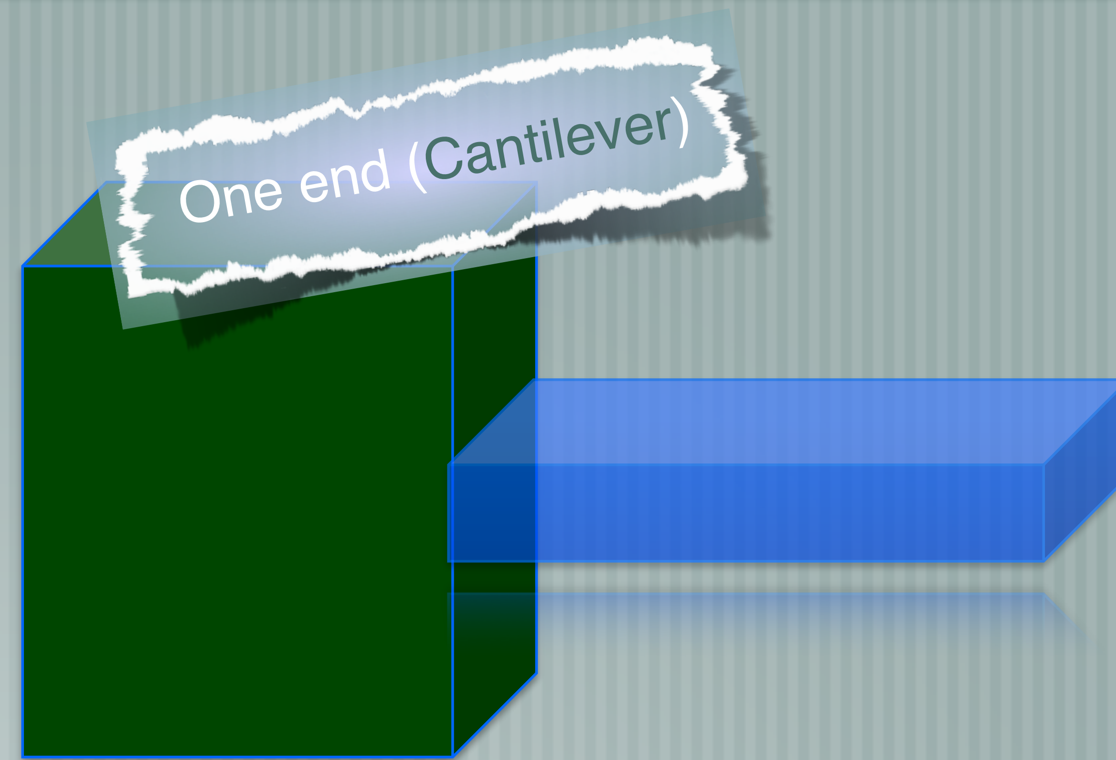
ครั้งที่ 3 (1.3)

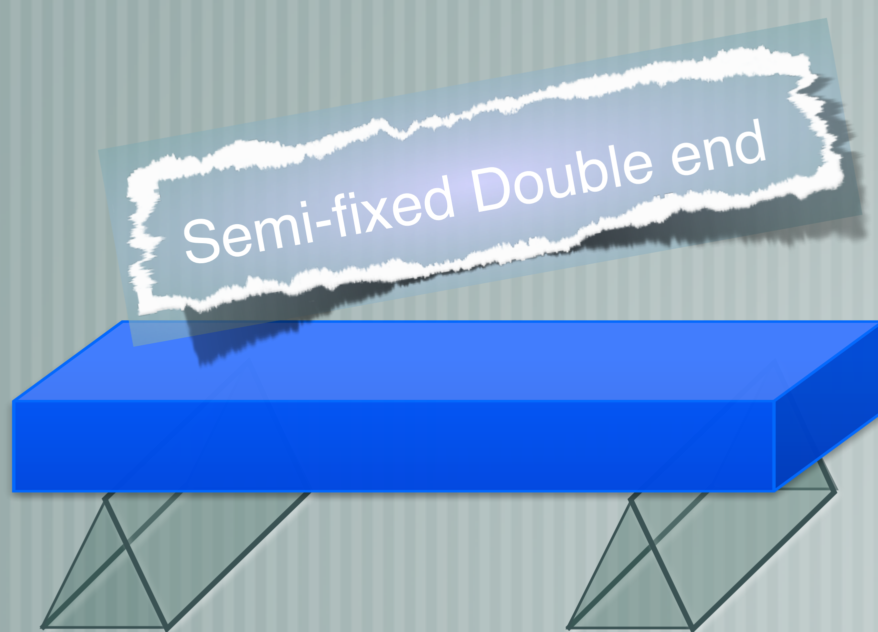
Intro

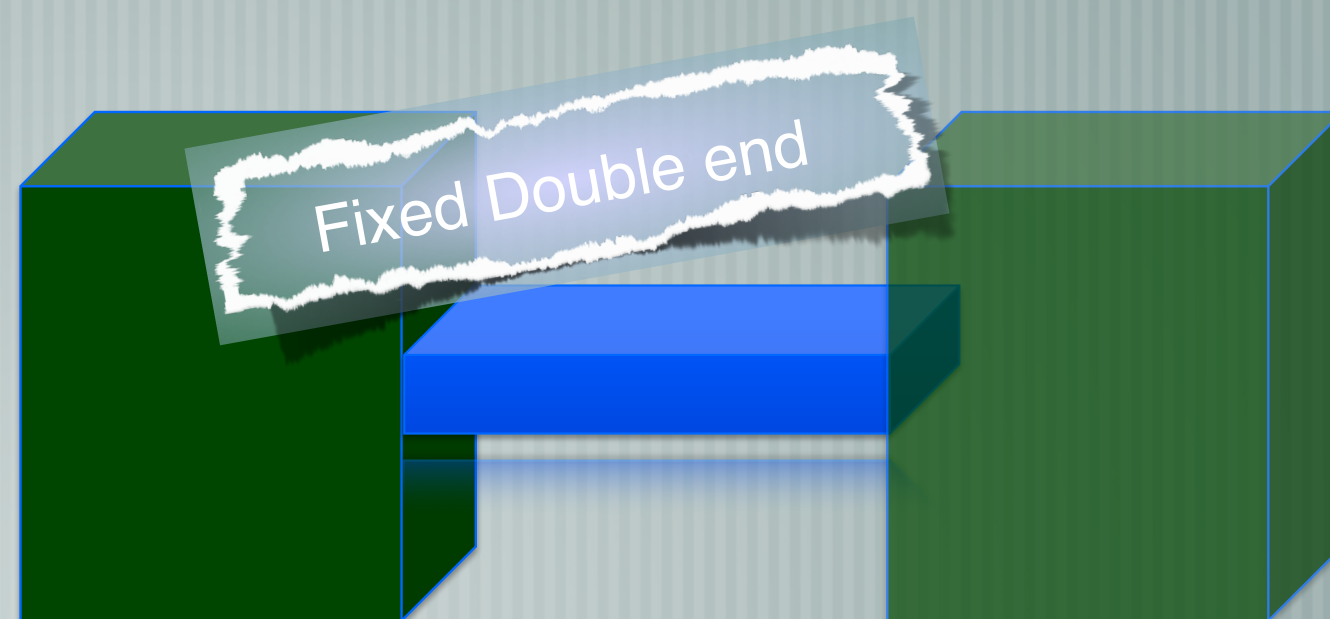
WIRE BENDING & MECHANICAL PRINCIPLE

Beam

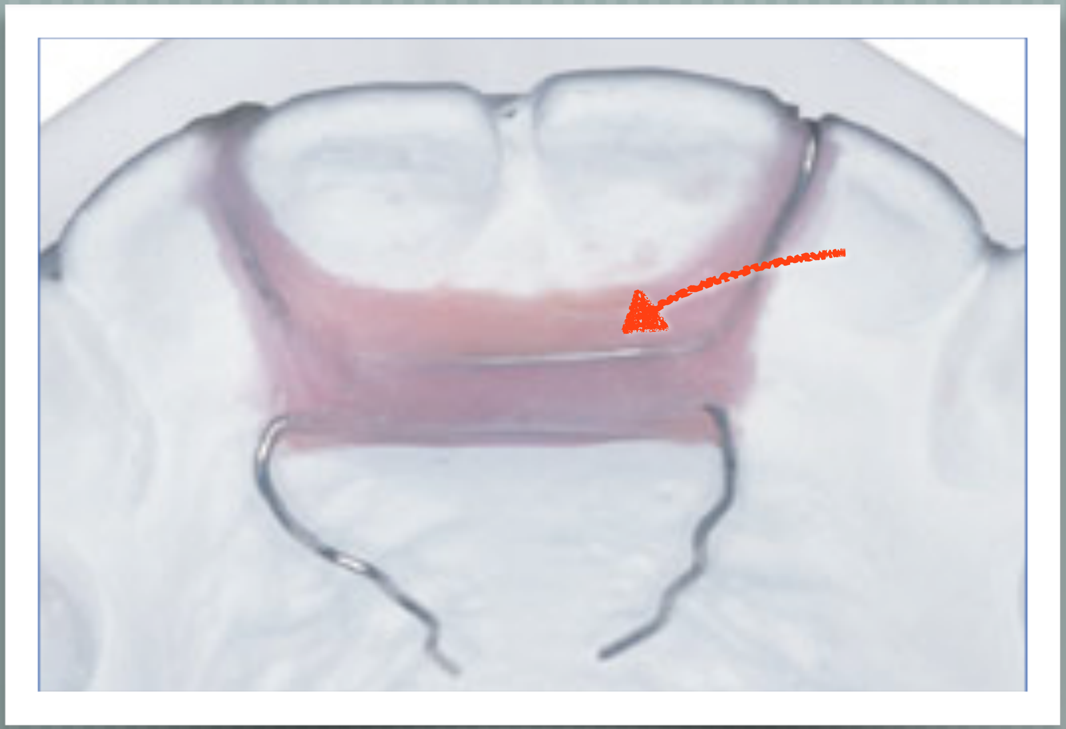
-One end (Cantilever)
-Double end (Supported beams)
    Fixes
    Semi-fixed

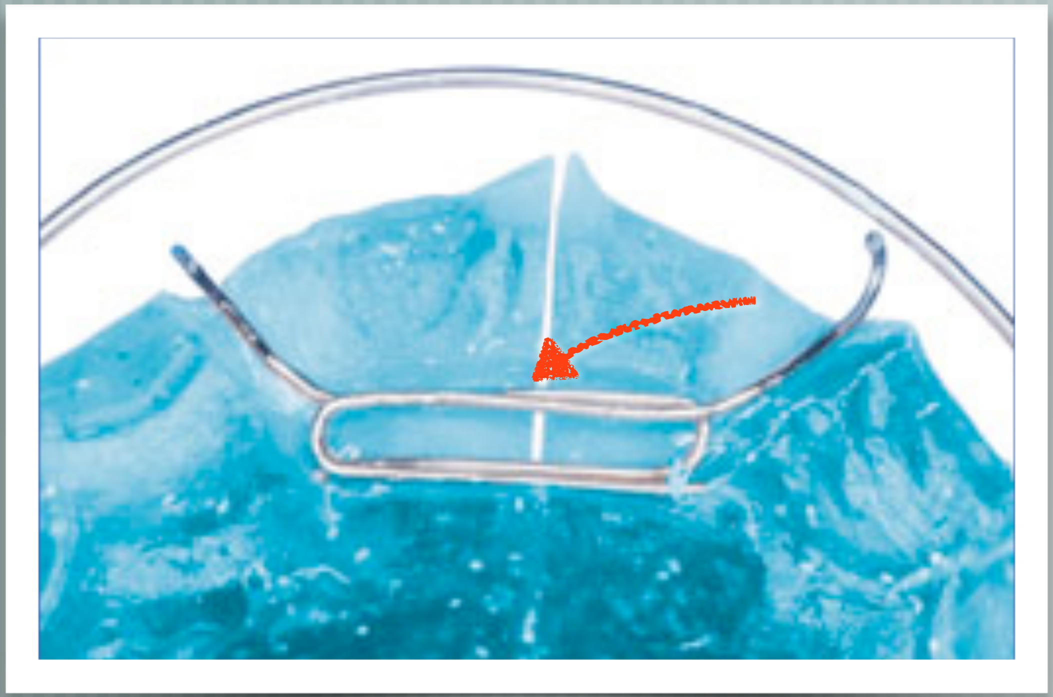


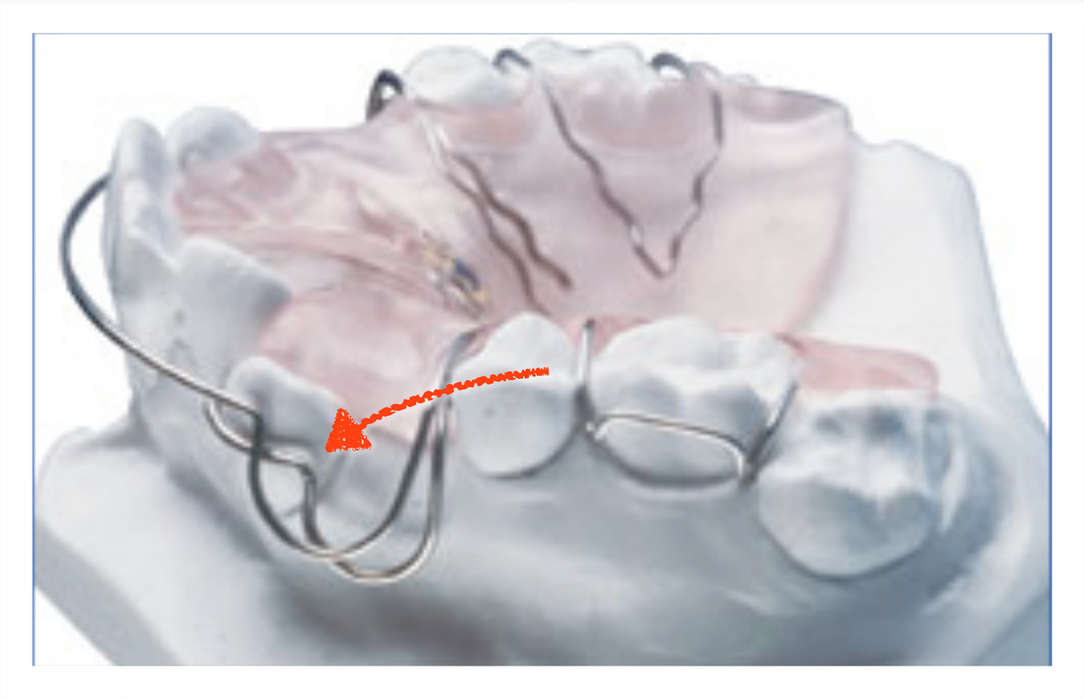




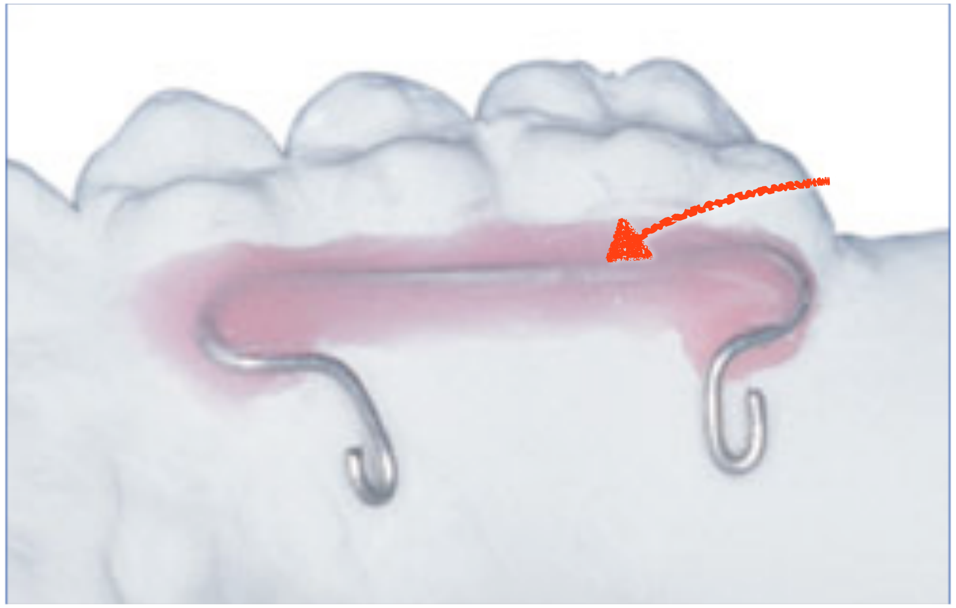
Cantilever in orthodontic appliances

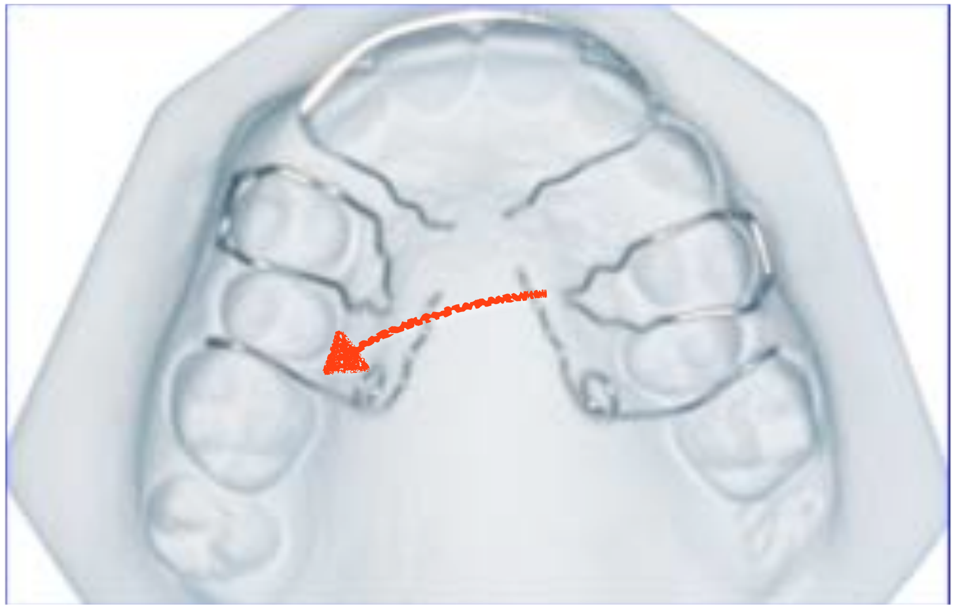


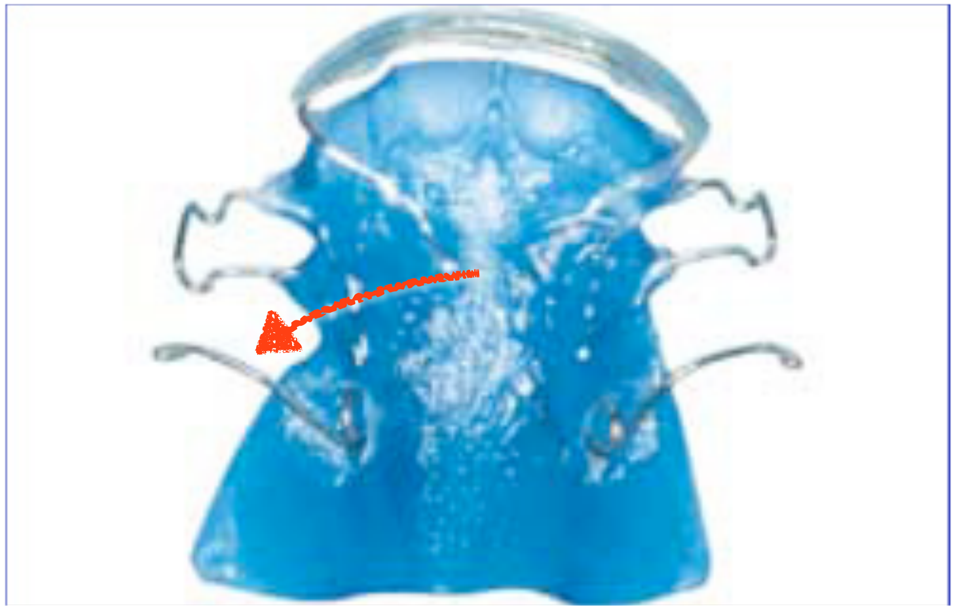




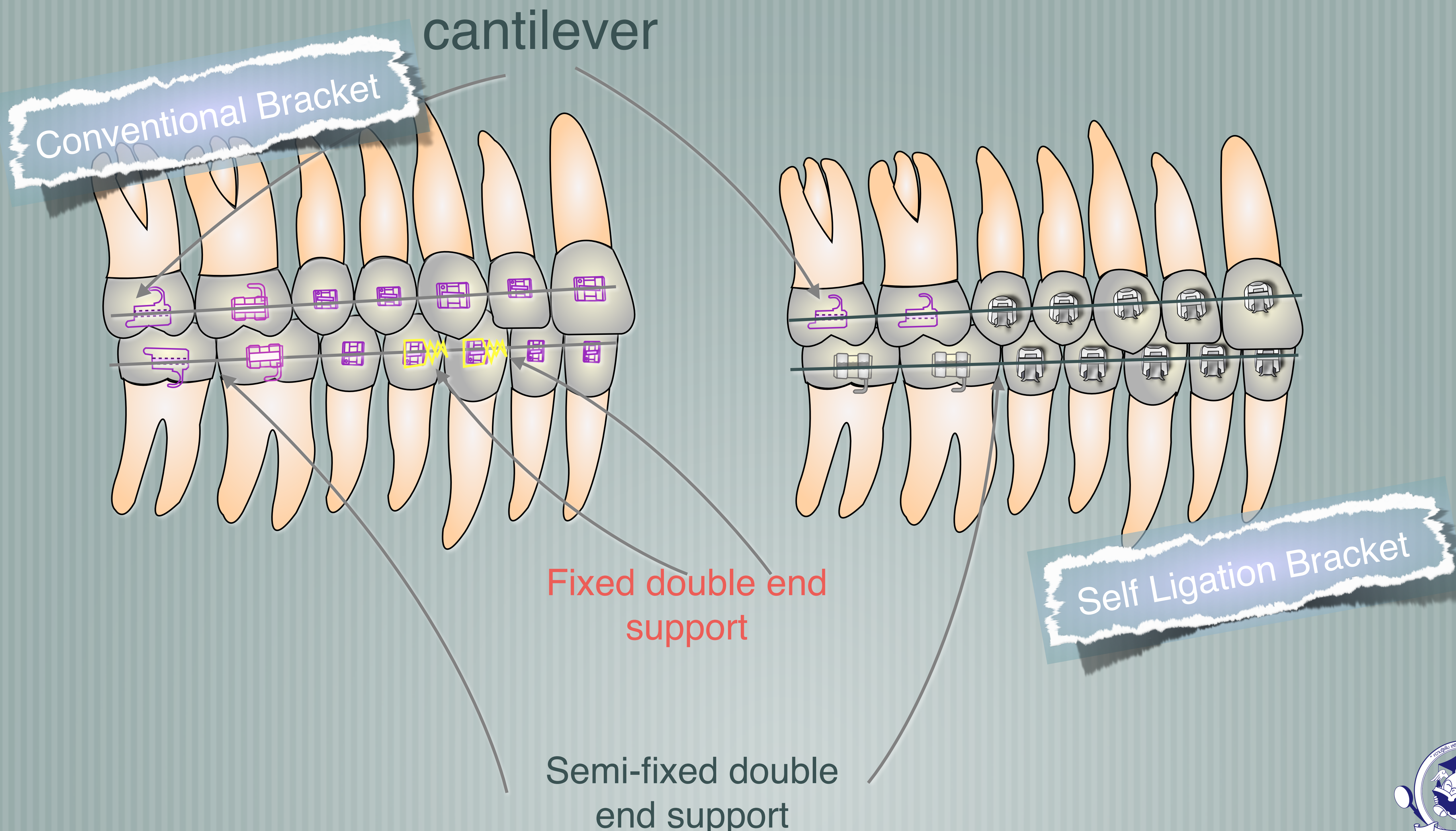
Cantilever







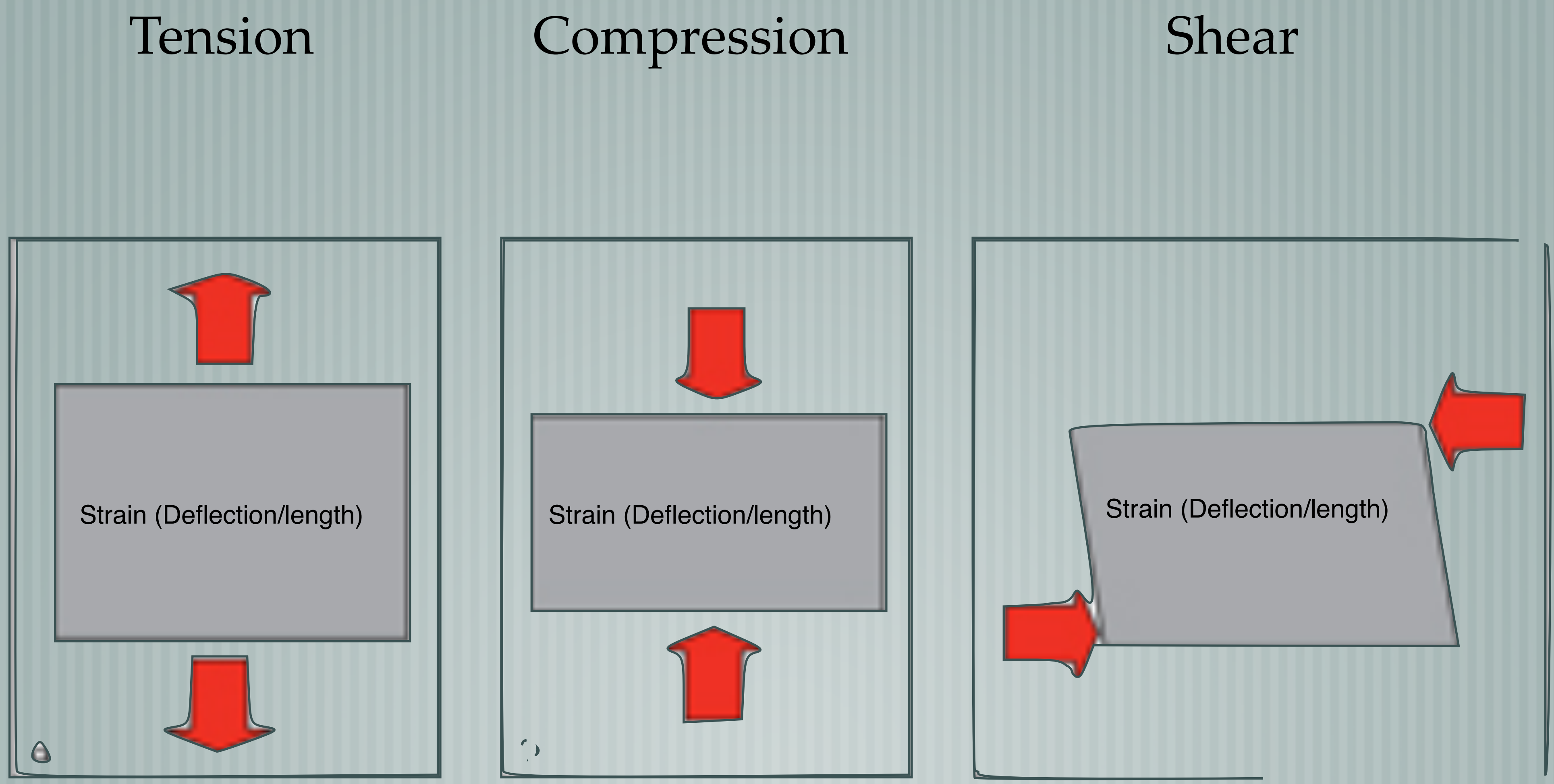
Beam in fixed orthodontic appliances



Physical Properties of Materials Used in Orthodontics

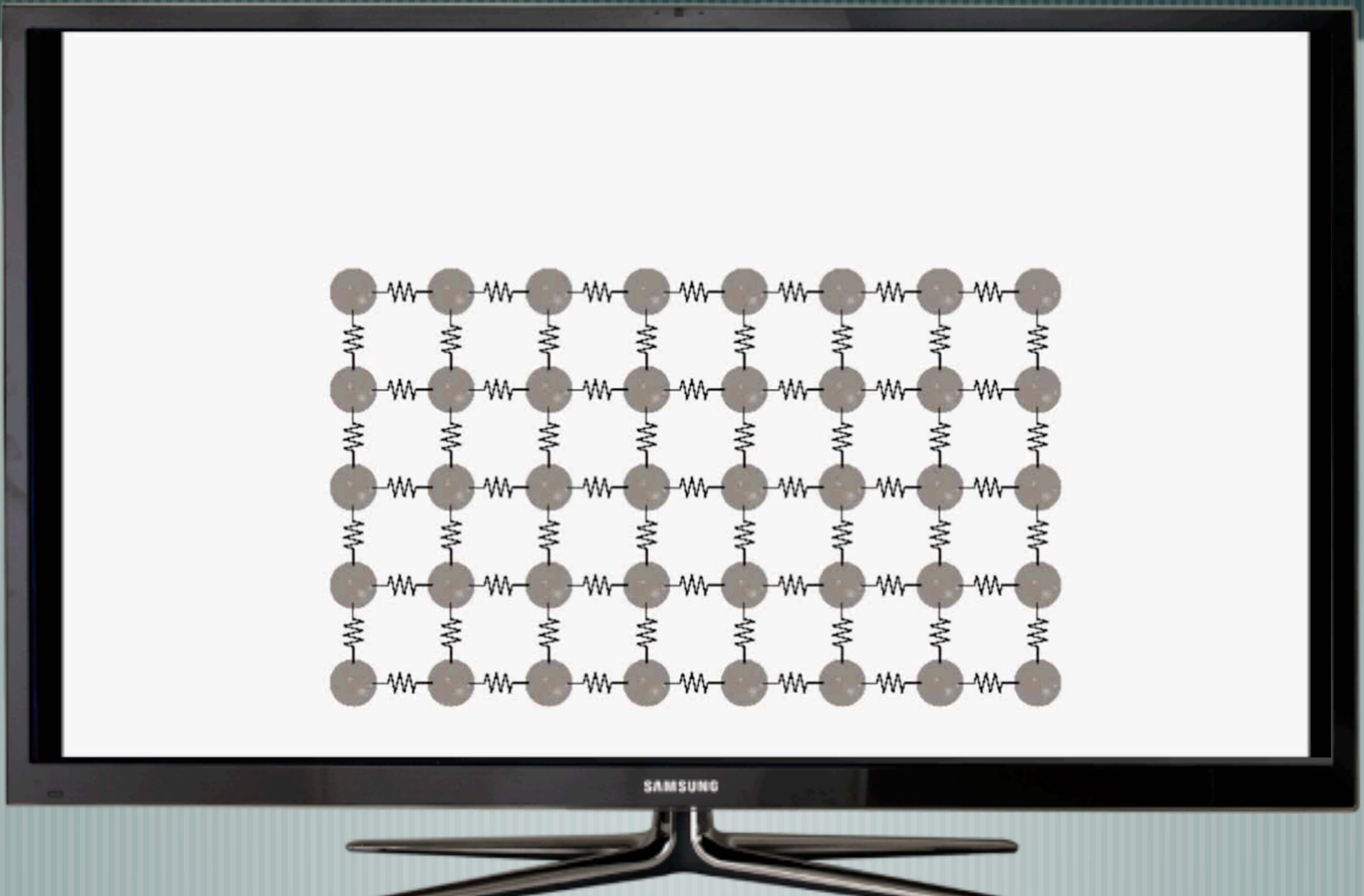
Physical Properties of Materials Used in Orthodontics

Stress (Force/area)



Physical Properties of Materials Used in Orthodontics

Young Modulus and Yield Strength (3:47)



Basic Properties of Material

Elastic Materials

Materials that can return to their original size when the stress is removed such as coil spring, NiTi, SS.

