Actual process
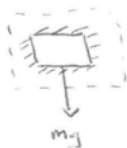

initial   final

$$\Delta(K.E) = 0$$
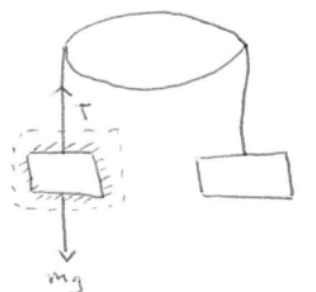$$\Delta(P.E) = -mgh$$
$$W_{on\,sys} = 0$$
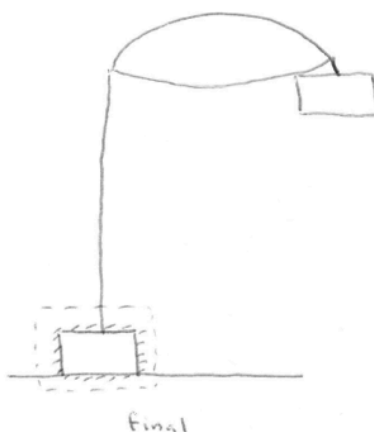$$Q = 0$$

$$0 + (-mgh) + \Delta U = 0 + 0$$

$$\boxed{\Delta U = mgh}$$

Hypothetical Reversible Path

initial   final

$$\Delta(K.E) = 0$$
$$\Delta(P.E) = \cancel{mgh} \ -mgh$$

a weight is
lifted in the   ← $W_{on\,sys} = -mgh$
surroundings

$$Q = 0$$

$$0 + (-mgh) + \Delta U = (-mgh) + 0$$

$$\therefore \Delta U = 0$$

Since $\Delta U = 0$, we are not at same state as final
state of the actual process. Must increase U
of body via heat for final states to coincide.

$$\therefore \boxed{\Delta S = \frac{Q_{rev}}{T} = \frac{mgh}{T}}$$