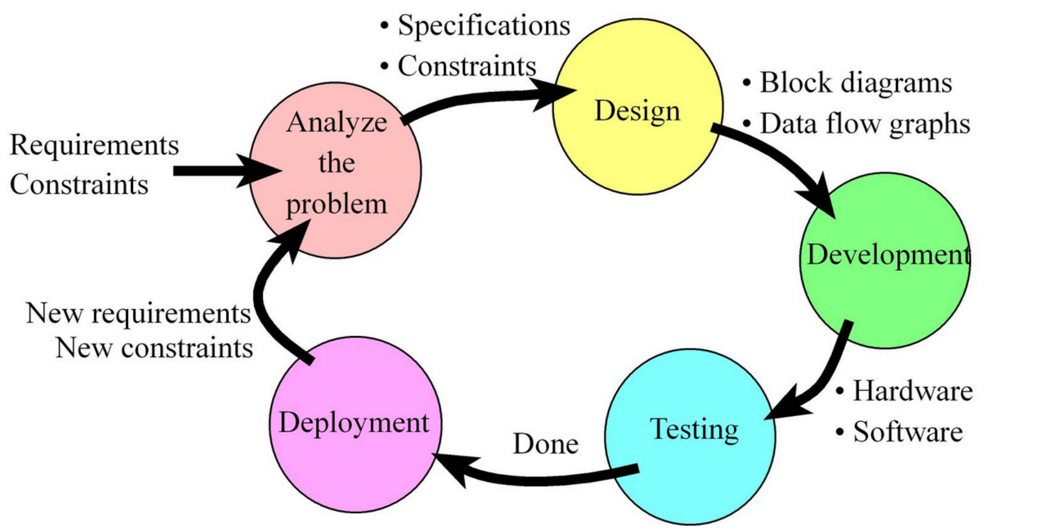
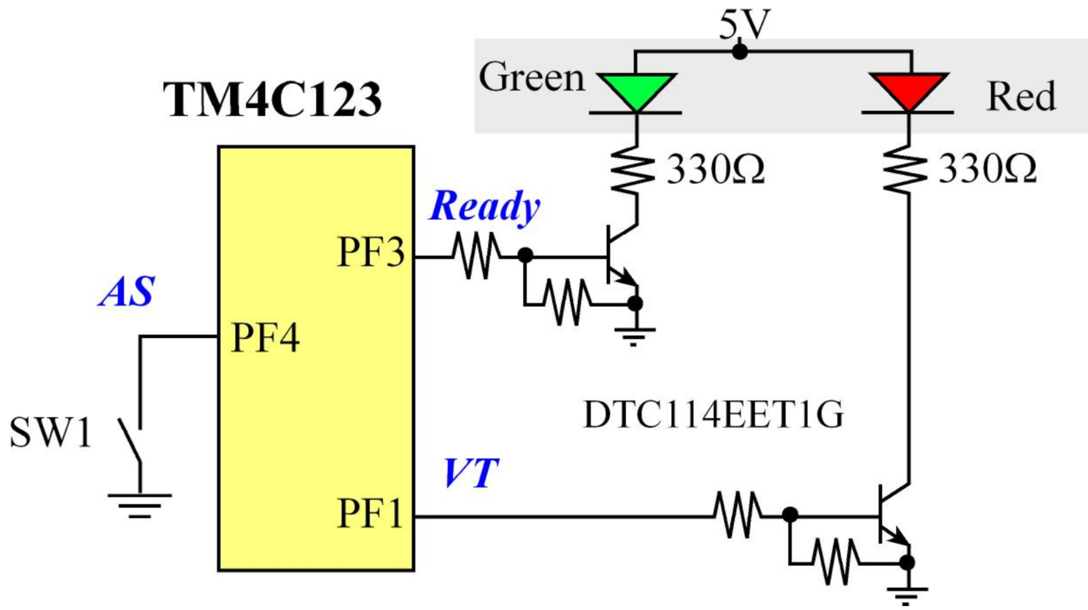
Life Cycle

In this section, we will introduce the product development process in general. The basic approach is introduced here, and the details of these concepts will be presented throughout the remaining chapters of the book. As we learn software/hardware development tools and techniques, we can place them into the framework presented in this section. As illustrated in Figure 7.1, the development of a product follows an analysis-design-implementation-testing-deployment cycle. For complex systems with long life-spans, we transverse multiple times around the life cycle. For simple systems, a one-time pass may suffice.

