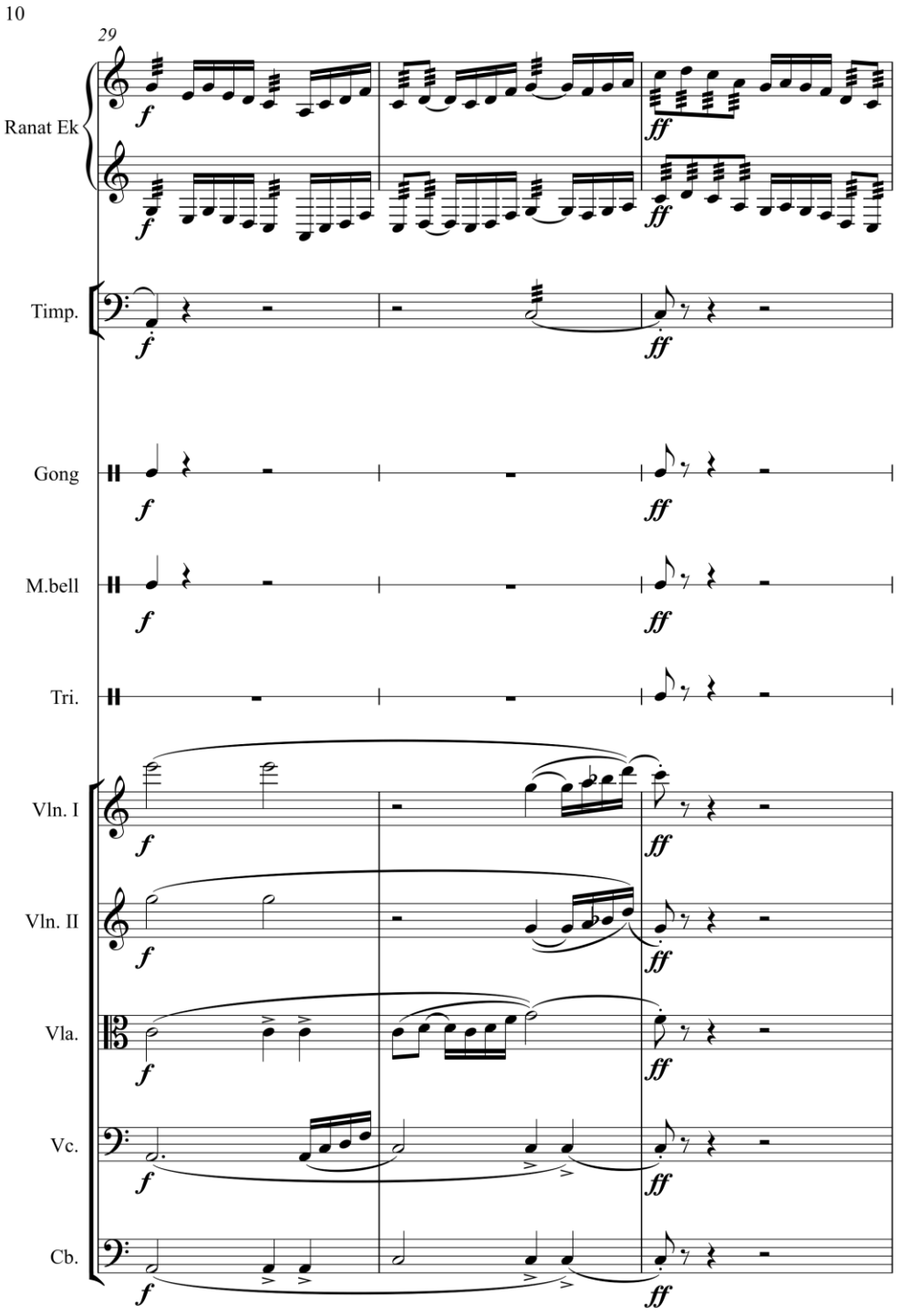
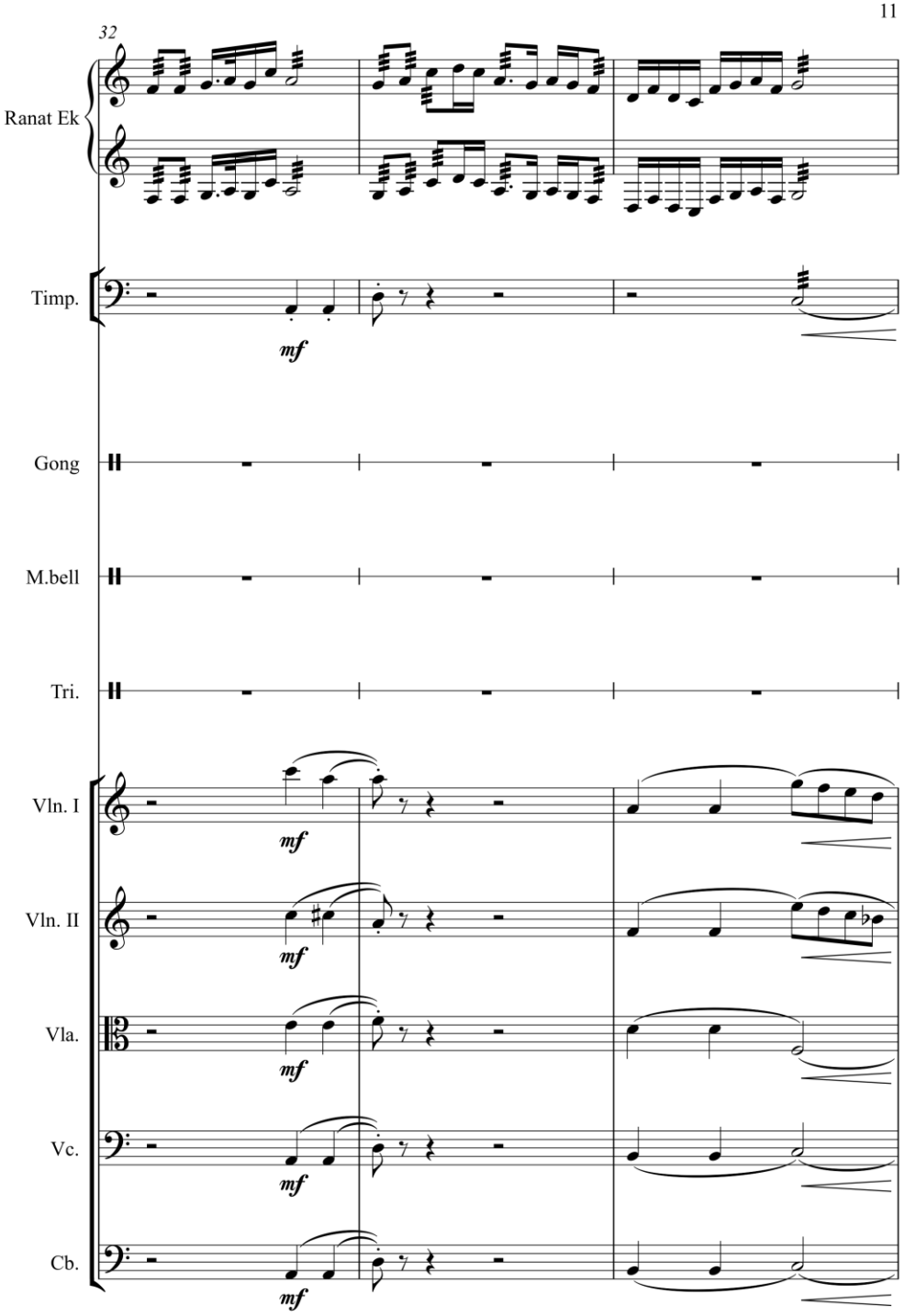
Tri.
arco.
Vln. I
arco.
Vln. II
arco.
Vla.
arco.
Vc.
arco.
Cb.

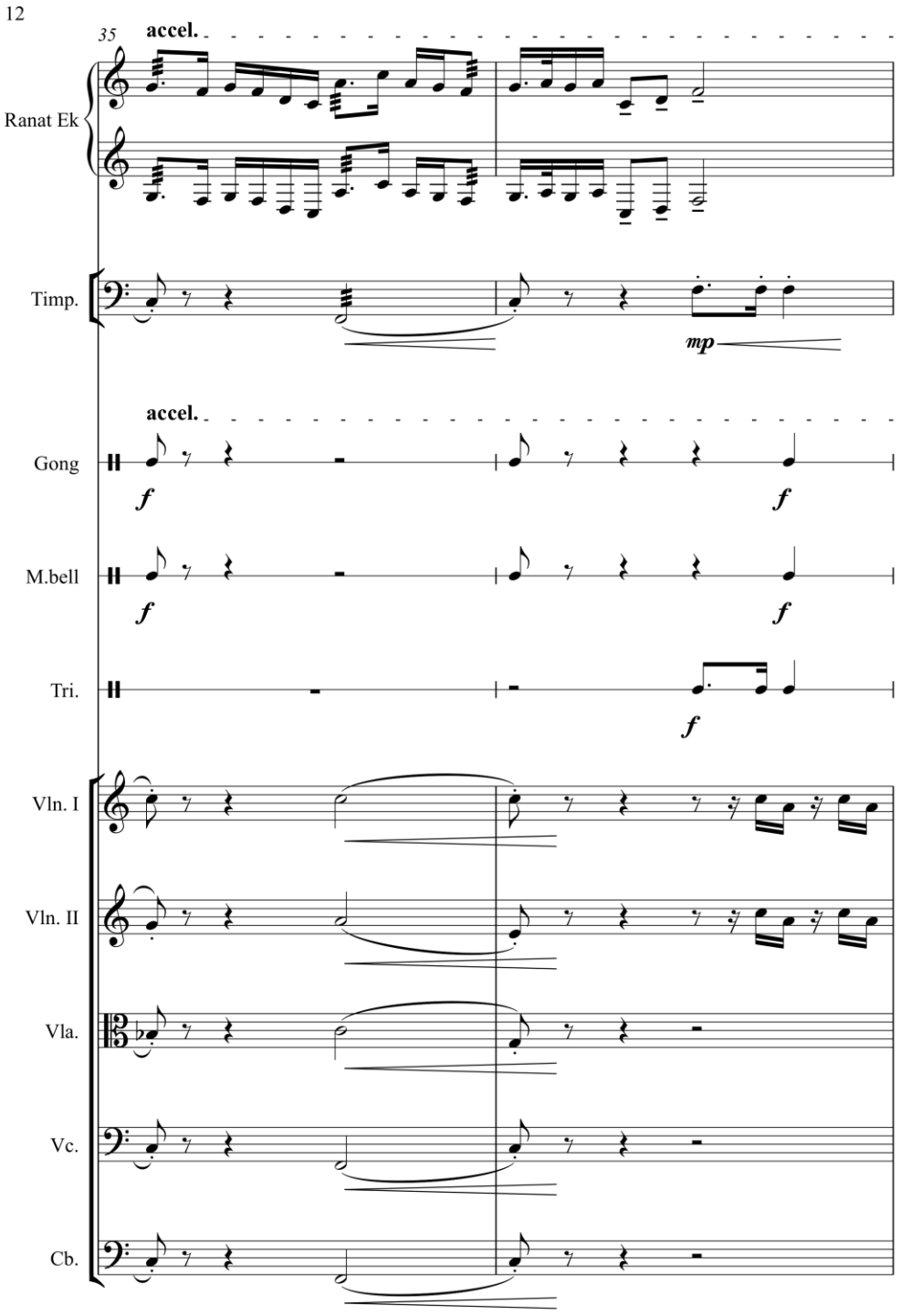

7
20
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
pizz.

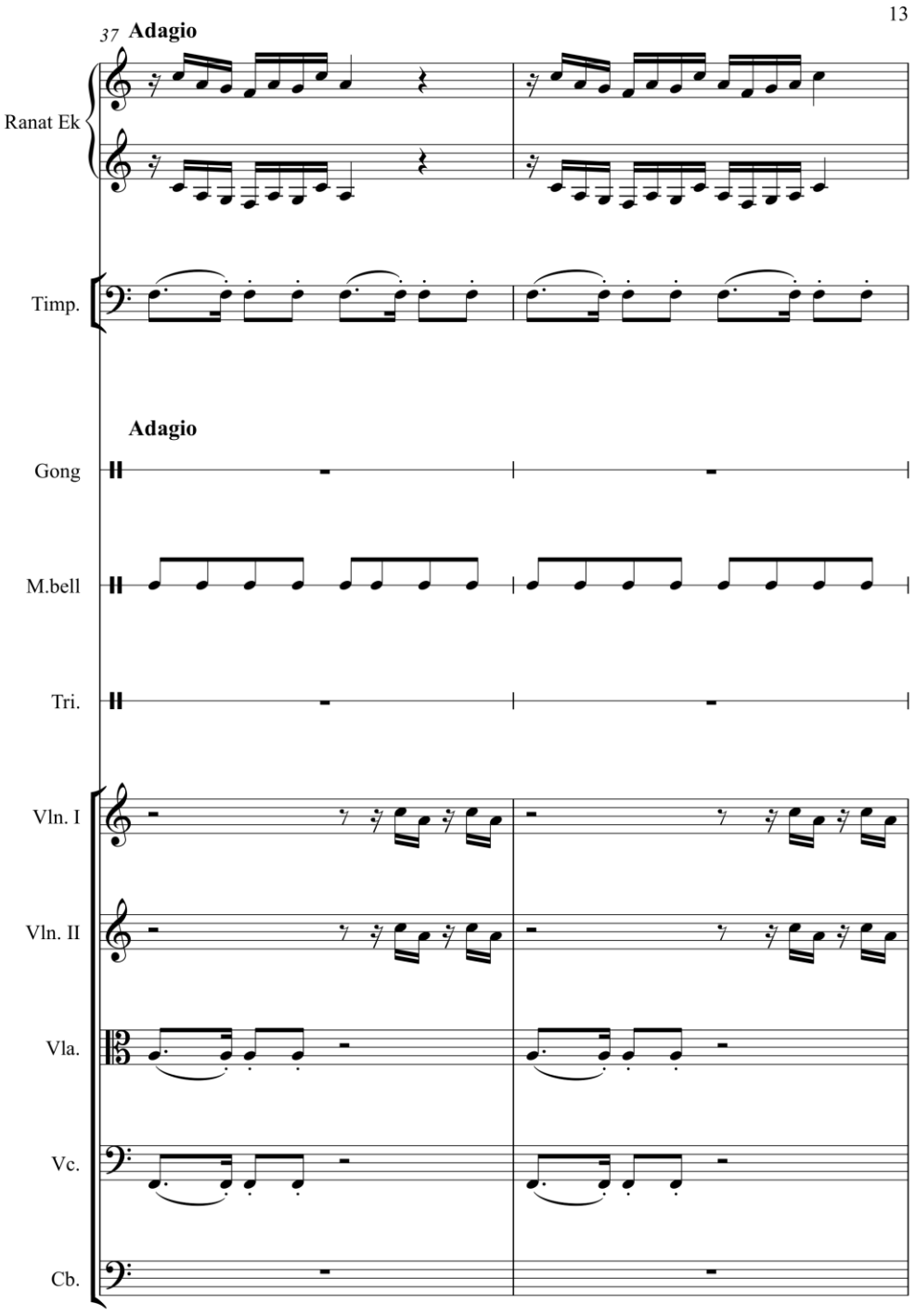

8
23
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco.
arco.
arco.
arco.
arco.

