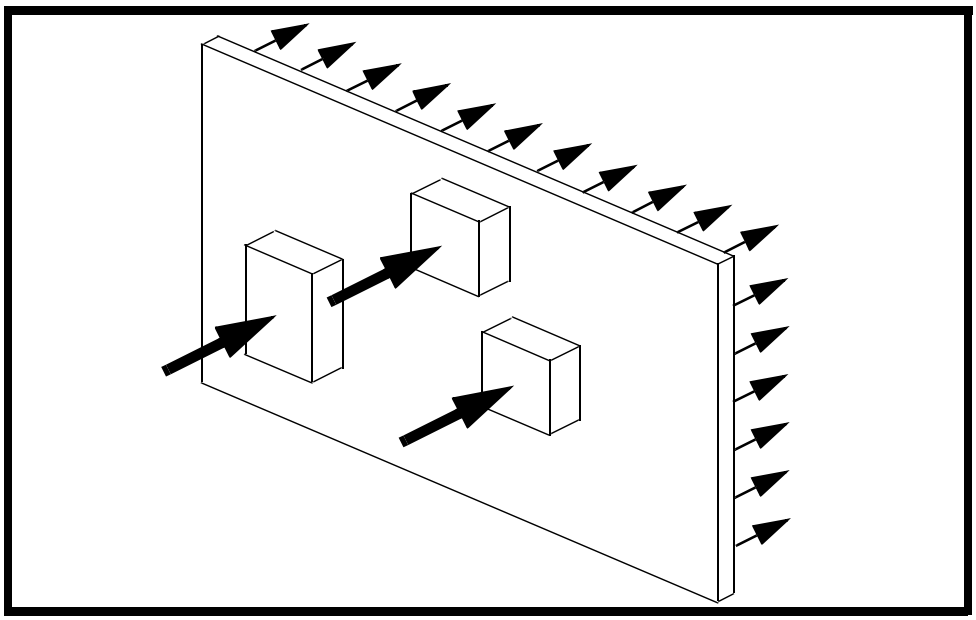
LESSON 6

Free Convection on a Printed Circuit Board



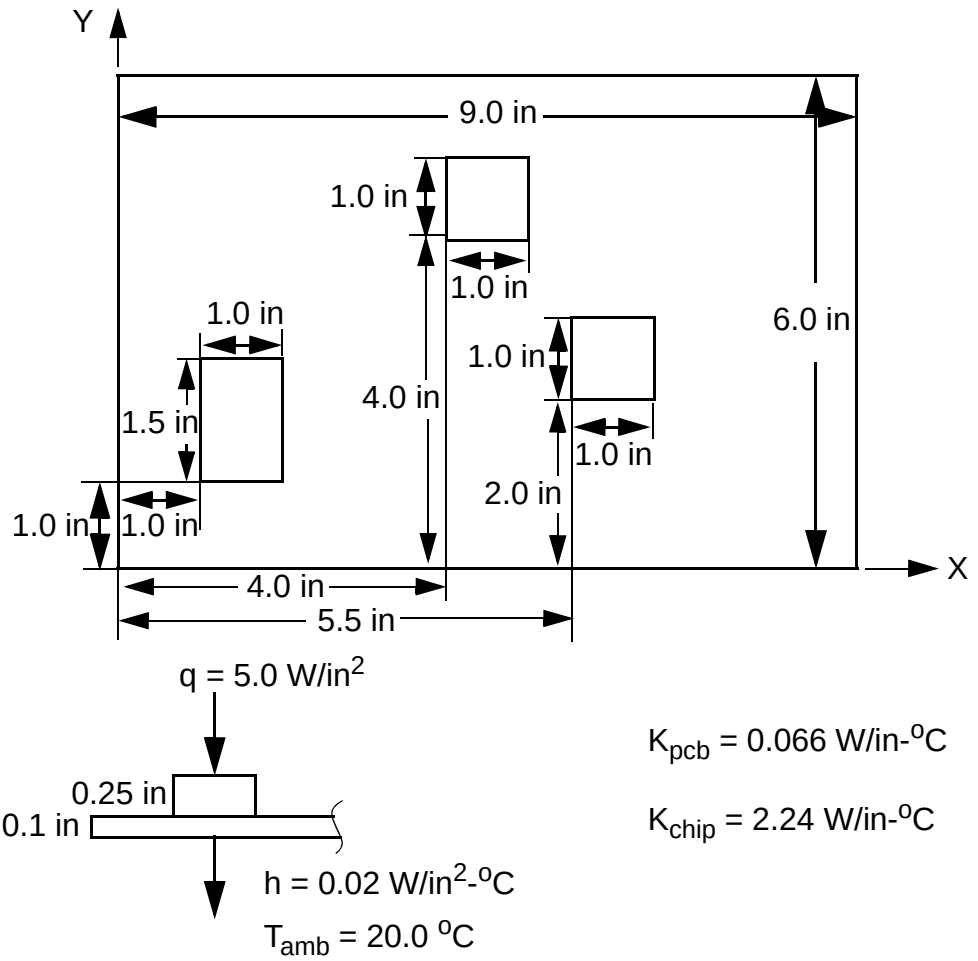
Objectives:

- Create a geometric representation of a printed circuit board.
- Apply thermal loading of free convection and heat fluxes to the model.
- Run a steady-state heat transfer analysis of the board.

Free Convection on PCB

Model Description:

Below is shown a model for a printed circuit board, complete with dimensions, material properties, and thermal loading conditions. You will create this model and analyzye it to determine the steady-state temperature distribution.



Exercise Procedure:

1. Start up MSC/NASTRAN for Windows 3.0.2 and begin to create a new model.

Double click on the icon labeled MSC/NASTRAN for Windows V3.0.2.

On the *Open Model File* form, select **New Model.**

Open Model File:	**New Model**

2. Turn off the Geometry Engine.

Tools/Advanced Geometry ● **Standard**

3. Create the materials of the model.

First, create a material called **pcb**.

Model/Material...

Title:	**pcb**
Conductivity, k:	**.066**

OK

Next, create a material called **chip**.

Model/Material...

Title:	**chip**
Conductivity, k:	**2.24**

OK

Cancel

4. Create the element properties for the model.

First, create a property for the printed circuit board called **pcb**.

Model/Property...

Title:	**pcb**

Material: **1..pcb**

Elem/Property Type...

Volume Elements: ● **Solid**

OK

OK

Next, create an element property for the chips called **chip**.

Title: **chip**

Material: **2..chip**

OK

OK

Cancel

5. Create the NASTRAN geometry for the model.

First, create surfaces to represent the board and the chips.

Geometry/Surface/Corners...

Create the board surface:

X:	*Y:*	*Z:*	
0	**0**	**0**	**OK**
9	**0**	**0**	**OK**
9	**6**	**0**	**OK**
0	**6**	**0**	**OK**

Create the first chip surface:

X:	*Y:*	*Z:*	
1	**1**	**0**	**OK**

X:	*Y:*	*Z:*	
2	**1**	**0**	**OK**
2	**2.5**	**0**	**OK**
1	**2.5**	**0**	**OK**

And the second chip surface:

X:	*Y:*	*Z:*	
4	**4**	**0**	**OK**
5	**4**	**0**	**OK**
5	**5**	**0**	**OK**
4	**5**	**0**	**OK**

And the third chip surface:

X:	*Y:*	*Z:*	
5.5	**2**	**0**	**OK**
6.5	**2**	**0**	**OK**
6.5	**3**	**0**	**OK**
5.5	**3**	**0**	**OK**

Cancel

To fit the display onto the screen, use the Autoscale feature.

View/Autoscale... **<CTRL A>**

Next, extrude the surfaces into solids.

Geometry/Volume/Extrude...

Select the largest surface, representing the board.

OK

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	X:	*Y:*	*Z:*
Base:	**0**	**0**	**0**
Tip:	**0**	**0**	**-.1**

OK

Select the three small surfaces, representing the chips.

