Intensive Computation

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Part A

Exercise 1 (5 points)	
Exercise 2 (6 points)	
Exercise 3 (4 points)	
Exercise 4 (7 points)	
Exercise 5 (4 points)	
Exercise 6 (6 points)	
Total (32 points)	

Student's Name

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***Matricola* number**

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Exercise 1 (5 points) - GPU & CUDA

Technical specifications	Compute capability (version)									
	1.0	**1.1**	**1.2**	**1.3**	**2.x**	**3.0**	**3.5**	**3.7**	**5.0**	**5.2**
Maximum dimensionality of grid of thread blocks	2				3					
Maximum x-dimension of a grid of thread blocks	65535					2^{31}-1				
Maximum y-, or z-dimension of a grid of thread blocks	65535									
Maximum dimensionality of thread block	3									
Maximum x- or y-dimension of a block	512				1024					
Maximum z-dimension of a block	64									
Maximum number of threads per block	512				1024					
Warp size	32									
Maximum number of resident blocks per multiprocessor	8					16			32	
Maximum number of resident warps per multiprocessor	24		32		48	64				
Maximum number of resident threads per multiprocessor	768		1024		1536	2048				
Technical specifications	**1.0**	**1.1**	**1.2**	**1.3**	**2.x**	**3.0**	**3.5**	**3.7**	**5.0**	**5.2**
	Compute capability (version)									

Consider an image represented by a matrix of size 800x4400x24. You would like to assign one thread to each matrix element.

a) How would you select the **2D grid** dimensions and **3D block** dimensions of your kernel to **minimize the number of idle threads** on a device having compute capability 3.7?

b) And on a device having compute capability 1.3?

Exercise 2 (6 points) - Number representation

- Represent the natural number range [0; 799] using the residue number system, considering:
    - Two different moduli sets consisting of 3 moduli at your choice, S1 and S2.
- Give an estimation of the representational efficiency in both cases, considering the single digit representation and the binary representation of the whole range.
- Represent X= 18 and Y=31 in **both residue systems** S1 and S2.
- Represent sum S=X+Y and the product P=XxY using **both residue systems** S1 and S2.
- Give the **mixed radix representation** associated to P represented using S1 or S2 of your choice.

Exercise 3 (4 points) – Number representation

Consider the radix-8 digit set [-5, 5] and consider to use three digits.

a) How many values can you represent?
b) What is the redundancy?
c) What is the redundancy index?

Exercise 4 (7 points) Performance equation

Suppose we have made the following measurements, where we are considering Arithmetic and Logic instructions AL, the **subset** of AL of only Arithmetic instructions ARIT and the **subset** of AL of only Logic instructions LOG:
Frequency of AL operations = 45%
Average CPI of other instructions = 5.2
Frequency of ARIT = 20% (on the total)
CPI of ARIT = 5.6
CPI of LOG = 3.5

Assume that the design alternatives are to decrease the average CPI of LOG operations to 1.5 or to decrease the average CPI of ARIT operations to 4.5 or to decrease the CPI of all Arithmetic and Logic instructions AL to 3.7.
Compare the design alternatives using the **processor performance equation** and show which alternative is more cost-effective computing the respective speedup.

Exercise 5 (4 points)

a) The analysis of a program has shown a speedup of 9.3 when running on 16 cores. What is the serial fraction according to Gustafson's law? And according to Amdahl's law?

b) Considering the serial fraction obtained in point a), compute the speedup when using 4 cores according to Gustafson's law and to Amdahl's law.

Exercise 6 (6 points)

a) Describe the pipelined multiplier for signed numbers and show how to use it to execute the product between A= -5 and B= 3.

b) Compute the **time** (propagation delay) to obtain the result and the **area** required by the whole circuit.