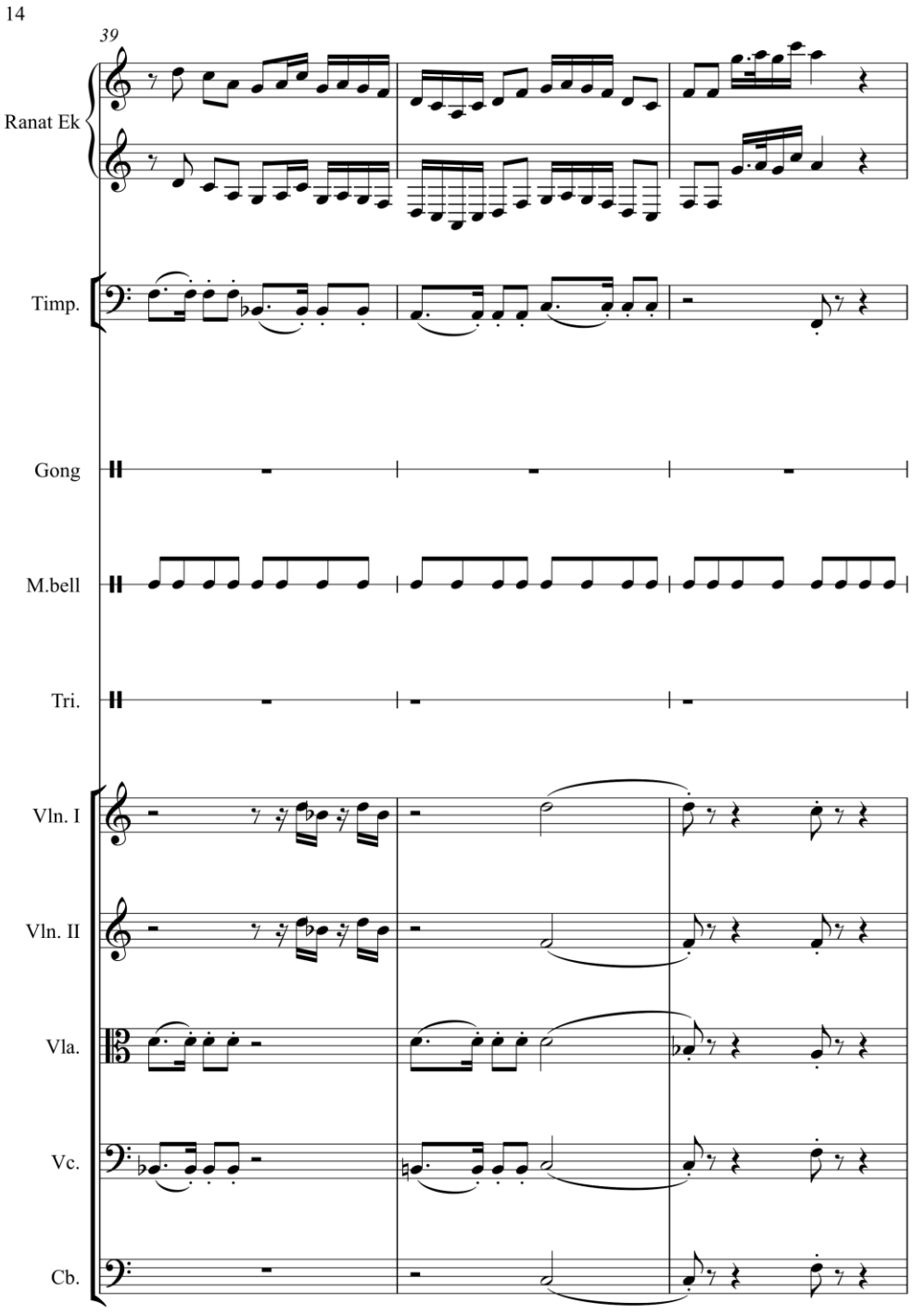

9
26
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
mf

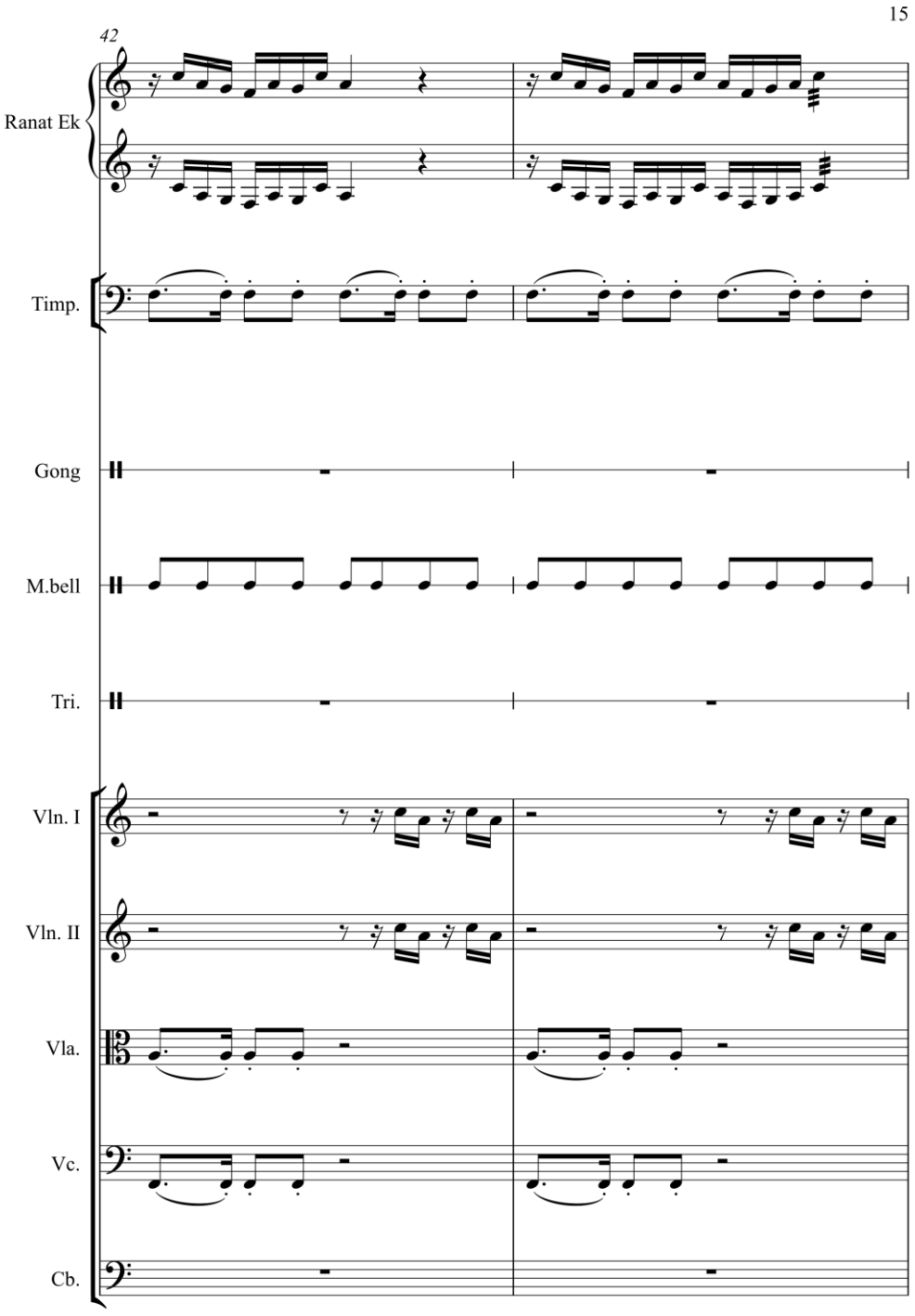

10
29
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
f
ff

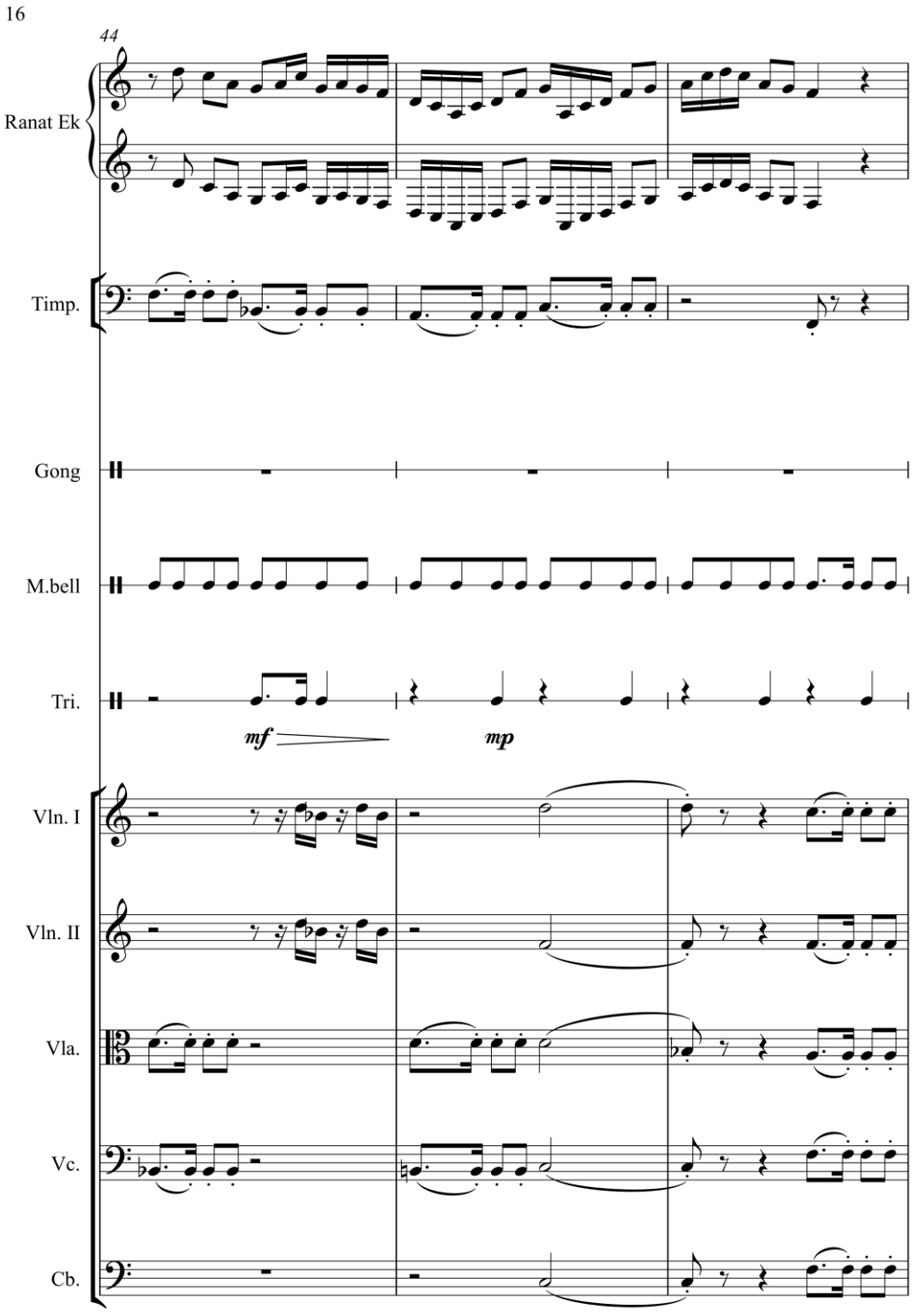

11
32
Ranat Ek
Timp.
mf
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

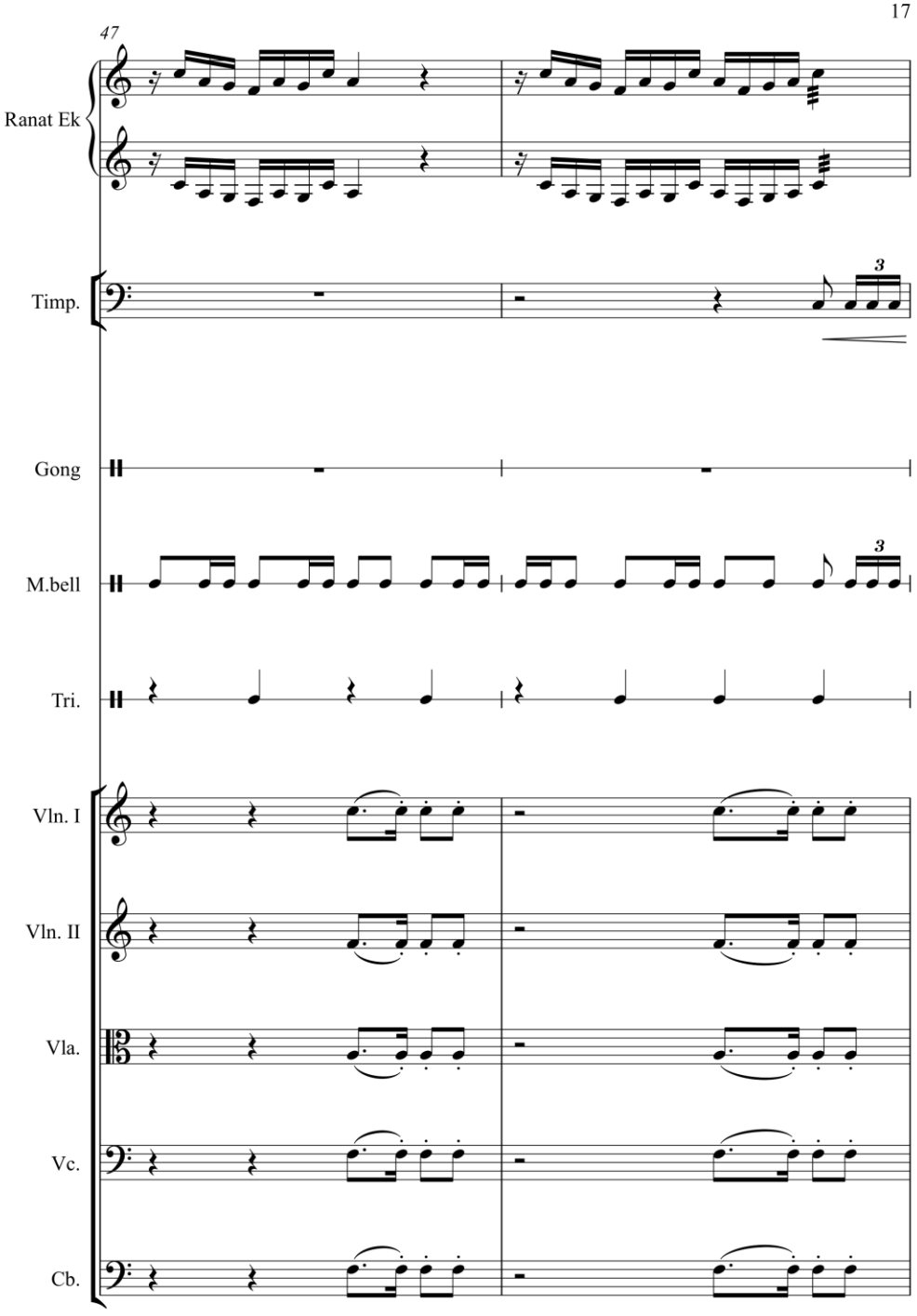

12
35
accel.
Ranat Ek
Timp.
mp
accel.
Gong
f
f
M.bell
f
f
Tri.
f
Vln. I
Vln. II
Vla.
Vc.
Cb.

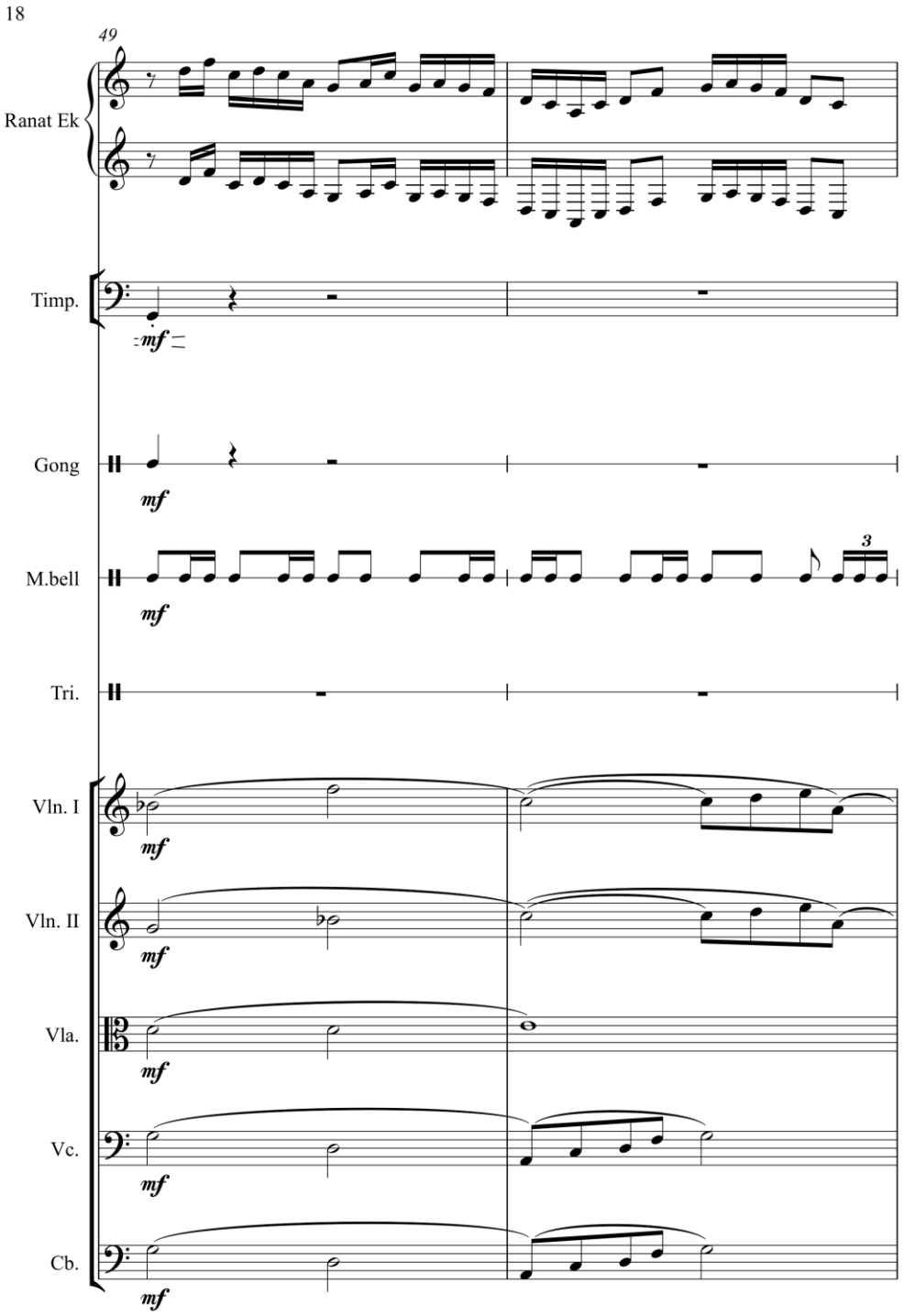

13
37 Adagio
Ranat Ek
Timp.
Adagio
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

