You are expected to **attempt all exercises** before the seminar and to **actively participate** in the seminar itself.

1. Consider a graph G, and let $e \in E(G)$.

   (a) Show that $v_0 e_1 v_1 e_2 v_2 \ldots e_m v_m e v_0$ is a shortest cycle containing e in G if and only if $v_0 e_1 v_1 e_2 v_2 \ldots e_m$ is a shortest $v_0 - v_m$-path in the graph G' with $V(G') = V(G)$ and $E(G') = E(G) \setminus \{e\}$.

   (b) Give an algorithm for finding a shortest cycle in G that contains e.

   (c) Give an efficient algorithm for finding a shortest cycle in G. Show that the algorithm is indeed efficient.

2. Find the strongly connected components of the following digraph.
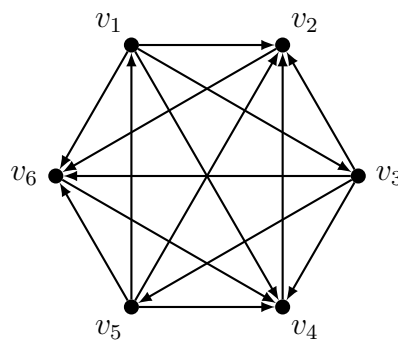
3. Consider the following spreadsheet, in which some cells contain a formula that depends on the values of other cells.

	a	b	c	d	e	f	g
1	e1+g5	a1−c5	110	a1+c1	180	f5−e1	c1+c2
2	a1+b1	a2+c4	240	a2+c2	120	f5−e2	e3+e5
3	a2+b2	a3−c3	100	a3+c1	200	f5−e3	f1+f2
4	a3+b3	a4+c2	220	a4+c2	100	f5−e4	f3+f4
5	a4+b4	a5−c1	130	a5+c5	120	g3+g4	g1+g2

   (a) Which of the values in columns c and e can be changed without changing the value of cell b2?

   (b) Is it possible to compute the values of all cells in the spreadsheet? Justify your answer.

   To answer these questions, you may want to consider the digraph D where $V(D)$ is the set of cells in the spreadsheet and $E(D)$ contains an arc from cell u to cell v if cell u contains a formula that depends on the value of cell v.