Plastic Materials

Materials unable to return to their original size such as ligature wire.

Viscoelastic Materials

Between these extremes, can show elastic and plastic behaviors at the same time. Examples of these materials are human skin, muscles, veins, nerves, and fibers.

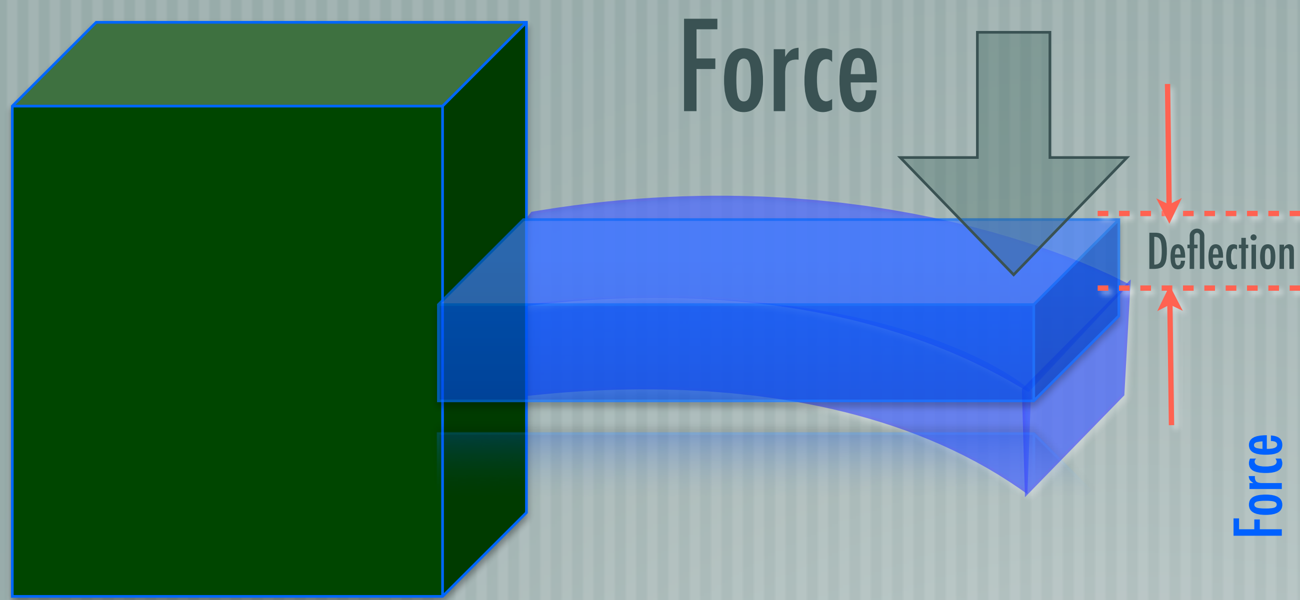
Basic Properties of Elastic Materials

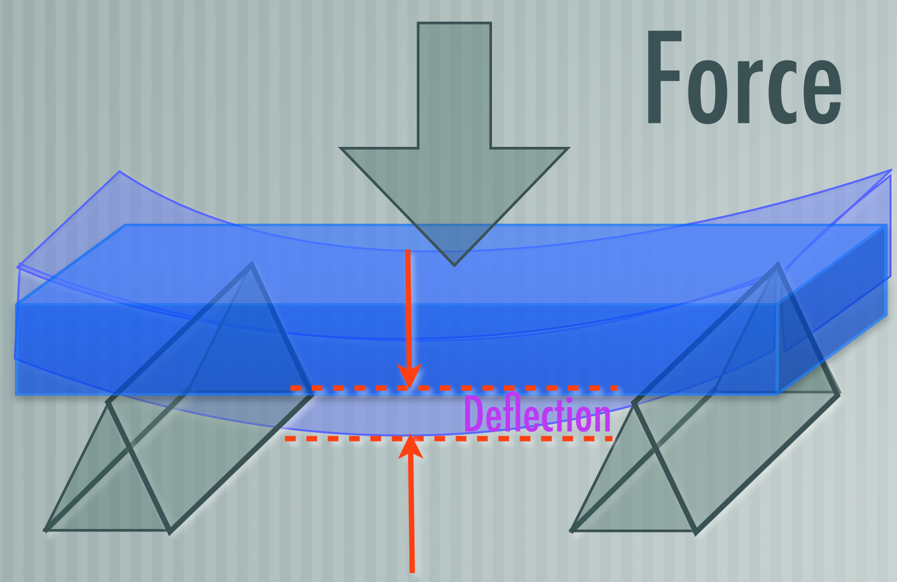
- Extrinsic factors (Shape)
- Intrinsic factors (E,Modulus)

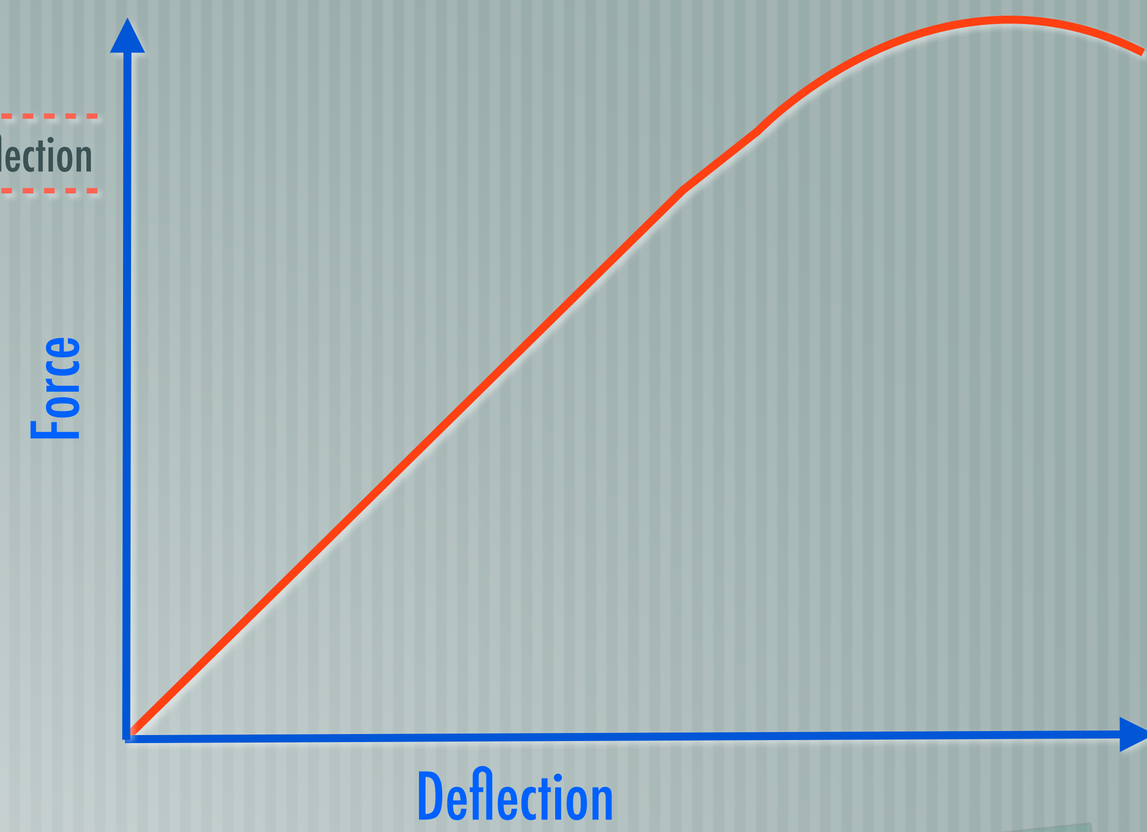
Material Considerations

Understanding the basic material to be able to select wire used in Tx

Load Deflection Experiment







Force(gm.) = action (push / pull/ twist)
Deflection(mm.) (bending or twisting)

Instron Testing Machine on Plastic (0:39)

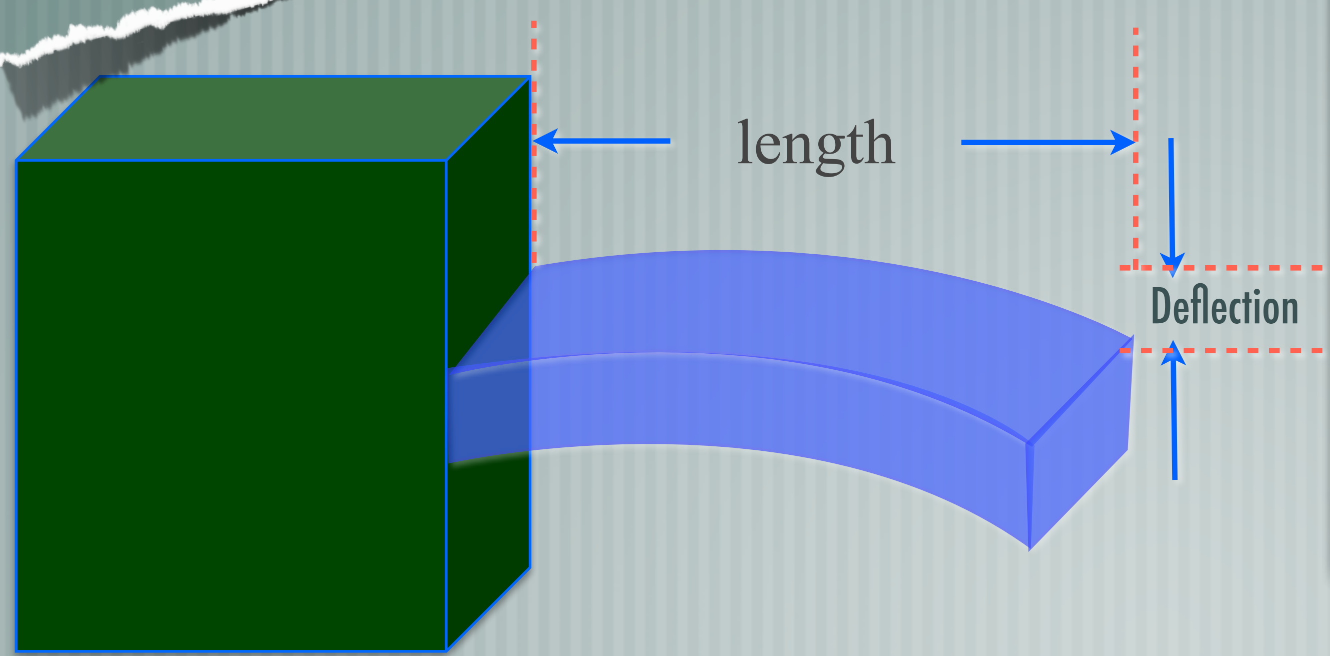
Instron Testing Machine on Metal (Elastic) (2:39)

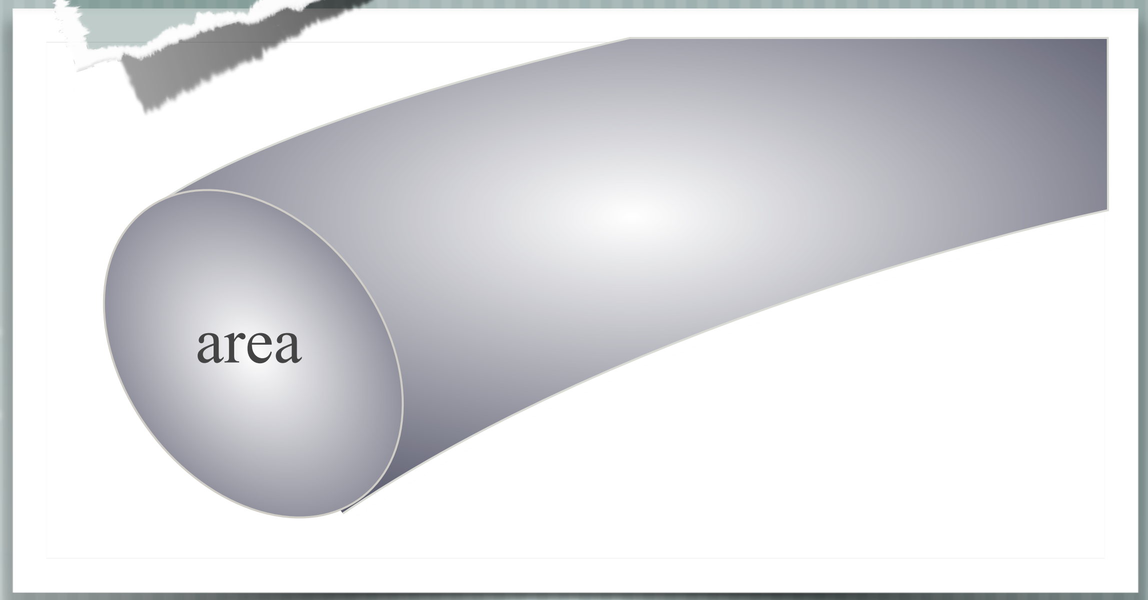
Stress & Strain

INTRINSIC PROPERTIES OF ELASTIC MATERIAL CALCULATED FROM FORCE & DEFLECTION

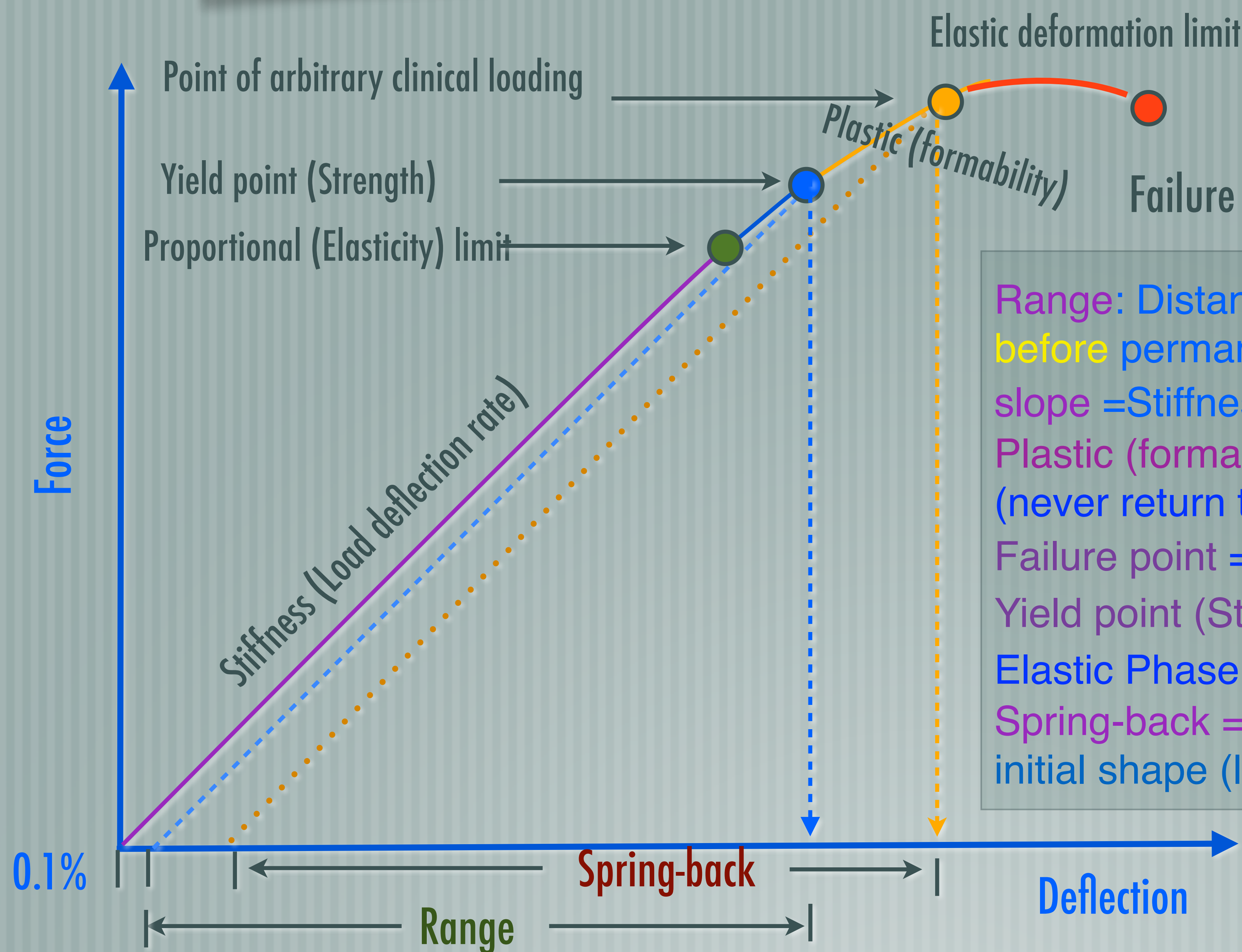
deflection/length
= Strain (เครียด)

force/area (gm./cm^2)
= Stress (เค้น)





Force Deflection Curve for Stainless Steel



Range: Distance a wire will bend elastically before permanent deformation will occur.

slope =Stiffness (ความแข็ง)

Plastic (formability) =Wire bending (T-Loop) (never return to initial shape)

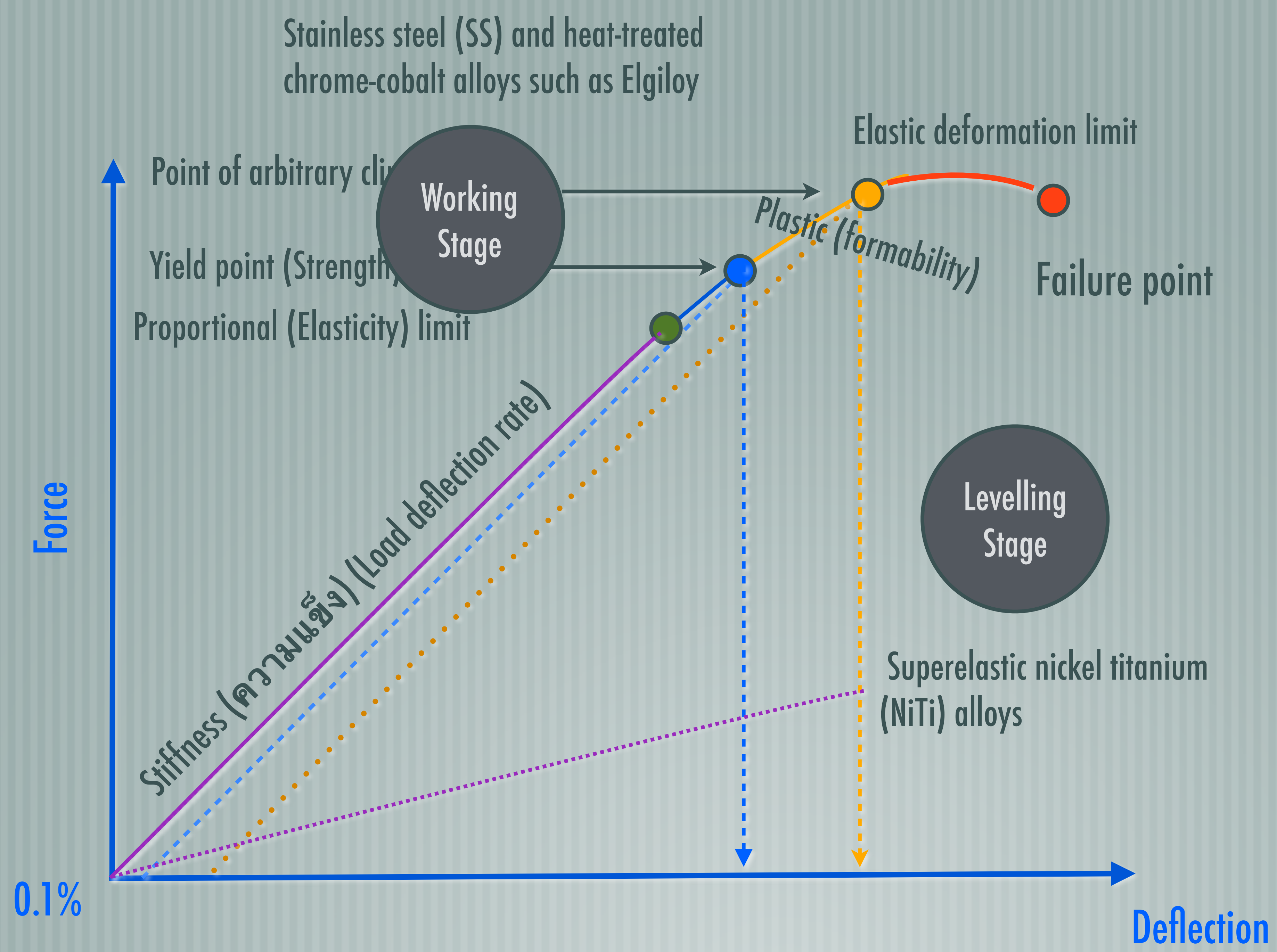
Failure point = ลวดหัก

Yield point (Strength) = จุดสุดท้ายก่อนเปลี่ยนจาก Elastic Phase ไป Plastic Phase

Spring-back = The amount of return of spring to initial shape (loop) (never return completely)

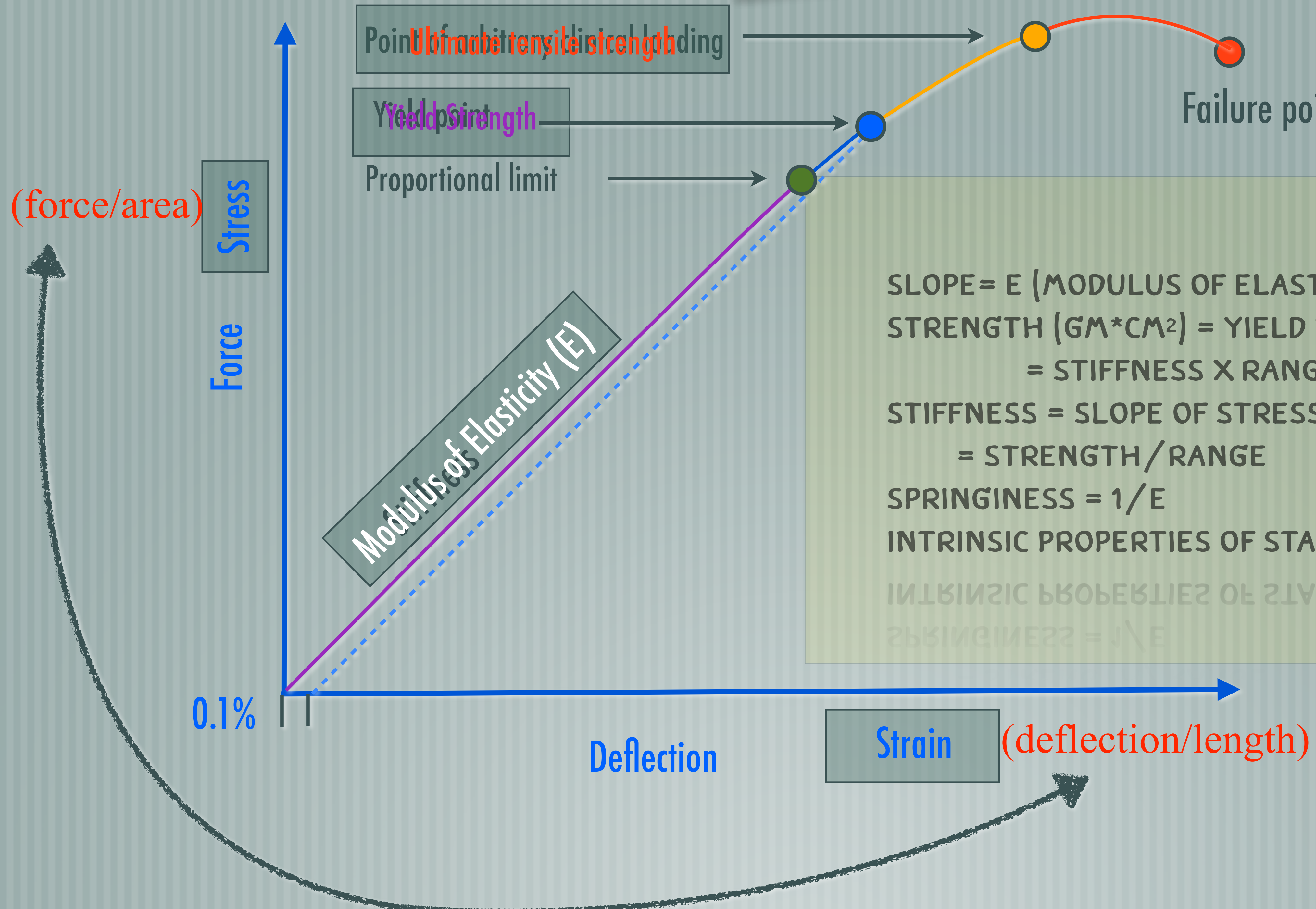
Strength = Stiffness x Range

Force Deflection Curve & Clinical Application



Stress Strain Curve

Force Deflection Curve



SLOPE= E (MODULUS OF ELASTICITY)

