1. Amdahl’s Law: Speedup with Enhancement = \[
\frac{\text{Execution Time without Enhancement}}{\text{Execution Time with Enhancement}}
\]
= \[
\frac{1}{(1-F) + (F/S)}
\], where F is the fraction of the task where the enhancement applies and S is the speedup factor of the enhancement.

a) Consider an enhancement which runs 20 times faster but which is only usable 25% of the time. What would be the speedup with the enhancement?

Speedup with Enhancement =

b) What if the enhancement is usable only 15% of the time?

Speedup with Enhancement =

c) To get a speedup of 99 from 100 processors, what percentage of the original program could be scalar? (“scalar” - the part of the program that cannot be parallelized.)

**Summing 100,000 Numbers on 100 Processors**

Processors start by running a loop that sums their subset of vector A numbers (vectors A and sum are shared variables, Pn is the processor’s number, i is a private variable)

\[
\text{sum}[Pn] = 0;
\]
\[
\text{for} \ (i = 1000*Pn; \ i < 1000*(Pn+1); \ i = i + 1) \quad \text{sum}[Pn] = \text{sum}[Pn] + A[i]
\]

The processors then coordinate in adding together the partial sums (half is a private variable initialized to 100 (the number of processors))

\[
\text{repeat} \quad \text{synch();} \quad \text{/* synchronize first */}
\]
\[
\text{if } (\text{half}\%2 = 0 \ & \ & Pn == 0)
\quad \text{sum}[0] = \text{sum}[0] + \text{sum}[\text{half}-1];
\]
\[
\text{half} = \text{half}/2;
\]
\[
\text{if } (Pn < \text{half})
\quad \text{sum}[Pn] = \text{sum}[Pn] + \text{sum}[Pn+\text{half}];
\]
\[
\text{until } (\text{half} == 1); \quad \text{/* final sum in sum[0] */}
\]
2. Trace the second segment of code that adds together the partial sums assuming 10 processors (Pn = 10).

\[ \text{sum}[P0] \text{sum}[P1] \text{sum}[P2] \text{sum}[P3] \text{sum}[P4] \text{sum}[P5] \text{sum}[P6] \text{sum}[P7] \text{sum}[P8] \text{sum}[P9] \]

\[ P0 \quad P1 \quad P2 \quad P3 \quad P4 \quad P5 \quad P6 \quad P7 \quad P8 \quad P9 \quad \text{half} = 10 \]