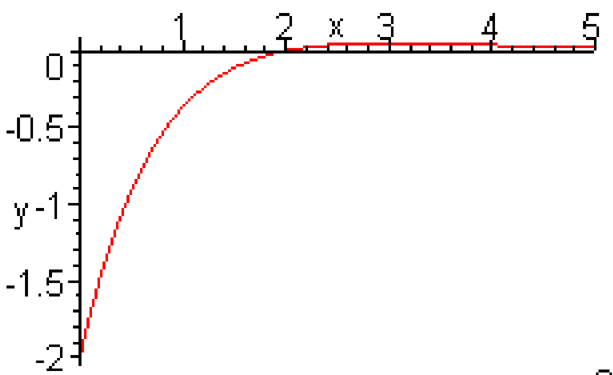
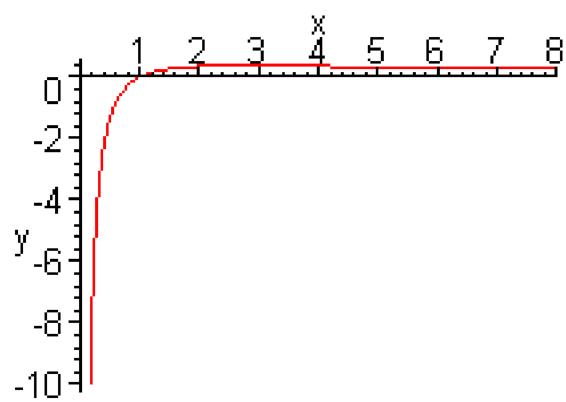
2. Consider $f(x) = (x^2 - e^{2x} + 1)(3x + 8)$, then the product rule gives $f'(x) = 3(x^2 - e^{2x} + 1) + (3x + 8)(2x - 2e^{2x})$.

4. Consider $f(x) = \frac{1}{x^2}\ln(x) - e^{2x}(x^2 - 1) = x^{-2}\ln(x) - e^{2x}(x^2 - 1)$. The product rule gives $f'(x) = x^{-2}\left(\frac{1}{x}\right) + (-2x^{-3})\ln(x) - \left(e^{2x}(2x) + 2e^{2x}(x^2 - 1)\right) = x^{-3}(1 - 2\ln(x)) - 2e^{2x}(x^2 + x - 1)$.

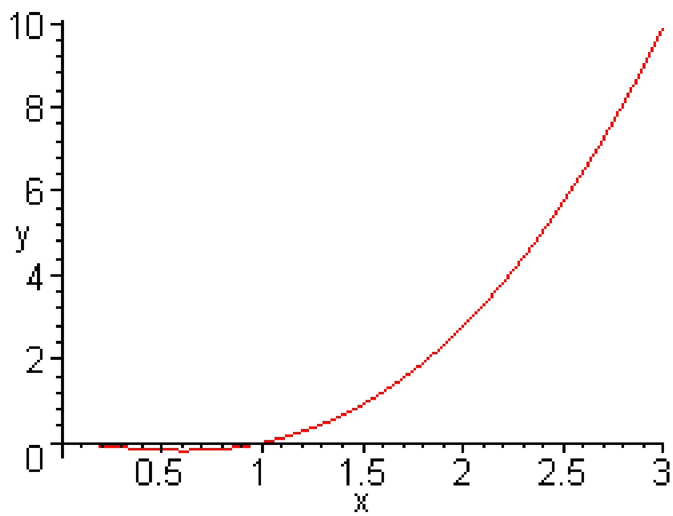
6. $y = (x - 2)e^{-x}$
Domain is all x.
y-intercept: $y(0) = -2$, so $(0, -2)$.
x-intercept: Since the exponential function is not zero, $y = 0$ when $x = 2$.
Horizontal asymptote: As $x \to \infty$, $y \to 0$, so $y = 0$ is a horizontal asymptote (looking to the right).
Derivative: By the product rule, $y'(x) = -(x - 2)e^{-x} + e^{-x} = (3 - x)e^{-x}$.
Critical points satisfy $y'(x) = 0$, so $3 - x = 0$ or $x = 3$. With $y(3) = e^{-3} \simeq 0.0498$, $(3, 0.0498)$ is a maximum.
The graph is below.





7. $y = \frac{1}{x}\ln(x) = x^{-1}\ln(x)$
Domain is $x > 0$.
y-intercept: None since outside the domain.
x-intercept: $y = 0$ implies that $\ln(x) = 0$ or $x = 1$.
Vertical asymptote: At the edge of the domain, so when $x = 0$.
Derivative: By the product rule, $y'(x) = x^{-1}\left(\frac{1}{x}\right) - x^{-2}\ln(x) = x^{-2}(1 - \ln(x))$.
Critical points satisfy $y'(x) = 0$, so $1 - \ln(x) = 0$ or $x = e^1 = e$. With $y(e) = e^{-1}\ln(e) = e^{-1} \simeq 0.368$, $(2.72, 0.368)$ is a maximum.
The graph is above to the right.

