

# Frequency Response 해석

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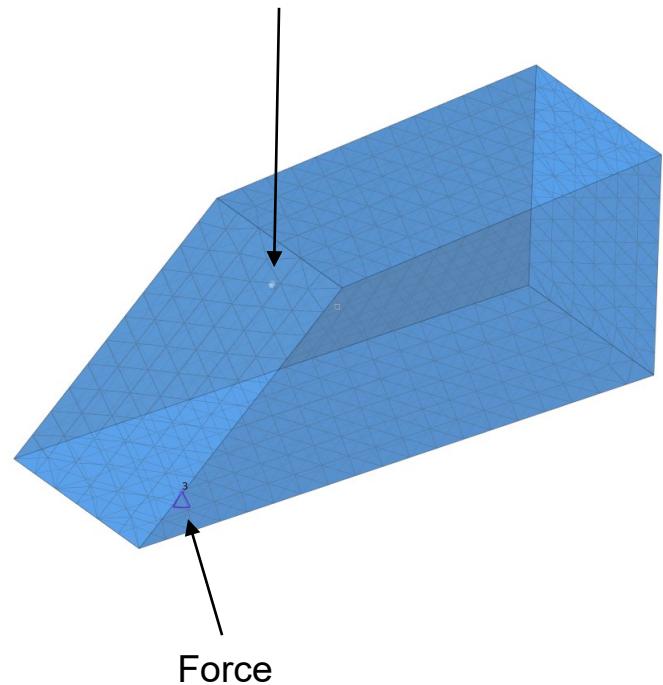


# 목차

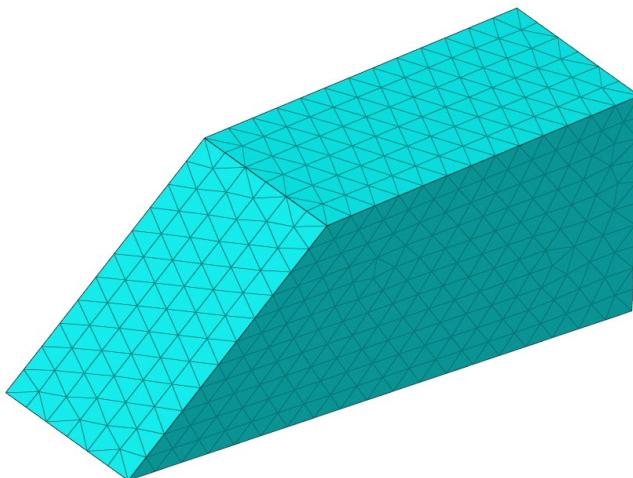
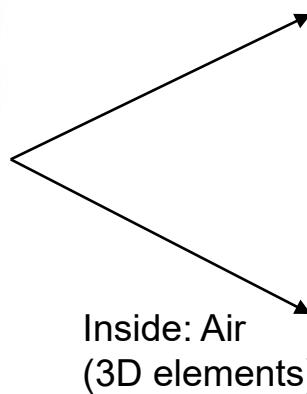
- 예제 문제
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# ACOUSTIC ANALYSIS OF A HALF CAR MODEL

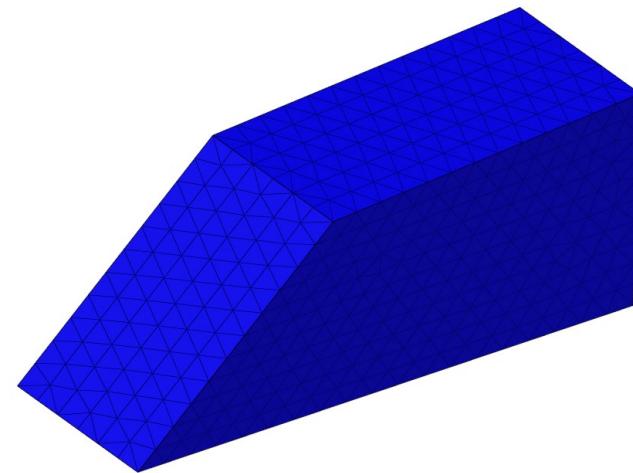
Location near the ear of driver



Outside: Solid  
(2D shell elements)



Inside: Air  
(3D elements)



