



ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Elementos de Máquinas para Automação

PMR 3307 – Exercício 2

Falha por Impacto

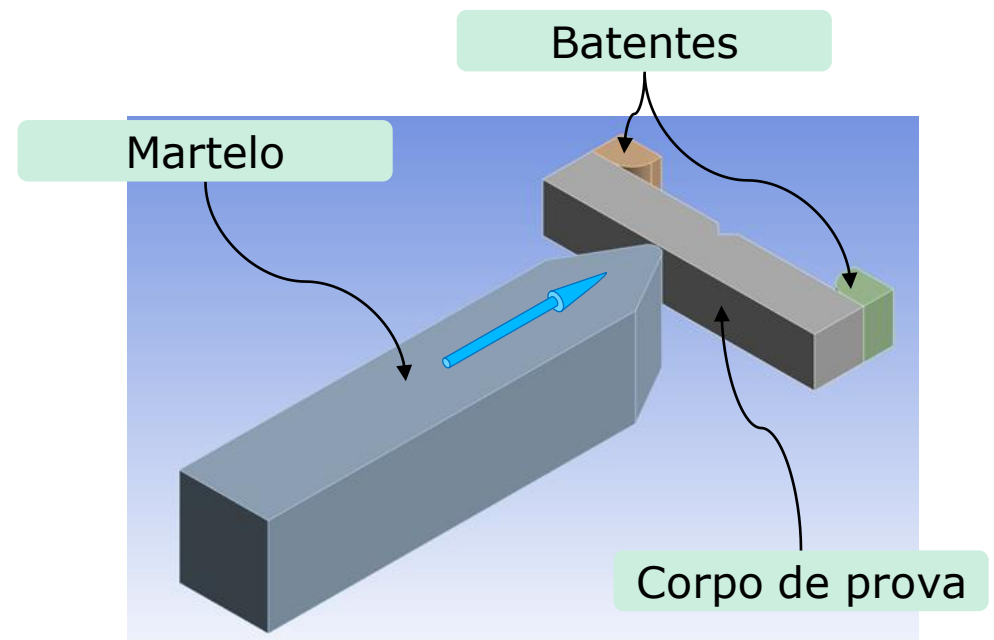
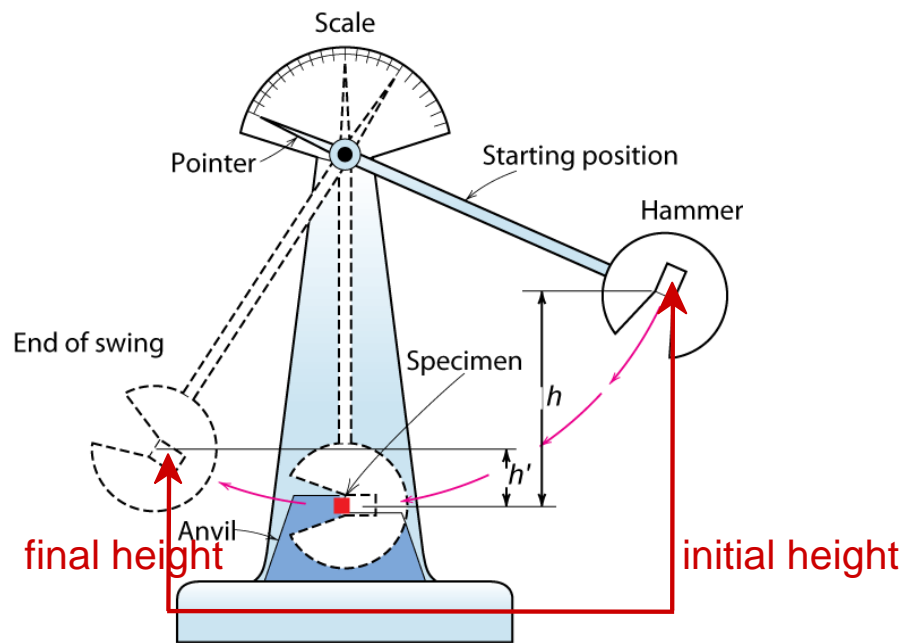
2023.2



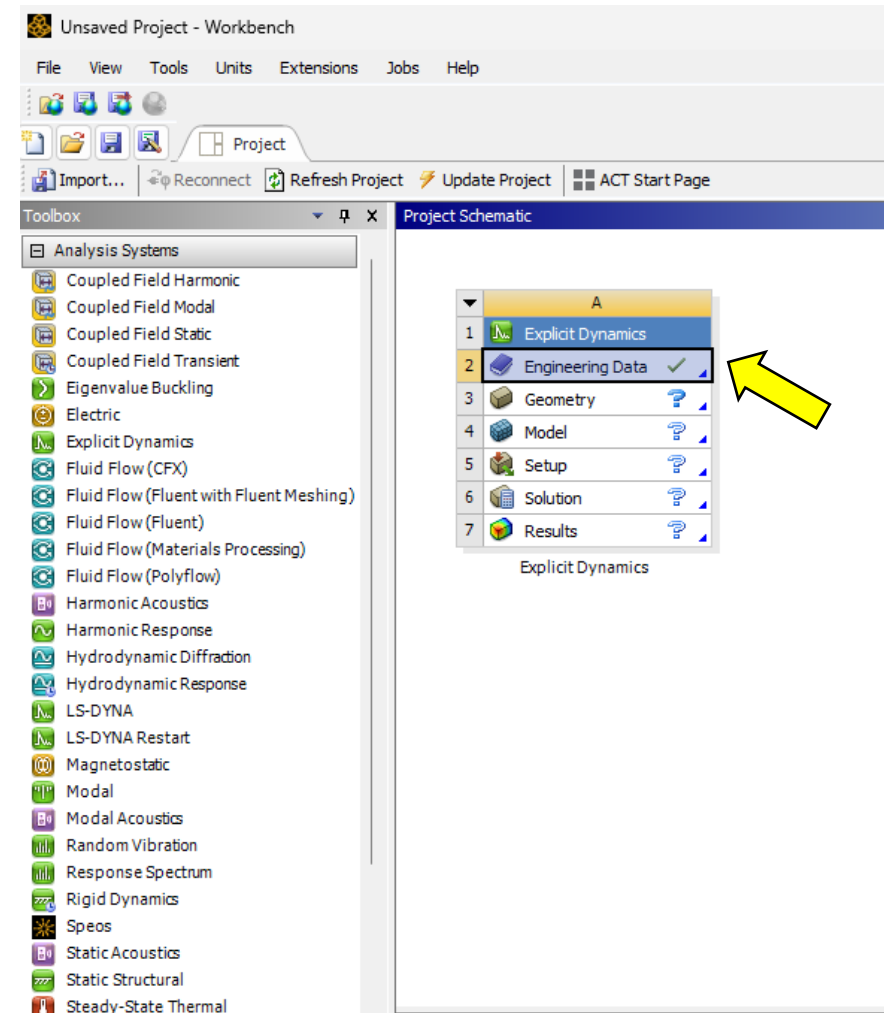
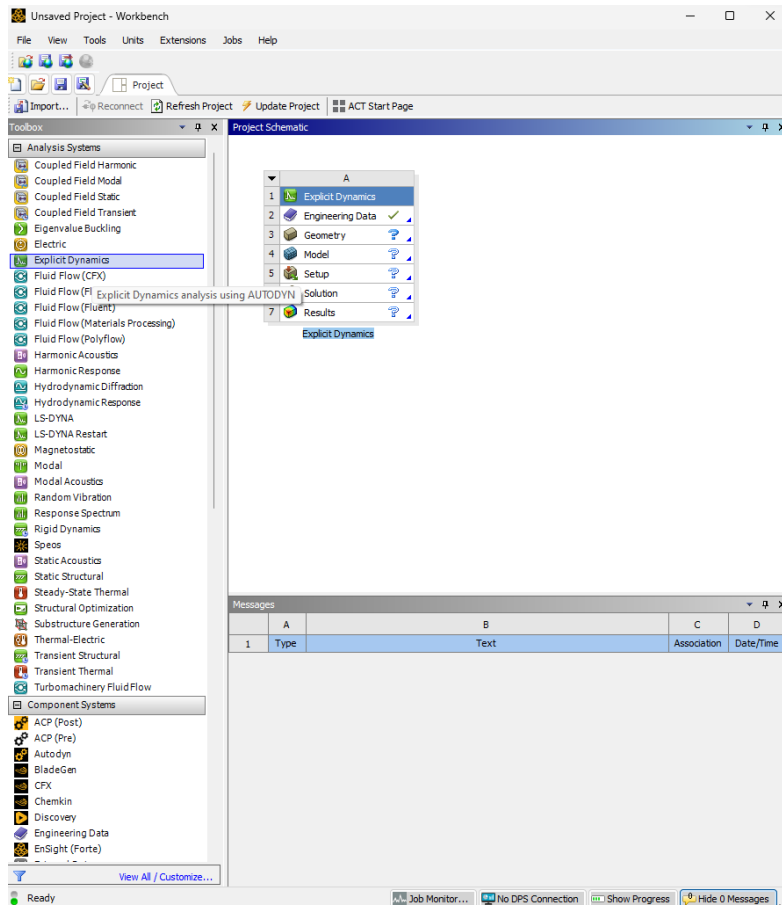
Simulação de impacto

Exercício 2

Simulação do ensaio Charpy



Tutorial





Unsaved Project - Workbench

File Edit View Tools Units Extensions Jobs Help

Project A2:Engineering Data

Filter Engineering Data Engineering Data Sources

Toolbox

- Field Variables
 - Temperature
 - Frequency
 - Coordinate X
 - Coordinate Y
 - Coordinate Z
 - Shear Angle
 - Degradation Factor
 - Create Field Variable ...
- Physical Properties
 - Density
 - Isotropic Secant Coefficient of Thermal Expansion
 - Orthotropic Secant Coefficient of Thermal Expansion
 - Isotropic Instantaneous Coefficient of Thermal Expansion
 - Orthotropic Instantaneous Coefficient of Thermal Expansion
 - Melting Temperature
 - Material Dependent Damping
 - Damping Factor (a)
 - Damping Factor (B)
- Linear Elastic
 - Isotropic Elasticity
 - Orthotropic Elasticity
 - Anisotropic Elasticity
 - Viscoelastic
- Hyperelastic Experimental Data
 - Uniaxial Test Data
 - Biaxial Test Data
 - Shear Test Data
 - Volumetric Test Data
 - Simple Shear Test Data
 - Uniaxial Tension Test Data
 - Uniaxial Compression Test Data
- Hyperelastic
 - Neo-Hookean
 - Arruda-Boyce
 - Gent
 - Blatz-Ko

Engineering Data Sources

	A	B	C	D
1	Data Source		Location	Description
2	★ Favorites			Quick access list and default items
3	ANSYS GRANTA Materials Data for Simulation (Sample)			Sampling of ANSYS Granta material datasheets. Visit ANSYS GRANTA Materials Data for Simulation to learn about the full product with broader coverage of material data (e.g. linear, non-linear, temperature dependant, fatigue etc.) which includes more than 700 material datasheets.
4	General Materials			General use material samples for use in various analyses.
5	Additive Manufacturing Materials			Additive manufacturing material samples for use in additive manufacturing analyses.
6	Geomechanical Materials			General use material samples for use with geomechanical models.
7	Composite Materials			Material samples specific for composite structures.

Outline of Favorites

	A	B	C	D	E	F
1	Contents of Favorites		Add	✓	Source	Description
2	Material					
3	Air				Fluid	
4	Structural Steel				General	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
5	Water Liquid				Fluid	

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Density	7850	kg m ⁻³
3	Isotropic Secant Coefficient of Thermal Expansion		
5	Isotropic Elasticity		
11	Strain-Life Parameters		
19	S-N Curve	Tabular	
23	Tensile Yield Strength	2,5E+08	Pa
24	Compressive Yield Strength	2,5E+08	Pa
25	Tensile Ultimate Strength	4,6E+08	Pa
26	Compressive Ultimate Strength	0	Pa



Seleção dos materiais

Unsaved Project - Workbench

File Edit View Tools Units Extensions Jobs Help

Project A2:Engineering Data X

Filter Engineering Data Engineering Data Sources

Toolbox

- Field Variables
 - Temperature
 - Frequency
 - Coordinate X
 - Coordinate Y
 - Coordinate Z
 - Shear Angle
 - Degradation Factor
 - Create Field Variable ...
- Physical Properties
 - Density
 - Isotropic Secant Coefficient of Thermal Expansion
 - Orthotropic Secant Coefficient of Thermal Expansion
 - Isotropic Instantaneous Coefficient of Thermal Expansion
 - Orthotropic Instantaneous Coefficient of Thermal Expansion
 - Melting Temperature
 - Material Dependent Damping
 - Damping Factor (a)
 - Damping Factor (B)
- Linear Elastic
 - Isotropic Elasticity
 - Orthotropic Elasticity
 - Anisotropic Elasticity

Engineering Data Sources

	A	B	C	D
1	Data Source		Location	Description
5	Additive Manufacturing Materials	<input type="checkbox"/>		analyses.
6	Geomechanical Materials	<input type="checkbox"/>		General use material samples for use with geomechanical models.
7	Composite Materials	<input type="checkbox"/>		Material samples specific for composite structures.
8	General Non-linear Materials	<input type="checkbox"/>		General use material samples for use in non-linear analyses.
9	Explicit Materials	<input type="checkbox"/>		Material samples for use in an explicit analysis.
10	Hyperelastic Materials	<input type="checkbox"/>		Material stress-strain data samples for curve fitting.
11	Magnetic B-H Curves	<input type="checkbox"/>		B-H Curve samples specific for use in a magnetic analysis.
12	Thermal Materials	<input type="checkbox"/>		Material samples specific for use in a thermal analysis.
13	Fluid Materials	<input type="checkbox"/>		Material samples specific for use in a fluid analysis.

