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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 class. Any other source must be specified clearly.

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**1. (10 points)** Let  $L$  over  $\Sigma = \{1, 2, 3, a, b, c, -\}$  be the language of names where every name has to begin with a letter ( $a, b,$  or  $c$ ). The dash character ( $-$ ) always has to be followed by another non-dash character.

- (a) Give a recursive definition for  $L$ .
- (b) Give a regular expression for  $L$ .

**2. (75 points)** Give a regular expression for the following languages.

- (a) The set of strings over  $\{1, 2, 3, a, b, c\}$  that start and end with a number. Strings can have a length of 1 or greater.
- (b) The set of strings over  $\{1, 2, 3, a, b, c\}$  that contain exactly two numbers and the sum of the numbers is even.
- (c) The set of strings over  $\{a, b, c\}$  in which all the  $a$ 's precede the  $b$ 's, which in turn precede the  $c$ 's. It is possible that there are no  $a$ 's, or  $b$ 's, or  $c$ 's and the string is empty.
- (d) The set of strings over  $\{a, b, c\}$  in which all the  $a$ 's precede the  $b$ 's, which in turn precede the  $c$ 's. It is possible that there are no  $a$ 's, or  $b$ 's, or  $c$ 's, but  $\lambda$  is not in the language.
- (e) The set of strings over  $\{1, 2, 3, a\}$  that do not begin with 123.

**3. (15 points)** The following DFA  $M1$  accepts all strings that end in 'ab'. Give a 5-tuple that formally describes the DFA.

