1 | **Salt Flats**

1.1 | **1)**

N/A

1.2 | **2&3)**

$$\vec{v}(t) = \frac{d}{dt}\vec{f}(t) \quad = \begin{bmatrix} 2t \\ 12\cos(t) + 1 \end{bmatrix}$$
$$\vec{a}(t) = \frac{d^2t}{dt^2}\vec{f}(t) \quad = \begin{bmatrix} 2 \\ -12\sin(t) \end{bmatrix}$$

1.3 | **4)**

$$\begin{aligned} v(t) &= ||\vec{v}(t)|| \\ v(\pi) &= ||\vec{v}(\pi)|| \\ &= || \begin{bmatrix} 2\pi \\ 12\cos(\pi) + 1 \end{bmatrix} || \\ &= || \begin{bmatrix} 2\pi \\ -11 \end{bmatrix} || \\ &= \sqrt{(2\pi)^2 + (-11)^2} \\ &= \sqrt{4\pi^2 + 121} \end{aligned}$$

$$\begin{aligned} a(t) &= ||\vec{a}(t)|| \\ a(\pi) &= ||\vec{v}(\pi)|| \\ &= || \begin{bmatrix} 2 \\ -12\sin(\pi) \end{bmatrix} || \\ &= || \begin{bmatrix} 2 \\ 0 \end{bmatrix} || \\ &= \sqrt{(2)^2 + (0)^2} \\ &= \sqrt{4} \\ &= 2 \end{aligned}$$

1.4 | **5)**

$$\begin{aligned} v(t) &= ||\vec{v}(t)|| \\ &= \sqrt{\vec{v}_x(t)^2 + \vec{v}_y(t)^2} \\ &= \sqrt{4t^2 + 144\cos^2(t) + 24\cos(t) + 1} \end{aligned}$$

We know that both $\cos^2(t)$ and $\cos(t)$ have a maximum value of 1, and they are maximized at $t \in \{x : \frac{x}{2\pi} \in \mathbb{Z}\}$. However, $4t^2$ is quadratic, and it does not have a maximum value, as it diverges as t increases or decreases towards infinity. We do know, however, that the function is bounded between -2π and 3π. The value(s) that fits this is -2π (and 2π):

$$\begin{aligned} max(v(t)) &= \sqrt{4(2\pi)^2 + 144\cos^2(2\pi) + 24\cos(2\pi) + 1} \\ &= \sqrt{16\pi^2 + 144 + 24 + 1} \\ &= \sqrt{16\pi^2 + 169} \end{aligned}$$

1.5 | **6)**

$$\begin{aligned} a(t) &= ||\vec{a}(t)|| \\ &= \sqrt{\vec{a}_x(t)^2 + \vec{a}_y(t)^2} \\ &= \sqrt{4 + 144\sin^2(t)} \end{aligned}$$

We know that the maximum value of $\sin^2(t)$ is 1, so the above becomes

$$\begin{aligned} max(a) &= \sqrt{4 + 144} \\ &= \sqrt{148} \\ &= 2\sqrt{37} \end{aligned}$$

We have no units so I can't tell if I can survive this or not.

1.6 | **7)**

To get the distance travelled, we need to get the length of the parametric function. We can try to do this by using arc length. We know that because this is a parametric equation from $\mathbb{R}^1 => \mathbb{R}^2$, we can rewrite the function as two functions that are $\mathbb{R}^1 => \mathbb{R}^1$:

$$\begin{aligned} f_x(t) &= t^2 - 9 \\ f_y(t) &= 12\sin(t) - t \end{aligned}$$

This is great because we can get $\frac{dx}{dt}$ and $\frac{dy}{dt}$:

$$\begin{aligned} \frac{dx}{dt} &= 2t \\ \frac{dy}{dt} &= 12\cos(t) - 1 \end{aligned}$$

Therefore:

$$\begin{aligned} \frac{dy}{dx} &= \frac{\frac{dy}{dt}}{\frac{dx}{dt}} \\ &= \frac{12\cos(t) - 1}{2t} \end{aligned}$$