Chapter 4 Questions.

Program Verification.

Semantics of programs: the partial correctness relation $\models_{par}$.

Recall what $\models_{par} \{\!| phi |\!\} P \{\!| psi |\!\}$ means: **"For all stores that satisfy phi, if P runs on such a store and if that run terminates, then the resulting store satisfies psi."**

Question 1

Which of the following triples is valid with respect to the partial correctness relation $\models_{par}$?
(As in the textbook, we assume all occurring variables x, y, ... have type integer.)

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1. $\{\!| x > -1 |\!\}$ y = x + x; $\{\!| x > -2 |\!\}$
2. $\{\!| x = 5 \wedge y = 3 |\!\}$ x = y; y = x; $\{\!| x = 3 \wedge y = 5 |\!\}$
3. $\{\!| T |\!\}$ while (x > 4) x = x - 1; $\{\!| x = 4 |\!\}$
4. $\{\!| T |\!\}$ if (x > 5) { y = x - 1;} else {y = x + 1;} $\{\!| y > 3 |\!\}$
5. $\{\!| T |\!\}$ x = 1; x = 2; $\{\!| x = 1 \wedge x = 2 |\!\}$

Question 2

Which of the following programs P satisfies the triple $\{\!| T |\!\}$ P $\{\!| z = max(x,y) |\!\}$ with respect to partial correctness: $\models_{par} \{\!| T |\!\}$ P $\{\!| z = max(x,y) |\!\}$
where max(x,y) is the larger number of x and y (e.g. max(-1,3) = 3)?

1. ```
   if (x > y) {
         z = x + 1;
   } else {
         z = y + 1;
   }
   z = z - 1;
   ```
2. ```
   if (x > y) {
         z = y + 1;
   } else {
         z = x + 1;
   }
   z = z - 1;
   ```
3. ```
   if (x > y) {
         z = x;
   } else {
         z = y + 1;
   }
   z = z - 1;
   ```
   ```

4.
```
if (x > y) {
        z = x + 1;
  } else {
        z = y + 1;
  }
  z = z + 1;
```
5.
```
if (x > y) {
        z = y;
  } else {
        z = x;
  }
  z = z;
```

Question 3

The program P:

```
x = y;
if (x < z) { x = z; }
```

satisfies which of the following Hoare triples with respect to the partial correctness relation $\models_{par}$?

1. $(\!| x = y |\!)\ P\ (\!| x = y |\!)$
2. $(\!| x < y |\!)\ P\ (\!| x = y |\!)$
3. $(\!| y < z |\!)\ P\ (\!| x = z |\!)$
4. $(\!| y = z |\!)\ P\ (\!| x < y |\!)$
5. None of the above.

Question 4

Consider the program:

```
y = x - y - 1;
x = x + 1;
y = 2*x + y;
```

What fact about the starting state would guarantee that, after the program has run, x = y?

1. x = y.
2. y = -1.
3. y = 2x.
4. y = y + 3.
5. None of the above.

Invariants of while-statements.

Question 5

Which of the following is an invariant of the while-statement in the program

```
a = 0;
z = 0;
while (a != y)
{
      z = z + x;
      a = a + 1;
}
```

with respect to partial correctness $\models_{par}$?

1. z = x * y
2. z = x * a
3. z = a * y
4. y = z * a
5. x = y * a

Question 6

Which of the following is an invariant of the while-statement in the program

```
z = 0;
a = 1;
while (a != y+1) {
        z = z + a;
        a = a + 1;
}
```

with respect to partial correctness $\models_{par}$?

1. z = a + y.
2. z = a(a + y).
3. 2z = (a - 1)a.
4. 2z = a + 1.
5. The while loop has no invariant.

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