# COUPLED FREQUENCY RESPONSE ANALYSIS

$$\frac{1}{\rho} \nabla p + \ddot{\mathbf{u}} = 0$$

Inviscid flow  
(linear pressure-density relation)

$$p + \beta(\nabla \cdot \mathbf{u}) = 0$$

Continuity equation

Governing equation of the fluid domain

$$\frac{\ddot{p}}{\beta} - \frac{1}{\rho} \nabla^2 p = 0$$

$p$  : Pressure of fluid domain

$\mathbf{u}$  : Displacement of structural domain

$\beta$  : Compressibility of fluid domain

$\rho$  : Density of structural domain

Effect of structure on the fluid domain

$$\mathbf{M}_F \ddot{p} + \mathbf{C}_F \dot{p} + \mathbf{K}_F p - \mathbf{A}_{int} \ddot{\mathbf{u}} = \mathbf{s}_F$$

Effect of fluid on the structural domain

$$\mathbf{M}_S \ddot{\mathbf{u}} + \mathbf{C}_S \dot{\mathbf{u}} + \mathbf{K}_S \mathbf{u} - \mathbf{A}_{int}^T p = \mathbf{s}_S$$

$$\left[ \begin{array}{cc} \mathbf{M}_S & 0 \\ -\mathbf{A}_{int} & \mathbf{M}_F \end{array} \right] \begin{bmatrix} \ddot{\mathbf{u}} \\ \ddot{p} \end{bmatrix} + \left[ \begin{array}{cc} \mathbf{C}_S & 0 \\ 0 & \mathbf{C}_F \end{array} \right] \begin{bmatrix} \dot{\mathbf{u}} \\ \dot{p} \end{bmatrix} + \left[ \begin{array}{cc} \mathbf{K}_S & \mathbf{A}_{int}^T \\ 0 & \mathbf{K}_F \end{array} \right] \begin{bmatrix} \mathbf{u} \\ p \end{bmatrix} = \begin{bmatrix} \mathbf{s}_S \\ \mathbf{s}_F \end{bmatrix}$$

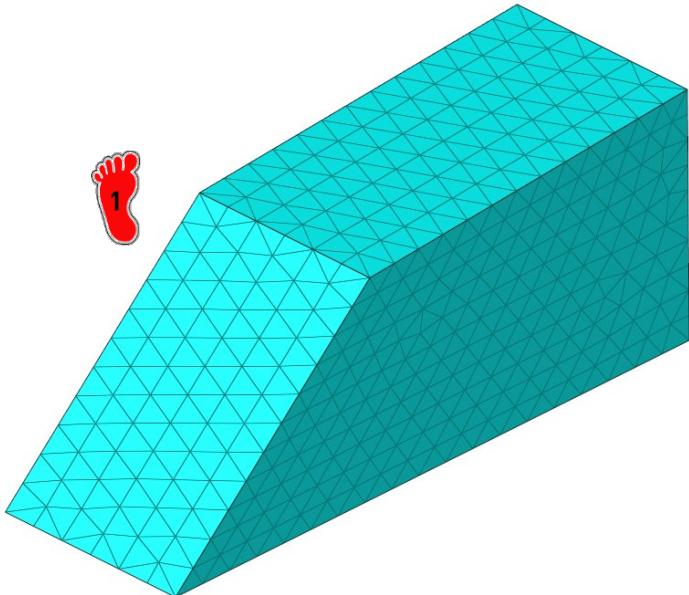
	Fluid	Structure
Mass matrix	$\mathbf{M}_F$	$\mathbf{M}_S$
Damping matrix	$\mathbf{C}_F$	$\mathbf{C}_S$
Stiffness matrix	$\mathbf{K}_F$	$\mathbf{K}_S$
Source vector	$\mathbf{s}_F$	$\mathbf{s}_S$

$\mathbf{A}_{int}$  : Interface matrix

$\ddot{\mathbf{u}}$  : Acceleration of the structural grids at the fluid-structure interface

