PROBLEM 15.181

All dimensions given, \( \frac{\Delta B}{\Delta D} \) given, constant

Want \( \frac{\Delta F}{\Delta B D}, \frac{\Delta F}{\Delta A D} \)

\( F \) is a point on rod coincident with \( E \) at time shown. It is not the generic point coincident with \( E \) for all configurations. If it were, \( \vec{V}_F \) & \( \vec{a}_F \) would be zero, since \( F \) would always be at \( E \) \& \( VE = 0 \).

Thus \( F \) is a point on the rod at a distance from \( B \) of \( \sqrt{\Delta B^2 + \Delta E^2} \). It could be painted on rod. That's the point for which we want \( \vec{V} \) & \( \vec{a} \).
Set up coordinate systems so that \[ Y \]

\[ X \]

\[ F = E \]

Since \( F \) at \( \angle \)F from B, it never moves within xy system. To an observer at B, \( F \) is always at \( \angle \)F. (So there is no \( \hat{j} \) component to this length.)

This is a standard relative velocity problem.

\[ \overrightarrow{w}_{BD} \]

\[ \dot{\overrightarrow{r}} \]

\[ \hat{j} = \sin \theta \hat{i} - \cos \theta \hat{j} \]

\[ \hat{i} = \text{you figure it out} \]
ACCELERATION

Again, since \( F \) is fixed in \( xy \) system, this is a standard relative acceleration problem.

\[
\ddot{a}_F = \ddot{a}_E + \dot{a}_E \times \dot{a}_E
\]

If this is worked through however, there are 3 unknowns & only 2 equations: \( AFX \), \( AFE \), \( AB \).

The trouble is that we don't know the direction of \( \ddot{a}_E \). It's not like the slider crank. There is no rigid cylinder @ \( E \) allowing only motion along the \( \theta \) direction. The collar is free to rotate, so the \( \ddot{a}_E \) need not be along an axis where the rod is fixed.

So we don't have enough equations. So what to do?
Point E doesn't move:

\[ V_E = 0, \quad a_E = 0 \]

We can write an equation for acceleration (5-term) that has all the terms in it:

\[ a_E = a_B + \ldots \]

When this is written out and all terms are added, should get 0. Note that \( a_E - \text{car} \neq 0 \) since to an observer at B, \( \| \text{BE} \| \) is getting longer & longer. So \( V_{\text{Ex}} \) & \( a_{\text{Ex}} \neq 0 \).

This relationship between \( \text{B} \) & \( E \) leads to two more equations. One of them can be used for the third equation needed.