Final Take-Home Exam - ASEN 5007

For CAETE students:
return on or before Tu May 7, 2013, 6PM
No EO necessary

Submittal instructions on exam front page

Location: course homepage, scroll to bottom
-> Midterm and Final Exam material link

Very important: work independently !

No consultation with others is permitted

This Year's Problem: Heat Conduction

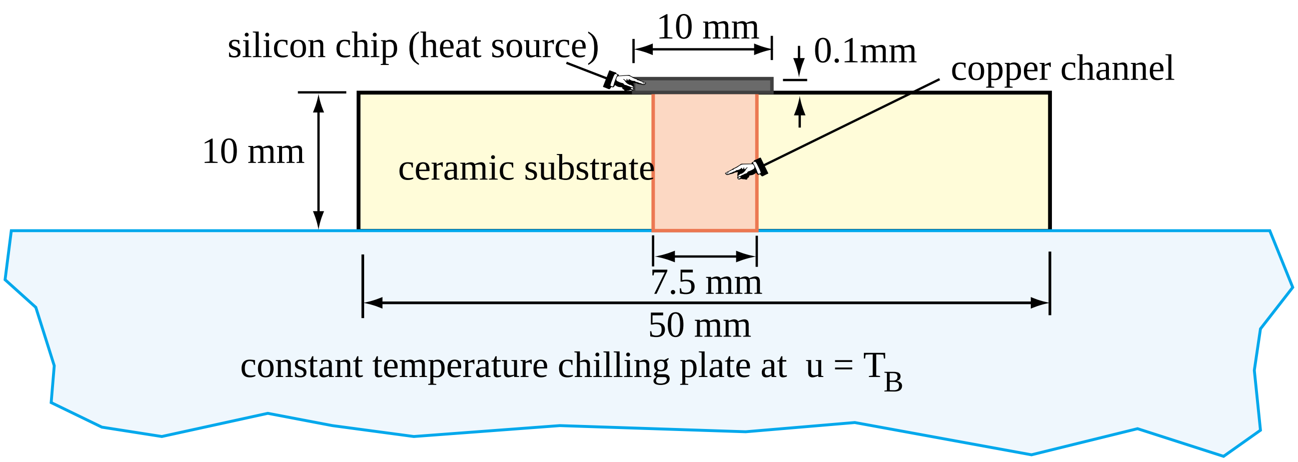
Question 1: Short questions

Question 2-4: FEM Equation Derivation

Question 5: Application Problem with numerical data

Programming required: Question 5.
Use of a CAS might be useful for Questions 2-4 to save time - see Hints there

Question 5: Application Problem

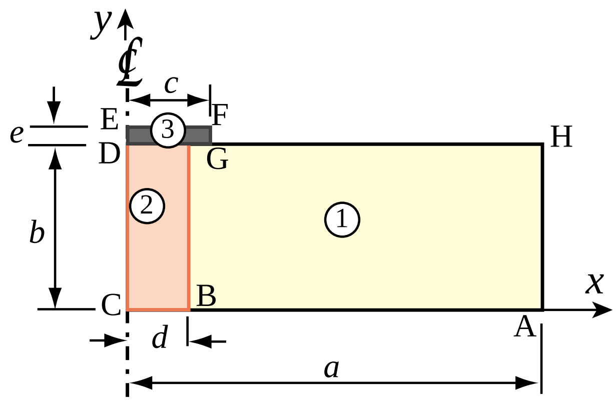


Question 5: Computational Domain

Components:

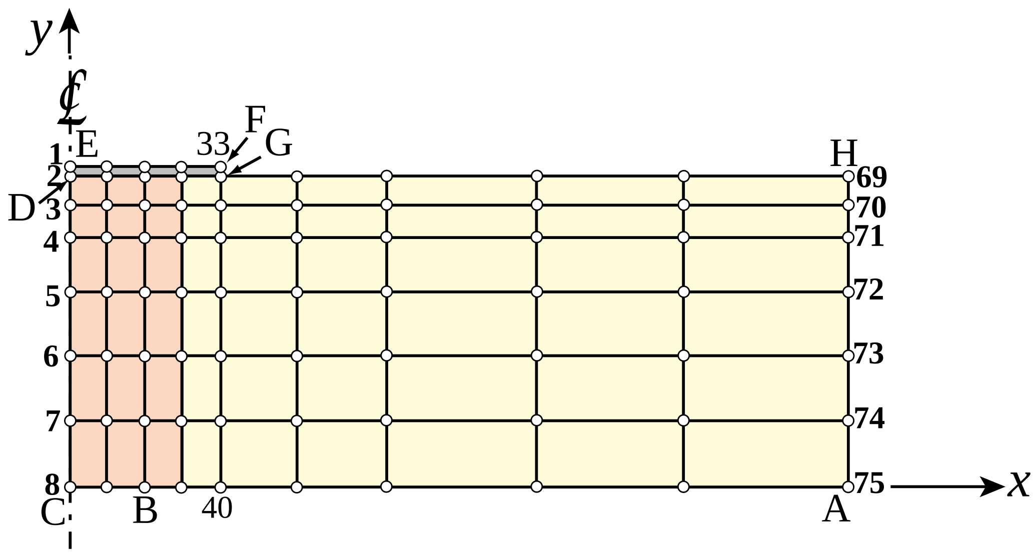
1. AlO_2 ceramic matrix
2. copper channel
3. silicon chip

(Dimensions DE and FG not to scale in sketch)

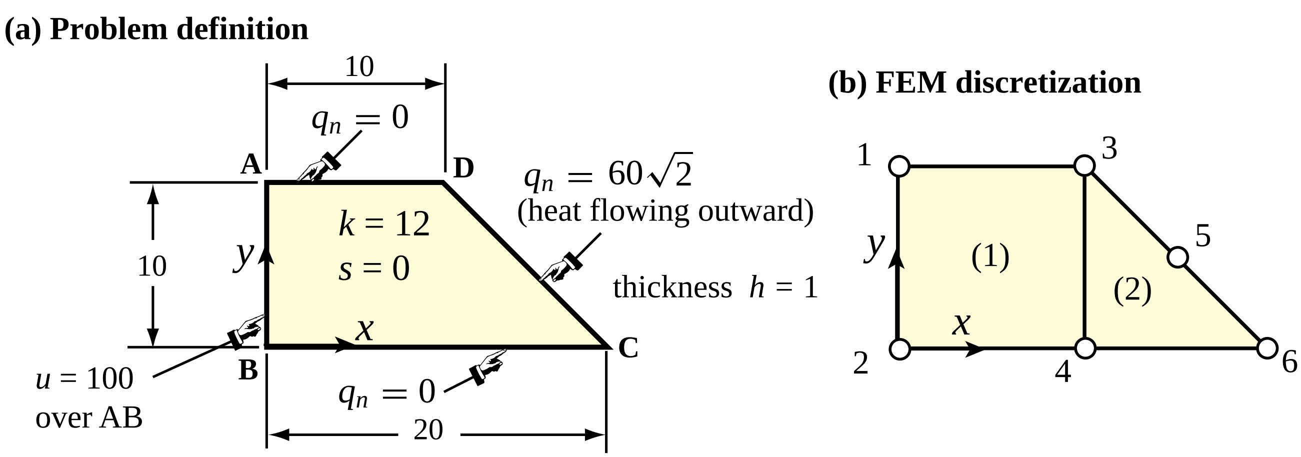


a = 25 mm
b = 10 mm
c = 5 mm
d = 3.75 mm
e = 0.1 mm

Question 5: Recommended Mesh (like this one, or finer)



