1. (a) Elliptic paraboloid ($y \geq 0$)
   (b) Hyperboloid of one sheet
   (c) The plane $x + y + z = 2$
2. (a) $x = t,\ y = \sqrt{8} + \sqrt{2}\,t,\ z = 1 + t$
   (b) $v = 2\left(\frac{1}{t} + t\right)$
   (c) $\kappa(1) = \frac{\sqrt{2}}{8}$
   (d) $a_T(1) = 0$ and $a_N(1) = 2\sqrt{2}$
3. (a) The limit does not exist.
   (b) The limit is 2.
4. (a) $dz = \frac{x}{\sqrt{x^2+y^2}}dx + \frac{y}{\sqrt{x^2+y^2}}dy$
   (b) $f(3.06, 3.92) \simeq f(3,4) + dz|_{(3,4)} = 4.972$
5. (a) $D_{\mathbf{u}}F(P) = 2\sqrt{3}$
   (b) $\|\nabla F(P)\| = \sqrt{206}$
   (c) In the direction $\frac{1}{\sqrt{206}}\langle 9, 10, 5\rangle$
   (d) $9x + 10y + 5z = 33$
   (e) $D_{\overrightarrow{PQ}}F(P) = 0$
   (f) $\frac{\partial z}{\partial y} = -\frac{2x^2 + 2yz^3}{x + 3y^2z^2}$
6. Note that $\frac{\partial z}{\partial x} = 2xy\frac{\partial f}{\partial u}$ and $\frac{\partial z}{\partial y} = f(u) - 2y^2\frac{\partial f}{\partial u}$ leading to the result.
7. The points $(-1,-1)$ and $(1,1)$ are both local minima while $(0,0)$ is a saddle point.
8. $(-\frac{2}{\sqrt{3}}, \frac{2}{\sqrt{3}}, -\frac{2}{\sqrt{3}})$
9. (a) $\frac{1}{4}(1 - \cos(16))$
   (b) $\frac{\pi}{4}(\sin 5 - \sin 4)$
   (c) $\frac{81\sqrt{18}\,(2 - \sqrt{2})\pi}{5}$
10. (a) $\int_{-3}^{3}\int_{-\sqrt{9-x^2}}^{\sqrt{9-x^2}}\int_{\sqrt{1+x^2+y^2}}^{\sqrt{19-x^2-y^2}} dzdydx$
    (b) $\int_{0}^{2\pi}\int_{0}^{3}\int_{\sqrt{1+r^2}}^{\sqrt{19-r^2}} rdzdrd\theta$
11. $\frac{16}{5}$
12. $f^{(27)}(-6) = \frac{9}{28}$

13. (a) $\dfrac{x^3}{5+x^2} = \sum_{n=0}^{\infty} \dfrac{(-1)^n x^{2n+3}}{5^{n+1}}$ $\quad R = \sqrt{5}$

(b) $\dfrac{\arctan(3x^2)}{x} = \sum_{n=0}^{\infty} \dfrac{(-1)^n 3^{2n+1} x^{4n+1}}{2n+1}$ $\quad R = \dfrac{1}{\sqrt{3}}$

14. $\int_0^{0.1} xe^{-x^3}\,dx = \sum_{n=0}^{\infty} \dfrac{(-1)^n (0.1)^{3n+2}}{(3n+2)n!} \simeq 0.004998$

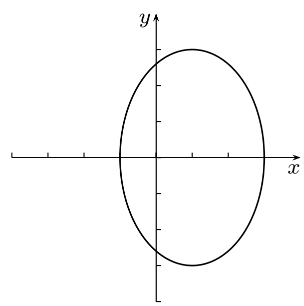
15. (a) $f(x) = \dfrac{1}{3} + \sum_{n=1}^{\infty} \dfrac{(-1)^n (2n-1)!!(x-9)^n}{3^{2n+1}2^n n!}$ $\quad R = 9$

(b) $R_2(x) = \dfrac{-15(x-9)^3}{8(3!)(z^{7/2})}$ which implies that $|R_2(9.5)| \leq 1.78 \times 10^{-5}$

16. (a) $\dfrac{dy}{dx} = \dfrac{-3\cot t}{2}$ and $\dfrac{d^2y}{dx^2} = \dfrac{-3}{4\sin^3 t}$

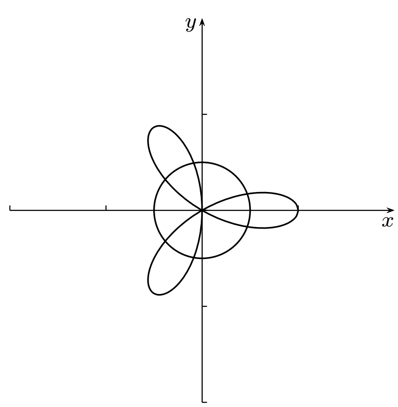
(b) Vertical tangents at $(-1, 0)$ and $(3, 0)$; horizontal tangents at $(1, -3)$ and $(1, 3)$

(c) The curve is the ellipse $\frac{(x-1)^2}{4} + \frac{y^2}{9} = 1$



(d) $I = -12\int_0^{\pi} \sin^2 t\,dt$ and $A = -I$

17. (a) The curves are a rose with 3 petals and a circle respectively



(b) $A = 3\left(\int_0^{\pi/9} \dfrac{1}{4}\,d\theta + \int_{\pi/9}^{\pi/6} \cos^2(3\theta)\,d\theta\right)$

(c) $L = 6\int_0^{\pi/6} \sqrt{1 + 8\sin^2(3\theta)}\,d\theta$