Outline of Explicit Materials

	A	B	C	D	E
1	Contents of Explicit Materials		Add	Source	Description
3	ADIPRENE	<input type="checkbox"/>	<input type="checkbox"/>	Exp	LA-4167-MS. May 1 1969. Selected Hugoniot
4	Air (Atmospheric)	<input type="checkbox"/>	<input type="checkbox"/>	Exp	"Thermodynamic and Transport Properties of Fluids, SI Units", GFC Rogers, YR Mayhew
5	AL 1100-O	<input type="checkbox"/>	<input type="checkbox"/>	Exp	"Equation of State and Strength Properties of Selected Materials". Steinberg D.J. LLNL. Feb 1991



Seleção do material do corpo de provas

Unsaved Project - Workbench

File Edit View Tools Units Extensions Jobs Help

Project A2:Engineering Data

Filter Engineering Data Engineering Data Sources

Toolbox

- Field Variables
 - Temperature
 - Frequency
 - Coordinate X
 - Coordinate Y
 - Coordinate Z
 - Shear Angle
 - Degradation Factor
 - Create Field Variable ...
- Physical Properties
 - Density
 - Isotropic Secant Coefficient of Thermal Expansion
 - Orthotropic Secant Coefficient of Thermal Expansion
 - Isotropic Instantaneous Coefficient of Thermal Expansion
 - Orthotropic Instantaneous Coefficient of Thermal Expansion
 - Melting Temperature
 - Material Dependent Damping
 - Damping Factor (α)
 - Damping Factor (β)
- Linear Elastic
 - Isotropic Elasticity
 - Orthotropic Elasticity
 - Anisotropic Elasticity
 - Viscoelastic
- Hyperelastic/Experimental Data
 - Uniaxial Test Data
 - Biaxial Test Data
 - Shear Test Data
 - Volumetric Test Data
 - Simple Shear Test Data
 - Uniaxial Tension Test Data
 - Uniaxial Compression Test Data

Engineering Data Sources

	A	B	C	D
1	Data Source		Location	Description
5	Additive Manufacturing Materials			analyses.
6	Geomechanical Materials			General use material samples for use with geomechanical models.
7	Composite Materials			Material samples specific for composite structures.
8	General Non-linear Materials			General use material samples for use in non-linear analyses.
9	Explicit Materials			Material samples for use in an explicit analysis.
10	Hyperelastic Materials			Material stress-strain data samples for curve fitting.
11	Magnetic B-H Curves			B-H Curve samples specific for use in a magnetic analysis.
12	Thermal Materials			Material samples specific for use in a thermal analysis.
13	Fluid Materials			Material samples specific for use in a fluid analysis.

Outline of Explicit Materials

	A	B	C	D	E
1	Contents of Explicit Materials	Add	Source		Description
6	AL 2024		Exp		LS-4167-MS, May 1 1969, Selected Hugoniot
7	AL 2024-T4		Exp		"Equation of State and Strength Properties of Selected Materials", Steinberg D.J., LLNL, Feb 1991
8	AL 6061-T6		Exp		"Equation of State and Strength Properties of Selected Materials", Steinberg D.J., LLNL, Feb 1991

Add to A2: Engineering Data

Properties of Outline Row 3: AL 1100-O

	A	B	C
1	Property	Value	Unit
2	Density	2707	kg m ⁻³
3	Specific Heat Constant Pressure, C_p	884	J kg ⁻¹ C ⁻¹
4	Steinberg Guinan Strength		
13	Shear Modulus	2,71E+10	Pa
14	Shock EOS Linear		



Seleção do material do martelo

Unsaved Project - Workbench

File Edit View Tools Units Extensions Jobs Help

Project A2:Engineering Data

Filter Engineering Data Engineering Data Sources

Toolbox

- Field Variables
 - Temperature
 - Frequency
 - Coordinate X
 - Coordinate Y
 - Coordinate Z
 - Shear Angle
 - Degradation Factor
 - Create Field Variable ...
- Physical Properties
 - Density
 - Isotropic Secant Coefficient of Thermal Expansion
 - Orthotropic Secant Coefficient of Thermal Expansion
 - Isotropic Instantaneous Coefficient of Thermal Expansion
 - Orthotropic Instantaneous Coefficient of Thermal Expansion
 - Melting Temperature
 - Material Dependent Damping
 - Damping Factor (alpha)
 - Damping Factor (beta)
- Linear Elastic
 - Isotropic Elasticity
 - Orthotropic Elasticity
 - Anisotropic Elasticity
 - Viscoelastic
- Hyperelastic Experimental Data
 - Uniaxial Test Data

Engineering Data Sources

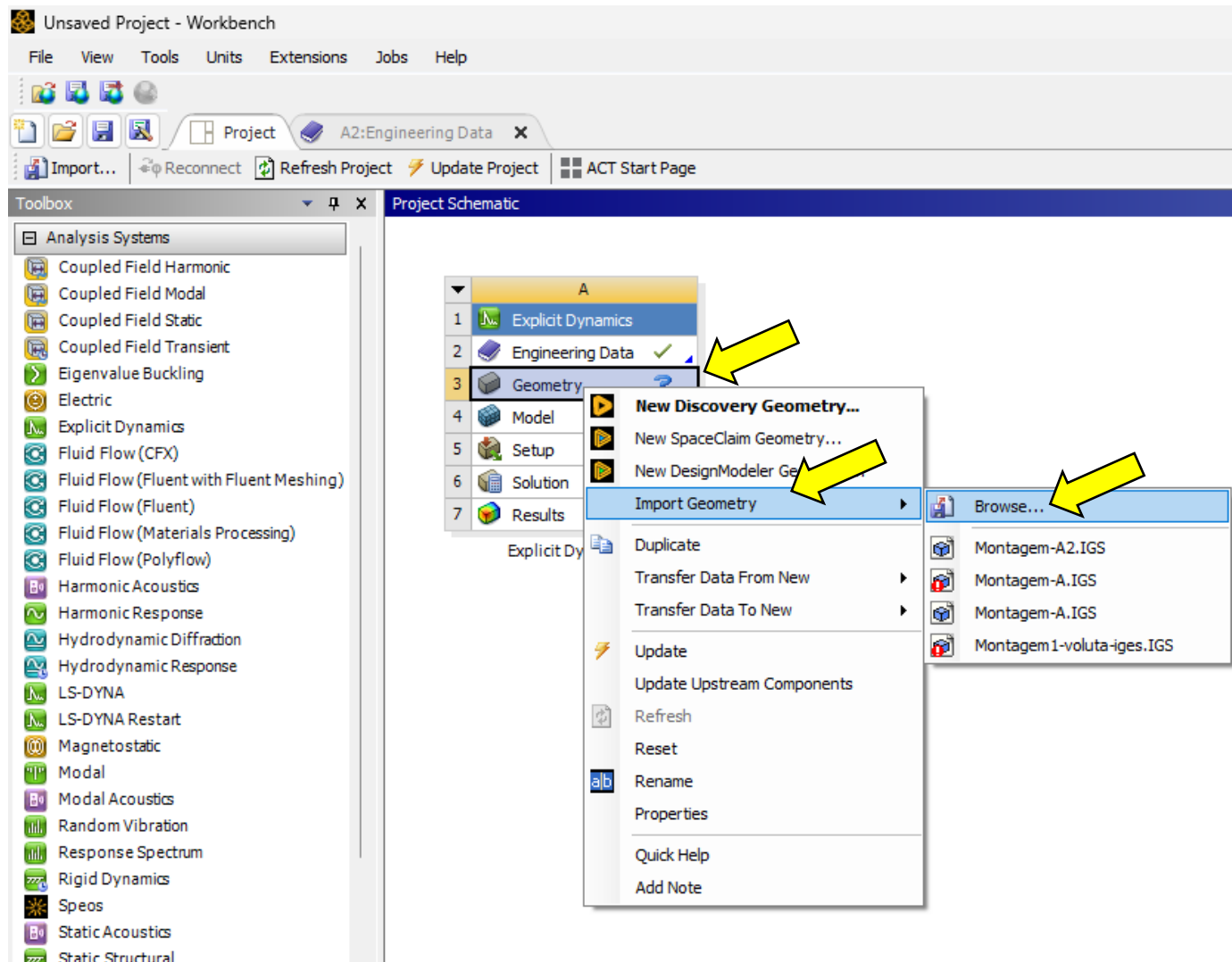
	A	B	C	D
	Data Source		Location	Description
1				
3	ANSYS GRANTA Materials Data for Simulation (Sample)			Sampling of ANSYS Granta material datasheets. Visit ANSYS GRANTA Materials Data for Simulation to learn about the full product with broader coverage of material data (e.g. linear, non-linear, temperature dependant, fatigue etc.) which includes more than 700 material datasheets.
4	General Materials			General use material samples for use in various analyses.
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6	Geomechanical Materials			General use material samples for use with geomechanical models.
7	Composite Materials			Material samples specific for composite structures.
8	General Non-linear Materials			General use material samples for use in non-linear analyses.
9	Explicit Materials			Material samples for use in an explicit analysis.

Outline of Explicit Materials

	A	B	C	D	E
	Contents of Explicit Materials	Add	Source		Description
1					
166	STEEL 1006		Exp	Johnson + Cook	
167	STEEL 4340		Exp	Engng. Frac. Mech. Vol 21. No. 1, pp 31-48. 1985 Johnson + Cook	
168	STEEL S-7		Exp	LA-4167-MS, May 1 1969. Selected Hugoniot: EOS 7th Int. Symp. Ballistics.	
169	STEEL V250		Exp	"Equation of State and Strength Properties of Selected Materials". Steinberg D.J. LLNL, Feb 1991	
170	STNL STEEL		Exp	AFATL-TR-84-59, June 1984, Matuska D.A. HULL Users Manual	
171	STRENGTH		Exp	LA-4167-MS, May 1 1969. Selected Hugoniot	

