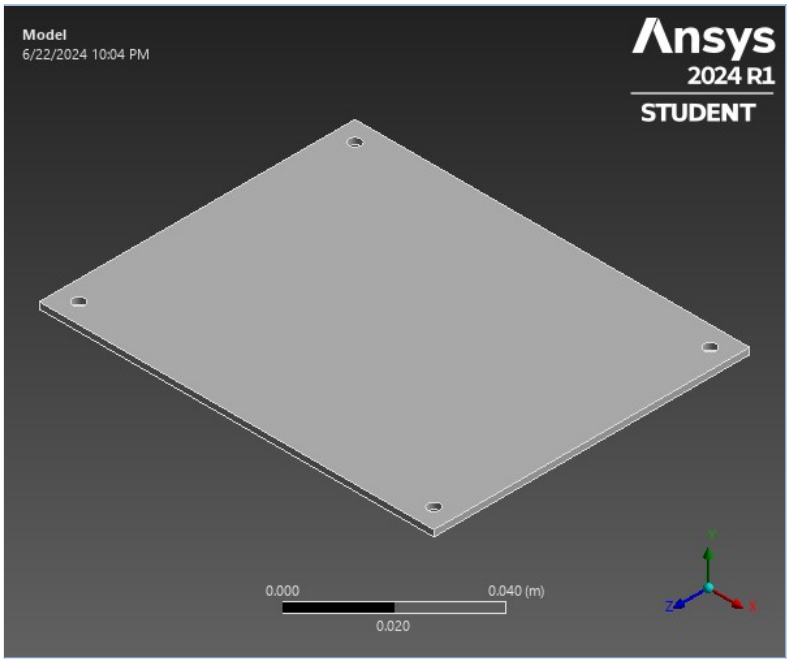
Project*

First Saved	Saturday, June 22, 2024
Last Saved	Saturday, June 22, 2024
Product Version	2024 R1
Save Project Before Solution	No
Save Project After Solution	No



Contents

Units

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4)

TABLE 2
Model (A4) > Geometry Imports

Object Name	*Geometry Imports*
State	Solved

TABLE 3
Model (A4) > Geometry Imports > Geometry Import (A3)

Object Name	*Geometry Import (A3)*
State	Solved
Definition	
Source	C:\Users\Ronen\AppData\Local\Temp\WB_Ronen_11072_2\wbnew_files\dp0\SYS\DM\SYS.dsco
Type	Discovery
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	Yes
Parameters	Independent
Parameter Key	
Attributes	Yes
Attribute Key	
Named Selections	Yes
Named Selection Key	
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	Yes
Coordinate System Key	
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

Geometry

TABLE 4
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\Ronen\AppData\Local\Temp\WB_Ronen_11072_2\wbnew_files\dp0\SYS\DM\SYS.dsco
Type	Discovery
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.1 m
Length Y	1.635e-003 m
Length Z	8.e-002 m
Properties	
Volume	1.2758e-005 m³
Mass	2.4263e-002 kg
Scale Factor Value	1.
Statistics	
Bodies	11
Active Bodies	11
Nodes	44860
Elements	25154
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	Yes
Parameters	Independent
Parameter Key	
Attributes	Yes
Attribute Key	
Named Selections	Yes
Named Selection Key	
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	Yes
Coordinate System Key	
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 5
Model (A4) > Geometry > Parts

Object Name	*SYS\Body1*	*SYS\Body2*	*SYS\Body3*	*SYS\Body4*	*SYS\Body5*	*SYS\Body6*	*SYS\Body7*	*SYS\Body8*	*SYS\Body9*	*SYS\Body10*	*SYS\Body11*
State	Meshed										
Graphics Properties											
Visible	Yes										
Transparency	1										
Definition											
Suppressed	No										
Stiffness Behavior	Flexible										
Coordinate System	Default Coordinate System										
Reference Temperature	By Environment										
Treatment	None										
Material											
Assignment	FR-4 Epoxy	Copper									
Nonlinear Effects	Yes										
Thermal Strain Effects	Yes										
Bounding Box											
Length X	0.1 m	7.e-003 m									
Length Y	1.6e-003 m	3.5e-005 m									
Length Z	8.e-002 m	1.5e-003 m									
Properties											
Volume	1.2755e-005 m³	3.2375e-010 m³									
Mass	2.4234e-002 kg	2.8921e-006 kg									
Centroid X	5.e-002 m	1.8706e-002 m									
Centroid Y	8.e-004 m	-1.75e-005 m									