STRENGTH (GM*CM^2) = YIELD POINT

= STIFFNESS X RANGE

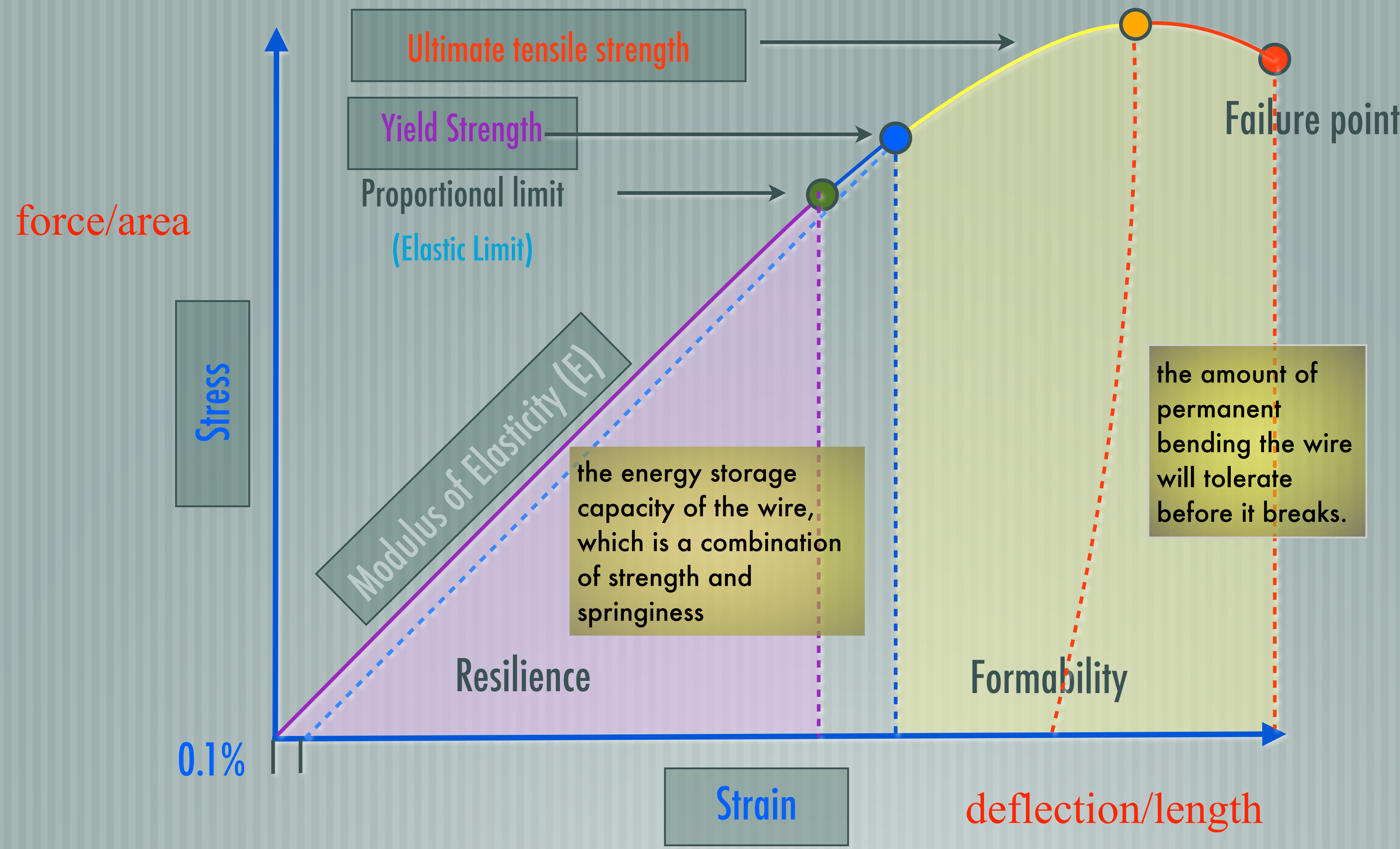
STIFFNESS = SLOPE OF STRESS/STRAIN CURVE

= STRENGTH/RANGE

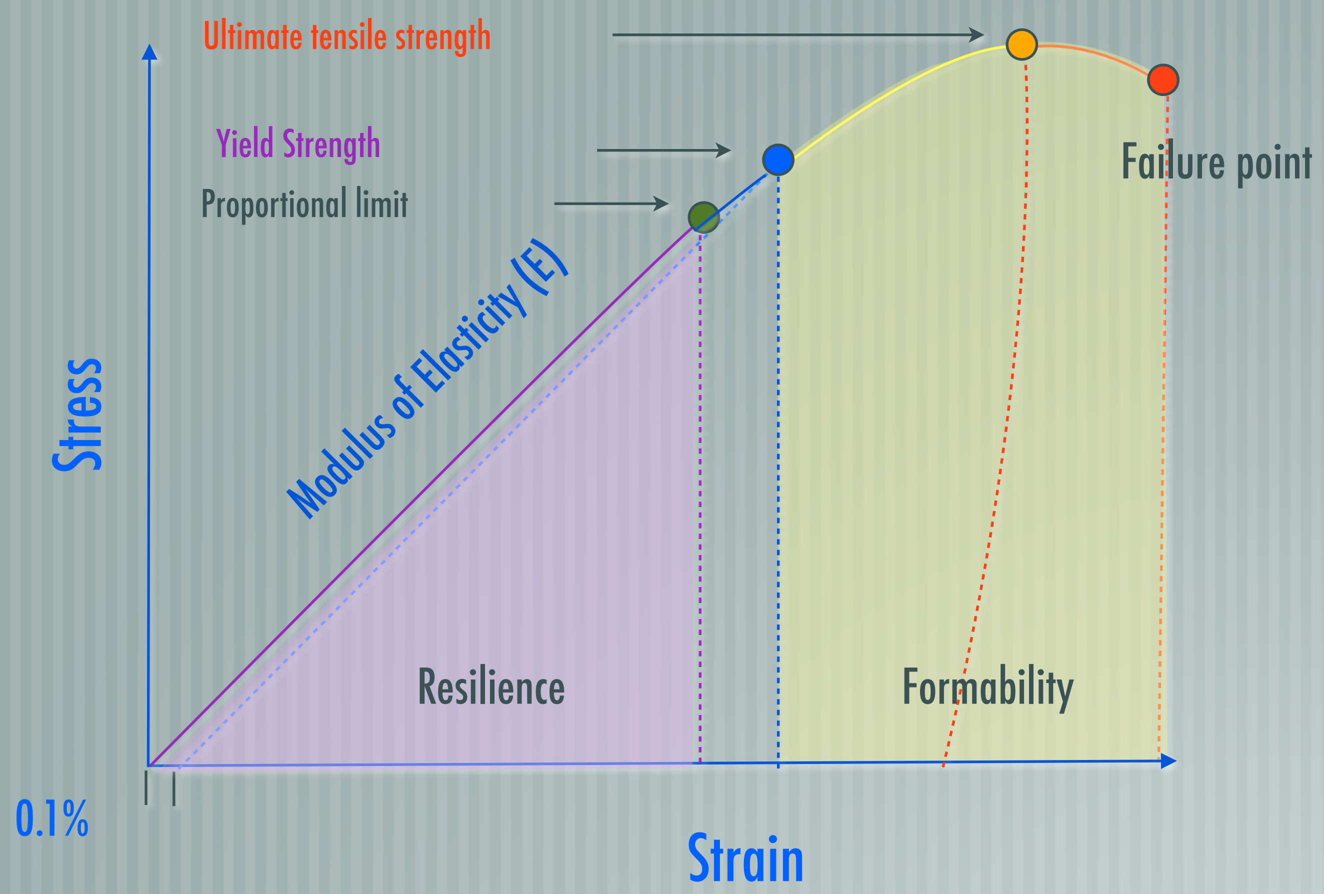
SPRINGINESS = 1/E

INTRINSIC PROPERTIES OF STAINLESS STEEL

Stress Strain Curve & Orthodontic Purpose



Stress Strain Curve & Orthodontic Purpose



ULTIMATE TENSILE STRENGTH : BITING FORCE RESISTANCE

PROPORTIONAL LIMIT : ELASTIC LIMIT

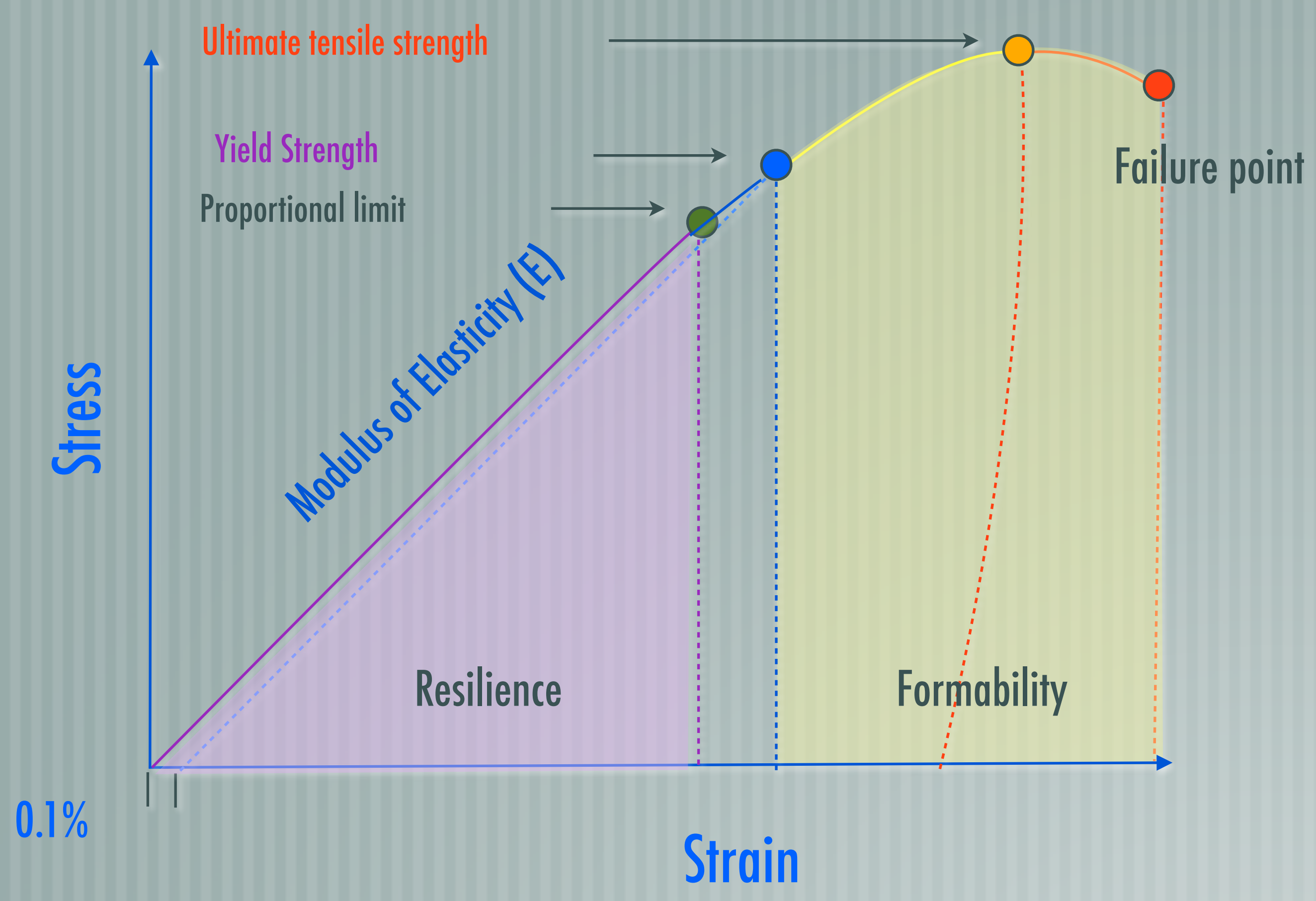
FORMABILITY : WIRE BENDING

RESILIENCE : SPRINGINESS

FAILURE POINT : WIRE BROKEN

MODULUS OF ELASTICITY (E): FORCE CONSISTENCY

Ideal orthodontic wire

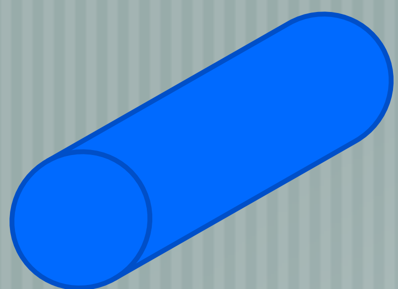
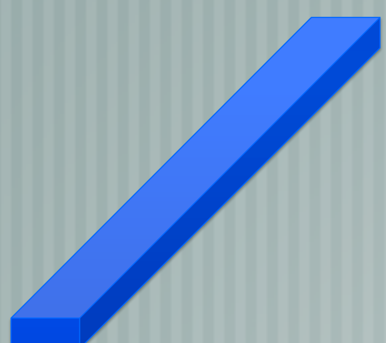
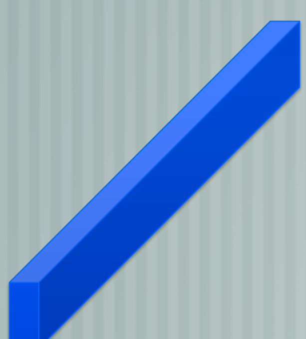


- HIGH STRENGTH
- HIGH SPRINGINESS
- HIGH FORMABILITY
- HIGH RESILIENCE
- HIGH RANGE
- LOW STIFFNESS
- CHEAP, WELDABLE

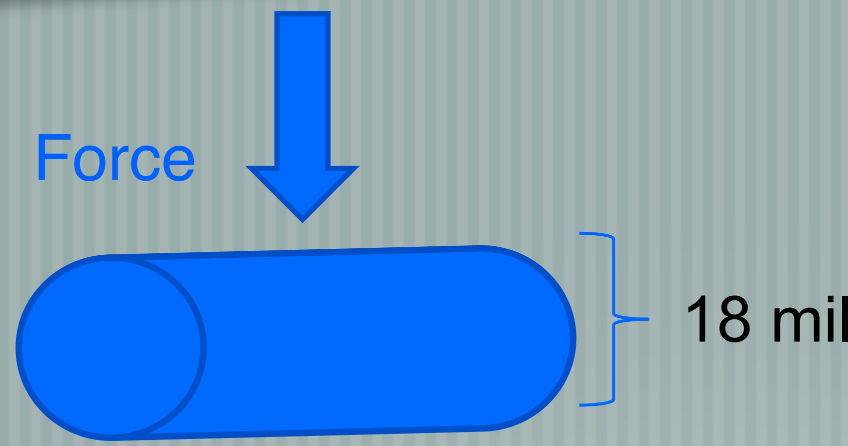
Measurement unit

INCH	MM	MILS
1	25	1000
1x(16/1000)	25x(16/1000)	1000x(16/1000)
0.016	0.4	16
.017 x.025	0.425 x 0.625	17 x 25
0.001	0.025	1

Round Wire Vs Rectangular Wire

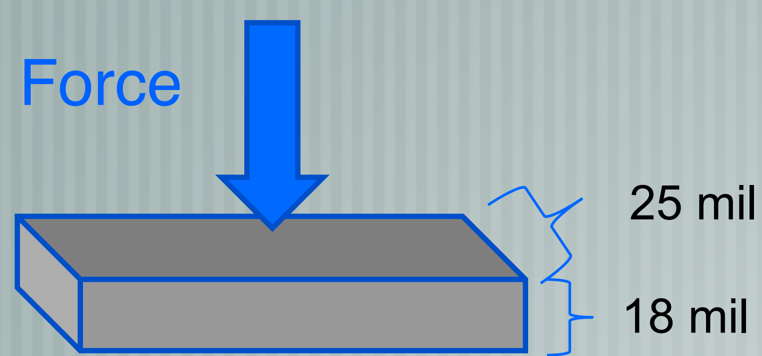
	Round Wire	.014 : .016 : .018 : .020 (Inch) 14 : 16 : 18 : 20 (Mil) .35 : .4 : .45 : .5 (mm.)
	Rectangular Edgewise Wire	.016x.022 : .018x.025 (Inch) 16x22 : 18x25 (Mil) 0.4x.55 : .45x.625 (mm.)
	Rectangular Ribbon Wire	

Round Wire Vs Rectangular Wire



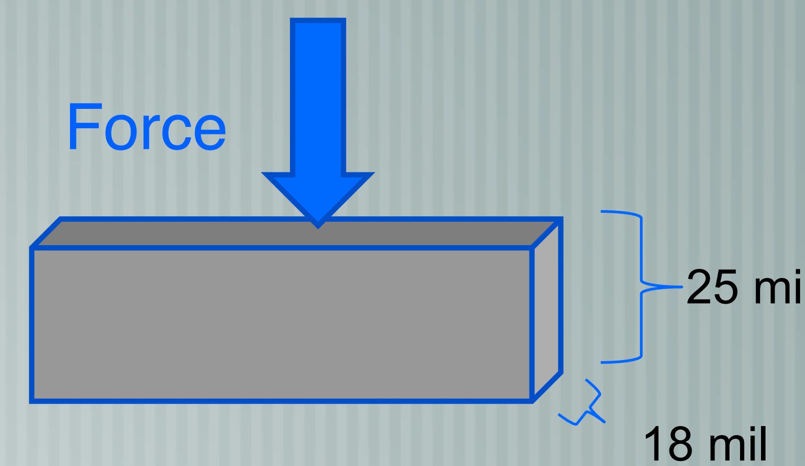
Round Wire

2nd order bend



Rectangular Edgewise Wire

1st order bend



Ribbon Wire

WIRE MATERIAL AND ITS DEVELOPMENT

-GOLD ALLOY (PLATINUM PALLADIUM)
-STAINLESS STEEL 18-8 (CHROMIUM 18% NICKEL 8% ALLOYS)
-CO-AXIAL STRAND
-ELGILOY (COBALT CHROMIUM ALLOYS)
-NICKEL-TITANIUM (NITI)
-BETA-TITANIUM (TITANIUM MOLYBDENUM ALLOY, TMA)

Heat treated Gold alloy

(platinum palladium)

Comparative Properties of Orthodontic Wires

	Modules of elasticity (10^6psi)	Material stiffness	Set angle (degrees)*
Gold (heat-treated)	12	0.41	12
S.S. Truchrome-Rocky Mtn	29	1	NA
Aust, S.S. - TP Labs	28	0.97	12

*Degree of bending around 1/4 inch radius before permanent deformation

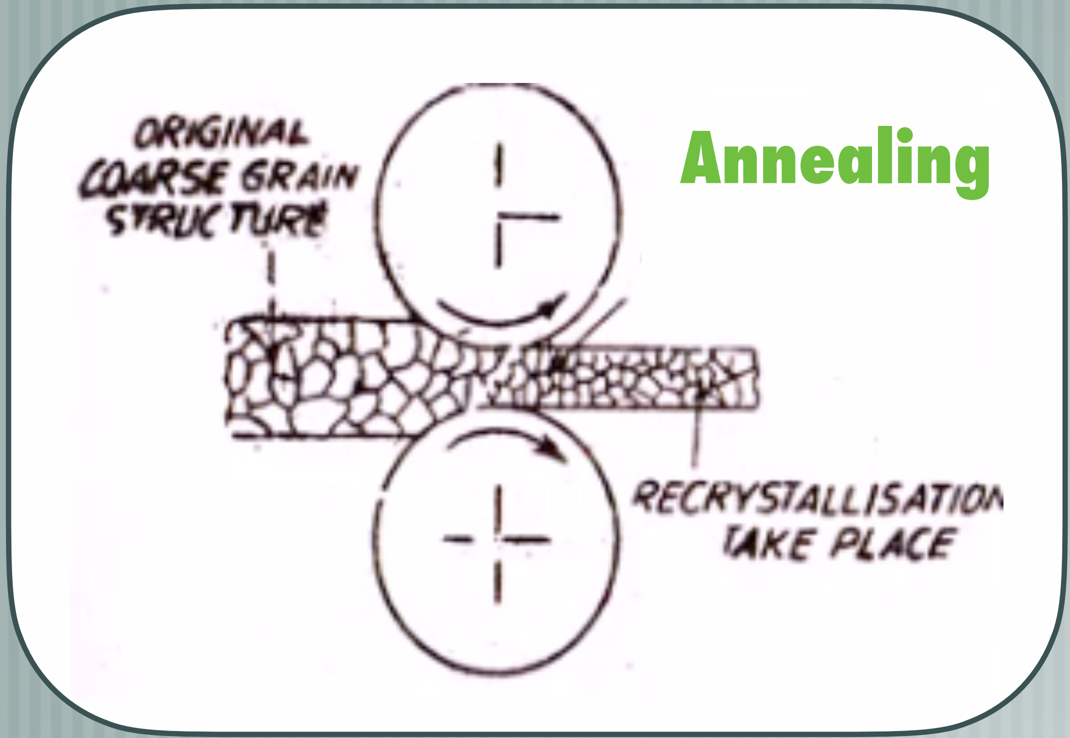
good to tolerate intraoral conditions
@ 22X25 mils (Rectangular Shape)

Stainless steel 18-8 (chromium 18% nickel 8% alloys)

- Better springiness strength
- Intraoral corrosion resistance
- Cold working & annealing process
- The more anneal, the less springiness, the softer SS, the more formability (dead soft)
- The more cold working, the more springiness, the less formability (Super stainless Steel)

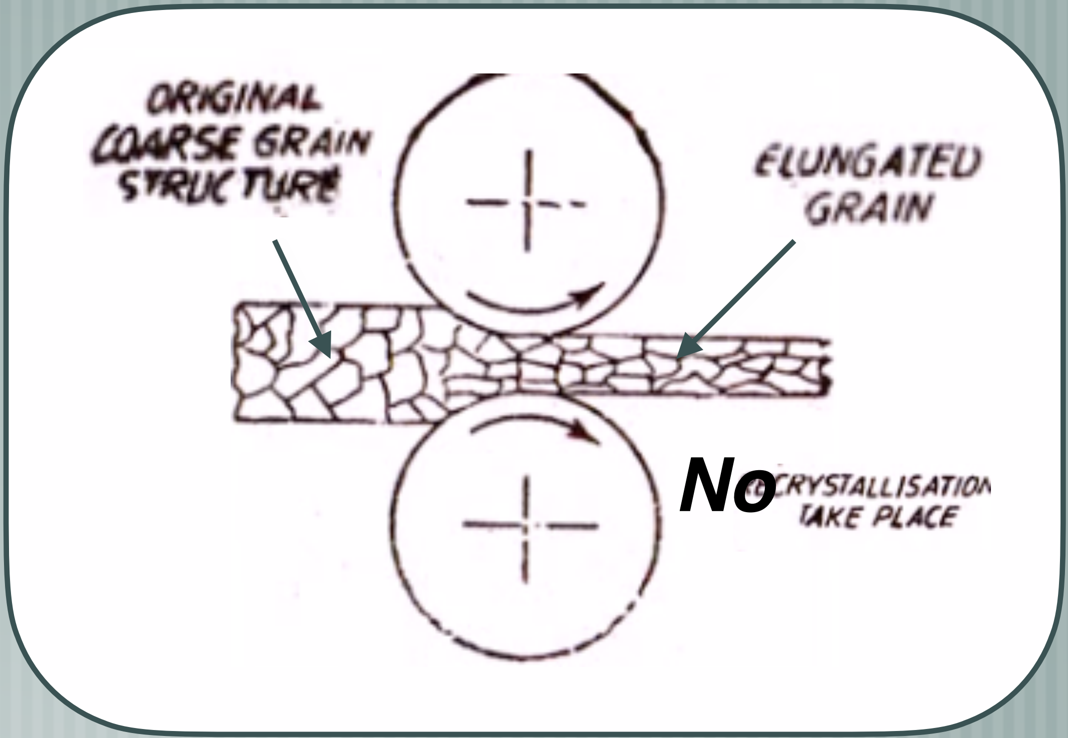
Working of Metal Processes

Heat working



Less power to work
Better grain produced

Cold working



Elongated grain produced
Better surface finish

Working of Metal Processes

Hot working VS Cold working

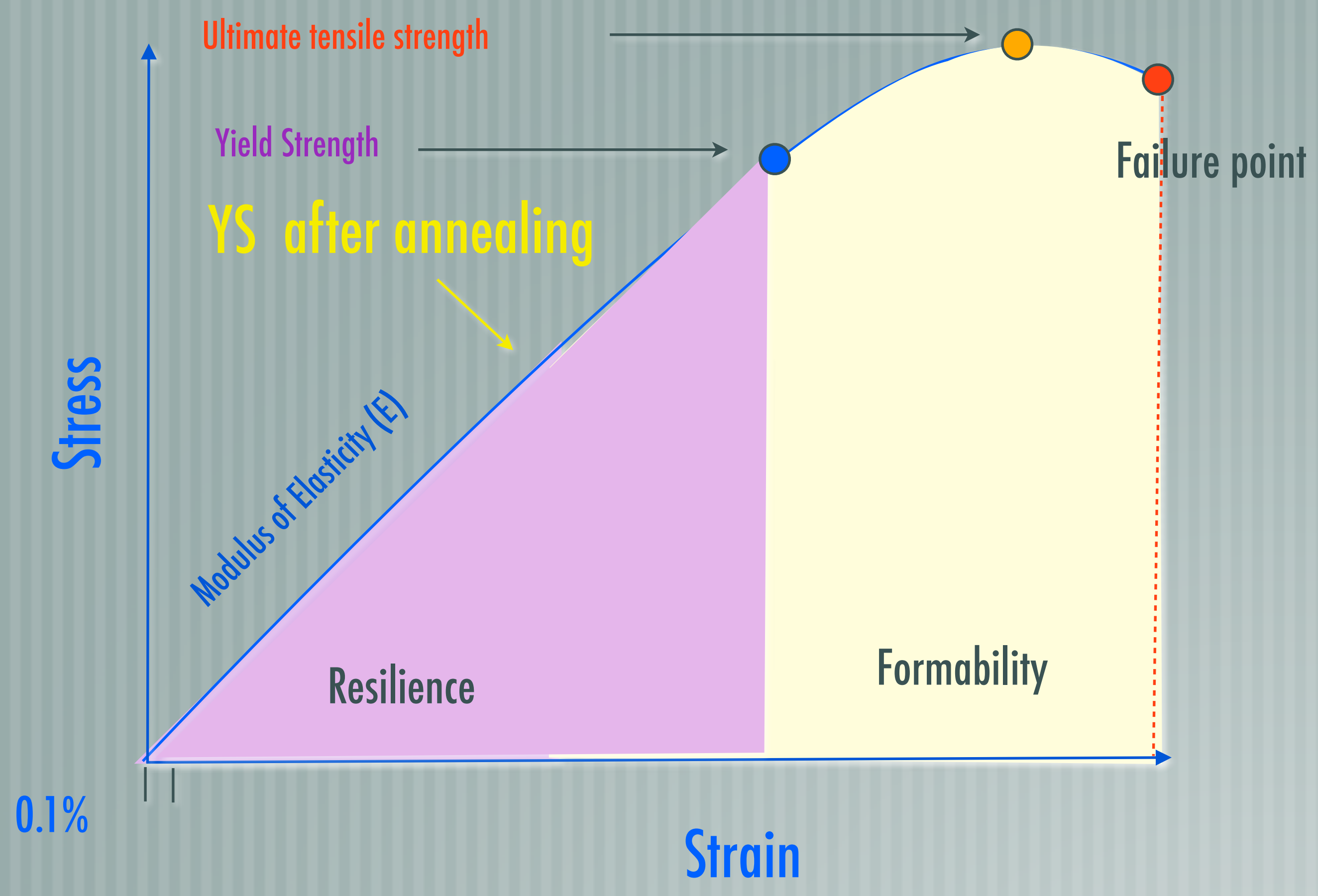
Hot working

- Annealing /heat treatment
- Hot rolling, forging (Fire and Hammer), welding (jointed by heating point)
- Above recrystallisations temperature
- New grain formed
- Can be used to adjust between harder and more brittle, to softer and more ductile.
- Softened and prepared for further work—such as shaping, stamping, or forming.

Cold working

- Squeezing, bending, drawing, and shearing
- The crystal grains inclusions to distort following the flow of the metal
- Below recrystallisations temperature (ambient temperature)
- No transformation in grain structure
- Harder, stiffer, and stronger, but less plastic, and may cause cracks of the piece.
- The possible uses are large flat sheets, complex folded shapes, metal tubes, screw heads and threads, riveted joints, and much more.