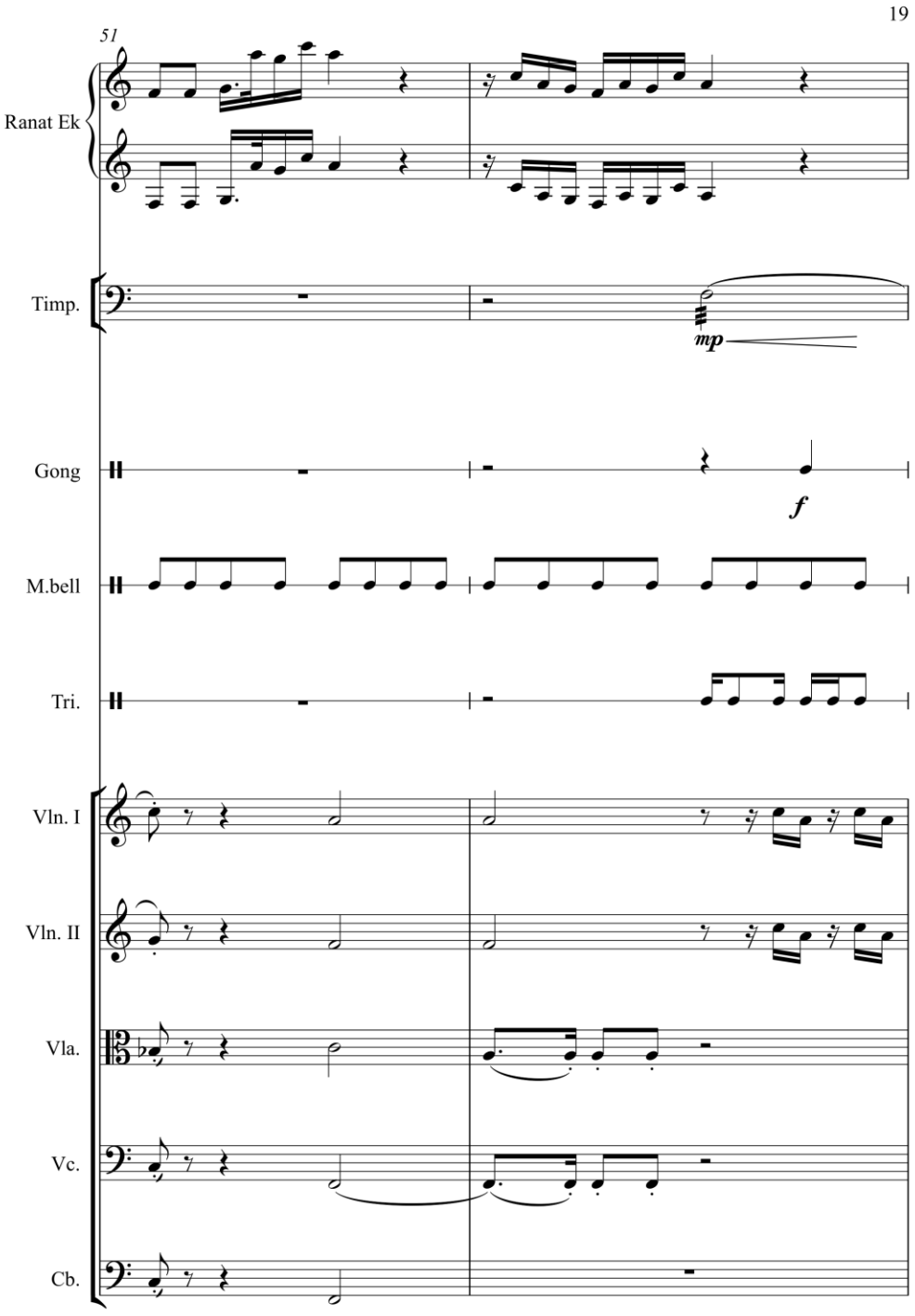

14
39
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

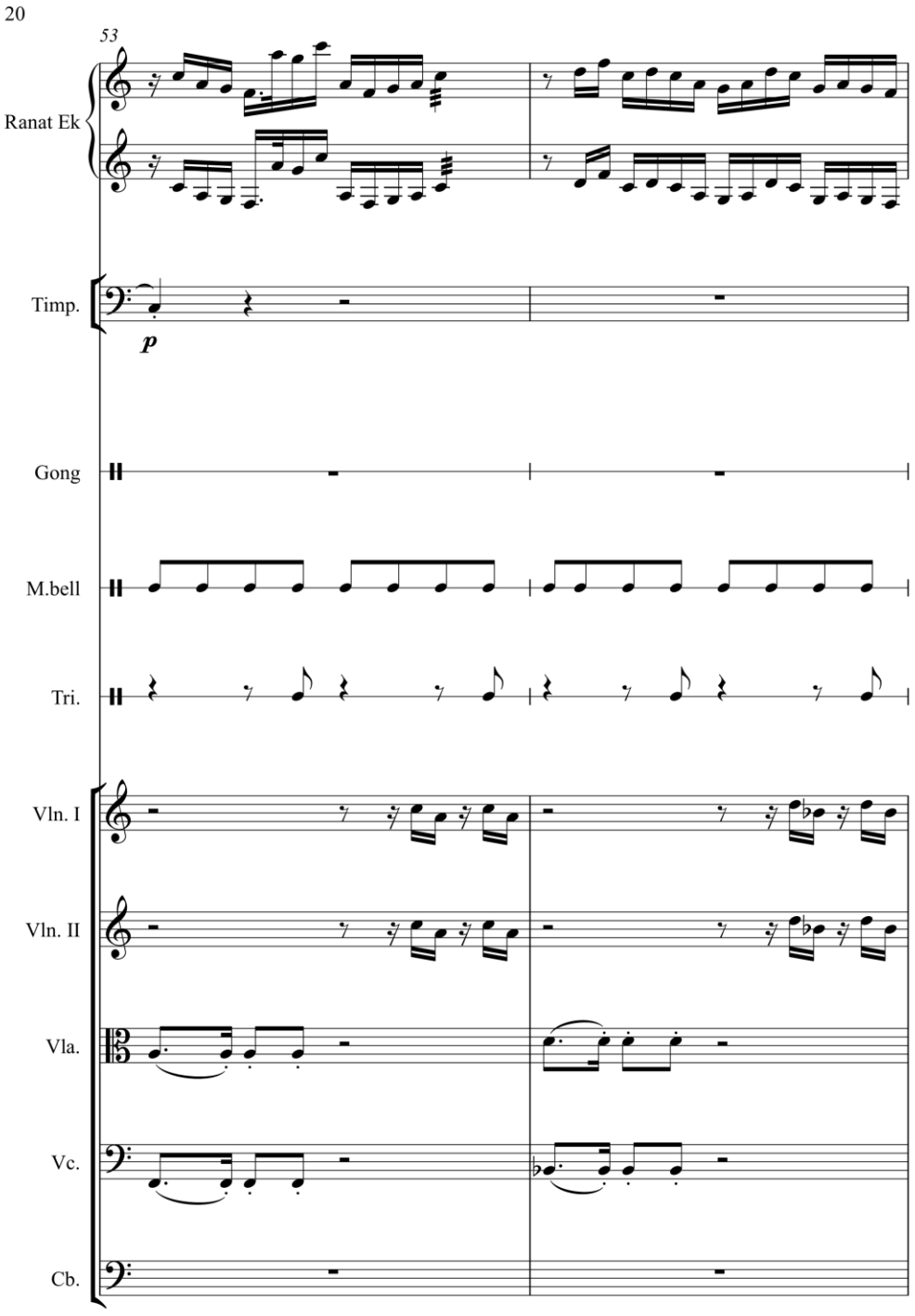

15
42
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

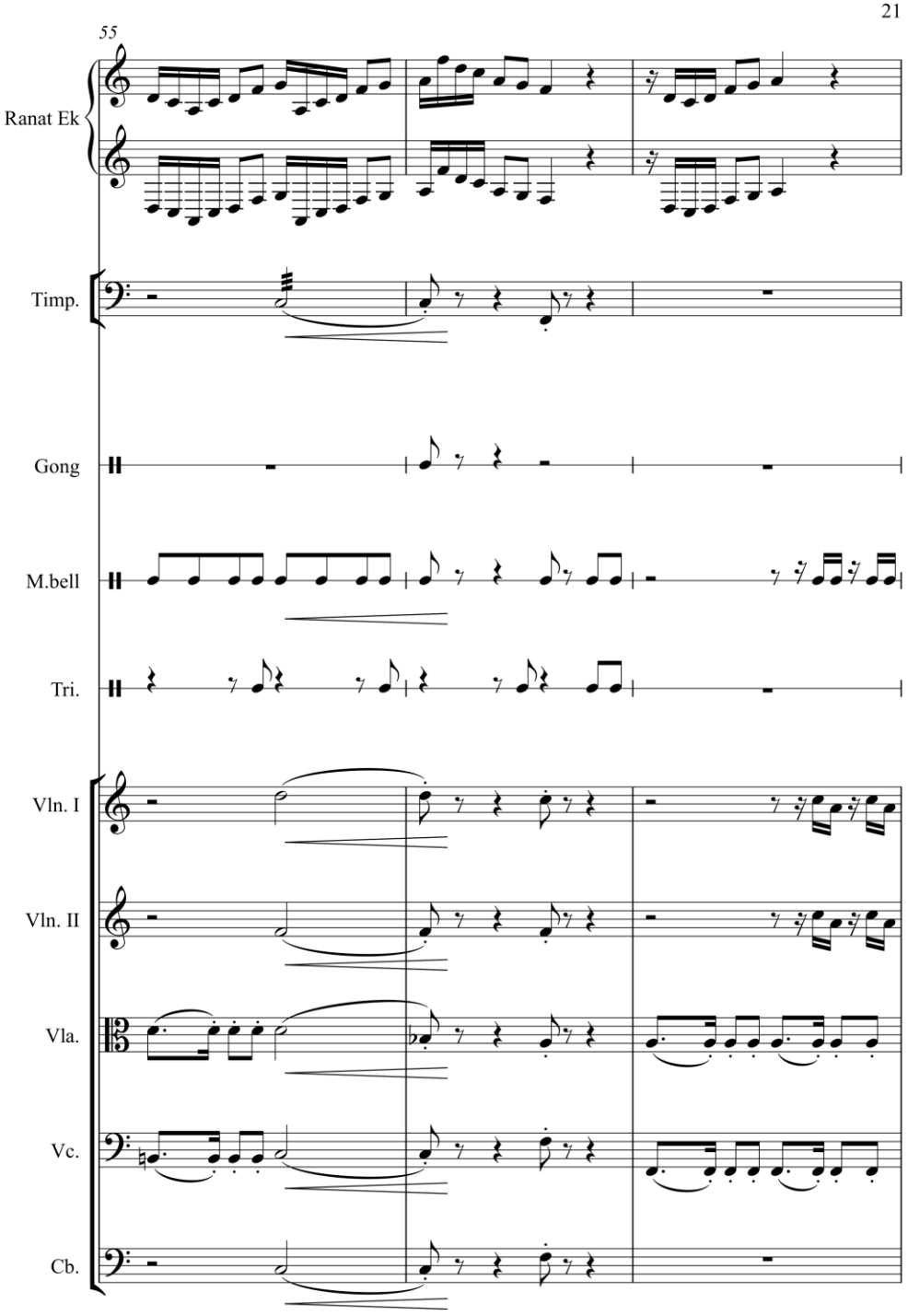

16
44
Ranat Ek
Timp.
Gong
M.bell
Tri.
mf
mp
Vln. I
Vln. II
Vla.
Vc.
Cb.

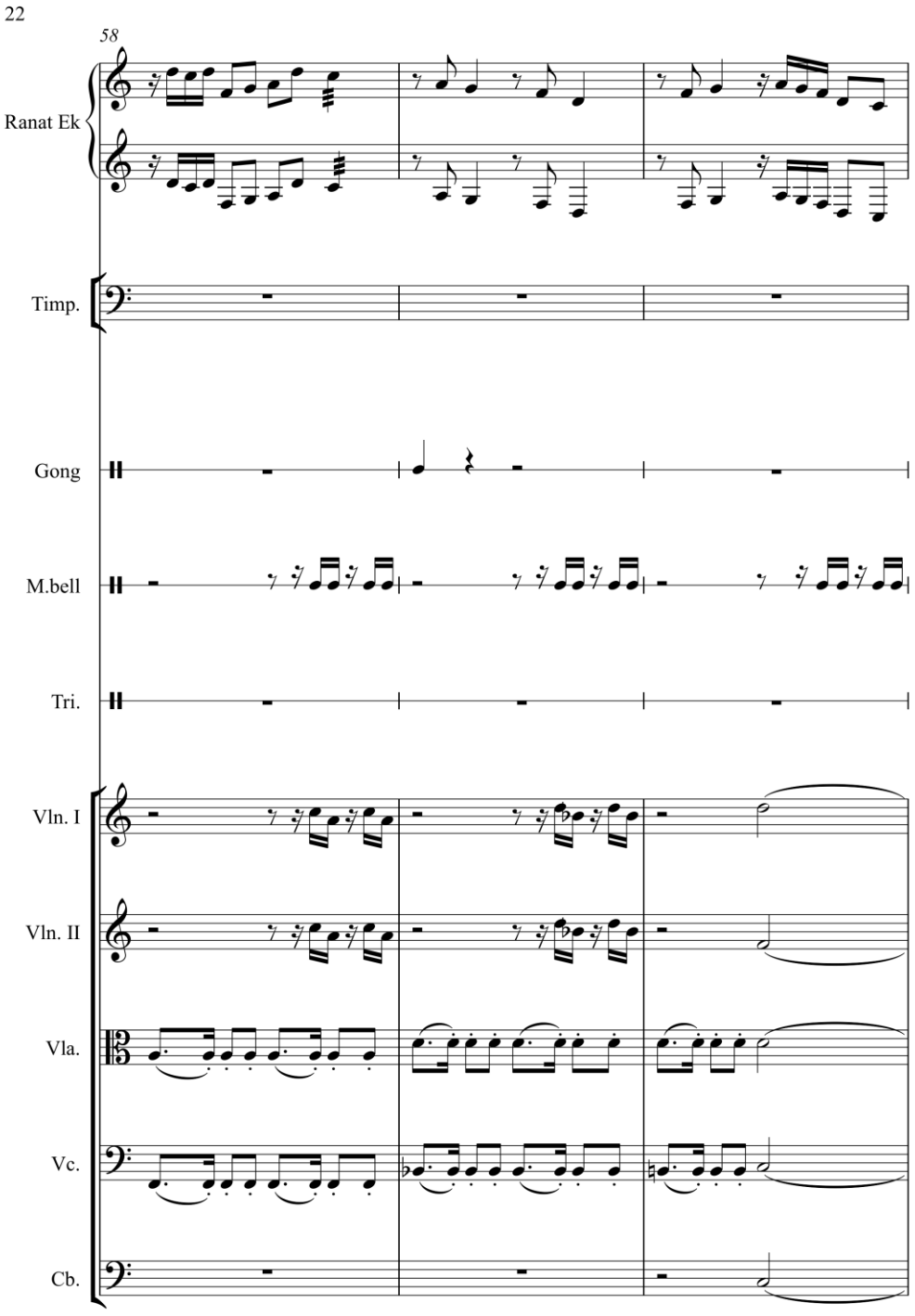

17
47
Ranat Ek
Timp.
3
Gong
M.bell
3
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

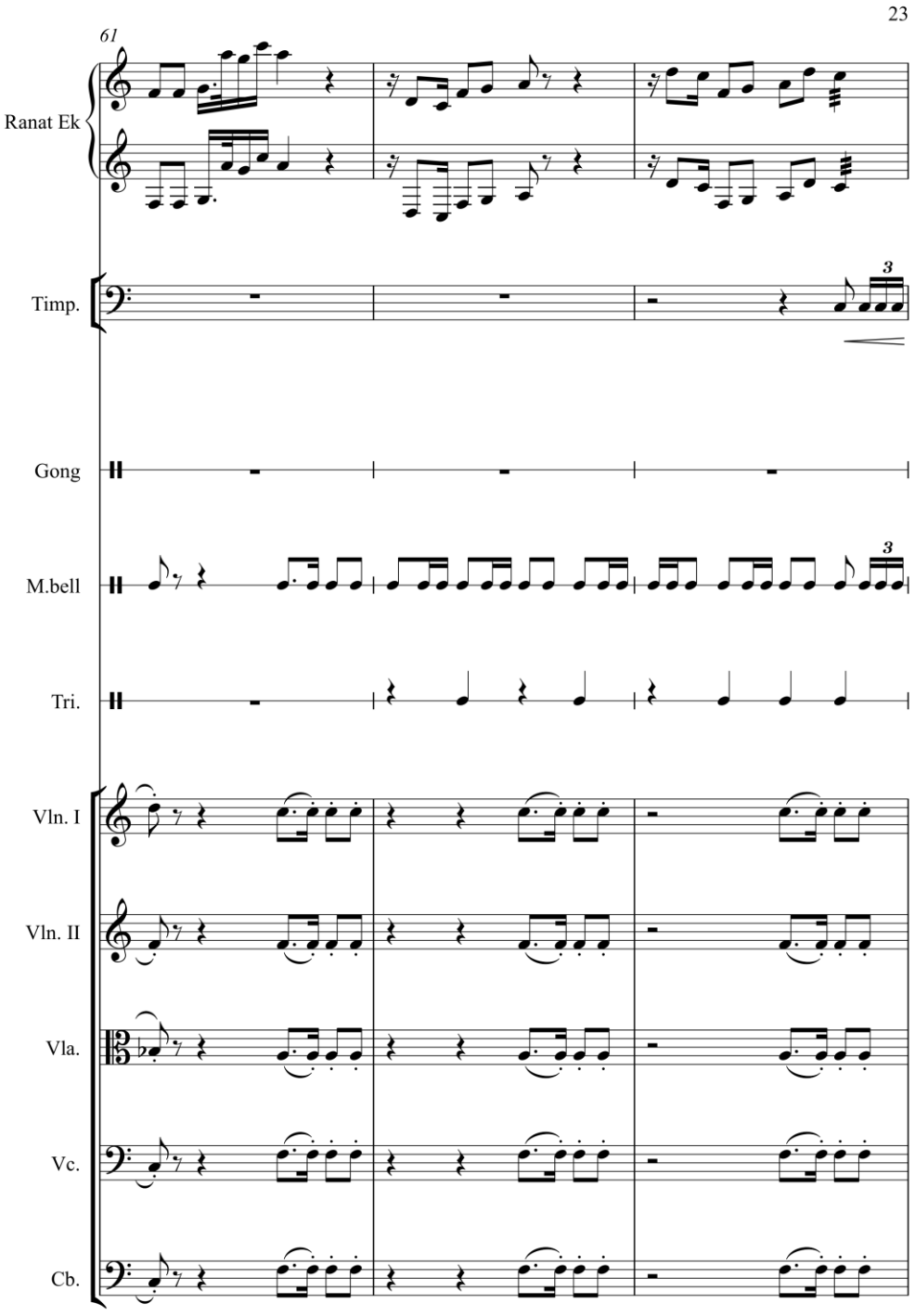

18
49
Ranat Ek
Timp.
mf
Gong
mf
M.bell
mf
3
Tri.
Vln. I
mf
Vln. II
mf
Vla.
mf
Vc.
mf
Cb.
mf