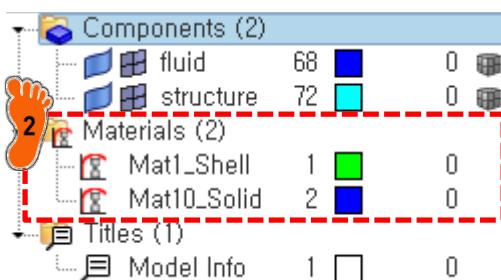
$p$  : Pressure of the fluid grids at the fluid-structure interface

# 정적하중조건 설정 (1)



1 "Half\_Car.hm" 불러오기

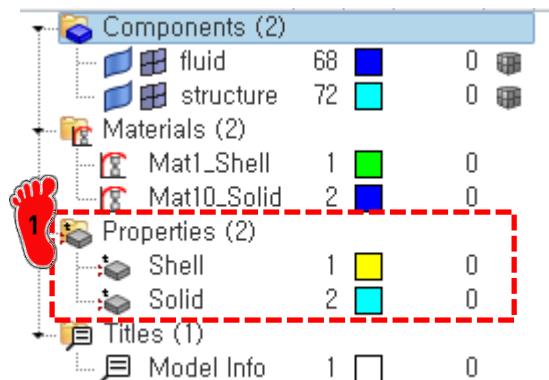
2 재료 생성 후 물성치 입력



Name	Value
Solver Keyword	MAT1
Name	Mat1_Shell
ID	1
Color	<span style="color: green;">█</span>
Include	[Master Model]
Defined	<input checked="" type="checkbox"/>
Card Image	MAT1
User Comments	Hide In Menu/Export
E	210000,0
G	
NU	0,3
RHO	7,85e-09

Name	Value
Solver Keyword	MAT10
Name	Mat10_Solid
ID	2
Color	<span style="color: blue;">█</span>
Include	[Master Model]
Defined	<input checked="" type="checkbox"/>
Card Image	MAT10
User Comments	Hide In Menu/Export
BULK	
RHO	1,2e-12
C	343000,0

# 정적하중조건 설정 (2)



Property 생성 후 재료 반영

- (1) PSHELL  
→ T=2.0 입력

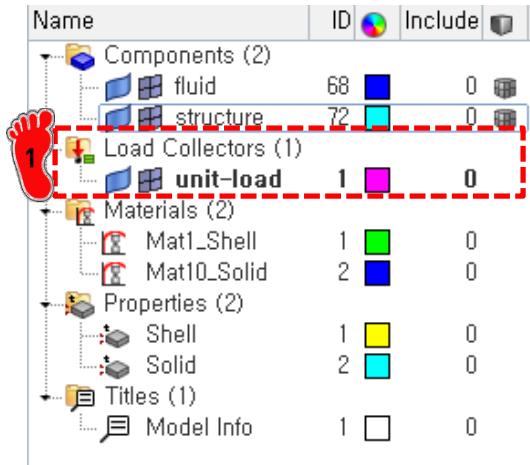
- (2) PSOLID  
→ FCTN: PFLUID 선택

각 components에 생성한 property 부여

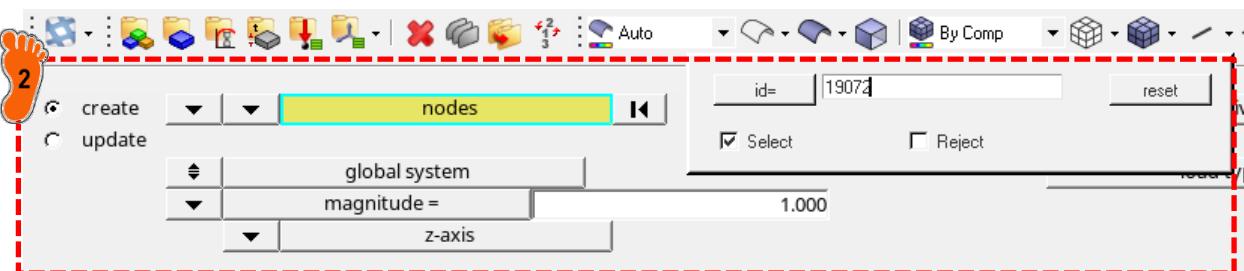
Name	Value
Solver Keyword	PSHELL
Name	Shell
ID	1
Color	<span style="background-color: yellow; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span>
Include	[Master Model]
Defined	<input checked="" type="checkbox"/>
Card Image	PSHELL
Material	(1) Mat1_Shell
User Comments	Hide In Menu/Export
T	2.0
MID2	1
MID2_opts	<input type="checkbox"/>
I12_T3	<input type="checkbox"/>