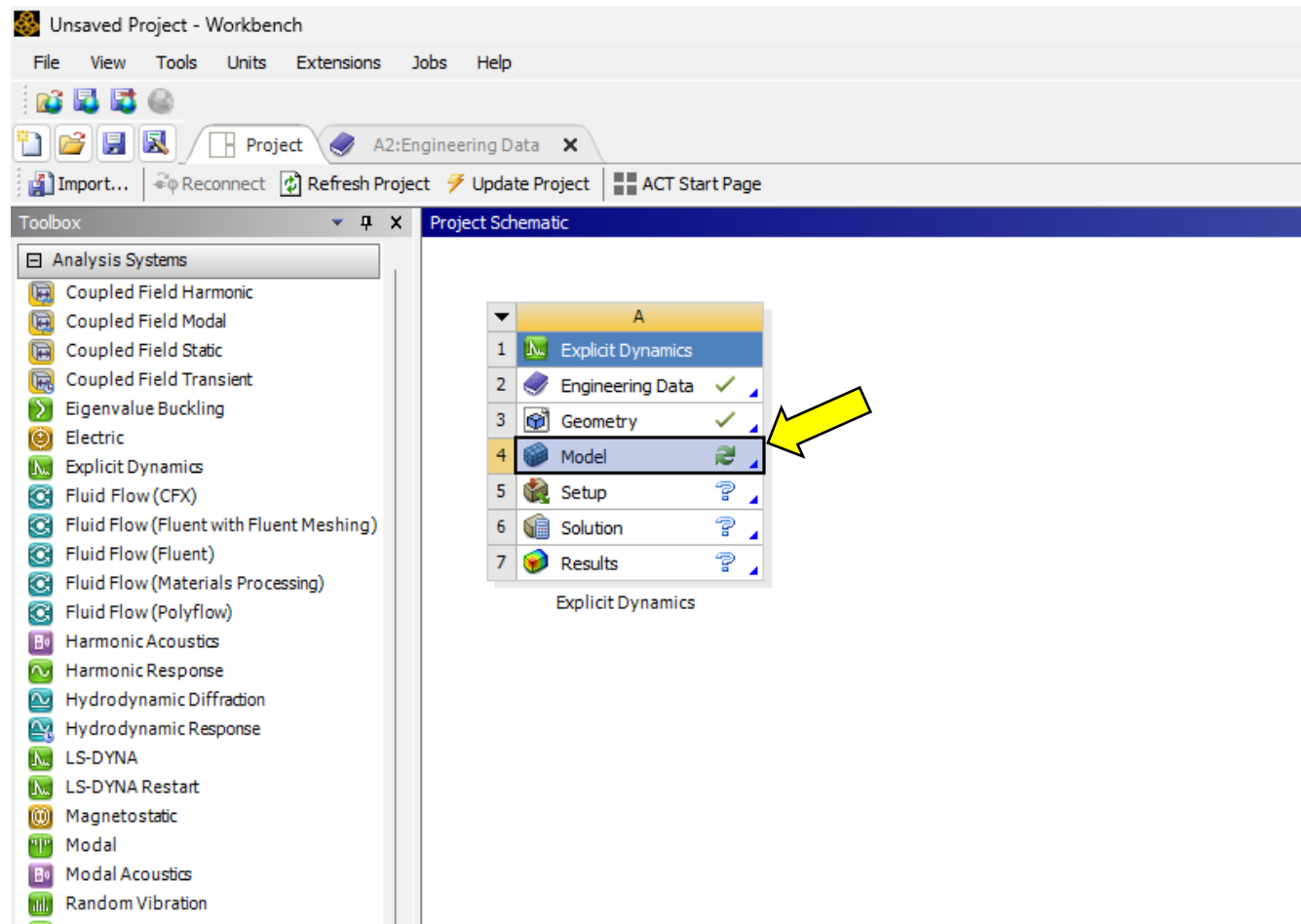


Importando a geometria



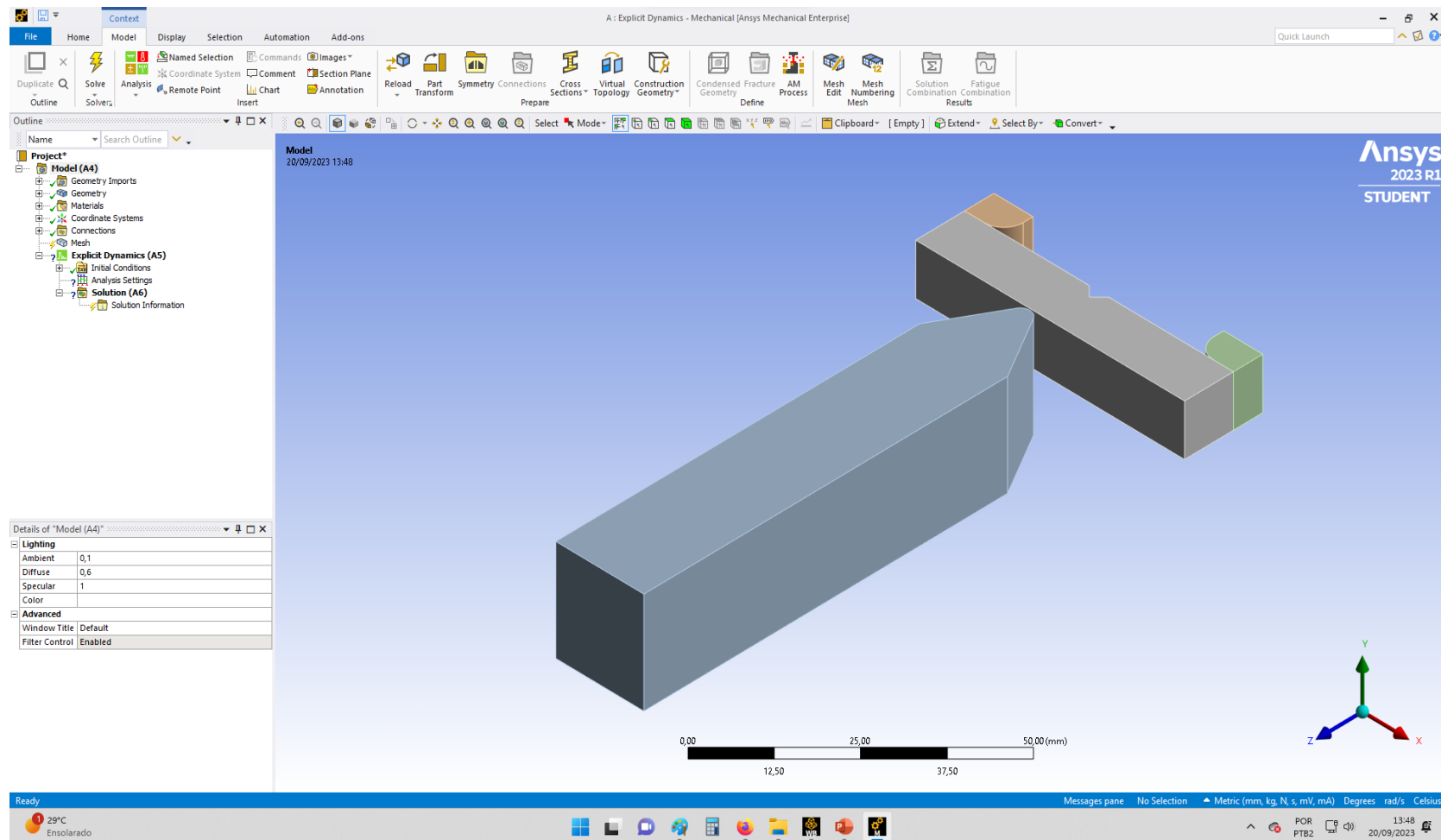


Modelando



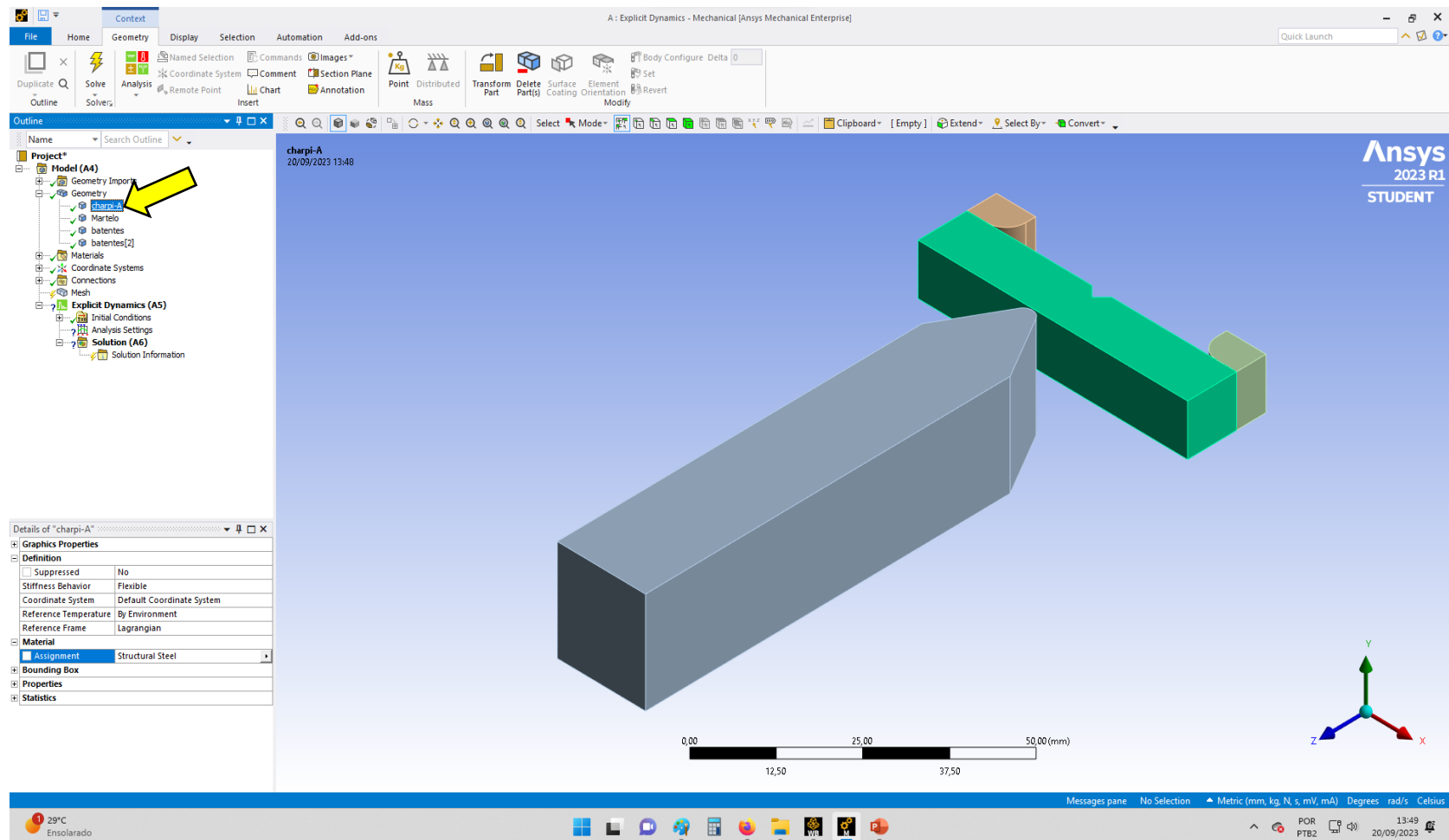


Ambiente de modelagem após a importação



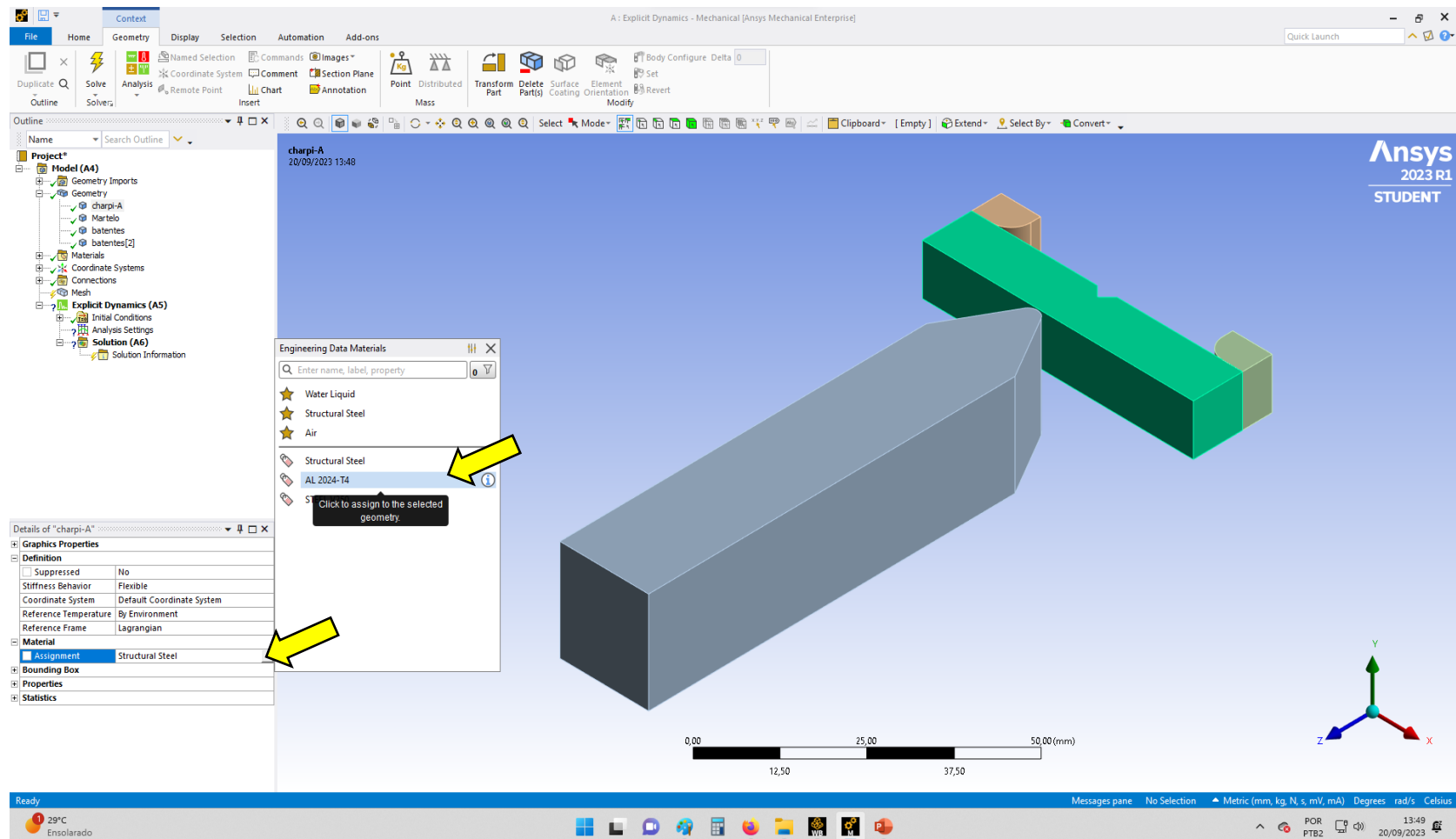


Atribuindo o material do corpo de provas



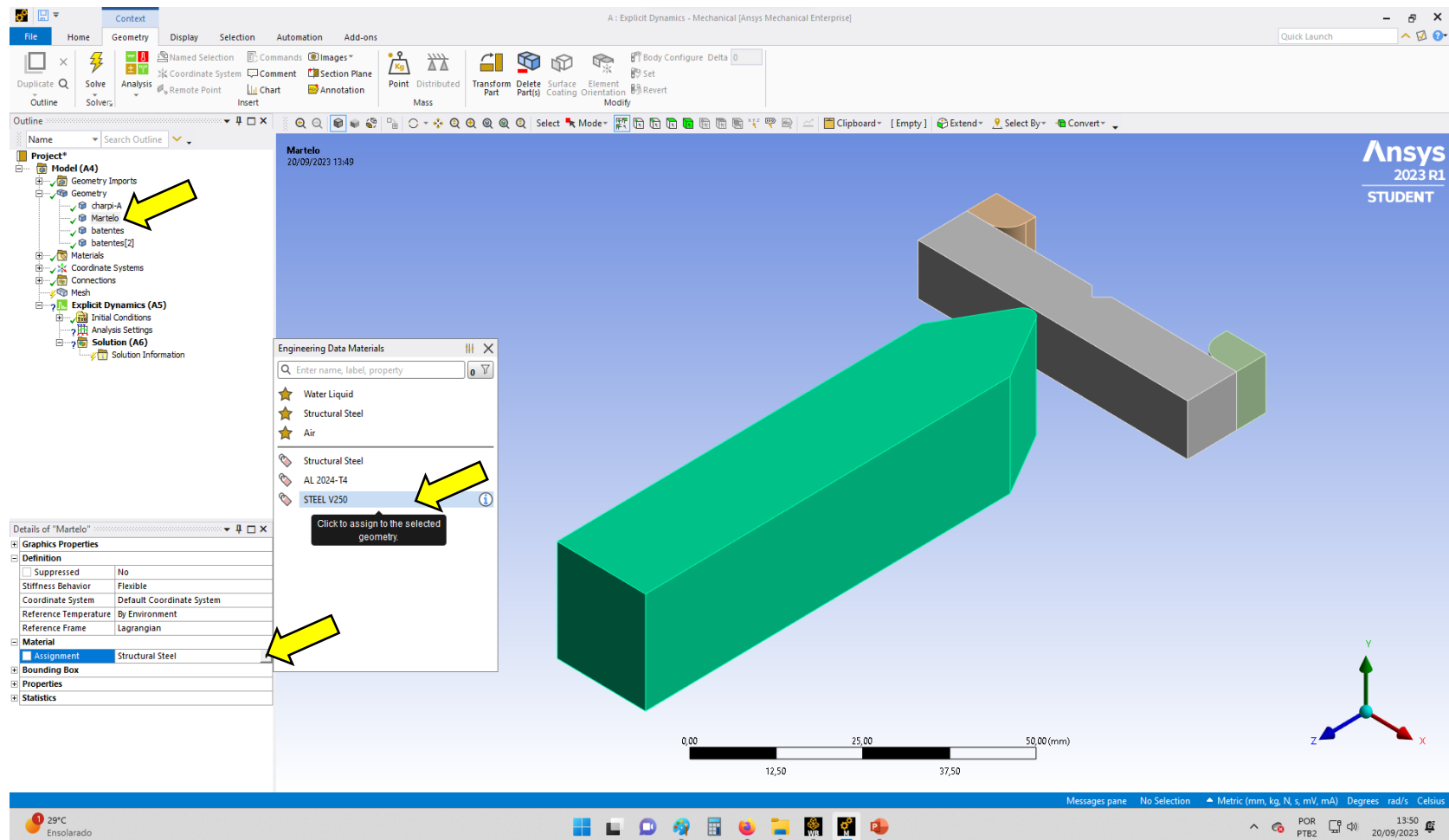


Atribuindo o material do corpo de provas





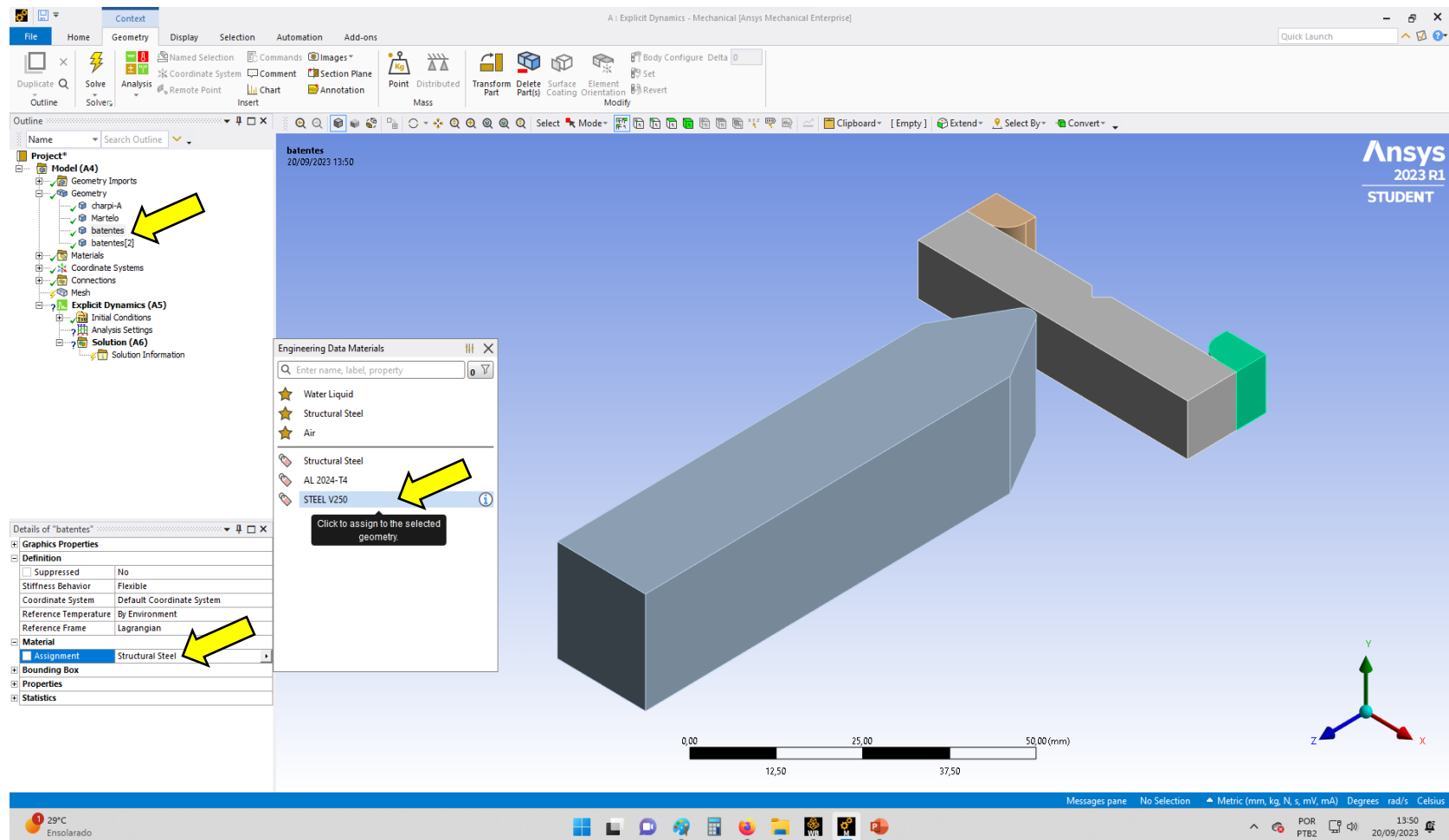
Atribuindo o material do martelo





Atribuindo o material ao batente (1)