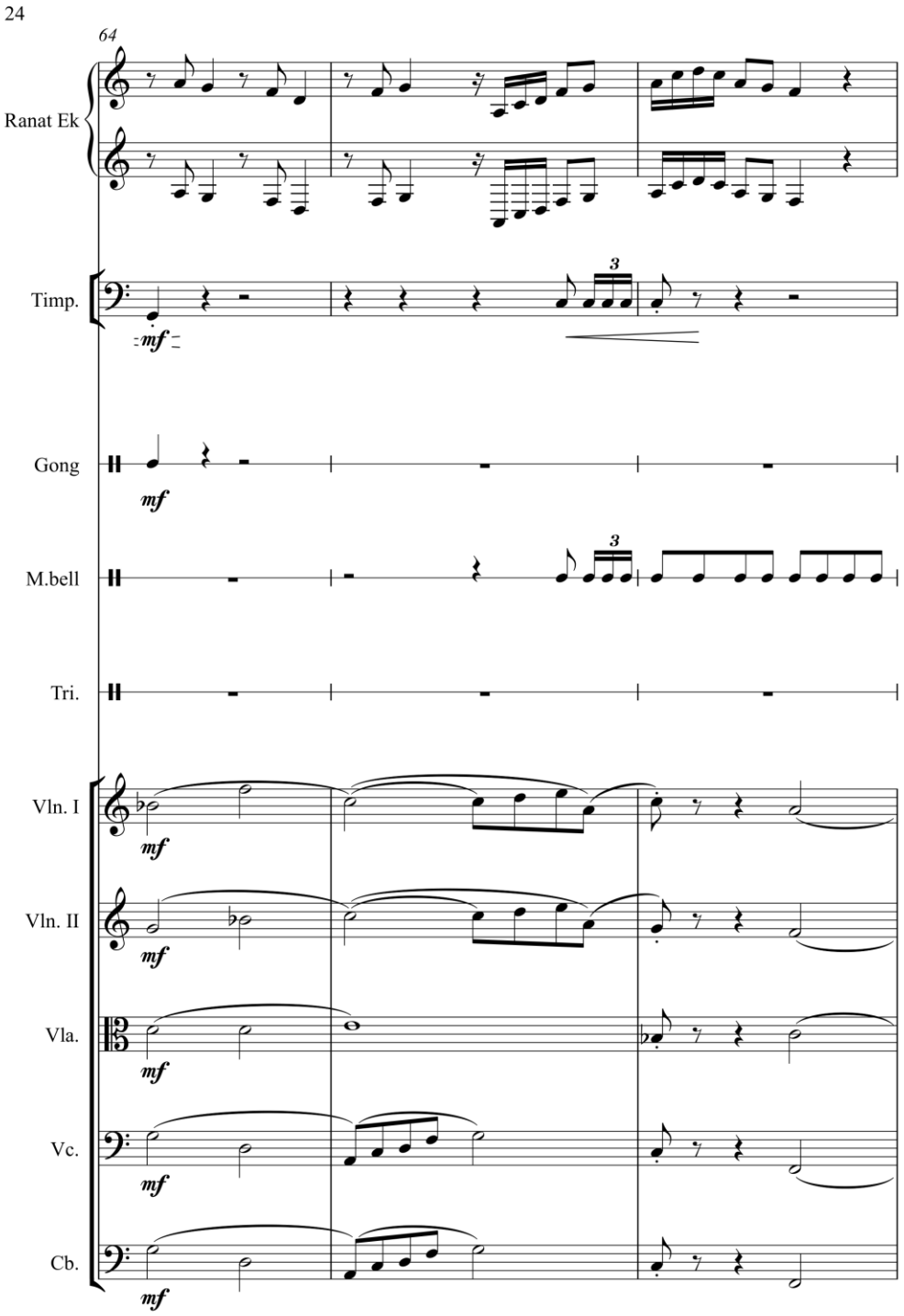

19
51
Ranat Ek
Timp.
mp
Gong
f
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

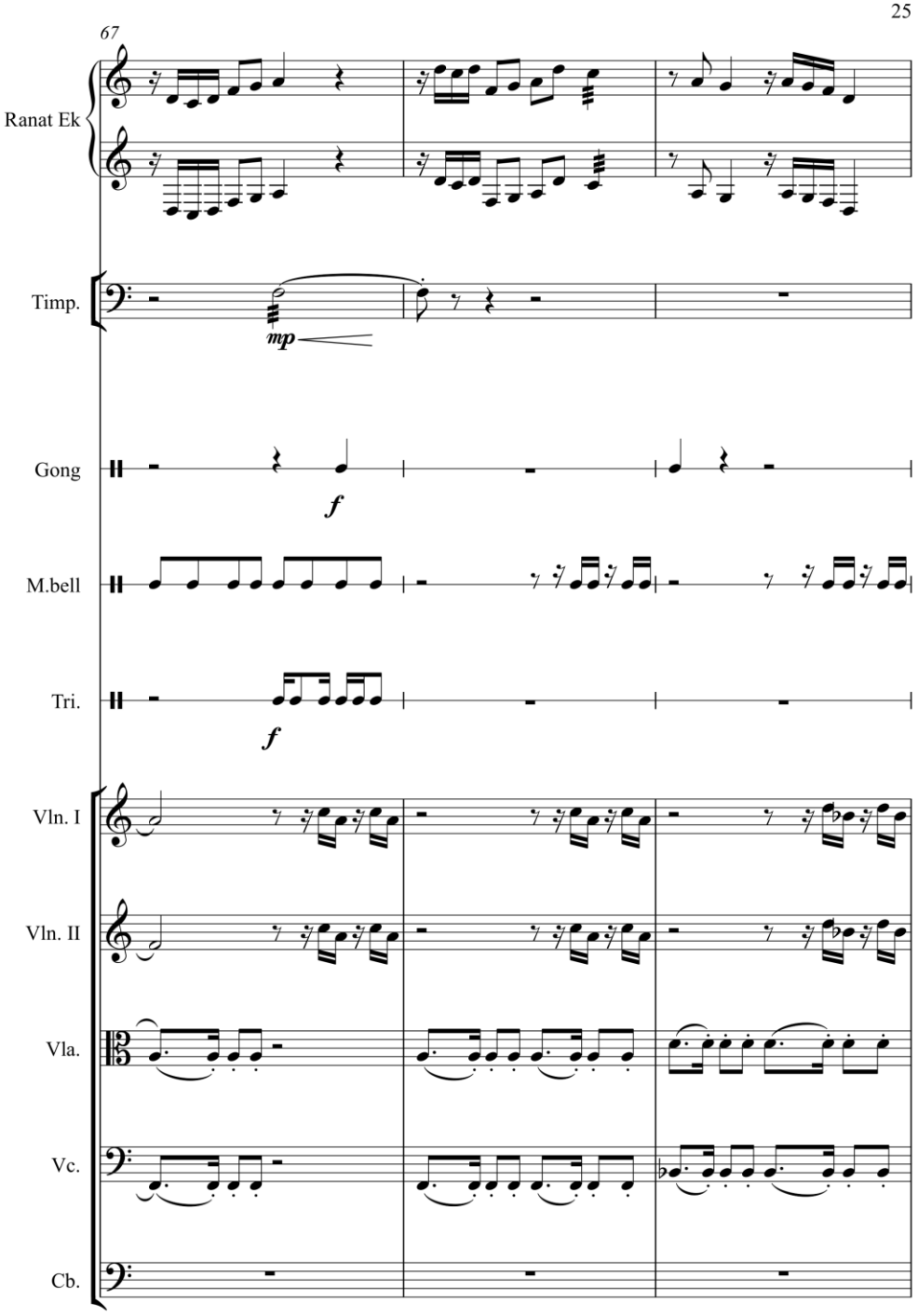

20
53
Ranat Ek
Timp.
p
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

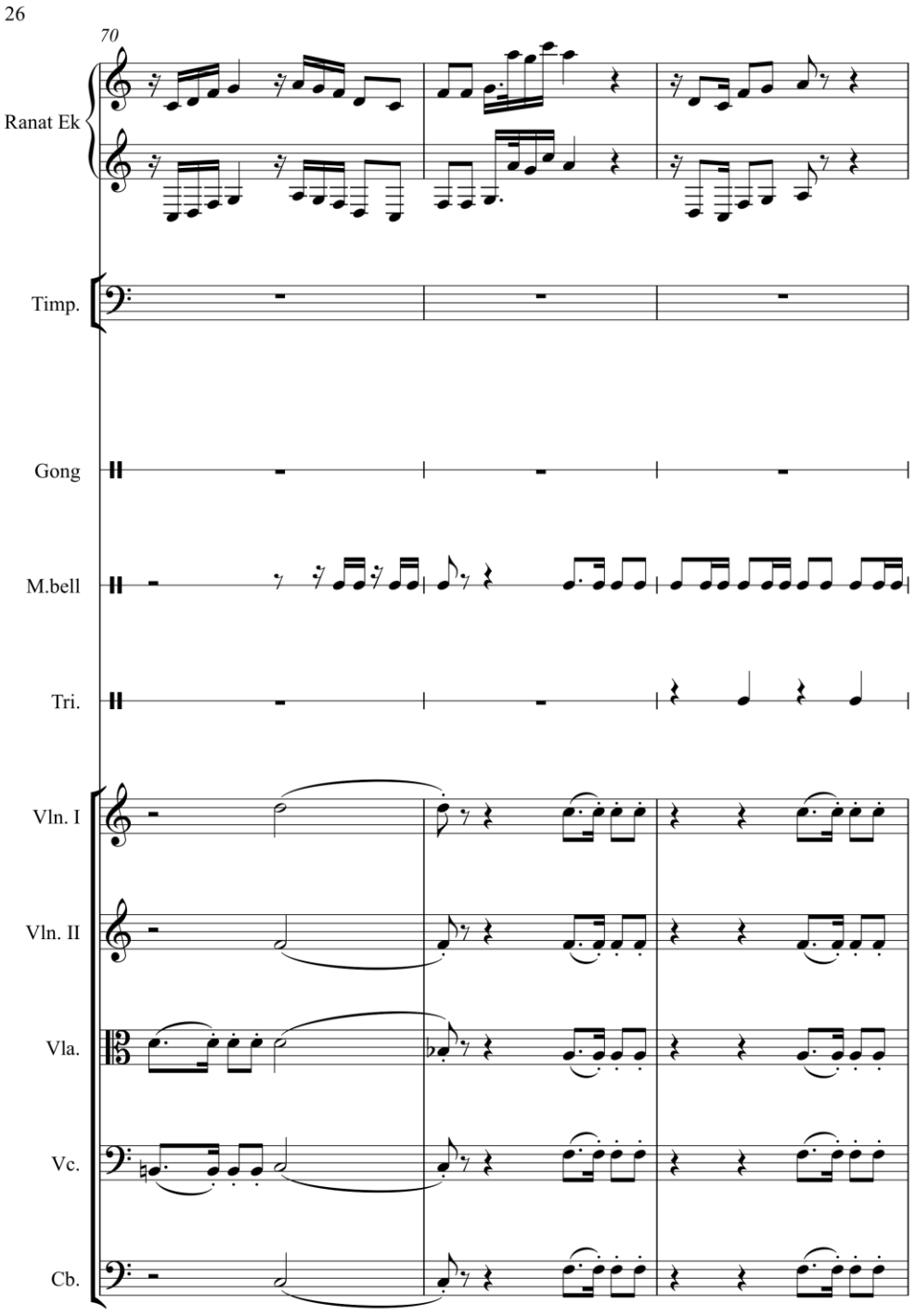

21
55
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

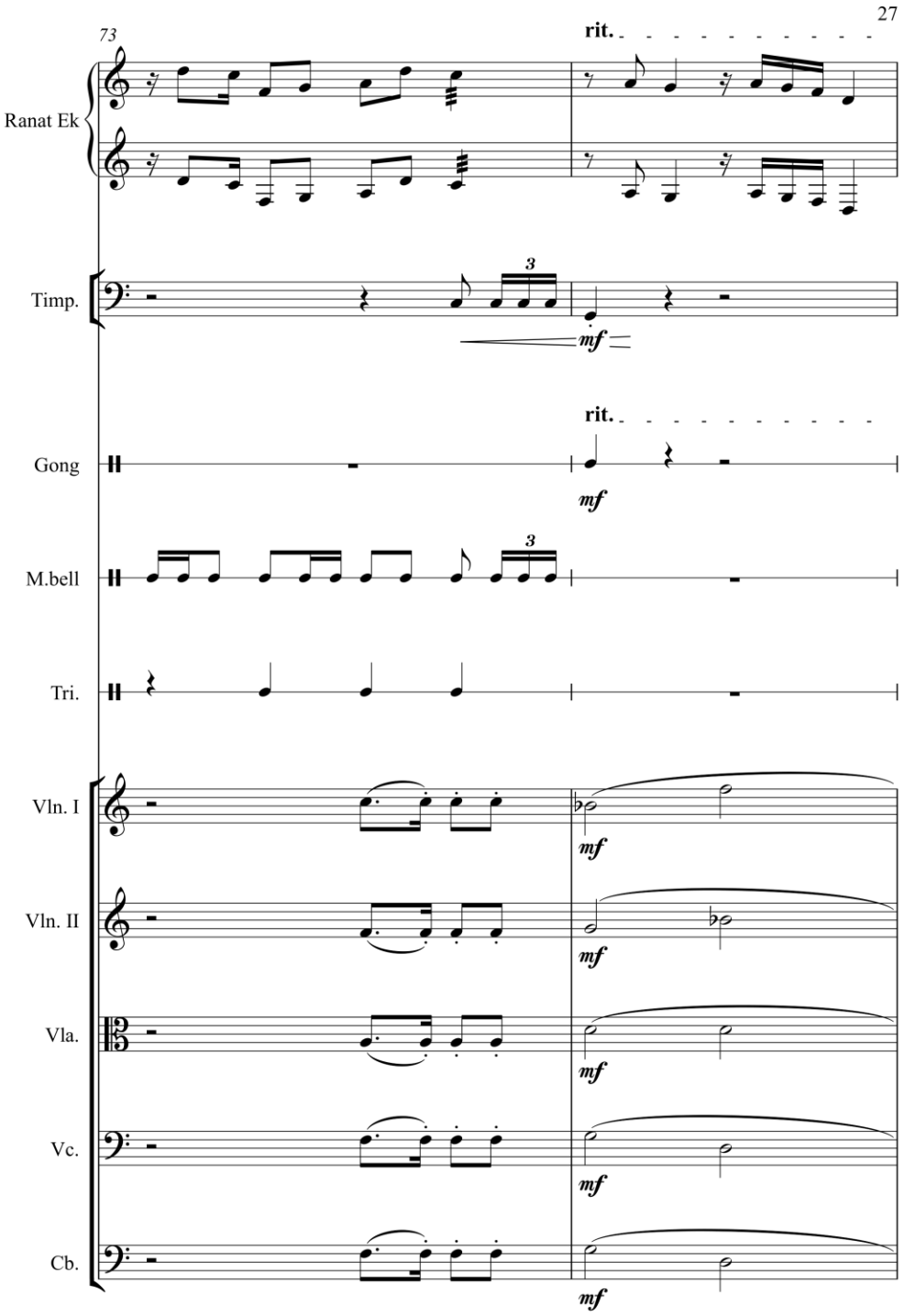

22
58
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

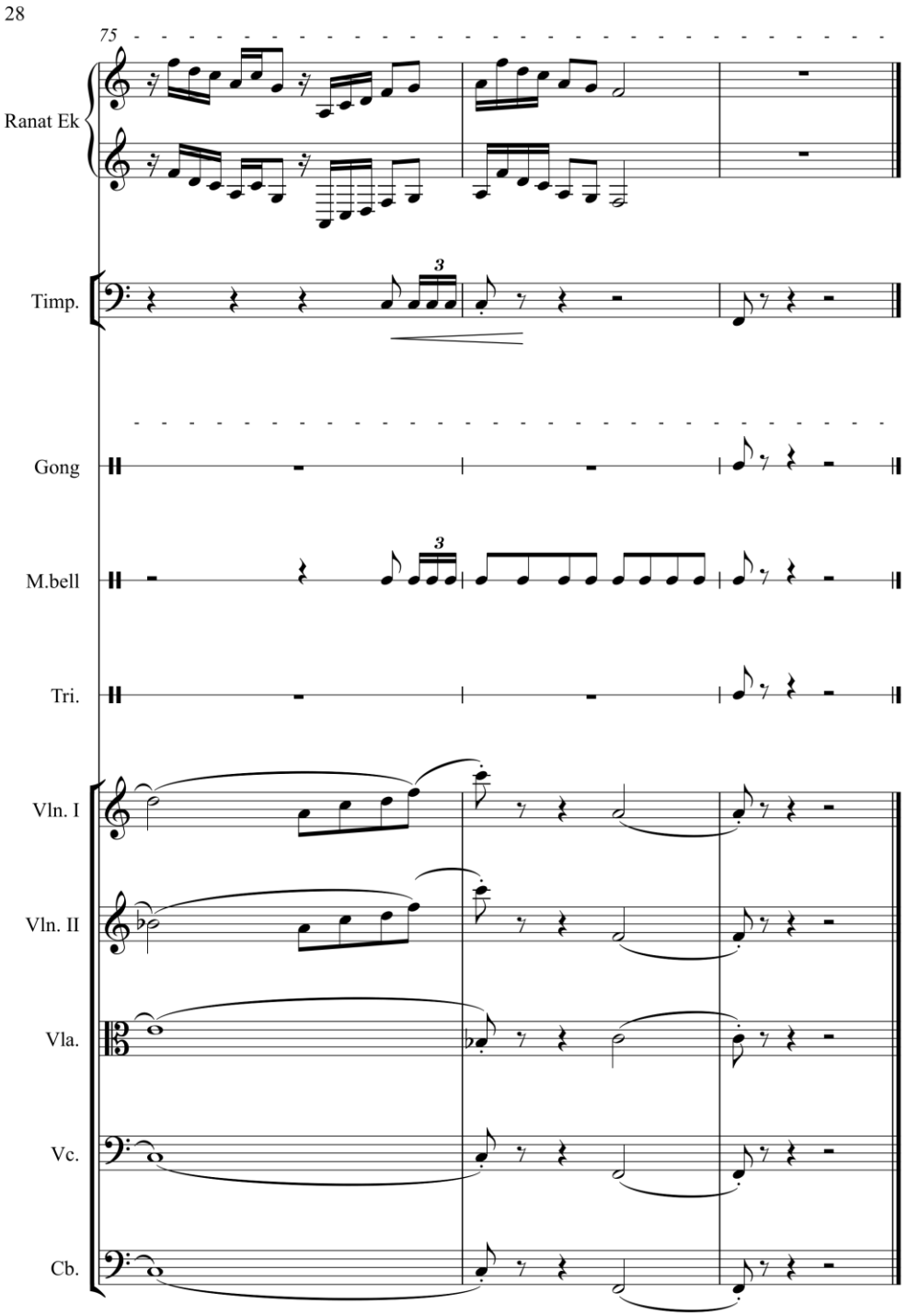

23
61
Ranat Ek
Timp.
3
Gong
M.bell
3
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

