1. a. pre-condition: \{N \geq 1\}  
post-condition: \{(1 \leq \text{LAST} \leq N \land A[\text{LAST}] = Y \land \text{for every } 1 \leq i \leq N, A[i] \neq Y) \lor (\text{for every } 1 \leq k \leq N, A[k] \neq Y) \land \text{UNCH}((\text{LAST})) \} \land \text{UNCH}(A)\}

b. pre-condition: \{S \geq 0\}  
post-condition: \{D = M - S \land \text{UNCH}(M, S)\}

2. No, the program computes the identify function when the initial value of \(y\) is less than 0, but the given function, \(f\), is undefined in this case.

3. The interface for an object designed to represent a controlled sector of airspace in an air traffic control system.

4. \(f = (y \geq 0 \rightarrow x, y := x + y, 0) = (y > 0 \rightarrow x, y := x + y, 0 \mid y = 0 \rightarrow x, y := x, y)\)

5. As explained in class, this is too strong, since the living room ceiling MAY already be painted before painting it in order to satisfy the post-condition.


7. a. true; b. false; c. true

8. a. \(P \Rightarrow I, \ \{I \land b\} \ S \ \{I\}, \ (I \land \neg b) \Rightarrow Q\)

b. **INITIALIZATION:** Does \(P \Rightarrow I?\)

\[
P: (\text{true} \land y = 5 \land x = 0) \Rightarrow (x = 5 - y) \ \checkmark
\]

**PRESERVATION:** Does \(\{I \land b\} \ s \ \{I\}?\)

\[
I \land b: \{x = 5 - y \land y \neq 0\}
\]

\[
x := x + 1
\]

\[
\{x - 1 = 5 - y \land y \neq 0\}
\]

\[
y := y - 1
\]

\[
\{x - 1 = 5 - (y + 1) \land y + 1 \neq 0\} \iff \{x = 5 - y \land y \neq -1\} \Rightarrow I \ \checkmark
\]

**FINALIZATION:** Does \((I \land \neg b) \Rightarrow Q?\)

\[
(I \land \neg b): (x = 5 - y \land y = 0) \Rightarrow x = 5 = Q \ \checkmark
\]

9. It is necessary to show \((x = 5 - y \land y \neq 0) \Rightarrow \wp(x := x + 1; y := y - 1, x = 5 - y)\)

(1) \(
\wp(x := x + 1; y := y - 1, x = 5 - y) = \wp(x := x + 1, x = 5 - (y - 1))
\]

\[
= (x + 1 = 5 - (y - 1))
\]

\[
= (x = 5 - y)
\]

(2) Clearly, \((x = 5 - y \land y \neq 0) \Rightarrow (x = 5 - y). \ \text{QED}\)
10. Let $G$ be $\text{temp} := x$, $H$ be $x := y$, and $I$ be $y := \text{temp}$. By observation, then, $g = (x,y,\text{temp} := x,y,x)$, $h = (x,y,\text{temp} := y,y,\text{temp})$, and $i = (x,y,\text{temp} := x,\text{temp},\text{temp})$.

To prove $f = [P]$, we must show: $f = (x,y,\text{temp} := y,x,x) = i \circ h \circ g$

$$i \circ h \circ g = (x,y,\text{temp} := x,\text{temp},\text{temp}) \circ (x,y,\text{temp} := y,y,\text{temp}) \circ (x,y,\text{temp} := x,y,x)$$
$$= (x,y,\text{temp} := x,\text{temp},\text{temp}) \circ (y,y,x)$$
$$= (x,y,\text{temp} := y,x,x)$$
$$= f$$

Therefore, $f = [P]$.

11. c

12. a. Real-time systems must meet their timing constraints. There is typically significant performance overhead in object-oriented systems because extra code is required to mediate access to attributes and handle calls to operations.

b. The language includes a modified thread mechanism which allows threads to be specified that will not be interrupted by the language garbage collection mechanism. Asynchronous event handling and timing specification (both relative and absolute) have also been included.

13. a. The pattern is comprised of a set of sensors which provide information about the environment and a set of actuators that can change the environment. In response to environmental changes detected by sensors, control signals are sent to the system actuators. The pattern is normally used (of course...) in control systems.

b. car anti-skid braking system

14. That estimates of effort for development planning become more and more accurate as the project progresses.

15. If a customer is willing to allow the developer to retain ownership of the source code and reuse it in other projects, the price charged may then be less.

16. a. The term is used to describe the software development planning process used in XP.

b. In XP, effort points is a relative prediction of the effort that will be required to implement a given user story.

Velocity is the number of effort points implemented by the team per day.

Once you have a velocity estimate and the set of stories with their estimated effort points for a system, you can calculate the total effort in person-days to implement the system.
17. *Precedentedness* reflects the previous experience of the organization with this type of project. (A measure of “very low” means no previous experience; “extra-high” means that the organization is completely familiar with this application domain.) It is used in the Size exponent computation of the estimated effort.