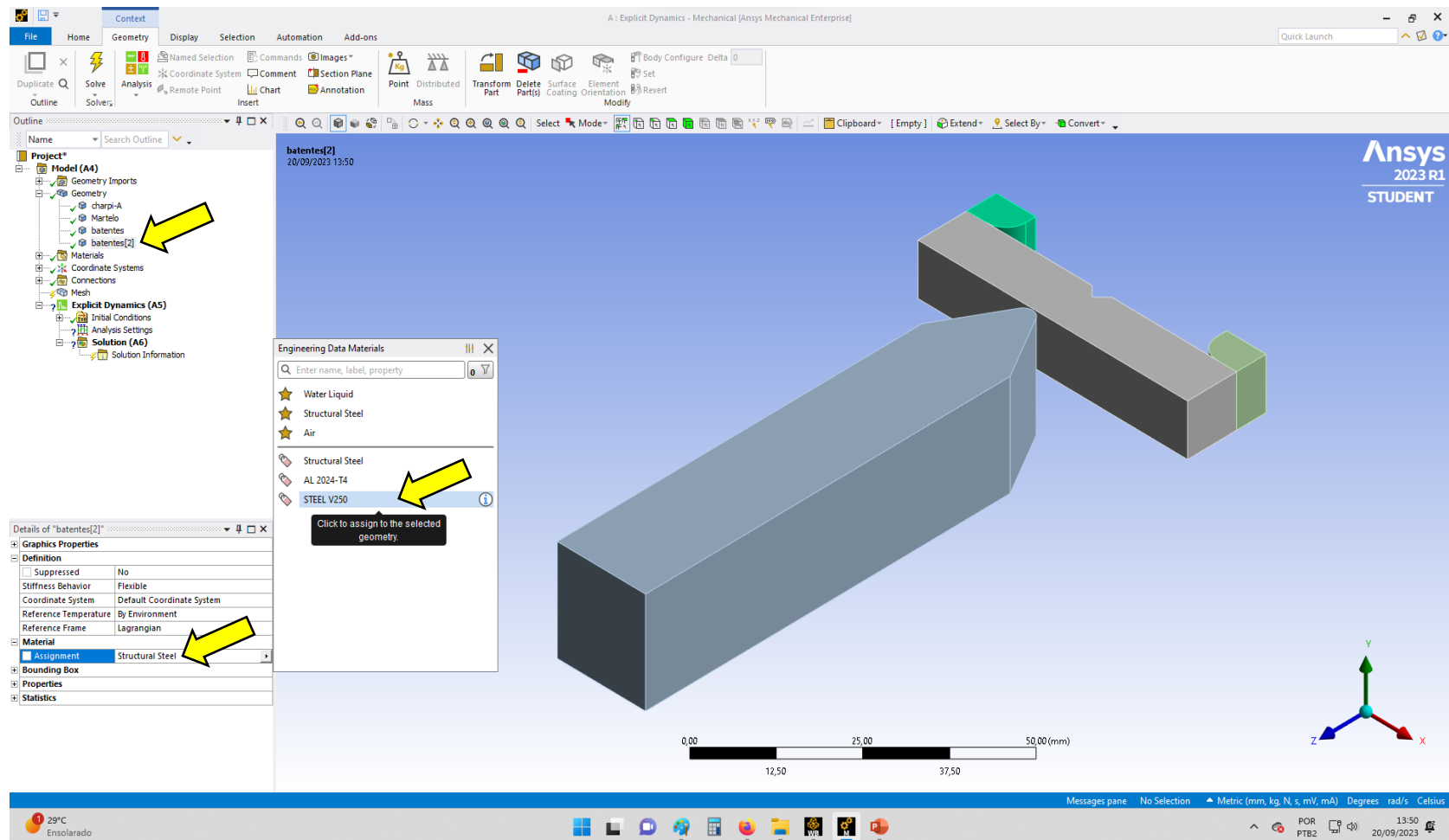
O material é o mesmo do martelo





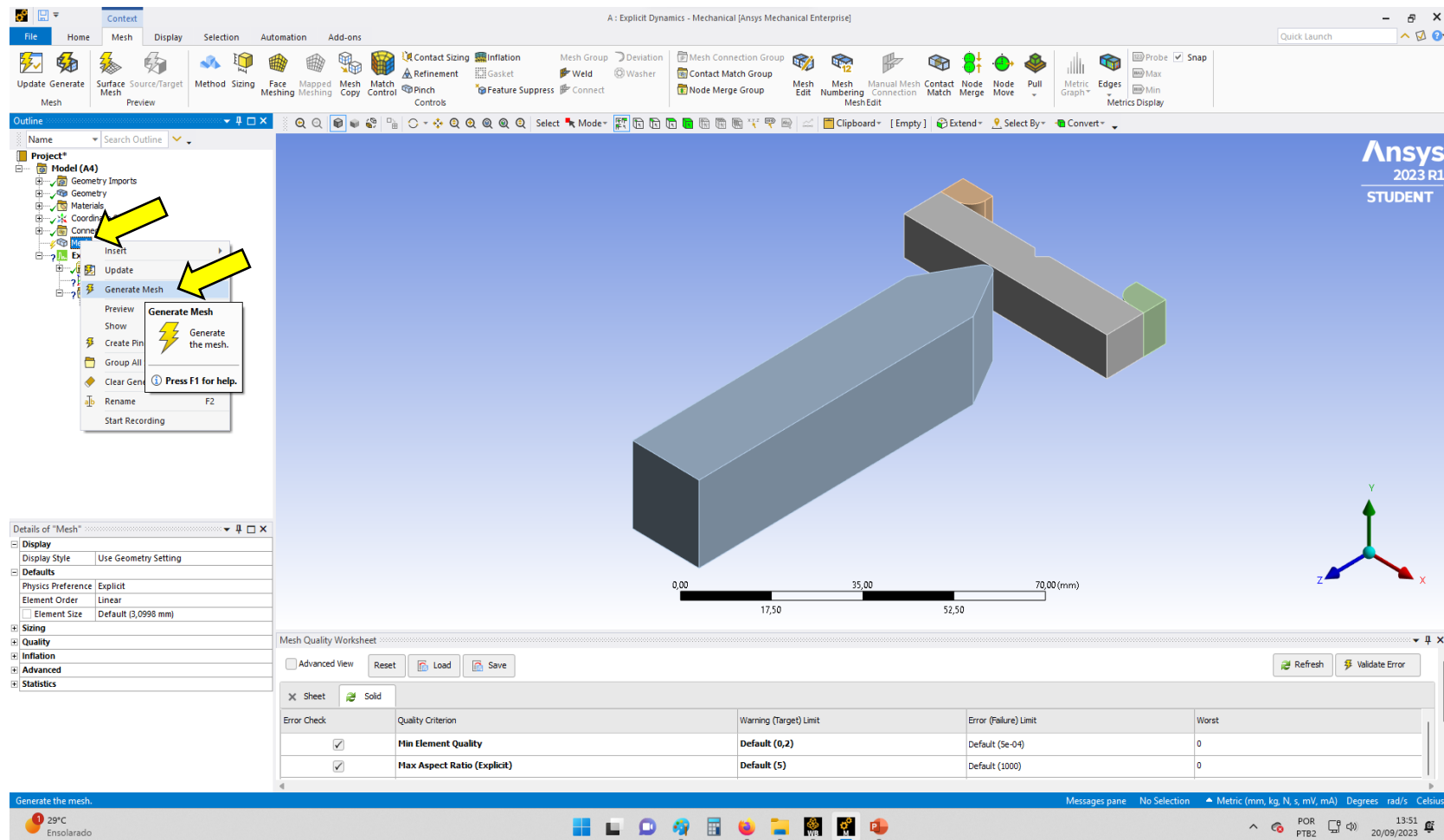
Atribuindo o material do batente (2)

O material é o mesmo do martelo





Gerando a malha





Gerando a malha

Seleção pelo sólido

Body (Ctrl-B)
Select or highlight bodies on your model. Use the Ctrl button or hold the mouse button to select multiple bodies.
Press F1 for help.

Mesh Quality Worksheet

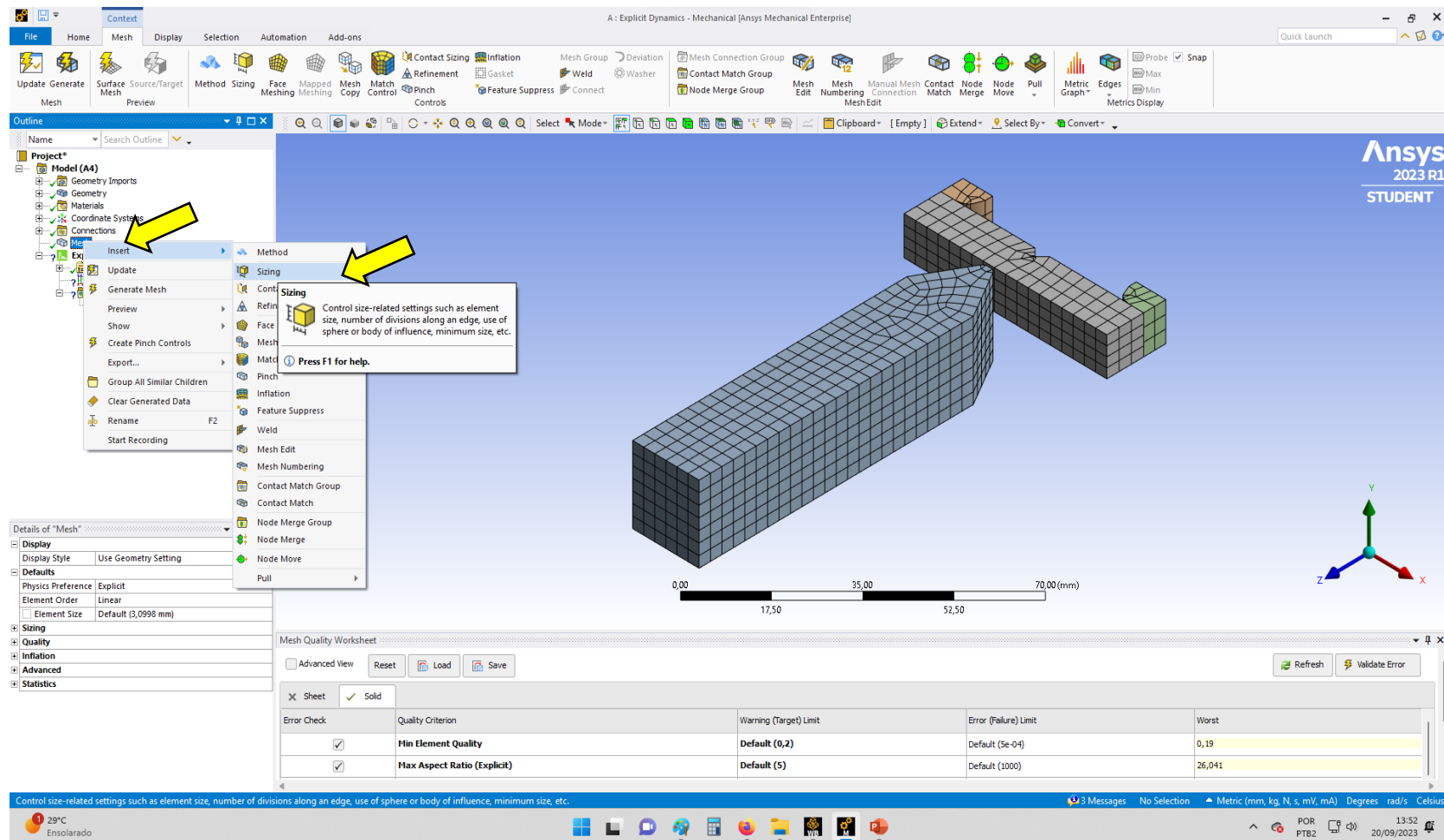
Error Check	Quality Criterion	Warning (Target) Limit	Error (Failure) Limit	Worst
<input checked="" type="checkbox"/>	Min Element Quality	Default (0,2)	Default (5e-04)	0,19
<input checked="" type="checkbox"/>	Max Aspect Ratio (Explicit)	Default (5)	Default (1000)	26,041

Ready
29°C Ensolarado
3 Messages No Selection Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
POR PTB2 13:52 20/09/2023