Name	Value
Solver Keyword	PSOLID
Name	Solid
ID	2
Color	<span style="background-color: cyan; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span>
Include	[Master Model]
Defined	<input checked="" type="checkbox"/>
Card Image	PSOLID
Material	(2) Mat10_Solid
User Comments	Hide In Menu/Export
CORDM options	BLANK
ISOP	
FCTN	PFLUID
HOURGLS_OPT	<input type="checkbox"/>
PSOLIDX	<input type="checkbox"/>

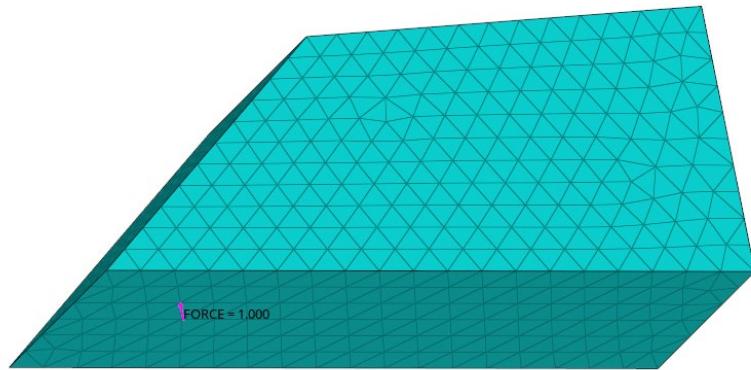
# 주파수 의존함수 입력



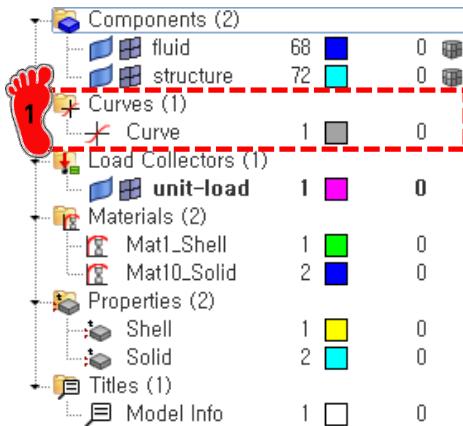
1 Load collector 생성



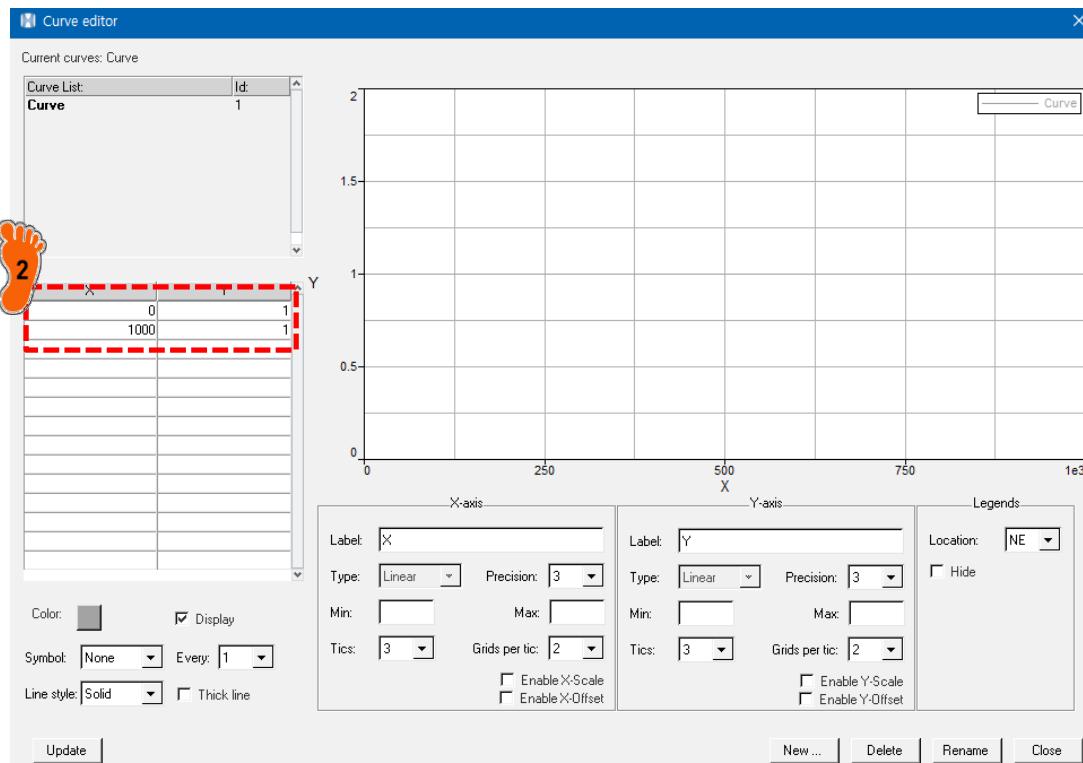
2 Node id: 10972  
Z 방향 1N 하중 부여



# 동적하중조건으로 변환



Name	Value
Solver Keyword	TABLED1
Name	Curve
ID	1
Color	[Master Model]
Include	<input checked="" type="checkbox"/>
Defined	<input checked="" type="checkbox"/>
User Comments	
Curve Type	FE Curve
Card Image	TABLED1
NEGATIVE.ID	<input type="checkbox"/>
ID	1
XAXIS	LINEAR
YAXIS	LINEAR
FLAT	
No of rows	2
Data: X, ...	



- 1 Curve 생성
- 2 (X,Y): (0,1), (1000,1) 입력
- 3 Card image: TABLED1 선택

# 해석 케이스 설정 (1)

Name	ID	Color	Include
Components (2)			
fluid	68	blue	0
structure	72	cyan	0
Curves (1)			
Curve	1	grey	0
Load Collectors (3)			
unit-load	1	magenta	0
rload1	2	orange	0
freq1	3	dark red	0
Materials (2)			
Mat1_Shell	1	green	0
Mat10_Solid	2	blue	0
Properties (2)			
Shell	1	yellow	0
Solid	2	cyan	0