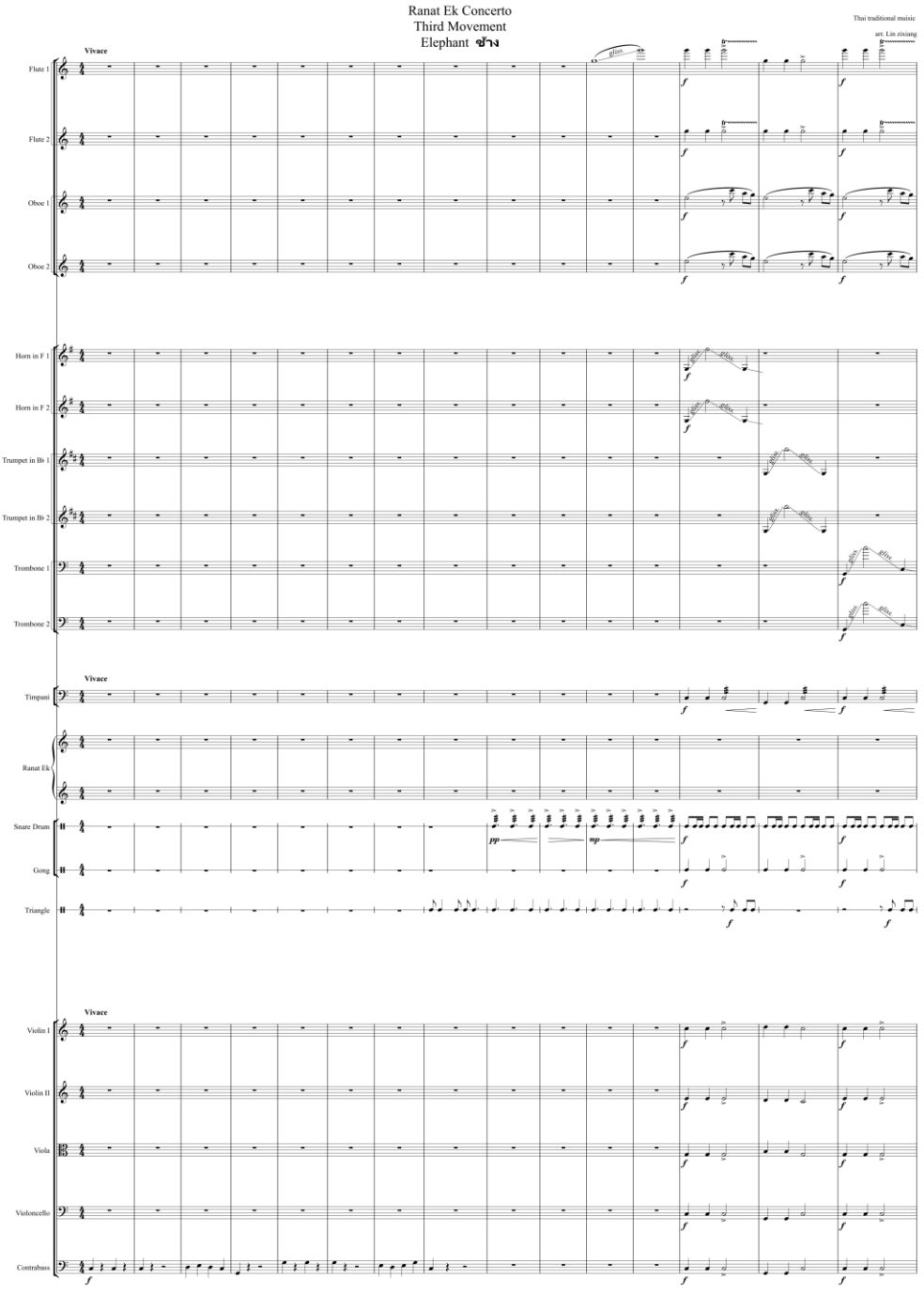

24
64
Ranat Ek
Timp.
mf
3
Gong
mf
M.bell
3
Tri.
Vln. I
mf
Vln. II
mf
Vla.
mf
Vc.
mf
Cb.
mf

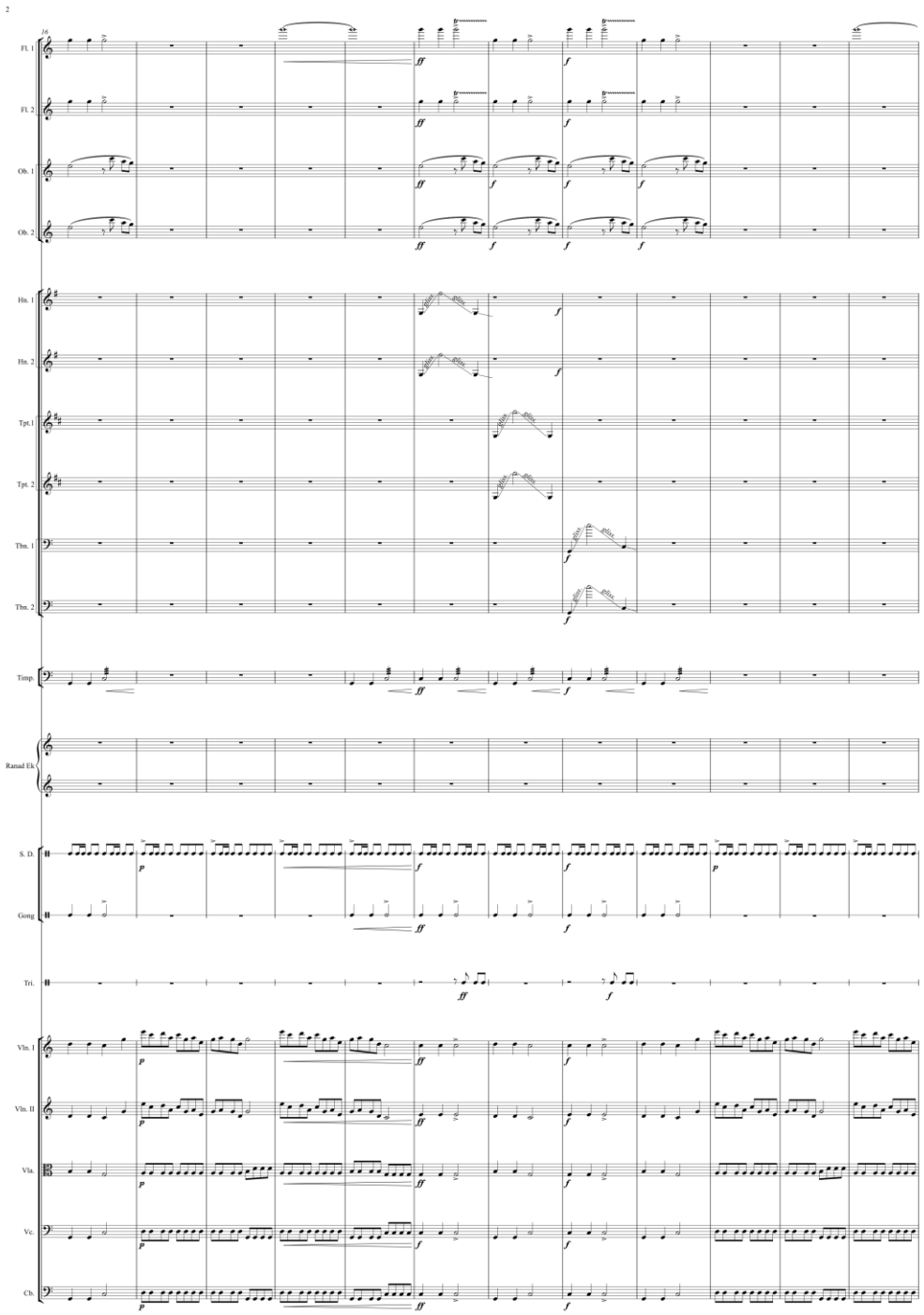

25
67
Ranat Ek
Timp.
mp
Gong
f
M.bell
Tri.
f
Vln. I
Vln. II
Vla.
Vc.
Cb.

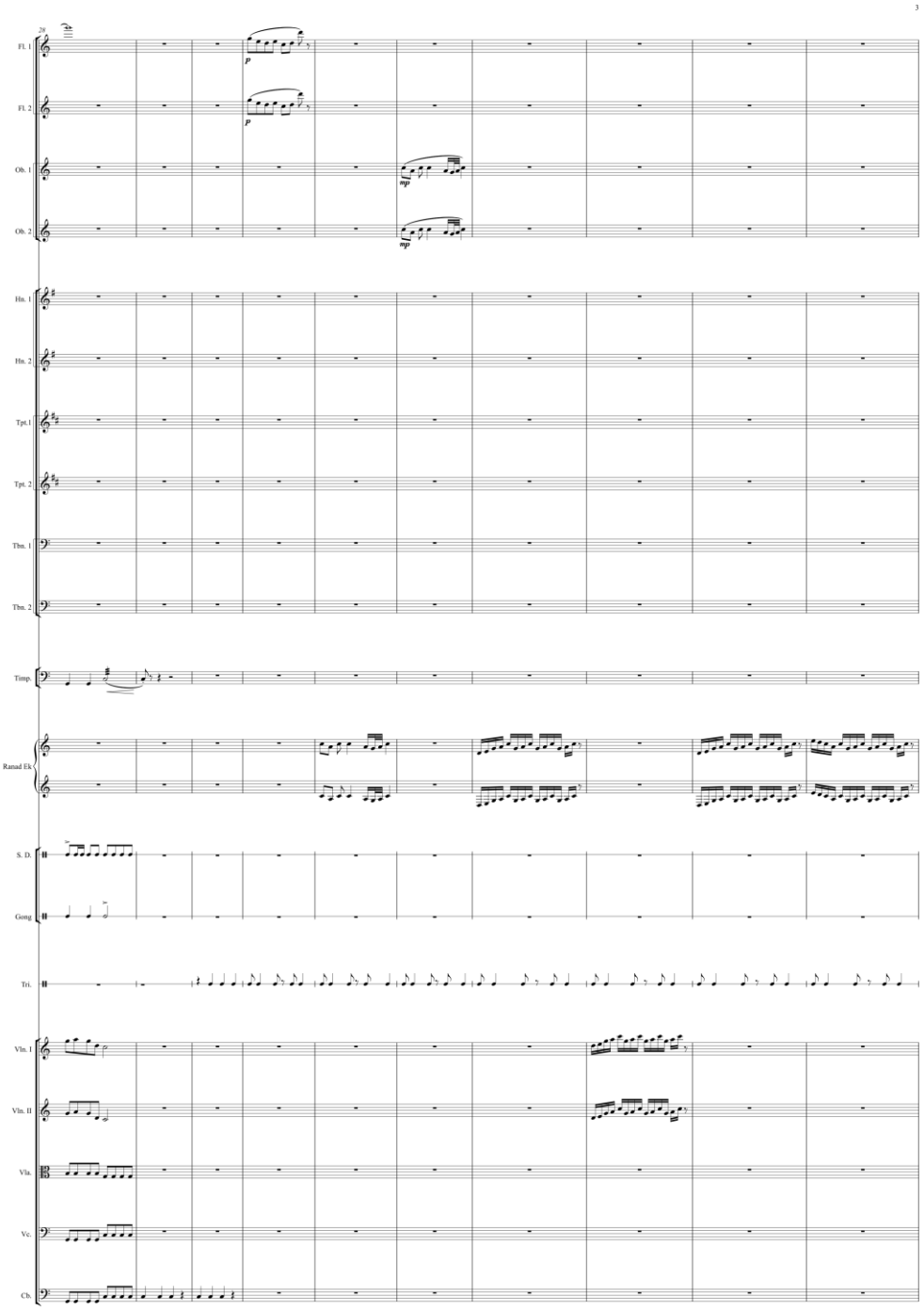

26
70
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

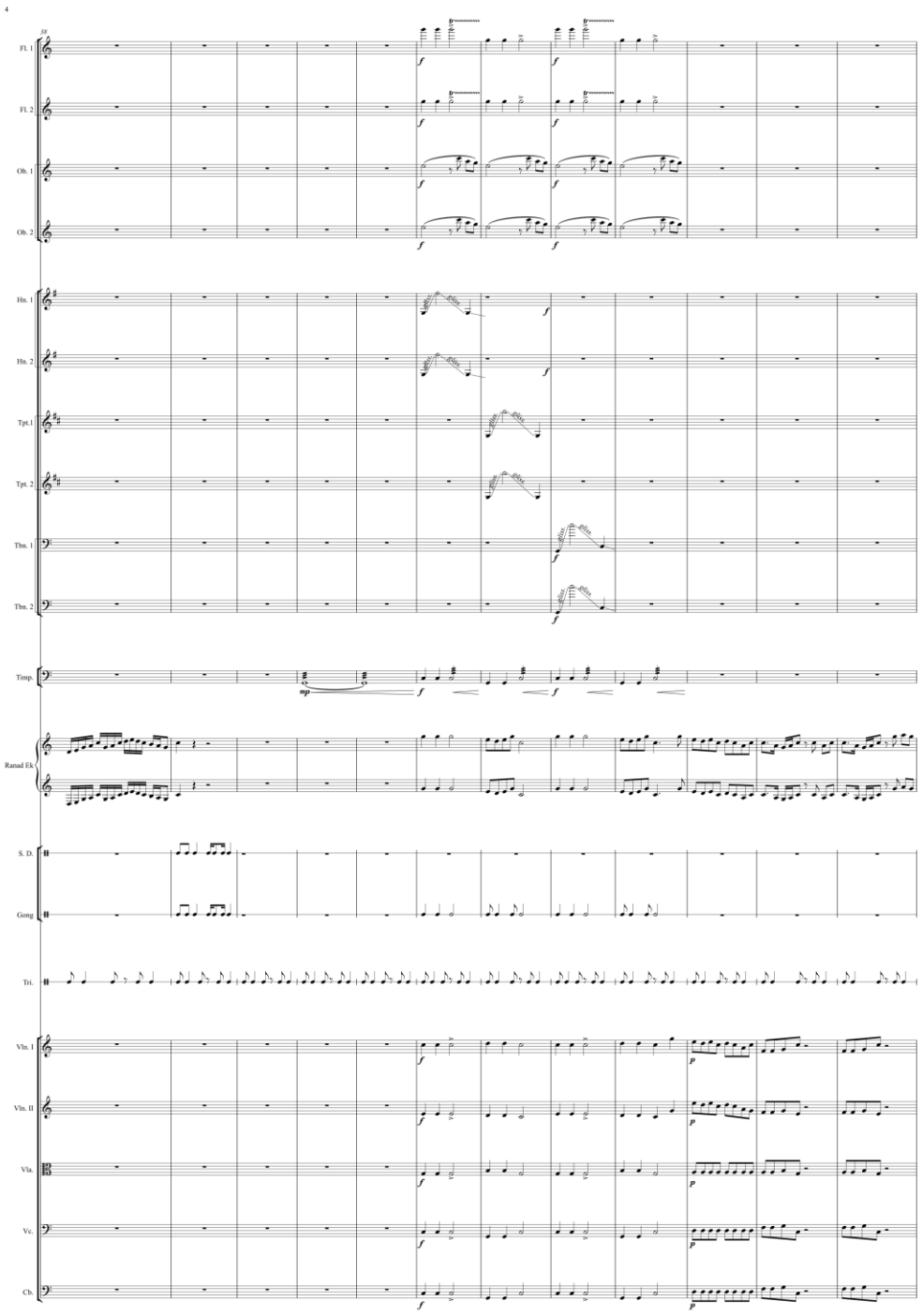

27
73
rit.
Ranat Ek
Timp.
mf
rit.
Gong
mf
M.bell
Tri.
Vln. I
mf
Vln. II
mf
Vla.
mf
Vc.
mf
Cb.
mf