Refinando a malha

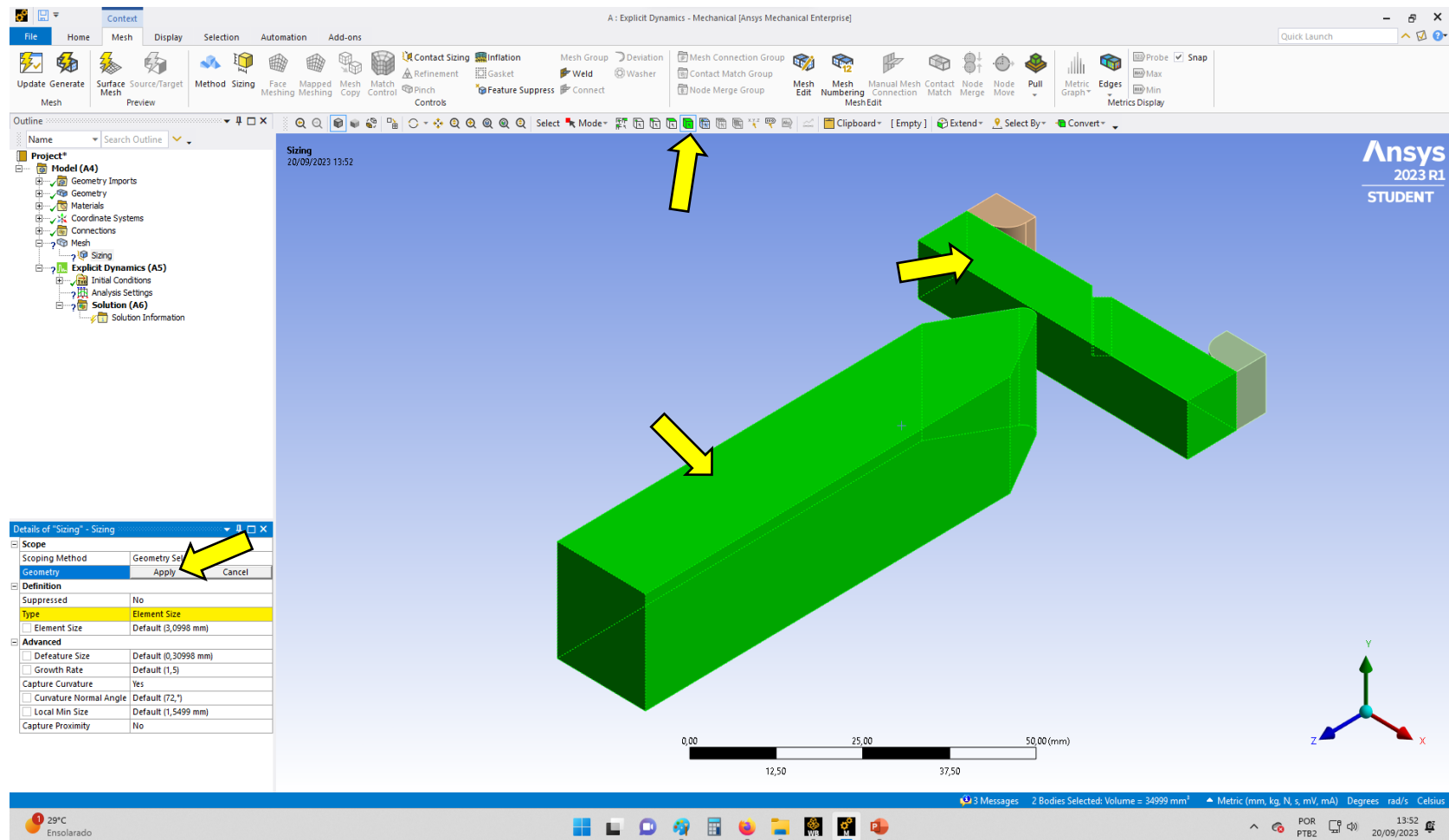
Selecionar somente o martelo e o corpo de prova





Refinando a malha

Selecionar somente o martelo e o corpo de prova





Refinando a malha

Selecionar somente o martelo e o corpo de prova

1,4mm
ou
0,0014m

Cuidado com as unidades!

0,00 12,50 25,00 37,50 50,00 (mm)

3 Messages No Selection Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius

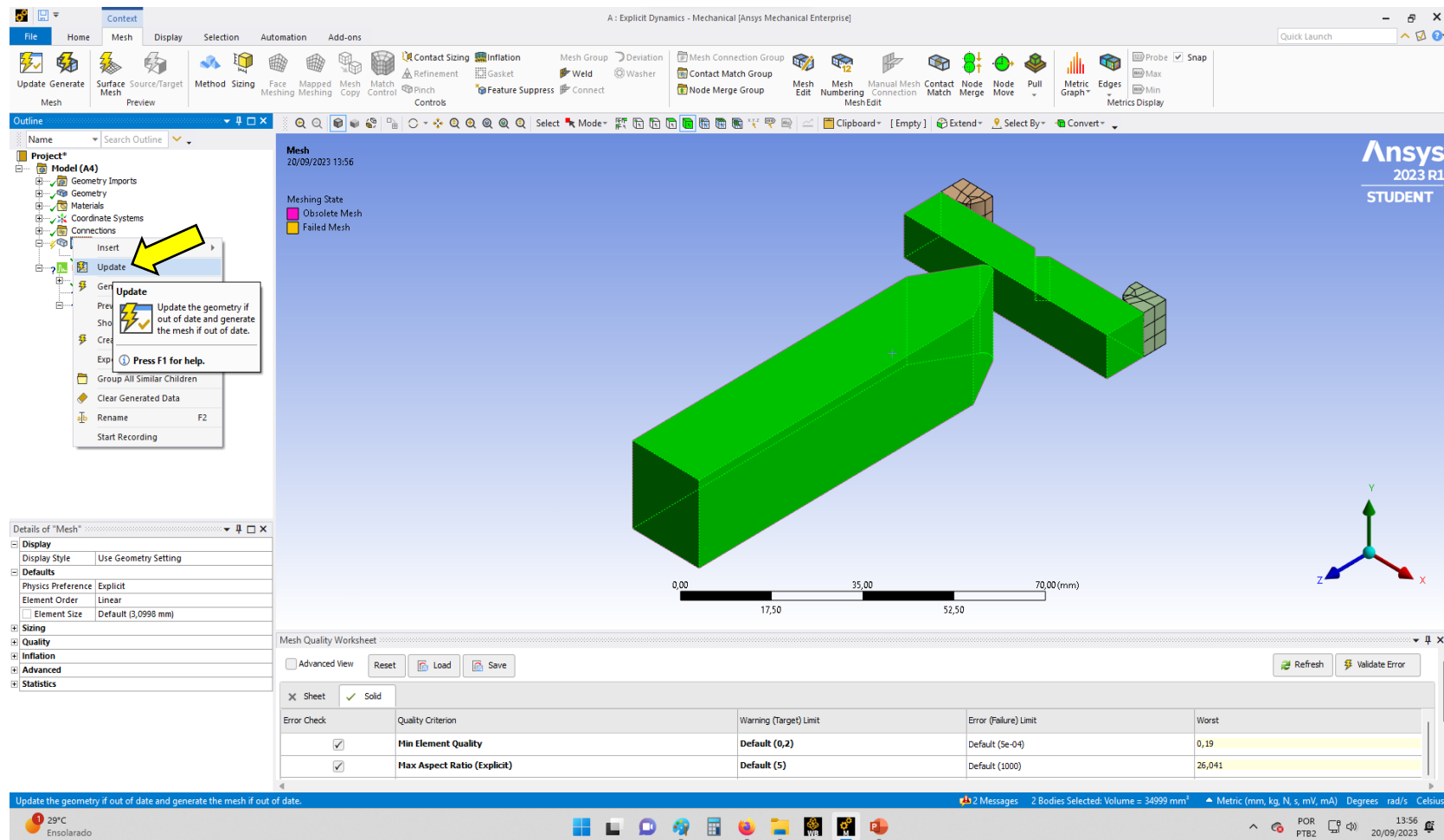
29°C Ensolarado

POR PTB2 14:57 20/09/2023



Refinando a malha

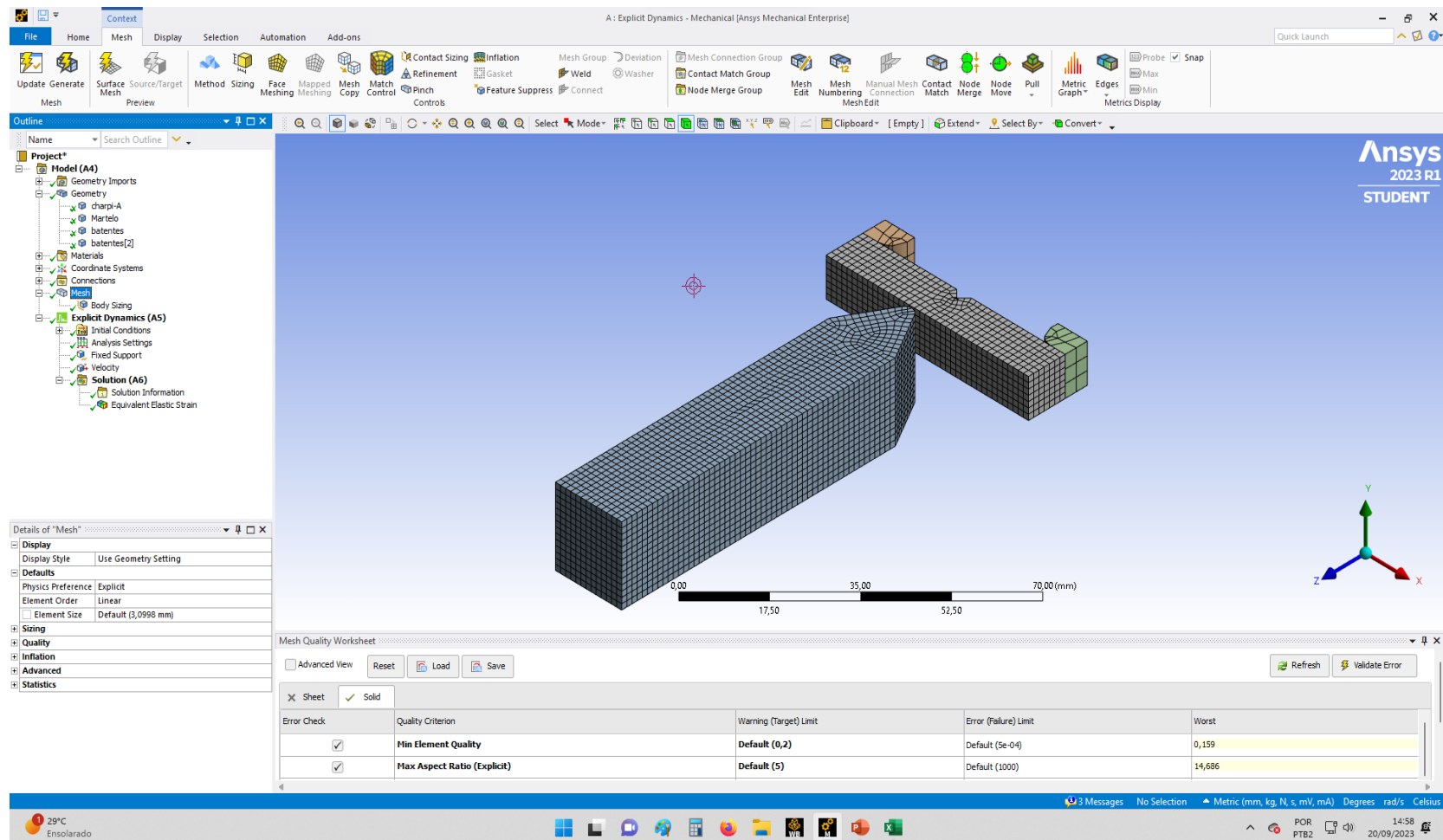
Atualizando a malha





Refinando a malha

Malha após a atualização



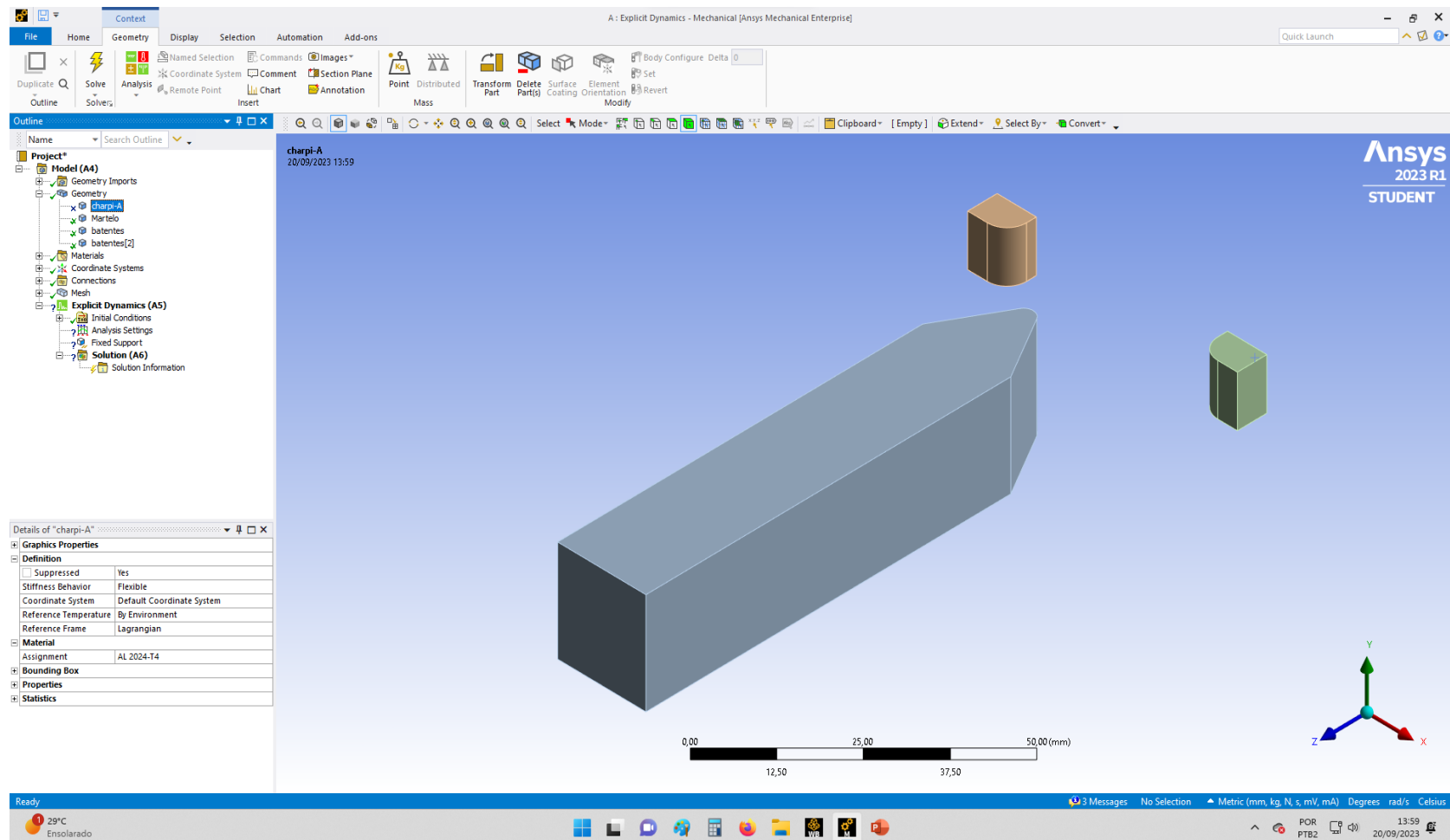


É necessário suprimir temporariamente o corpo de prova para ter acesso total aos batentes