OK

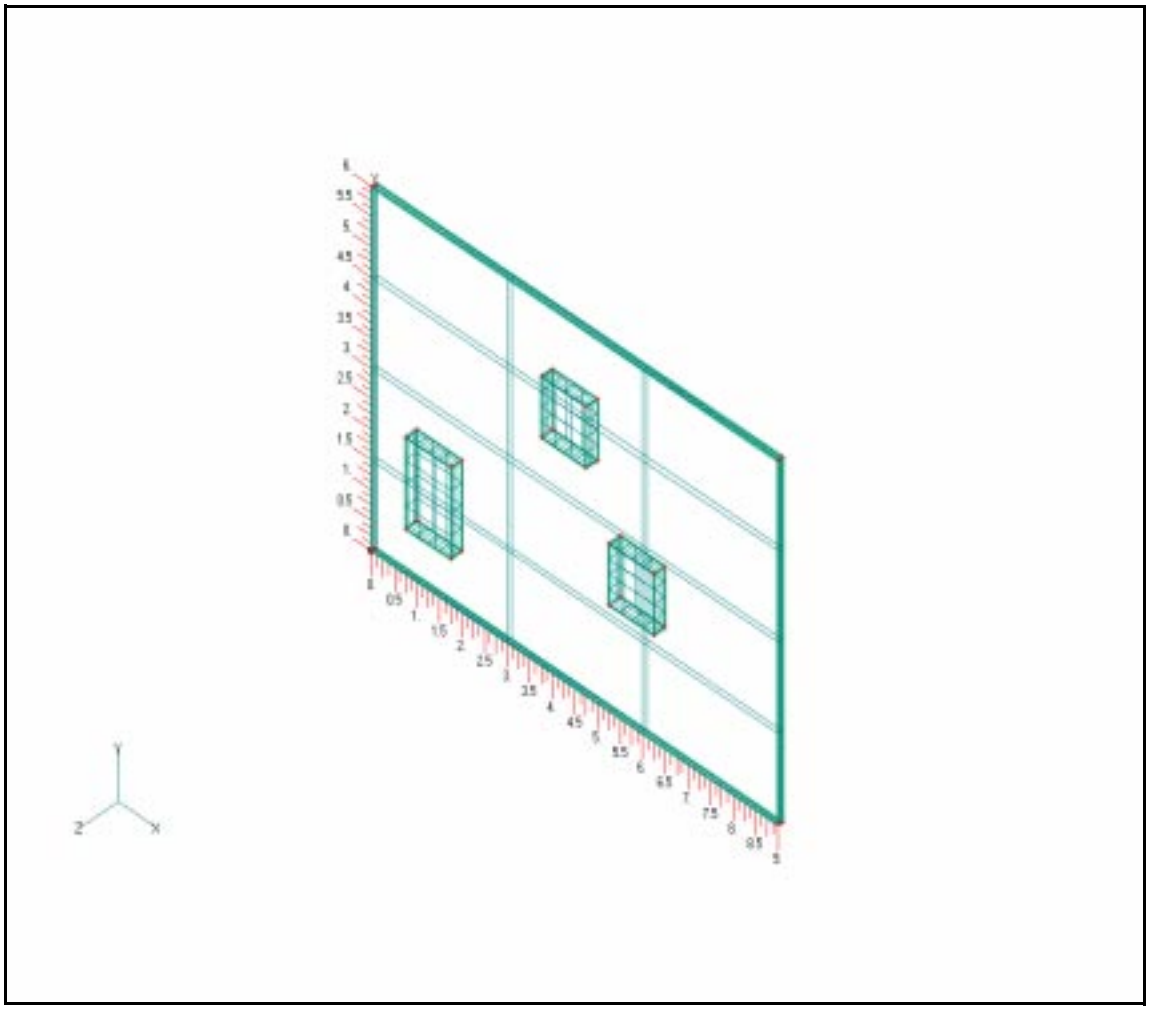
	X:	*Y:*	*Z:*
Base:	**0**	**0**	**0**
Tip:	**0**	**0**	**.25**

OK

Cancel

Your model should be like the following figure:

Figure 6.1: The isometric view of the model.



6. Set the default size for the mesh.

Mesh/Mesh Control/Default Size

Size: **0.25**

OK

7. Create the mesh for the model.

First, turn off all labels to keep the screen from getting “messy”.

View/Options...

Quick Options...

Labels Off

Done

Apply

OK

Next, create the mesh for the pcb (the circuit board).

Mesh/Geometry/Volume...

Select the largest solid (the board).

OK

Property: **1..pcb**

OK

Finally create the mesh for the chips.

Mesh/Geometry/Volume...

Select the three smaller solids (the chips).