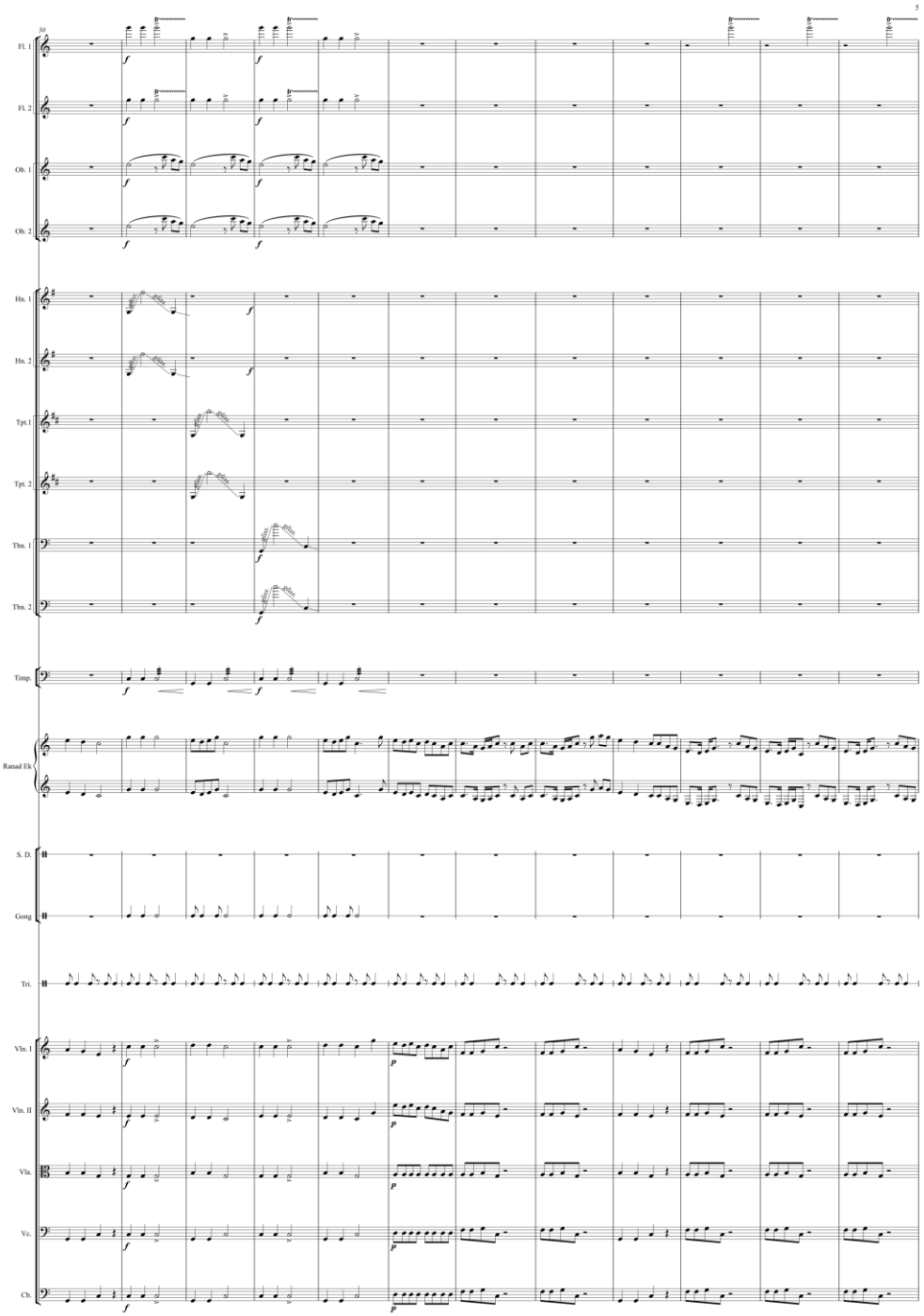

28
75
Ranat Ek
Timp.
Gong
M.bell
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

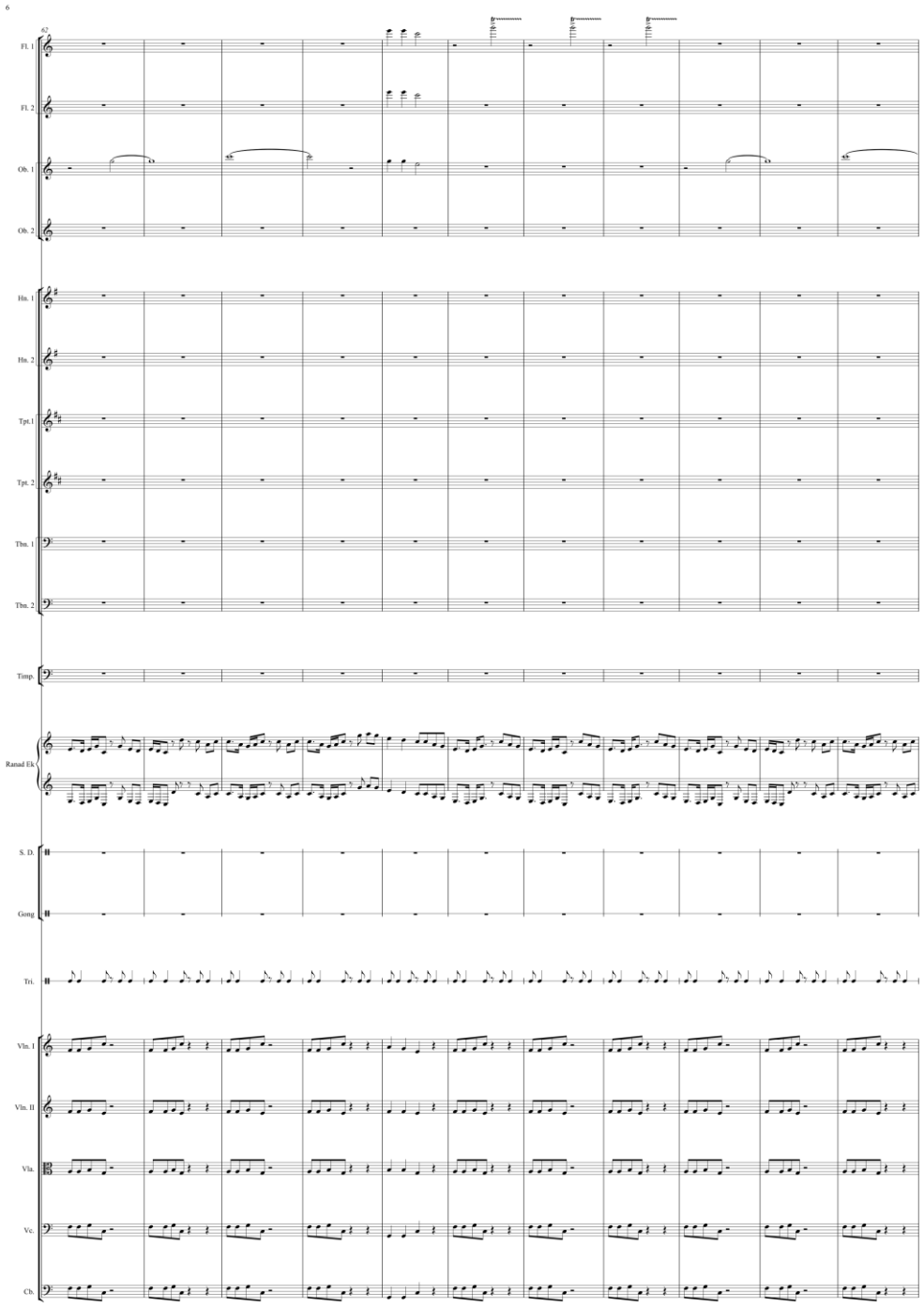

Ranat Ek Concerto
Third Movement
Elephant ช้าง
Thai traditional muisic
arr. Lin zixiang
Vivace
Flute 1
Flute 2
Oboe 1
Oboe 2
Horn in F 1
Horn in F 2
Trumpet in Bb 1
Trumpet in Bb 2
Trombone 1
Trombone 2
Vivace
Timpani
Ranat Ek
Snare Drum
Gong
Triangle
Vivace
Violin I
Violin II
Viola
Violoncello
Contrabass