Condições de contorno

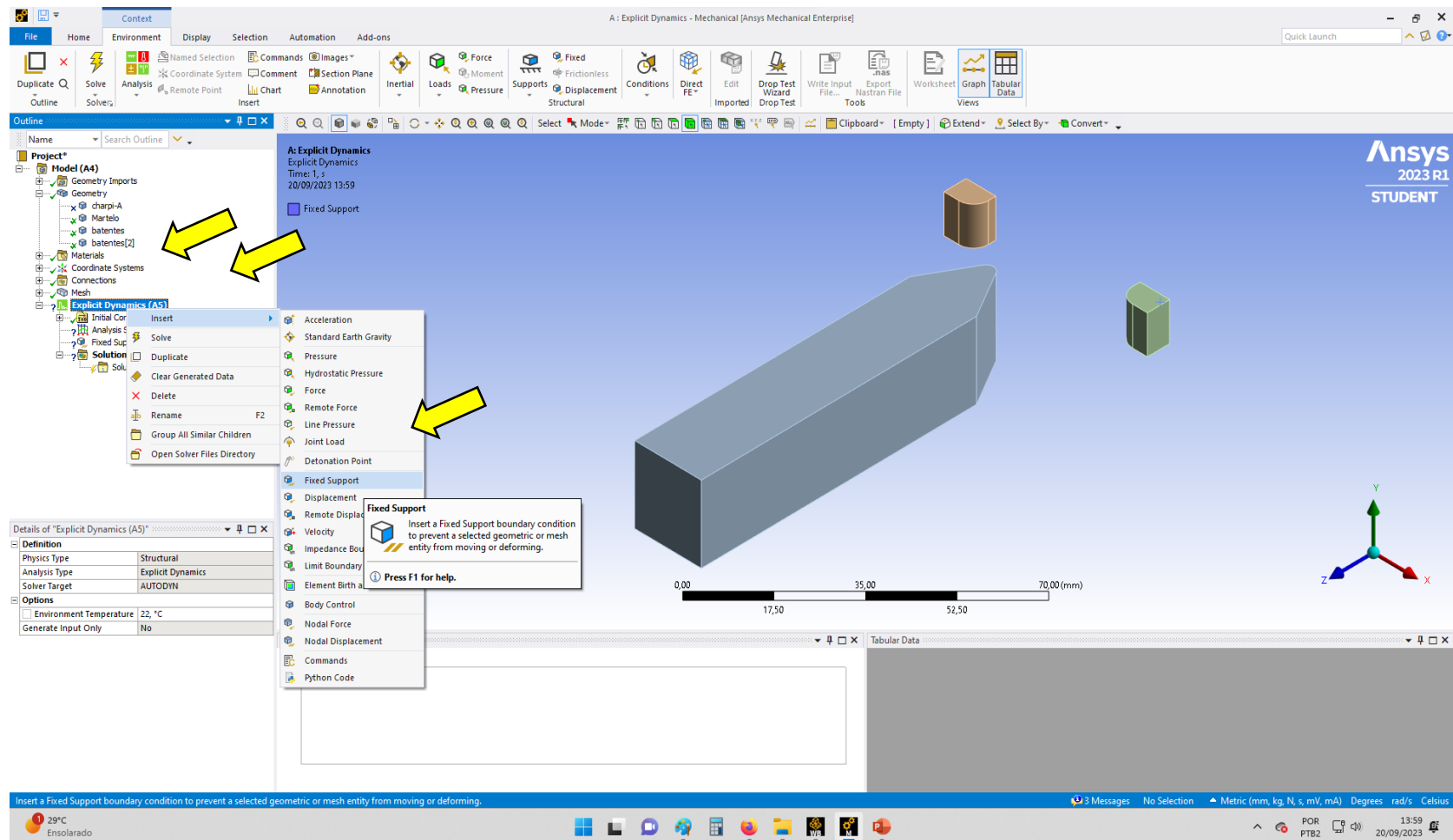
Imagem após a supressão corpo de prova





Condições de contorno

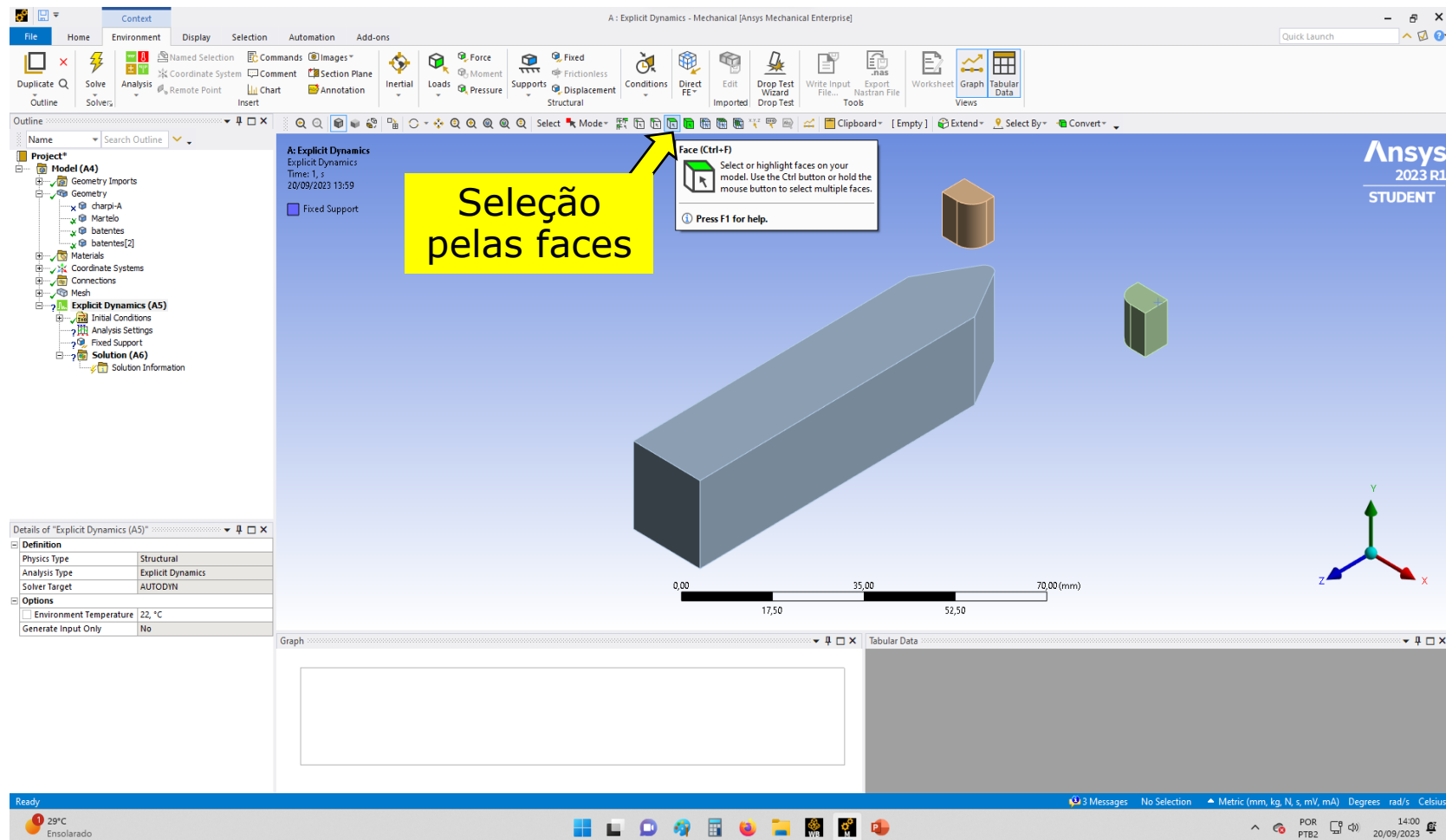
Definindo os batentes como suportes rígidos





Condições de contorno

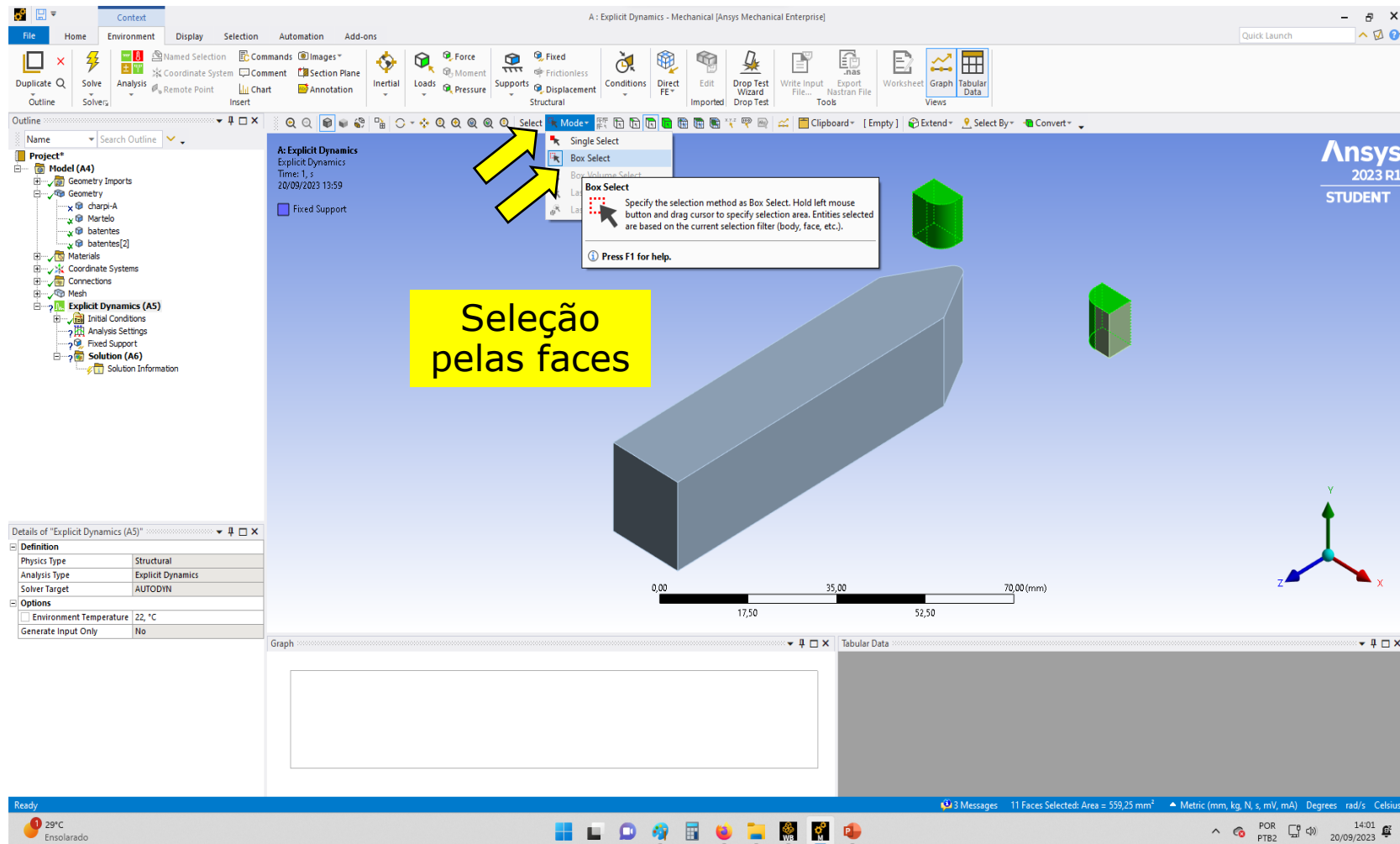
Definindo os batentes como suportes rígidos





Condições de contorno

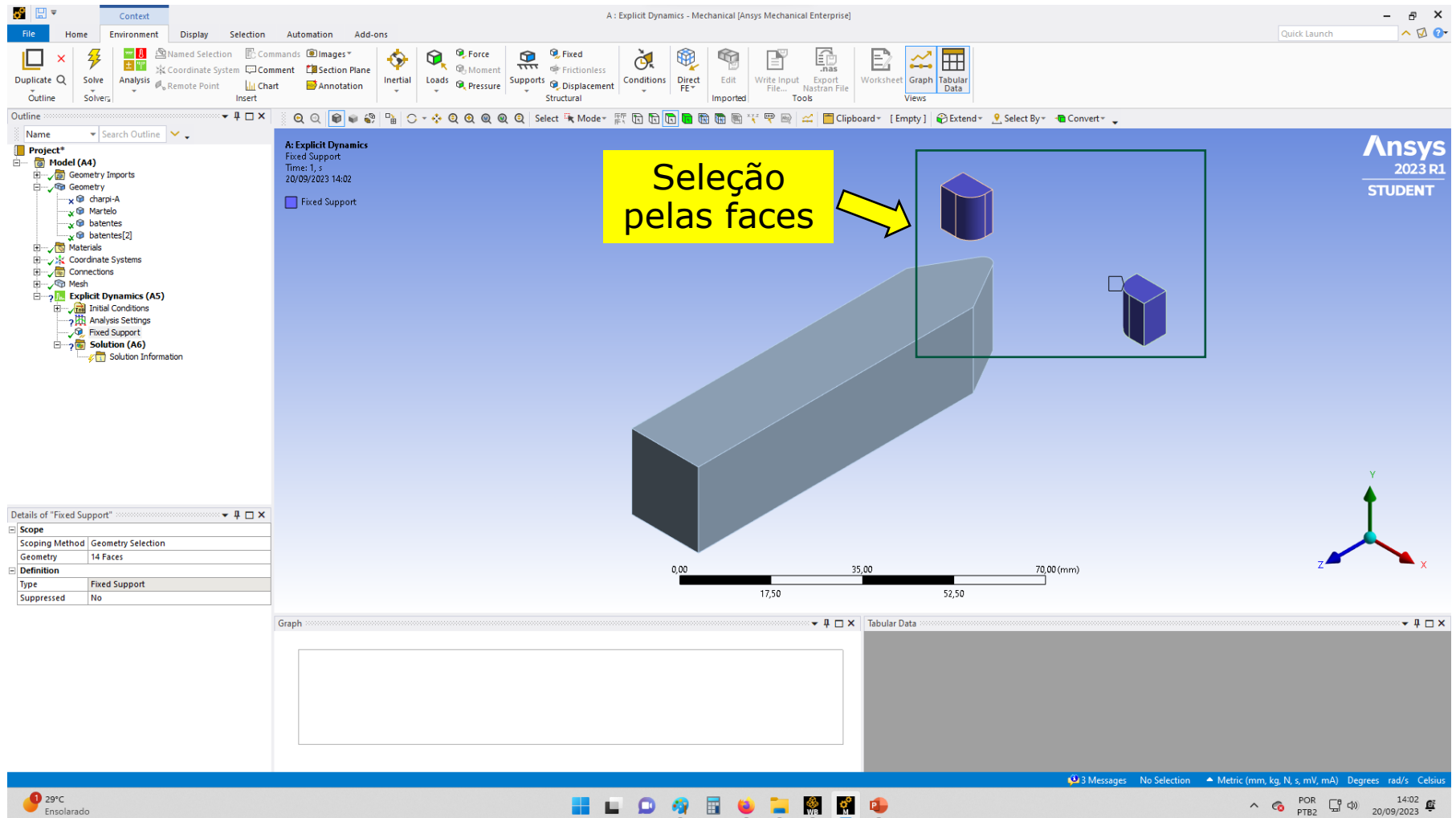
Definindo os batentes como suportes rígidos





