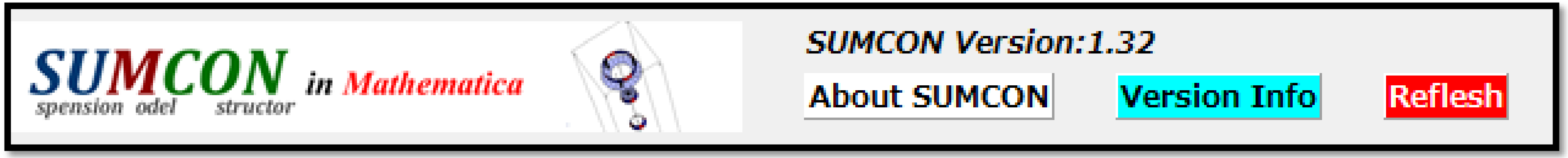
JGW-G1605034



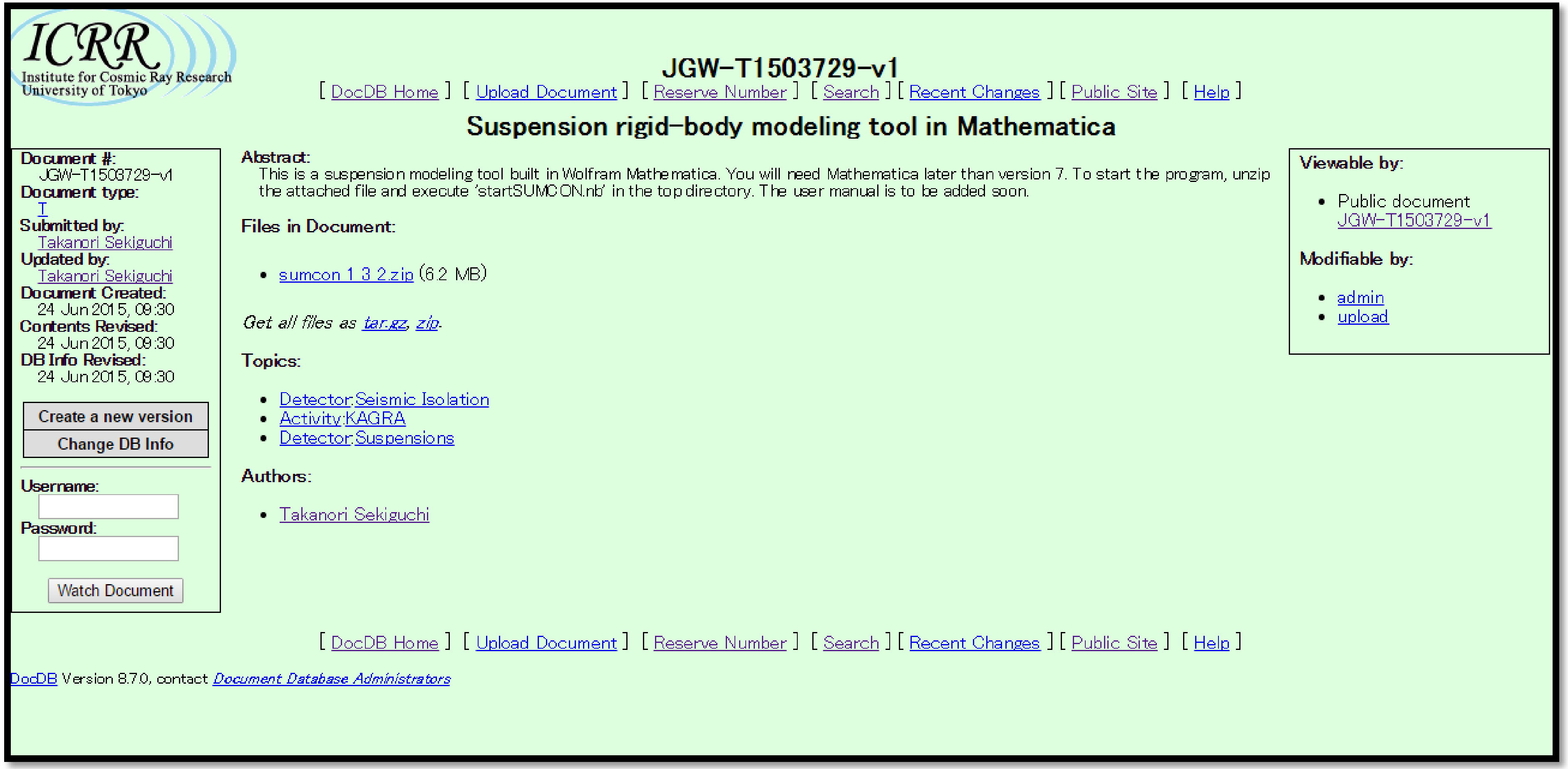
SUMCON User's Manual

Mechanical suspension modeling tool in Mathematica

Contents

❖ Preparation / Installation

1) Install the Modeling tools from the below URL ;
http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=3729


ICRR
Institute for Cosmic Ray Research
University of Tokyo

JGW-T1503729-v1

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Suspension rigid-body modeling tool in Mathematica

Document #:
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Takanori Sekiguchi
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Takanori Sekiguchi
Document Created:
24 Jun 2015, 09:30
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24 Jun 2015, 09:30
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24 Jun 2015, 09:30

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Abstract:
This is a suspension modeling tool built in Wolfram Mathematica. You will need Mathematica later than version 7. To start the program, unzip the attached file and execute 'startSUMCON.nb' in the top directory. The user manual is to be added soon.

Files in Document:

- sumcon 1 3 2.zip (6.2 MB)

Get all files as tar.gz, zip.

Topics:

- Detector:Seismic Isolation
- Activity:KAGRA
- Detector:Suspensions

Authors:

- Takanori Sekiguchi

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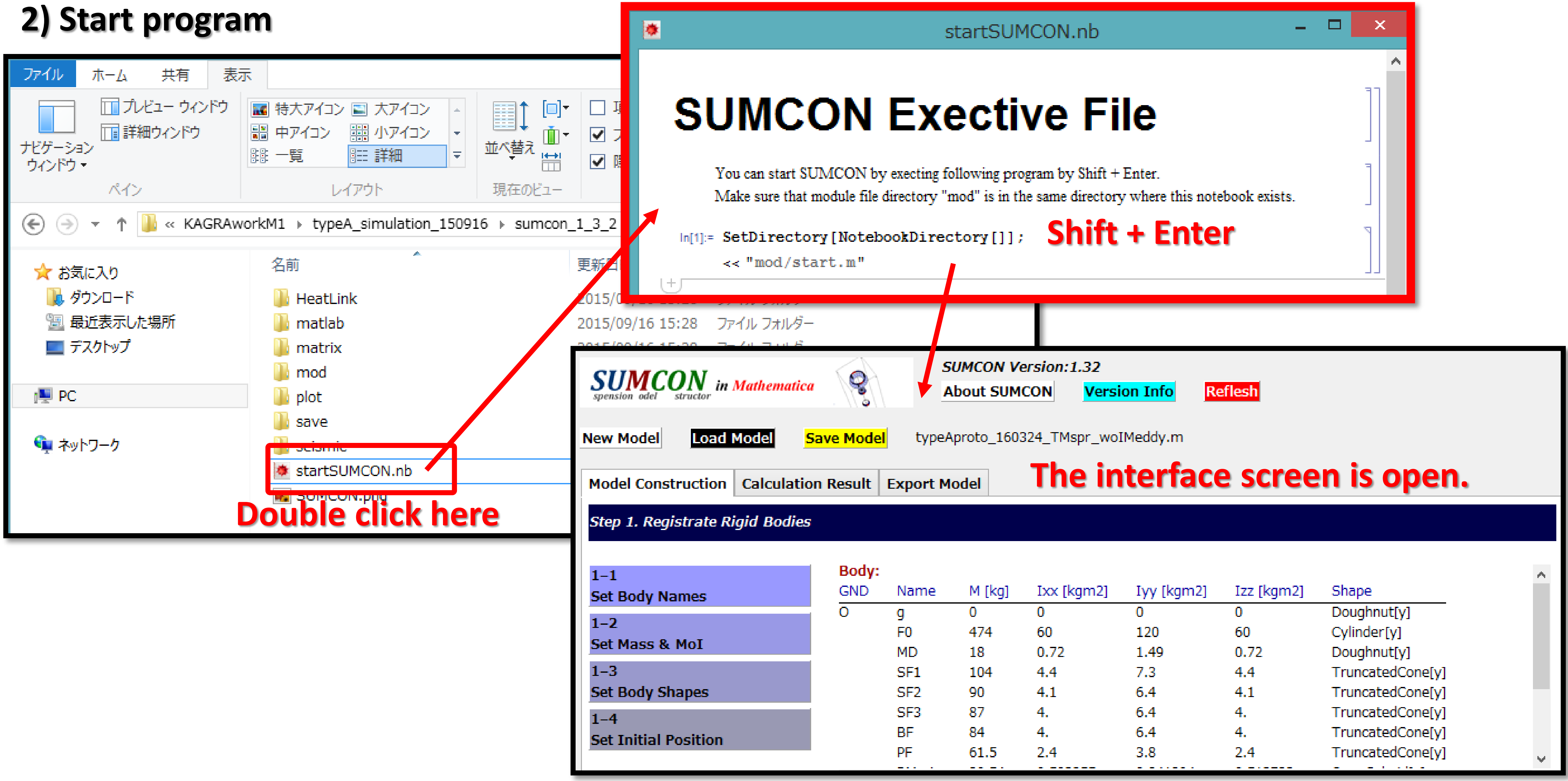
DocDB Version 8.7.0, contact *Document Database Administrators*