Titles (1)			
Model Info	1	black	0

- 1 Load collectors 생성  
 (1) RLOAD1  
 → EXCITED: unit-load 선택  
TC: Curve 선택

- (2) FREQ1  
 → FREQ1 체크  
F1:0, DF:1, NDF:200 입력

Name	Value
Solver Keyword	RLOAD1
Name	rload1
ID	2
Color	
Include	[Master Model]
Card Image	RLOAD1
User Comments	Hide In Menu/Export
+ EXCITEID	(1) unit-load
- DELAY_OPTION	<input type="checkbox"/>
DELAY	
- DPHASE_OPTION	<input type="checkbox"/>
DPHASE	
+ TC	(1) Curve
TD	<Unspecified>
TYPE	

Name	Value
Name	freq1
ID	3
Color	
Include	[Master Model]
Card Image	FREQ1
User Comments	Hide In Menu/Export
FREQ	<input type="checkbox"/>
+ FREQ1	<input checked="" type="checkbox"/>
NUMBER_OF_FREQ1 =	1
ID	3
F1	0,0
DF	1,0
NDF	200
FREQ2	<input type="checkbox"/>
FREQ3	<input type="checkbox"/>
FREQ4	<input type="checkbox"/>
FREQ5	<input type="checkbox"/>

# 해석 케이스 설정 (2)

Name	ID	Include
Components (2)		
fluid	68	0
structure	72	0
Curves (1)		
Curve	1	0
Load Collectors (5)		
unit-load	1	0
rload1	2	0
freq1	3	0
eigrl1	4	0
eigrl2	5	0
Materials (2)		
Mat1_Shell	1	0
Mat10_Solid	2	0
Properties (2)		
Shell	1	0
Solid	2	0
Sets (1)		
set1	1	0
Titles (1)		
Model Info	1	0

Name	Value
Solver Keyword	EIGRL
Name	eigrl1
ID	4
Color	■
Include	[Master Model]
Card Image	EIGRL
User Comments	Hide In Menu/Export
V1	
V2	600.0
ND	50
MSG_LVL	
MAXSET	
SHFSCL	
NORM	MASS