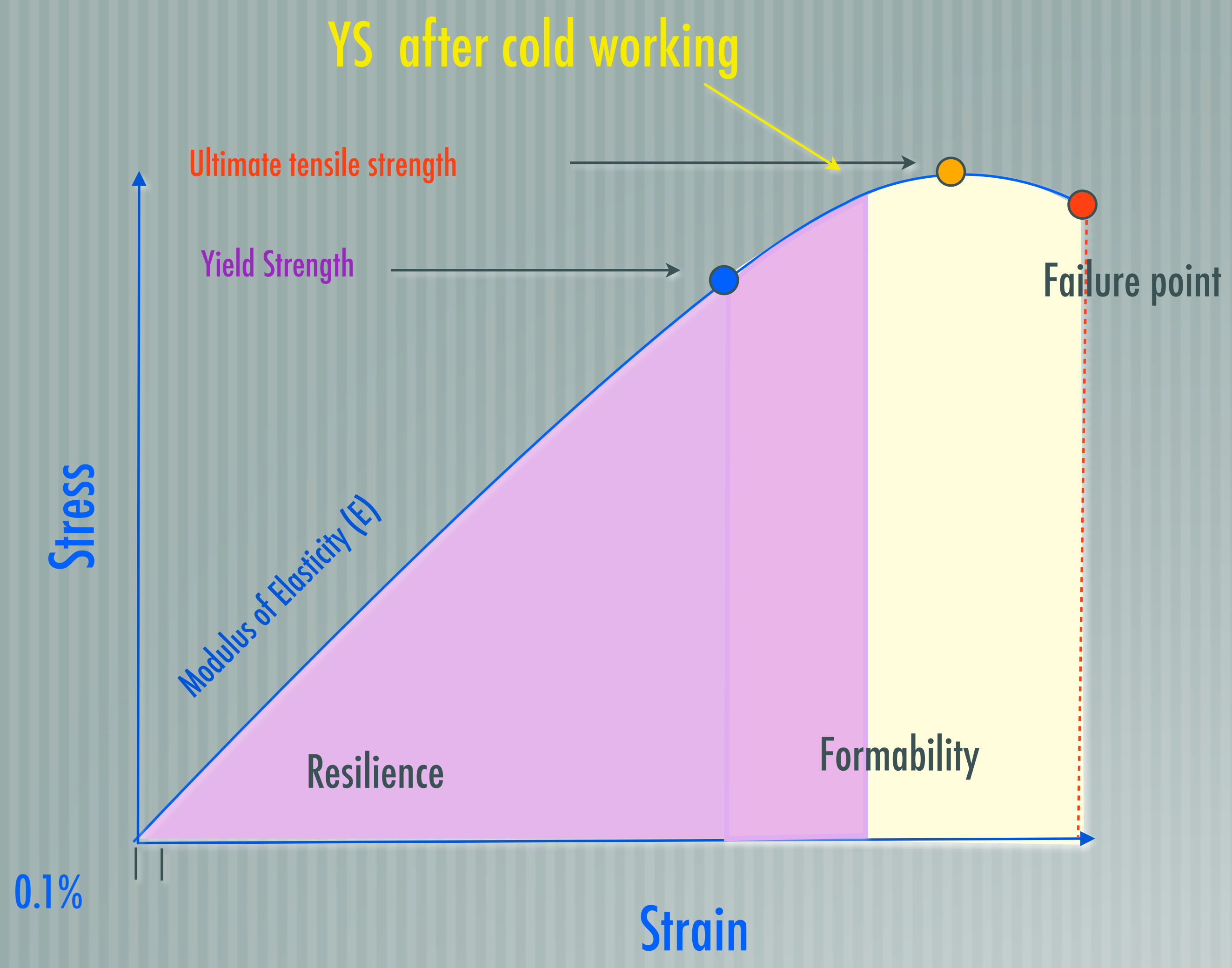
Annealing & Cold working



Annealing : SS wires are soft and formable

Ligature wire (Dead soft)

Annealing & Cold working



Cold Working : High YS
Brittle, High springiness
(Super SS)

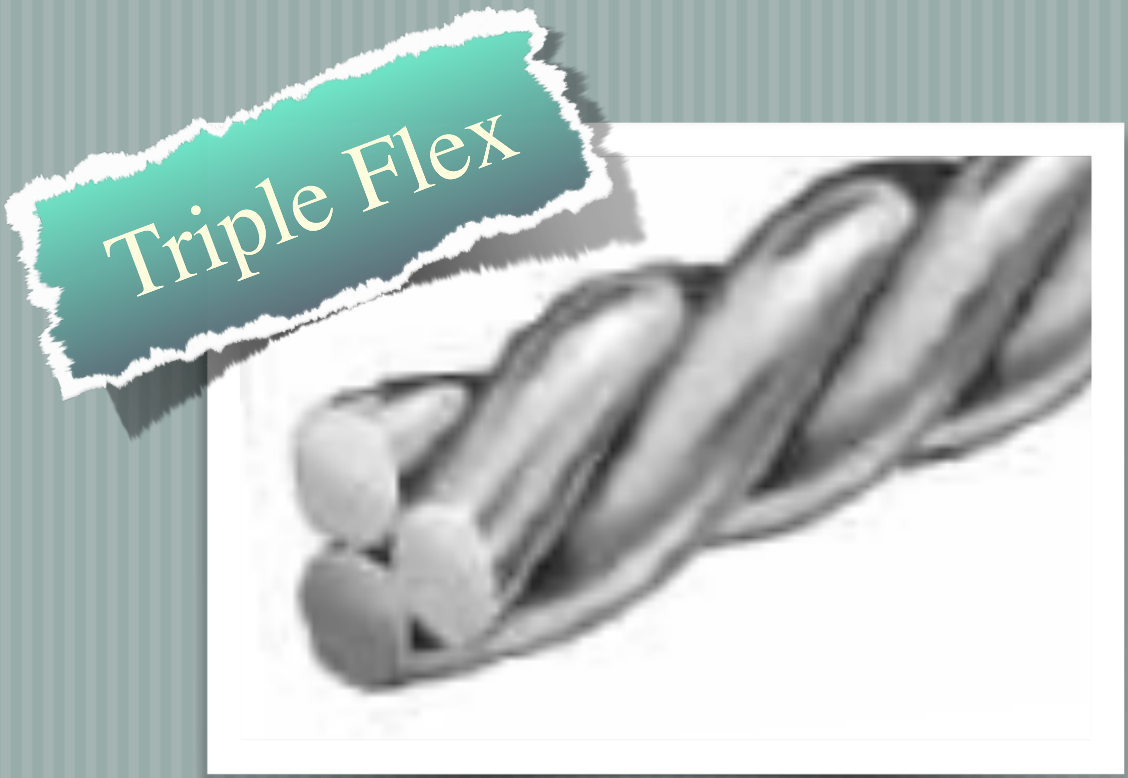
Co-axial arch wire

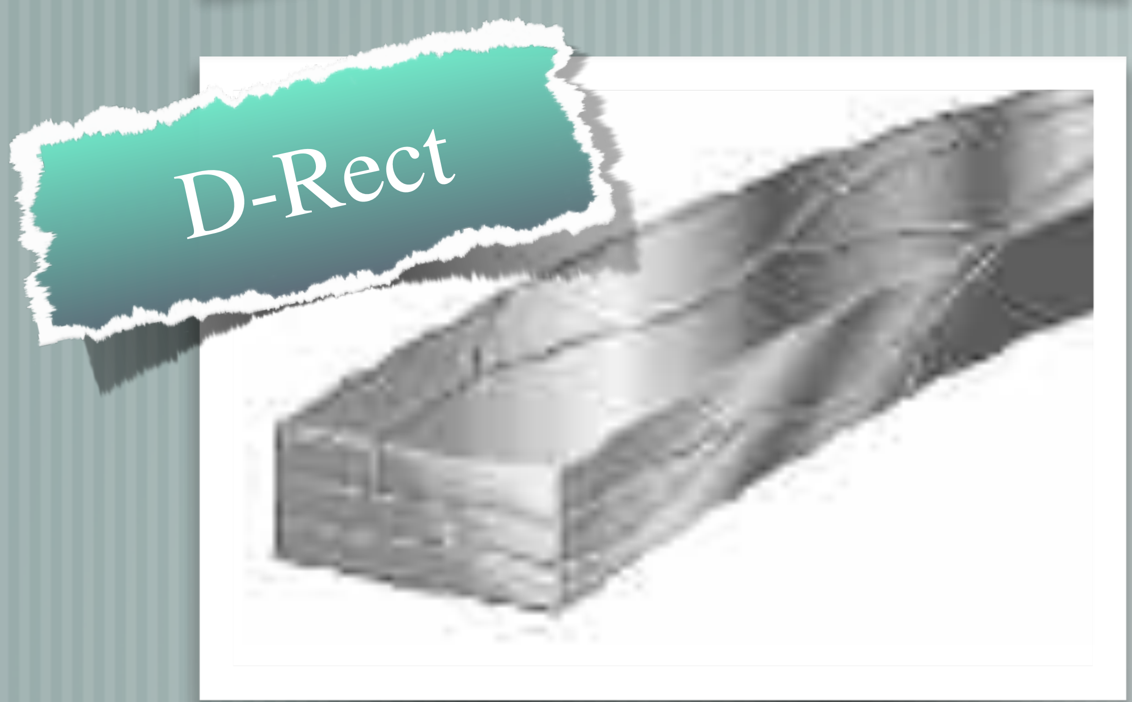
Comparative Properties of Orthodontic Wires

	Modules of elasticity (10^6 psi)	Material stiffness relative to steel	Set angle (degrees)*
Stainless steel *Truchrome—Rocky Mtn*	29	1.00	NA
Triple strand 9 mil *Triple-flex—Ormco*	3.9[b]	0.13	62
Coaxial 6 strand *Respond—Ormco*	1.25[b]	0.04	49
Braided rect. 9 strand *Force 9—Ormco*	1.50[b]	0.05	56
Braided rect. 8 strand *D-Rect—Ormco*	1.25[b]	0.04	88
Braided rect. A-NiTi *Turbo—Ormco*	0.50[b]	0.02	88

*Degree of bending around 1/4 inch radius before permanent deformation

Co-axial stand : Respond (Ormco)





Eight-strand braided SS

Nine-strand rectangular braided

Elgiloy (Cobalt chromium alloys)

Comparative Properties of Orthodontic Wires

	Modules of elasticity (10^6 psi)	Material stiffness relative to steel	Set angle (degrees)*
Stainless steel *Truchrome—Rocky Mtn*	29	1.00	NA
Cobalt chromium *Elgiloy—Rocky Mtn*	28	0.97	16

*Degree of bending around 1/4 inch radius before permanent deformation

Elgiloy (Cobalt chromium alloys)

-more formable (annealing alike)

-Chair side hardened possible by heat treatment (Cold working alike)

-not commonly used today

NiTi Alloy (Nickel-titanium)

Comparative Properties of Orthodontic Wires

	Modules of elasticity (10^6 psi)	Material stiffness relative to steel	Set angle (degrees)*
Stainless steel *Truchrome*—Rocky Mtn	29	1.00	NA
A-NiTi *Nitinol SE*—Unitek	12[2]	0.41	NA
M-NiTi *Nitinol*—Unitek	4.8	0.17	42

*Degree of bending around 1/4 inch radius before permanent deformation

NiTi Alloy (Nickel-Titanium)

NiTi Alloy (Nickel-Titanium)

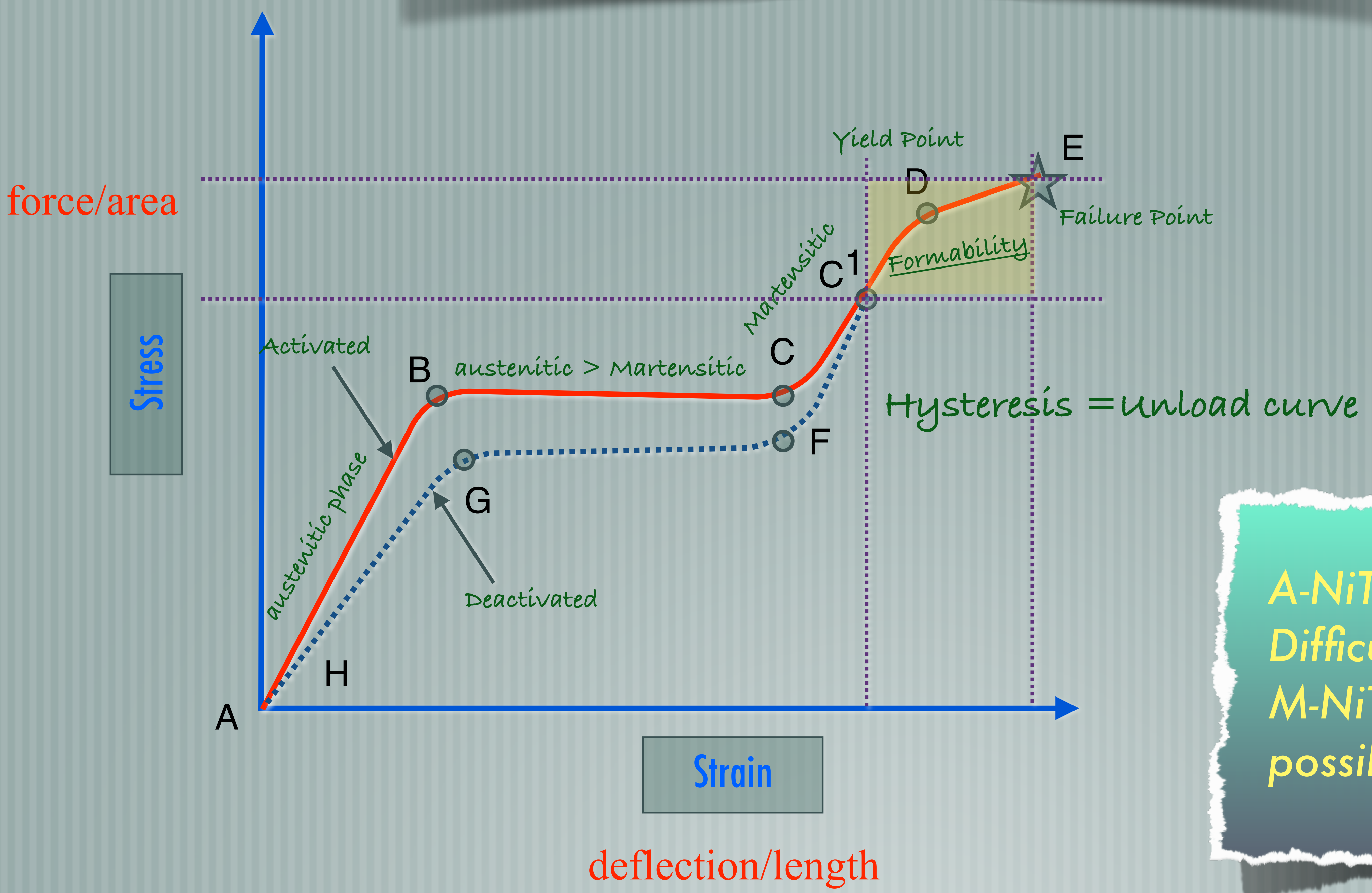
- Shape memory
- Super elasticity
- Less formability

A-NiTi, M-NiTi

1970, Nitinol (M-NiTi) :
Nitinol (Unitek), Orthonol, (Rocky mountain)

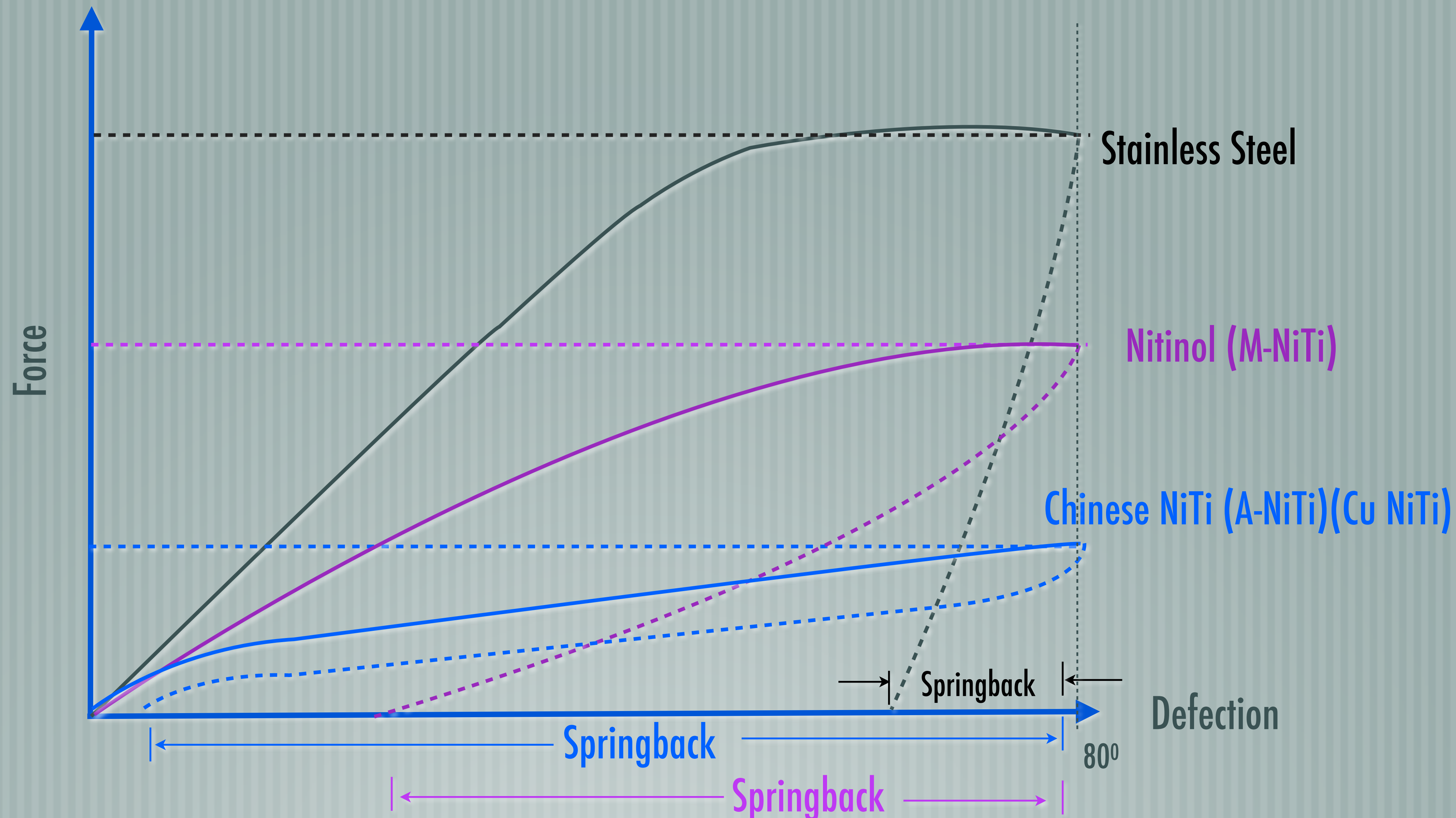
1980, Chinese NiTi (A-NiTi) : Cu NiTi (Ormco), Sentinol
SE NiTi (Super elastic NiTi)
Nitinol SE (Unitek)

Stress Strain Curve for A- NiTi



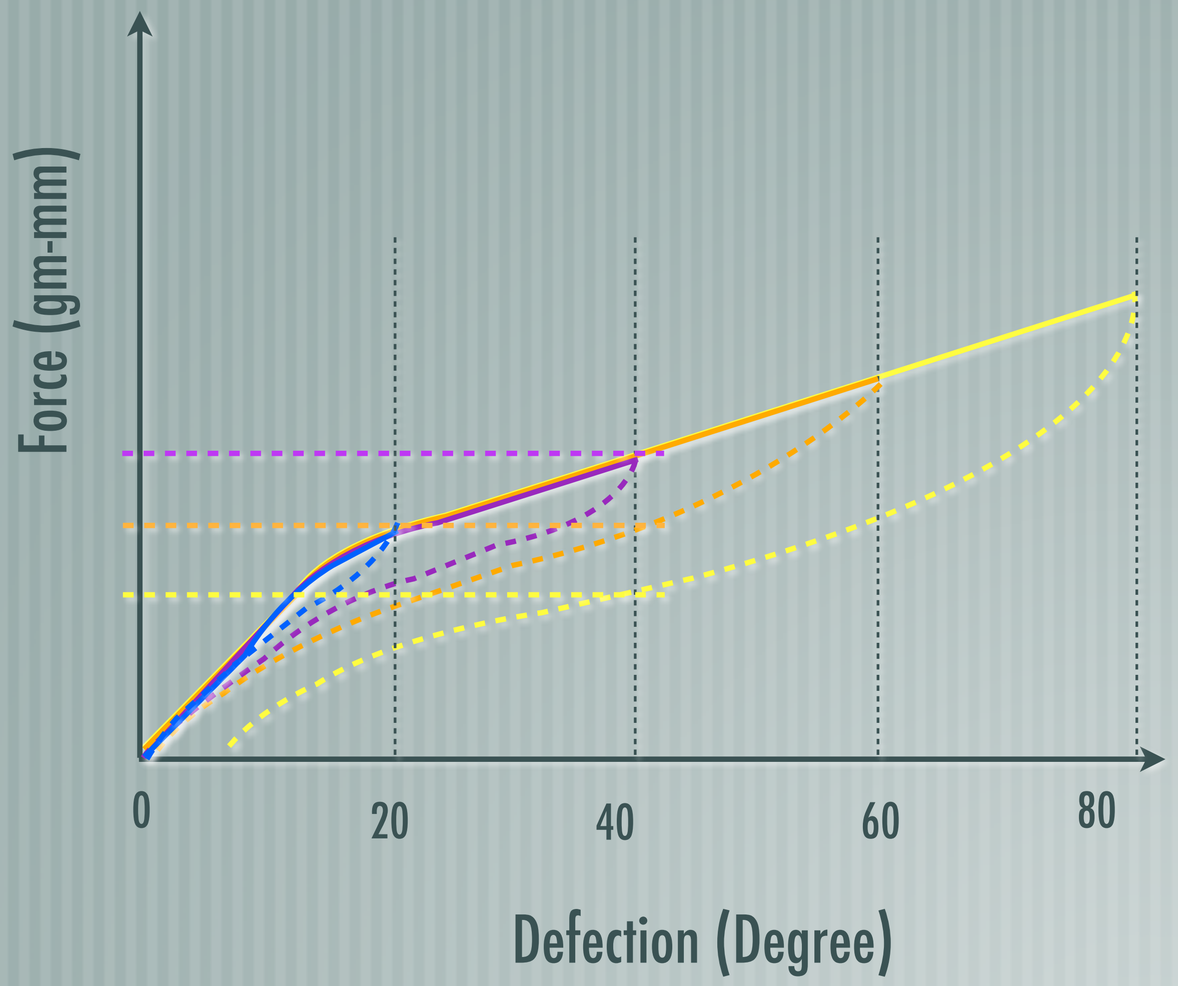
A-NiTi (Cu NiTi): Difficult to bend
M-NiTi : Bending possible

SPRINGBACK COMPARISON



A-NiTi > M-NiTi >>> SS

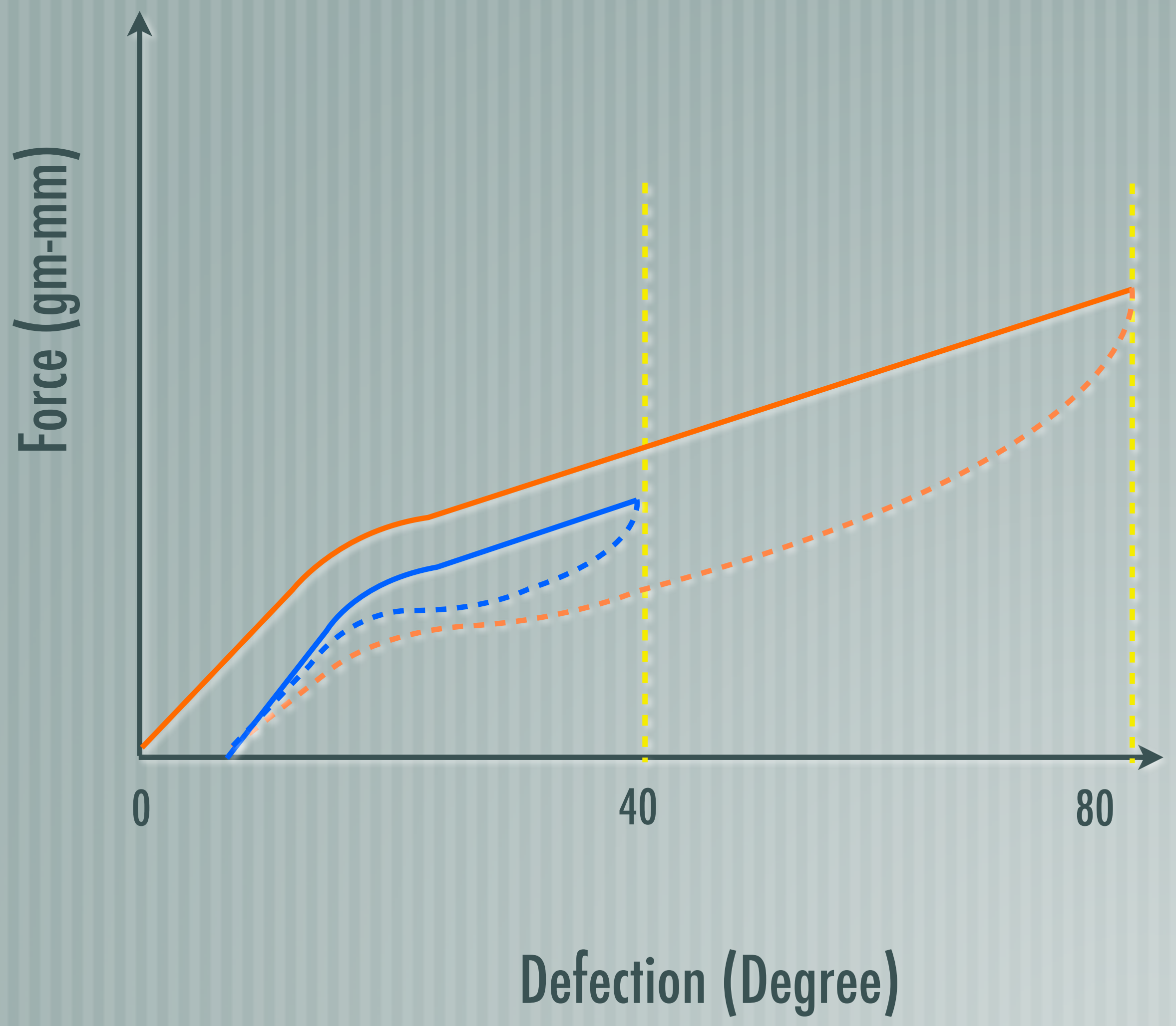
Activation and deactivation curve (Hysteresis effect) for A-NiTi(SE)



-Unload curve changes at different activation

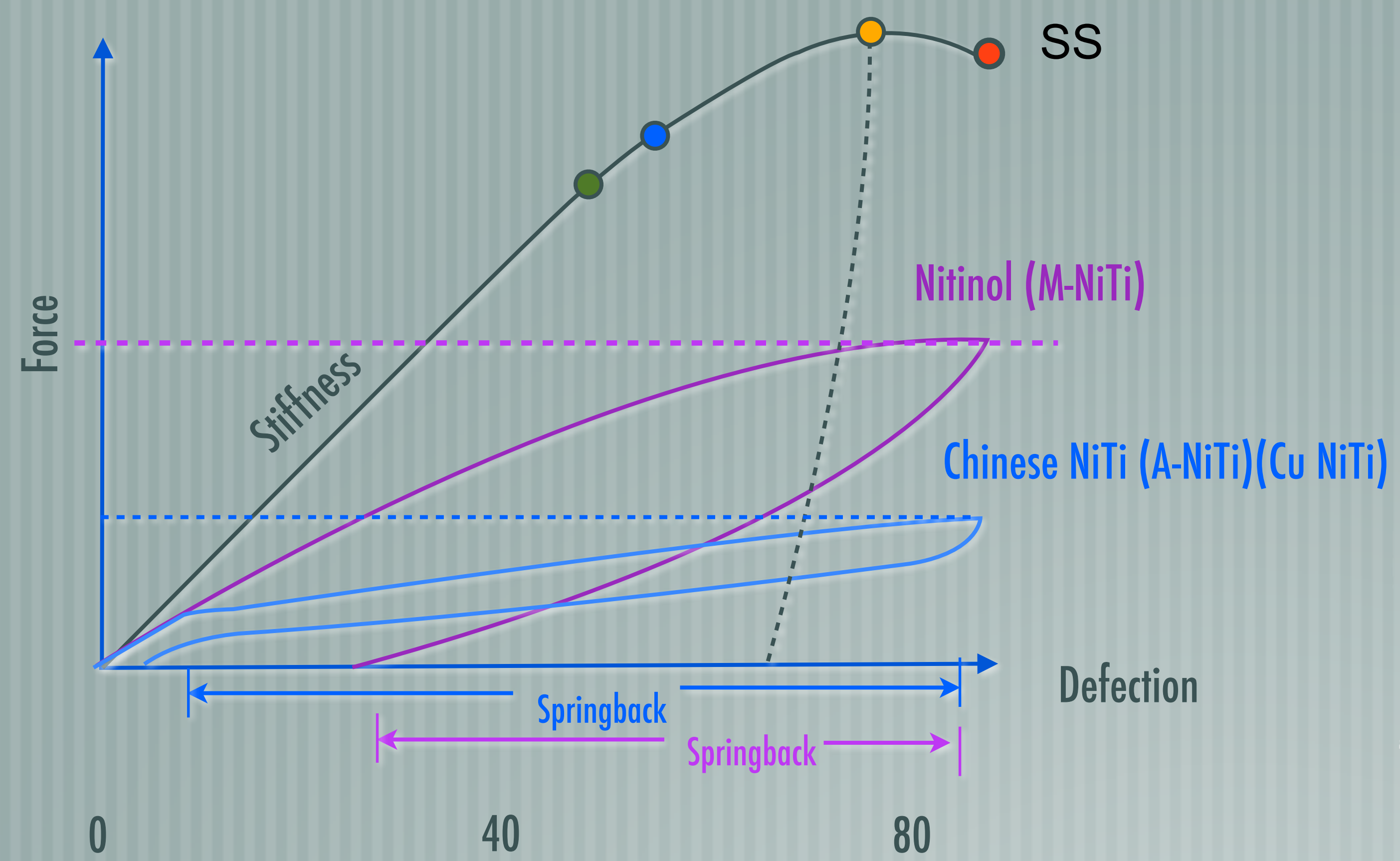
- Unique behaviour for only A-NiTi

Activation(to 8o degrees)and reactivation(to 4o degrees) curves for austenitic NiTi wire.



