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Q1.
(a)

Q2.
(b)

Q3.
(c)

Q4.
$$r = 1, \theta = \frac{\pi}{8}t, z = sin\theta = sin\frac{\pi}{8}t$$
Velocity
$$\dot{r} = 0, \dot{\theta} = \frac{\pi}{8} \, , \, \dot{z} = \frac{\pi}{8}cos\frac{\pi}{8}t$$
$$v = \sqrt{v_r{}^2 + v_\theta{}^2 + v_z{}^2}$$
$$= \sqrt{\frac{\pi^2}{8} + \frac{\pi}{8}cos\left(\frac{\pi}{2}\right)^2}$$
$$= \sqrt{\frac{\pi^2}{8}}$$
$$= \frac{\pi}{8}$$
Acceleration
$$\ddot{r} = 0, \ddot{\theta} = 0 \, , \ddot{z} = -\frac{\pi^2}{64}sin\frac{\pi}{8}t$$
$$a = \sqrt{a_r{}^2 + a_\theta{}^2 + a_z{}^2}$$
$$= \sqrt{\left(-\frac{\pi^2}{64}sin\frac{\pi}{8}t\right)^2}$$
$$= \frac{\pi^2}{64}sin\frac{\pi}{8}t$$

$$= 0.1542 m/s^2$$

Q5.
$$\dot{\theta} = \frac{\pi}{3}$$
$$\dot{\varphi} = \frac{2\pi}{3}$$
$$R = 200t^2 + 50$$
$$\dot{R} = 400t, \ddot{R} = 400$$
$$\ddot{\varphi} = 0$$
$$\ddot{\theta} = 0$$
$$\varphi = \frac{2\pi}{3}t$$
$$\theta = \frac{\pi}{3}t$$
$$a_r = \ddot{r} - r\dot{\varphi}^2 - r\dot{\theta}^2 \cos\varphi^2$$
$$= 400 - (200t^2 + 50) \cdot \left(\frac{2\pi}{3}\right)^2 - (200t^2 + 50)\frac{\pi}{3}^2 (\cos\frac{2\pi}{3}t)^2$$
$$= 400 - 438.65 - 27.42$$
$$= -66.07 mm/s^2$$

$$a_\theta = r\ddot{\theta}\cos\varphi + 2\dot{r}\dot{\theta}\cos\varphi - 2r\dot{\theta}\dot{\varphi}\sin\varphi$$
$$= 2 \cdot 400t \cdot \frac{\pi}{3} \cdot \cos\left(\frac{2\pi}{3}t\right) - 2(200t^2 + 50)\frac{\pi}{3} \cdot \frac{2\pi}{3} \cdot \sin\left(\frac{2\pi}{3}t\right)$$
$$= 418.81 - 8.017$$
$$= 410.792 m/s^2$$

$$a_\varphi = r\ddot{\varphi} + 2\dot{r}\dot{\varphi} + r\dot{\theta}2\sin\varphi\cos\varphi$$
$$= 2 \cdot 400t\frac{2\pi}{3} + (200t^2 + 50)\frac{\pi}{3}2\sin\left(\frac{2\pi}{3}t\right)\cos\left(\frac{2\pi}{3}t\right)$$
$$= \frac{800}{3}\pi + 3.827$$
$$= 841.585 m/s^2$$
$$a = \sqrt{a_r^2 + a_\theta^2 + a_\varphi^2}$$
$$= \sqrt{-66.07^2 + 410.792^2 + 841.585^2}$$

$$= 938.82 mm/s^2$$