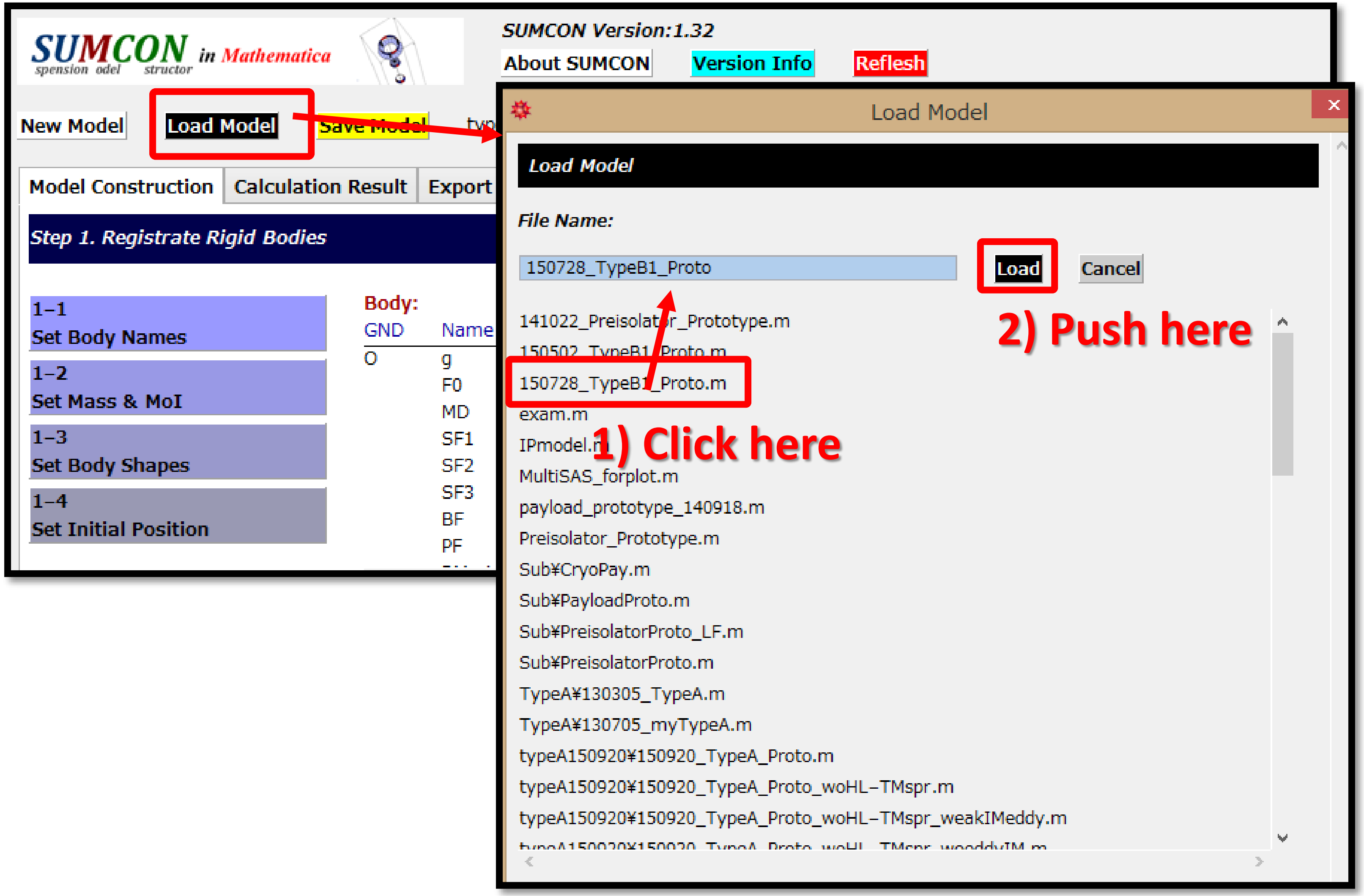
❖ Preparation / Starting program

2) Start program



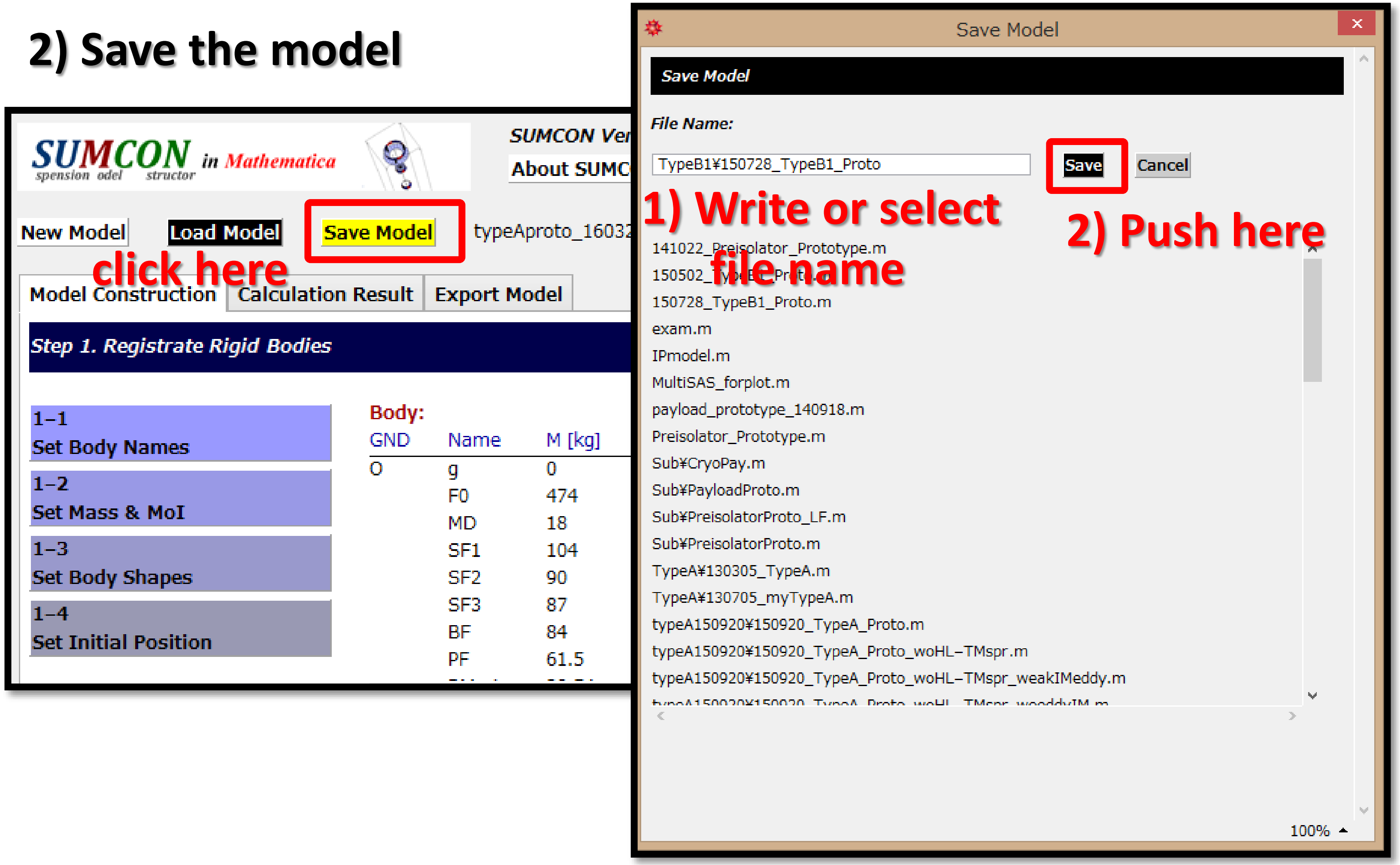
❖ Preparation / Load a model file

2) Load previous file



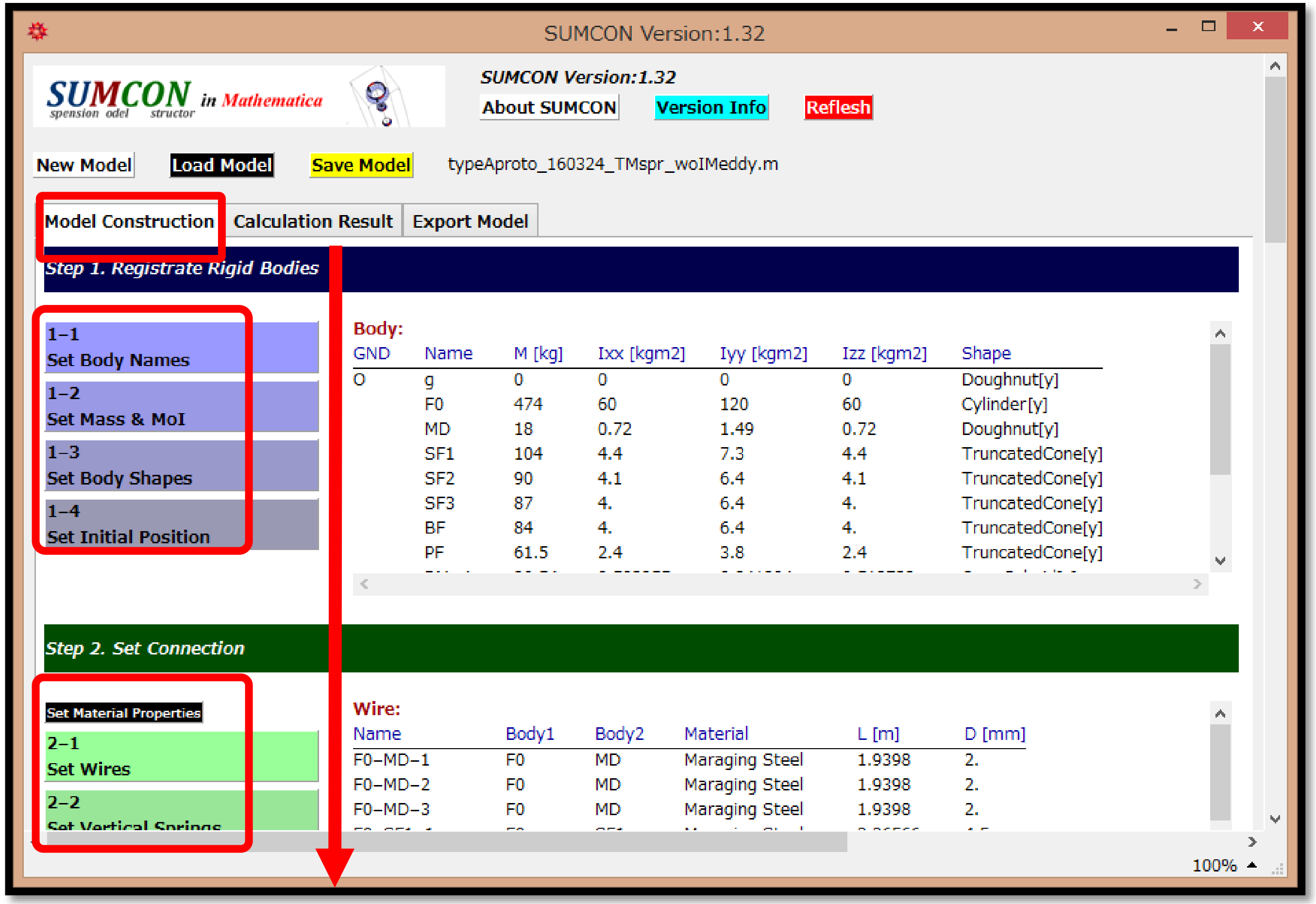
❖ Preparation / Save a model file

2) Save the model

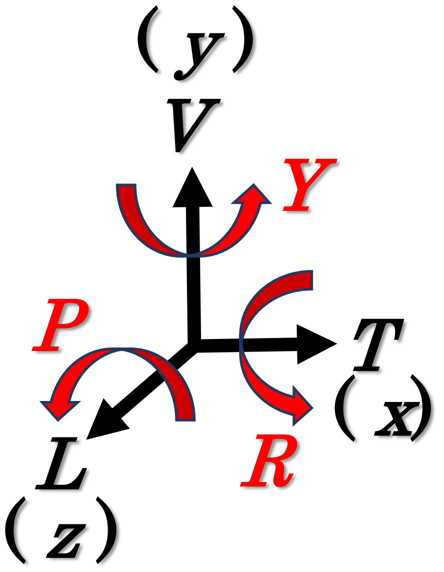


❖ Model construction

1) You should registrate suspension parameters as follows.