The amount of force exerted could be considerably increased by untying it from a bracket and then retying it

Clinical Application
for wire used in orthodontic



A-NiTi (Cu NiTi): Initial wire
M-NiTi : Later stage of treatment, more stiffer needed
SS: Most stiffer wire, Bendable

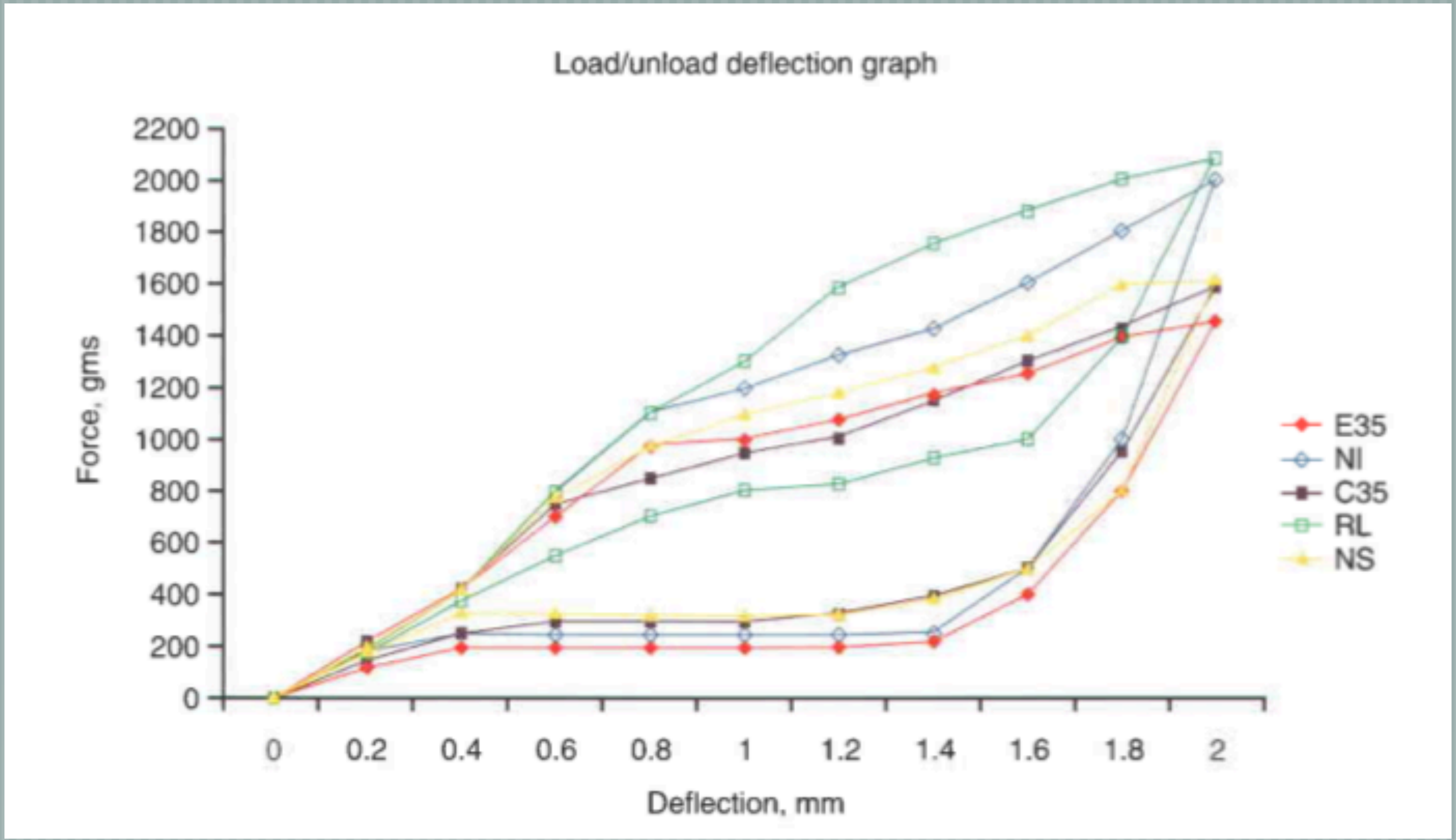


FIGURE 10-9 Activation and reactivation curves for five currently available superelastic NiTi wires (E35 = Elastinol 35, Masel; NI = Nitinol heat-activated, Unitek; C35 = Copper NiTi 35° C; RL = Remaitan Lite, Dentarum; NS = Neosentalloy F200). Note that the curves differ considerably in the amount of force delivered on activation, which for orthodontic use is the part of the curve that is important. Since these wires are used in the initial stage of treatment, when tooth movement is primarily tipping, rotation, and extrusion, light force is desirable. (Redrawn from Gurgel et al.[3])

Beta-Titanium (Titanium molybdenum alloy, TMA)

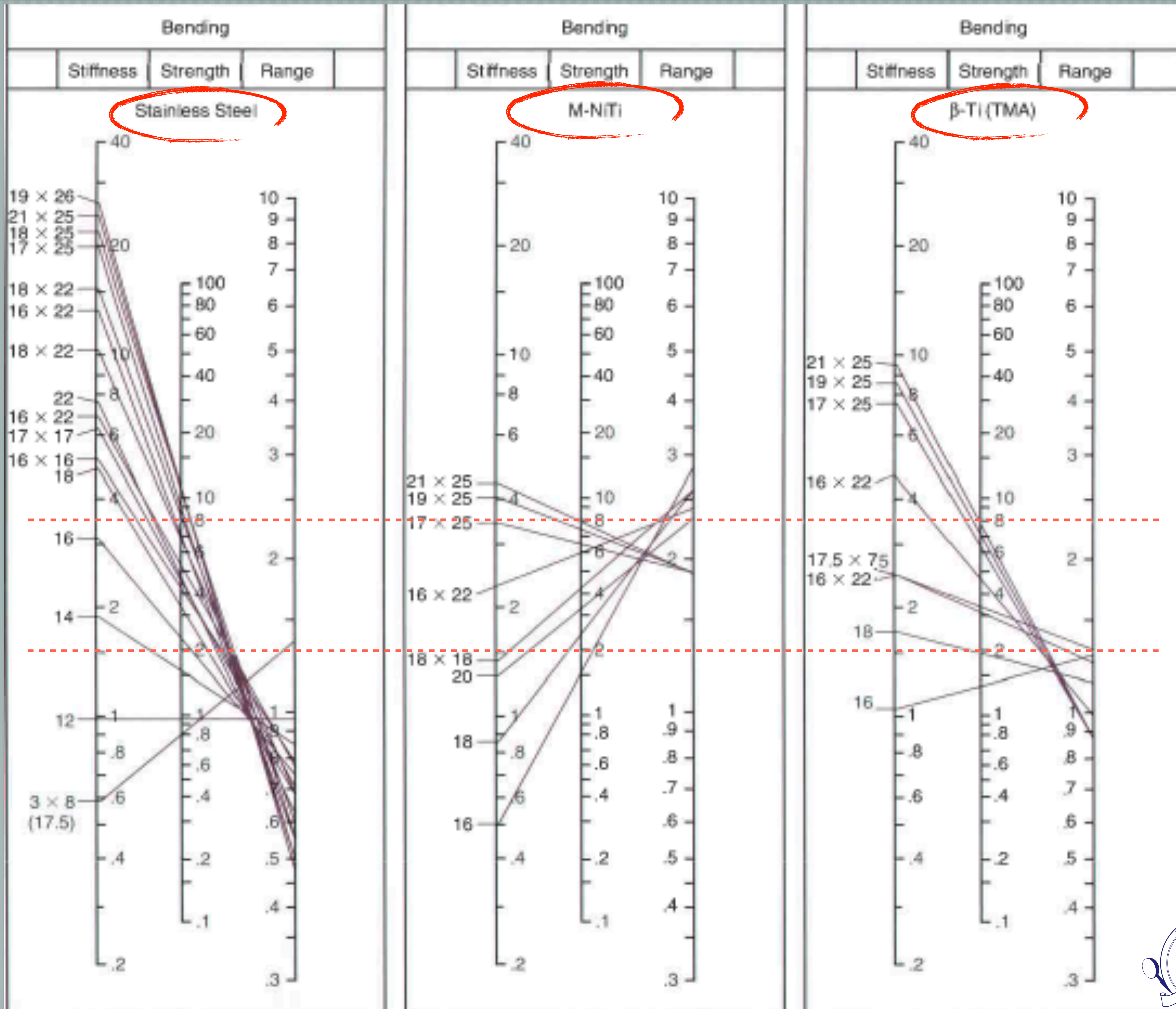
Elastic Property Ratios: 16 and 18 mil Wire in Bending

	STRENGTH		STIFFNESS		RANGE	
	.016	.018	.016	.018	.016	.018
Stainless steel	1.0		1.0		1.0	
TMA	0.6	0.6	0.3	0.3	1.8	1.8
M-NiTi	0.6	0.6	0.2	0.2	3.9	3.9

Half the force but twice the working range of stainless steel

…operty Ratios: 19 × 25 Wire in Bending (B) and Torsion (T)

	STRENGTH		STIFFNESS		RANGE	
	B	T	B	T	B	T
Stainless steel	1.0		1.0		1.0	
TMA	0.6	0.6	0.3	0.3	1.8	2.0
M-NiTi	0.6	0.8	0.2	0.1	4.0	5.4



Bending
Stiffness
Strength
Range
Stainless Steel
19 × 26
21 × 25
18 × 25
17 × 25
18 × 22
16 × 22
18 × 22
22
16 × 22
17 × 17
16 × 16
18
16
14
12
3 × 8
(17.5)
Bending
Stiffness
Strength
Range
M-NiTi
21 × 25
19 × 25
17 × 25
16 × 22
18 × 18
20
18
16
Bending
Stiffness
Strength
Range
β-Ti (TMA)
21 × 25
19 × 25
17 × 25
16 × 22
17.5 × 7.5
16 × 22
18
16

Clinical Application

Intrinsic Factor

The most flexible orthodontic wire materials : used initially NiTi

The most stiff orthodontic wire materials: towards end of treatment SS, TMA

Wire sequence in orthodontics (Conventional)

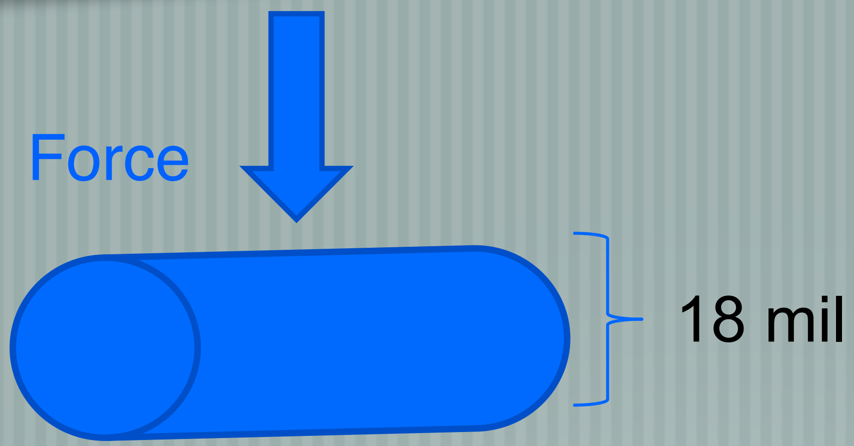
Phase I: Leveling & aligning NiTi 014", 016", 018"

Phase II: Rotational control NiTi 16x22 or 17x25

Phase III: Major mechanics Stainless steel 016", 16x22, 17x25,

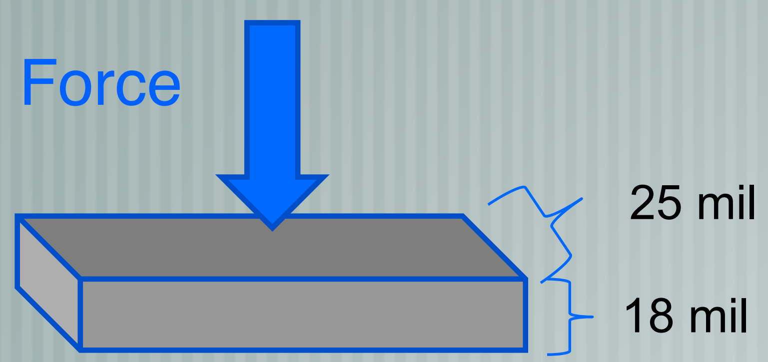
Phase III: Finishing 16 NiTi, 16x22 NiTi, 17x25 NiTi

Round Wire Vs Rectangular Wire



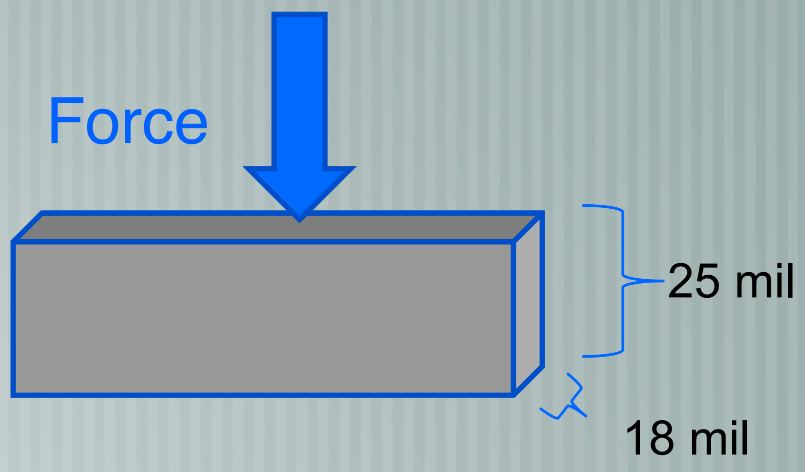
Round Wire

2nd order bend



Rectangular Edgewise Wire

1st order bend



Ribbon Wire

Wire selection in orthodontics (AVS)

Levelling stage : NiTi Wire >> Amount of crowding

1st order = In-out and rotation : Round Wire

2nd order = Tipping : Edgewise or Round Wire

3rd order = Torque : Edgewise

Working stage : SS Wire >> Anchorage requirement

Sliding Mechanic (Friction) : Round Wire

Non Sliding Mechanic (Non Friction): Edgewise Wire

Finishing stage : NiTi Wire >> Finishing Needed, RWT (Bracket Install and Case Type)

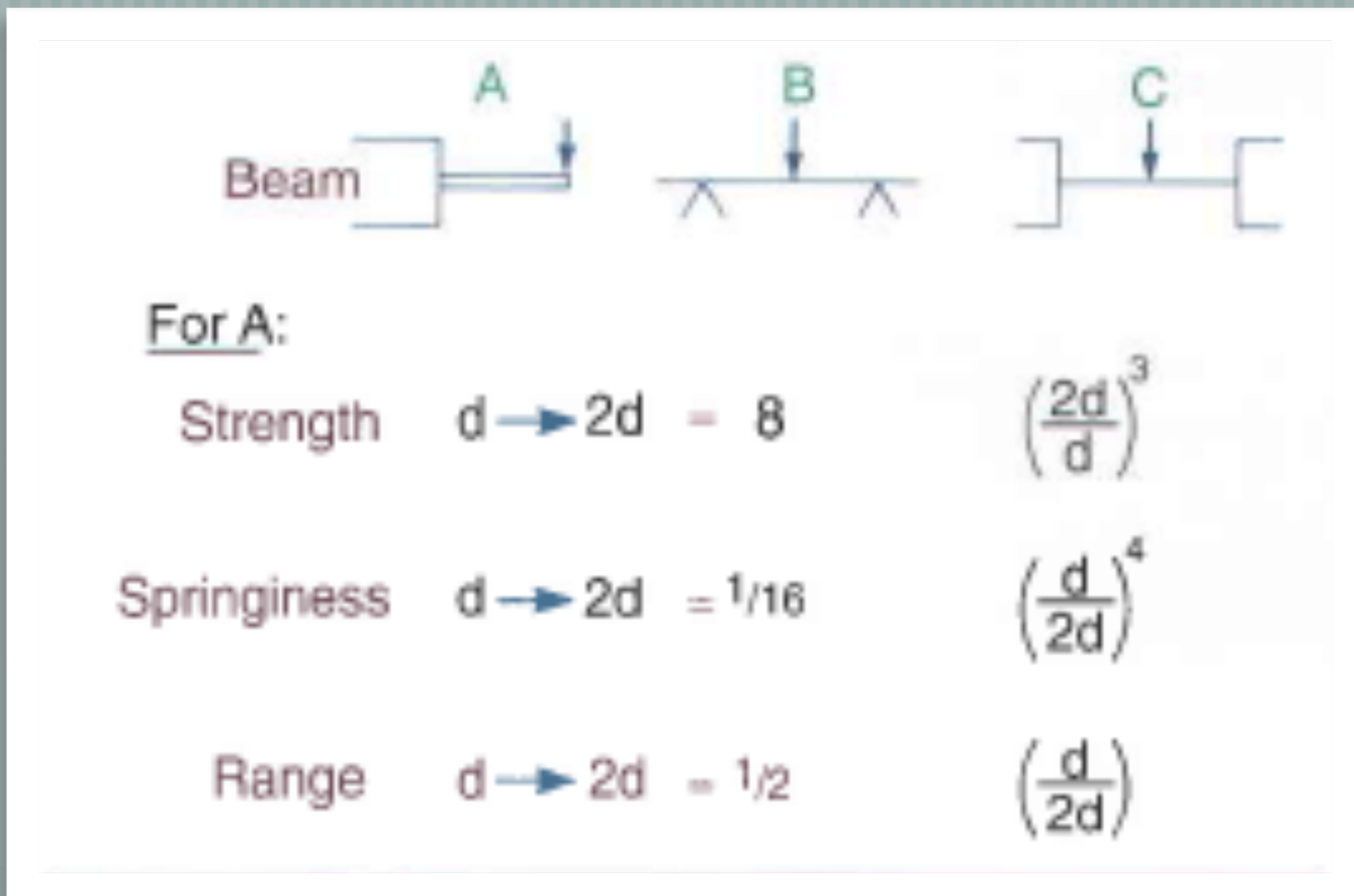
1st 2nd 3rd order : Edgewise

Extrinsic Factor

Diameter or Cross-section

Length and Attachment

Effects of Diameter or Cross-section



No matter about type of beam and ligation

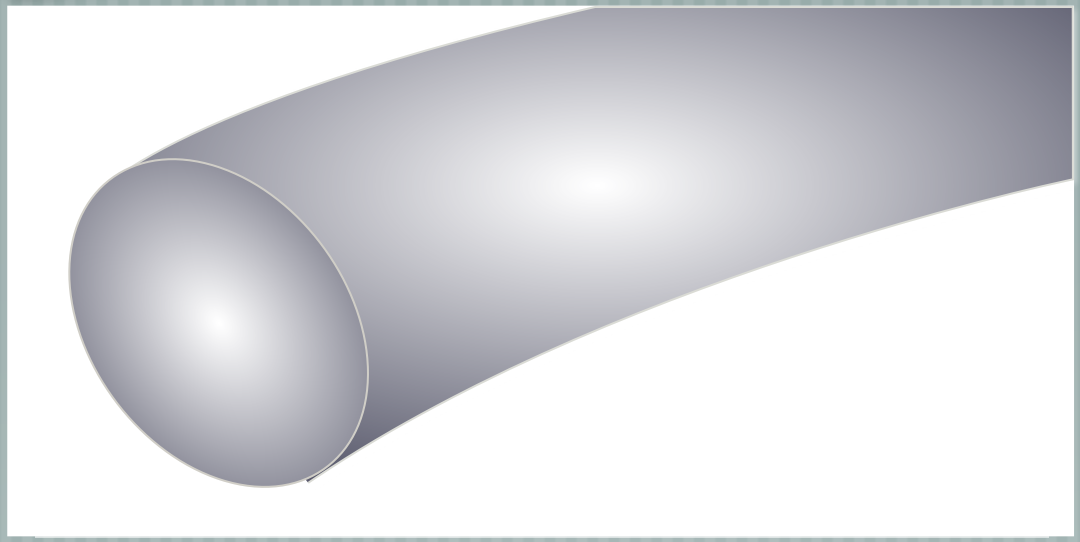
Clinical Example : Wire size, Crimping stop, Crimping Hook, Solder

Sensitivity : Increase diameter of wire

Springiness ↓ (Fourth) > Strength ↑ (Cube) > Range ↓ (1:1)

Wire manufacturing

Effects of Diameter or Cross-section



Sensitivity : decrease diameter of wire

Springiness ↑ (Fourth) > Strength ↓ (Cube) > Range ↑ (1:1)

$$\begin{pmatrix} \text{Springiness} = (3)^4 \\ \text{Strength} = (1/3)^3 \\ \text{Range} = (1/3) \end{pmatrix} \times 3 = \begin{matrix} \text{Springiness} = 27 \\ \text{Strength} = 1/9 \\ \text{Range} = 1 \end{matrix}$$

$$\begin{pmatrix} \text{Springiness} = (6)^4 \\ \text{Strength} = (1/6)^3 \\ \text{Range} = (1/6) \end{pmatrix} \times 6 = \begin{matrix} \text{Springiness} = 216 \\ \text{Strength} = 1/36 \\ \text{Range} = 1 \end{matrix}$$

Effects of Length & Ligation

Beam

Strength	1/2	1/4	1	2
Springiness	1	8	1	1/4
Range	1	4	1	1/2

Does matter about type of beam and ligation

Sensitivity : Increase the length of wire

Springiness ↑↑ (Cube) > Range ↑(Square) > Strength ↓ (1:1)

Clinical Example :
Length : Loop, Inter bracket distance, Skip bracket engagement,
Ligation : Bracket type, ligation material,

Clinical application

Effects of Length

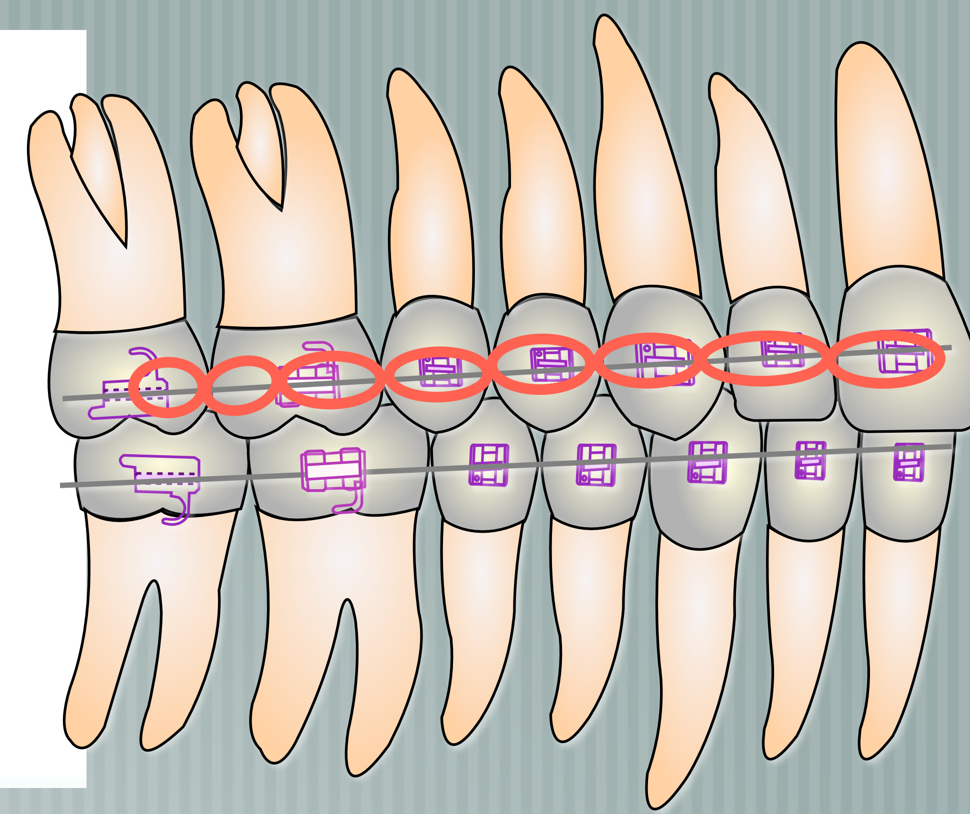
Sensitivity : Increase the length of wire

Springiness ↑(Cube) > Range ↑(Square) > Strength ↓(1:1)

Springiness = $(2)^3$	=	Springiness = 8
Strength = (1/2)		Strength = 1/2
Range = $(2)^2$		Range = 4

Effects of Attachment

Beam	L	2L	2L
Strength	1/2	1	2
Springiness	1	1	1/4
Range	1	1	1/2



Sensitivity : Type of Ligation

Springiness ↓↓(Square) > Range ↓(1:1) > Strength ↑(1:1)

Clinical application

Effects of Attachment

Sensitivity : Type of Ligation

Springiness ↓ (Square) > Range ↓ (1:1) > Strength ↑ (1:1)

Springiness = 1	=	Springiness = 1/4
Strength = 1		Strength = 2
Range = 1		Range = 1/2

Clinically use in point of Extrinsic property consideration

Size & Length

cross section area,
loop forming (lengthening wire)
Full engage in every single bracket
or skip engagement

Shape

circle, rectangular

Ligation

Active SL, passive SL, conventional
(wire, o-ring)

SUMMARY OF CLINICAL CONSIDERATION IN MECHANICAL POINT OF VIEW

- Force magnitude (Strength)
  light force
- Force constancy (High range, Low stiffness)
  consistency of the applied force over the range of activation of the appliance obtained by reducing load-defection rate
- Reducing the cross-section of a wire (low strength)
  Co-axial SS, Small wire
- Lengthening the wire
  Increasing the interbracket distance (M-D bracket width)
  bypass bonding tooth/teeth
  auxiliary spring (intrusion arch, 2x4)
  Incorporating loop in the wire
- Use of memory alloys
  Intrinsic factor