Centroid Z	4.e-002 m	5.0215e-002 m	5.3771e-002 m	6.266e-002 m	5.5548e-002 m	5.7326e-002 m	6.4437e-002 m	5.1993e-002 m	6.0882e-002 m	6.6215e-002 m	5.9104e-002 m
Moment of Inertia Ip1	1.2871e-005 kg·m²	5.2831e-013 kg·m²									
Moment of Inertia Ip2	3.2959e-005 kg·m²	1.3901e-011 kg·m²									
Moment of Inertia Ip3	2.0099e-005 kg·m²	1.3373e-011 kg·m²									
Statistics											
Nodes	24660	2020									
Elements	16054	910									
Mesh Metric	None										
CAD Attributes											
PartTolerance:	0.00000001										
SCRootPartComponent											
Color:130.130.130											

TABLE 6
Model (A4) > Materials

Object Name	*Materials*
State	Fully Defined
Statistics	
Materials	2
Material Assignments	0

Coordinate Systems

TABLE 7
Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]
Transfer Properties	
Source	
Read Only	No

Connections

TABLE 8
Model (A4) > Connections

Object Name	*Connections*
State	Fully Defined
Auto Detection	
Generate Automatic Connection On Refresh	Yes
Transparency	
Enabled	Yes
Statistics	
Contacts	19
Active Contacts	19
Joints	0
Active Joints	0
Beams	0
Active Beams	0
Bearings	0
Active Bearings	0
Springs	0
Active Springs	0
Body Interactions	0
Active Body Interactions	0

TABLE 9
Model (A4) > Connections > Contacts

Object Name	*Contacts*
State	Fully Defined
Definition	
Connection Type	Contact
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Auto Detection	
Tolerance Type	Slider

Tolerance Slider	0.
Tolerance Value	3.2018e-004 m
Use Range	No
Face/Face	Yes
Face-Face Angle Tolerance	75. °
Face Overlap Tolerance	Off
Cylindrical Faces	Include
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Bodies
Statistics	
Connections	19
Active Connections	19

TABLE 10
Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region*	*Contact Region 2*	*Contact Region 3*	*Contact Region 4*	*Contact Region 5*	*Contact Region 6*	*Contact Region 7*	*Contact Region 8*	*Contact Region 9*	*Contact Region 10*	*Contact Region 11*
State	Fully Defined										
Scope											
Scoping Method	Geometry Selection										
Contact	1 Face										2 Faces
Target	1 Face										2 Faces
Contact Bodies	SYS\Body1										SYS\Body2
Target Bodies	SYS\Body2	SYS\Body3	SYS\Body4	SYS\Body5	SYS\Body6	SYS\Body7	SYS\Body8	SYS\Body9	SYS\Body10	SYS\Body11	SYS\Body8
Protected	No										
Definition											
Type	Bonded										
Scope Mode	Automatic										
Behavior	Program Controlled										
Trim Contact	Program Controlled										
Trim Tolerance	3.2018e-004 m										
Contact APDL Name											
Target APDL Name											
Suppressed	No										
Display											
Element Normals	No										
Advanced											
Formulation	Program Controlled										
Small Sliding	Program Controlled										
Detection Method	Program Controlled										
Penetration Tolerance	Program Controlled										
Elastic Slip Tolerance	Program Controlled										
Normal Stiffness	Program Controlled										
Update Stiffness	Program Controlled										
Pinball Region	Program Controlled										
Geometric Modification											
Contact Geometry Correction	None										
Target Geometry Correction	None										

