Task 5
Static deformation of a piezoceramic transducer with multi-electrode coating

Individual assignments

Write a program code in ANSYS APDL to compute a static deformation of a piezoelectric transducer with multi-electrode coating in a shape of a disk (axisymmetric problem) or a long cylinder with the cross section of the given shape (plane strain problem). Build a mapped finite element mesh. Analyze the convergence of results for various density of finite element mesh. Provide the resulting finite element mesh with element coordinate systems shown. Plot the computation results (deformed shape, distribution of displacements, electric field vector, electric induction vector, von Mises stresses, graph of characteristic component of the electric field vector along the path with surface electrodes). Analyze the results and prepare a report.

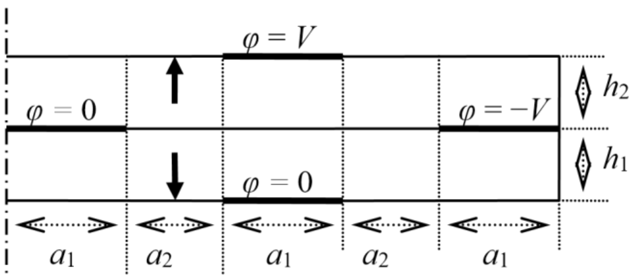
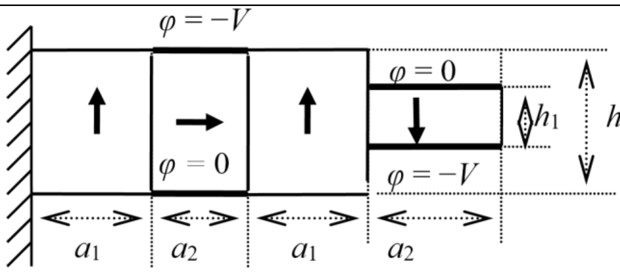
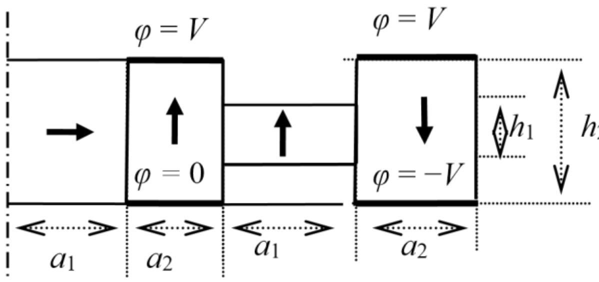
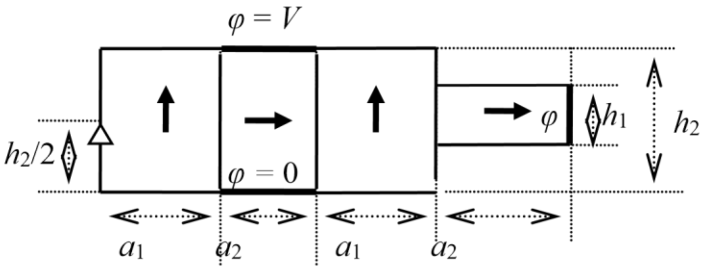
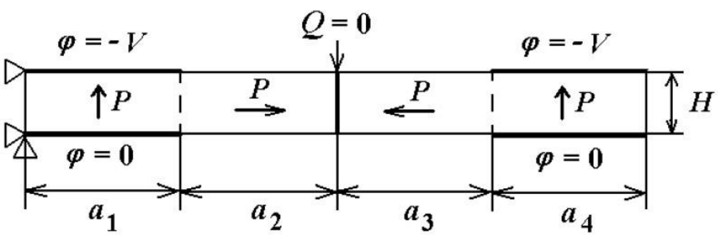
Requirements to the report.