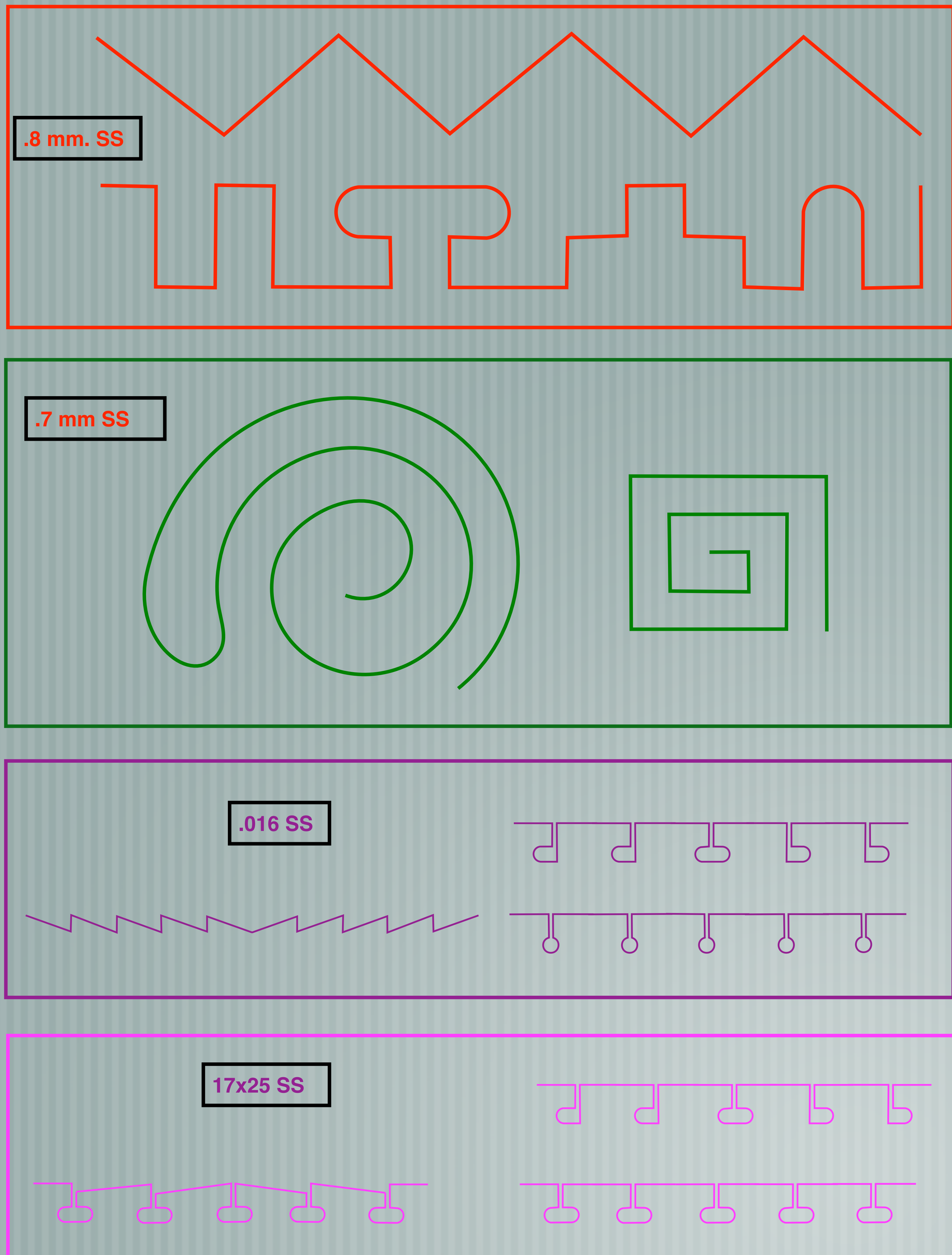
SUMMARY OF CLINICAL CONSIDERATION

Intrinsic Factors

- Wire Type Selection
  SS, A-NiTi, TMA

Extrinsic Factors

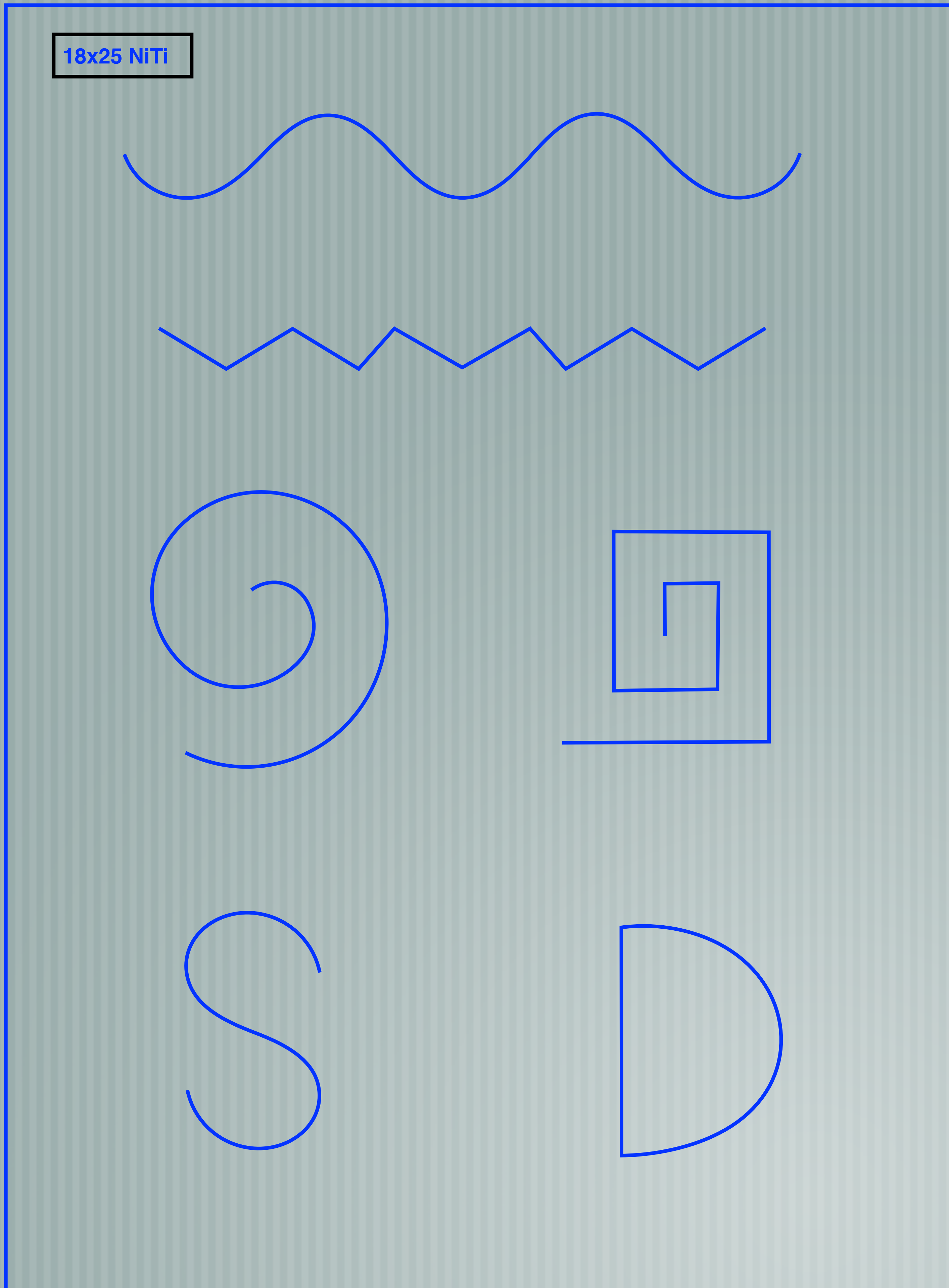
- Wire Bending (Loop & Spring Design)
- Lengthening wire
  - Bracket Placement (Inter BKT distance)
  - Bracket Slot Size (Play)
  - Bracket Ligation (Play)
  - Wire size & Shape Selection
    Small wire at initial phase
    Round, Co-axial SS, Rectangular wire
  - Torsion 2/5E



WIRE BENDING (LAB)

Stainless Steel Wire

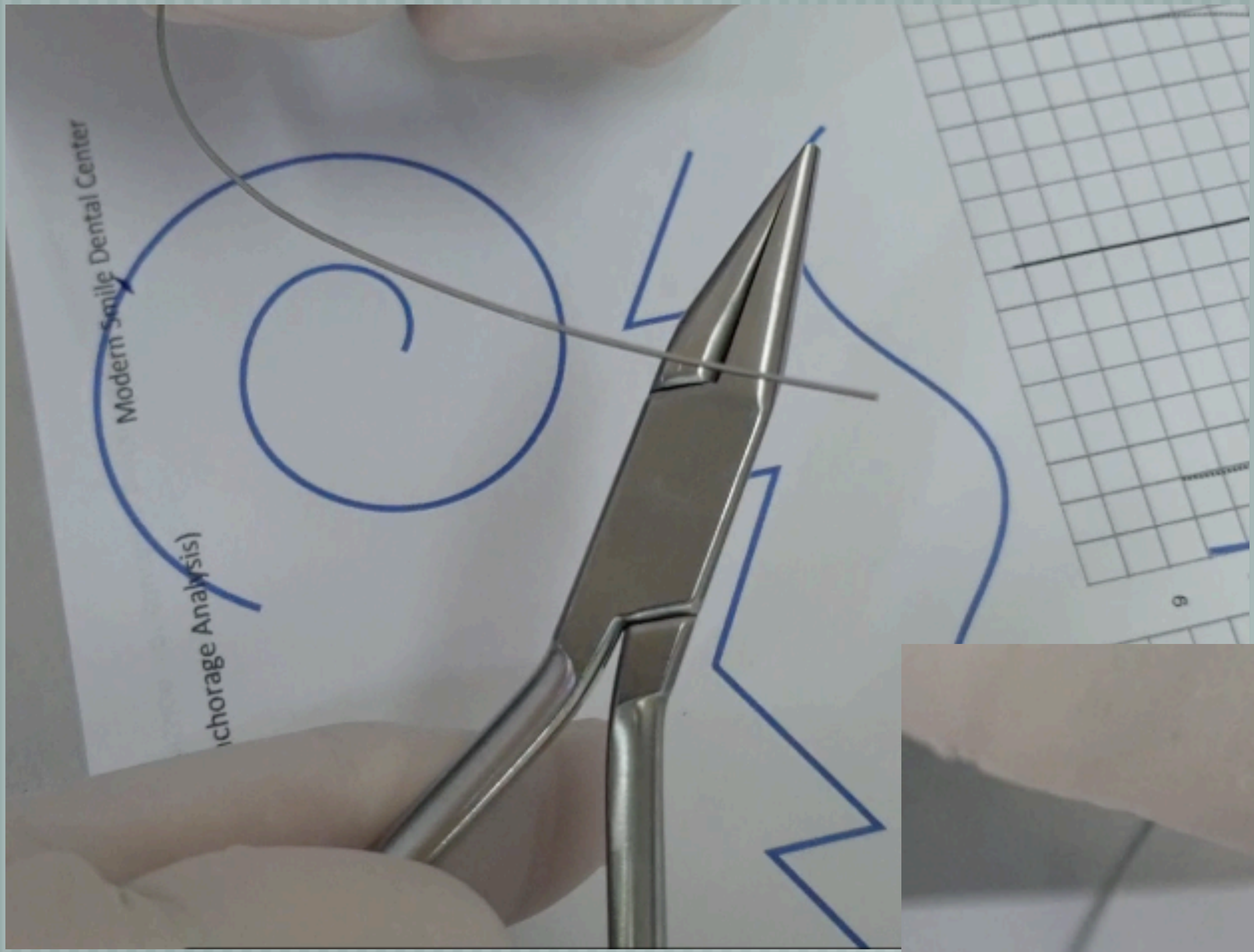
- ดัดลวดตามแบบ plate ที่ให้ไป โดยใช้ลวด 0.7 mm.SS และ 0.018” SS เพื่อเป็นการฝึกมือและเข้าใจถึงพฤติกรรมของลวดทั้ง NiTi และ Stainless Steel
-ใช้ลวด preform 17x25 SS และ NiTi เพื่อฝึกหัดทำเทคนิกการ manage wire ในระบบ AVS

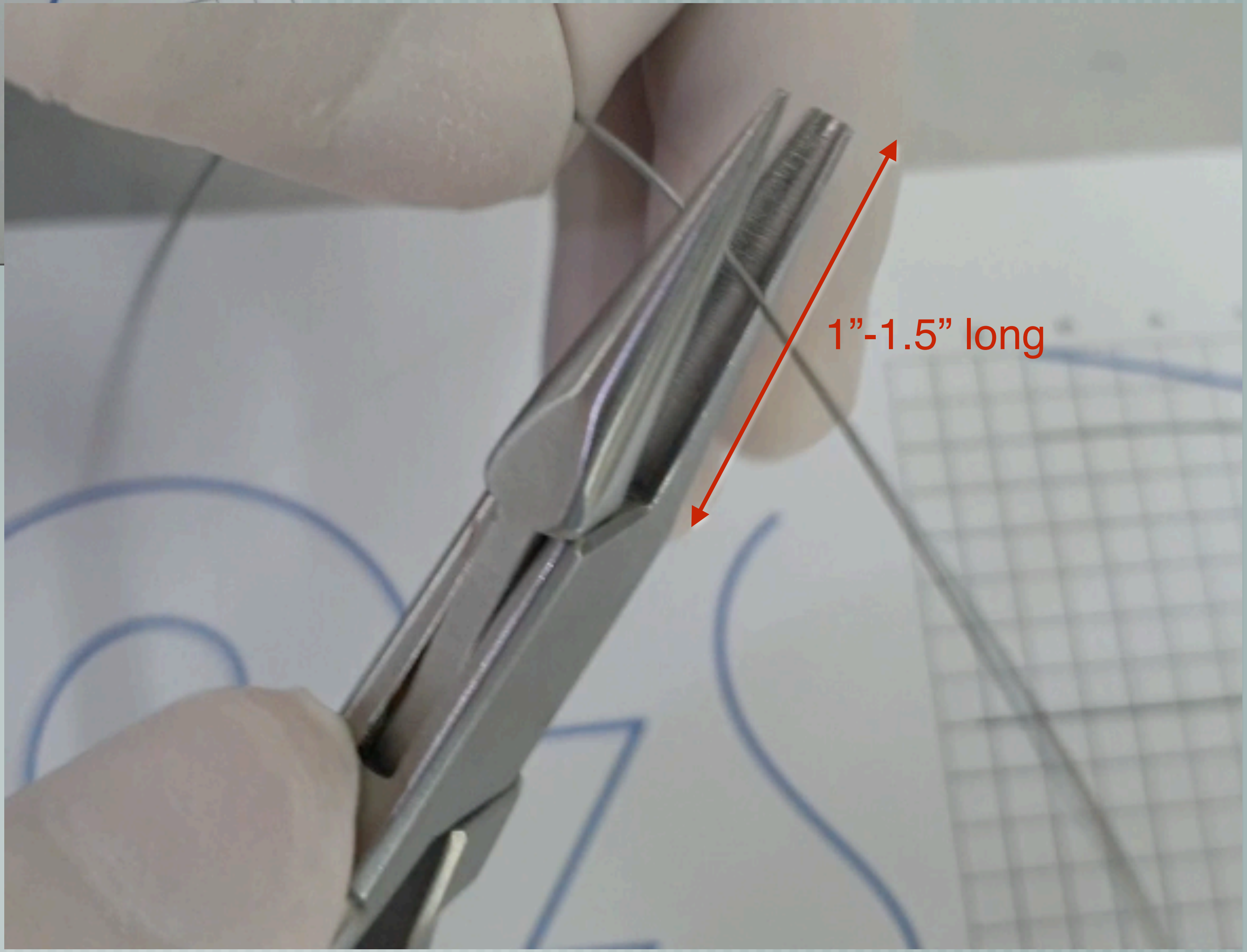


NiTi Wire Bending

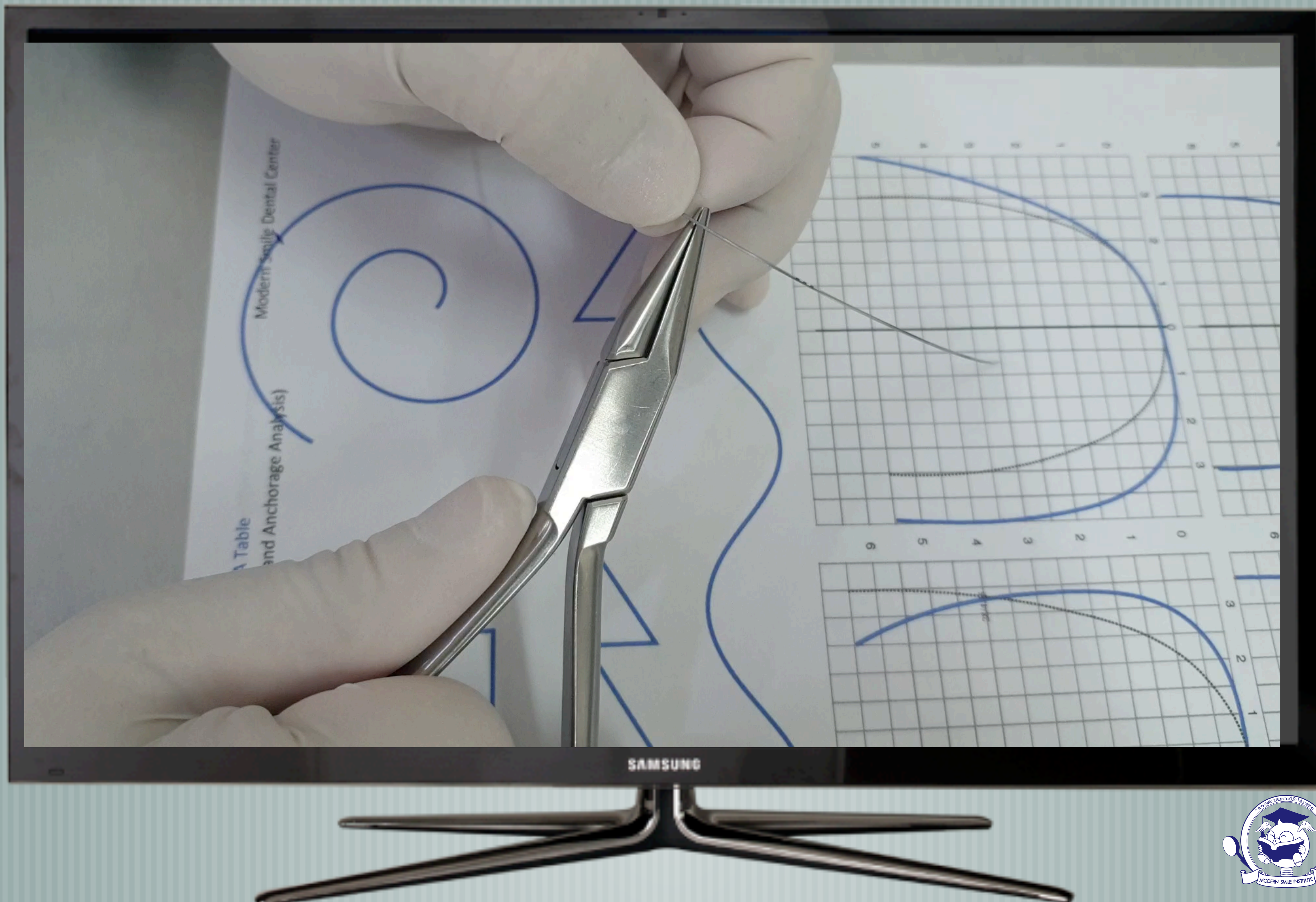
- ดัดลวดตามแบบ plate ที่ให้ไป โดยใช้ลวด 0.7 mm.SS และ 0.018” SS เพื่อเป็นการฝึกมือและเข้าใจถึงพฤติกรรมของลวดทั้ง NiTi และ Stainless Steel
-ใช้ลวด preform 17x25 SS และ NiTi เพื่อฝึกหัดทำเทคนิกการ manage wire ในระบบ AVS

Long Beak Half Round Pliers (1.5 inch)

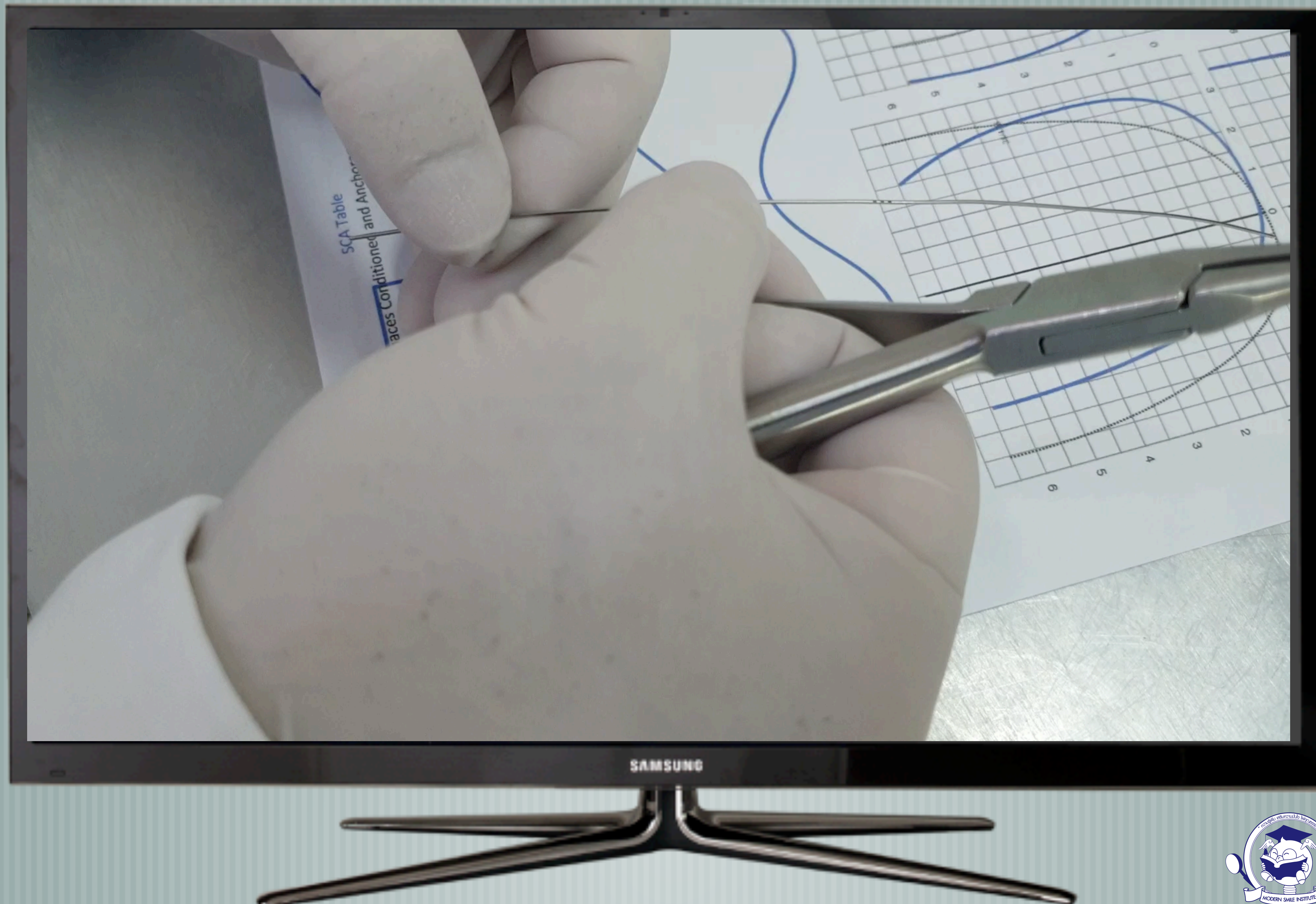




NiTi Wire Bending Practice : (0:52)

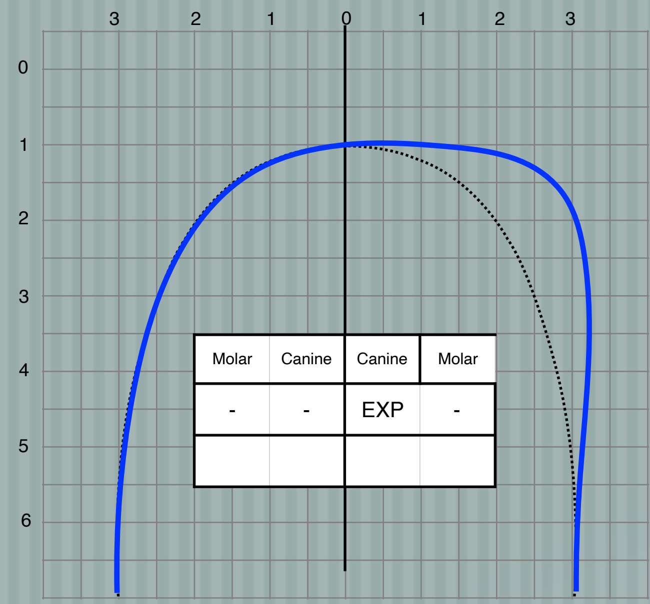


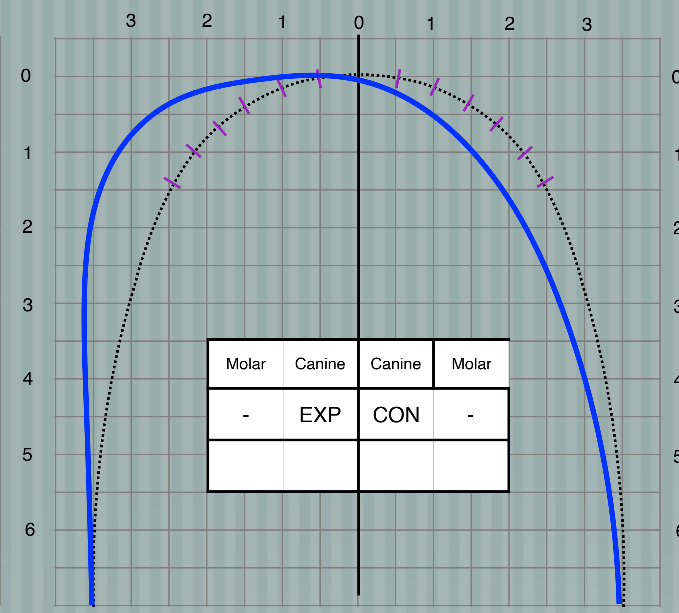
NiTi Wire Bending Practice : (8:28)