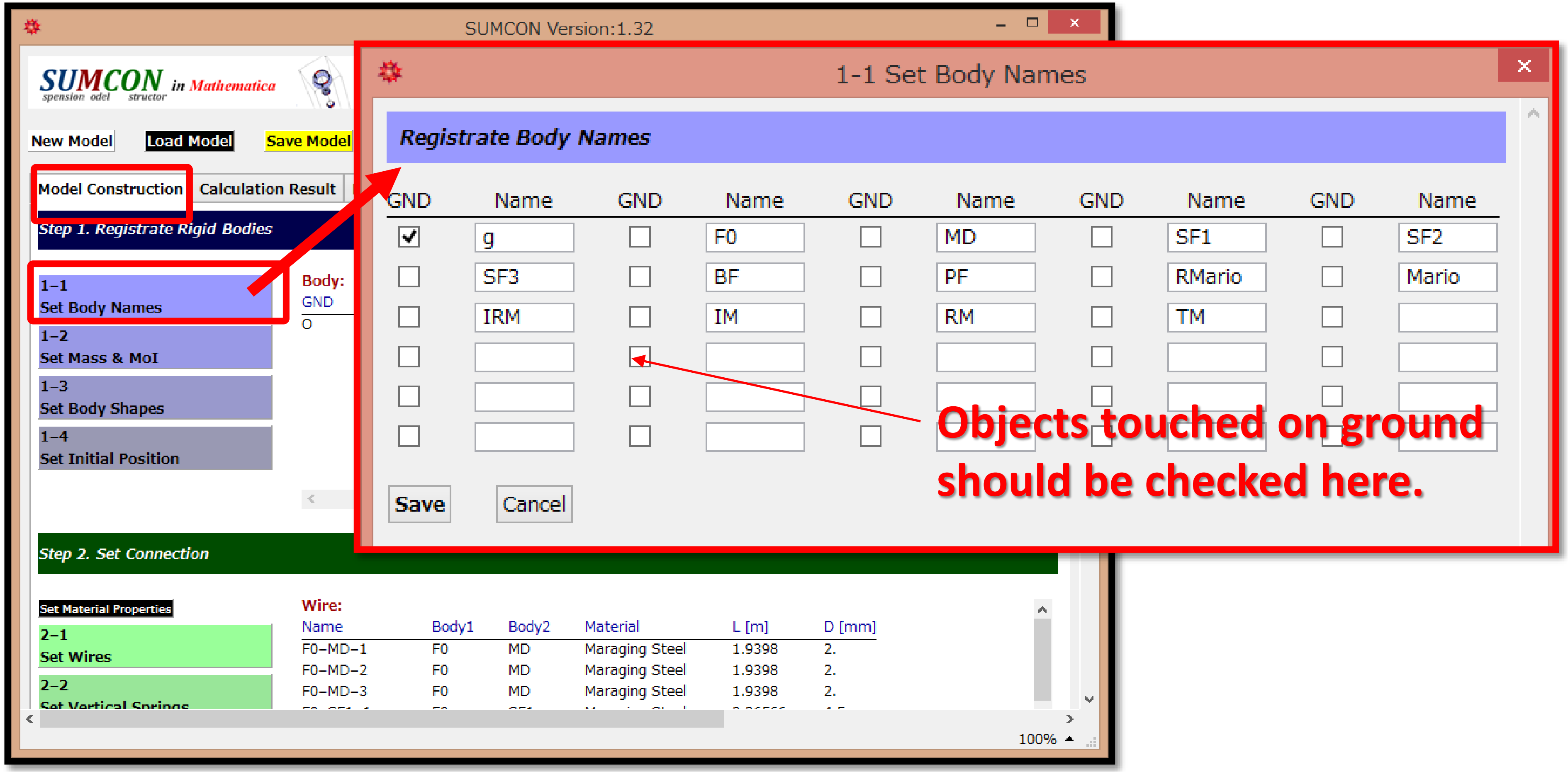


Axes definition



❖ Model construction / Step 1. / Set Body Names

2) Set suspension names

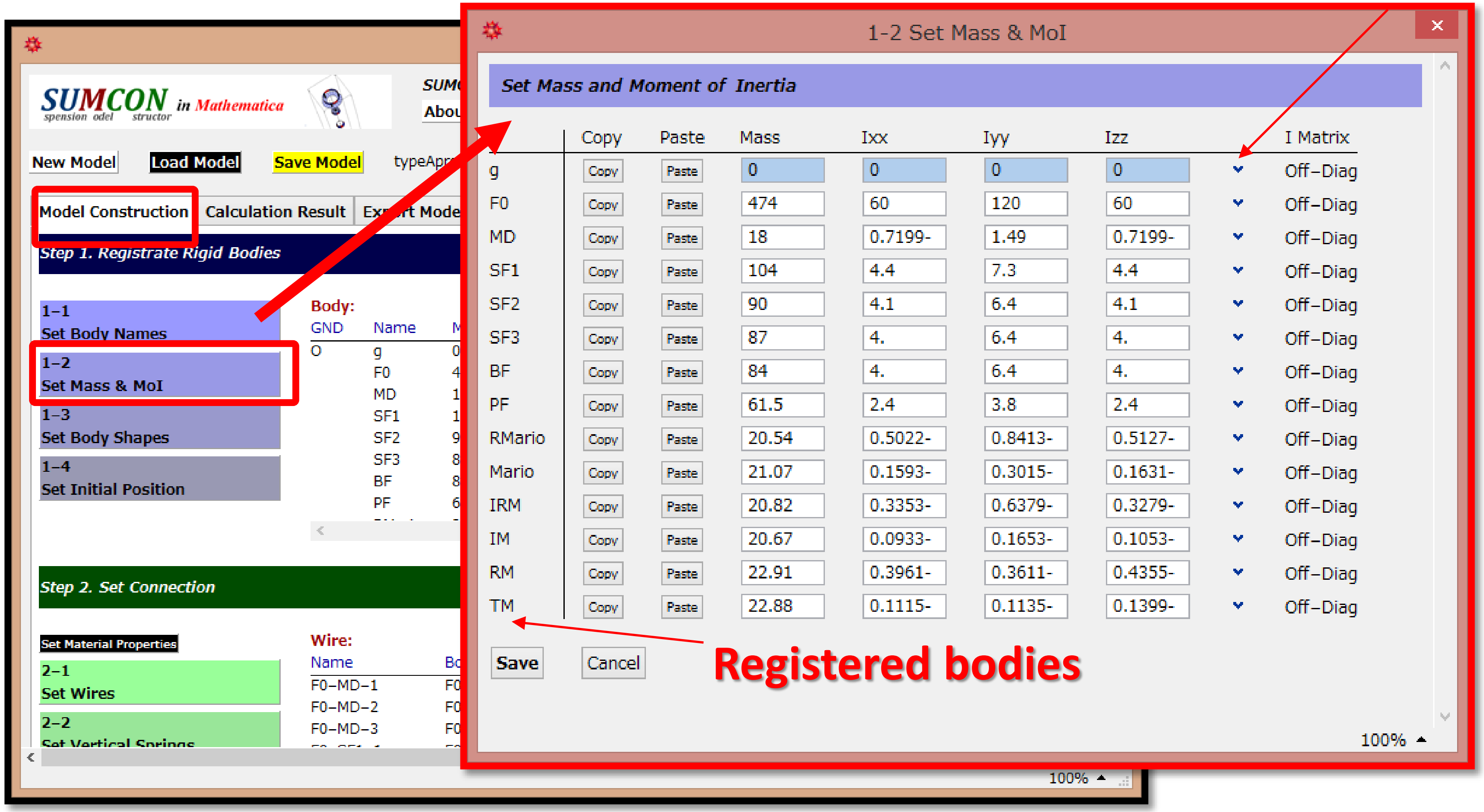


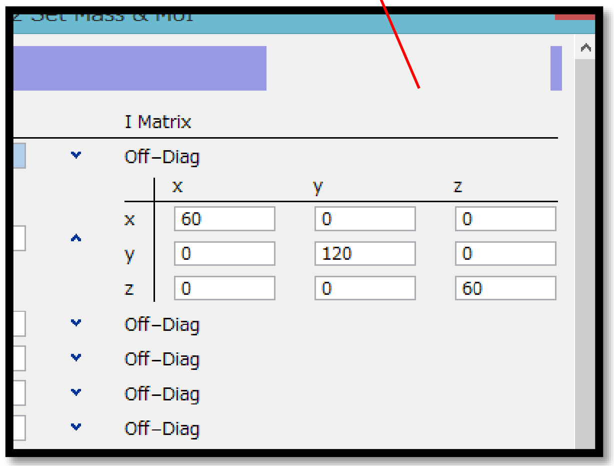
2) Click “save”, otherwise, the registered information is vanished.

❖ Model construction / Step 1. / Set Mass&

If the inertia has non-diag elements,
Please click the “Off-diag”.
Registration page is open.

3) Set Masses and Moment of inertia

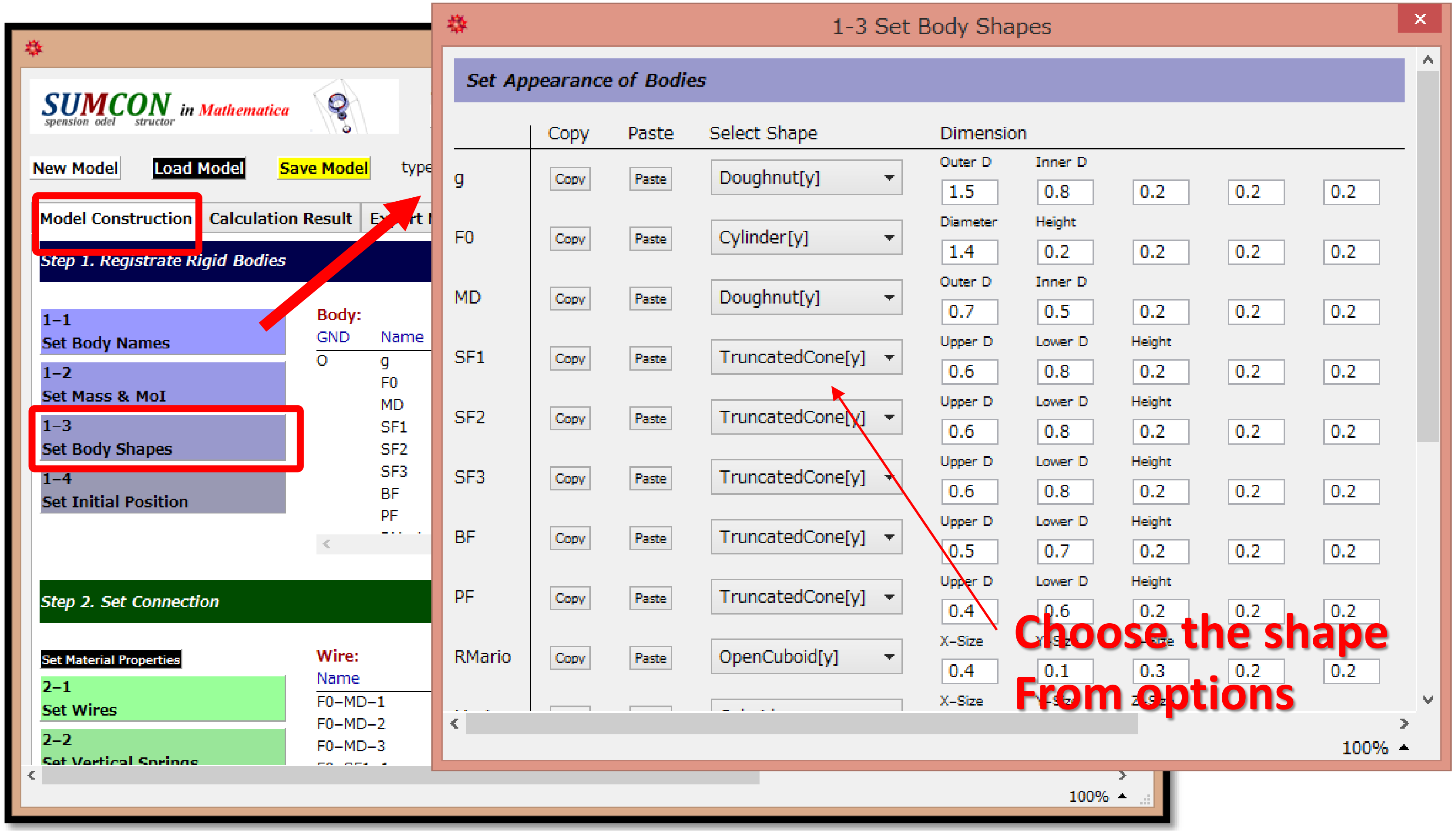




2) Click “save”, otherwise, the registered information is vanished.

❖Model construction / Step 1. / Body shape

4) Set suspension body shapes

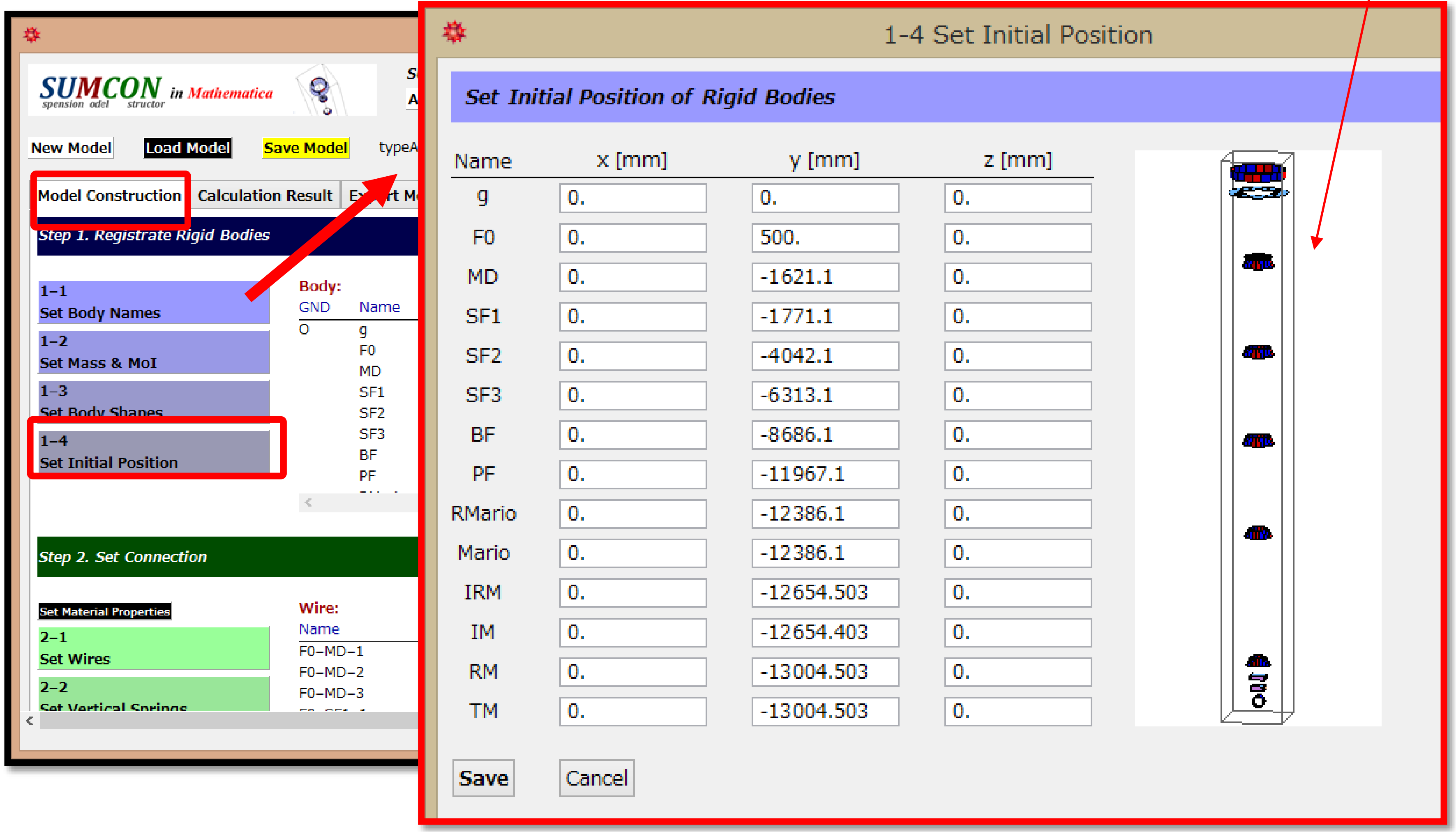


2) Click “save”, otherwise, the registered information is vanished.

❖ Model construction / Step 1.

5) Set suspension initial positions

The shape, you chose in the step 1-3, should be reflected to this screen.