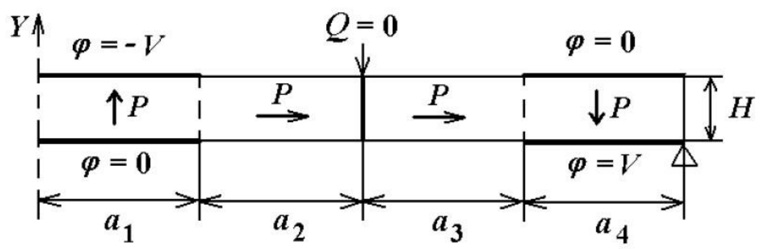
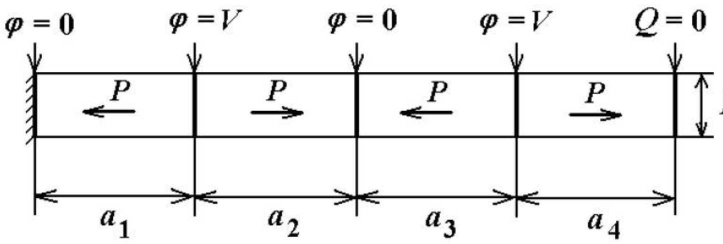
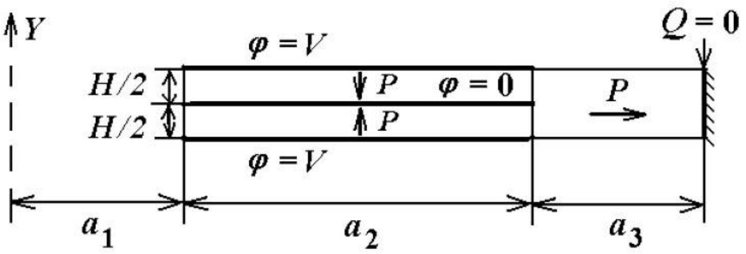
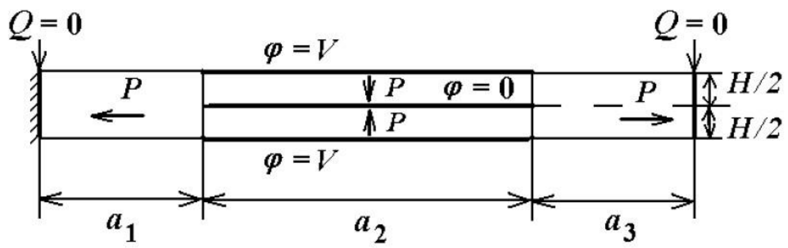
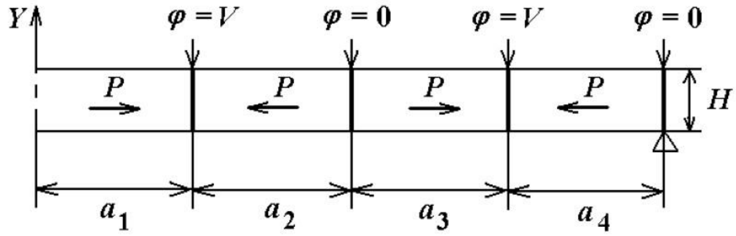
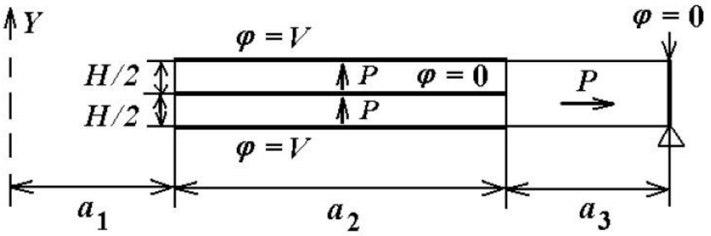
The report should contain the name of the student, the full description of the problem and the results obtained in ANSYS:

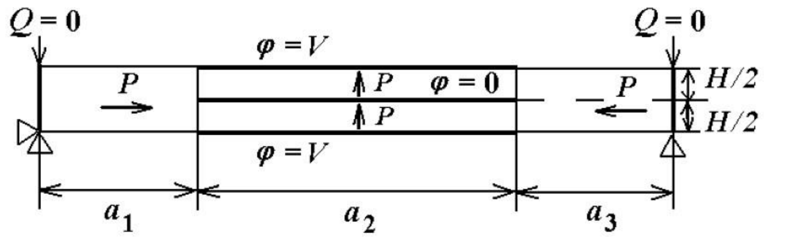
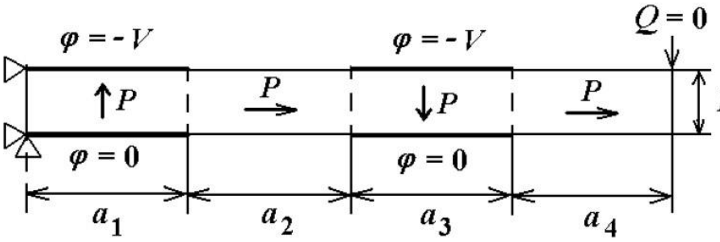
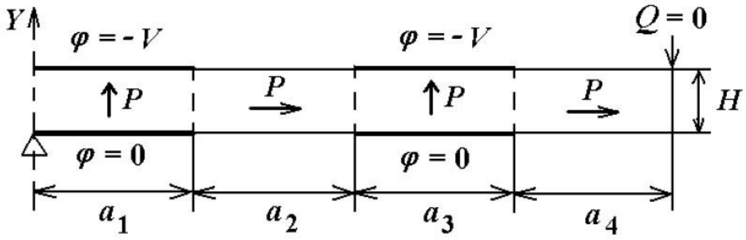
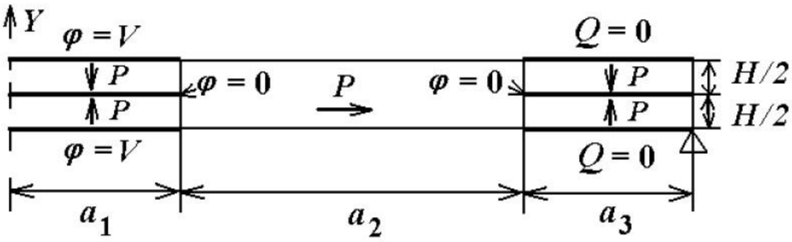
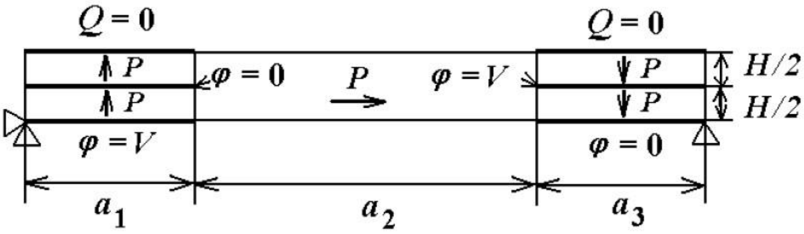
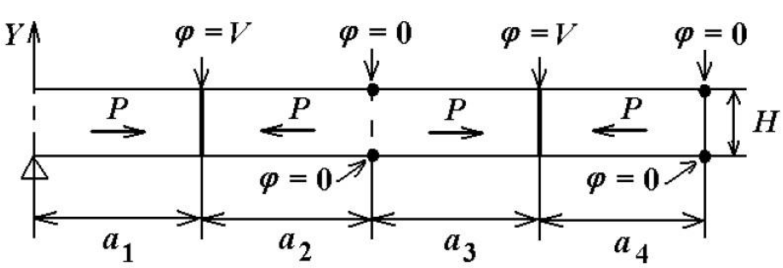
- Mapped finite element mesh with boundary conditions and the element systems for each finite element (check the direction of the polarization vector)
- Deformed shape of the disk
- Distribution of the displacements UX
- Distribution of the displacements UY
- Distribution of the displacement vector
- Distribution of the electric potential
- Distribution of the electric field vector
- Distribution of the electric induction vector
- Distribution of the stress intensity (von Mises stresses)
- Graph along the path on the surface electrodes for the characteristic component of the electric field vector

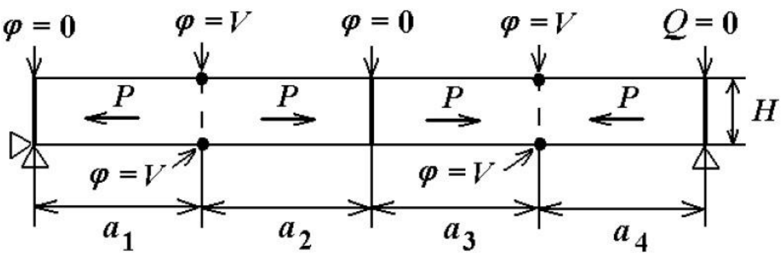
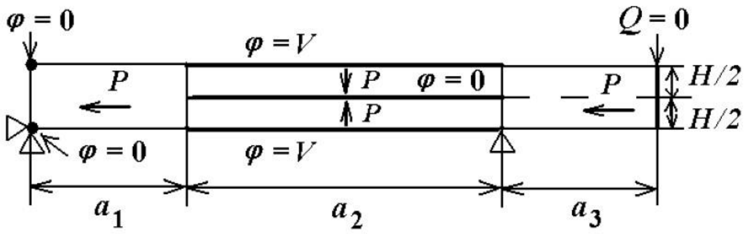
Table 1. **Suggestions for domain shape**

The variants of individual tasks are presented in the table. All sections of piezoelectric transducers are made of piezoceramics PZT-4, which material properties are provided in the above example problem (see program code). The electrodized surfaces are shown in thick lines or dots, the values of electric potential or total electric charge are provided nearby. The rigidly fixed boundaries are marked by external hatching, the triangles outside the boundaries denote the fixation conditions in the corresponding point of the 2D disk section (UX=0 or UY=0). The boundaries without any labels indicate homogeneous natural boundary conditions. For axisymmetric problems, the axis of rotation is shown on the left by a dashed line.