Name	Value
Solver Keyword	SET
Name	set1
ID	1
Include	[Master Model]
Defined	<input checked="" type="checkbox"/>
Card Image	SET_GRID
Set Type	non-ordered
Entity IDs	1 Nodes
User Comments	Hide In Menu/Export
TYPE	GRID
SUBTYPE	LIST
No of rows	1
ID	18881



1 Load collectors 두 개 생성

→ Card image: EIGRL  
V1: 600, ND: 50 입력



2 Set 생성

→ Card image: SET\_GRID  
Entity IDs: Node id  
18881 추가

# 해석 케이스 설정 (4)

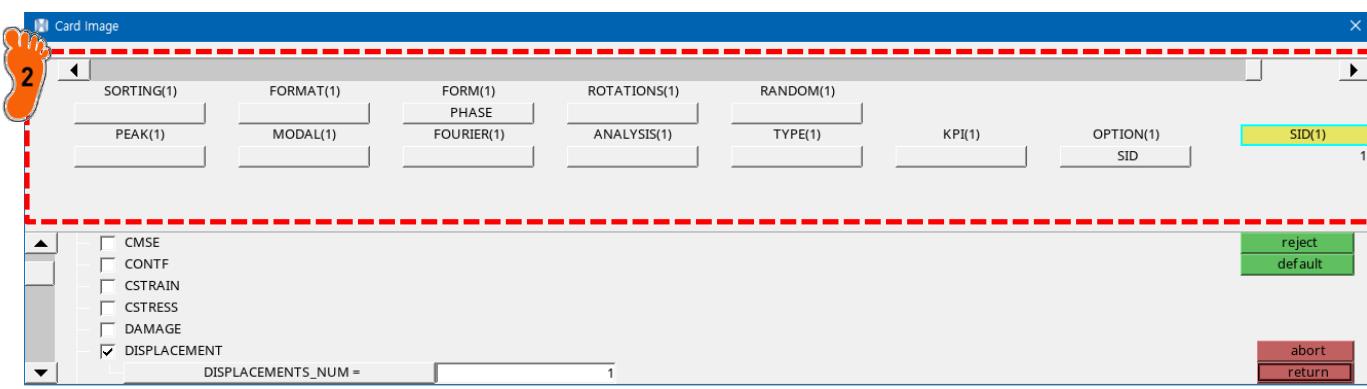
Name	Value
Solver Keyword	SUBCASE
Name	subcase1
ID	1
Include	[Master Model]
User Comments	Hide In Menu/Export
<b>Subcase Definition</b>	
Analysis type	Freq. resp (modal) 1
SPC	<Unspecified>
SUPORT1	<Unspecified>
DLOAD	(2) rload1
MPC	<Unspecified>
METHOD (STRUCT)	(4) eigr1
METHOD (FLUID)	(5) eigr2
FREQ	(3) freq1
SDAMPING (STRUCT)	<Unspecified>
SDAMPING (FLUID)	<Unspecified>
STATSUB (PRELOAD)	<Unspecified>

1 Load step 생성  
Analysis type: Freq. resp (modal)

DLOAD: rload1  
METHOD(STRUCT): eigr1  
METHOD(FLUID): eigr2  
FREQ: freq1

2 Control card → GLOBAL OUTPUT REQUEST 클릭  
→ DISPLACEMENT 클릭  
→ Form(1): PHASE 선택  
OPTIONS(1): SID 선택  
SID(1): SET 선택

FORMAT	INCLUDE_BULK	K42GG	delete
GAPRM	INCLUDE_CTRL	LABEL	disable
GLOBAL_CASE_CONTROL	INFILE	LOADLIB	enable
GLOBAL_OUTPUT_REQUEST	A2GG	M2GG	
GRDSET	B2PP	M2PP	next
GROUNDCHECK	K2GG	MDSDIR	prev
HISOUT	K2PP	MECHCHECK	return



# 해석 케이스 설정 (5)



ACMDL

[INTER]	[INFOR]	[FSET]	[SSET]	[NORMAL]	[SKNEPS]	[DSKNEPS]	+
DIFF	ALL						
[INTOL]	[ALLSET]	[SRCHUNIT]	[MAXGRID]				