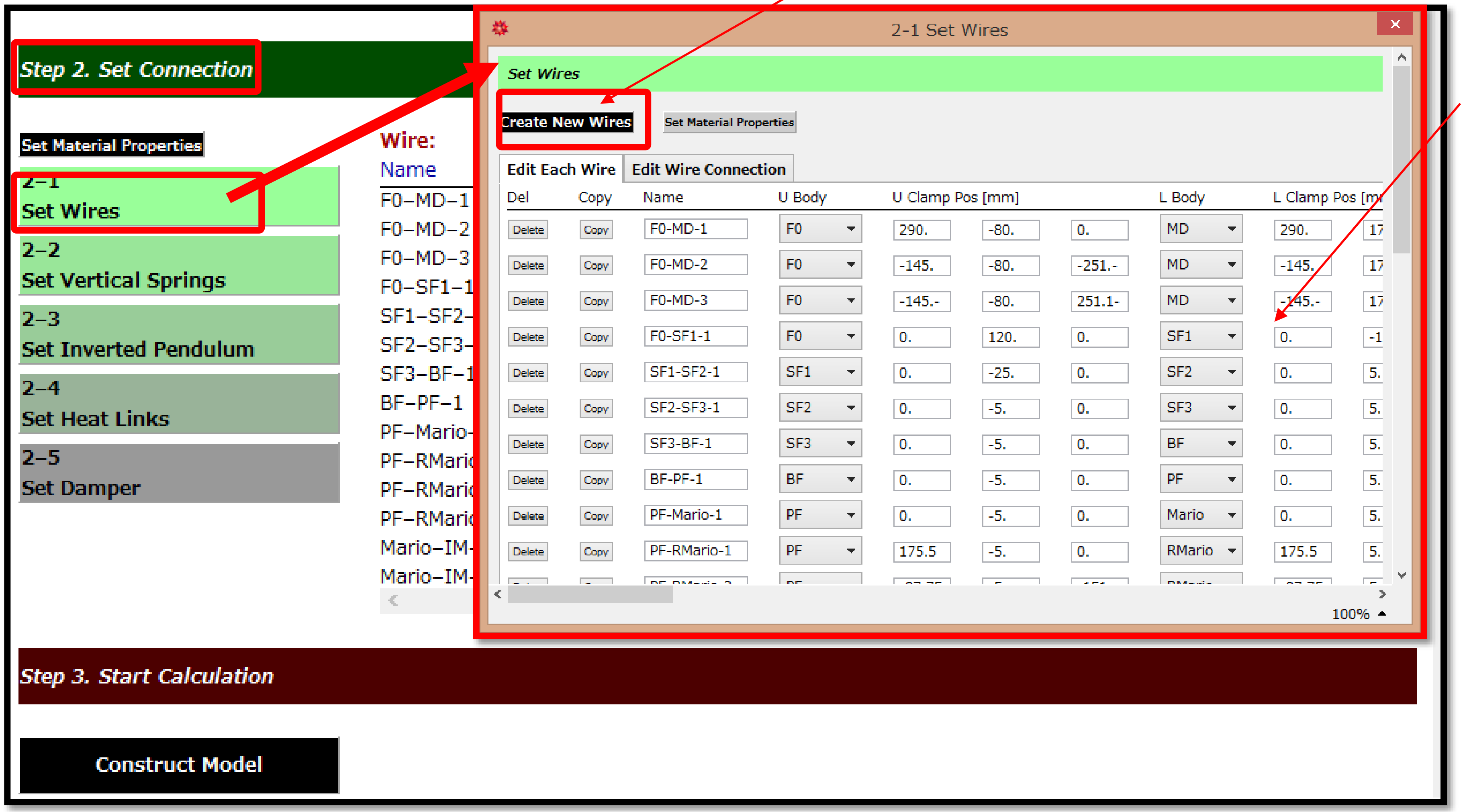


Name	x [mm]	y [mm]	z [mm]
g	0.	0.	0.
F0	0.	500.	0.
MD	0.	-1621.1	0.
SF1	0.	-1771.1	0.
SF2	0.	-4042.1	0.
SF3	0.	-6313.1	0.
BF	0.	-8686.1	0.
PF	0.	-11967.1	0.
RMario	0.	-12386.1	0.
Mario	0.	-12386.1	0.
IRM	0.	-12654.503	0.
IM	0.	-12654.403	0.
RM	0.	-13004.503	0.
TM	0.	-13004.503	0.

2) Click “save”, otherwise, the registered information is vanished.

❖ Model construction / Step 2. / Set wires

1) Set suspension wire information, by clinking here

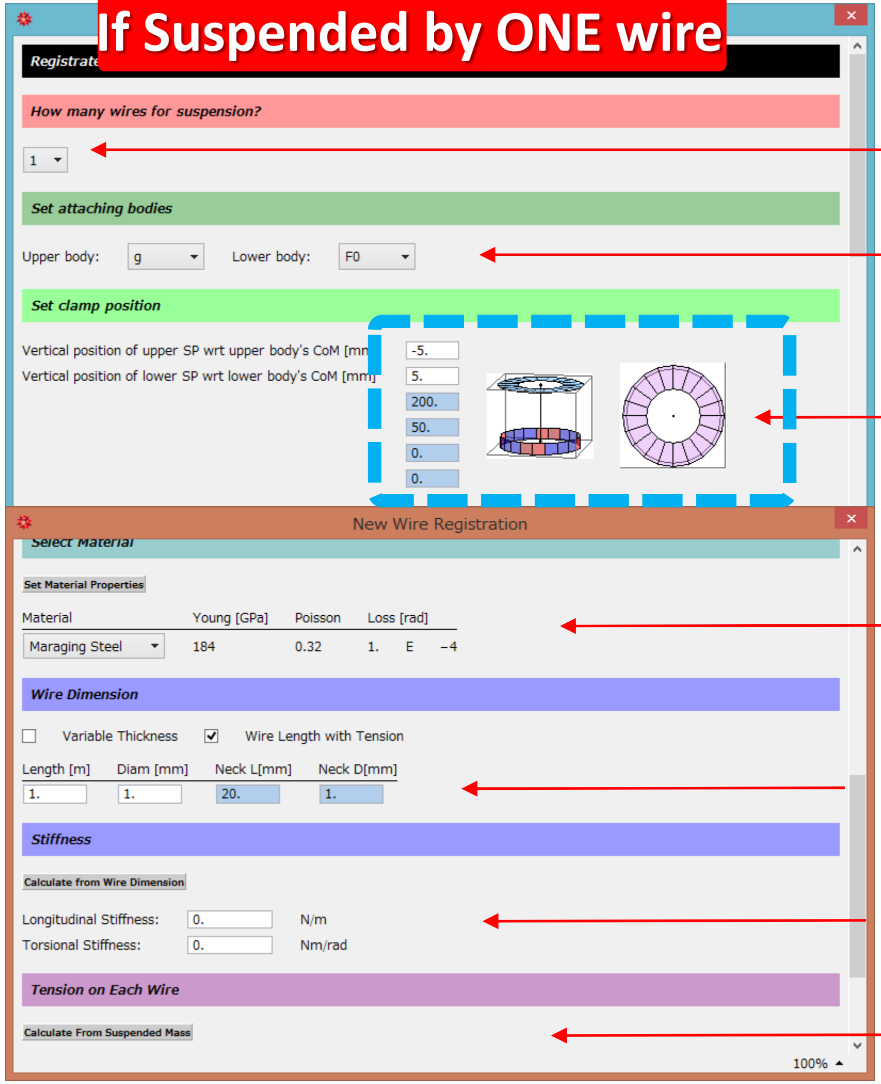


In more detail, please See p. 12 ~ p. 15

❖ Model construction / Step 2. / Set wires

2 - i) Set suspension wire information

If Suspended by ONE wire



The number of the wires

Upper & lower body name

Suspension position of the upper & lower body (From body's Center of Mas)

Wire material (They are registered already. mostly.)

1)Length, 2) diameter, 3) Neck length, 4) Neck dimeter

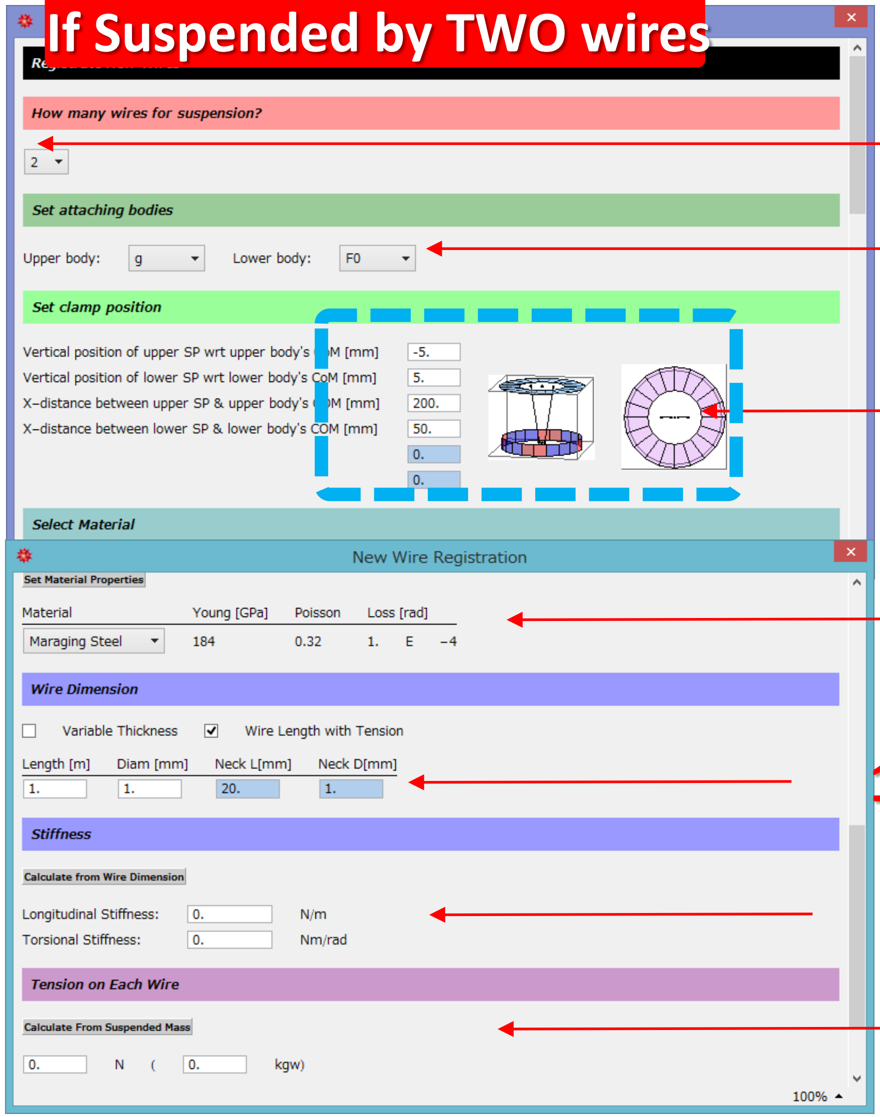
Wire stiffness

Tension on each wire

❖ Model construction / Step 2. / Set wires

2 - ii) Set suspension wire information

If Suspended by TWO wires



The number of the wires

Upper & lower body name

Suspension position of the upper & lower body (From body's Center of Mas)

Wire material (They are registered already. mostly.)

1)Length, 2) diameter, 3) Neck length, 4) Neck dimeter

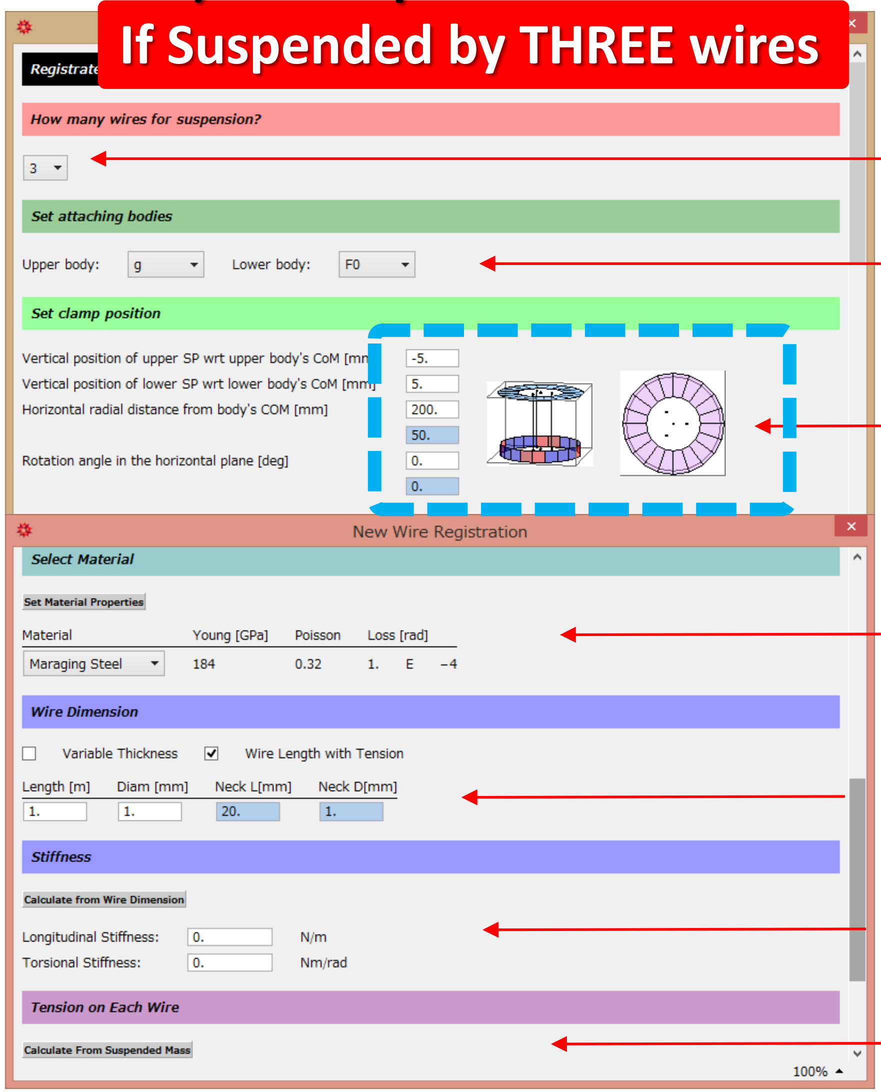
Wire stiffness

Tension on each wire

❖Model construction / Step 2. / Set wires

2 - iii) Set suspension wire information

If Suspended by THREE wires



The number of the wires

Upper & lower body name

Suspension position of the upper & lower body
(From body's Center of Mas)

Wire material (They are registered already. mostly.)

