Assignment 1:
Dynamics and Statics for a Simple Language

YOUR NAME*

Due: Friday, September 22, 2023

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*YOUR COLLABORATORS AND ACKNOWLEDGMENTS

A Dynamics of E

$\boxed{e\ \mathsf{val}}$

$$\frac{}{\mathtt{num}[n]\ \mathsf{val}} \qquad \frac{}{\mathtt{str}[s]\ \mathsf{val}}$$

$\boxed{e \longmapsto e'}$

$$\frac{}{\mathtt{plus}(\mathtt{num}[n_1];\mathtt{num}[n_2]) \longmapsto \mathtt{num}[n_1+n_2]} \qquad \frac{e_1 \longmapsto e_1'}{\mathtt{plus}(e_1;e_2) \longmapsto \mathtt{plus}(e_1';e_2)}$$

$$\frac{e_2 \longmapsto e_2'}{\mathtt{plus}(\mathtt{num}[n_1];e_2) \longmapsto \mathtt{plus}(\mathtt{num}[n_1];e_2')} \qquad \frac{}{\mathtt{times}(\mathtt{num}[n_1];\mathtt{num}[n_2]) \longmapsto \mathtt{num}[n_1 \cdot n_2]}$$

$$\frac{e_1 \longmapsto e_1'}{\mathtt{times}(e_1;e_2) \longmapsto \mathtt{times}(e_1';e_2)} \qquad \frac{e_2 \longmapsto e_2'}{\mathtt{times}(\mathtt{num}[n_1];e_2) \longmapsto \mathtt{times}(\mathtt{num}[n_1];e_2')}$$

$$\frac{}{\mathtt{cat}(\mathtt{str}[s_1];\mathtt{str}[s_2]) \longmapsto \mathtt{str}[s_1\hat{}s_2]} \qquad \frac{e_1 \longmapsto e_1'}{\mathtt{cat}(e_1;e_2) \longmapsto \mathtt{cat}(e_1';e_2)}$$

$$\frac{e_2 \longmapsto e_2'}{\mathtt{cat}(\mathtt{str}[s_1];e_2) \longmapsto \mathtt{cat}(\mathtt{str}[s_1];e_2')} \qquad \frac{}{\mathtt{len}(\mathtt{str}[s]) \longmapsto \mathtt{num}[|s|]} \qquad \frac{e \longmapsto e'}{\mathtt{len}(e) \longmapsto \mathtt{len}(e')}$$

$$\frac{e_1\ \mathsf{val}}{\mathtt{let}(e_1;x.e_2) \longmapsto [e_1/x]e_2} \qquad \frac{e_1 \longmapsto e_1'}{\mathtt{let}(e_1;x.e_2) \longmapsto \mathtt{let}(e_1';x.e_2)}$$

$\boxed{e\ \mathsf{err}}$

$$\frac{}{\mathtt{plus}(\mathtt{str}[s];e_2)\ \mathsf{err}} \qquad \frac{}{\mathtt{plus}(\mathtt{num}[n];\mathtt{str}[s])\ \mathsf{err}} \qquad \frac{e_1\ \mathsf{err}}{\mathtt{plus}(e_1;e_2)\ \mathsf{err}} \qquad \frac{e_2\ \mathsf{err}}{\mathtt{plus}(\mathtt{num}[n];e_2)\ \mathsf{err}}$$

$$\frac{}{\mathtt{times}(\mathtt{str}[s];e_2)\ \mathsf{err}} \qquad \frac{}{\mathtt{times}(\mathtt{num}[n];\mathtt{str}[s])\ \mathsf{err}} \qquad \frac{e_1\ \mathsf{err}}{\mathtt{times}(e_1;e_2)\ \mathsf{err}} \qquad \frac{e_2\ \mathsf{err}}{\mathtt{times}(\mathtt{num}[n];e_2)\ \mathsf{err}}$$

$$\frac{}{\mathtt{cat}(\mathtt{num}[n];e_2)\ \mathsf{err}} \qquad \frac{}{\mathtt{cat}(\mathtt{str}[s];\mathtt{num}[n])\ \mathsf{err}} \qquad \frac{e_1\ \mathsf{err}}{\mathtt{cat}(e_1;e_2)\ \mathsf{err}} \qquad \frac{e_2\ \mathsf{err}}{\mathtt{cat}(\mathtt{str}[s];e_2)\ \mathsf{err}}$$

$$\frac{}{\mathtt{len}(\mathtt{num}[n])\ \mathsf{err}} \qquad \frac{e\ \mathsf{err}}{\mathtt{len}(e)\ \mathsf{err}} \qquad \frac{e_1\ \mathsf{err}}{\mathtt{let}(e_1;x.e_2)\ \mathsf{err}}$$

$\boxed{e \Downarrow e'}$

$$\frac{}{\mathtt{num}[n] \Downarrow \mathtt{num}[n]} \qquad \frac{}{\mathtt{str}[s] \Downarrow \mathtt{str}[s]} \qquad \frac{e_1 \Downarrow \mathtt{num}[n_1] \qquad e_2 \Downarrow \mathtt{num}[n_2]}{\mathtt{plus}(e_1;e_2) \Downarrow \mathtt{num}[n_1+n_2]} \qquad \frac{e_1 \Downarrow \mathtt{num}[n_1] \qquad e_2 \Downarrow \mathtt{num}[n_2]}{\mathtt{times}(e_1;e_2) \Downarrow \mathtt{num}[n_1 \cdot n_2]}$$

$$\frac{e_1 \Downarrow \mathtt{str}[s_1] \qquad e_2 \Downarrow \mathtt{str}[s_2]}{\mathtt{cat}(e_1;e_2) \Downarrow \mathtt{str}[s_1 s_2]} \qquad \frac{e \Downarrow \mathtt{str}[s] \qquad |s| = n}{\mathtt{len}(e) \Downarrow \mathtt{num}[n]} \qquad \frac{e_1 \Downarrow e_1' \qquad [e_1'/x]e_2 \Downarrow e_2'}{\mathtt{let}(e_1;x.e_2) \Downarrow e_2'}$$

B Statics of E

$\boxed{\Gamma \vdash e : \tau}$

$$\frac{x : \tau \in \Gamma}{\Gamma \vdash x : \tau} \qquad \frac{}{\Gamma \vdash \mathtt{num}[n] : \mathtt{num}} \qquad \frac{}{\Gamma \vdash \mathtt{str}[s] : \mathtt{str}} \qquad \frac{\Gamma \vdash e_1 : \mathtt{num} \qquad \Gamma \vdash e_2 : \mathtt{num}}{\Gamma \vdash \mathtt{plus}(e_1; e_2) : \mathtt{num}}$$

$$\frac{\Gamma \vdash e_1 : \mathtt{num} \qquad \Gamma \vdash e_2 : \mathtt{num}}{\Gamma \vdash \mathtt{times}(e_1; e_2) : \mathtt{num}} \qquad \frac{\Gamma \vdash e_1 : \mathtt{str} \qquad \Gamma \vdash e_2 : \mathtt{str}}{\Gamma \vdash \mathtt{cat}(e_1; e_2) : \mathtt{str}} \qquad \frac{\Gamma \vdash e : \mathtt{str}}{\Gamma \vdash \mathtt{len}(e) : \mathtt{num}}$$

$$\frac{\Gamma \vdash e_1 : \tau_1 \qquad \Gamma, x : \tau_1 \vdash e_2 : \tau_2}{\Gamma \vdash \mathtt{let}(e_1; x.e_2) : \tau_2}$$