TABLE 11
Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region 12*	*Contact Region 13*	*Contact Region 14*	*Contact Region 15*	*Contact Region 16*	*Contact Region 17*	*Contact Region 18*	*Contact Region 19*
State	Fully Defined							
Scope								
Scoping Method	Geometry Selection							
Contact	2 Faces							
Target	2 Faces							
Contact Bodies	SYS\Body3		SYS\Body4		SYS\Body5	SYS\Body6	SYS\Body7	SYS\Body9
Target Bodies	SYS\Body5	SYS\Body8	SYS\Body7	SYS\Body9	SYS\Body6	SYS\Body11	SYS\Body10	SYS\Body11
Protected	No							
Definition								
Type	Bonded							
Scope Mode	Automatic							
Behavior	Program Controlled							
Trim Contact	Program Controlled							
Trim Tolerance	3.2018e-004 m							

Contact APDL Name	
Target APDL Name	
Suppressed	No
Display	
Element Normals	No
Advanced	
Formulation	Program Controlled
Small Sliding	Program Controlled
Detection Method	Program Controlled
Penetration Tolerance	Program Controlled
Elastic Slip Tolerance	Program Controlled
Normal Stiffness	Program Controlled
Update Stiffness	Program Controlled
Pinball Region	Program Controlled
Geometric Modification	
Contact Geometry Correction	None
Target Geometry Correction	None

Mesh

TABLE 12
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Element Quality
Defaults	
Physics Preference	Mechanical
Element Order	Linear
Element Size	1.e-003 m
Sizing	
Use Adaptive Sizing	Yes
Resolution	3
Mesh Defeaturing	No
Transition	Fast
Span Angle Center	Coarse
Initial Size Seed	Assembly
Bounding Box Diagonal	0.12807 m
Average Surface Area	1.1181e-004 m²
Minimum Edge Length	3.5e-005 m
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Standard Mechanical
Target Element Quality	0.7
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
Inflation Element Type	Wedges
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	44860
Elements	25154
Show Detailed Statistics	No

TABLE 13
Model (A4) > Mesh > Mesh Controls

Object Name	*Body Sizing*
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	10 Bodies
Definition	
Suppressed	No
Type	Element Size
Element Size	1.e-004 m

Advanced	
Behavior	Soft

Modal (A5)

TABLE 14
Model (A4) > Analysis

Object Name	*Modal (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Modal
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 15
Model (A4) > Modal (A5) > Initial Condition

Object Name	*Pre-Stress (None)*
State	Fully Defined
Definition	
Pre-Stress Environment	None Available

TABLE 16
Model (A4) > Modal (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Options	
Max Modes to Find	6
Limit Search to Range	No
On Demand Expansion Option	Program Controlled
-- On Demand Expansion	No
Solver Controls	
Damped	No
Solver Type	Program Controlled
Rotordynamics Controls	
Coriolis Effect	Off
Campbell Diagram	Off
Advanced	
Contact Split (DMP)	Program Controlled
Output Controls	
Stress	No
Back Stress	No
Strain	No
Contact Data	No
Nodal Forces	No
Volume and Energy	No
Euler Angles	No
Calculate Reactions	No
General Miscellaneous	No
Result File Compression	Program Controlled
Analysis Data Management	
Solver Files Directory	C:\Users\Ronen\circuit_board_modal_analysis_files\dp0\SYS\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Contact Summary	Program Controlled
Delete Unneeded Files	Yes
Solver Units	Active System
Solver Unit System	mks

TABLE 17
Model (A4) > Modal (A5) > Loads

Object Name	*Fixed Support*
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Type	Fixed Support
Suppressed	No

Solution (A6)

TABLE 18
Model (A4) > Modal (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.

Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	18. s
MAPDL Memory Used	1.3594 GB
MAPDL Result File Size	15.313 MB
Post Processing	
Beam Section Results	No

The following bar chart indicates the frequency at each calculated mode.

