Performance Engineering Tutorial
Design of Experiments

Exercise 1. We wish to investigate the effect of a GCC compiler optimization flag on the execution time (E) of a code that calculates digits of π. We use a 2^k factorial design without replication and with $k = 2$ factors. The first factor is the GCC optimization flag[1] (F), with ON/OFF levels, and the second factor is the number of digits D that we require the generator to compute, with levels 10000 or 20000. We have collected following measurements:

$E\ [s]$	$F = OFF$	$F = ON$
$D = 10000$	1.1	1.5
$D = 20000$	5.9	4.3

Question 1.1 Give the sign table for the design and quantify the effects q_0, q_F, q_D, q_{FD}.
Question 1.2 Quantify the percentages of variation explained by the factors and their interaction.

Exercise 2. Consider a 2^3 full factorial design where the factors can take the following levels:

Factor	Low level	High level
Number of users (A)	300	500
Number of cores (B)	20	30
Available memory (C)	6GB	8GB

Question 2.1 List all possible experiments for this design.
Question 2.2 Generate a sign table for this design.
Question 2.3 Suppose now that we wish to add to the experiment other four factors: L1 Cache size (D), L2 Cache size (E), Processor speed (F), Utilization level (G). If we want to use a 2^{7-4} fractional factorial design, how should we revise the sign table?
Question 2.4 What are the confoundings for A, B and C in the 2^{7-4} design?

Exercise 3 (Requires calculator). Consider three factors A, B, C with 2 levels each. Analyze the 2^3 design shown in the following table:

	A_1		A_2	
	C_1	C_2	C_1	C_2
B_1	100	15	120	10
B_2	40	30	20	50

For example, the measured value 15 corresponds to the experiment where $A = A_1$, $B = B_1$, and $C = C_2$.

Question 3.1 Quantify the effects and all interactions.
Question 3.2 Quantify percentages of variation explained. Then sort the factors in order of decreasing importance.

[1] The values shown in this exercise are actual numbers. The optimization flag is *-O2* with gcc 4.6.3.