

# HW01

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## 1 Problem 1

1.  $x$  is even  $\&\& y == x + 1$  is strongest
2.  $1 \leq x \leq 3$  is strongest
3.  $x > 0 \&\& y > 0$  is strongest
4.  $x$  is divisible by 50 is strongest
5. None
6.  $abs(result * result - x) \leq 0.000001$  is strongest

## 2 Problem 2

1. Is Valid
2. Is Valid
3. Not valid, since  $i + j + 1 - 1 = i + j$ , so the post-condition can still be  $i + j \neq 0$
4. Not valid, if  $m == y$  then it must be the reverse of if condition:  $y \geq x$  for sure.  
The post condition should be  $(m == x \ \&\& \ x > y) || (m == y \ \&\& \ y \geq x)$

### 3 Problem 3

1. Valid, since  $C$  code  $F$ , and we have  $B =_i C$ . As  $B$  is stronger than  $C$ , it can also achieve what  $C$  can do.
2. Possibly invalid, since we only have  $C$  code  $F$ , while  $E =_i F$ . We cannot induce from the weaker one to the stronger one.

## 4 Problem 4

1. 

```
{ x > 0 }
  x = 10;
    { x == 10 }
  y = 20 - x;
    { x == 10 && y == 10 }
  z = y + 4;
    { x == 10 && y == 10 && z == 14 }
  y = 0;
    { x == 10 && y == 10 && y == 0 }
```
2. 

```
{ |x| > 11 }
  x = -x;
    { |x| > 11 }
  x = x * x;
    { x > 121 }
  x = x + 1;
    { x > 122 }
```
3. 

```
{ |x| < 5 }
  if (x > 0) {
    { (|x| < 5 && x > 0) = (0 < x < 5) }
    y = x + 2;
    { (0 < x < 5) && (2 < y < 7) }
  } else {
    { |x| < 5 && x <= 0) = (-5 < x <= 0) }
    y = x - 1;
    { (-5 < x <= 0) && (-6 < y <= -1) }
  }
  { ((0 < x < 5) && (2 < y < 7)) || ((-5 < x <= 0) && (-6 < y <= -1)) }
```

## 5 Problem 5

1.     { wp( $x = -5, y > -2 * x$ ) = ( $y > 10$ ) }  
            $x = -5;$   
       { wp( $z = 2 * x + y, z > 0$ ) = ( $2 * x + y > 0$ ) = ( $y > -2 * x$ ) }  
            $z = 2 * x + y;$   
       {  $z > 0$  }
  
2.     { wp(if ( $x > 0$ )  $x = x + 6$ ; else  $x = 4 - x$ ; ,  $x > 7$ )  
           = ( $x > 0 \ \&\& \ x > 1$ ) || ( $x \leq 0 \ \&\& \ x < -3$ )  
           = ( $x > 1$ ) || ( $x < -3$ ) }  
       if ( $x > 0$ ) {  
           { wp( $x = x + 6 \ \&\& \ x > 7$ ) = ( $x > 1$ ) }  
            $x = x + 6;$   
       else {  
           { wp( $x = 4 - x \ \&\& \ x > 7$ ) = ( $x < -3$ ) }  
            $x = 4 - x;$   
       }  
       {  $x > 7$  }
  
3.     { wp(if ( $x > 4$ )  $x = x - 3$ ; else if ( $x < -4$ )  $x = x + 3$ ; else  $x = x + 1$ ; ,  $x > 0$ )  
           = ( $x > 4 \ \&\& \ x > 3$ ) || ( $x \leq 4 \ \&\& \ ((x < -4 \ \&\& \ x > -3) \ || \ (x \geq -4 \ \&\& \ x > -1))$ )  
           = ( $x > 4$ ) || ( $-1 < x \leq 4$ )  
           = ( $x > -1$ ) }  
       if ( $x > 4$ ) {  
           { wp( $x = x - 3, x > 0$ ) = ( $x > 3$ ) }  
            $x = x - 3;$   
       } else {  
           { wp(if ( $x < -4$ )  $x = x + 3$ ; else  $x = x + 1$ ; ,  $x > 0$ )  
               = ( $x < -4 \ \&\& \ x > -3$ ) || ( $x \geq -4 \ \&\& \ x > -1$ )  
               = ( $x > -1$ ) }  
           if ( $x < -4$ ) {  
               { wp( $x = x + 3, x > 0$ ) = ( $x > -3$ ) }  
                $x = x + 3;$   
           } else {  
               { wp( $x = x + 1, x > 0$ ) = ( $x > -1$ ) }  
                $x = x + 1;$   
           }  
       }  
       {  $x > 0$  }
  
4.     { wp( $x = y + 2, x > 2 * y - 1$ ) = ( $y + 2 > 2 * y - 1$ ) = ( $y < 3$ ) }  
        $x = y + 2;$   
       { wp( $z = x + 1, z > 2 * y$ ) = ( $x > 2 * y - 1$ ) }

```

z = x + 1;
{ z > 2 * y }

```

```

5. { wp(if (x >= 0) z = x; else z = x + 1;, z != 0)
    = (x >= 0 && x != 0) || (x < 0 && x != -1)
    = (x > 0) || (x < -1) }
if (x >= 0)
{ wp(z = x, z != 0) = (x != 0) }
  z = x;
else
{ wp(z = x + 1, z != 0) = (x != -1) }
  z = x + 1;
{ z != 0 }

```

## 6 Problem 6

1.     `{ x < 2 }`  
          `{ wp(z < 0, z = x - 1 ) = (x < 1) }`  
              `z = x - 1;`  
          `{ wp(w > 0, w = -z) = (z < 0) }`  
              `w = -z;`  
          `{ wp(w > 1, w = w + 1) = (w > 0) }`  
              `w = w + 1;`  
      `{ w > 1 }`

Sufficient or Insufficient: Insufficient, since  $(x < 1)$  is stronger than  $(x < 2)$

2.     `{ (x == y && y > 0) || (y != x) }`  
      `{ wp(if (x == y) x = -1; else x = y - 1;, x < y)`  
          `= (x == y && y > -1) || (x != y && true)`  
          `= (x == y && y > -1) || (x != y) }`  
          `if (x == y)`  
      `{ wp(x < y, x = -1) = (y > -1)}`  
          `x = -1;`  
      `else`  
      `{ wp(x < y, x = y - 1) = true }`  
          `x = y - 1;`  
      `{ x < y }`

Sufficient or Insufficient: Sufficient