№	Scheme	Input data
1		Axisymmetric problem a_1 = 0.3 cm a_2 = 0.2 cm h_1 = 0.5 mm h_2 = 0.5 mm V = 10 V
2		Plain strain a_1 = 0.5 cm a_2 = 0.6 cm h_1 = 0.5 mm h_2 = 1 mm V = 10 V
3		Axisymmetric problem a_1 = 0.4 cm a_2 = 0.3 cm h_1 = 1 mm h_2 = 1.5 mm V = 5 V
4		Plain strain a_1 = 0.5 cm a_2 = 0.9 cm h_1 = 0.5 mm h_2 = 1 mm V = 10 V Find the value of the electric potential on the free electrode
5		Plain strain $a_1 = a_4$ = 0.8 cm $a_2 = a_3$ = 0.7 cm H = 3 mm V = 10 V

<table>
<tr><td>6</td><td>
</td><td>Axisymmetric problem
$a_1 = a_4 = 0.5$ cm
$a_2 = a_3 = 0.7$ cm
$H = 3$ mm
$V = 10$ V</td></tr>
<tr><td>7</td><td>
</td><td>Plain strain
$a_1 = a_4 = 0.7$ cm
$a_2 = a_3 = 0.6$ cm
$H = 2$ mm
$V = 5$ V</td></tr>
<tr><td>8</td><td>
</td><td>Axisymmetric
problem
$a_1 = a_3 = 2$ cm
$a_2 = 3$ cm
$H = 5$ mm
$V = 10$ V</td></tr>
<tr><td>9</td><td>
</td><td>Plain strain
$a_1 = a_3 = 3$ cm
$a_2 = 4$ cm
$H = 4$ mm
$V = 10$ V</td></tr>
<tr><td>10</td><td>
</td><td>Axisymmetric
problem
$a_1 = a_3 = 0.6$ cm
$a_2 = a_4 = 0.7$ cm
$H = 2$ mm
$V = 10$ V</td></tr>
<tr><td>11</td><td>
</td><td>Axisymmetric
problem
$a_1 = 1$ cm, $a_3 = 2$ cm
$a_2 = 3$ cm
$H = 5$ mm
$V = 5$ V</td></tr>
</table>

12		Plain strain $a_1 = a_3 = 3$ cm $a_2 = 4$ cm $H = 6$ mm $V = 10$ V
13		Plain strain $a_1 = a_3 = 0.7$ cm $a_2 = a_4 = 0.8$ cm $H = 3$ mm $V = 10$ V
14		Axisymmetric problem $a_1 = a_2 = 0.8$ cm $a_2 = a_4 = 0.6$ cm $H = 3$ mm $V = 7$ V
15		Axisymmetric problem $a_1 = a_3 = 1$ cm $a_2 = 2$ cm $H = 5$ mm $V = 5$ V
16		Plain strain $a_1 = a_3 = 2$ cm $a_2 = 4$ cm $H = 8$ mm $V = 10$ V
17		Axisymmetric problem $a_1 = a_3 = 0.9$ cm $a_2 = a_4 = 0.11$ cm $H = 3$ mm $V = 10$ V

18		Plain strain $a_1 = a_4$ = 0.11 cm $a_2 = a_3$ = 0.9 cm H = 2 mm V = 5 V
19		Plain strain $a_1 = a_3$ = 1.5 cm $a_2 = a_4$ = 3 cm H = 4 mm V = 5 V

Variant No.	Student name
1.	Губанов Александр Сергеевич
2.	Догаев Никита Сергеевич
3.	Завялкин Денис Витальевич
4.	Катасонов Никита Андреевич
5.	Кириллова Елена Владимировна
6.	Крабченко Руслан Андреевич
7.	Лушпанов Андрей Александрович
8.	Непряхин Даниил Олегович
9.	Петров Илья Сергеевич
10.	Половинкина Дарья Александровна
11.	Ражук Никита Викторович
12.	Ривкин Михаил Борисович
13.	Сенчукова Ангелина Александровна
14.	Степанова Ирина Александровна
15.	Федоров Юрий Владимирович
16.	Филоненко Никита Сергеевич
17.	Шагал Анастасия Михайловна
18.	Щукин Константин Вадимович
19.	Kamps Jeroen