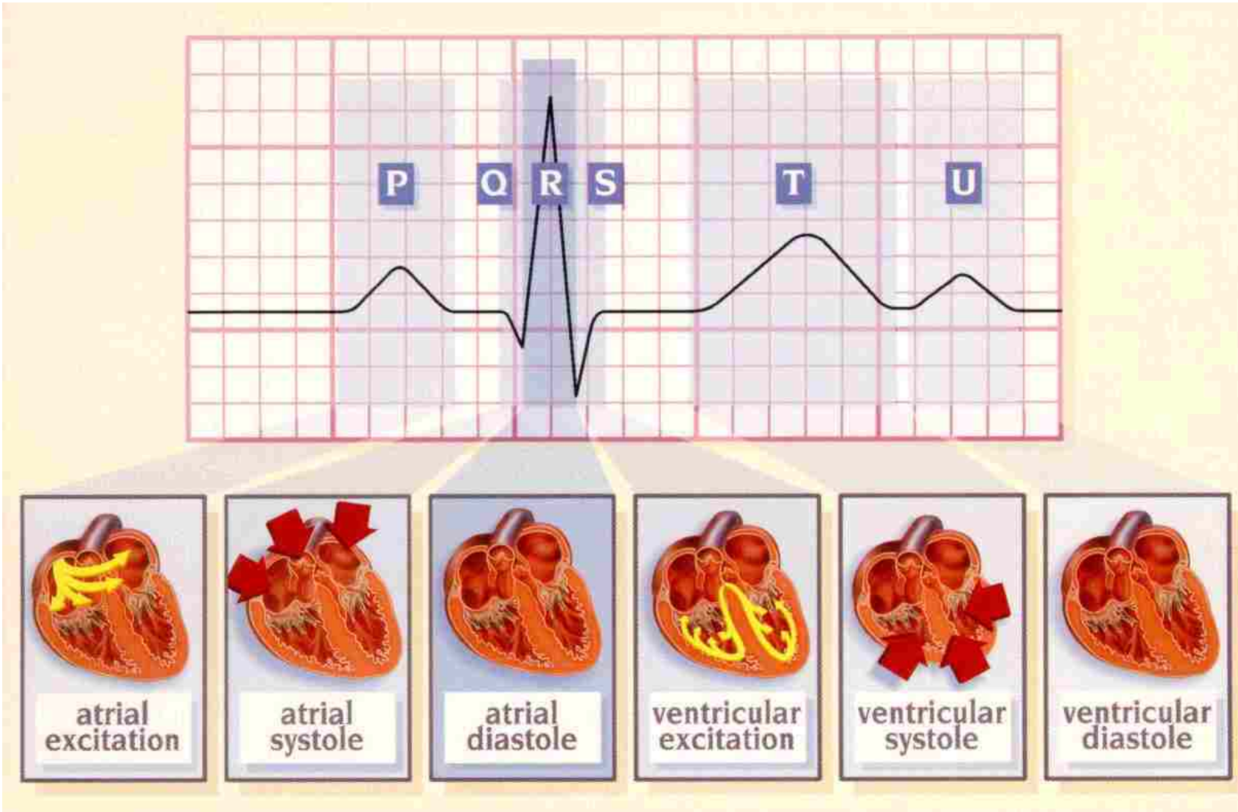


Solving a complex problem by breaking it into simpler subtasks is an effective approach to design. There is one input called the **Atrial sensor** (AS), and two outputs **Ready** and **Ventricular trigger** (VT). AS input is connected to PF4. In a real pacemaker, electrodes (wires) are attached to the heart and electronics are used to sense the activity of the heart. In this lab, a switch will be used to emulate the operation of the atrial sensor. When the switch SW1 is pressed (AS=0) it means the atria has begun to contract. When the switch SW1 is released, it means the atria have completed contraction. The Ready output is connected to PF3. The LED will be **green** when Ready is high. The Ready signal is used for debugging, and not part of an actual pacemaker. In a real pacemaker, electrodes (wires) are attached to the heart, and electrical pulses are generated that stimulate the heart, causing it to beat. In this lab, the VT output is connected to PF1, such that the LED will be **red** when VT is high. A 250 ms pulse will cause the ventricules to contract.



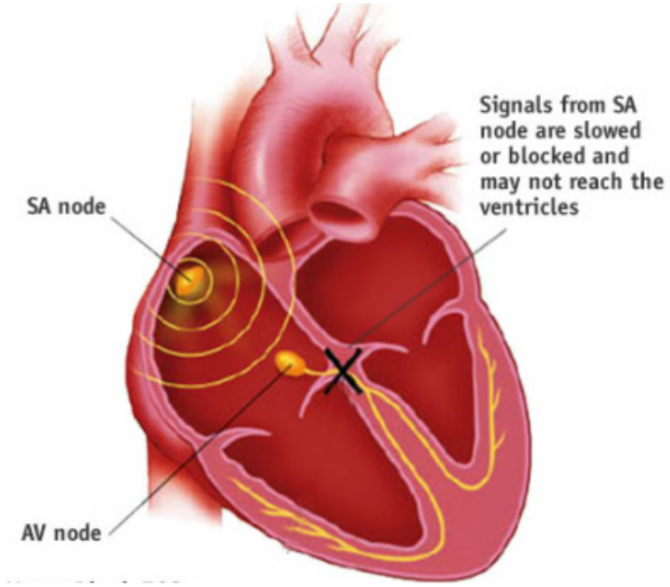
you will walk through the design process to build a very simple pacemaker. The system will read from a switch, makes decisions, and outputs to an LED. You will learn and understand the steps required to initialize parallel ports. You will write subroutines that wait for the switch to be pressed, wait for the switch to be released, and create an output pulse of fixed duration.

The heart has four chambers. Blood follows from the veins into the right atrium, into the right ventricle, out to the lungs to collect oxygen, back to the left atrium, into the left ventricle, and then out to the body via the arteries. In a normal heart the left and right atria contract first, followed