**Answer 1:**

Given Clock Frequency = 210Hz

|  |  |  |  |
| --- | --- | --- | --- |
| Instruction Category | Occurrence | Cycle per Instruction | Clock Cycles Required |
| ALU | 60 | 5 | 60\*5 = 300 |
| Load & Save | 19 | 3 | 19\*3 = 57 |
| Branch | 14 | 4 | 14\*4 = 56 |
| Others | 7 | 1 | 7\*1 = 7 |
| Total Cycles Required | | | 300 + 57 + 56 + 7 = 420 |

So, total Cycles required is 420 cycles.

As the clock frequency is 210Hz so the total time taken for execution will be 410/210 = 2 second

For the second program, as it is mentioned that the machine can do either CPU operation or I/O operation and it is provided that the time taken for I/O operation is 1 sec.

So, for the second operation the time taken for CPU operation will be 2 – 1 = 1 second.

Number of Floating-point operations = 6 \* 106

So, these operations need to be done in 1 second.

As we know MFLOPS = Total Floating-point operation / CPU computation time

So, the MFLOPS = 6 \* 106

**Answer 2:**

|  |  |  |  |
| --- | --- | --- | --- |
| Instructions | Meaning | Clock cycle for S4 (IE) | Remarks |
| I5 (SUB R5, R6, R5) | R5 ← R5 + R6 | 1 |  |
| I4 (MUL R2, R6, R5) | R5 ← R2 × R6 | 2 | This will not get executed as the condition is mentioned in the assignment i.e. “if the only branch is taken” |
| I3 (BQEZ R3, I5) | if R3 ≥ 0, jump to I5 | 2 |  |
| I2 (DIV R5, R3, R3) | R3 ← R5/R3 | 3 | As R3 & R5 are used in I1 so this will get stall in ID i.e. S2 |
| I1 (MUL R3, R4, R5) | R5 ← R3 × R4 | 2 |  |
| I0 ADD R0, R1, R2) | R2 ← R0 + R1 | 1 |  |
| Instructions | Meaning |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| I5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | IF | ID | OF | IE | MO |
| I4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| I3 |  |  |  | IF |  |  |  |  |  |  | IF | ID | OF | IE | IE | MO |  |  |  |  |
| I2 |  |  | IF | ID | - | - | OF | IE | IE | IE | MO |  |  |  |  |  |  |  |  |  |
| I1 |  | IF | ID | OF | IE | IE | MO |  |  |  |  |  |  |  |  |  |  |  |  |  |
| I0 | IF | ID | OF | IE | MO |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Clock Cycle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

**According to the required format**:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S5 (MO) |  |  |  |  | I0 |  | I1 |  |  |  | I2 |  |  |  |  | I4 |  |  |  | I5 |
| S4 (IE) |  |  |  | I0 | I1 | I1 |  | I2 | I2 | I2 |  |  |  | I3 | I3 |  |  |  | I5 |  |
| S3 (OF) |  |  | I0 | I1 |  |  | I2 |  |  |  |  |  | I3 |  |  |  |  | I5 |  |  |
| S2 (ID) |  | I0 | I1 | I2 | - | - |  |  |  |  |  | I3 |  |  |  |  | I5 |  |  |  |
| S1 (IF) | I0 | I1 | I2 | I3 | - | - | - | - | - | - | I3 |  |  |  |  | I5 |  |  |  |  |
| Clock Cycle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |