1. Which is more important in embedded systems: Throughput or latency?

   Latency is the time taken for a task to complete execution. On the other hand, throughput is the number of tasks completed per unit time. Thus, both parameters define the speed and performance of the embedded system. As embedded system requires a low power consumption, the throughput of the system cannot be greatly increased. Also, if we try to increase the throughput the latency will also increase and vice versa. Thus, in embedded systems, latency is more important than throughput to control the power consumption of the system.

2. What are Important characteristics of:

   a. A software design methodology for embedded computing systems?

   b. A hardware design methodology?

   c. A complete hardware/software methodology?

   a. Software Design Methodology

   Software design methodologies include support for all the communication protocols that the embedded system can support, the size of the program should be as small as possible to compensate the low storage space of an embedded system and proper implementation and used of memory systems and caches in the system.

   b. Hardware Design Methodology

   Hardware Design Methodologies include low power consumption, dimensions of the embedded systems and the communication interfaces that need to be implemented in the system. As embedded systems have low power storage available, the clock rate and other interconnections need to be designed in order to increase make most use of this available power.

   c. Hardware/Software Methodology

   Hardware/Software Methodologies include system security, non-recurring cost and product cost, performance of the embedded system and flexibility of the system. All these factors depend on both the hardware and software design of the system.

3. Plot computation versus communication energy in a wireless network. State your assumptions.

   a. Determine the computation and communication required for a node to receive two 16-bit integers and multiply them together.

   b. Plan total system energy as a function of computation versus communication energy.

   a. To receive two 16-bit numbers we will require to transfer 32 bits of data and the total amount of communication energy required will be **32 * x joules.**

      Where x = energy required for a single bit to transfer.

      To multiply two 16-bit integers we will require 16^2 steps i.e. 256 steps.

      Therefore, the total computation energy required will be **256 * y joules.**

      Where y = energy required for a single operation.

      Considering x and y are almost equal we can say that the energy required for computation is much more than that required for transfer.

   b. The total system energy will be **32x + 256y joules.**

4. What are the basic characteristics of a digital signal processor?

   The basic characteristics of DSP include:

   - Fast multiply-accumulate units

   - Multiple access memory architectures

   - High speed arithmetic

   - Real time data transfer from outside world

5. Draw a chart comparing the characteristics of several types of processors (RISC, DSP, VLIW, GPU) with regard to several application characteristics. (flexibility, energy, performance).

Processor Type	Flexibility	Energy	Performance
RISC	Used in general purpose embedded systems	Least	Low on performance
DSP	Used in image processing, voice recognition, etc.	Moderate	Better than RISC due to better computation capabilities
VLIW	Used in DSP and sometimes in RISC architectures	Lesser than most superscalar systems	Fastest for highly independent instructions
GPU	Used for graphics processing like gaming, display, etc.	Highest	Best performance due to superscalar architecture.

6. Identify possible instructions in matrix multiplication.

- Multiply instruction for multiplying two elements.
- Addition instruction to add all the products of a single row and column.
- Branch instruction for looping these operations
- Load/Store instruction for storing result

7. Compare and contrast performing a matrix multiplication using subword parallel instructions and vector instructions. How do the code fragments for the two approaches differ? How do these differences affect performance?

Subword parallel instructions will have to be packed into a word if operands do not fall in proper order. Subword instruction set may sometimes offer packing operations. As these instructions work on shorter operand sizes, they are less accurate.

The vector instruction set operates on larger set of inputs and also on longer operand sizes. On the other hand, vector instructions require specialized registers and will also require longer time to fill and empty instructions from the pipeline.

8. Identify, the longest execution path through the given code.

The longest path for the given code will be if all the 'for' loops get executed i.e. all 4 nested 'for' loops and also the 'if' condition is satisfied which contains more 3 instructions.