OK

Property: **2..chip**

OK

Finally, remove coincident nodes of the model.

Tools/Check/Coincident Nodes...

Select All

OK

When asked, “OK to Specify Additional Range of Nodes to Merge?” respond with **No**.

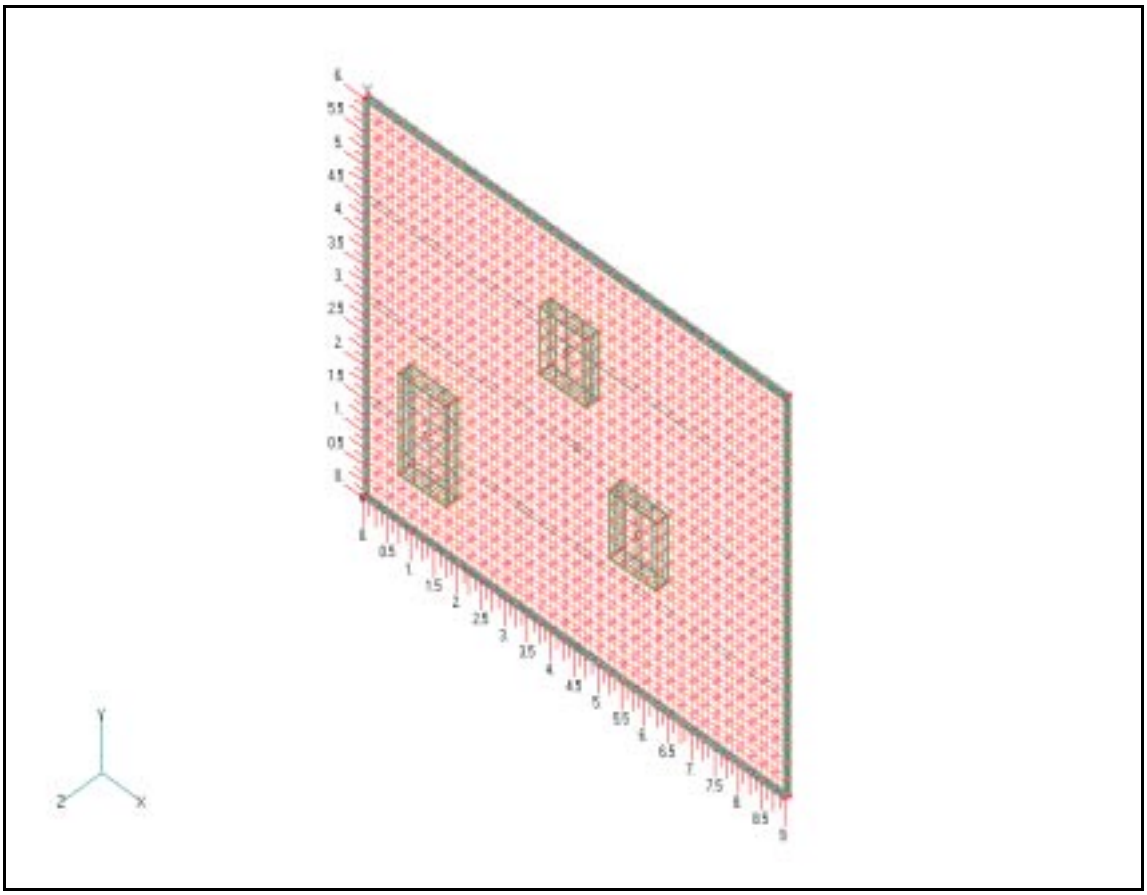
No

☒ **Merge Coincident Entities**

OK

Your model should be like the following figure:

Figure 6.2: The meshed model



8. Create the thermal loading for the model.

First, a load set must first be created before creating the appropriate model loading.

Model/Load/Set...

Title: **thermal**

OK

Next, apply a uniform default temperature to the model.

Model/Load/Body...

(next to Thermal options) ☒ **Active**

Default Temperature: **20**

OK

Change the view to make applying the loads easier.

