Task 1.1

$i = 0; while(i < size(a)) \{x = x + a[i]; i = i + 1\}$

Task 2.1

(a) $< s, n = 5 >$

$\rightarrow \quad < b; s, n = 5 >$

$\rightarrow \quad < n = 3 * n + 1; s, n = 5 >$

$\rightarrow \quad < s, n = 16 >$

$\rightarrow \quad < b; s, n = 16 >$

$\rightarrow \quad < n = n/2; s, n = 16 >$

$\rightarrow \quad < s, n = 8 >$

$\rightarrow \quad < b; s, n = 8 >$

$\rightarrow \quad < n = n/2; s, n = 8 >$

$\rightarrow \quad < s, n = 4 >$

$\rightarrow \quad < b; s, n = 4 >$

$\rightarrow \quad < n = n/2; s, n = 4 >$

$\rightarrow \quad < s, n = 2 >$

$\rightarrow \quad < b; s, n = 2 >$

$\rightarrow \quad < n = n/2; s, n = 2 >$

$\rightarrow \quad < s, n = 1 >$

$\rightarrow \quad < skip, n = 1 >$

(b) $M(s, \sigma) = \{\{n = 1\}\}$

Task 2.2

(a) $M(s, \sigma) = \{\perp_d\}$

(b) $M(s, \sigma) = \{\{n = 0\}\}$

(c) $M(s, \sigma) = \{\{n = -1\}\}$

(d) $M(s, \sigma) = M(y := a[x], \sigma) = \{\{x = 1, a = [0, 3, 2, 1], y = 3\}\}$

(e) $M(s, \sigma) = M(z := 0, \sigma) = \{\{x = -1, a = [0, 3, 2, 1], z = 0\}\}$

(f) $M(s, \sigma) = M(y := a[x], \{x = 5, a = [0, 3, 2, 1], z = 0\}) = \{\perp_e\}$

Task 3.1

(a) **Unsatisfied**. Post-condition is false, as i becomes 0.

(b) **Satisfied**. Pre-condition and post-condition passes. $i = 0 \land i \geq 0$ and $x = 6 \land x \geq 1$.

(c) **Satisfied**. Same reason as above. Program doesn't terminate and errors.

(d) **Satisfied**. Pre-condition is false thus, the triple is satisfied.

(e) **Satisfied**. Same reason as above.

(f) **Unsatisfied**. Post-condition is false, as $x = 0$.

(g) **Unsatisfied**. Post-condition is false, since i is updated throughout the program. At the end, $i = 0$, $x = 6$, and thus, $x \neq 0!$ or $x \neq 1$.

(h) **Satisfied**. Fixes the previous problem by saving i in another variable, k. Precondition and post-condition passes. At the end, $i = 0 \land x = 6 \land k = 3$ and thus, $x = k!$.

Task 3.2

(a) Valid. If $y = 0$ then causes an error which is fine for partial correctness. For all other states, they terminate in a state satisfying the post-condition.

(b) Not valid since with $y = 0$ leads to runtime error, $x/0$. Fixed: $[x \geq 0 \land y > 0]z := x/y[z \geq 0]$

(c) Valid

(d) Not valid, since we don't know the contents of array, a. They can be negative which makes the post condition false. So, I changed the program and to make it use the absolute value instead. Fixed: $\{i \geq 0 \land i < |a|\}x := |a[i]|\{x \geq 0\}$

Task 3.3

Since $r := r*(-2)$, we need to make n be even so that it ends on a positive and passes the post-condition. $[r = 1 \land \exists k \in \mathbb{Z}.n = 2 * k]m := n$; while $n \neq 0\{r := r * (-2); n := n - 1\}[r = 2^m]$

Task 4.1

I spent about 3 hours on this.