Condições de contorno

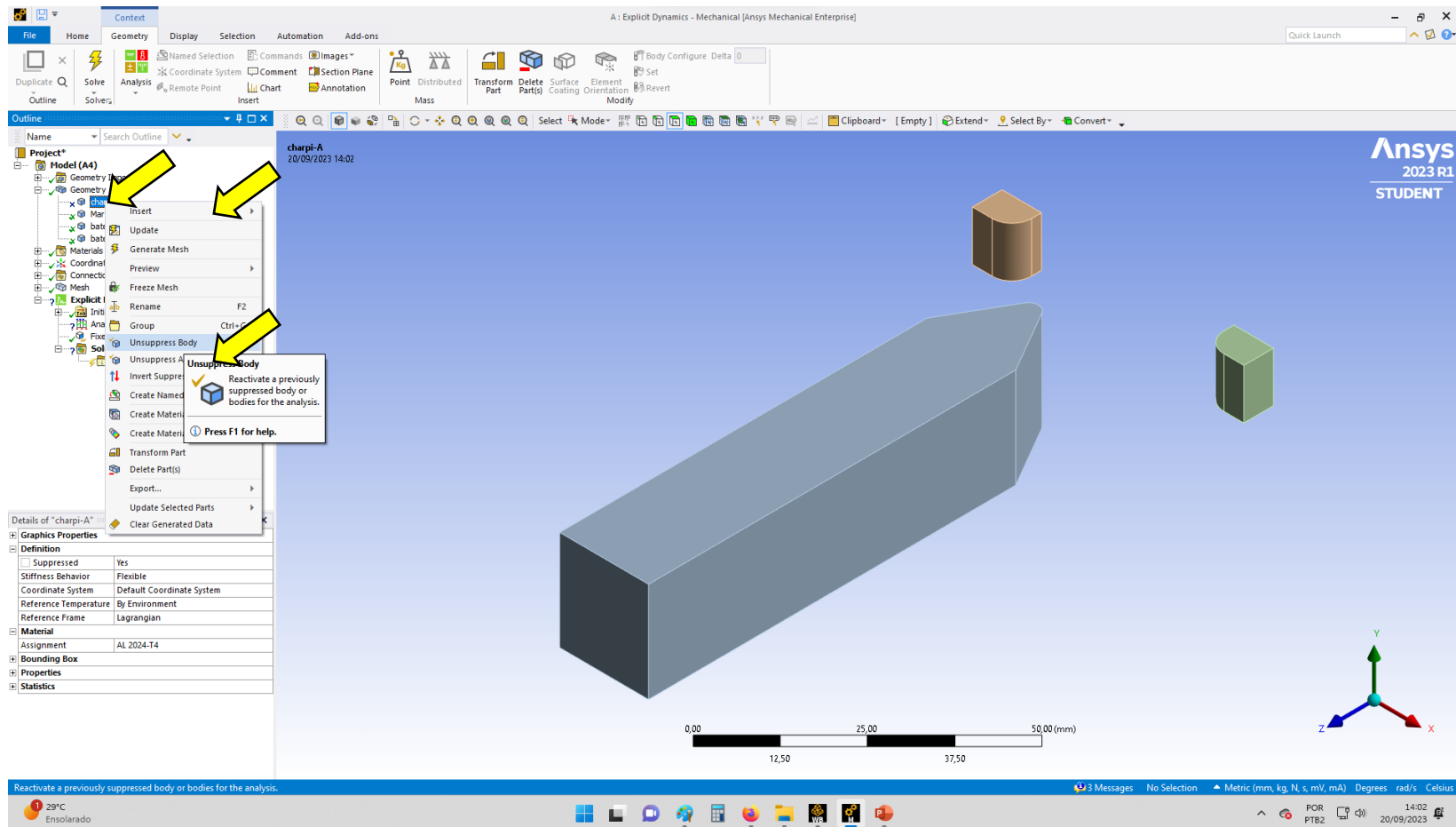
Definindo os batentes como suportes rígidos





Condições de contorno

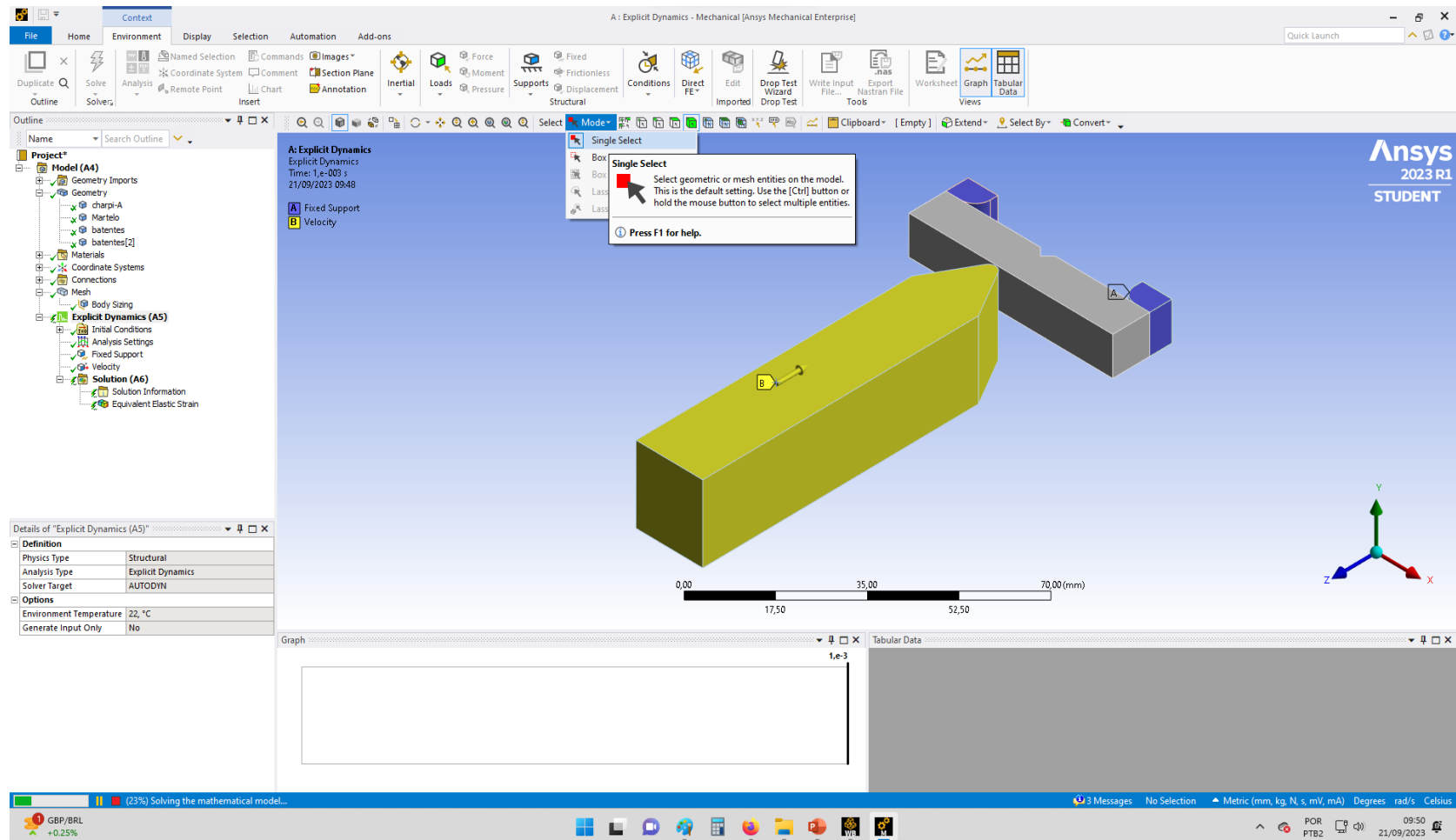
Desuprimindo o corpo de prova





Condições de contorno

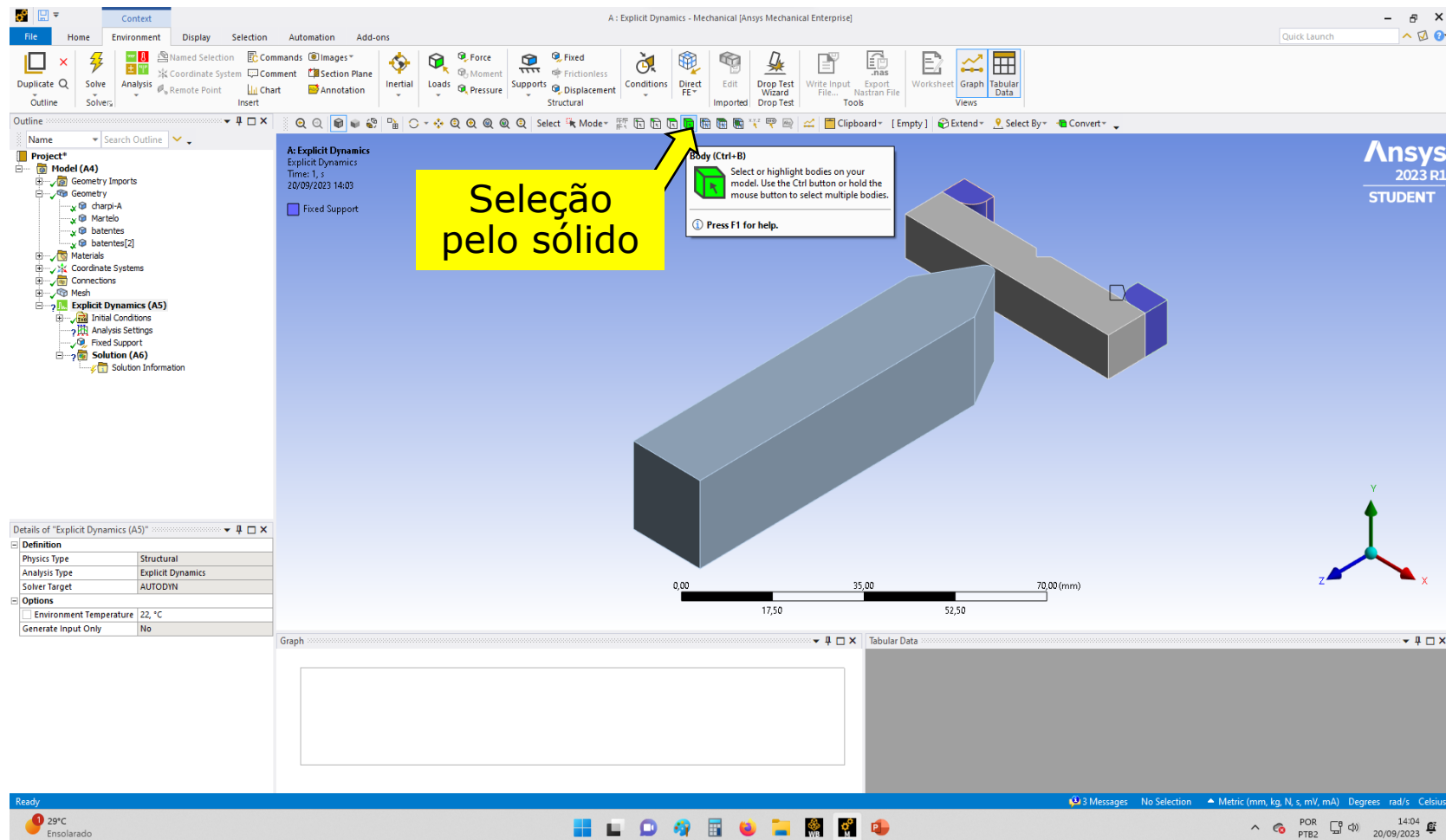
Retornando a seleção simples





Condições de contorno

Definindo a velocidade do martelo





Condições de contorno

Definindo a velocidade do martelo

Vamos assumir que a trajetória final é praticamente linear, e energia cinética equivale a do martelo padronizado ($m=9,87\text{kg}$)

The screenshot displays the ANSYS Workbench software interface. The 'Context' tab is active, showing the 'Velocity' boundary condition being applied to the hammer. The 'Details of Explicit Dynamics (A5)' panel is open, showing the 'Definition' tab with the following settings:

- Physics Type: Structural
- Analysis Type: Explicit Dynamics
- Solver Target: AUTODYN
- Options: Environment Temperature: 22, °C; Generate Input Only: No

The 'Graph' panel shows 'Nodal Displacement' and 'Commands'. The 'Velocity' boundary condition is being applied to the hammer, with a note indicating 'Use the Velocity support to specify a displacement per unit time.' The 'Velocity' boundary condition is being applied to the hammer, with a note indicating 'Use the Velocity support to specify a displacement per unit time.'



Condições de contorno

Definindo a velocidade do martelo

The screenshot displays the Ansys 2023 R1 Student interface for an Explicit Dynamics simulation. The main window shows a 3D model of a hammer (green) and a target (grey). The left sidebar shows the project tree with the following structure:

- Project*
 - Model (A4)
 - Geometry Imports
 - Geometry
 - chapa-A
 - Martelo
 - batentes
 - batentes[2]
 - Materials
 - Coordinate Systems
 - Connections
 - Mesh
 - Explicit Dynamics (A5)
 - Initial Conditions
 - Analysis Settings
 - Fixed Support
 - Velocity
 - Solution (A6)
 - Solution Information

The 'Details of Velocity' dialog box is open, showing the following settings:

- Scope: Geometry Selection (highlighted with a yellow arrow)
- Scoping Method: Geometry Selection
- Geometry: Apply
- Definition
 - Type: Velocity
 - Define By: Components
 - Coordinate System: Global Coordinate System
 - X Component: 0, mm/s (step applied)
 - Y Component: 0, mm/s (step applied)
 - Z Component: -30000 mm/s (step applied)
 - Suppressed: No

The bottom right corner shows a tabular data table:

Steps	Time [s]	X [mm/s]	Y [mm/s]	Z [mm/s]
1	0	0	0	-30000

The status bar at the bottom indicates: 3 Messages, 1 Body Selected: Volume = 29539 mm³, Metric (mm, kg, N, s, mV, mA), Degrees, rad/s, Celsius, 29°C, Ensolarado, 14:05, 20/09/2023.