Addendum B: Describes Demo Problem Posted in Notebook Cell 12B



Demo Problem in Notebook: Driver Script

```
(*  Define FE model *)

NodeCoordinates= N[{{0,10},{0,0},{10,10},{10,0},{15,5},{20,0}}];
ElemNodes={{1,2,4,3},{3,4,6,5}};
PrintPoissonNodeCoordinates[NodeCoordinates,
      "Node Coordinate Data",{8,4}];
numele=Length[ElemNodes]; numnod=Length[NodeCoordinates];
ElemTypes=Table["Quad4",{numele}];
ElemMaterial=Table[12,{numele}]; ElemFabrication=Table[1,{numele}];
ElemForces=Table[{0,{0,0,0,0}},{numele}];
ElemForces[[2]]={0,{0,0,N[60*Sqrt[2]],N[60*Sqrt[2]]}};
PrintPoissonElementNodesMatFab[ElemNodes,ElemMaterial,
       ElemFabrication,"Element Data",{9,4}];
PrintPoissonElementForces[ElemNodes,ElemForces,
      "Element Forces",{6,3}];
FreedomValues=FreedomTags=Table[0,{numnod}];
FreedomValues[[1]]=FreedomValues[[2]]=100; (* T @ 1,2*)
FreedomTags[[1]]=FreedomTags[[2]]=1; (* prescribed T *)
PrintPoissonFreedomActivity[FreedomTags,FreedomValues,
       "DOF Activity Data",{6,3}];
elepar={9,1.5,1,12,{0.15,1,1}};
nodpar={3.5,1.5,-8,5,12,{0.7,0.2,0.9}}; typspec={};
Plot2DMesh[NodeCoordinates,ElemTypes,ElemNodes,{},typspec,
  nodpar,elepar,{False,True,True,True,True},Automatic,
  "Plot of FEM Mesh"];
ProcessOptions={True};

(*  Solve problem and print results *)

{u,f}=LinearSolutionOfPoissonModel[NodeCoordinates,
      ElemTypes,ElemNodes,ElemMaterial,ElemFabrication,
      ElemForces,FreedomTags,FreedomValues,ProcessOptions];
PrintPoissonNodeTempForces[u,f,"Computed Solution",{6,4}];

(* Contour plot temperature distribution: 2 plotters tested *)

umax=Max[Abs[u]]; Nsub=8;
ContourPlotNodeFuncOver2DMesh[NodeCoordinates,ElemNodes,
  u,umax,Nsub,1/2,"Computed Temp Dist: Polygon Plotter"];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates,
 ElemNodes,u,{-umax,umax,umax/10},{True,False,False,False,
 False,False},{},1/2,"Computed Temp Dist: Band Plotter"];
```

Demo Problem: Printed Output

Node Coordinate Data

node	x-coor	y-coor
1	0.0000	10.0000
2	0.0000	0.0000
3	10.0000	10.0000
4	10.0000	0.0000
5	15.0000	5.0000
6	20.0000	0.0000

Element Data

elem	nodelist	conductivity	thickness
1	{1, 2, 4, 3}	12.0000	1.0000
2	{3, 4, 6, 5}	12.0000	1.0000

Element Forces

elem	nodelist	source s	flux q12	flux q23	flux q34	flux q41
1	{1, 2, 4, 3}	0.000	0.000	0.000	0.000	0.000
2	{3, 4, 6, 5}	0.000	0.000	0.000	84.853	84.853

DOF Activity Data

node	DOF-tag	DOF-value
1	1	100.000
2	1	100.000
3	0	0.000
4	0	0.000
5	0	0.000
6	0	0.000

Computed Solution

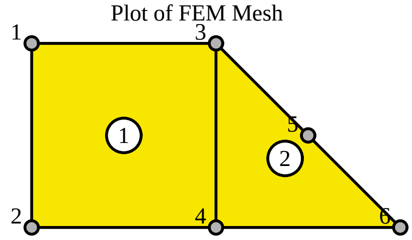
node	temperature	thermal-force
1	100.0000	600.0000
2	100.0000	600.0000
3	0.0000	-300.0000
4	0.0000	0.0000
5	-50.0000	-600.0000
6	-100.0000	-300.0000

Required in Exam

Demo Problem: Plot Output

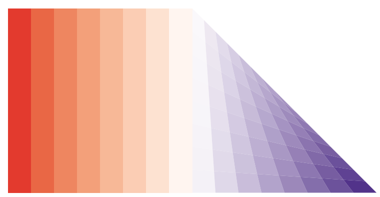
(a)

Plot of FEM Mesh



(b)

Comp Temp Dist: Polygon Plotter



(c)

Comp Temp Dist: Band Plotter