THEORY OF CONCURRENCY
EXAM
Friday January 27, 2006, 10.00 - 13.00

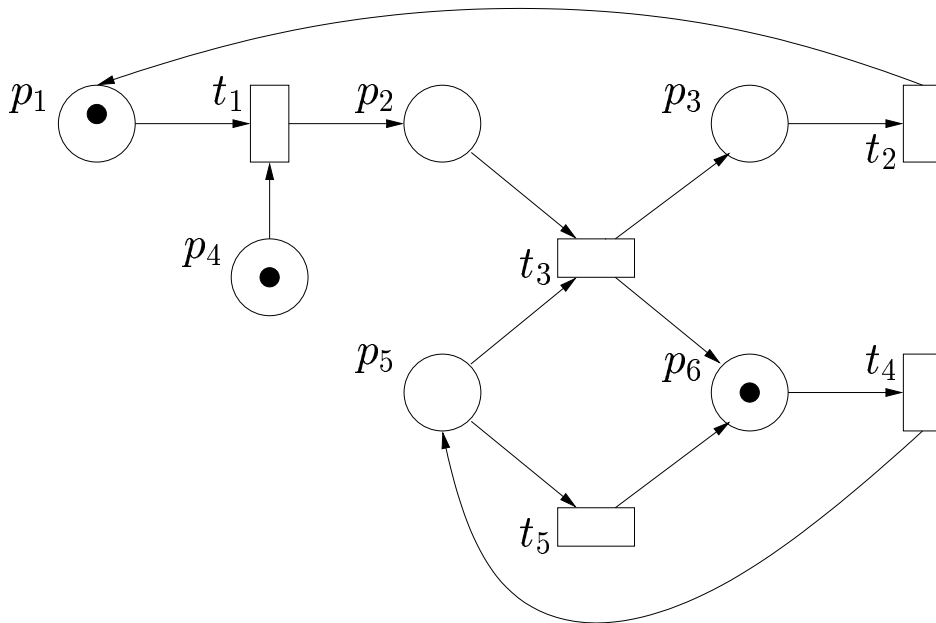This exam consists of 5 questions.
Answers may be given both in English and in het Nederlands.

Question 1   *20 pt*
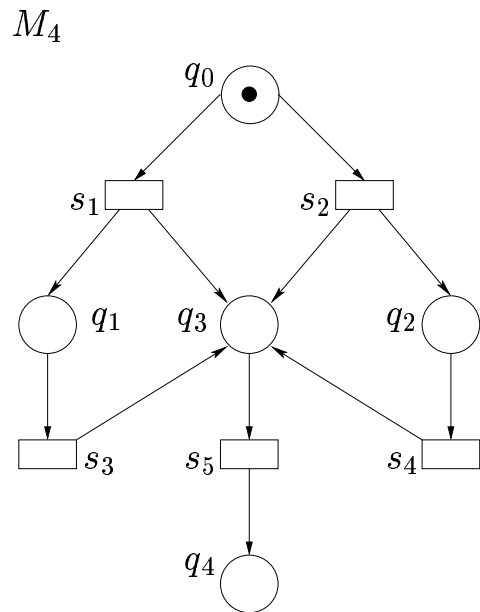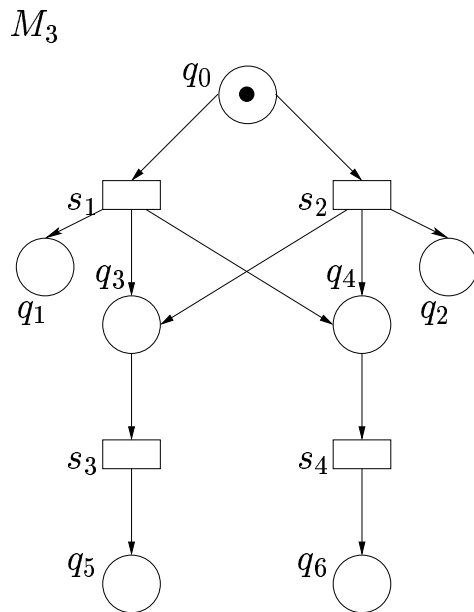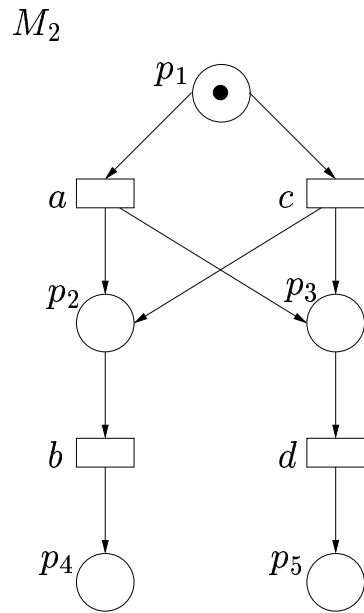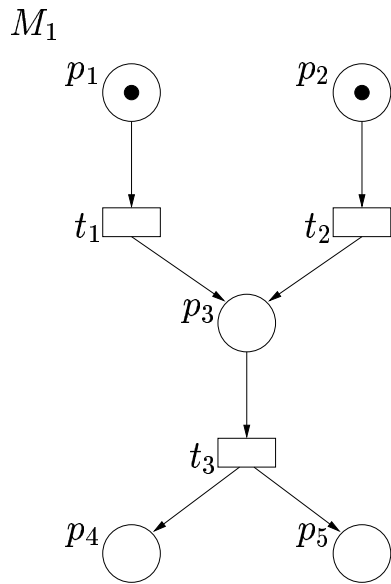Consider the following EN system $M = (P, T, F, C_{in})$:

(a) Give the sequential configuration graph $SCG(M)$ of M.