OUTPUT	KEYWORD	FREQ
OUTPUT	HGFREQ	ALL
OUTPUT	H3D	ALL
OUTPUT	OPTI	ALL

number\_of\_outputs =

3

PARAM, AUTOSPC, V1  
YES  
[G\_V1]  
PARAM, G, 0.060  
[VALUE]  
PARAM, GFL, 0.120

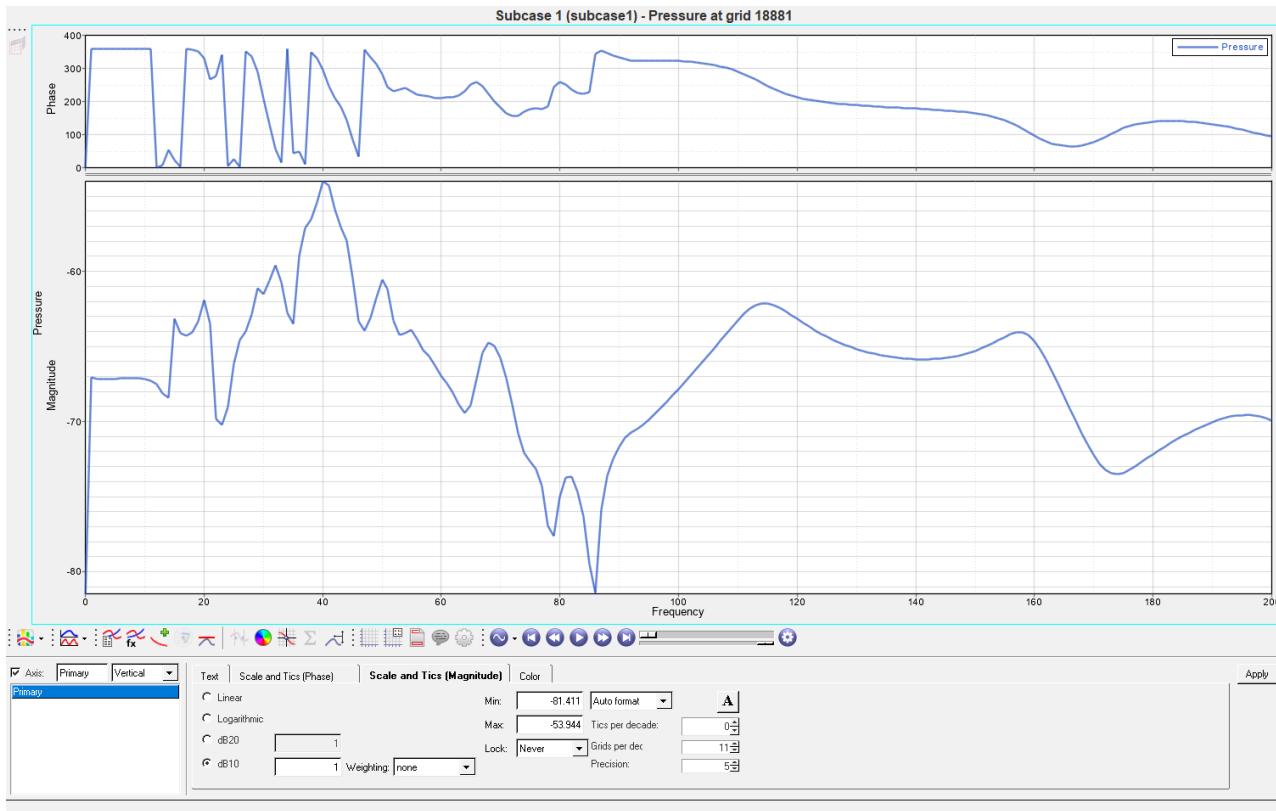
Control cards에서 다음과 같은 항목 선택

1 ACMDL 설정  
→ Inter: Diff 선택  
INFOR: ALL 선택

2 OUTPUT 설정

3 PARAM 설정  
→ AUTOSPC: YES 선택  
G: 0.06 입력  
GFL: 0.12 입력  
(균일 감쇠 계수)

# 해석 케이스 설정 (6)



1 Nodes로 바꾼 후 한번 더 클릭

2 그림처럼 해석을 진행할 node 선택한 후 proceed