Condições de contorno

Definindo a velocidade do martelo

Velocidades nas direções (X e Y) = 0

Velocidade na direção (Z) = -30.000 a -35.000 mm/s ou -30 a -35 m/s

Steps	Time [s]	X [mm/s]	Y [mm/s]	Z [mm/s]
1	0	0	0	-30000
2	1	0	0	-30000



Condições de contorno

Definindo os parâmetros da simulação

0,001 s

0,00 35,00 70,00 (mm)

17,50 52,50

Graph

Tabular Data

Steps	End Time [s]
1	1.e-003

3 Messages 1 Body Selected: Volume = 29539 mm³ Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius

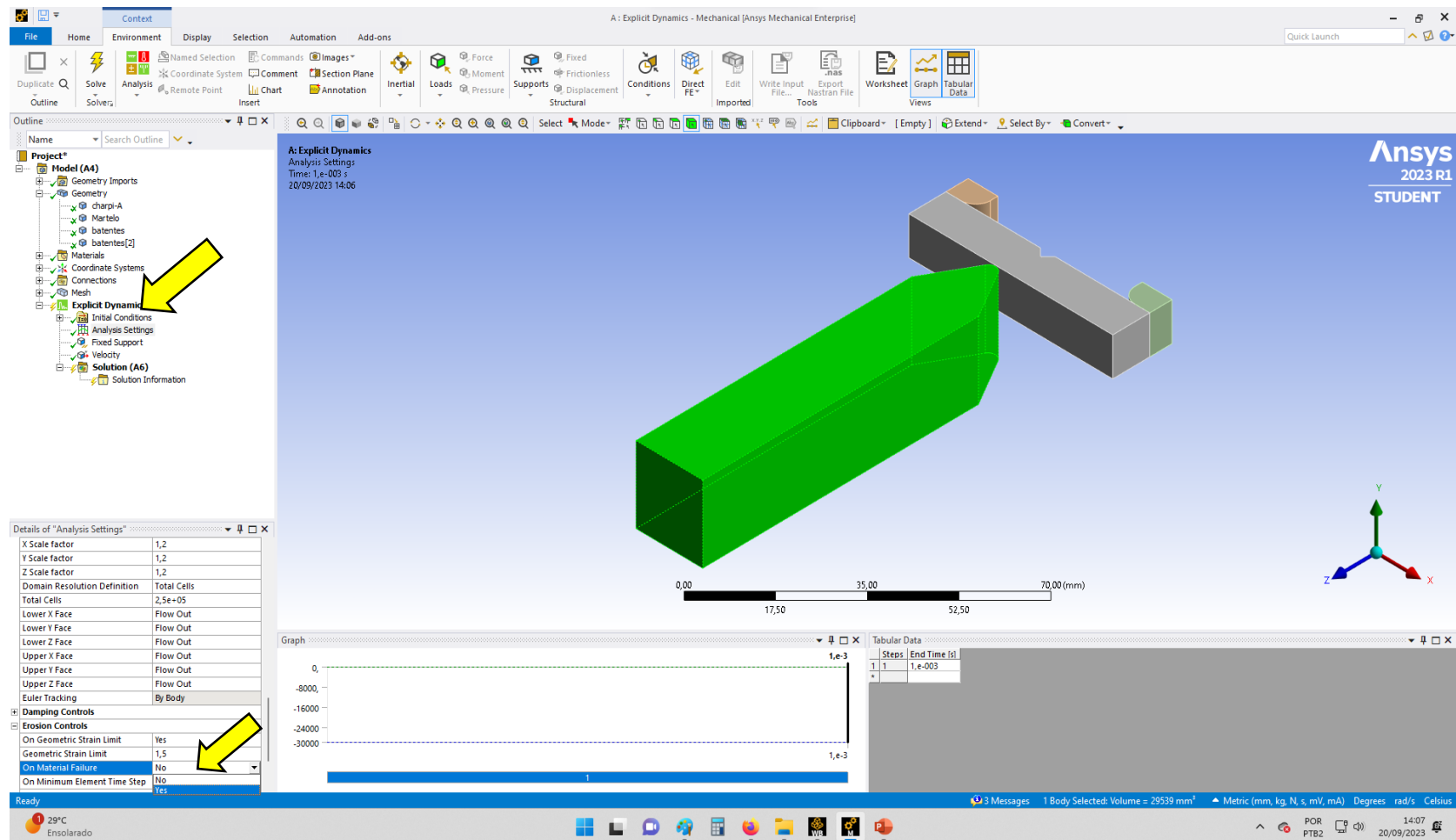
29°C Ensolarado

POR PTB2 14:06 20/09/2023



Condições de contorno

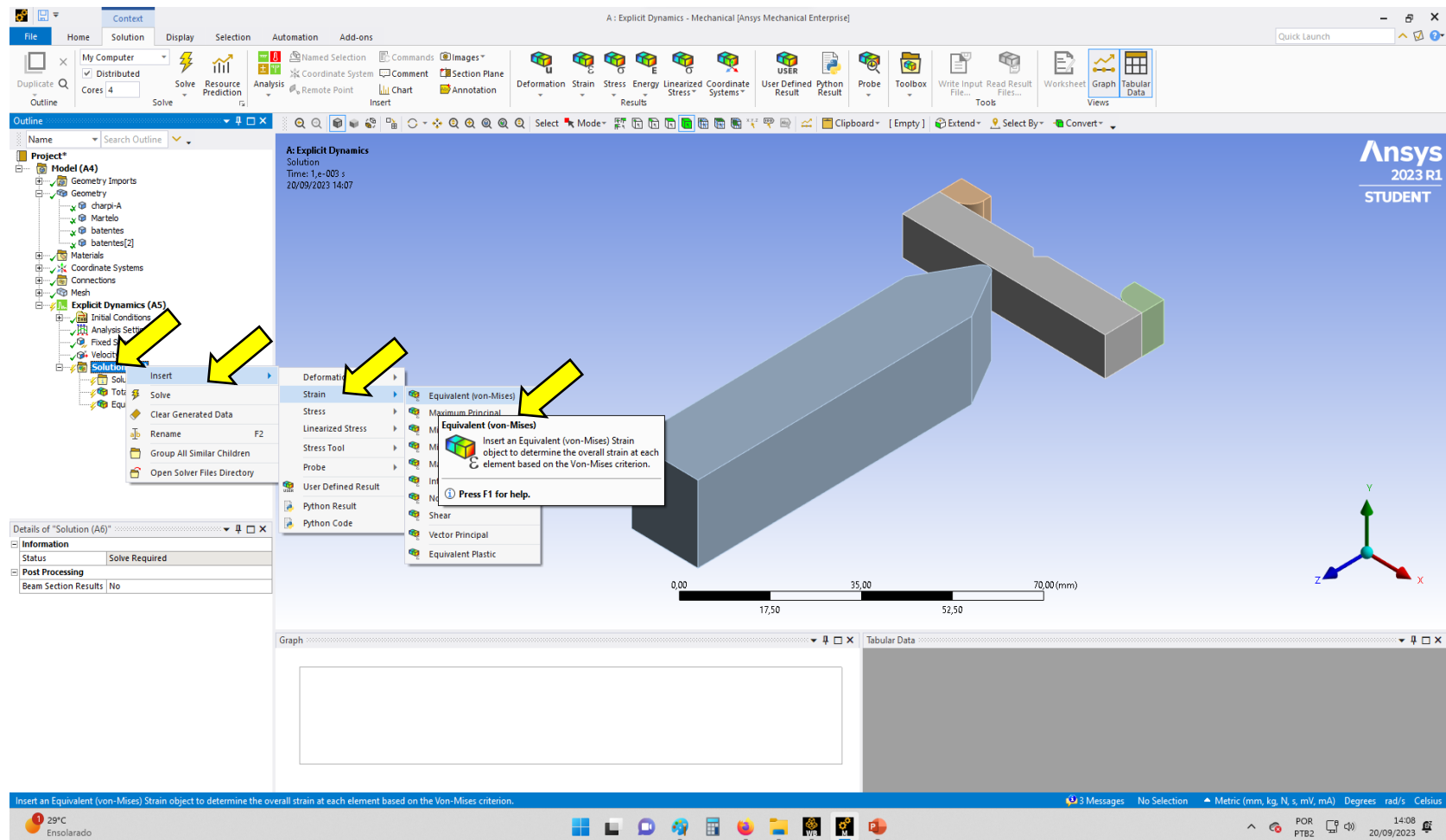
Definindo que o material vai romper





Condições de contorno

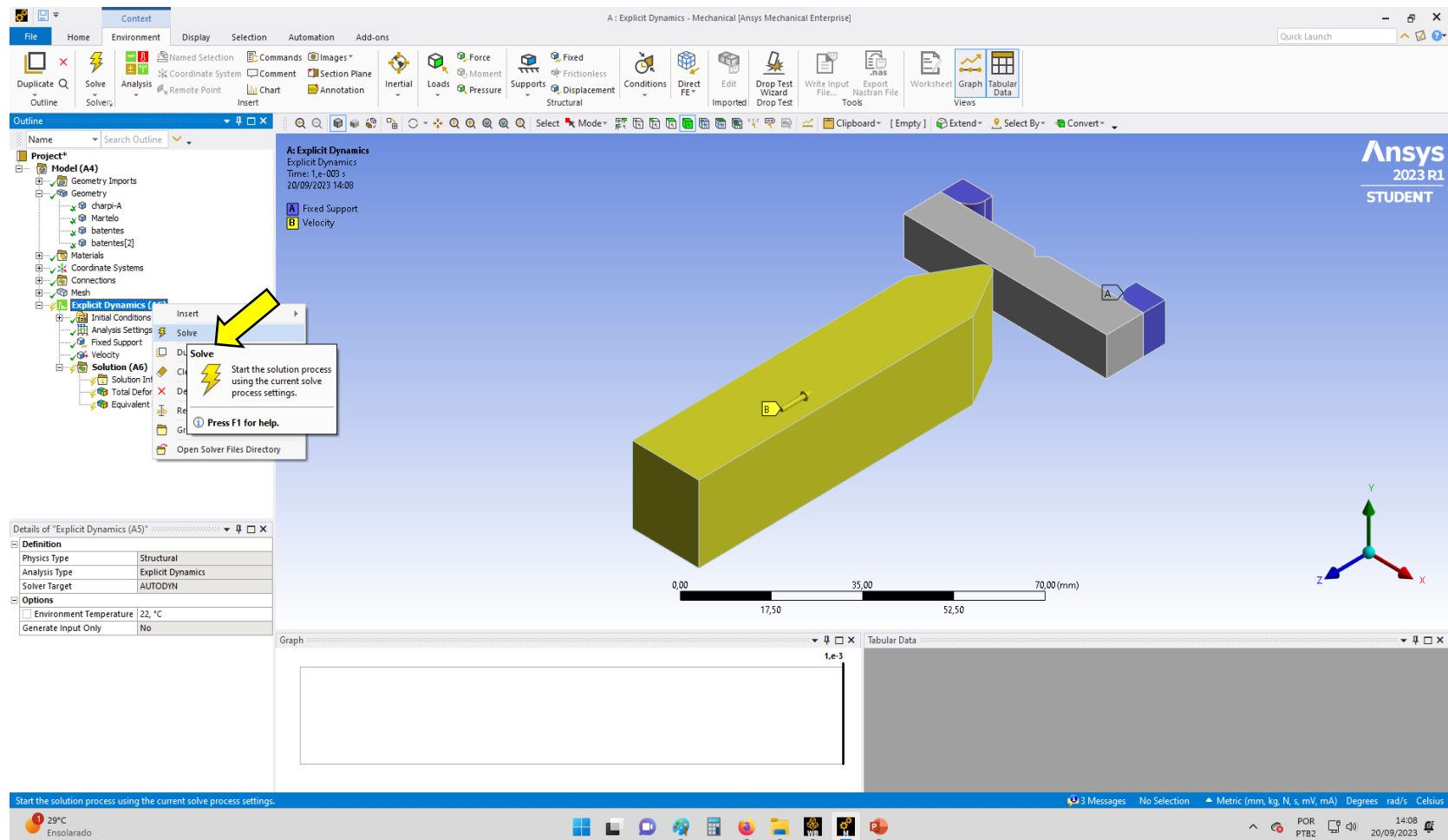
Definindo os parâmetros de saída da simulação





Condições de contorno

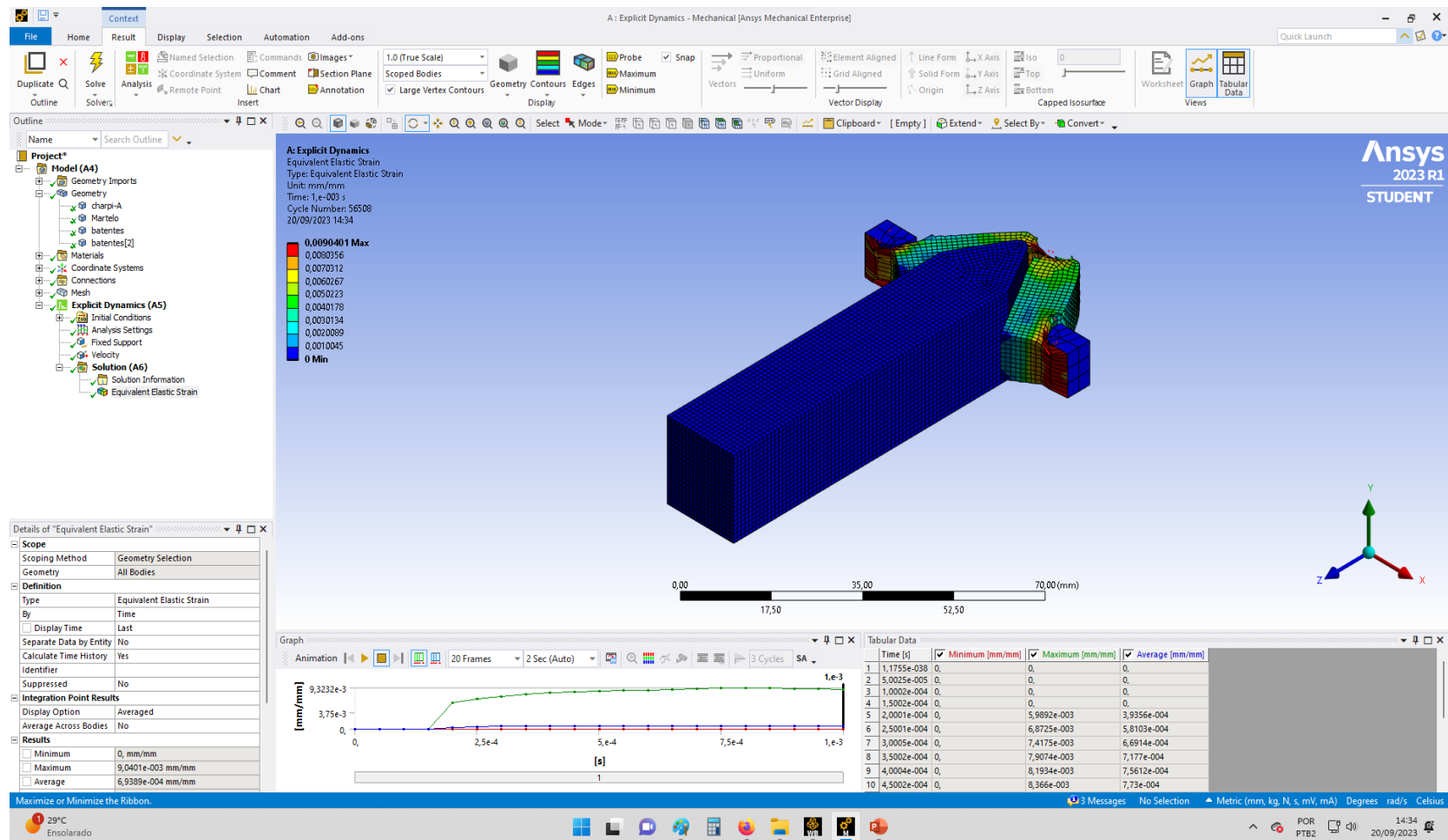
Solve!





Condições de contorno

Pronto!





FIM