by a pause. This pause allows blood to flow from the two atria into the two ventricles. After the pause the ventricles contract causing blood to flow from the right ventricle to the lungs and from the left ventricle to the body. Figure 7.3 shows the normal operation of the heart. Atrial systole is when the atria are contracting, and ventricle systole is when the ventricles are contracting. **Systole** is when the heart gets smaller, ejecting or pumping blood. Diastole is the time when the chambers are relaxing. **Diastole** is when the heart gets larger, refilling with more blood for the next cycle.



Electrical signals cause this *1) atrial contraction, 2) pause, 3) ventricular contraction* sequence each time the heart beats. The sinoatrial node (SA) begins the sequence and will ultimately determine how fast the heart will beat. The SA node sends an electrical signal across the atria causing the atria to contract. The atrial ventricular node (AV) will create the delay before sending the electrical signal onto the ventricles. One type of heart disease is called **heart block**, where the AV node is damaged. The consequences of heartblock are the electrical signal may be delayed, partially blocked (every other beat goes through) or completely blocked. In this lab we will create a machine to treat complete heart block, meaning no atrial signals are passed on to the ventricles. With complete heart block, the atria beat at one rate, and the ventricles beat at a different and slower rate. Beating out of sync, the heart is very inefficient as a pump.

The machine we will create in Lab 7 will treat patients with complete heart block, recreating the normal *1) atrial contraction, 2) pause, 3) ventricular contraction* sequence.


SA node
Signals from SA node are slowed or blocked and may not reach the ventricles
AV node