

$$\sqcup ab \sqcup \vdash^n \sqcup ab \sqcup ab \sqcup$$

$$\begin{array}{c} \text{M} \\ \downarrow \\ > L_U \rightarrow R \xrightarrow{a \neq L} \sqcup R_U^2 a L_U^2 a \sqcup \\ \downarrow U \\ R_U \end{array}$$

$$\sqcup ab \sqcup \vdash \sqcup ab U \quad (\because L_U)$$

$$\vdash \sqcup \underline{a} b U \quad (\because R)$$

$$\vdash \sqcup \underline{\underline{a}} b U \quad (\text{copy } a)$$

$$\vdash \sqcup \sqcup b U \sqcup \quad (R_U^2)$$

$$\vdash \sqcup \sqcup b U \underline{a} \quad (\text{paste } a)$$

$$\vdash \sqcup \underline{\underline{a}} b U a \quad (L_U^2)$$

$$\vdash \sqcup \underline{a} b U a \quad (\text{paste } a)$$

$$\vdash \sqcup a \underline{b} U a \quad (R)$$

$$\vdash \sqcup a \underline{\underline{b}} U a \quad (\text{copy } b)$$

$$\vdash \sqcup a \sqcup \sqcup a \sqcup \quad (R_U^2)$$

$$\vdash \sqcup a \sqcup \sqcup a \underline{b} \quad (\text{paste } b)$$

$\vdash \quad \sqcup a \underline{\sqcup} \sqcup ab \quad (L_U^2)$

$\vdash \quad \sqcup a \underline{b} \sqcup ab \quad (\text{paste } b)$

$\vdash \quad \sqcup ab \underline{\sqcup} ab \quad (R)$

$\vdash \quad \sqcup ab \sqcup ab \underline{\sqcup} \quad (R_U)$

Ques: Right - Shifting TM \rightarrow ✓ 2 times

$\sqcup w \underline{\sqcup} \vdash \underline{\sqcup \sqcup w \sqcup}$

Where w contains no blank characters.

$\sqcup w \underline{\sqcup} \vdash \sqcup \underline{w} \sqcup \quad (L)$

$\vdash \sqcup \underline{\sqcup} \sqcup \quad (\text{copy 'w'})$

$\vdash \sqcup \sqcup \underline{\sqcup} \quad (R_U)$

$\vdash \sqcup \sqcup \underline{w} \quad (\text{paste 'w'})$

$\vdash \sqcup \underline{\sqcup} w \quad (L_U)$

$\vdash \underline{\sqcup} \sqcup w \quad (L) \checkmark$

$\vdash \underline{\sqcup \sqcup w \sqcup} \quad (R_U^2)$

$$\begin{array}{c} & \boxed{a \neq \perp \rightarrow \perp R_{\perp} a L_{\perp}} \\ & \downarrow \perp \checkmark \\ R_{\perp}^2 \end{array}$$

3 times ✓

$$\perp a b \perp \vdash \perp \perp a b \perp \checkmark$$

$$\begin{array}{llll} \perp a b \perp & \vdash & \perp a \underline{b} \perp & (L) \\ & \vdash & \perp a \perp \perp & (\text{copy } b) \\ & \vdash & \perp a \perp \underline{\perp} & (R_{\perp}) \\ & \vdash & \perp a \perp \underline{b} & (\text{paste } b) \\ & \vdash & \perp a \underline{\perp} b & (L_{\perp}) \\ & \vdash & \perp \underline{a} \perp b & (L) \\ & \vdash & \perp \underline{\perp} \perp b & (\text{copy } \perp) \\ & \vdash & \perp \perp \underline{\perp} b & (R_{\perp}) \\ & \vdash & \perp \perp \underline{a} b & (\text{paste } a) \\ & \vdash & \perp \underline{\perp} a b & (L_{\perp}) \\ & \vdash & \underline{\perp} \perp a b & (L) \\ & \vdash & \perp \perp a b \underline{\perp} & (R_{\perp}^2) \end{array}$$

Ques: Left-Shifting TM

$\boxed{U \in W}$

$U \text{ (a) } b \text{ } \underline{U} \vdash ab \text{ } \underline{U} /$

$U ab \text{ } \underline{U} \vdash \underline{U} ab U \text{ (L)}_U$

$\vdash U \underline{a} b U \text{ (R)}$

$\vdash U \underline{U} b U \text{ (copy 'a')} \checkmark$

$\vdash \underline{U} U b U \text{ (L)} \checkmark$

$\vdash \frac{a}{a} U b U \text{ (paste 'a')} \checkmark$

$\vdash a \underline{U} b U \text{ (R)} \checkmark$

$\vdash a U \underline{b} U \text{ (R)} \checkmark$

$\vdash a U \underline{U} U \text{ (copy 'b')} \checkmark$

$\vdash a \underline{U} U U \text{ (L)}$

$\vdash a \underline{b} U U \text{ (paste 'b')} \checkmark$

$\vdash a b \underline{U} U \text{ (R)} \checkmark$

$\vdash a b \underline{U} U \text{ (R)} \checkmark$

$\vdash a b \underline{U} \text{ (L)}_U$

