1. (10 points) Above is a diagram of the forwarding unit. For each assignment of instructions below, what values should be generated on the OpASel and OpBSel lines?

a. ID/EX: add $5, $2, $3  
   EX/MEM: add $4, $0, $3  
   MEM/WB: add $4, $0, $2  
   OpASel: 0  
   OpBSel: 0

b. ID/EX: add $1, $2, $3  
   EX/MEM: mul $3, $2, $1  
   MEM/WB: sub $3, $1, $2  
   OpASel: 0  
   OpBSel: 2

c. ID/EX: add $1, $2, $3  
   EX/MEM: sw $2, 0($5)  
   MEM/WB: sub $3, $1, $2  
   OpASel: 0  
   OpBSel: 1
2. (10 points) For each snippet below, how many cycles will elapse between beginning execution of the instruction labeled start and the beginning of correct execution of the instruction labeled end. Assume all registers initialized to zero and speculative execution with branches predicted not taken.

```
start: addi $1, $0, 1
end:   addi $2, $0, 2

cycles: 1
```

Notes:

The branch will introduce a 1-cycle bubble due to the incorrect prediction.

```
start: j two
one:   j end
two:   beq $0, $0 one
end:   addi $1, $0, 0

cycles: 4
```

Forwarding handles all the data hazards here. No bubbles.

```
start: addi $1, $0, 1
       add $2, $1, $1
       add $1, $1, $2
end:   addi $5, $0, 0

cycles: 3
```

```
start: addi $1, $0, 5
one:   addi $2, $2, 1
       add $3, $3, $2
       beq $1, $2, end
       j one
end:   addi $5, $0, 0

cycles: 21
```

1 cycle setup, 4-cycle loop executed 5 times. Last time through the loop the j isn't executed (so only 3 cycles) but the branch mispredict adds a 1-cycle bubble.