War & Peace Cluster, Summit Program
Physics Assignment 3

This assignment is related to the program "Making of the Bomb". You might also supplement that material with sources from the library or online. Note: if you do use extra material be careful not to include sources about the hydrogen bomb (also known as the H bomb or a thermonuclear bomb). This assignment is strictly about the atomic bomb (A bomb).

In the development of the atomic bomb and its deployment over Japan

1. What is the main goal of an atomic or nuclear bomb, particularly in regard to how it differs from a conventional (chemical) bomb? To what extent does radiation play a role?
   The principle goal is to cause destruction first through the shock wave, and secondly by simultaneously igniting fires throughout the city. In both of these the atomic bomb mirrors the chemical weapons, but on a much larger scale.
   Although is responsible for a significant number of deaths, mostly from exposure to the intense flash, and the more horrific ones, radiation is more of a side issue, much less important that the blast and fires.

2. What were the main problems that the scientists and engineers faced, and how did they solve those problems?
   a. For both uranium and plutonium bombs the problem of "fizzle"
      i. In the case of the uranium gun type bomb, caused by the increased rate of fusion in one half of the bomb due to the premature arrival of neutrons from the other half.
      ii. In the case of the plutonium implosion type bomb, caused by impurities in the plutonium.
   b. In the case of the uranium bomb, the relative scarcity of the desirable isotope (^{235}U), and so the need for a high level of enrichment. (Note the option of natural uranium and moderation is only feasible for power stations, not bombs)
   c. In the case of the plutonium implosion type bomb the need to provide a spherically symmetric shock wave from chemical explosives surrounding the core.

3. From where does the concept of critical mass come? How does this limit the size of an atomic bomb?
   a. It is the smallest amount of material required to make a sample of fissile material explode. If the sample is too small (less than the critical mass) then the net rate of fission in the sample (which produces new neutrons) is less that the rate at which neutrons are lost by escape to the outside, and the sample will not explode. Fission reactions will still occur, and the sample will heat up, but not to the point of exploding.
   b. In the case of the uranium bomb two pieces of uranium are brought together, and neither piece can be as much as one critical mass in size. That means that the final configuration of the bomb cannot contain as much as two critical masses of material.
   c. In the case of the plutonium bomb, there is only one piece of material, which is compressed to increase the rate of production of neutrons by fission of the plutonium. The original piece cannot be as much as one critical mass of plutonium.