1. The diagonal of the rectangle on the left below shows (a blown-up picture of) an infinitesimal displacement from the point $(x,\, y)$ to the nearby point
   $(x + dx,\, y + dy)$.

   - Label the rectangle with the lengths of the sides.
   - Express the sides of the rectangle indicated by arrows as vectors.
     Use the unit vectors $\hat{\boldsymbol{x}}$ and $\hat{\boldsymbol{y}}$.
   - The diagonal of this rectangle is the vector differential $d\vec{r}$. Express $d\vec{r}$ in terms of $\hat{\boldsymbol{x}}$ and $\hat{\boldsymbol{y}}$.

     Solution $d\vec{r} = dx\,\hat{\boldsymbol{x}} + dy\,\hat{\boldsymbol{y}}$

   - Find the length $ds = |d\vec{r}|$ of the diagonal.

     Solution $ds = \sqrt{dx^2 + dy^2}$

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2. The diagonal of the "rectangle" on the right above shows (a blown-up picture of) the *same* infinitesimal displacement, now expressed in polar coordinates, from the point $(r,\, \phi)$ to the nearby point $(r + dr,\, \phi + d\phi)$.

   - Label the rectangle with the lengths of the sides. *Careful!*
   - Express the sides of the rectangle indicated by arrows as vectors.
     Use the natural orthonormal basis defined by the picture, that is, let $\hat{r}$ be the unit vector which points in the direction of increasing $\vec{r}$, and let $\hat{\phi}$ be the unit vector which points in the direction of increasing ϕ. Do not attempt to express these vectors in terms of $\hat{\boldsymbol{x}}$ and $\hat{\boldsymbol{y}}$! You do not need to worry about the fact that some sides of the rectangle aren't straight; the rectangle is so small that this error is negligible.
   - The diagonal of this rectangle is again the vector differential $d\vec{\boldsymbol{r}}$. Express $d\vec{\boldsymbol{r}}$ in terms of $\hat{r}$ and $\hat{\phi}$

     Solution $d\vec{\boldsymbol{r}} = dr\,\hat{\boldsymbol{r}} + r d\phi\,\hat{\boldsymbol{\phi}}$

   - Find the length $ds = |d\vec{r}|$ of the diagonal.

     Solution $ds = \sqrt{dr^2 + r^2 d\phi^2}$