(b) When is a transition of an EN system live?
Which transitions of M are live and which not? Explain why.

(c) Give $C \in \mathbb{C}_M$ and all $U \subseteq T$ with $\#U \geq 2$ such that $U \operatorname{\mathbf{con}} C$.

(d) Determine all confusions of M and argue whether they are conflict-increasing,
conflict-decreasing, or neither; and symmetric or not.

Question 2   *18 pt*

(a) Let $M = (P, T, F, C_{in})$ and $M' = (P', T', F', C'_{in})$ be two EN systems.
Define when they are configuration equivalent ($M \approx M'$) and when they
are firing sequence equivalent ($M \approx_{fs} M'$).

(b) Give a short argument proving that configuration equivalence implies
firing sequence equivalence.

(c) Consider the EN systems M_1, M_2, M_3, and M_4 as given next.
Determine for each pair, M_i, M_j with $i \neq j$, whether or not they are
configuration equivalent or firing sequence equivalent.
Explain your answers.

M_1

p_1 p_2

t_1 t_2

p_3

t_3

p_4 p_5

M_2

p_1

a c

p_2 p_3

b d

p_4 p_5

M_3

q_0

s_1 s_2

q_1 q_3 q_4 q_2

s_3 s_4

q_5 q_6

M_4

q_0

s_1 s_2

q_1 q_3 q_2

s_3 s_5 s_4

q_4

Question 3   *27 pt*

Let M be the contact-free EN-system of Question 1.

(a) Draw a process $N = (P_N, T_N, F_N, \phi_1, \phi_2)$ such that, for every $t \in T$, there is at least one $s \in T_N$ with $\phi_2(s) = t$.

(b) Indicate clearly in the diagram of N from (a), all lines, three slices, and an additional cut.

(c) For the process N from (a), draw its contracted version $\mathbf{ctr}(N)$.

(d) Determine the independency relation $\mathbf{ind}(M)$ of M.

(e) Let $x = t_1 t_4 t_3 t_2 t_4 t_5$. Give the dependency graph $\mathbf{dep}_M(x)$ of x and its pruned version $\mathbf{pru}(\mathbf{dep}_M(x))$.

(f) Let $y = t_1 t_4 t_5 t_4 t_3 t_2$ and x as in (e).
Does y belong to the trace $[x]_{\mathbf{ind}(M)}$? Why (not)?

Question 4   *15 pt*

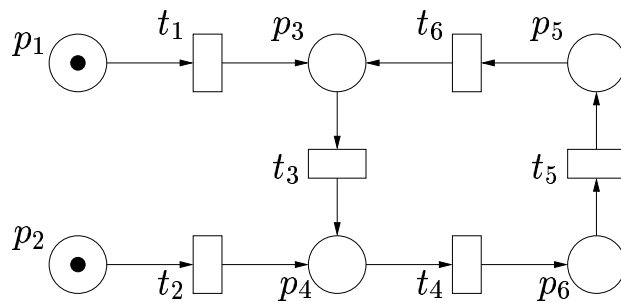Consider the P/T systeem $M = (P, T, F, W, C_{in})$ as drawn below.
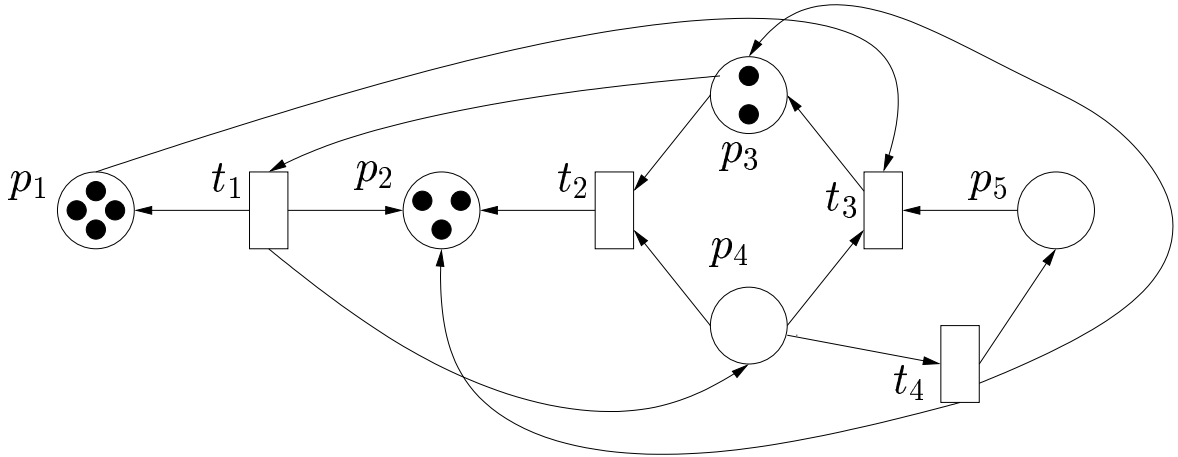
(a) Compute the configurations D_1 and D_2 of M such that $C_{in}[t_1 t_4\rangle D_1$ and $C_{in}[t_1 t_2\rangle D_2$.

(b) Demonstrate that M is not live.

(c) Prove that $SCG(M)$, the configuration graph of M, is infinite.

Question 5   *20 pt*

M is the P/T system as drawn below.

(a) When is a P/T system (P, T, F, W, C_{in}) a free choice system?
Verify that M is a free choice system.

(b) Give the matrix $\underline{M}$ and compute the p-invariants of M.

(c) Give all siphons, traps, and subsystems of M.

(d) Use the answers given at (b) and (c) to determine whether or not M is safe, live, bounded.

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the end