Problem 1

(1) Personal computer - Macbook
Personal mobile device - iPhone
Embedded computer - Navigation system within car
Server computer - Video game multiplayer servers
Supercomputer - IBM Roadrunner supercomputer
Warehouse computer (Cloud computing) - Amazon Web Services (EC2 & S3)

(2)
- Personal computer: This device must be able to handle a multitude of tasks at the same time and be relatively silent and therefore energy efficient as they will be connected to the home and the user at all times.
- Personal mobile device: This device must be portable and be able to withstand impacts and motion without damage to the internal processors and battery.
- Embedded computer: This computer must be able store a vast amount of information as it will be working offline most of the time and therefore needs to have the data it needs to function on hand at all times.
- Server computer: Servers are usually very big and are required to be able to handle a lot of traffic as people are logging in and out constantly. The processors have to be fast and the energy constraint is not much of a problem.
- Supercomputer: These computers are used for massive tasks such as scientific simulations and large computations therefore, they require immense processing power as well as a large amount of storage space due to their large collection of data.
- Warehouse computer: These computers need to be encrypted as they handle a large amount of sensitive information and this also requires a large amount of storage space for that data.

(3) One computer that is not listed above in any of the categories but would be fitting, is the calculator. This would be an example of a mobile computer since it provides one function and for the most part, they are portable. The calculator, or even a simple adding machine, was one of the first computers to exist for the sole purpose of dealing with numbers. For this reason, it would be an ideal example of a mobile computer.

Problem 2

(1) The five components of computer architecture are, input, output, memory, datapath, and control. These five components come together to form every computer. Every computer contains parts from each of these five categories and this allows for it to function properly. The input serves the basic function of supplying the computer with information such as the task which needs to be done as well as any other givens. The datapath and control form the processor which actually completes the task, with the help of the memory. The memory's function is to supply the processor with the needed data and instructions in order to complete the task. Finally comes the output which is the result of the processor's computation.

(2) A smartphone is an example of a computer, which implies that its parts will fall into each of the five categories. The input and output can be said to be the touchscreen display of the phone as this is what the user interacts with and through which gives the computer its tasks. The 4 gigabytes of memory and the processor can be found to be in Apple's A12 chip, this is where the memory, datapath, and control categories can be found.

(3) If we take personal computer for example, the parts that make that type of computer up are relatively the same however, differ in many ways. For a large scale PC, the inputs and outputs are no longer just a screen. Inputs are given by external peripherals such as a keyboard and a mouse, and the output is seen through an external monitor. The memory as well on these computers is not the same since on a PC, the sticks of RAM are not integrated directly on the processor rather, they are connected to the motherboard and are of larger size. Up to 64 gigabytes is valid compared to the lowly 4 on the smartphone. The processor, datapath and control, is also designed for much higher intensity work and has tens of cores whereas a smartphone may only have a few. Essentially, each of the parts performs the same function, but the integration of each of them is vastly different.

Problem 3

(1)

$$\text{CPU time} = \frac{\text{Instruction Count} \times \text{CPI}}{\text{Clock Rate}}$$

- Processor A:

$$\text{CPU Time} = \frac{(0.4)(1) + (0.2)(2) + (0.4)(6)}{1 \times 10^9} = 3.2 \times 10^{-9}\ s$$

- Processor B:

$$\text{CPU Time} = \frac{(0.4)(1.5) + (0.2)(3) + (0.4)(7)}{2 \times 10^9} = 2 \times 10^{-9}\ s$$

This shows that Processor B is faster than Processor A since it has a shorter CPU time. To determine how much faster, the CPU time of the first processor can be divided by the time of the second, $\frac{3.2\times10^{-9}}{2\times10^{-9}}$, which gives a value of 1.6 times faster.

(2)

$$\text{Amdahl's Law} = \frac{T_{\text{affected}}}{\text{Improvement Factor}} + T_{\text{unaffected}}$$

$$\text{Improvement Factor} = 2$$

$$T_{\text{affected}} = \frac{(0.2)(\text{Branch Instruction CPI})}{\text{CPU Clock Rate}}$$

$$T_{\text{unaffected}} = \frac{(0.4)(\text{ALU CPI}) + (0.4)(\text{Memory Load CPI})}{\text{CPU Clock Rate}}$$

- Processor A:

$$\text{CPU time} = \frac{1}{2} \times \frac{(0.2)(2)}{1 \times 10^9} + \frac{(0.4)(1) + (0.4)(6)}{1 \times 10^9} = 3 \times 10^{-9}\ s$$

$$\frac{(\text{CPU Time})_1}{(\text{CPU Time})_2} = \frac{3.2 \times 10^{-9}}{3 \times 10^{-9}} = 1.0667$$

- Processor B:

$$\text{CPU time} = \frac{1}{2} \times \frac{(0.2)(3)}{2 \times 10^9} + \frac{(0.4)(1.5) + (0.4)(7)}{2 \times 10^9} = 1.85 \times 10^{-9}\ s$$

$$\frac{(\text{CPU Time})_1}{(\text{CPU Time})_2} = \frac{2 \times 10^{-9}}{1.85 \times 10^{-9}} = 1.0811$$

From the calculations above, it can be seen that with the acceleration of the performance of the branch instructions, Processor A is about 1.067 times faster, and Processor B is about 1.08 times faster than the speed without the acceleration.

Problem 4

(1) Moore's Law states that integrated circuit resources will double every two years.

(2) The textbook likely removed the idea of "designing with Moore's Law in mind" due to the fact that it is not a foundational construct of computer architecture any longer. "No exponential growth can last forever," and this is true for Moore's Law as well since it can be seen to be slowing down as time progresses. Integrated circuits are not doubling in power and performance every two years and for this reason, it was likely taken out of the 2^{nd} edition of the book.

(3) The fact the Moore's Law is no longer valid, provides implications of stagnation within the advancement of computer processors and memory. Possible solutions may only come in the form of vastly different ways of making transistors and computer parts in general. As the end of the Law nears, the traditional transistor will likely have to be replaced by a new form of technology, such as quantum mechanical transistors. This would be the most extreme form of multiprocessing as quantum computers can evaluate far more tasks simultaneously than traditional computers with any amount of cores.