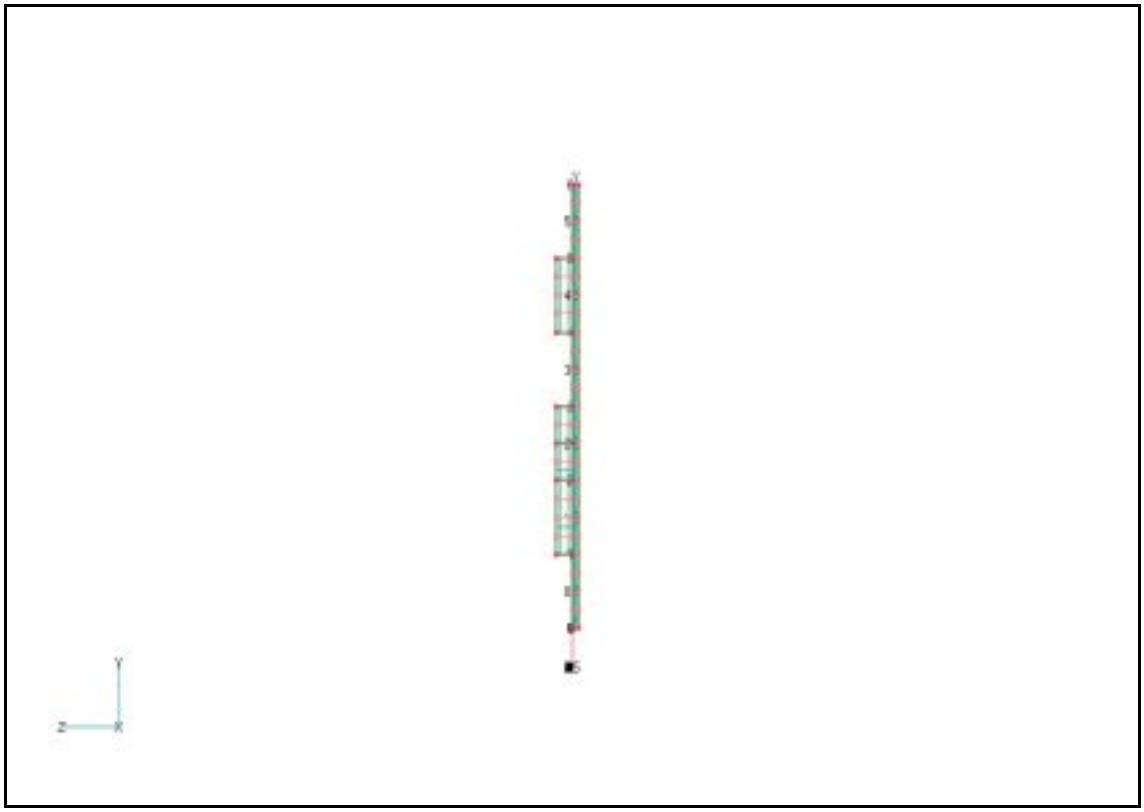
View/Rotate... **<F8>**

YZ Right

OK

Your model should be like the following figure:

Figure 6.3: The model set with default temperature.



Apply a heat flux to the chips in the model.

Model/Load/Elemental...

Hold shift and drag a box around the left edges of all chip elements.

OK

Type: ● **Heat Flux**

Value: **5**

OK

Face: **2**

OK

Apply free convection to the back of the board in the model.

Hold shift and drag a box around the right edges of all board elements.