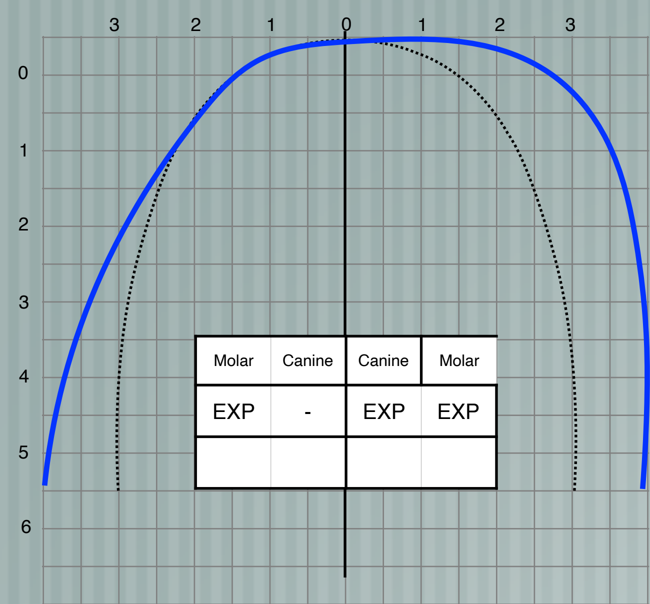


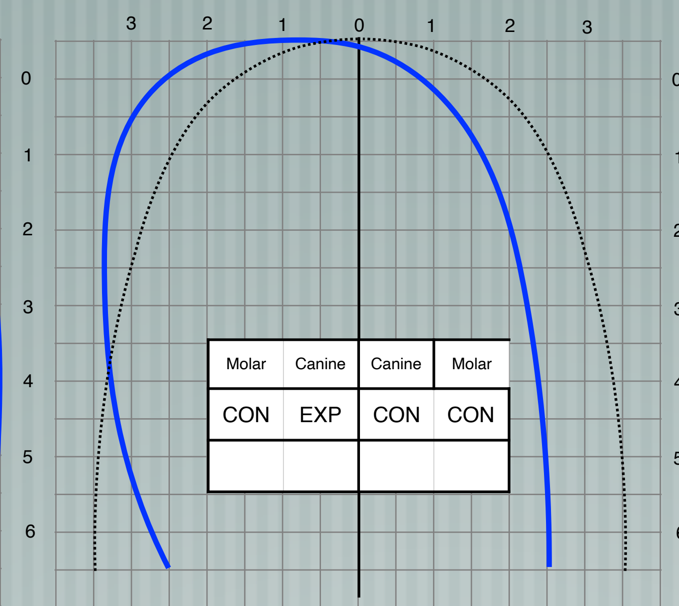
18x25 NiTi

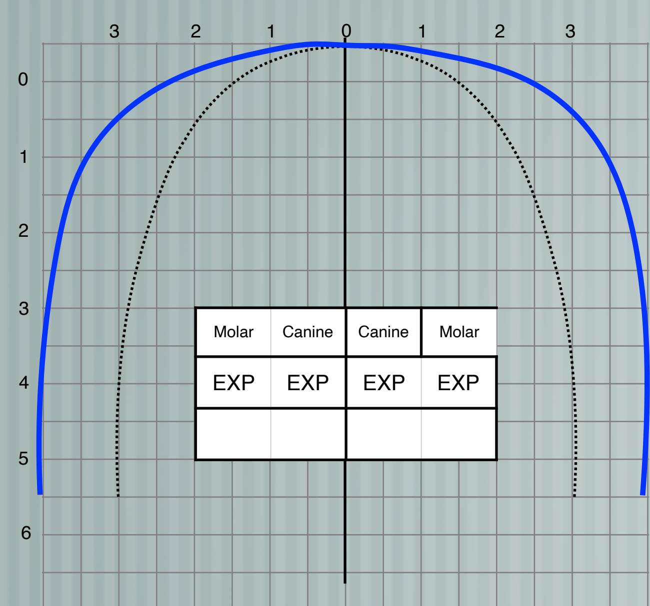
NiTi Wire Bending Practice : ACDN

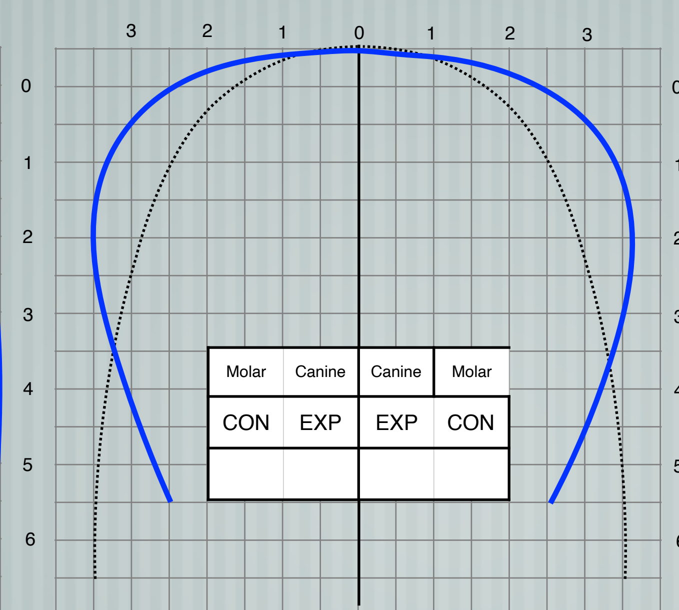












Molar	Canine	Canine	Molar
Q1 Molar Part	Q1 Canine Part	Q2 Canine Part	Q2 Molar Part
Q4 Molar Part	Q4 Canine Part	Q3 Canine Part	Q3 Molar Part

Molar	Premolar	Canine	Canine	Premolar	Molar
Q1 Molar Part	Q1 Premolar Part	Q1 Canine Part	Q2 Canine Part	Q2 Premolar Part	Q2 Molar Part
Q4 Molar Part	Q3 Premolar Part	Q4 Canine Part	Q3 Canine Part	Q3 Premolar Part	Q3 Molar Part

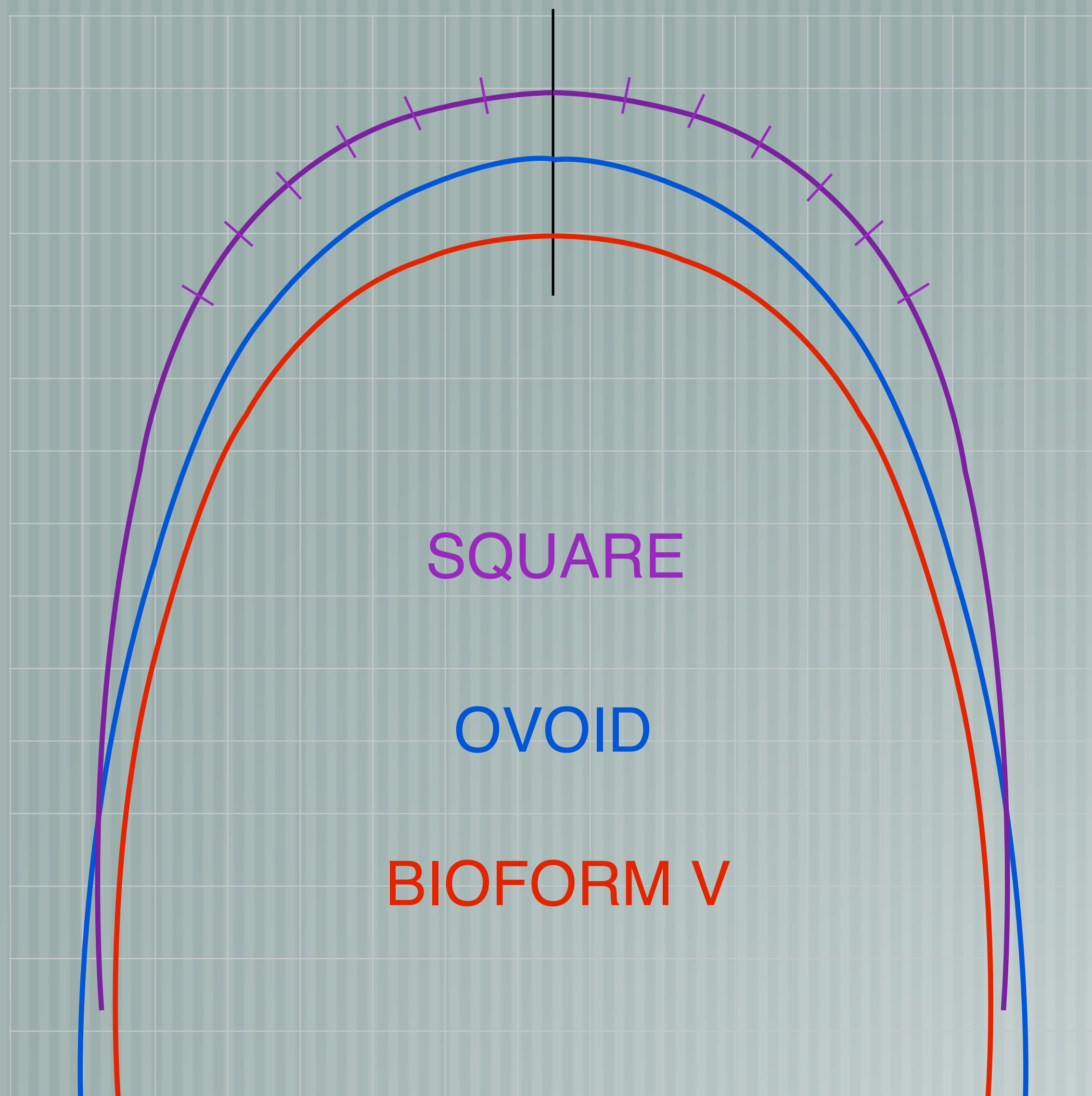
NiTi Wire bending : CDN (2:52)

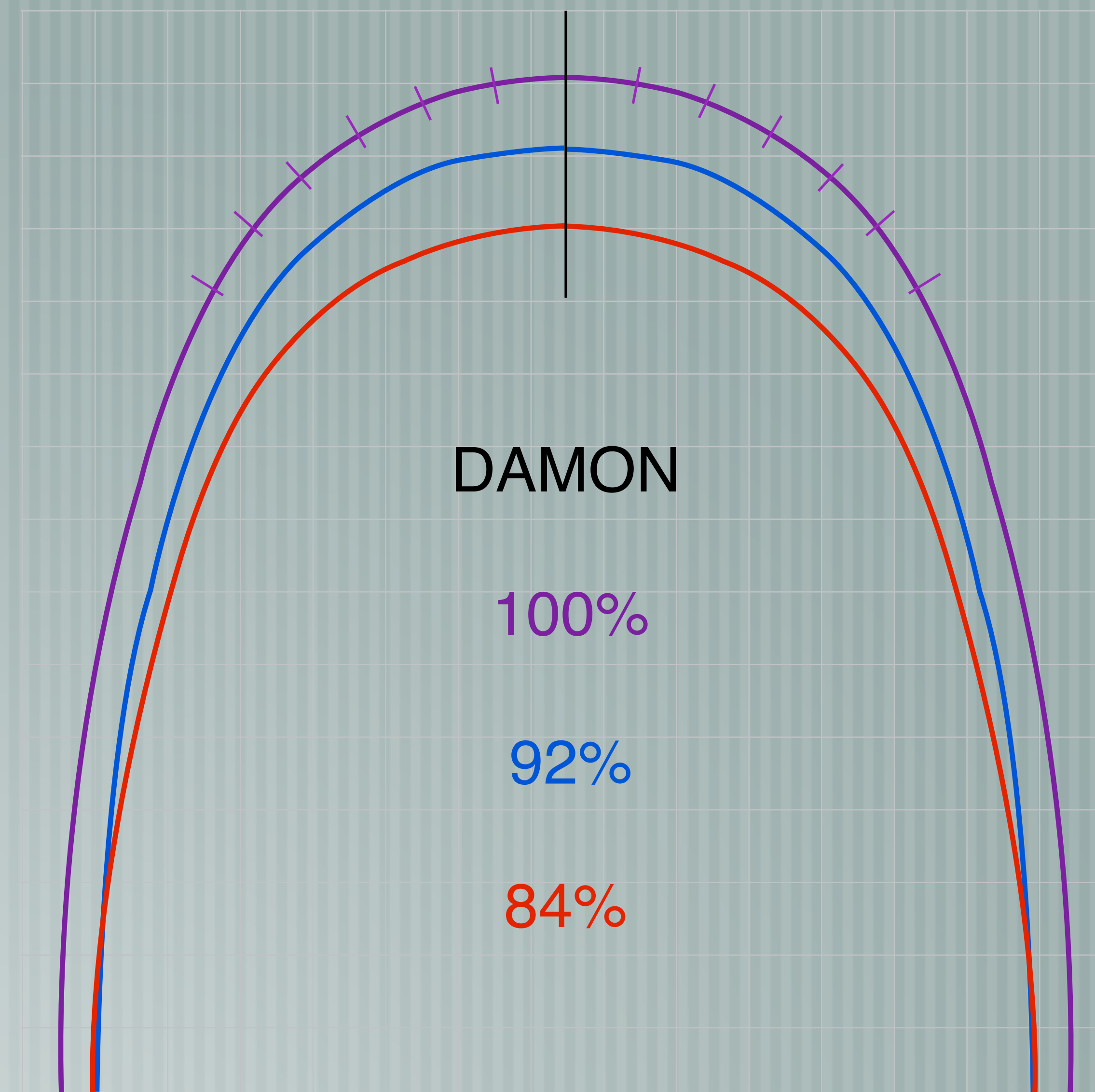
← 1 inch →

Compare size to scale for reproduction distortion.

Arch form Template

Modern Smile Institute

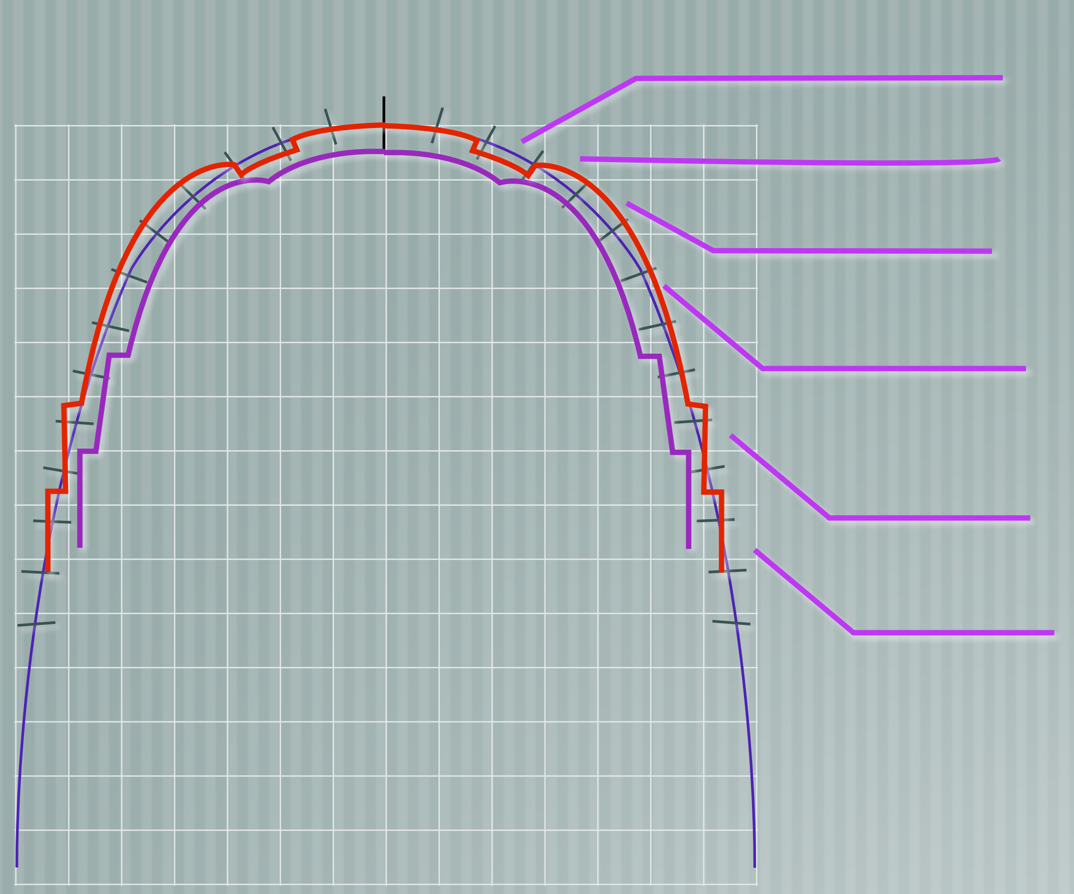




Three plane of space

1st order bend	In-out bending
2nd order bend (Artistic Bend)	Up-down bending
3rd order bend	Torque

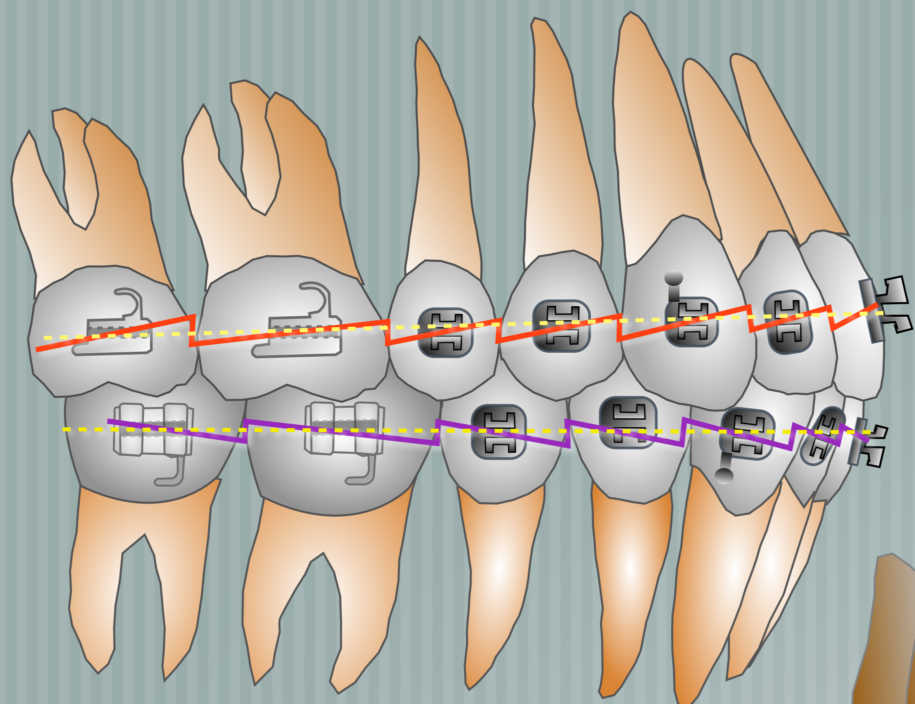
1st order bend and arch coordination

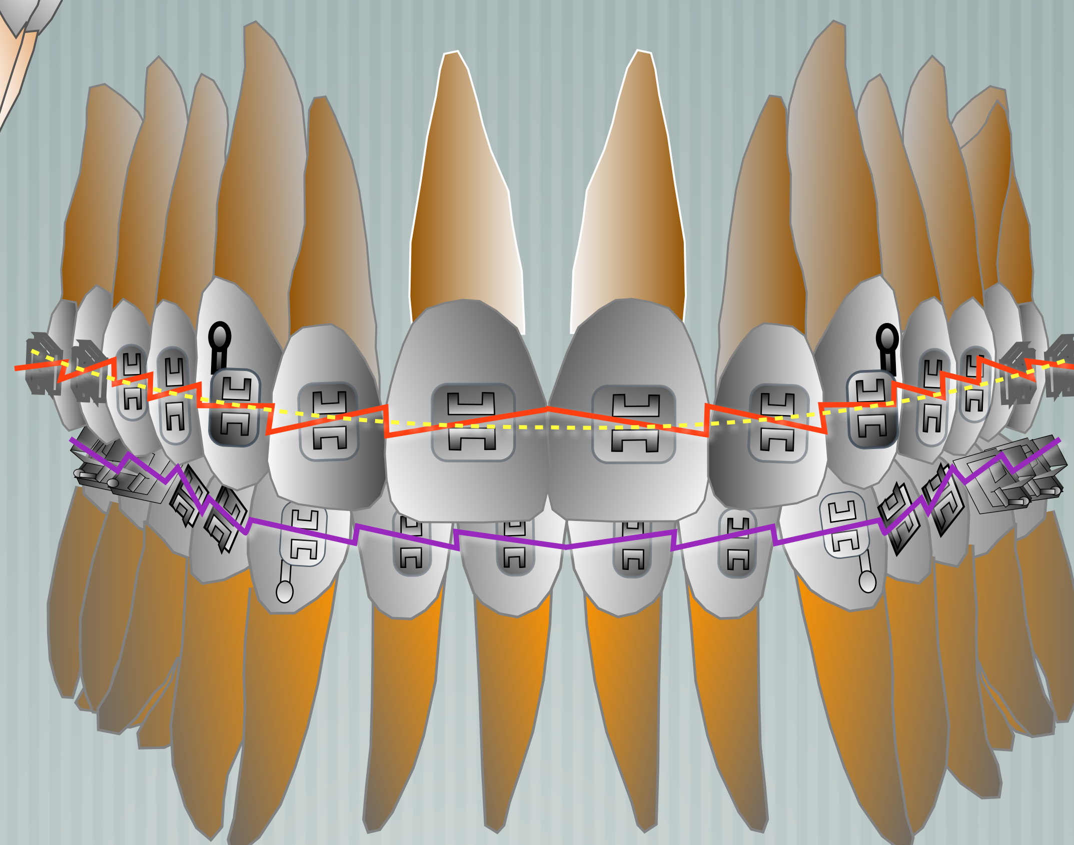


In-out bending

16 SS & 17x25 SS

2nd order bend (Artistic Bend)

