Theory

Task 4.

The given **for loop** (*) we have converted to the following **while loop** (**), which is considered to be the same. The reason for the conversion is that we already have type-checking rules for the **while loop**:

$$for\ (int\ i = e_0; e_1; s_1)\ s_2\ (*)$$

$$int\ i; i = e_0; while(e1)\{s2; s1;\}$$

$$\dfrac{\Gamma' = \Gamma, (\ell, \mathrm{i{:}\ int})\ \dfrac{\dfrac{\dfrac{}{\Gamma' \vdash_e i{:}\ int}\ (int\ literal)\quad \dfrac{}{\Gamma' \vdash_e e_0{:}\ int}\ (int\ literal)}{\Gamma' \vdash_s i = e_0;}\ (assign)\quad \dfrac{\dfrac{}{\Gamma' \vdash_e e_1{:}\ bool}\ (bool)\quad \dfrac{\dfrac{\dfrac{}{\Gamma' \vdash_s s2}\ (stmt\ expr)\quad \dfrac{}{\Gamma' \vdash_s s1}\ (stmt\ expr)}{\Gamma' \vdash_{sl} s2; s1;}\ (seq)}{\Gamma' \vdash_s \{s2; s1;\}}\ (block)}{\Gamma' \vdash_s\ while\ (e_1)\{s2; s1;\}}\ (while)}{\Gamma' \vdash_{sl} i = e_0; while\ (e_1)\{s2; s1;\}}\ (seq)\ \forall_{\mathrm{int}}{:}\ (\ell, \mathrm{i}{:}\ int) \notin \Gamma}{\Gamma \vdash_{sl} int\ i; i = e_0; while\ (e_1)\{s2; s1;\}}\ (var\ decl)$$

Following the above derivation, we can state that the formal rule for the expression (*) will look like this:

for $\Gamma' = \Gamma, (\ell, \mathrm{i{:}\ int})$

$$\frac{\Gamma' \vdash_e\ i{:}\ int\ \Gamma' \vdash_e\ e_0{:}\ int\ \Gamma' \vdash_e\ e_1{:}\ bool\ \Gamma' \vdash_s\ s1\ \Gamma' \vdash_s\ s2\ \forall_{\mathrm{int}}{:}\ \big(\ell, \mathrm{i}{:}\ int\big) \notin \Gamma}{\Gamma \vdash_s\ for\ \big(int\ i\ =\ e_0;\ e_1;\ s_1\big)\ s_2}$$

Task 5.

$$\dfrac{\dfrac{\Gamma' = \Gamma, (\ell, y{:}\ int[\,])\ \dfrac{\dfrac{\dfrac{}{\Gamma' \vdash_e y{:}\ int[\,]}\ (int\ array)\ \dfrac{\dfrac{}{\Gamma' \vdash_e\ 2{:}\ int}\ (int\ literal)}{\Gamma' \vdash_e\ new\ int[2]{:}\ int[\,]}\ (new\ array) int[\,] \prec int[\,]}{\Gamma' \vdash_s\ y = new\ int[2];}\ (assign)\ \dfrac{\dfrac{\dfrac{}{\Gamma' \vdash_e\ y : \mathrm{int}[\,]}\ (int\ array)\ \dfrac{}{\Gamma' \vdash_e\ 1{:}\ int}\ (int\ literal)}{\Gamma' \vdash_e y[1]{:}\ \mathrm{int}}\ (array\ lookup)\ \dfrac{}{\Gamma' \vdash_e\ 1{:}\ int}\ (int\ literal)}{\Gamma' \vdash_s y[1] = 1;}\ (assign)\ \dfrac{\dfrac{}{\Gamma' \vdash_e\ y{:}\ int[\,]}\ (int\ array)\ int[\,] \prec int[\,]\ (return{:}\ int[\,]) \epsilon}{}\ \Gamma'}{\Gamma' \vdash_s\ return\ y;}\ (return)}{\Gamma' \vdash_{sl} int[\,]\ y;\ y = new\ int[2];\ y[1] = 1;\ return\ y;}\ (seq)\ \ \forall_{\mathrm{int[]}}{:}\ (\ell, \mathrm{y}{:}\ int[\,]) \notin \Gamma}{\Gamma = (return{:}\ int[\,]) \vdash_{sl} int[\,]\ y;\ y = new\ int[2];\ y[1] = 1;\ return\ y;}\ (var\ decl)$$