OK

Type: ● **Convection**

Coefficient: **.02**

Temperature: **20**

OK

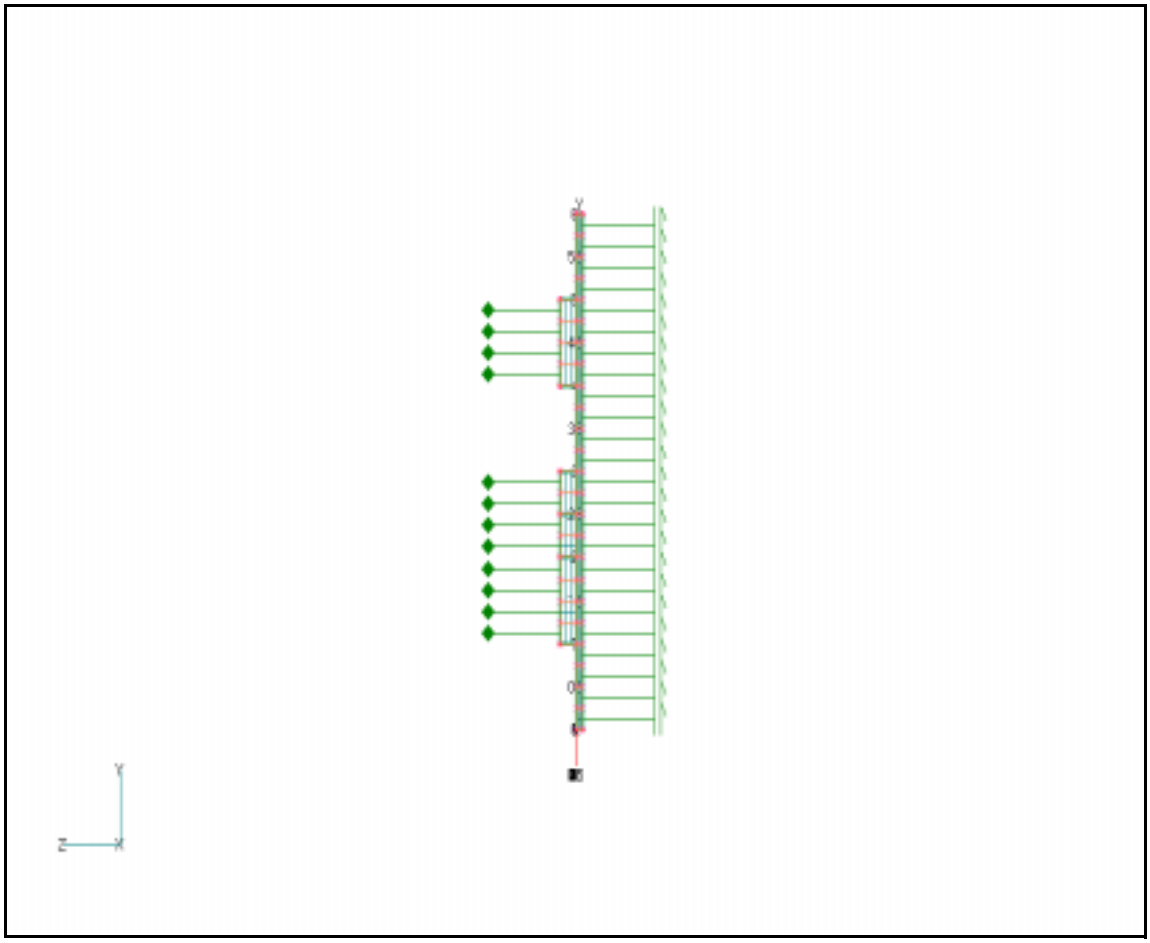
Face: **2**

OK

Cancel

Your loaded model should be like the following figure:

Figure 6.4: The loaded model.



9. Create the input file and run the analysis.

File/Analyze...

Analysis Type: **20..Steady-State Heat Transfer**

☒ **Run Analysis**

OK

When asked if you wish to save the model, respond **Yes**.

Yes

File Name: **pcb**

Save

When the MSC/NASTRAN manager is through running, MSC/NASTRAN will be restored on your screen, and the *Message Review* form will appear. To read the messages, you could select **Show Details**. Since the analysis ran smoothly, we will not bother with the details this time.

Continue

When asked if it is “OK to Begin Reading File C:\TEMP\pcb.xdb”, respond **Yes**.

Yes

10. Change the display to better view the results.

First, change the viewing angle.

View/Rotate... **<F8>**

Isometric

OK

Next, remove all geometry and thermal loading markers from the screen

View/Options... **<F6>**

Quick Options...

Geometry Off

☐ **Load - Heat Flux**

☐ **Load - Convection**

Done

OK

11. Create a final temperature distribution contour plot.

View/Select... **<F5>**

Model Style: ● **Quick Hidden Line**

Contour Style: ● **Contour**

Deformed and Contour Data...

Deformation: **31..Temperature**

Contour: **31..Temperature**

OK

OK

In Figure 6.5, notice the temperature gradients around the chips, where all the heat is produced.

When done, exit MSC/NASTRAN for Windows.

File/Exit

This concludes this exercise.

Figure 6.5: Free convection analysis on a printed circuit board