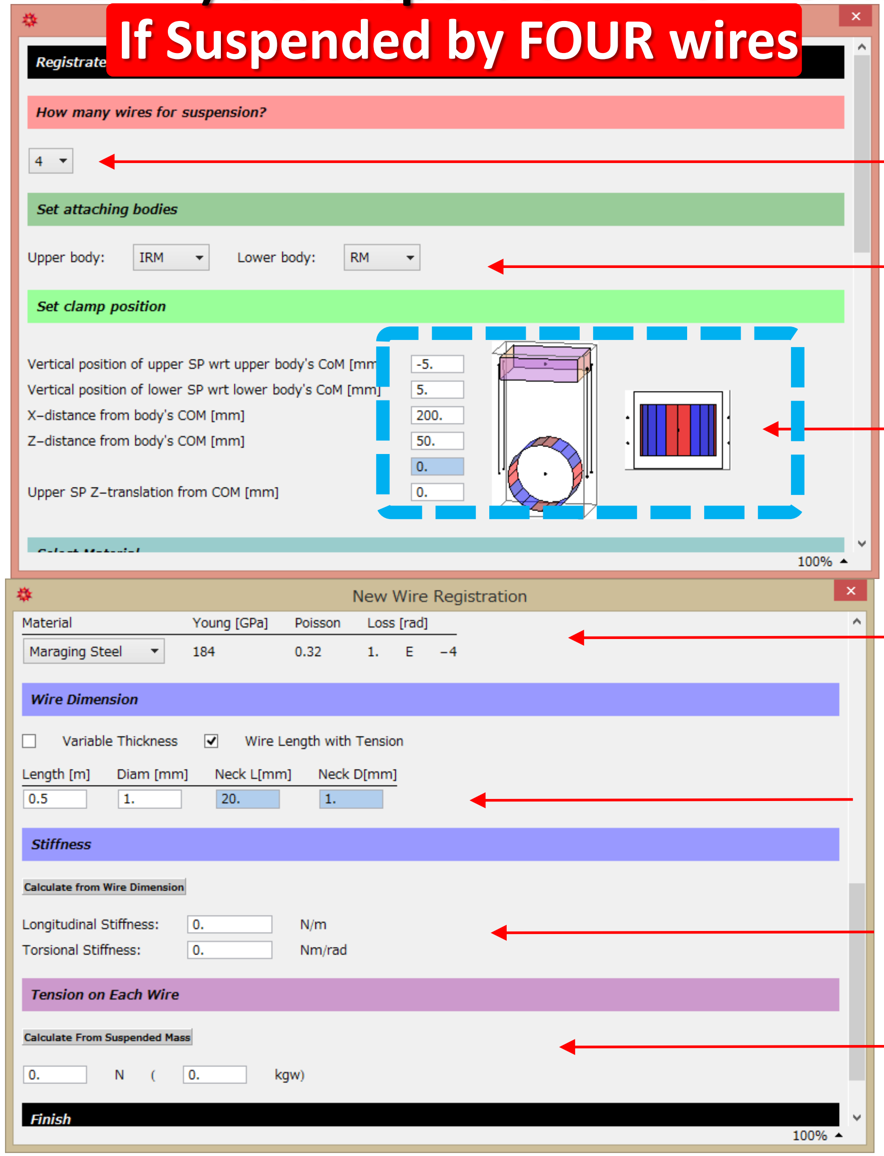
1)Length, 2) diameter, 3) Neck length, 4) Neck dimeter

Wire stiffness

Tension on each wire

❖ Model construction / Step 2. / Set wires

2 - iv) Set suspension wire information



The number of the wires

Upper & lower body name

Suspension position of the upper & lower body
(From body's Center of Mas)

Wire material (They are registered already. mostly.)

1)Length, 2) diameter, 3) Neck length, 4) Neck dimeter

Wire stiffness

Tension on each wire

❖ Model construction / Step 2. / Set wires

This sheet is output automatically.

2-1 Set Wires

Edit Each Wire | Edit Wire Connection

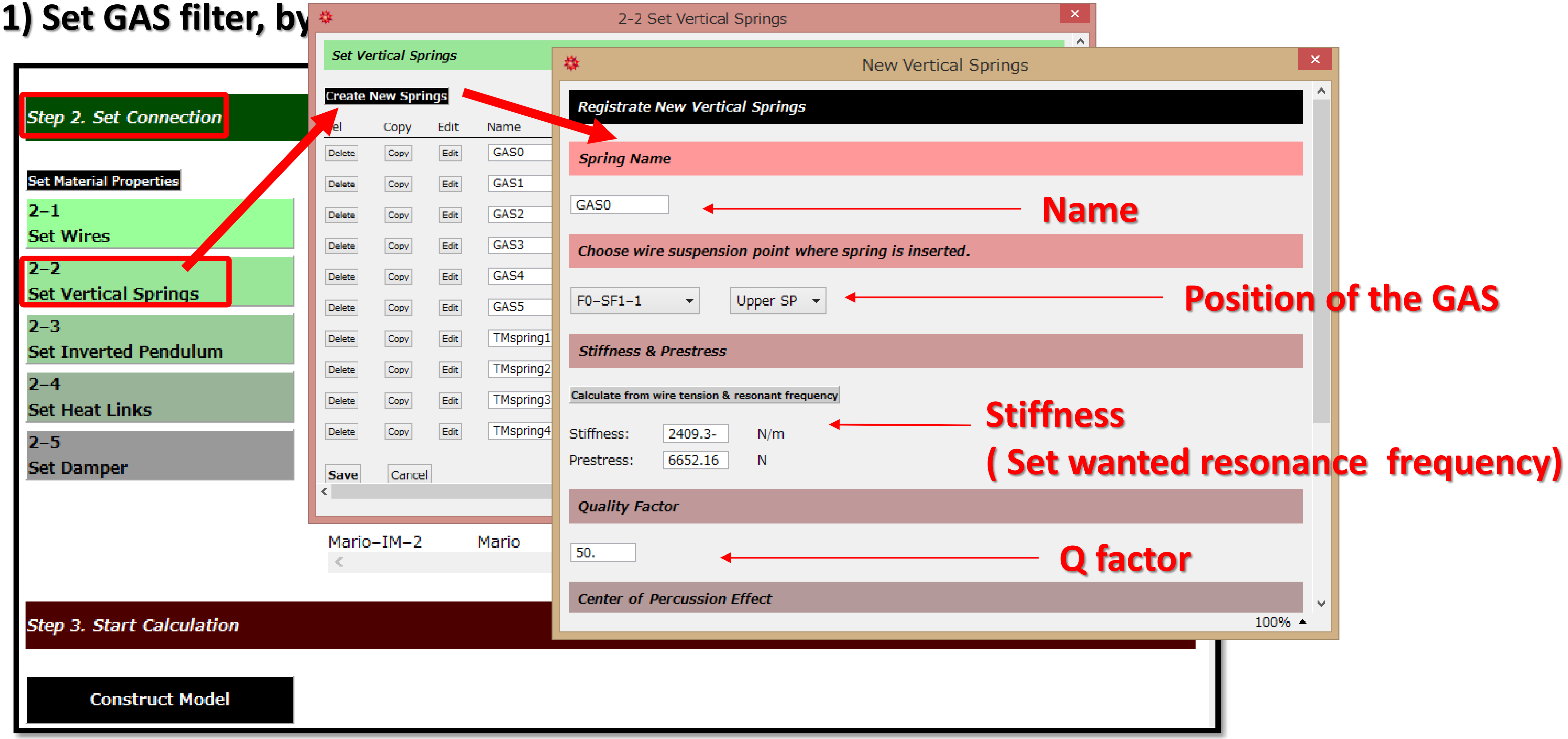
Del	Copy	Name	U Body	U Clamp Pos [mm]			L Body	L Clamp Pos [mm]			Mat	E [GPa]	Poission R	Los	[rad]		L [m]	D [mm]	NL [mm]	ND [mm]	T [N]	Upper Clamp Direction			Low
Delete	Copy	F0-MD-1	F0	290.	-80.	0.	MD	290.	17.	0.	C-70 Steel	200	0.3	3.	E	−4	1.6211	4.5000-	26.5	2.	294.3	0	-1	0	0
Delete	Copy	F0-MD-2	F0	-145.	-80.	-251.-	MD	-145.	17.	-251.-	C-70 Steel	200	0.3	3.	E	−4	1.6211	4.5000-	26.5	2.	294.3	0	-1	0	0
Delete	Copy	F0-MD-3	F0	-145.-	-80.	251.1-	MD	-145.-	17.	251.1-	C-70 Steel	200	0.3	3.	E	−4	1.6211	4.5000-	26.5	2.	294.3	0	-1	0	0
Delete	Copy	F0-SF1-1	F0	0.	120.	0.	SF1	0.	2.5	0.	Maraging Steel	184	0.32	1.	E	−4	2.2711	4.5000-	30.5	3.	6652.16	0	-1	0	0
Delete	Copy	SF1-SF2-1	SF1	0.	-44.	0.	SF2	0.	2.5	0.	Maraging Steel	184	0.32	1.	E	−4	2.271	4.5000-	30.5	3.	5546.5-	0	-1	0	0
Delete	Copy	SF2-SF3-1	SF2	0.	-44.	0.	SF3	0.	2.5	0.	Maraging Steel	184	0.32	1.	E	−4	2.271	4.5000-	30.5	3.	4440.99	0	-1	0	0
Delete	Copy	SF3-BF-1	SF3	0.	-44.	0.	BF	0.	2.5	0.	Maraging Steel	184	0.32	1.	E	−4	2.373	4.5000-	30.5	3.	3335.4	0	-1	0	0
Delete	Copy	BF-PF-1	BF	0.	-54.5	0.	PF	0.	1.5	0.	Maraging Steel	184	0.32	1.	E	−4	3.281	4.5000-	30.5	3.	2354.4	0	-1	0	0
Delete	Copy	PF-Mario-1	PF	0.	-79.0-	0.	Mario	0.	1.5	0.	Maraging Steel	184	0.32	1.	E	−4	0.169	4.5000-	40.5	2.	712.206	0	-1	0	0
Delete	Copy	PF-RMario-1	PF	0.	20.	-175.5	RMario	0.	17.	-175.5	Copper Beryllium	134	0.3	5.	E	−6	0.287	4.5000-	40.5	2.	857.394	0	-1	0	0
Delete	Copy	PF-RMario-2	PF	151.9-	20.	87.75	RMario	151.9-	17.	87.75	Copper Beryllium	134	0.3	5.	E	−6	0.287	4.5000-	40.5	2.	857.394	0	-1	0	0
Delete	Copy	PF-RMario-3	PF	-151.-	20.	87.75	RMario	-151.-	17.	87.75	Copper Beryllium	134	0.3	5.	E	−6	0.287	4.5000-	40.5	2.	857.394	0	-1	0	0
Delete	Copy	Mario-IM-1	Mario	94.	-5.	110.	IM	94.	5.	110.	Copper Beryllium	134	0.3	5.	E	−6	0.2684-	0.6	0.	0.6	464.994	0	-1	0	0
Delete	Copy	Mario-IM-3	Mario	-94.	-5.	110.	IM	-94.	5.	110.	Copper Beryllium	134	0.3	5.	E	−6	0.2684-	0.6	0.	0.6	464.994	0	-1	0	0
Delete	Copy	Mario-IM-4	Mario	-94.	-5.	-110.	IM	-94.	5.	-110.	Copper Beryllium	134	0.3	5.	E	−6	0.2684-	0.6	0.	0.6	464.994	0	-1	0	0
Delete	Copy	RMario-IRM-1	RMario	171.7	5.	161.	IRM	171.7	30.	161.	Copper Beryllium	134	0.3	5.	E	−6	0.2425-	0.6	0.	0.6	610.182	0	-1	0	0
Delete	Copy	RMario-IRM-2	RMario	171.7	5.	-161.	IRM	171.7	30.	-161.	Copper Beryllium	134	0.3	5.	E	−6	0.2425-	0.6	0.	0.6	610.182	0	-1	0	0
Delete	Copy	RMario-IRM-3	RMario	-171.7	5.	161.	IRM	-171.7	30.	161.	Copper Beryllium	134	0.3	5.	E	−6	0.2425-	0.6	0.	0.6	610.182	0.	-1.	0.	0.
Delete	Copy	RMario-IRM-4	RMario	-171.7	5.	-161.	IRM	-171.7	30.	-161.	Copper Beryllium	134	0.3	5.	E	−6	0.2425-	0.6	0.	0.6	610.182	0.	-1.	0.	0.
Delete	Copy	IM-TM-1	IM	114.2	-40.	29.2	TM	114.2	-30.	29.2	Sapphire	345	0.3	2.	E	−7	0.33	1.6	0.	1.6	221.706	0	-1	0	0
Delete	Copy	IM-TM-2	IM	114.2	-40.	-29.2	TM	114.2	-30.	-29.2	Sapphire	345	0.3	2.	E	−7	0.33	1.6	0.	1.6	221.706	0	-1	0	0
Delete	Copy	IM-TM-3	IM	-114.2	-40.	29.2	TM	-114.2	-30.	29.2	Sapphire	345	0.3	2.	E	−7	0.33	1.6	0.	1.6	221.706	0	-1	0	0
Delete	Copy	IM-TM-4	IM	-114.2	-40.	-29.2	TM	-114.2	-30.	-29.2	Sapphire	345	0.3	2.	E	−7	0.33	1.6	0.	1.6	221.706	0	-1	0	0
Delete	Copy	IRM-RM-1	IRM	153.1-	50.	44.70-	RM	153.1-	50.	44.70-	Copper Beryllium	134	0.3	5.	E	−6	0.3308-	0.6	0.	1.	362.97-	0	-1	0	0
Delete	Copy	IRM-RM-2	IRM	153.1-	50.	-44.7-	RM	153.1-	50.	-44.7-	Copper Beryllium	134	0.3	5.	E	−6	0.3308-	0.6	0.	1.	362.97-	0	-1	0	0
Delete	Copy	IRM-RM-3	IRM	-153.-	50.	44.70-	RM	-153.-	50.	44.70-	Copper Beryllium	134	0.3	5.	E	−6	0.3308-	0.6	0.	1.	362.97-	0	-1	0	0
Delete	Copy	IRM-RM-4	IRM	-153.-	50.	-44.7-	RM	-153.-	50.	-44.7-	Copper Beryllium	134	0.3	5.	E	−6	0.3308-	0.6	0.	1.	362.97-	0	-1	0	0

