The answers must be the original work of the author. While discussion with others is permitted and encouraged, the final work should be done individually. You are not allowed to work in groups. You are allowed to build on the material supplied in the class. Any other source must be specified clearly.

**1.** *(10 points)*
The following DFA accepts the strings in which the number of "$a$"s modulo 3 is 0. The machine "resets" when it sees the "$r$" symbol. Give a 5-tuple that formally describes the DFA.
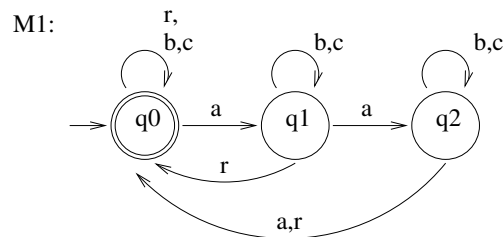


**2.** *(90 points, 5+10 points each)*
For each of the following languages:
(i) Construct a regular expression that describes the language. and
(ii) Build a DFA that accepts the described language. Explain how the machine works. No points will be given to machines without accompanying "comments".

**(a)** The empty set (over $\{a, b\}$).

**(b)** The empty string (over $\{a, b\}$).

**(c)** $\{w \mid w \in \{a, b\}^*$ and the length of $w$ is at least 5 $\}$

**(d)** $\{w \mid w \in \{a, b\}^*$ and $w$ ends with $a\}$

**(e)** $\{w \mid w \in \{a, b\}^*$, $w$ starts and ends with the same symbol, and $w \neq \lambda\}$

**(f)** The set of strings over $\{a, b\}$ that end with '$b$' and do not contain the substring '$aa$'.