

Instructions: Show all work. **Give exact answers** (yes, that means fractions, square roots and exponentials, and not decimals) unless specifically directed to give a decimal answer. This will require some operations to be done by hand even if not specifically directed to. Be sure to complete all parts of each question.

1. Convert the equation $x^2 + y^2 = 9$ from rectangular coordinates to cylindrical and spherical coordinates.

$$r = 3 \quad \text{cylindrical}$$

(here, this is like polar since it does not depend on z)

Spherical

$$(\rho \cos \theta \sin \varphi)^2 + (\rho \sin \theta \sin \varphi)^2 = 9$$

$$\rho^2 \cos^2 \theta \sin^2 \varphi + \rho^2 \sin^2 \theta \sin^2 \varphi = 9$$

$$\rho^2 \sin^2 \varphi (\underbrace{\cos^2 \theta + \sin^2 \theta}_{=1}) = 9$$

$$\rho^2 \sin^2 \varphi = 9 \quad \vee \quad \rho \sin \varphi = 3$$

2. Convert the equation $\rho = 4 \csc \varphi \sec \theta$ from spherical coordinates to rectangular and cylindrical coordinates.

$$(\rho = 4 \csc \varphi \sec \theta) \sin \varphi \cos \theta$$

$$\underbrace{\rho \sin \varphi \cos \theta}_{=x} = 4$$

$$x = 4 \quad \text{rectangular}$$

$$r \cos \theta = 4 \quad \text{cylindrical}$$