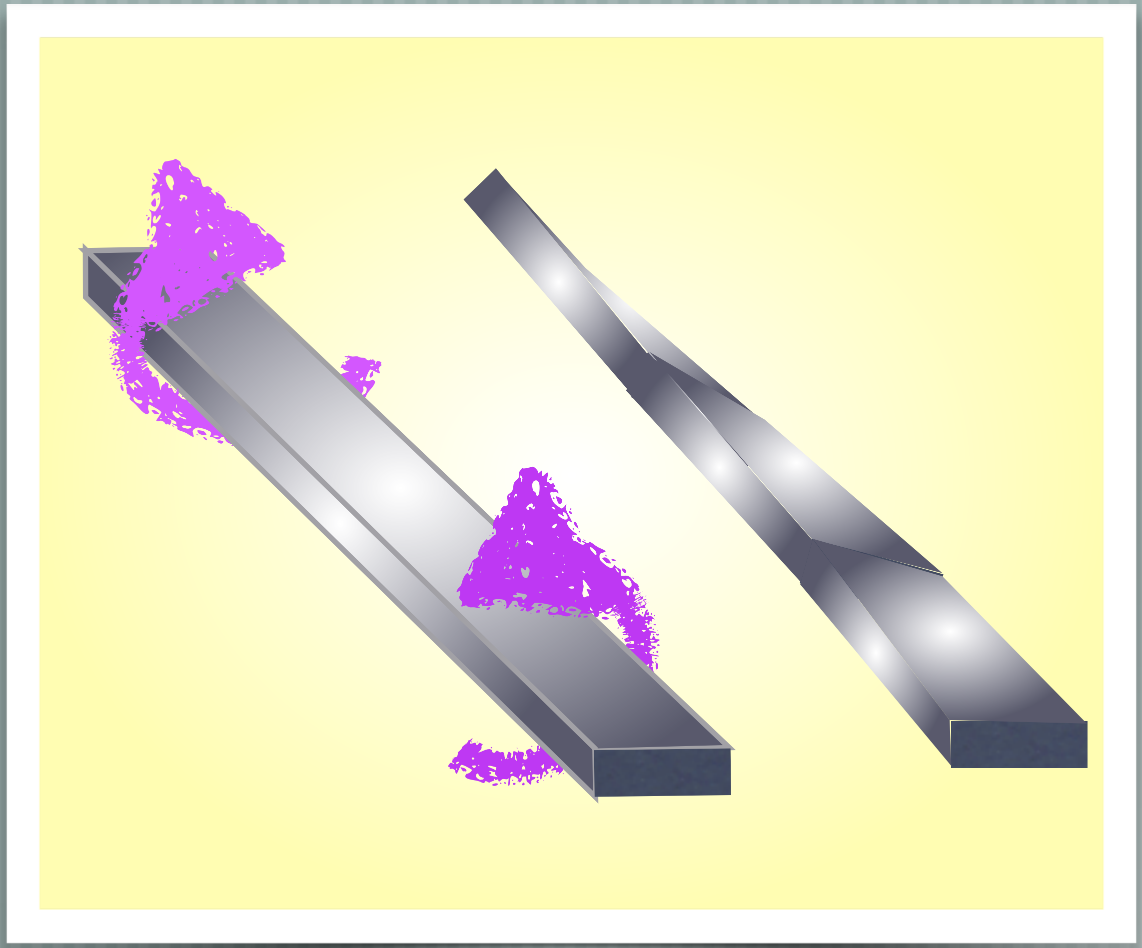




Up-down bending

16 SS & 17x25 SS

3rd order bend

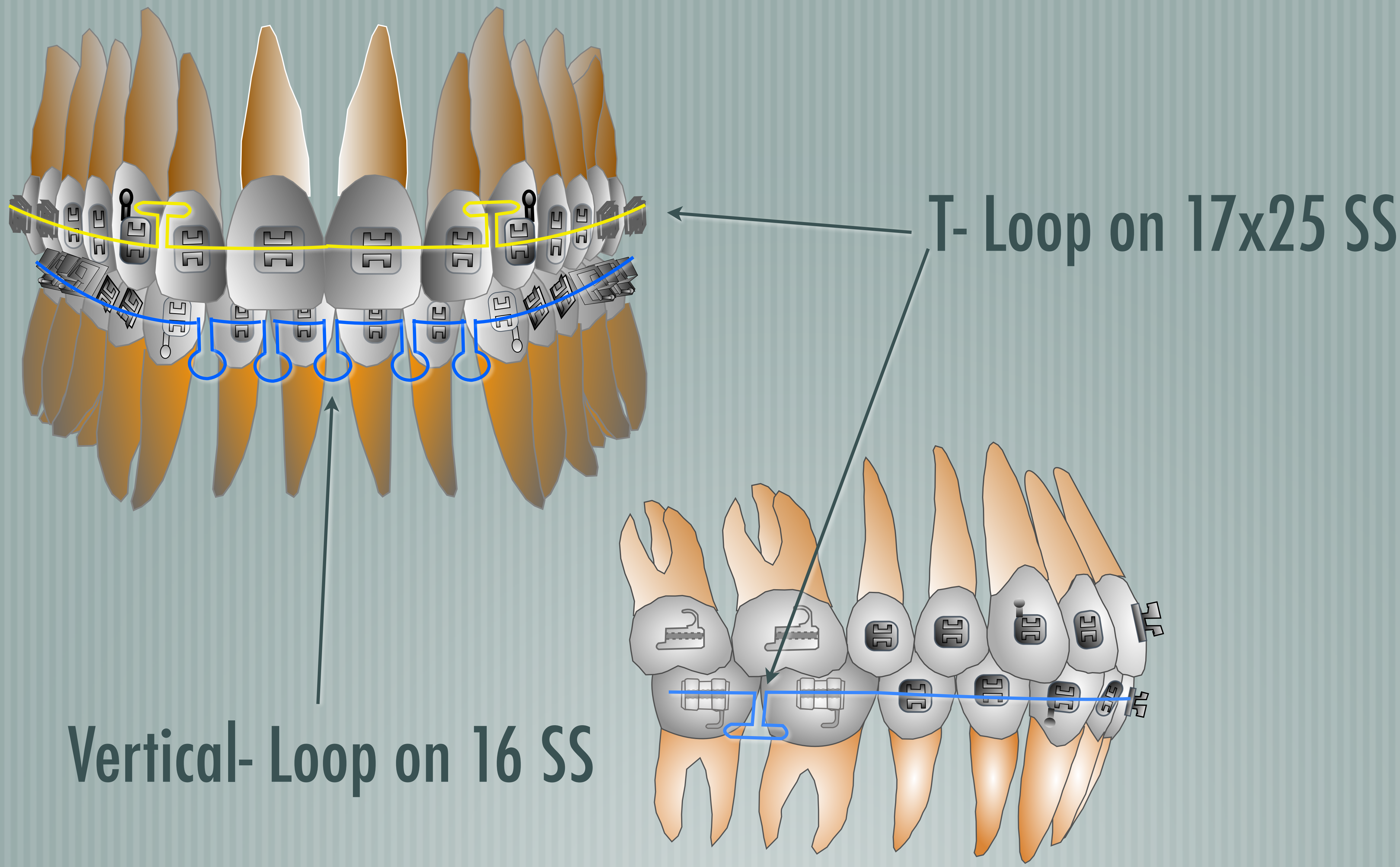


TORQUE

TWIST RECTANGULAR WIRE ABOUT 20°

BUCCAL CROWN TORQUE

LINGUAL CROWN TORQUE


T- Loop on 17x25 SS
Vertical- Loop on 16 SS

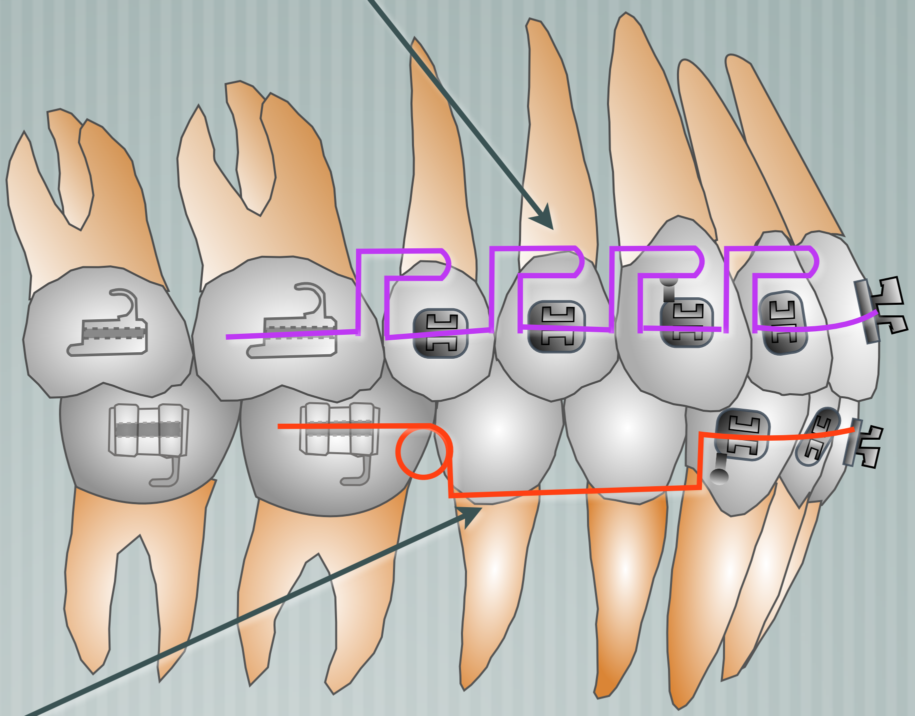

พิมพ์ประภา ศรีคำลี 48-1073 loop spring


พิมพ์ประภา ศรีคำลี 48-1073 loop spring

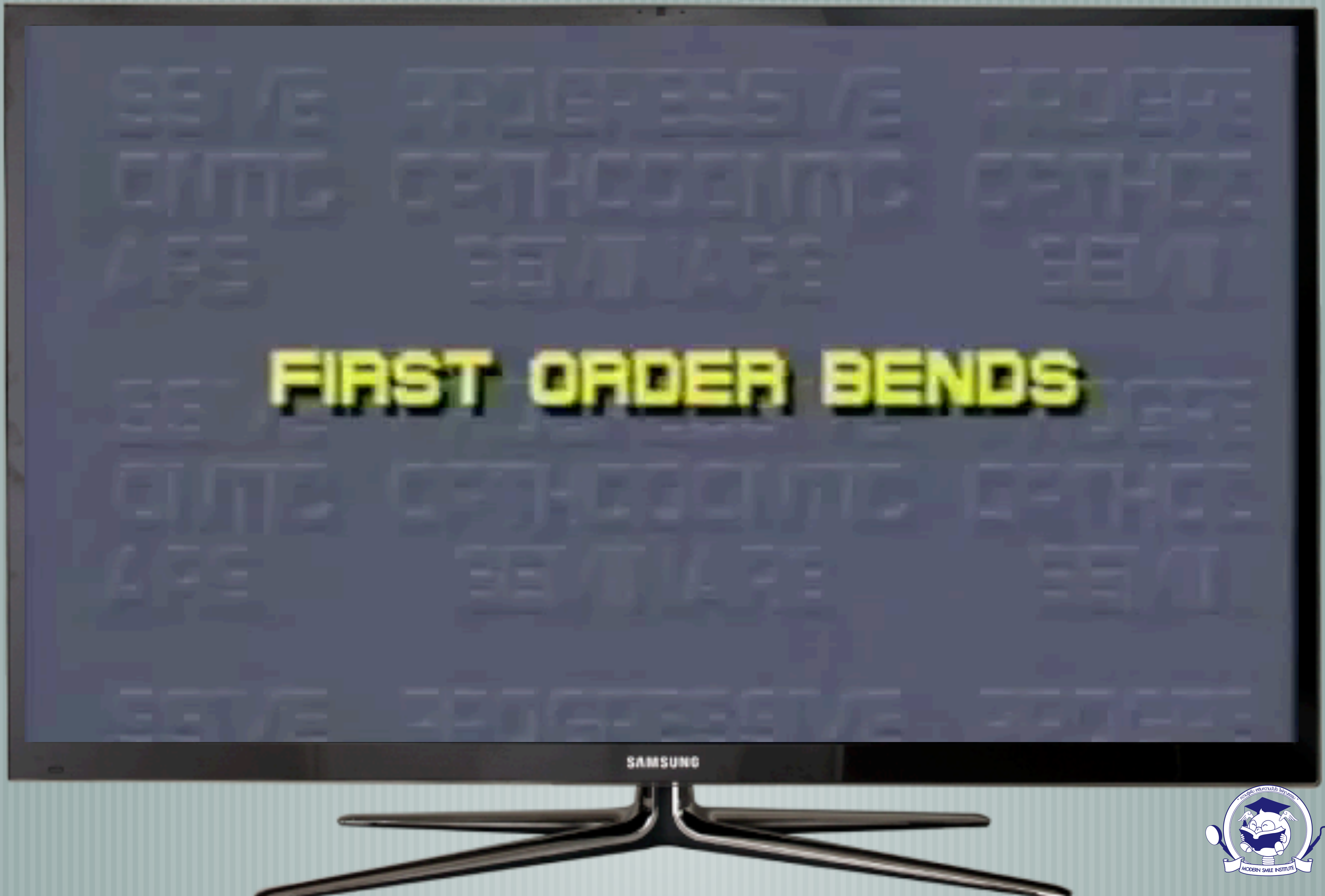

พิมพ์ประภา ศรีคำลี 48-1073 loop spring

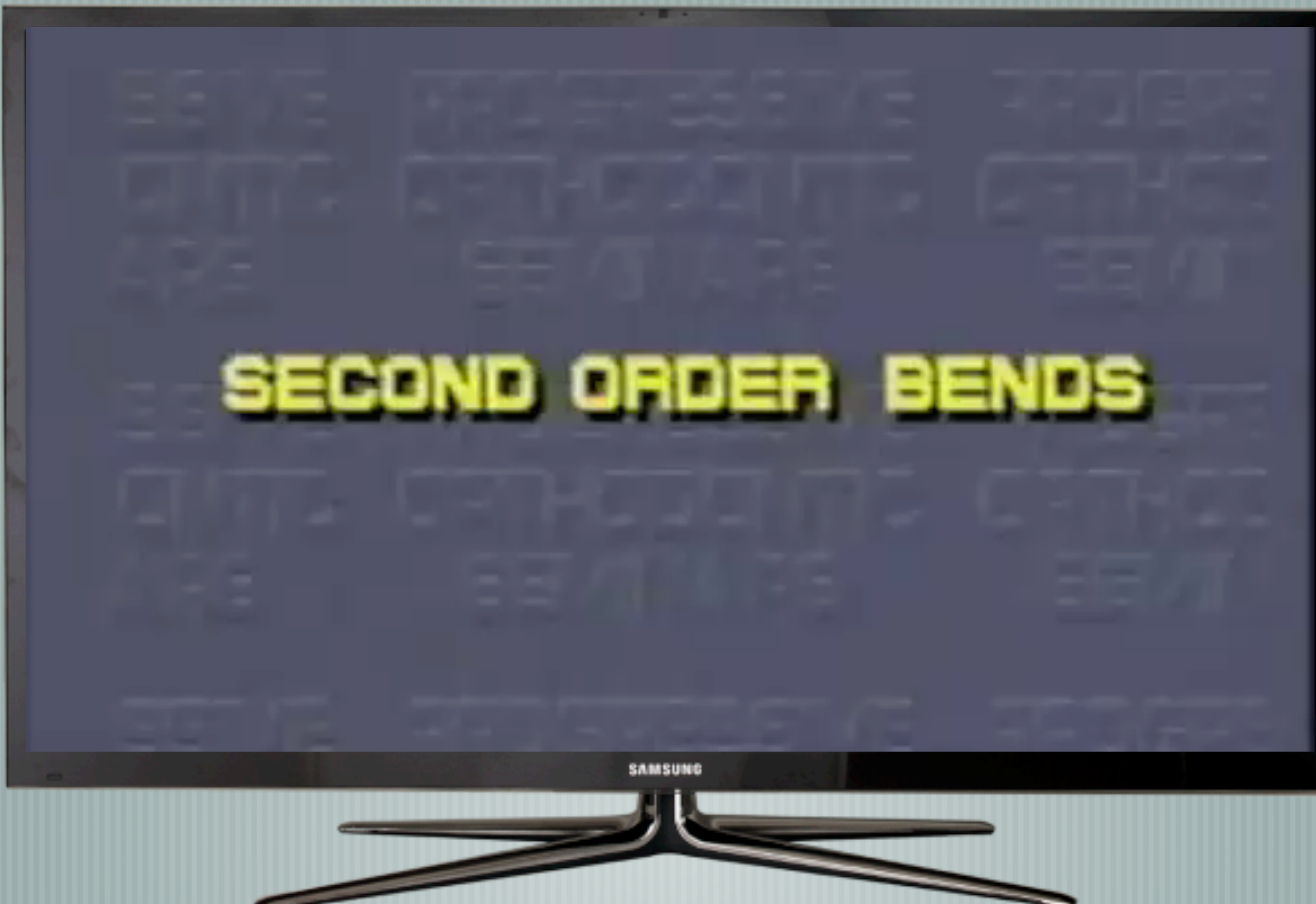
MEAW technique on 17 x 25 SS

(Multiple Loop Edgewise Archwire)



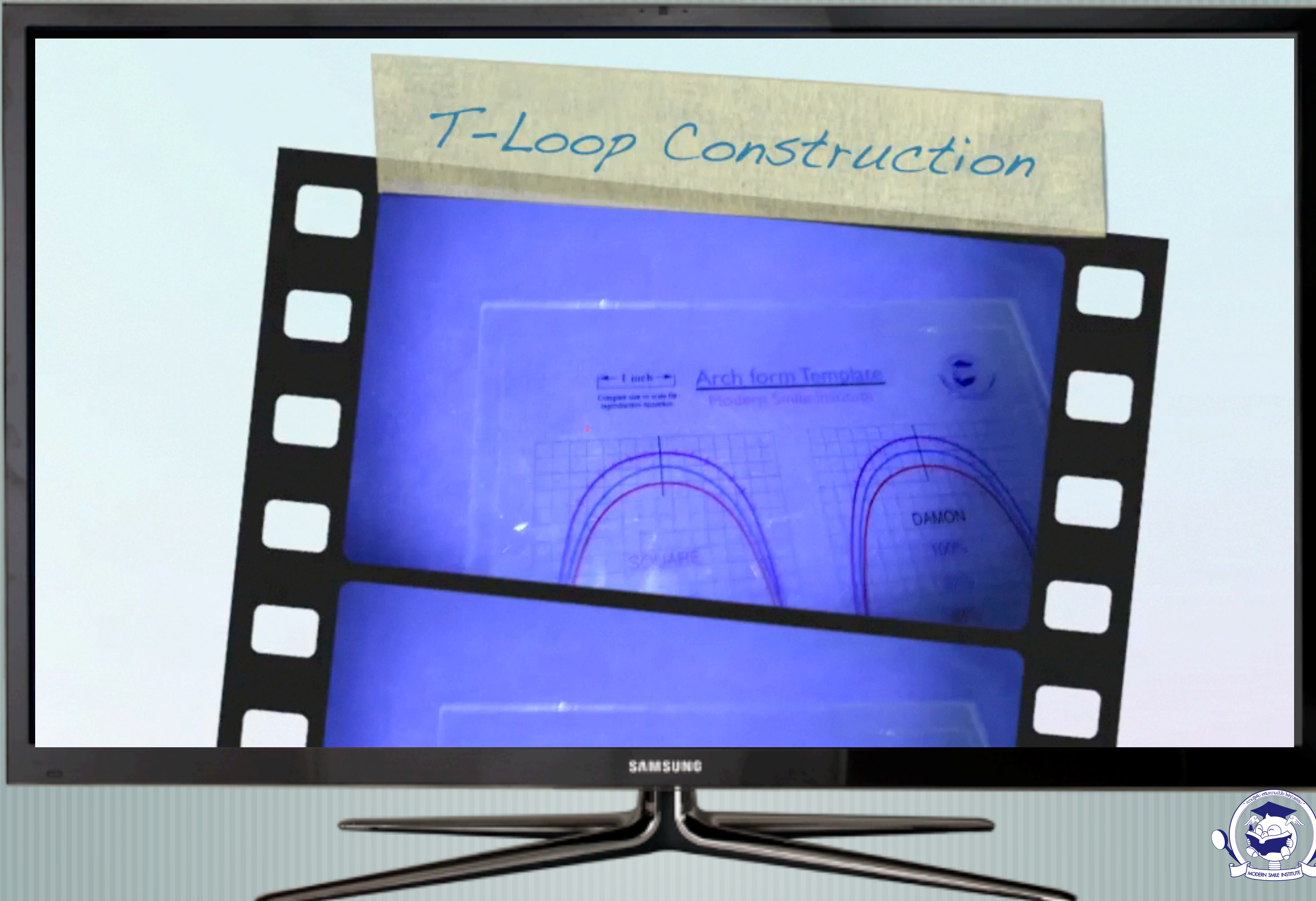
Utility arch on 17x25 SS

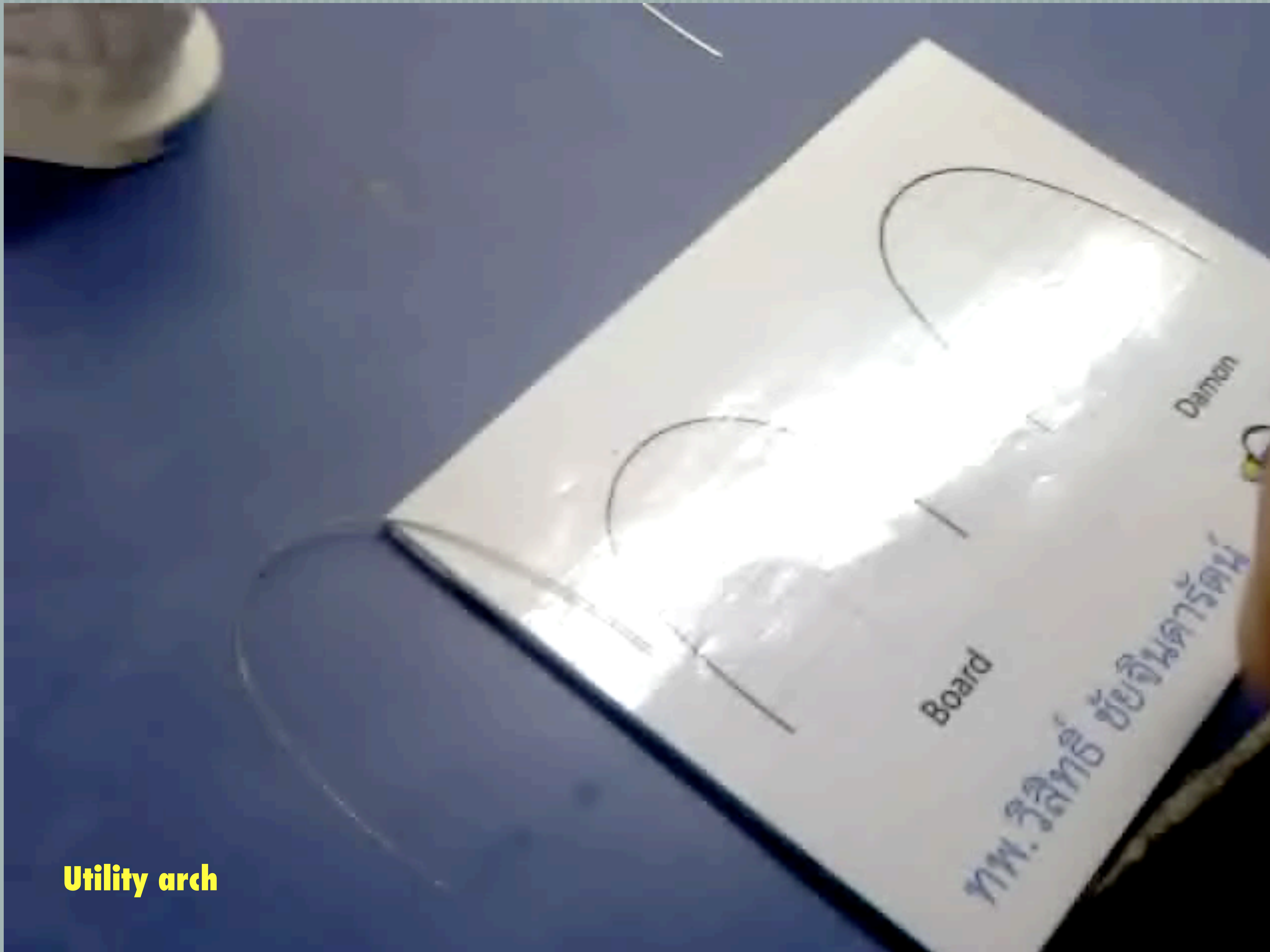

FIRST ORDER BENDS
SAMSUNG


SECOND ORDER BENDS
SAMSUNG


SAMSUNG

T-Loop Construction



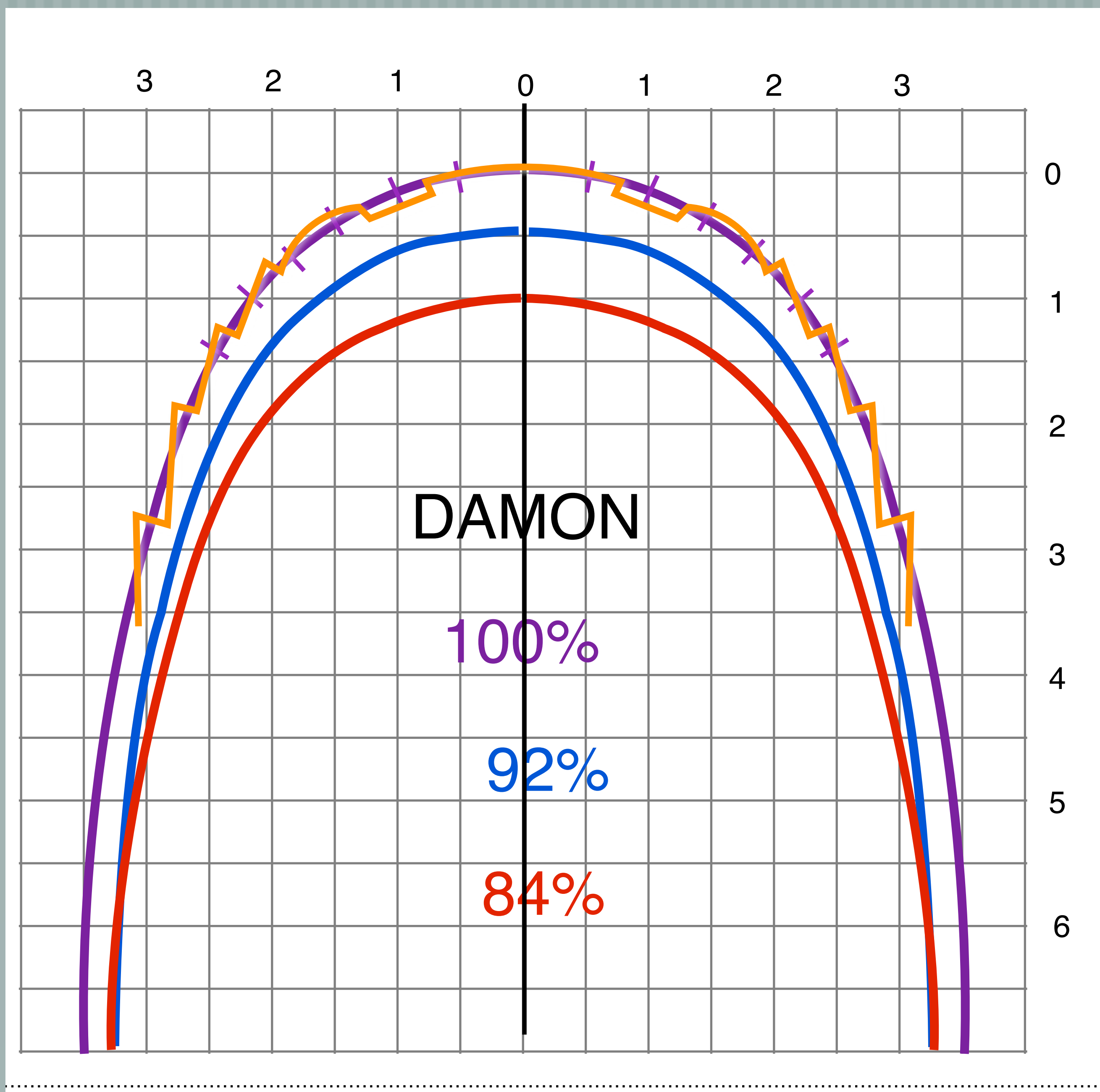


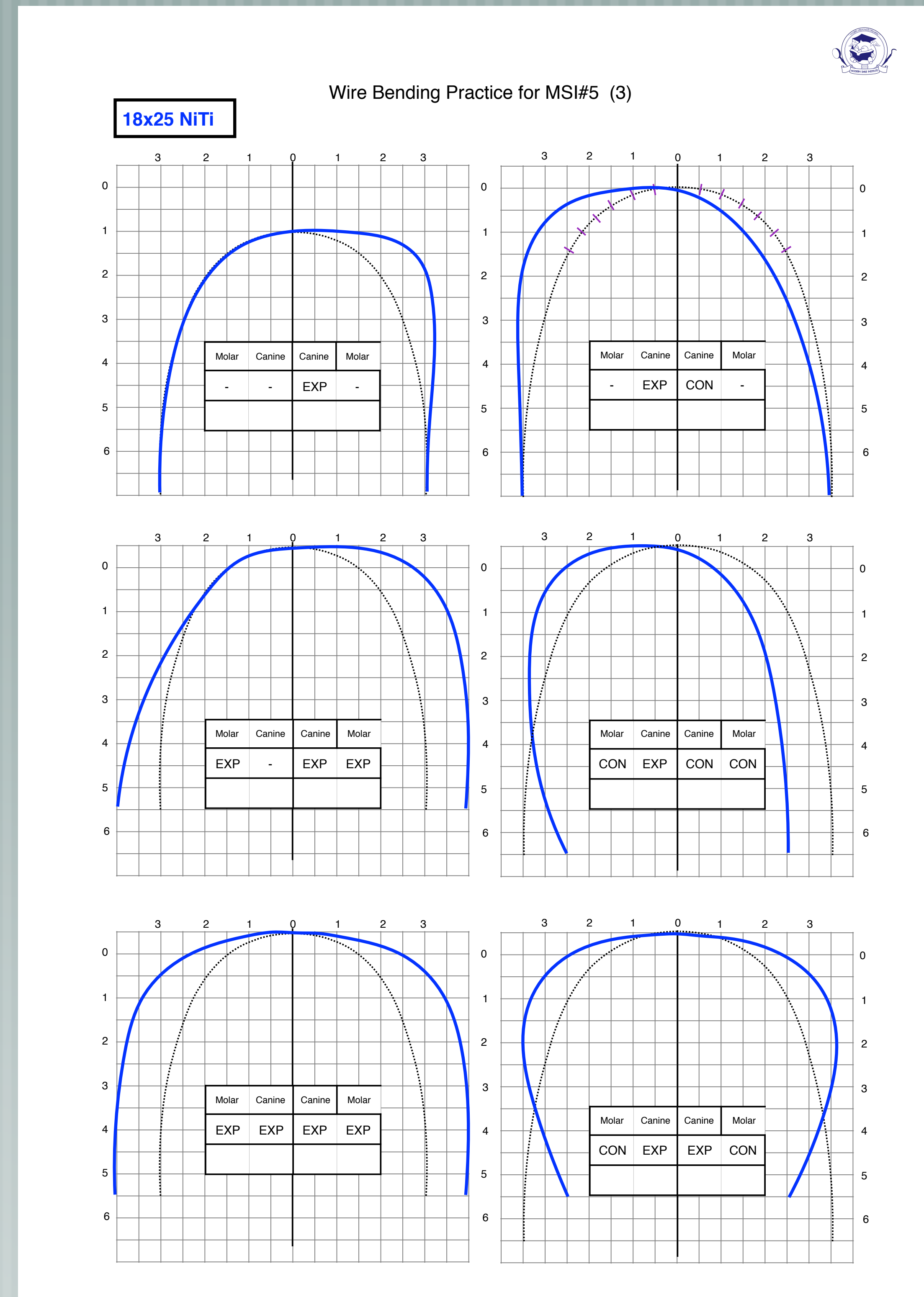
Utility arch

Wire Bending Exercise 1

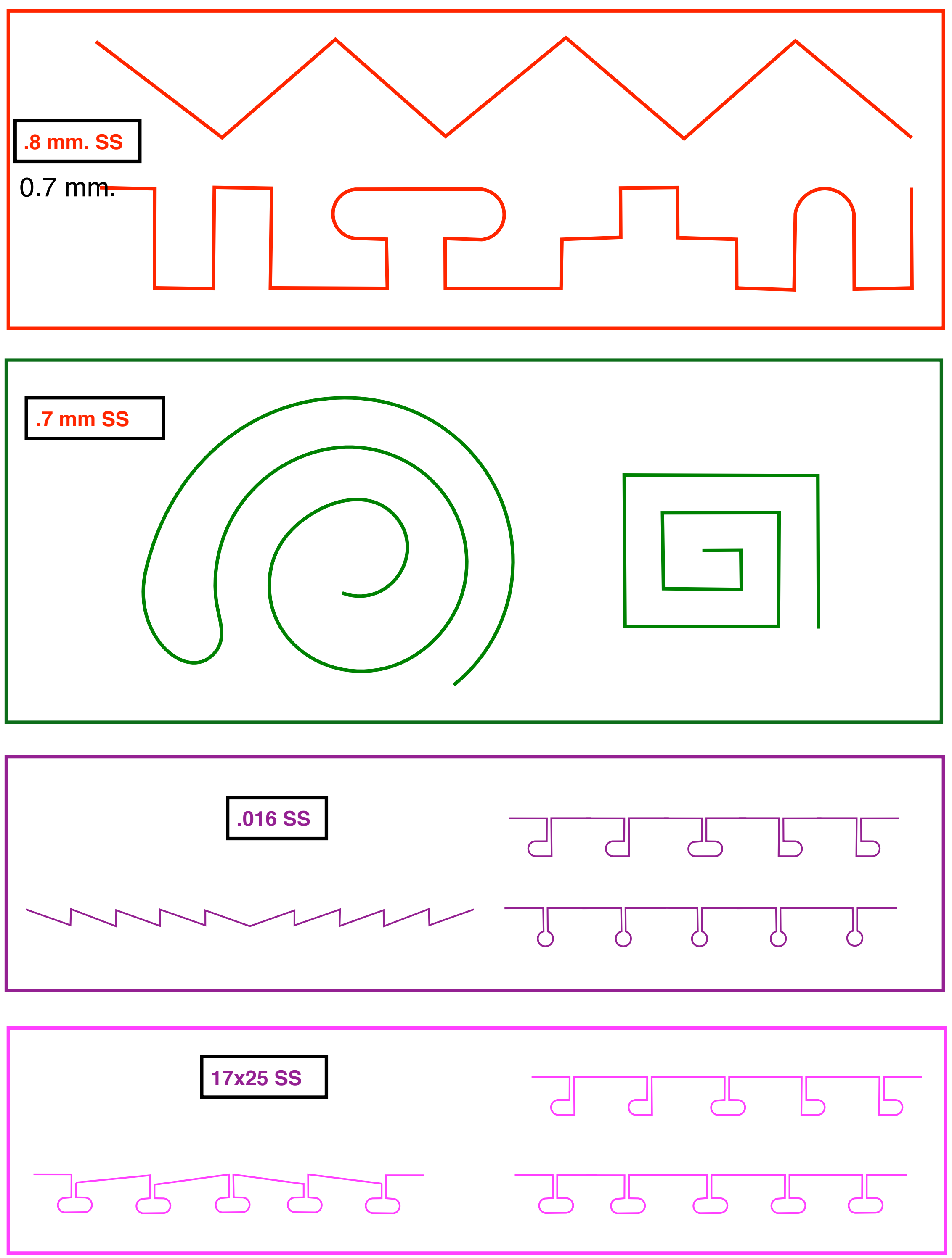
Wire Bending Exercise 2

Let's go to work on the wire bending exercise


DAMON
100%
92%
84%


Wire Bending Practice for MSI#5 (3)
18x25 NiTi
Molar Canine Canine Molar
- - EXP -
Molar Canine Canine Molar
- EXP CON -
Molar Canine Canine Molar
EXP - EXP EXP
Molar Canine Canine Molar
CON EXP CON CON
Molar Canine Canine Molar
EXP EXP EXP EXP
Molar Canine Canine Molar
CON EXP EXP CON

Wire Bending Practice for MSI#5 (1)



Wire Bending Practice for MSI#5 (2)