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so many fake sites. this is the first one which worked! Many thanks

PHYSICS 110A : CLASSICAL MECHANICS
HW 3 SOLUTIONS

(1) Taylor 6.6

(a) Here we are working with $ds = \sqrt{dx^2 + dy^2}$. For a function $y = y(x)$ we will pull out a dx to have:

$$ds = \sqrt{dx^2 + dy^2} = dx \sqrt{1 + \left(\frac{dy}{dx}\right)^2} = dx \sqrt{1 + (y')^2}.$$

(b) Similarly for a function $x = x(y)$ we have:

$$ds = \sqrt{dx^2 + dy^2} = dy \sqrt{1 + \left(\frac{dx}{dy}\right)^2} = dy \sqrt{1 + (x')^2}.$$

(c) Now for cylindrical coordinates we should remember the line element looks like:

$$d\vec{s} = dr + r d\phi + dz.$$

So for a function $r = r(\phi)$ we have:

$$ds = \sqrt{dr^2 + r^2 d\phi^2} = dr \sqrt{1 + \left(\frac{dr}{d\phi}\right)^2} = dr \sqrt{1 + (r')^2}.$$

An alternate and equivalent way to do this is to begin from the Euclidean distance in (a) and write x and y (and z , if needed) in the coordinate system you are transforming to. In this case

$$x = r \cos \phi, \quad y = r \sin \phi.$$

so

$$dx = \frac{dr}{d\phi} d\phi - r \sin \phi d\phi = \cos(\phi) dr - r \sin(\phi) d\phi$$

$$dy = \frac{dr}{d\phi} d\phi + r \cos \phi d\phi = \sin(\phi) dr + r \cos(\phi) d\phi$$

In which case, after some algebra and use of basic trig identities (which you should go through), we have

$$ds = \sqrt{(\cos^2 \phi + \sin^2 \phi) dr^2 + r^2 (\sin^2 \phi + \cos^2 \phi) d\phi^2} = \sqrt{dr^2 + r^2 d\phi^2}$$

which recognizes what we have above in a completely equivalent manner. This method is often useful when you don't know the specific names or line element of a specific coordinate system.

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