1. Consider the vector field $\mathbf{F} = (y, 0)$ on $\mathbb{R}^2$.

   (a) Draw a sketch of $\mathbf{F}$ on the region where $-2 \leq x \leq 2$ and $-2 \leq y \leq 2$. Check your answer with the instructor.

   (b) Consider the following two curves which start at $A = (-2, 0)$ and end at $B = (2, 0)$, namely the line segment $C_1$ and upper semicircle $C_2$.

   Add these curves to your sketch, and compute both $\int_{C_1} \mathbf{F} \cdot d\mathbf{r}$ and $\int_{C_2} \mathbf{F} \cdot d\mathbf{r}$. Check your answers with the instructor.

   (c) Based on your answer in (b), could $\mathbf{F}$ be $\nabla f$ for some $f: \mathbb{R}^2 \rightarrow \mathbb{R}$? Explain why or why not.

2. Consider the curve $C$ and vector field $\mathbf{F}$ shown below.

   (a) Calculate $\mathbf{F} \cdot \mathbf{T}$, where here $\mathbf{T}$ is the unit tangent vector along $C$. Without parameterizing $C$, evaluate $\int_C \mathbf{F} \cdot d\mathbf{r}$ by using the fact that it is equal to $\int_C \mathbf{F} \cdot \mathbf{T} \, ds$.

   (b) Find a parameterization of $C$ and a formula for $\mathbf{F}$. Use them to check your answer in (a) by computing $\int_C \mathbf{F} \cdot d\mathbf{r}$ explicitly.

3. Consider the points $A = (0, 0)$ and $B = (\pi, -2)$. Suppose an object of mass $m$ moves from $A$ to $B$ and experiences the constant force $\mathbf{F} = -mg\mathbf{j}$, where $g$ is the gravitational constant.

   (a) If the object follows the straight line from $A$ to $B$, calculate the work $W$ done by gravity using the formula from the first week of class.
(b) Now suppose the object follows half of an inverted cycloid $C$ as shown below. Explicitly parameterize $C$ and use that to calculate the work done via a line integral.

(c) Find a function $f : \mathbb{R}^2 \to \mathbb{R}$ so that $\nabla f = F$. Use the Fundamental Theorem of Line Integrals to check your answers for (a) and (b). Have you seen the quantity $-f$ anywhere before? If so, what was its name?

4. If you get this far, work #52 from Section 16.2:

48. Experiments show that a steady current $I$ in a long wire produces a magnetic field $B$ that is tangent to any circle that lies in the plane perpendicular to the wire and whose center is the axis of the wire (as in the figure). *Ampère’s Law* relates the electric current to its magnetic effects and states that

$$\int_C B \cdot dr = \mu_0 I$$

where $I$ is the net current that passes through any surface bounded by a closed curve $C$, and $\mu_0$ is a constant called the permeability of free space. By taking $C$ to be a circle with radius $r$, show that the magnitude $B = |B|$ of the magnetic field at a distance $r$ from the center of the wire is

$$B = \frac{\mu_0 I}{2\pi r}$$