VU Programm- und Systemverifikation
Assignment 2: Equivalence Partitioning and Boundary Value Testing

Name: ________________________________ Matr. number: ______________

Due: April 29, 4pm

Task 1: Equivalence Partitioning (5 points). A univariate polynomial equation of degree n is an equation of the form

$$\sum_{i=0}^{n} a_i \cdot x^i = 0 \qquad \text{or} \qquad a_n \cdot x^n + a_{n-1} \cdot x^{n-1} + \ldots + a_2 \cdot x^2 + a_1 \cdot x + a_0 = 0\,,$$

where $a_i \in \mathbb{R}$ (for $0 \leq i \leq n$) are numerical constants called *coefficients* and x is a *variable*. A polynomial equation is *zero* if all coefficients are zero, and *non-zero* otherwise. The solutions of this equation are the *roots* of the polynomial. A number a is a root if and only if the polynomial $(x - a)$ (where $a \in \mathbb{R}$) divides $\sum_{i=0}^{n} a_i \cdot x^i$. If $(x-a)^2$ divides $\sum_{i=0}^{n} a_i \cdot x^i$ then a is called a *multiple* root, otherwise a is a *simple* root. For non-zero polynomials, there is a highest power m such that $(x-a)^m$ divides $\sum_{i=0}^{n} a_i \cdot x^i$, which is called the *multiplicity* of the root a. If the polynomial is non-zero, the number of roots cannot exceed its degree (even counting the respective multiplicities). Note that there are polynomial equations which have no roots (e.g. $x^2 + 1 = 0$).

Let `unsigned roots (float` a_0`, ...)` be a function (which takes at least one parameter) that returns the number of roots of the non-zero polynomial determined by the coefficients given as a parameter. Multiplicities are counted accordingly, i.e., for the polynomial equation $x^3 + 2 \cdot x^2 - 7 \cdot x + 4 = 0$ which can be written as $(x + 4) \cdot (x - 1)^2$ and has the roots -4 and 1 with multiplicity 1 and 2, respectively, the output should be 3.

Provide *at least 5* equivalence classes derived using equivalence partitioning.

Condition	**Valid**	**ID**	**Invalid**	**ID**
non-zero polynomial	non-zero ($n+1$ coeff.):	(1)	zero	(2)
	no roots (e.g. x^2+1)	(3)		
	$k \leq n$ roots:			
	multiplicity $= 1$	(4)		
	multiplicity > 1	(5)		
	real roots exist	(6)		

Task 2: Boundary Value Testing (10 points). Use *Boundary Value Testing* to derive a test-suite for the method `roots`. For each test case, provide a brief explanation (why is this a boundary case?) and indicate which equivalence class(es) it covers. You can receive up to 1 point per test case.

Input	**Output**	**Classes Covered**
(0)	error	(2)
(0,0,0,0)	error	(2)
(1) *($1 = 0$, no roots, n=0)*	0	(1),(3)
(1,0,1) *($x^2 + 1 = 0$, no roots, n=1)*	0	(1),(3)
(-1,1) *($x - 1 = 0$, $n = 1, k = 1$)*	1	(1),(4)
(-1,0,1) *($x^2 - 1 = 0$, $n = k = 2$, simple)*	2	(1),(4)
(0,1,0,1) *($x^3 + x = 0$, $n = 3, k = 1$, simple)*	1	(1),(4)
(1,-2,1) *($(x - 1)^2 = 0$, $k = 2$, multipl.$= 2$)*	2	(1),(5)
(4,-7,2,1) *(see text)*	3	(1),(5)
(1,1,0,1) *($x^3 + x + 1 = 0$, $x = 0.68$)*	1	(4,6)

Please hand in your assignment via TUWEL (as a single PDF file) by April 29, 2015, 4pm.