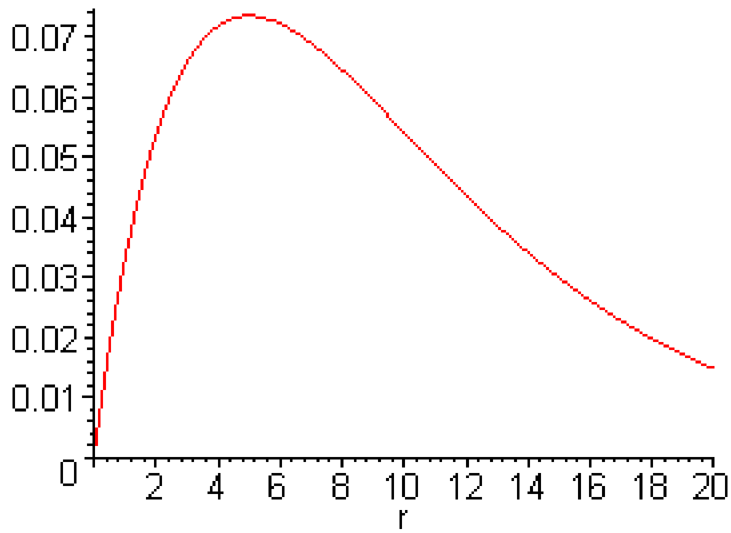
9. $y = x^2 \ln(x)$,
Domain is $x > 0$.
y-intercept: Outside the domain, so none.
x-intercept: Solve $x^2 \ln(x) = 0$. Since $x \neq 0$, then $\ln(x) = 0$ or $x = 1$, so $(1, 0)$
No asymptotes. However, $\lim_{x \to 0} y(x) = 0$. (This can be checked by a calculator, but requires more Calculus to confrim.)
Derivative: $y'(x) = x^2 \left(\frac{1}{x}\right) + 2x \ln(x) = x + 2x \ln(x)$.
Critical points when $y'(x) = 0$ or $x(2\ln(x) + 1) = 0$. Since $x \neq 0$, then $2\ln(x) = -1$ or $x = e^{-1/2} \simeq 0.6065$.
$y(e^{-1/2}) = e^{-1} \ln(e^{-1/2}) = -\frac{1}{2}e^{-1} \simeq -0.1839$, so there is a minimum at $\left(e^{-1/2}, -\frac{1}{2}e^{-1}\right) = (0.6065, -0.1839)$.



10. a. The equilibrium satisfies $N_e(0.8 - 0.04\ln(N_e)) = 0$. Since $N = 0$ is not in the domain. Thus, the equilibrium satisfies $0.04\ln(N_e) = 0.8$ or $\ln(N_e) = 20$. It follows that the equilibrium is $N_e = 4.852 \times 10^8$.

b. By the product rule, the derivative is $G'(N) = N(0.04/N) + (0.8 - 0.04\ln(N)) = 0.76 - 0.04\ln(N)$. The maximum growth rate satisfies $0.76 - 0.04\ln(N) = 0$ or $\ln(N) = 19$. Thus, the maximum rate of growth occurs at $N_{max} = e^{19} = 1.785 \times 10^8$ with a maximum growth rate of $G(N_{max}) = 7.139 \times 10^6$.

12. By the product rule, the derivative is $P'(r) = 0.04e^{-0.2r} - 0.008re^{-0.2r}$.The maximum probability occurs when the derivative is zero, $0.04e^{-0.2r} - 0.008re^{-0.2r} = 0.04e^{-0.2r}(1-0.2r)$ or $0.2r = 1$. Thus, the maximum probability of a seed landing occurs at $r = 5$ m with a probability of $P(5) = 0.0736$. The graph of the probability density function has an intercept at $(0,0)$ ($P(0) = 0$), a horizontal asymptote of $P = 0$ (since for large r, P becomes arbitrarily small), and a local maximum of $(5, 0.0736)$.



13. The velocity of air passing through the windpipe satisfies:

$$v(r) = Ar^2(R-r) = ARr^2 - Ar^3,$$

where A and R are constants. Differentiating $v(r)$ gives

$$v'(r) = 2ARr - 3Ar^2 = Ar(2R-3r).$$

Thus, critical points occur at $r_c = 0$ and $2R/3$. The former is clearly a minimum, so the maximum air velocity occurs at $r_c = 2R/3$ with a maximum air velocity of

$$v(2R/3) = A\left(\frac{2R}{3}\right)^2\left(R - \frac{2R}{3}\right) = \frac{4AR^3}{27}.$$