Save | Cancel

100%

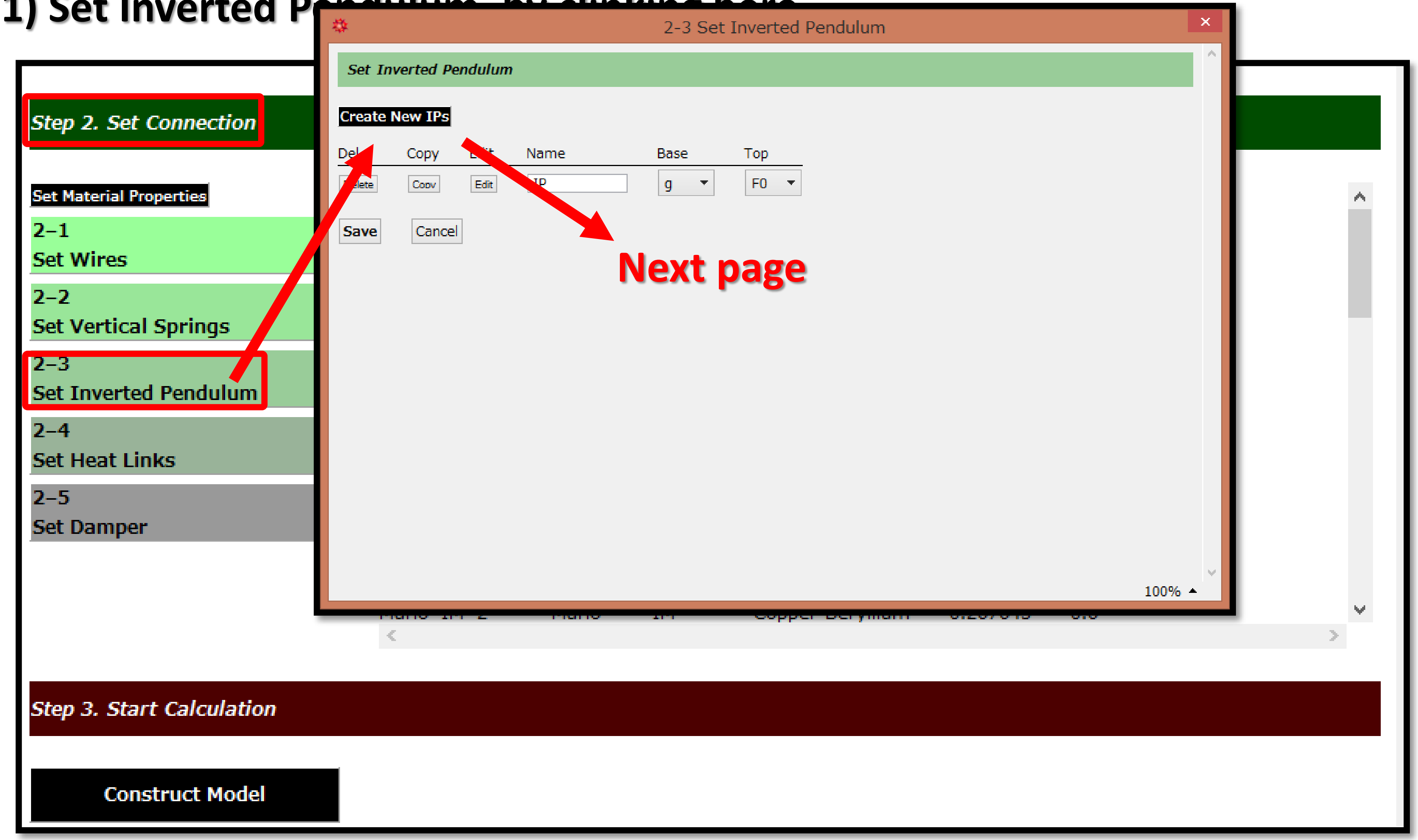
❖Model construction / Step 2. / Set Vertical springs (GAS)

1) Set GAS filter, by



❖Model construction / Step 2. / Set IP

1) Set Inverted Pendulum by clicking here



❖Model construction / Step 2. / Set IP

Name

Position of the IP

Position of the IP legs

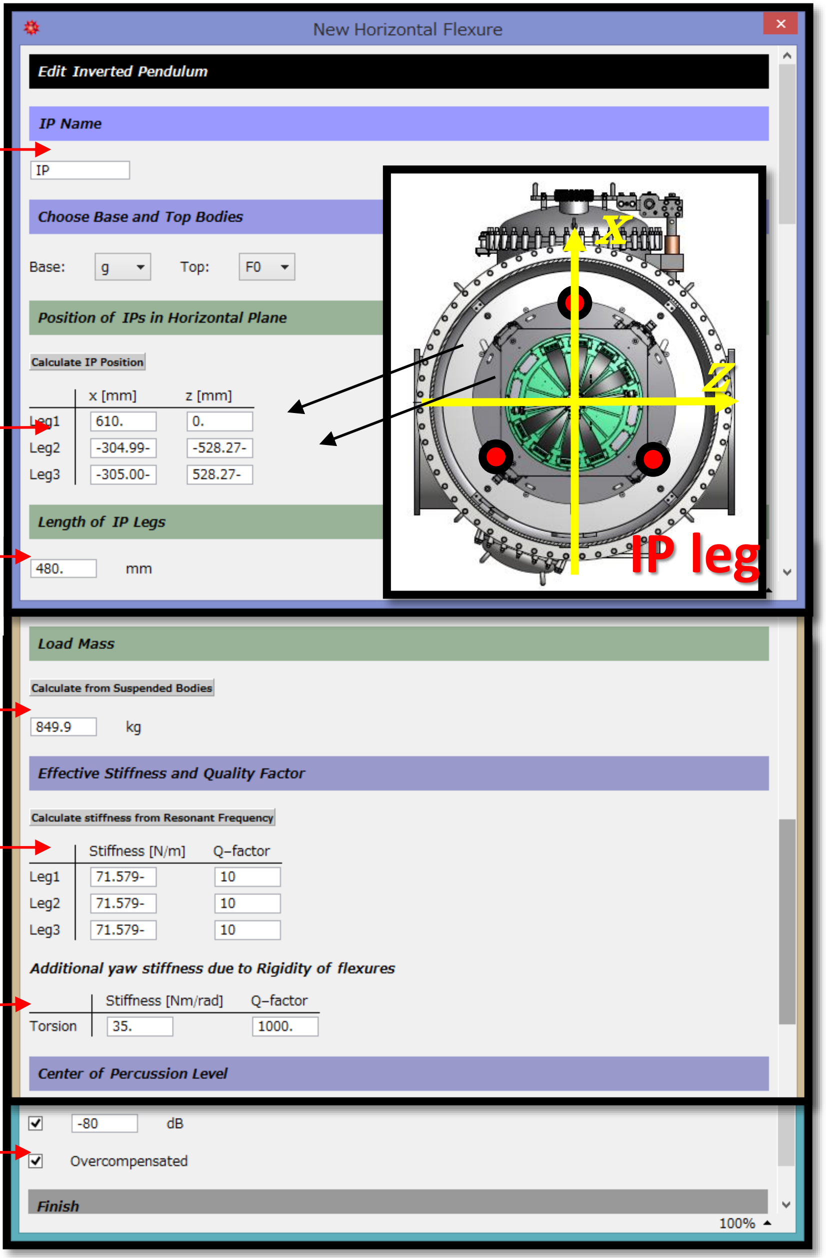
Length of the IP leg

Load mass on the IP

Effective bending stiffness of bottom flexure

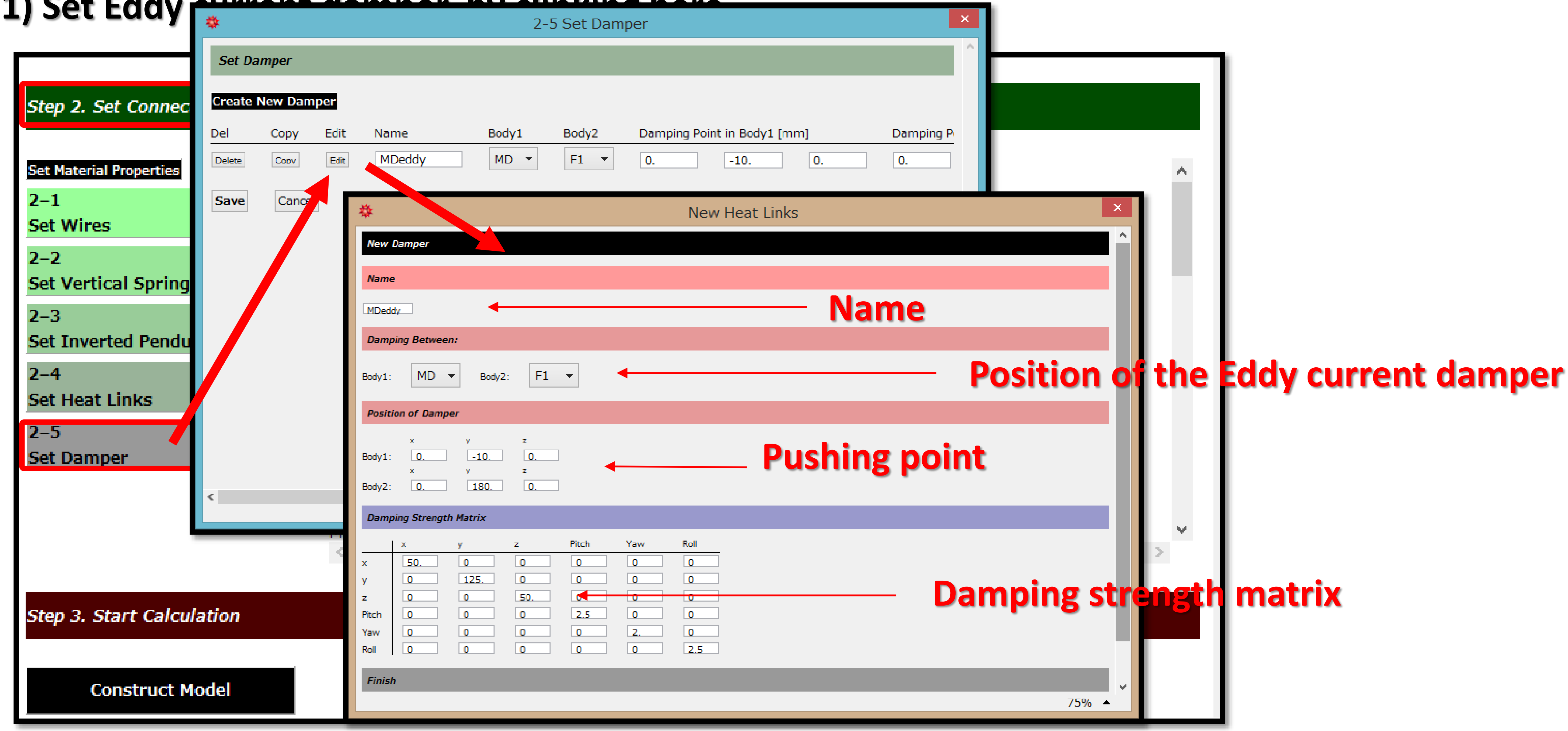
Additional torsion stiffness

CoP level



❖ Model construction / Step 2. / Damper

1) Set Eddy



❖ Model construction / Step 3.

