1) Use the chain rule to find $\frac{dz}{dt}$.

a) $z = x^2 y + xy^2$, $x = 2 + t^4$, $y = 1 - t^3$

b) $z = \sin x \cos x$, $x = \pi t$, $y = \sqrt{t}$

a) $\boxed{4(2xy + y^2)^3 - 3(x^2 + 2xy)t^2}$

b) $\boxed{\pi \cos x \cos y - \frac{1}{2\sqrt{t}} \sin x \sin y}$

2) Use the chain rule to find $\frac{dw}{dt}$.

a) $w = xe^{y/z}$, $x = t^2$, $y = 1 - t$, $z = 1 + 2t$

b) $w = xy + yz^2$, $x = e^t$, $y = e^t \sin t$, $z = e^t \cos t$

a) $\boxed{e^{y/z}\left(2t - \frac{x}{z} - \frac{2xy}{z^2}\right)}$

b) $\boxed{e^t\left[y + (x + z^2)(\cos t + \sin t) + 2yz(\cos t - \sin t)\right]}$

3) Use the chain rule to find $\frac{\partial z}{\partial s}$ and $\frac{\partial z}{\partial t}$.

a) $z = x^2 + xy + y^2$, $x = s + t$, $y = st$

b) $z = \sin \alpha \tan \beta$, $\alpha = 3s + t$, $\beta = s - t$

a) $\boxed{\frac{\partial z}{\partial s} = 2x + y + xt + 2yt, \quad \frac{\partial z}{\partial t} = 2x + y + xs + 2ys}$

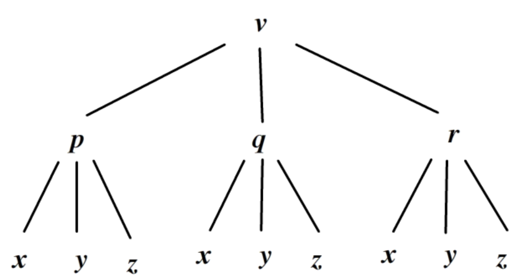
b) $\boxed{\frac{\partial z}{\partial s} = 3\cos \alpha \tan \beta + \sin \alpha \sec^2 \beta, \quad \frac{\partial z}{\partial t} = \cos \alpha \tan \beta - \sin \alpha \sec^2 \beta}$

4) Let $W(s,t) = F(u(s,t), v(s,t))$, where F, u, and v are differentiable, use the table of values to find $W_s(1,0)$ and $W_t(1,0)$.

	u	u_s	u_t	v	v_s	v_t	F_u	F_v
$(1,0)$	2	-2	6	3	5	4	-1	10

$$\boxed{W_s(1,0) = 52, \quad W_t(1,0) = 34}$$

5) Use a tree diagram to write out the chain rule for: $v = f(p,q,r)$ where, $p = p(x,y,z),\ q = q(x,y,z),\ r = r(x,y,z)$ assume all functions are differentiable.



$$\frac{\partial v}{\partial x} = \frac{\partial v}{\partial p}\frac{\partial p}{\partial x} + \frac{\partial v}{\partial q}\frac{\partial q}{\partial x} + \frac{\partial v}{\partial r}\frac{\partial r}{\partial x}$$
$$\frac{\partial v}{\partial y} = \frac{\partial v}{\partial p}\frac{\partial p}{\partial y} + \frac{\partial v}{\partial q}\frac{\partial q}{\partial y} + \frac{\partial v}{\partial r}\frac{\partial r}{\partial y}$$
$$\frac{\partial v}{\partial z} = \frac{\partial v}{\partial p}\frac{\partial p}{\partial z} + \frac{\partial v}{\partial q}\frac{\partial q}{\partial z} + \frac{\partial v}{\partial r}\frac{\partial r}{\partial z}$$

6) Differentiate implicitly to find $\frac{dy}{dx}$.

a) $x^2 - xy + y^2 - x + y = 0$

b) $\cos(x - y) = xe^y$

a) $\boxed{\frac{y - 2x + 1}{2y - x + 1}}$

b) $\boxed{\frac{\sin(x - y) + e^y}{\sin(x - y) - xe^y}}$

7) Differentiate implicitly to find $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$.

a) $x^2 + y^2 + z^2 = 3xyz$

b) $xyz = \cos(x + y + z)$

a) $\boxed{\frac{\partial z}{\partial x} = \frac{3yz - 2x}{2z - 3xy}, \frac{\partial z}{\partial y} = \frac{3xz - 2y}{2z - 3xy}}$

b) $\boxed{\frac{\partial z}{\partial x} = -\frac{yz + \sin(x + y + z)}{xy + \sin(x + y + z)}, \frac{\partial z}{\partial y} = -\frac{xz + \sin(x + y + z)}{xy + \sin(x + y + z)}}$

8) The radius of a right circular cylinder is increasing at a rate of 6 inches per minute, and the height is decreasing at a rate of 4 inches per minute. What are the rates of change of the volume and surface area when the radius is 12 inches and the height is 36 inches?

$$\boxed{\frac{dV}{dt} = 4608\pi \ in.^3/\text{min}, \frac{dS}{dt} = 624\pi \ in.^2/\text{min}}$$

9) Suppose $z = f(x, y)$, where $x = g(s, t)$ and $y = h(s, t)$, find and expression for $\frac{\partial^2 z}{\partial t^2}$.

$$\boxed{\frac{\partial^2 z}{\partial t^2} = \frac{\partial^2 z}{\partial x^2}\left(\frac{\partial x}{\partial t}\right)^2 + 2\frac{\partial^2 z}{\partial x \partial y}\frac{\partial x}{\partial t}\frac{\partial y}{\partial t} + \frac{\partial^2 z}{\partial y^2}\left(\frac{\partial y}{\partial t}\right)^2 + \frac{\partial z}{\partial x}\frac{\partial^2 x}{\partial t^2} + \frac{\partial z}{\partial y}\frac{\partial^2 y}{\partial t^2}}$$