FIGURE 1
Model (A4) > Modal (A5) > Solution (A6)

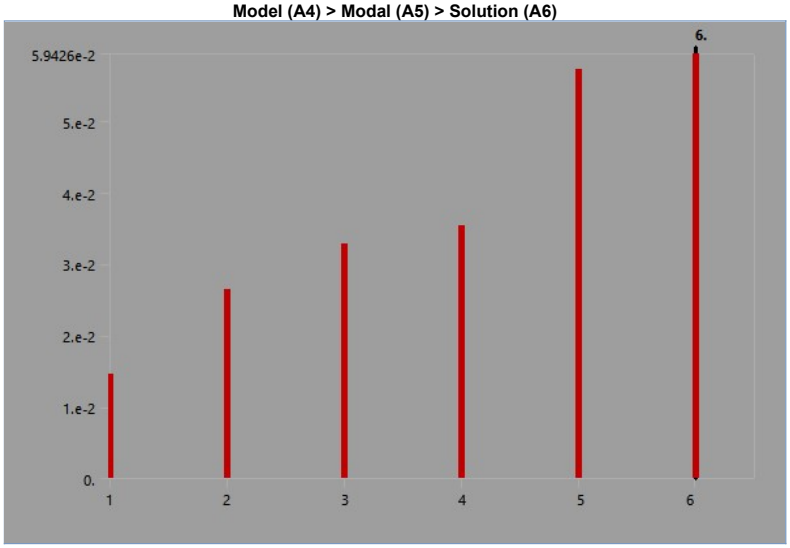


TABLE 19
Model (A4) > Modal (A5) > Solution (A6)

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 20
Model (A4) > Modal (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Post Output
Newton-Raphson Residuals	0
Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

TABLE 21
Model (A4) > Modal (A5) > Solution (A6) > Results

Object Name	*Total Deformation 2*	*Total Deformation 3*	*Total Deformation 4*	*Total Deformation 5*	*Total Deformation 6*	*Total Deformation 7*
State	Solved					
Scope						
Scoping Method	Geometry Selection					
Geometry	All Bodies					
Definition						
Type	Total Deformation					
Mode	1.	2.	3.	4.	5.	6.
Separate Data by Entity	No					
Identifier						
Suppressed	No					
Results						
Minimum	0. m					

Maximum	10.89 m	17.729 m	12.663 m	15.92 m	21.35 m	20.746 m
Average	5.1248 m	3.5906 m	6.1332 m	4.8383 m	3.4806 m	4.2619 m
Minimum Occurs On	SYS\Body1					
Maximum Occurs On	SYS\Body1					
Information						
Frequency	1.4543e-002 Hz	2.6423e-002 Hz	3.2761e-002 Hz	3.5301e-002 Hz	5.7301e-002 Hz	5.9426e-002 Hz

TABLE 22
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 2

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 23
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 3

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 24
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 4

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 25
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 5

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 26
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 6

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

TABLE 27
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 7

Mode	Frequency [Hz]
1.	1.4543e-002
2.	2.6423e-002
3.	3.2761e-002
4.	3.5301e-002
5.	5.7301e-002
6.	5.9426e-002