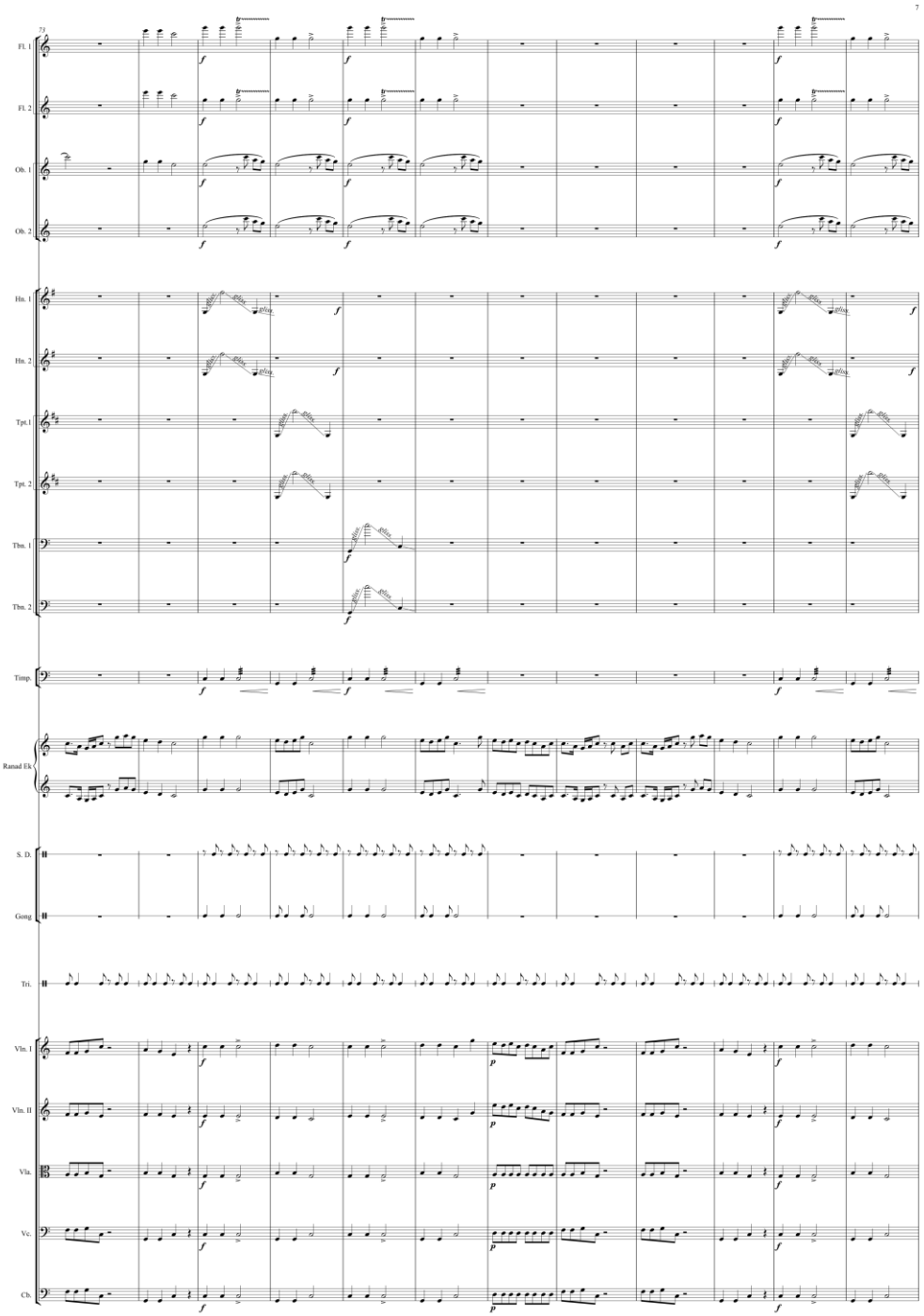

2
16
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

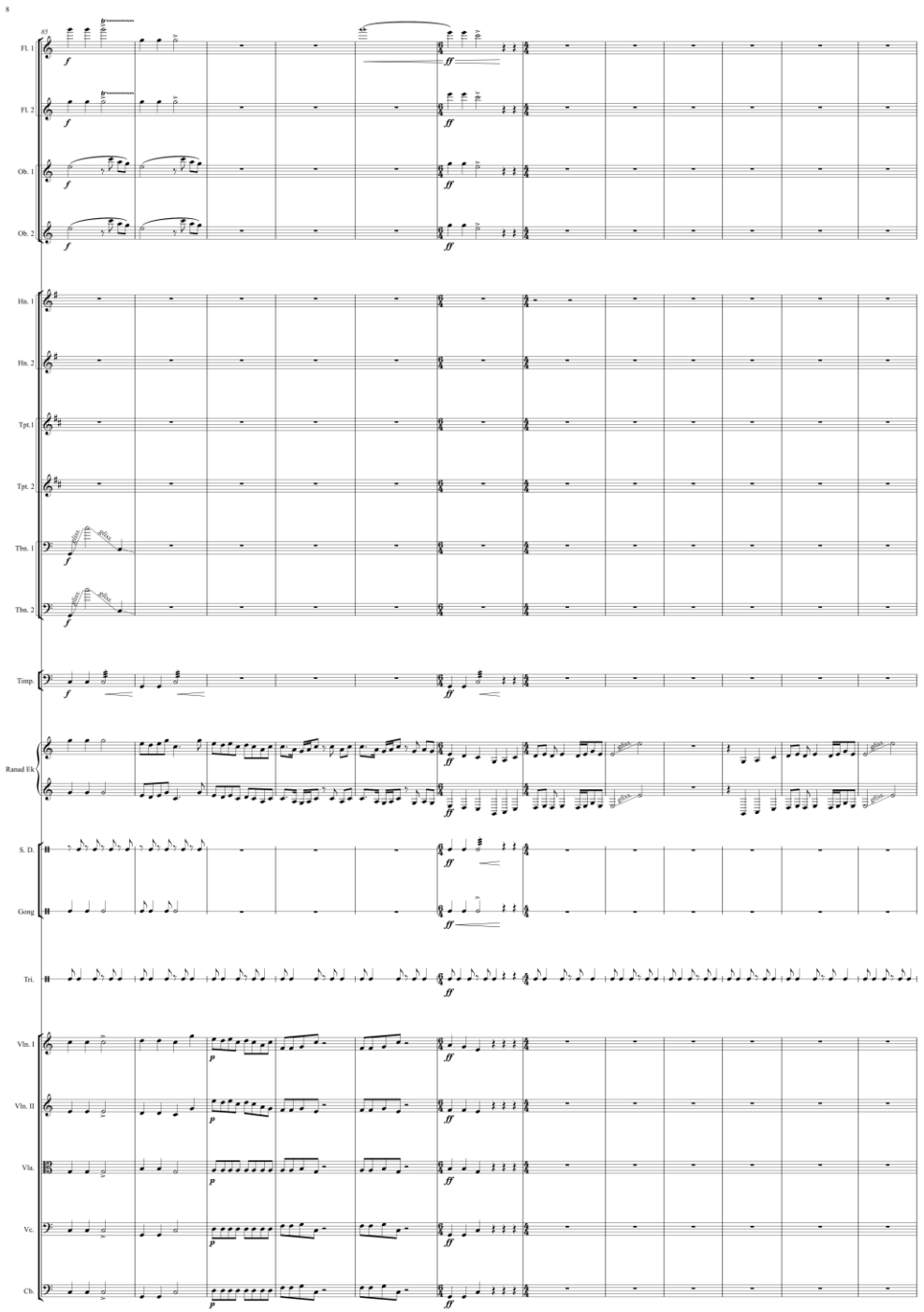

3
20
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

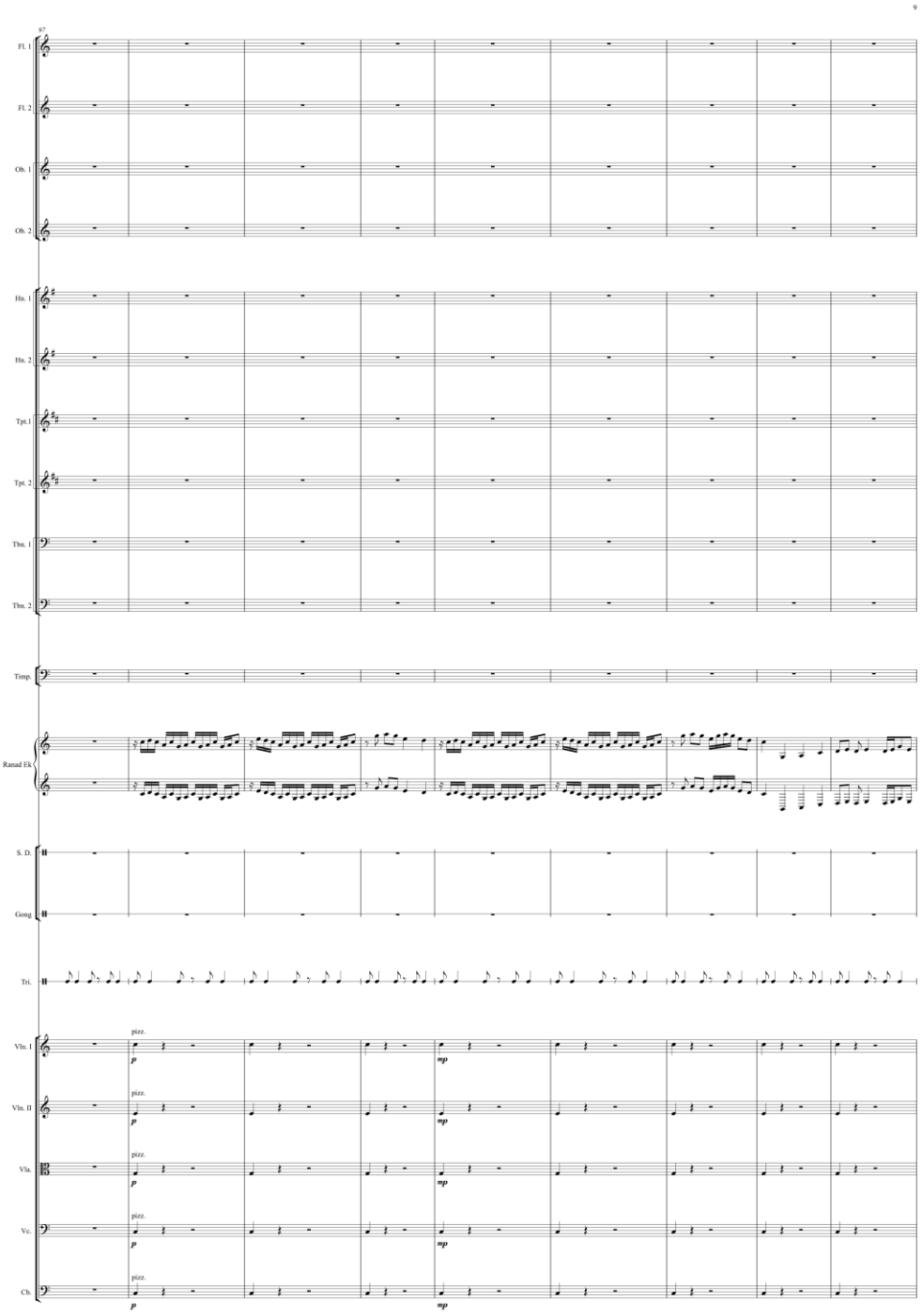

4
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

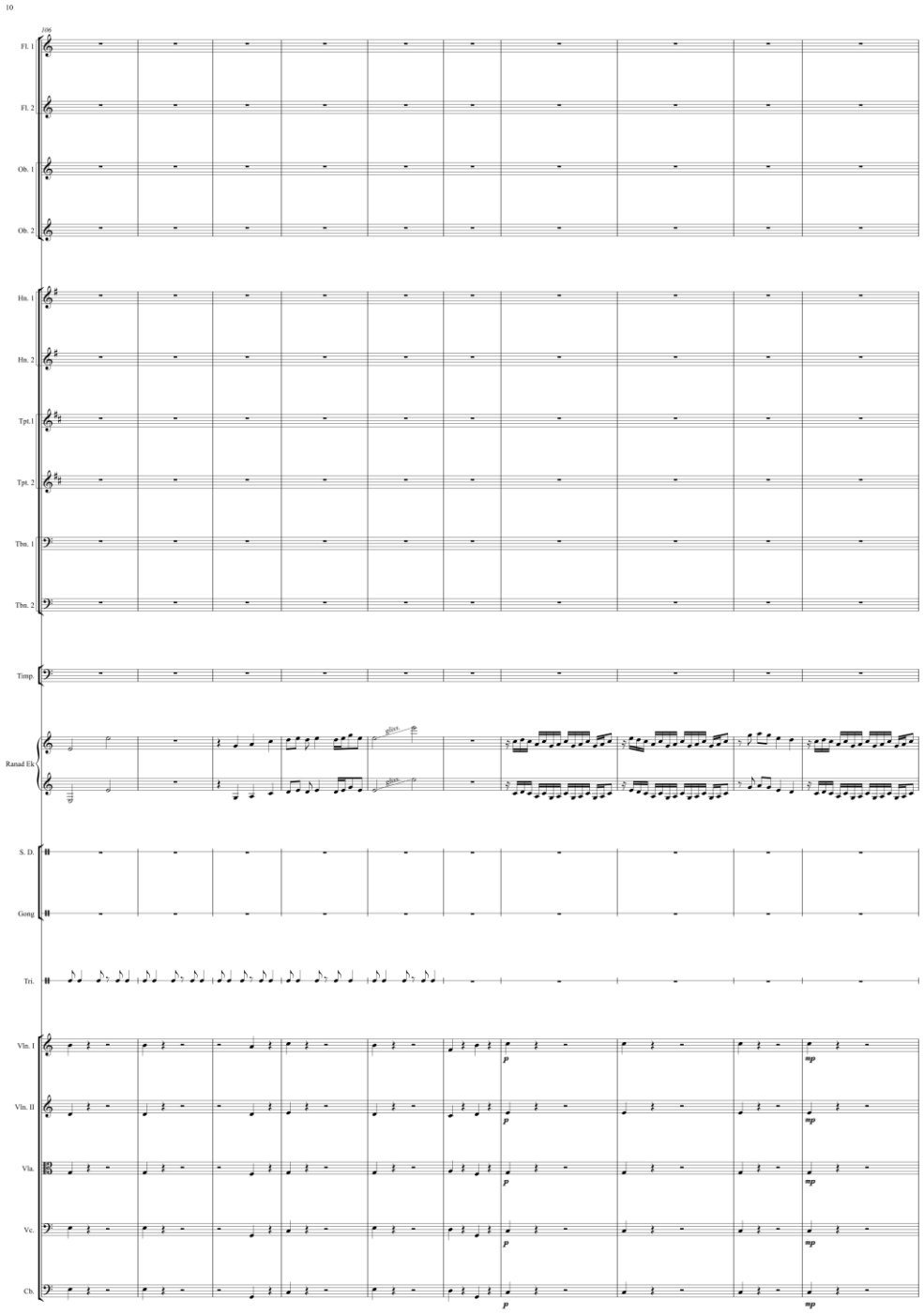

50
5
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

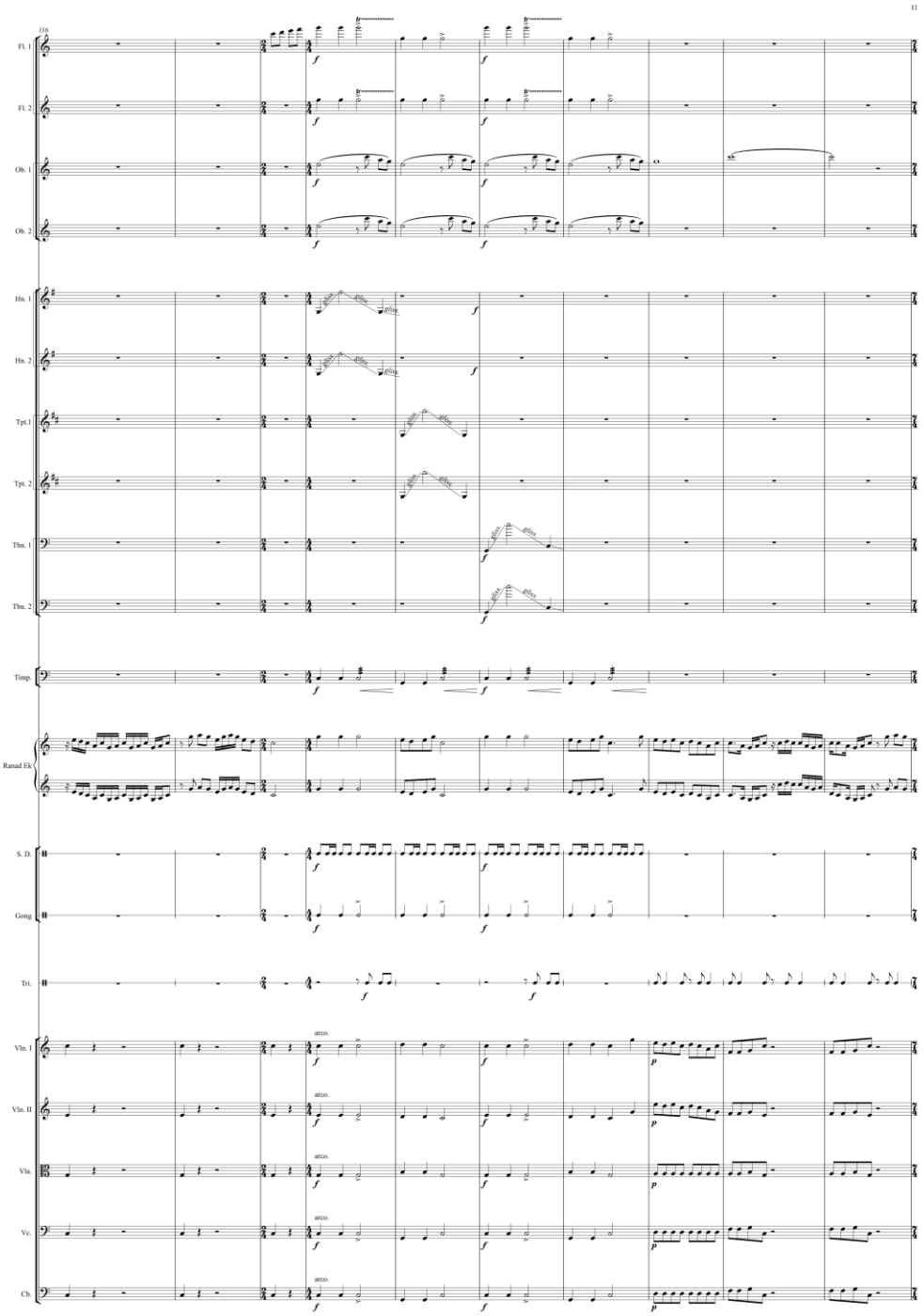

6
62
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

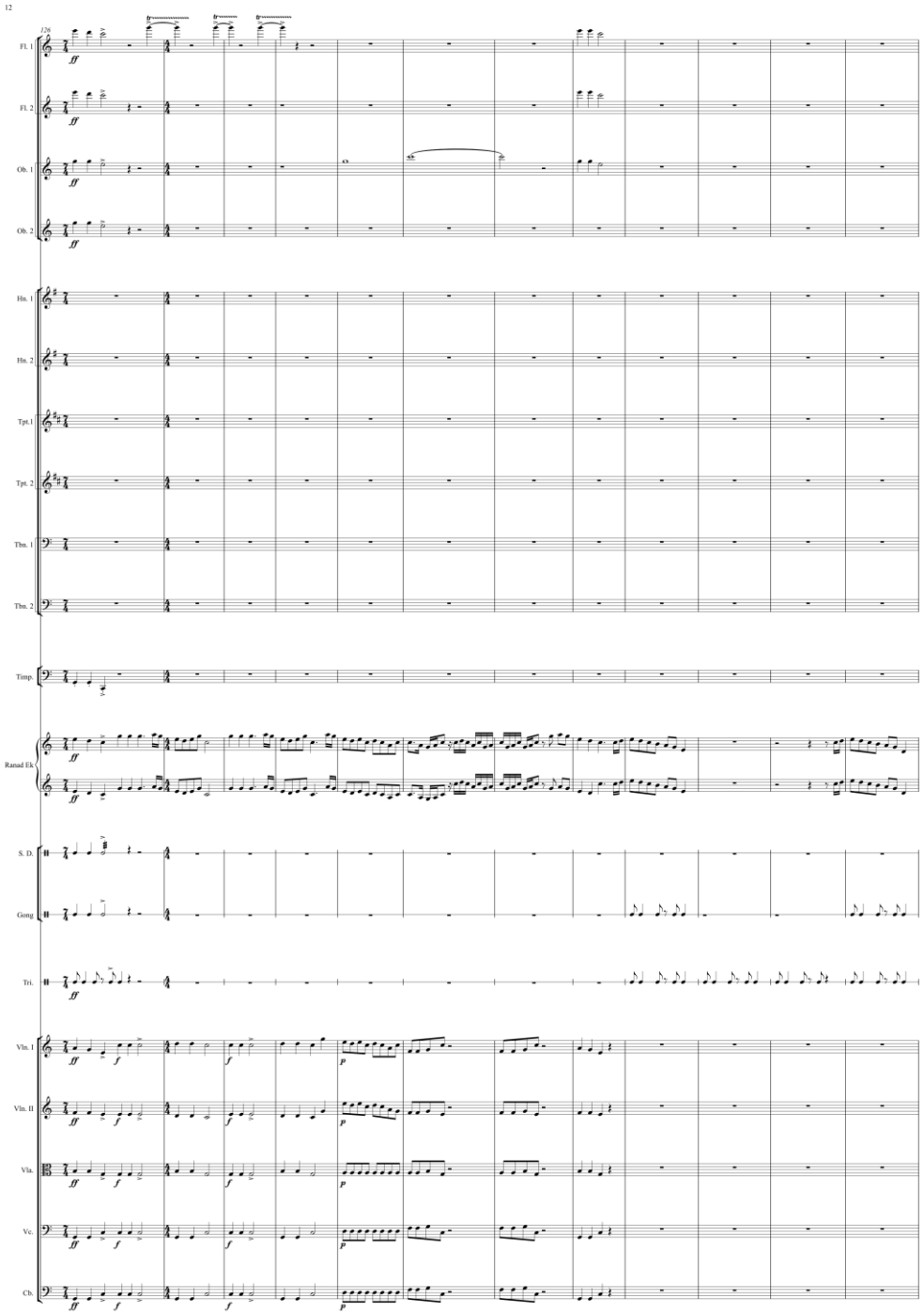

73
7
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

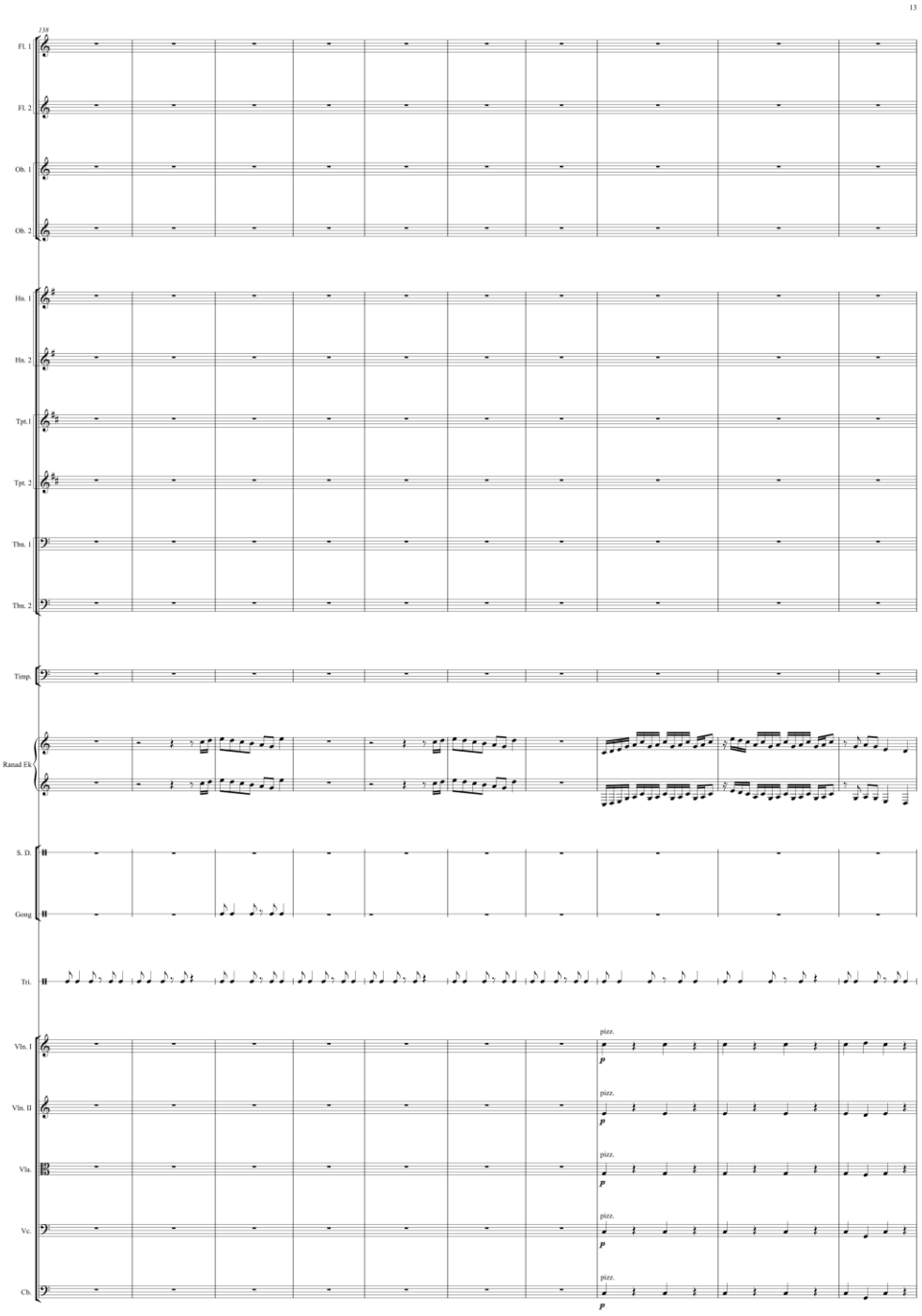

8
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt. 1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek.
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

