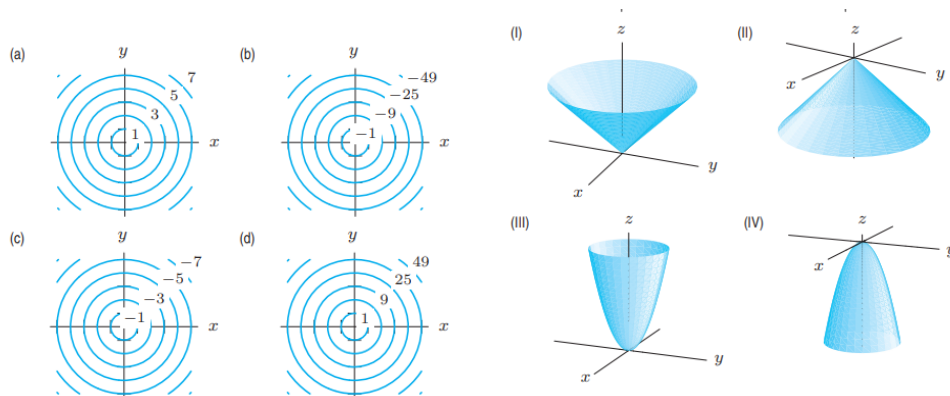1. (10 pts) Let $f(x) = \sqrt{x^2 - 1}$. Please answer the following questions.

   (a) (4 pts) Write down the domain and range of f.

   (b) (4 pts) Write out expressions for $f(x + 2)$ and $f(x) + 2$.

   (c) (2 pts) Does $f(x)$ have an inverse function? Explain.

2. (10 pts) For t in months, a population, in thousands, is approximated by a **continuous** function

$$P(t) = \begin{cases} e^{kt} & 0 \le t \le 12 \\ 100 & t > 12 \end{cases}$$

   (a) (3 pts) What is the initial value of the population?

   (b) (7 pts) What must be the value of k?

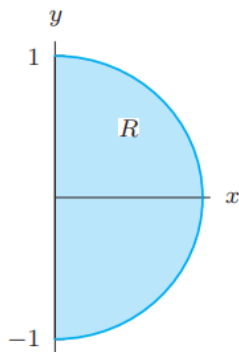3. (10 pts) Use the following table to answer the questions below

x	0	0.2	0.4	0.6	0.8	1.0
$f(x)$	3.7	3.5	3.5	3.9	4.0	3.9

   (a) (4 pts) Using the table, estimate $f'(0.6)$ and $f'(0.5)$.

   (b) (3 pts) Estimate $f''(0.6)$

   (c) (3 pts) Where do you think the maximum and minimum values of f occur in the interval $0 \le x \le 1$?

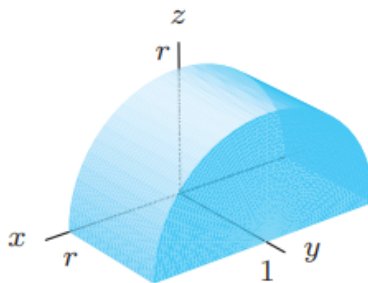4. (10 pts) Match the contour diagrams (a)–(d) with the surfaces (I)– (IV).

5. (10 pts) Your house lies on the surface $z = f(x, y) = 2x^2 - y^2$ directly above the point $(4, 3)$ in the xy plane.

   (a) (2 pts) How high above the xy plane do you live?

   (b) (4 pts) What is the slope of your lawn as you look from your house directly toward the z-axis (that is along the vector $(-4, -3)$)?

(c) (2 pts) When you wash your car in the driveway, on this surface above the point $(4, 3)$, which way does the water run off? (Give your answer as a two-dimensional vector.)

(d) (2 pts) What is the equation of the tangent plane to this surface at your house?

6. (10 pts) Use polar coordinate to integrate $f(x, y) = \sqrt{\frac{1}{x^2+y^2}}$ over the shaded region in the figure below.

7. (10 pts) We want to express the volume of the the half cylinder below as an integral of the cylindrical coordinate $\int_W f\, dV$ where W is the half cylinder and $dV = r\, dr\, d\theta\, dy$.

(a) (2 pts) What must the function f be?

(b) (5 pts) Write the limits of the integration.

(c) (3 pts) Evaluate the integral.

8. (10 pts) Let C be the line segment connecting the points $\mathbf{p} = (1, 2, 0)$ and $q = (0, 1, -1)$

(a) Find a curve $\mathbf{c}(t) : [a, b] \to \mathbb{R}^3$ that traces out C.

(b) Find the arc length of $\mathbf{c}(t)$.

(c) Find $\|\mathbf{p} - \mathbf{q}\|$.

9. (10 pts) Let $\mathbf{c}(t) = (\sin t, \cos t, t)$ with $0 \le t \le 2\pi$. Let $\mathbf{F}$ be defined by $\mathbf{F}(x, y, z) = (x, y, z)$. Compute $\int_{\mathbf{c}} \mathbf{F} \cdot d\mathbf{s}$.

10. (10 pts) Decide whether the following statements are true or false.

   (a) If a function is continuous, it must be differentiable.

   (b) The curl of a vector field is a vector.

   (c) The divergence of a vector field is a vector.

   (d) The function $f(x, y) = x^3 + y^3 - 3xy$ has two critical points.

   (e) A function having no critical points in a region R cannot have a global maximum in the region.