1) Consider an application with \( n \geq 3 \) processes in which each process holds an arbitrary integer value. Write an MPI program to find and print out the third largest value out of the \( n \) values held by the processes.

2) Write an MPI program that calculates and prints out the product from 1 to \( n \) of \( f(i) \), where \( n \) is the number of processes and the code for function \( f \) is given. You should use point-to-point communication only in your program.

3) Consider a vector processor with the following parameters:
   - add start-up cost = 6 cycles
   - multiply start-up cost = 7 cycles
   - dependence penalty = 4 cycles
   - memory access time = 12 cycles
   - vector register size = 64

and consider the following code run with fixed vectors of length 64:

\[
\begin{align*}
LV & \quad V1, Ra \\
MULTV & \quad V2, V1, V3 \\
ADDV & \quad V4, V1, V3 \\
SV & \quad Rb, V2 \\
SV & \quad Rc, V4 \\
\end{align*}
\]

Assume the store latency must be included in the time to execute the code. The entire sequence produces 64 results.

a) Assuming no chaining and a single memory pipeline, how many clock cycles per result does this code require?

b) If the vector sequence is chained, how many clock cycles per result are required?

c) Suppose the processor has three memory pipelines and chaining. If there are no memory bank conflicts in the accesses for the above code, how many clock cycles per result are required?
4) Consider the following dataflow graph and assume each operation takes 1 clock cycle:

```
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```

a) In a static dataflow system that uses acknowledgements, at what rate can the inputs be supplied to the system? Justify your answer.

b) In a static dataflow system that uses locks, at what rate can the inputs be supplied to the system? Justify your answer.