W(s) = \int_{S_0}^{S} \left( P_m - \frac{E V_{\infty}}{x} \sin(u) \right) du

W(s): Potential Energy
V(\dot{s}): Kinetic Energy
E(S, \dot{S}_T): W(S) + V(\dot{S})
\[ W(s) = -\int_{S_0}^{S} \left( P_m - \frac{EV_{oo}}{X} \right) \sin(u) \, du \]

\[ W(s) : \text{Potential Energy} \]

\[ V(\dot{s}_T) : \text{Kinetic Energy} \]

\[ E(S_T, \dot{S}_T) = W(s) + V(\dot{s}_T) \]
EQUAL AREA CRITERION

Clearly there is an initial energy level that if the system has, it won't be able to recover after the fault has been cleared.

\[ E_{cr} = W_{cr} + V_{cr} \]

\[ E_{cr} = W (\Pi - S_0) \]

\[ = -P_m (\Pi - 2S_0) \]

\[ -\frac{EV_0}{x} \cos(\Pi - S_0) + \frac{EV_0}{x} \cos S_0 \]

\[ = -P_m (\Pi - 2S_0) + \frac{2EV_0}{x} \cos S_0 \]

Corresponding to this \( E_{cr} \), there is a critical \( \Pi \).

Mathematically:

\[ \frac{1}{2} MS_T^2 + \int_{-P(u)}^{S_T} du < \int_{S_0}^{\Pi - S_0} du \]

\[ \frac{1}{2} MS_T^2 < \int_{-P(u)}^{S_T} du \]

We also saw that at the end of stage 2, we had:

\[ S_T = S_0 + \frac{M S_T^2}{2P_m} \rightarrow P_m (S_T - S_0) = \frac{1}{2} MS_T^2 \]

Thus, the criterion is:

\[ P_m (S_T - S_0) < T \int_{S_T} P(u) du \]
Critical $T$: 
\[ P_m (S_T - S_0) = \int_{S_0}^{S_T} \left( \frac{E V_0}{X} \sin u - P_m \right) du \]

**OTHER APPLICATIONS OF THE EQUAL-AREA CRITERION**

1. Sudden change in $P_m$

The idea is always the same: need to compare the initial energy after the change with the critical potential energy.

In this case, after $P_m$ changes, the potential energy curve changes as well.

\[ W(S) = -\int_{S_1}^{S} \left( P_m' - \frac{E V_0}{X} \sin u \right) du \]

This is the eq. point we need to use.
Initially, the potential energy the system has is
\[ W(S_0) = -\int_{S_1}^{S_0} \left( P_m' - \frac{E V_\infty}{x} \sin \mu \right) \, du \]

- No Kinetic Energy.
- Thus the criterion is
\[ W(S_0) \leq W(\Pi - S_1) \]
\[ -\int_{S_1}^{S_0} \left( P_m' - \frac{E V_\infty}{x} \sin \mu \right) \, du \leq -\int_{S_1}^{\Pi - S_1} \left( P_m' - \frac{E V_\infty}{x} \sin \mu \right) \, du \]
\[ \int_{S_0}^{S_1} \left( P_m' - \frac{E V_\infty}{x} \sin \mu \right) \, du \leq \int_{S_1}^{\Pi - S_1} \left( \frac{E V_\infty}{x} \sin \mu - P_m' \right) \, du \]
consistent with the shaded areas in the figure.

2. Sudden change in \( x \)

After the fault occurs \( x \) goes to \( 2x \)

\[ W(S_0) = -\int_{S_1}^{S_0} \left( P_m - \frac{E V_\infty}{2x} \sin \mu \right) \, du \]
- Critical potential energy:

\[ W(\pi - S_1) = \int_{S_1}^{\pi} (P_m - \frac{EV_0}{2x} \sin u) \, du \]

- Initially, no kinetic energy; thus, the criterion is

\[ W(S_0) \leq W(\pi - S_1) \]

\[ + \int_{S_0}^{S_1} (P_m - \frac{EV_0}{2x} \sin u) \, du \leq -\int_{S_1}^{\pi} (P_m - \frac{EV_0}{2x} \sin u) \, du \]

\[ \int_{S_0}^{S_1} (P_m - \frac{EV_0}{2x} \sin u) \, du \leq \int_{S_1}^{\pi} (\frac{EV_0}{2x} \sin u - P_m) \, du \]

consistent with the shaded areas in the figure.