1) Start the calculation, by clinking here

Step 2. Set Connection

Set Material Properties

2–1
Set Wires

2–2
Set Vertical Springs

2–3
Set Inverted Pendulum

2–4
Set Heat Links

2–5
Set Damper

Wire:

Name	Body1	Body2	Material	L [m]	D [mm]
F0–MD–1	F0	MD	Maraging Steel	1.9398	2.
F0–MD–2	F0	MD	Maraging Steel	1.9398	2.
F0–MD–3	F0	MD	Maraging Steel	1.9398	2.
F0–SF1–1	F0	SF1	Maraging Steel	2.26566	4.5
SF1–SF2–1	SF1	SF2	Maraging Steel	2.26644	4.5
SF2–SF3–1	SF2	SF3	Maraging Steel	2.26711	4.5
SF3–BF–1	SF3	BF	Maraging Steel	2.36766	4.5
BF–PF–1	BF	PF	Maraging Steel	3.3877	4.5
PF–Mario–1	PF	Mario	Maraging Steel	0.406237	4.5
PF–RMario–1	PF	RMario	Maraging Steel	0.227468	4.5
PF–RMario–2	PF	RMario	Maraging Steel	0.227468	4.5
PF–RMario–3	PF	RMario	Maraging Steel	0.227468	4.5
Mario–IM–1	Mario	IM	Copper Beryllium	0.267643	0.6
Mario–IM–2	Mario	IM	Copper Beryllium	0.267643	0.6

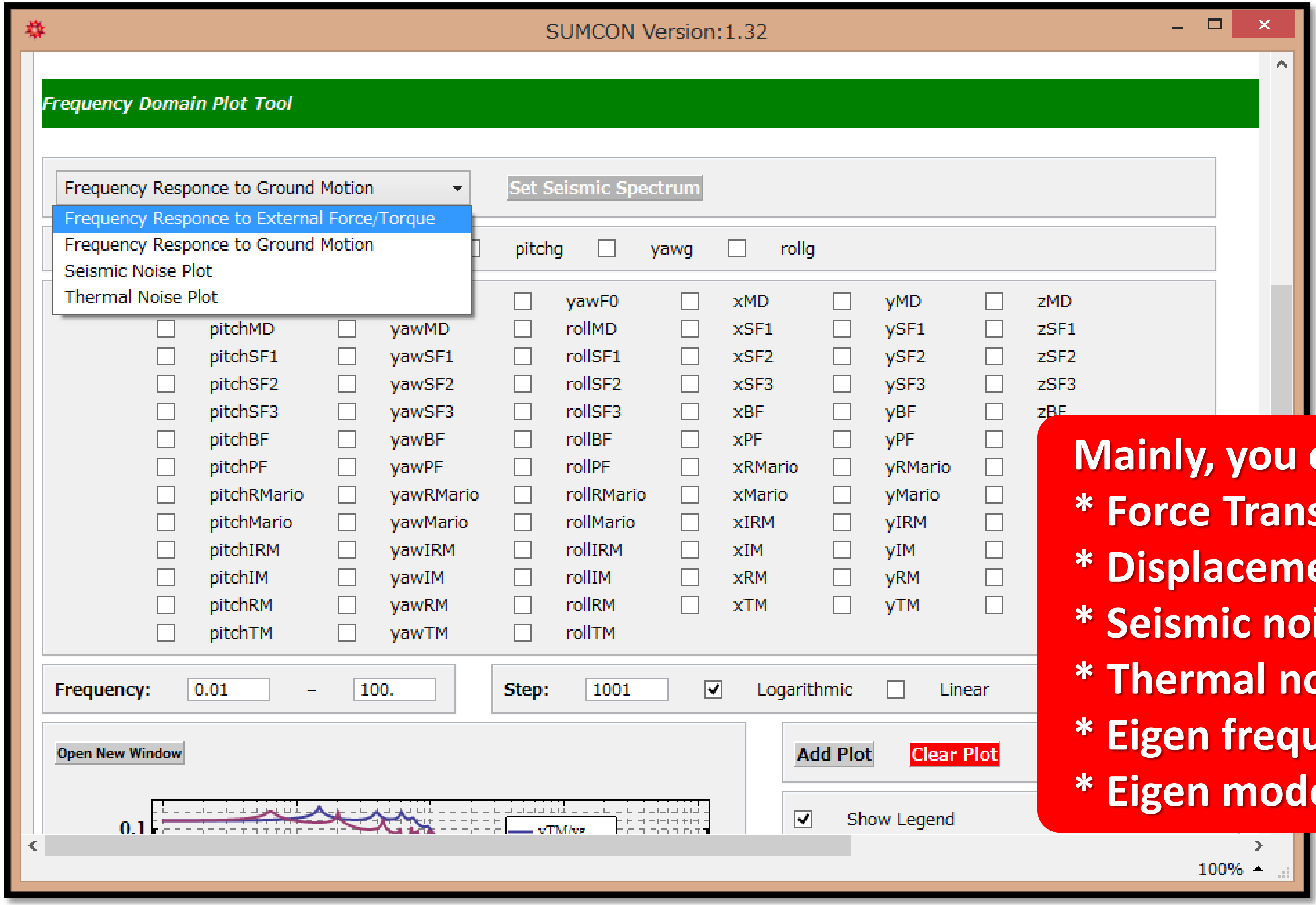
Step 3. Start Calculation

Construct Model

Start calculation, by pushing here!

❖ Model construction / Step 3.

1) In the end, you can get the frequency response, and its eigen mode shapes!



You can click anywhere!
Please play with this tool!

(Some stuffs are to be added.)

Mainly, you can plot(get) ;
* Force Transfer function
* Displacement Transfer function
* Seismic noise
* Thermal noise
* Eigen frequency
* Eigen mode shape

For example,

SUMCON in *Mathematica*

SUMCON Version:1.32

About SUMCON | Version Info | Reflesh

New Model | Load Model | Save Model | TypeB1¥150723_TypeB1_Proto.m

Model Construction | Calculation Result | Export Model

Model Basic Information

Degrees of Freedom:

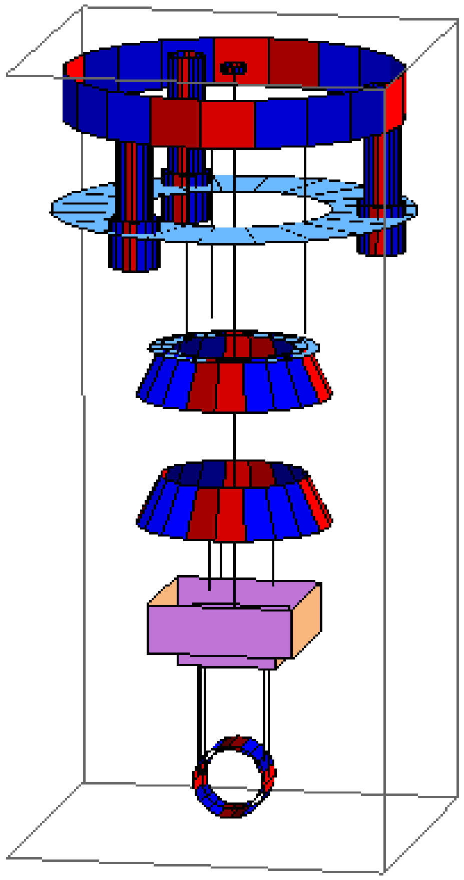
45	State Variables
6	Input Variables
3	Float Variables

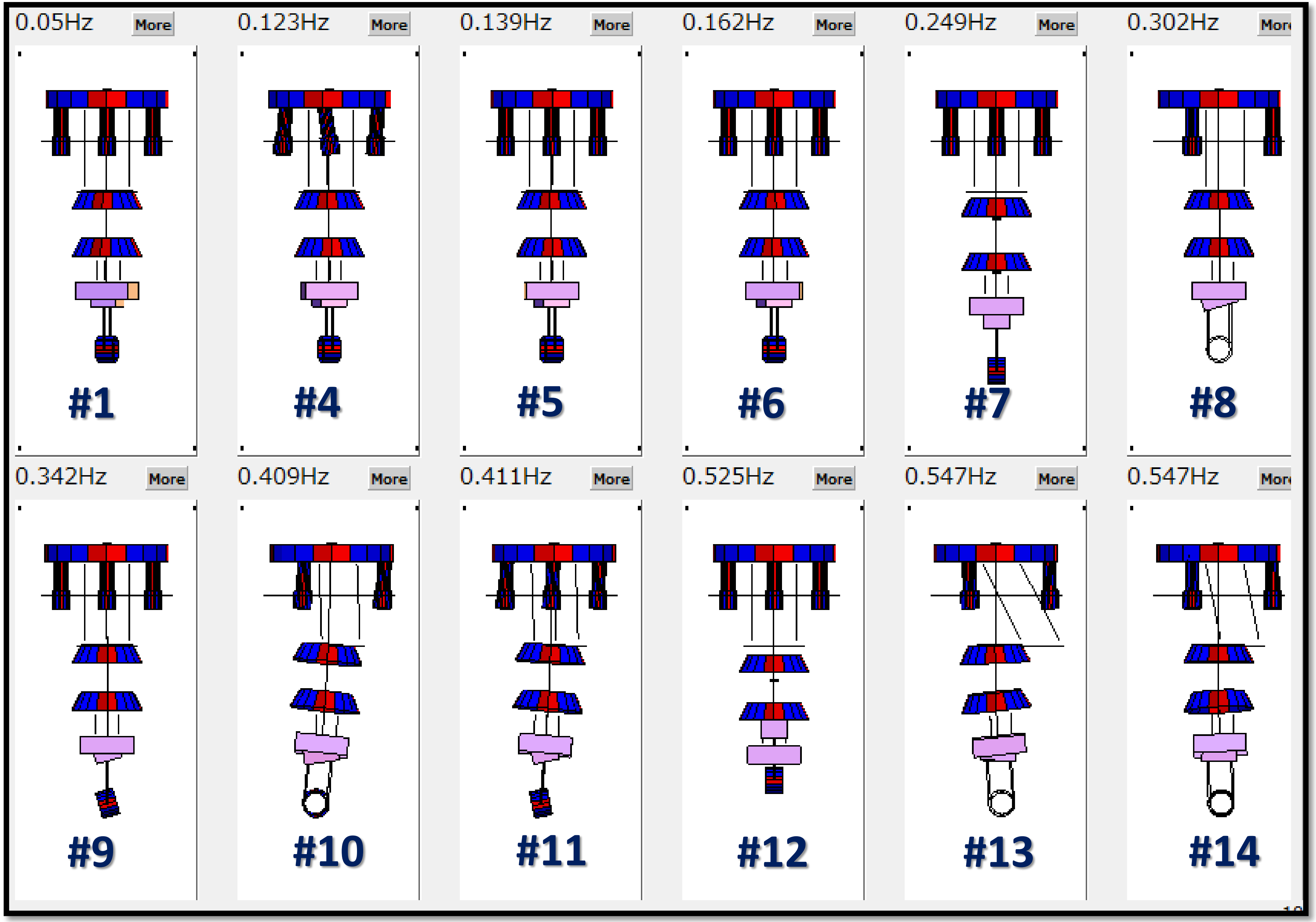
Ground Position:

xg → 0. yg → 0. zg → 0. pitchg → 0. yawg → 0. rollg → 0.