FIGURE 2
Model (A4) > Modal (A5) > Solution (A6) > Total Deformation 7 > Figure

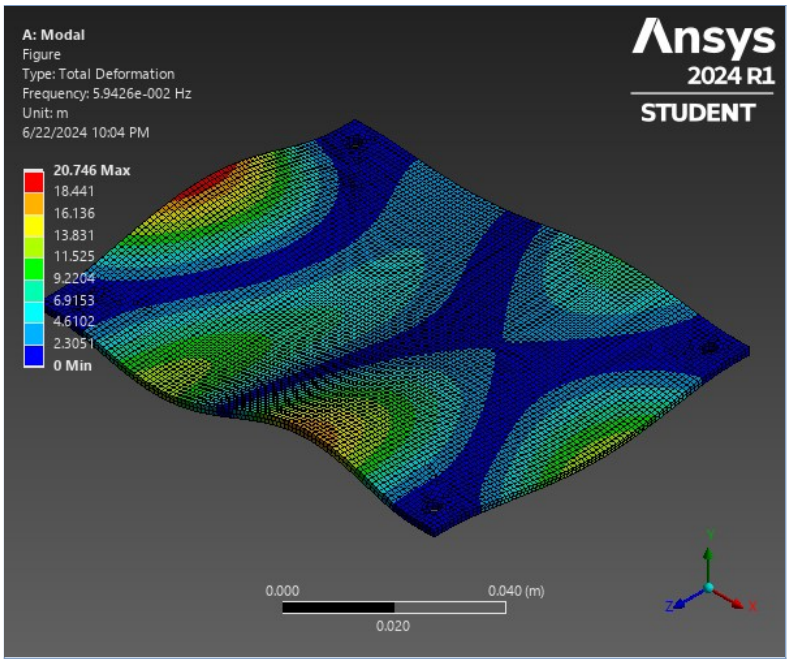


TABLE 28
Model (A4) > Modal (A5) > Solution (A6) > Command Snippet

Object Name	*Commands (APDL)*
State	Solved
File	
File Name	
File Status	File not found
Definition	
Suppressed	No
Output Search Prefix	my_
Invalidate Solution	No
Target	Mechanical APDL
Input Arguments	
ARG1	
ARG2	
ARG3	
ARG4	
ARG5	
ARG6	
ARG7	
ARG8	
ARG9	

Model (A4) > Modal (A5) > Solution (A6) > Commands (APDL)

```
!   Commands inserted into this file will be executed immediately after the ANSYS /POST1 command.

!   Active UNIT system in Workbench when this object was created:  Metric (m, kg, N, s, V, A)
!   NOTE:  Any data that requires units (such as mass) is assumed to be in the consistent solver unit system.
!               See Solving Units in the help system for more information.

/POST1
*DO,i,1,6,1
    SET,i,1
    ! Get the total number of nodes
    *GET,nnode,NODE,0,COUNT
    ! Initialize arrays for displacements
    *DIM,dispX,ARRAY,nnode,1
    *DIM,dispY,ARRAY,nnode,1
    *DIM,dispZ,ARRAY,nnode,1
    ! Get the displacements
    *VGET,dispX(1,1),NODE,1,U,X
    *VGET,dispY(1,1),NODE,1,U,Y
    *VGET,dispZ(1,1),NODE,1,U,Z
    ! Open file for writing
    /AUX15
    /FILNAME,'C:\Users\Ronen\Desktop\ansys-results\mode_shape_',i,'.txt'
    /OUTPUT,'C:\Users\Ronen\Desktop\ansys-results\mode_shape_',i,'.txt'
    ! Write header
    *VWRITE,'Node','X-Displacement','Y-Displacement','Z-Displacement'
    (A8,',',A16,',',A16,',',A16)
    ! Write data
    *DO,j,1,nnode,1
        *VWRITE,j,dispX(j,1),dispY(j,1),dispZ(j,1)
        (I8,',',E16.8,',',E16.8,',',E16.8)
    *ENDDO
```

```
    /OUTPUT
*ENDDO
FINISH
```

Material Data

FR-4 Epoxy

TABLE 29
FR-4 Epoxy > Constants

Thermal Conductivity	0.294 W m^-1 C^-1
Density	1900 kg m^-3
Specific Heat	1150 J kg^-1 C^-1

TABLE 30
FR-4 Epoxy > Color

Red	Green	Blue
99	226	184

TABLE 31
FR-4 Epoxy > Isotropic Elasticity

Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa	Temperature C
20	0.13	9.009	8.8496	

Copper

TABLE 32
Copper > Constants

Thermal Conductivity	400 W m^-1 C^-1
Density	8933 kg m^-3
Specific Heat	385 J kg^-1 C^-1

TABLE 33
Copper > Color

Red	Green	Blue
221	114	0

TABLE 34
Copper > Isotropic Elasticity

Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa	Temperature C
1.1e+011	0.34	1.1458e+011	4.1045e+010	