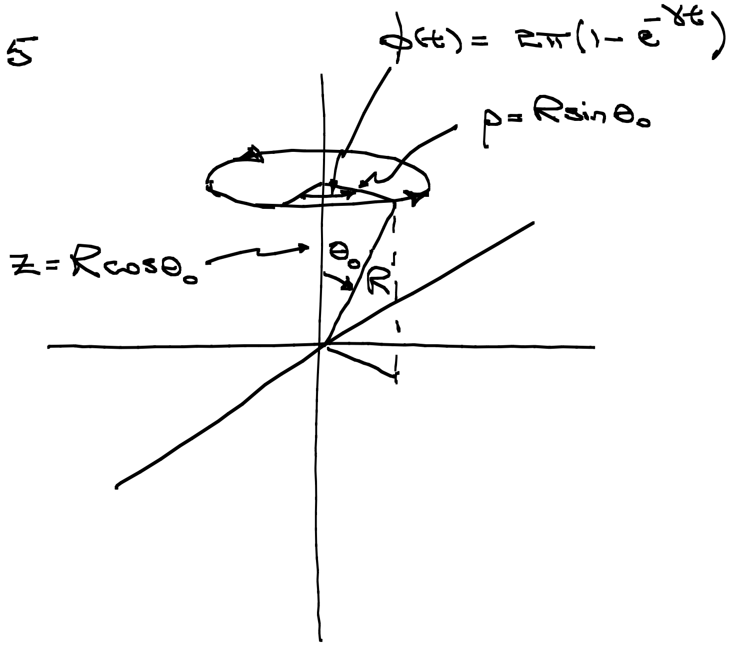
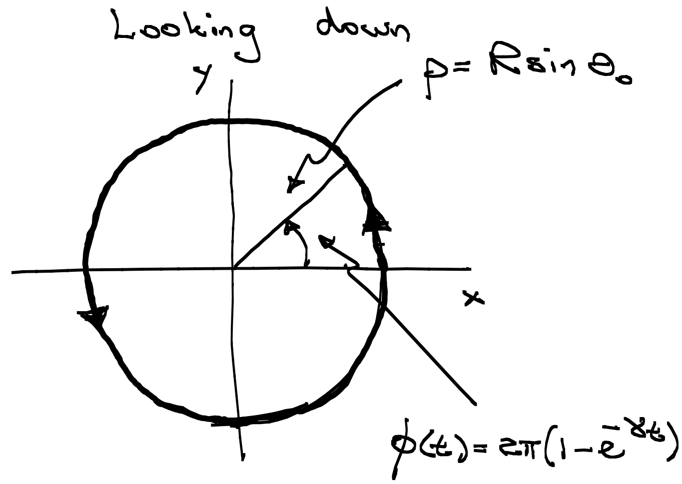
3.5





Trajectory

Spherical:

$r = R,\ \theta = \theta_0,\ \phi = 2\pi(1-e^{-\gamma t})$

(a) Cylindrical:

$\rho = R\sin\theta_0,\ \phi = 2\pi(1-e^{-\gamma t}),\ z = R\cos\theta_0$

(b) $\vec{r} = R\sin\theta_0\,\hat{\rho} + R\cos\theta_0\,\hat{z}$

$\hat{\rho}$ is the only thing in this expression that is changing in time.

(c) $\vec{v} = \dfrac{d\vec{r}}{dt} = R\sin\theta_0\underbrace{\dfrac{d\hat{\rho}}{dt}}_{\hat{\phi}\dot{\phi}} = R\underbrace{\dot{\phi}}_{2\pi\gamma e^{-\gamma t}}\sin\theta_0\,\hat{\phi} = 2\pi\gamma R\sin\theta_0\,e^{-\gamma t}\,\hat{\phi}$

$e^{-\gamma t}$ and $\hat{\phi}$ are changing in time

$d\hat{\rho} = \hat{\phi}\,d\phi$

$d\hat{\phi} = -\hat{\rho}\,d\phi$

$v = |\vec{v}| = 2\pi\gamma R\sin\theta_0\,e^{-\gamma t}$

(d) $\vec{a} = \dfrac{d\vec{v}}{dt} = -2\pi\gamma^2 R\sin\theta_0\,e^{-\gamma t}\,\hat{\phi} + 2\pi\gamma R\sin\theta_0\,e^{-\gamma t}\underbrace{\dfrac{d\hat{\phi}}{dt}}_{-\hat{\rho}\dot{\phi}}$

$\vec{a} = \underbrace{-2\pi\gamma^2 R\sin\theta_0\,e^{-\gamma t}\,\hat{\phi}}_{\text{slowing down in } \hat{\phi} \text{ direction}} \underbrace{- 4\pi^2\gamma^2 R\sin\theta_0\,e^{-2\gamma t}\,\hat{\rho}}_{\text{centripetal acceleration}}$

(e) $t=0$: $\phi=0$

$$\vec{v} = 2\pi\gamma R\sin\theta_0\,\hat{\phi}$$

$$\vec{a} = -2\pi\gamma^2 R\sin\theta_0\,\hat{\phi} - 4\pi^2\gamma^2 R\sin\theta_0\,\hat{\rho}$$

$t=\frac{1}{\gamma}\ln 2$: $\phi=\pi$

$e^{-\gamma t}=\frac{1}{2}$

$$\vec{v} = \pi\gamma R\sin\theta_0\,\hat{\phi}$$

$$\vec{a} = -\pi\gamma^2 R\sin\theta_0\,\hat{\phi} - \pi^2\gamma^2 R\sin\theta_0\,\hat{\rho}$$