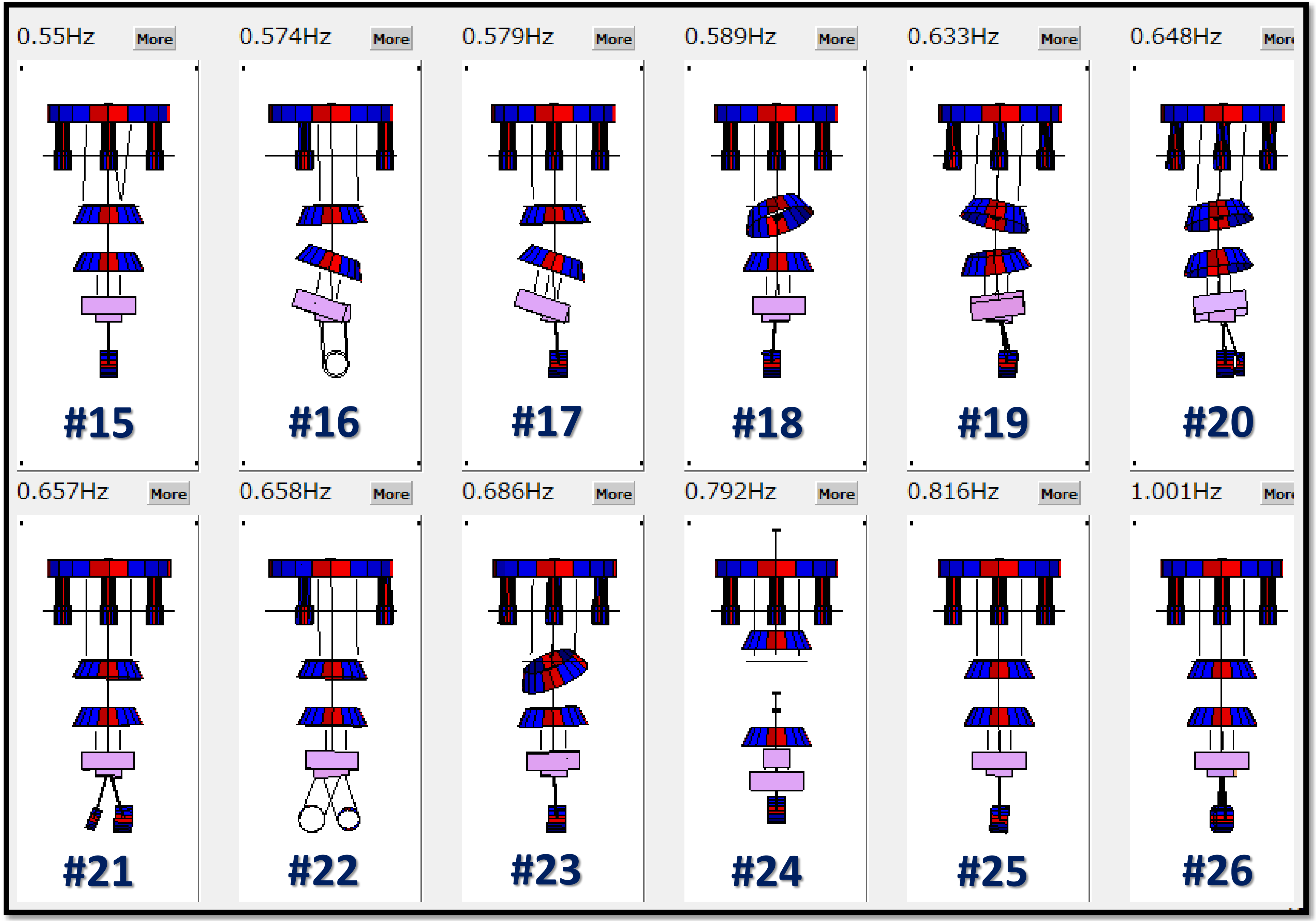
Equilibrium Point:

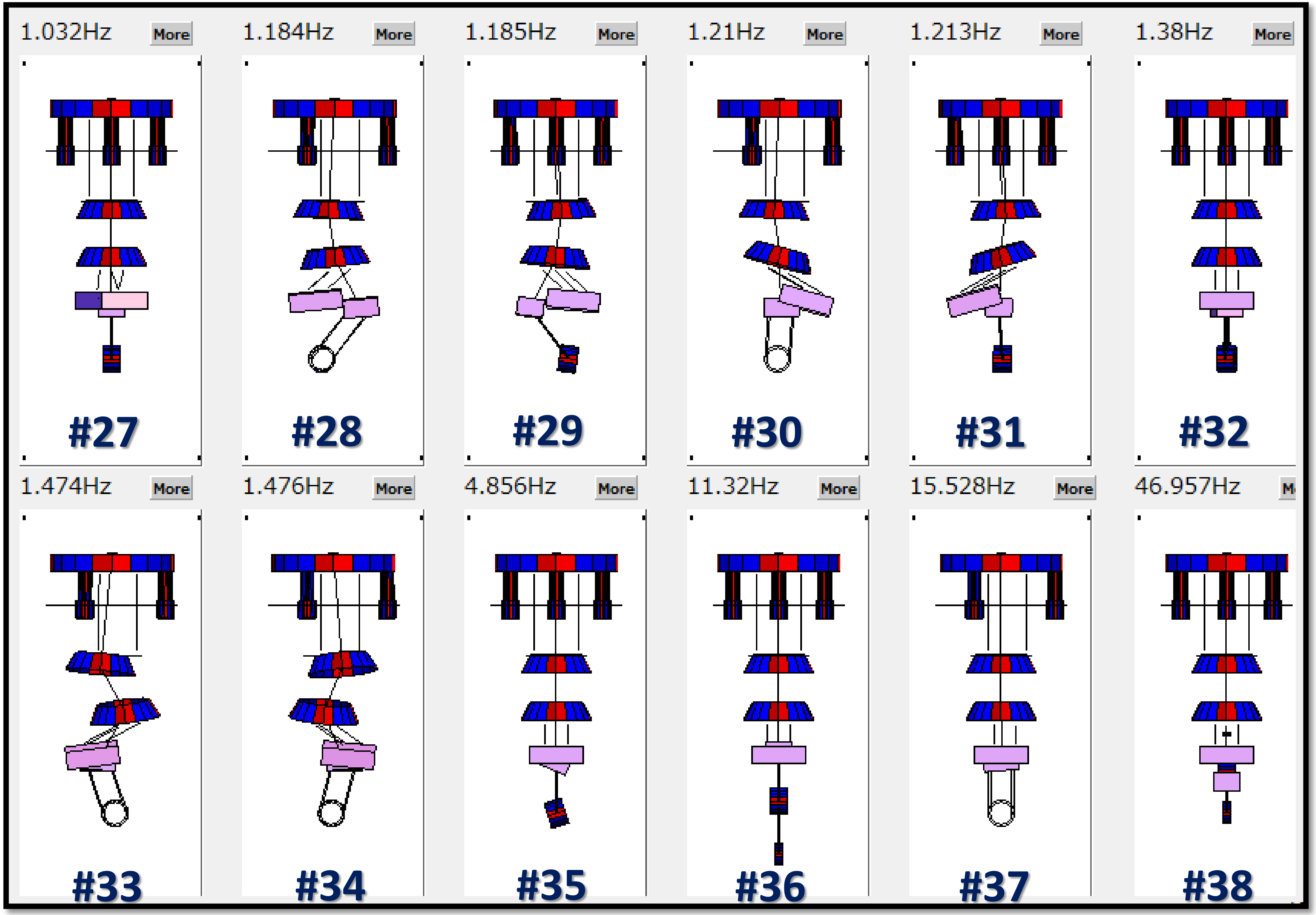
xF0 → 0.	zF0 → 0.	yawF0 → 0.	xMD → 0.	yMD → −0.572	zMD → 0.
pitchMD → 0.	yawMD → 0.	rollMD → 0.	xF1 → 0.	yF1 → −0.665	zF1 → 0.
pitchF1 → 0.	yawF1 → 0.	rollF1 → 0.	xF2 → 0.	yF2 → −1.1984	zF2 → 0.
pitchF2 → 0.	yawF2 → 0.	rollF2 → 0.	xIR → 0.	yIR → −1.6936	zIR → 0.
pitchIR → 0.	yawIR → 0.	rollIR → 0.	xIM → 0.	yIM → −1.7699	zIM → 0.
pitchIM → 0.	yawIM → 0.	rollIM → 0.	xRM → 0.	yRM → −2.3569	zRM → 0.
pitchRM → 0.	yawRM → 0.	rollRM → 0.	xTM → 0.	yTM → −2.3569	zTM → 0.
pitchTM → 0.	yawTM → 0.	rollTM → 0.	hGAS0 → 0.	hGAS1 → 0.	hGAS2 → 0.

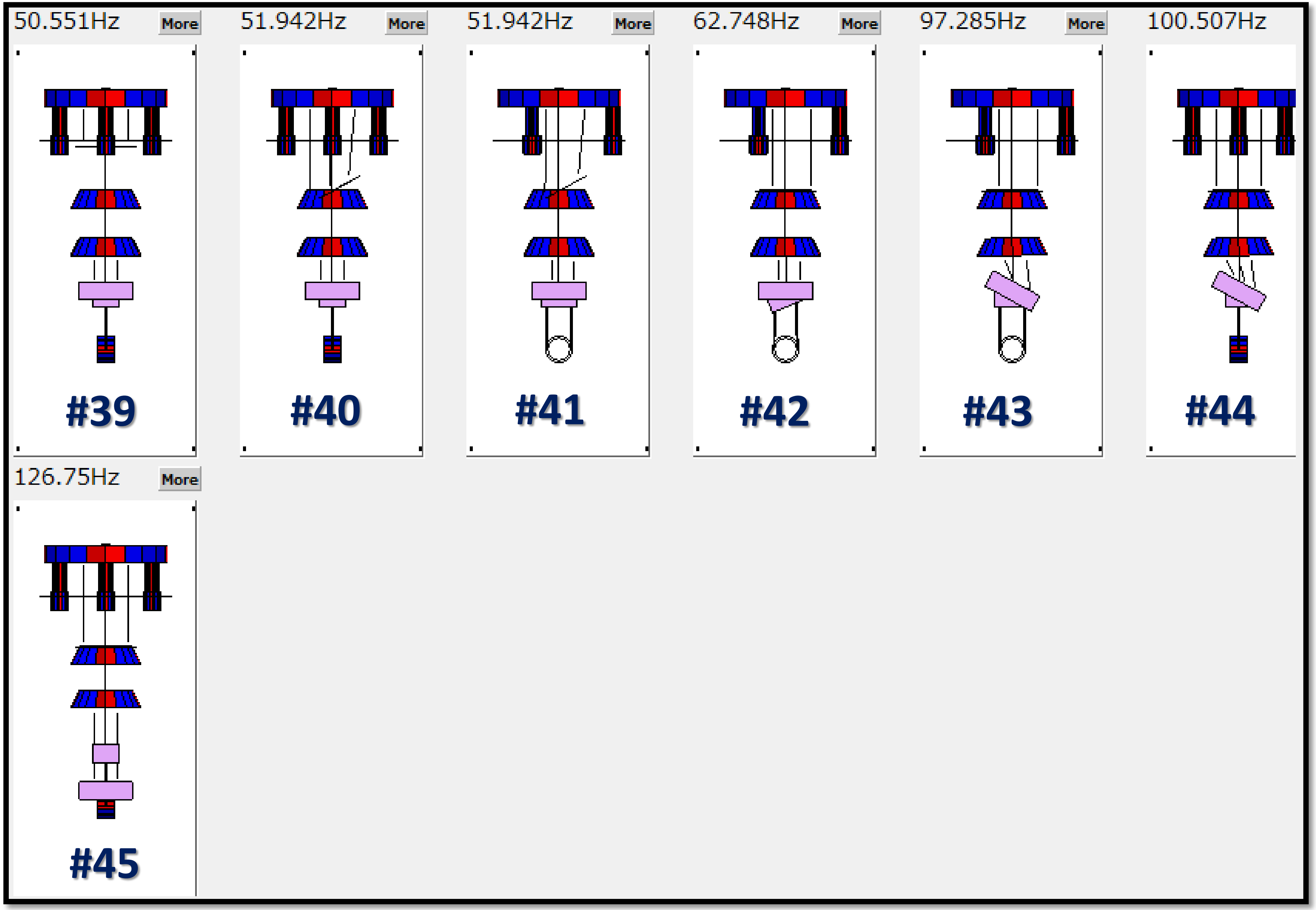




0.05Hz
More
#1
0.123Hz
More
#4
0.139Hz
More
#5
0.162Hz
More
#6
0.249Hz
More
#7
0.302Hz
#8
0.342Hz
More
#9
0.409Hz
More
#10
0.411Hz
More
#11
0.525Hz
More
#12
0.547Hz
More
#13
0.547Hz
#14


0.55Hz
More
#15
0.574Hz
More
#16
0.579Hz
More
#17
0.589Hz
More
#18
0.633Hz
More
#19
0.648Hz
#20
0.657Hz
More
#21
0.658Hz
More
#22
0.686Hz
More
#23
0.792Hz
More
#24
0.816Hz
More
#25
1.001Hz
#26


1.032Hz
More
#27
1.184Hz
More
#28
1.185Hz
More
#29
1.21Hz
More
#30
1.213Hz
More
#31
1.38Hz
More
#32
1.474Hz
More
#33
1.476Hz
More
#34
4.856Hz
More
#35
11.32Hz
More
#36
15.528Hz
More
#37
46.957Hz
#38


50.551Hz
More
#39
51.942Hz
More
#40
51.942Hz
More
#41
62.748Hz
More
#42
97.285Hz
More
#43
100.507Hz
More
#44
126.75Hz
More
#45