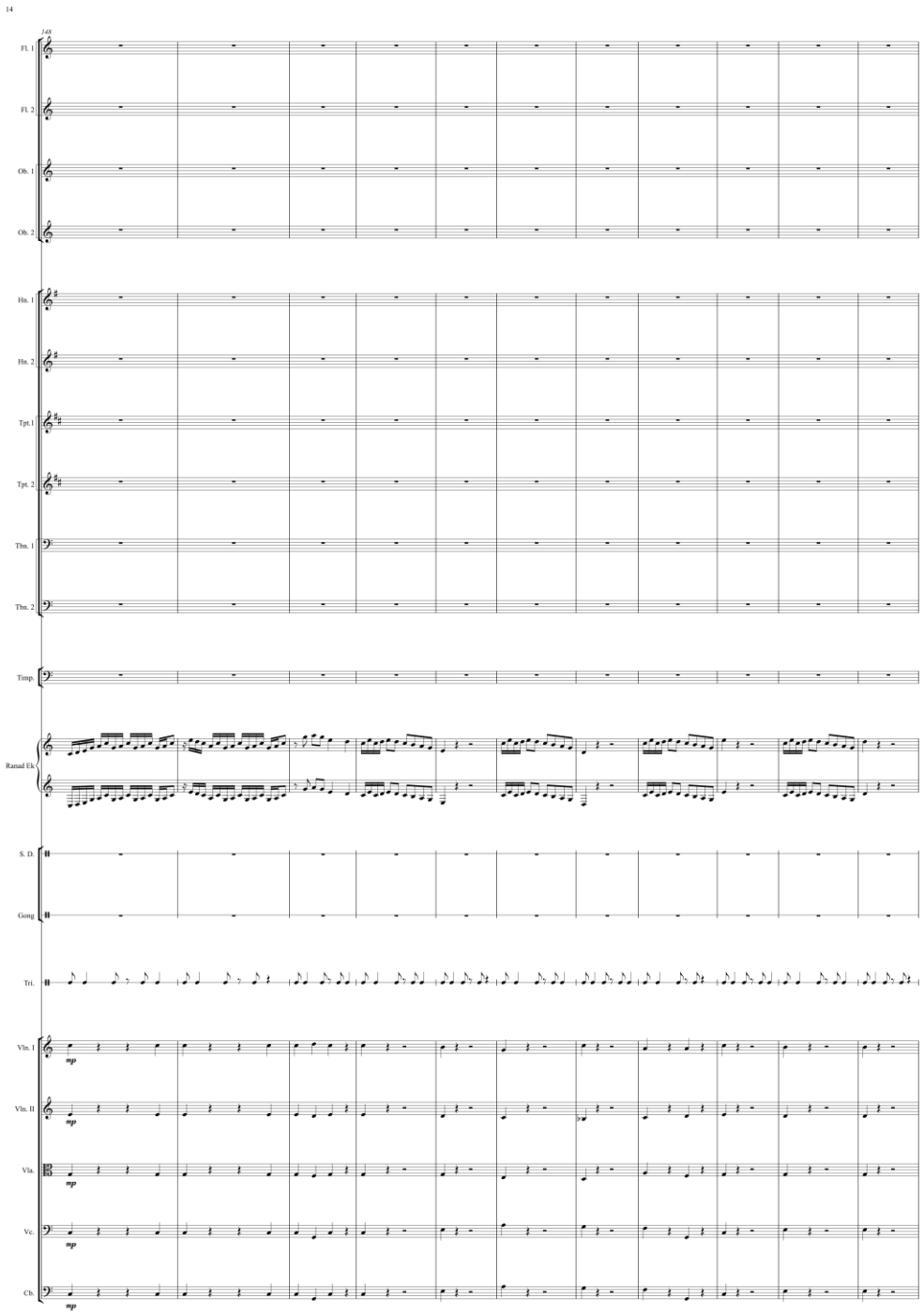

9
97
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
pizz.
p
mp

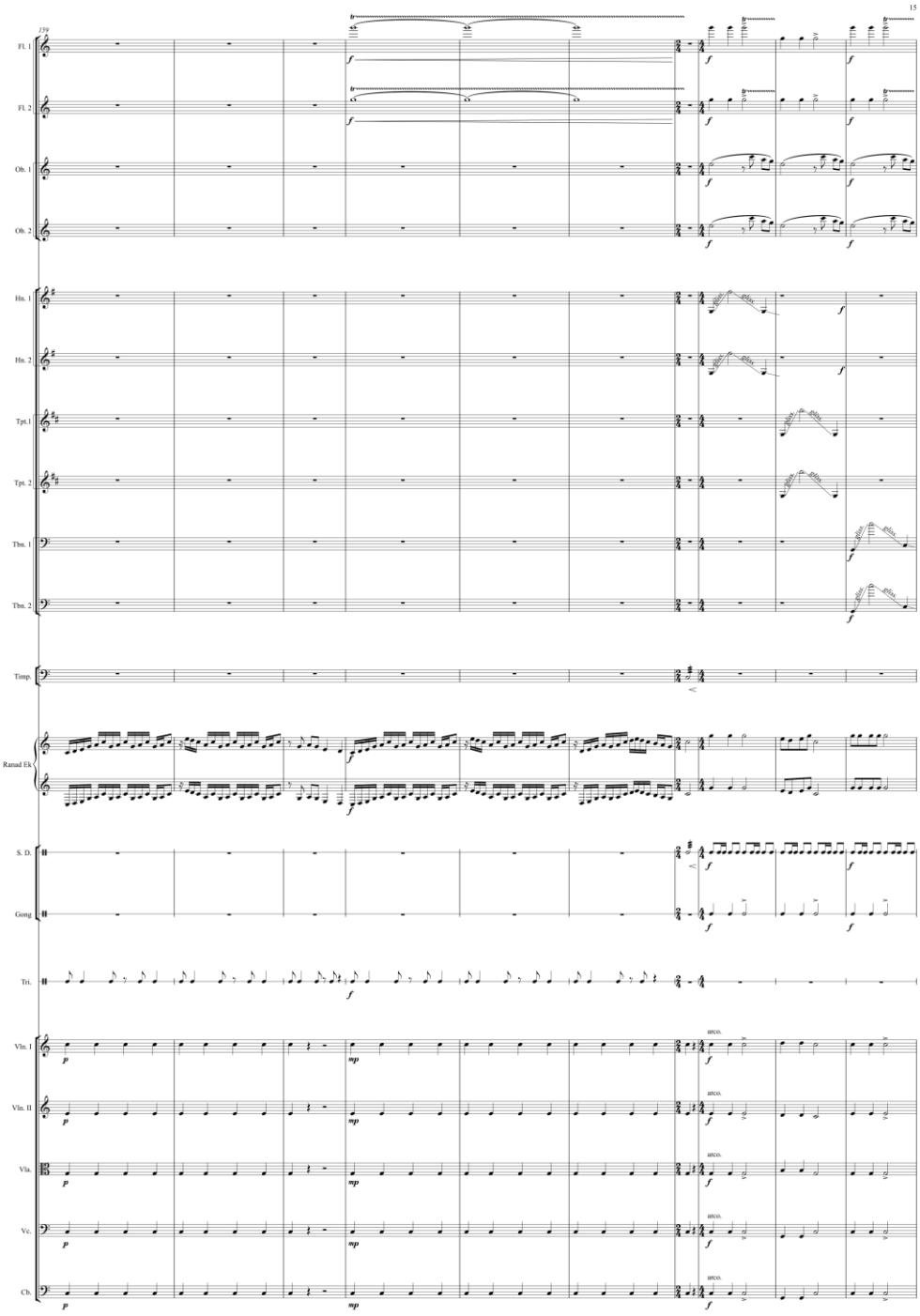

10
106
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
p
mp

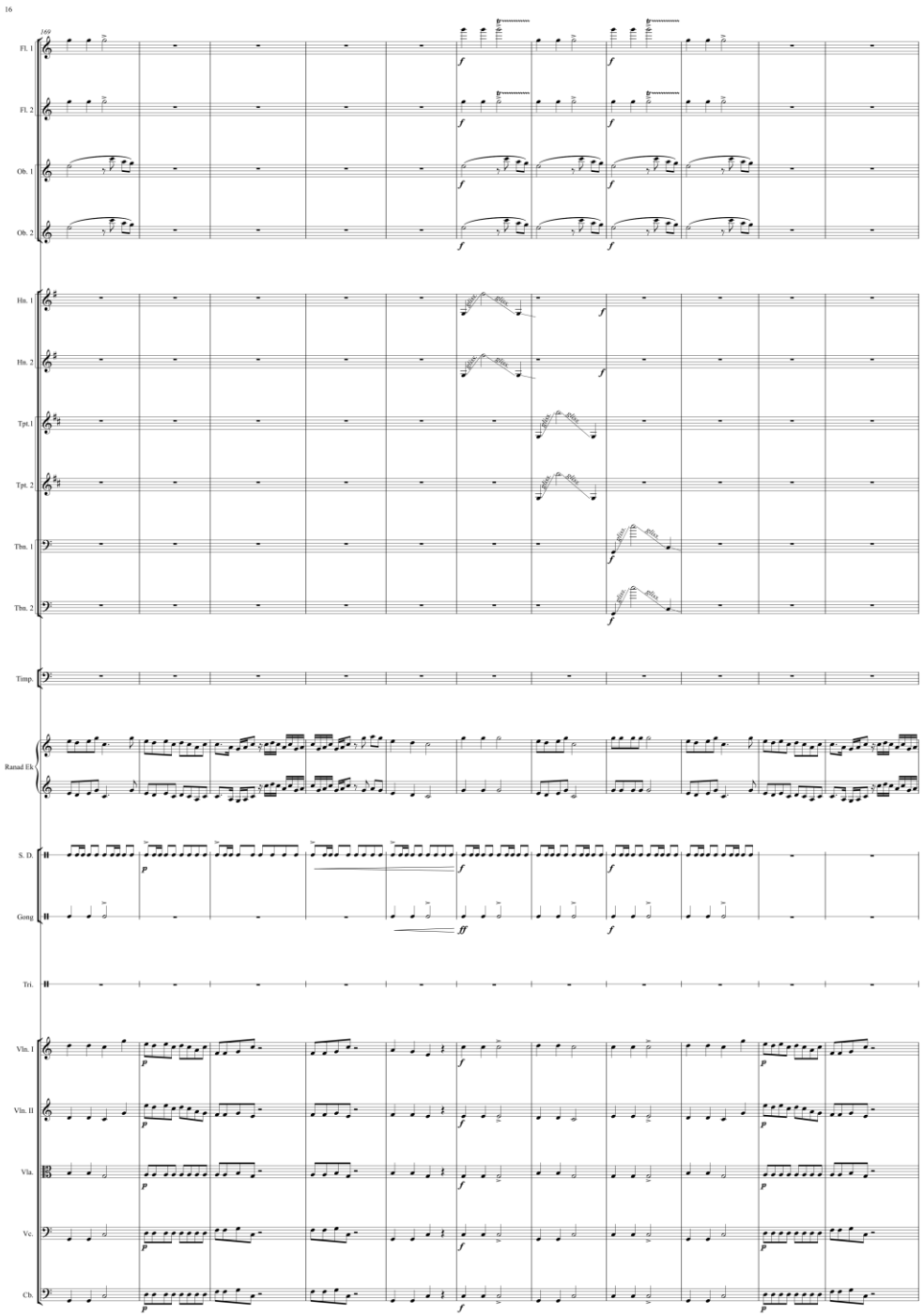

11
116
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco.

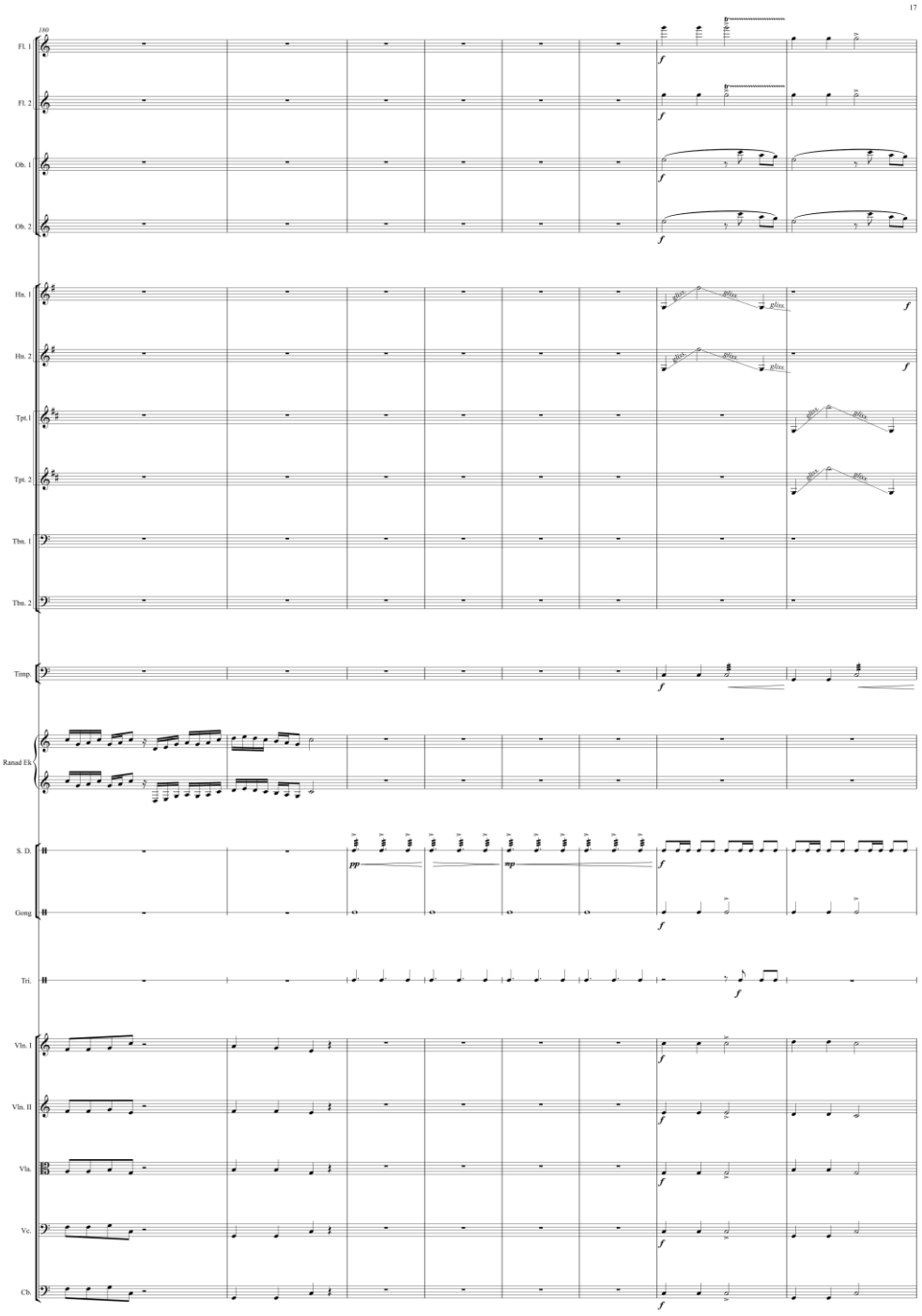

12
126
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

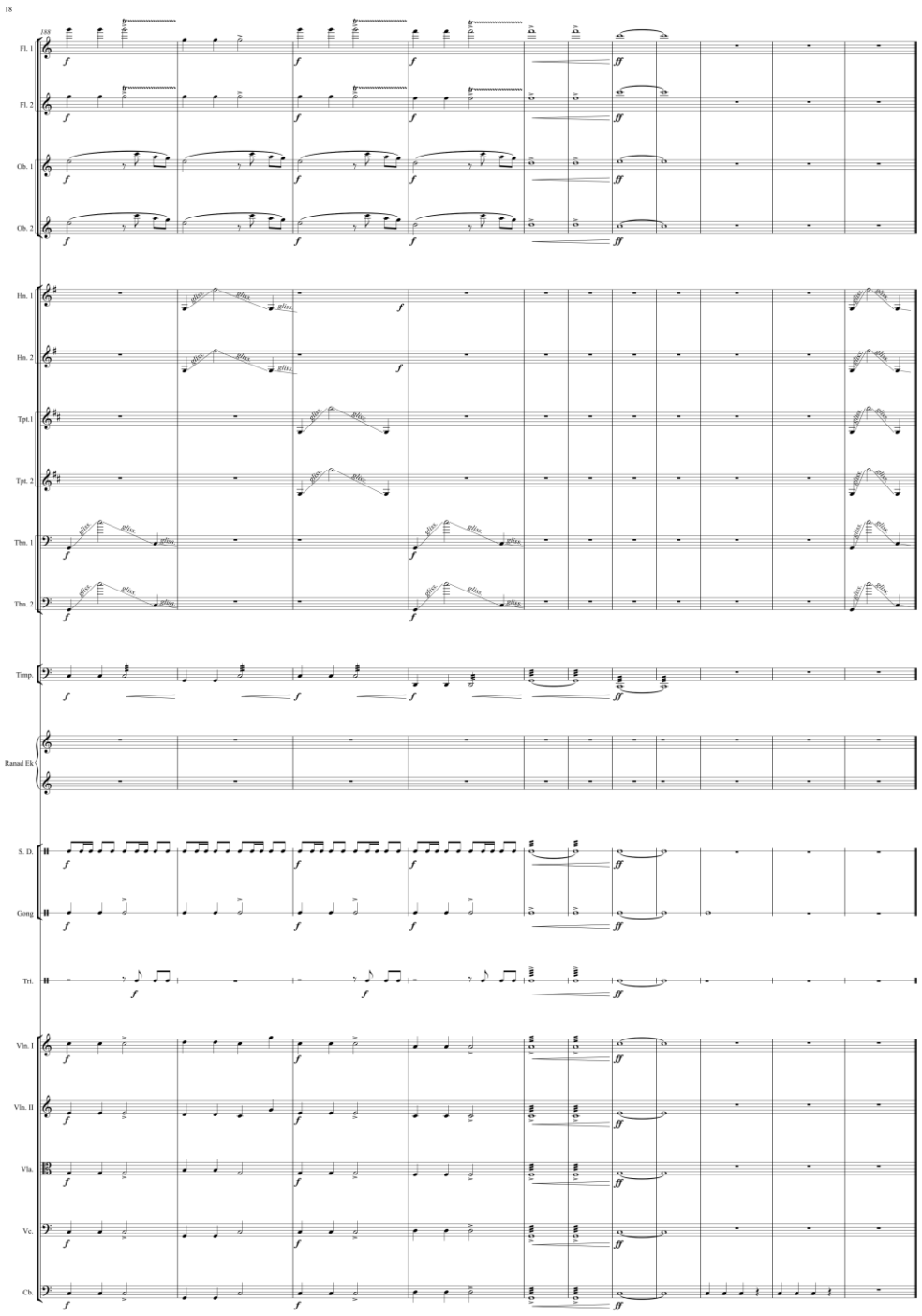

13
138
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
pizz.
p


14
148
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
mp


159
15
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.
arco.


16
169
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt.1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.


17
180
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt. 1
Tpt. 2
Tbn. 1
Tba. 2
Timp.
Ranad Ek
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.


18
188
Fl. 1
Fl. 2
Ob. 1
Ob. 2
Hn. 1
Hn. 2
Tpt. 1
Tpt. 2
Tbn. 1
Tbn. 2
Timp.
Ranad Ek.
S. D.
Gong
Tri.
Vln. I
Vln. II
Vla.
Vc.
Cb.

VITA