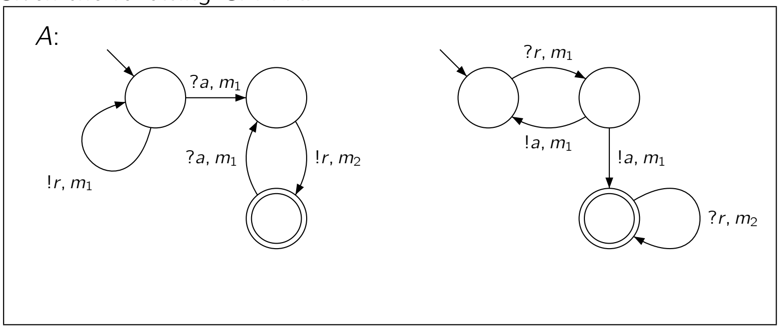
Exercise 1 (Safe Realizability): (6 Points)

Given the following CFM A:



Show that A is not safe by finding a configuration that is reachable from the initial configuration γ_0 of A and from which a final configuration γ_e cannot be obtained. Justify your answer by indicating the sequence of configurations leading from the initial configuration γ_0 to the deadlock configuration γ_d and arguing why a final configuration is not reachable from γ_d.

Exercise 2 (Deadlock freeness): (7 Points)

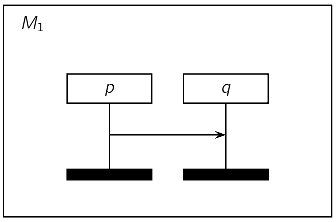
For well-formed language $L \subseteq Act^*$, and proper word $w \in Act^*$, i.e., w is a prefix of a well-formed word, let: $L \models^{df} w$ iff $(\forall p \in \mathcal{P}.\ \exists v \in L.\ w{\restriction}p$ is a prefix of $v{\restriction}p)$. Language L is closed under $\models^{df}$ iff $L \models^{df} w$ implies $w \in Pref(L)$.

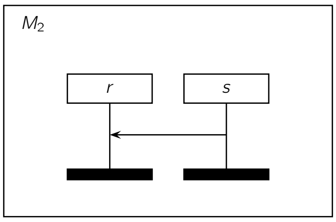
A language $L \subseteq Act^*$ is closed under $\vdash^{df}$ iff for all $v, w \in Pref(L)$ and all processes $p \in \mathcal{P}$: $\big(v{\restriction}p = w{\restriction}p$ and $vx \in Pref(L)$ for $x \in Act_p$ and wx is prefix of a well-formed word$\big)$ implies $wx \in Pref(L)$.

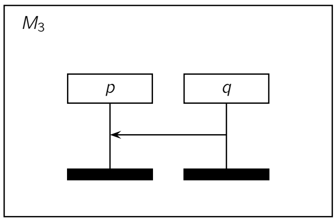
Prove the following statement: *A language L is closed under $\models^{df}$ iff L is closed under $\vdash^{df}$.*

Exercise 3 (Safe Realizability): (6 Points)

Check (i.e., by using the definitions) whether language L_i ($i \in \{1, 2\}$) is closed under $\models$ and $\models^{df}$:

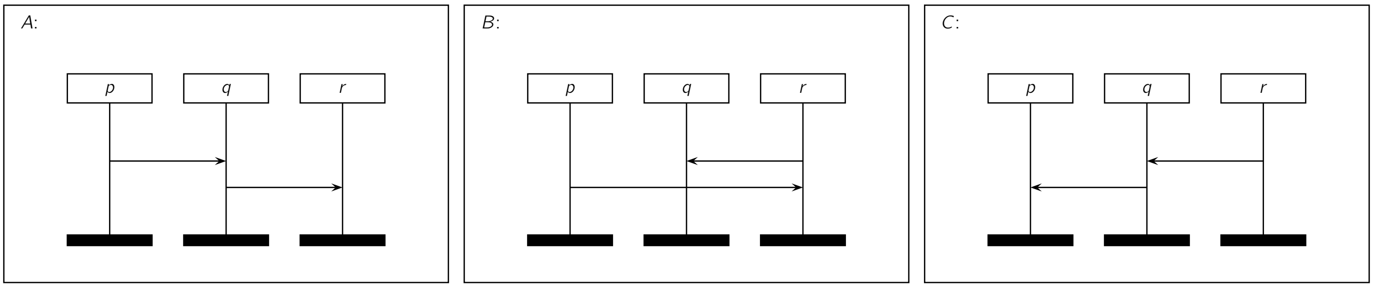






$L_1 = \{w \mid w \in Lin(\{M_1, M_2\})\}$ and $L_2 = \{w \mid w \in Lin(\{M_1, M_3\})\}$
Which of the languages is realizable or even safely realizable? Justify your answers.
(Note that $Lin(\{M, M'\}) = Lin(M{\cdot}M') \cup Lin(M'{\cdot}M)$.)

Exercise 4 (Regular Expressions and Realizability): (6 Points)



Check whether the following regular expressions are realisable or not:

- $\alpha_1 = A^* + B^* + C^*$,
- $\alpha_2 = A \cdot (B + C)^*$,
- $\alpha_3 = (A \cdot B \cdot C)^*$,
- $\alpha_4 = (A \cdot B)^*$,
- $\alpha_5 = (A \cdot C)^*$,

and if so, whether they can be realized by a universally bounded, deadlock-free CFM?