1. **C.** By the Second Derivative Test, if f has a horizontal tangent line, then the concavity determines the feature of the graph. If the graph is concave up at a horizontal tangent line, then the graph feature is a relative minimum.

2. **B.** Average value $= \dfrac{1}{b-a}\displaystyle\int_a^b f(x)dx$. Here, the integral is $\dfrac{1}{4}\displaystyle\int_{-2}^{2} x^2dx = \dfrac{8/3-(-8/3)}{4} = \dfrac{4}{3}$

3. **D.** The factorial function grows much faster than any exponential so eventually $n!$ dominates e^{n^2}. Therefore, the limit is $-\infty$.

4. **C.** First we need to determine when $f(x)$ is increasing. $f'(x) = 3 - 3x^2 \longrightarrow x = \pm 1$. So $g(x)$ gives us a rectangle with width 2 and height 1. Area $= 2$.

5. **B.** The maximum area of a triangle with a fixed perimeter occurs when the triangle is equilateral. Thus the side length is $\frac{2s}{3}$. Since the area of an equilateral triangle with side length x is given by $\dfrac{x^2\sqrt{3}}{4}$, our desired area is $\dfrac{s^2\sqrt{3}}{9}$.

6. **E.** $f(x) = \ln x^{-1} = -\ln x$. So $f'(x) = \dfrac{-1}{x}$. Thus, $f'(1) = -1$.

7. **C.** The Intermediate Value Theorem guarantees a root of $f(x)$ when there exists points a and b such that $f(a) < 0 < f(b)$ or $f(a) > 0 > f(b)$ AND $f(x)$ is continuous. Since continuity is implied by differentiability, conditions I and III suffice.

8. **D.** $\displaystyle\int_{-2}^{2} f(x)dx = 7 \longrightarrow \int_{2}^{-2} f(x)dx = -7$. $\displaystyle\int_{5}^{2} f(x)dx + \int_{2}^{-2} f(x)dx = \int_{5}^{-2} f(x)dx = (3)+(-7) = -4$. Thus, $\displaystyle\int_{5}^{-2} 2f(x)dx = -8$ and $\displaystyle\int_{5}^{-2} -3dx = 21$. Thus the answer is $-8+21 = 13$.

9. **D.** Suppose the lines are tangent to $f(x)$ and $g(x)$ at $x = a$ and $x = b$ respectively. Then because the tangent lines must have the same slope, $f'(a) = f'(b) \rightarrow 2a-2 = -2b+10 \rightarrow a+b = 6$. Suppose also that the tangent line is of the form $y = mx + h$. Then the points $(a, f(a))$ and $(b, f(b))$ must be on this line. Thus we have $a^2 - 2ab + 3 = (2a-2)(a) + h$ and $-b^2 + 10b - 17 = (-2b+10)(b) + h$. Solving for h in both equations and setting equal yields $a^2 + b^2 = 20$. With this equation and $a + b = 6$, we have that either $a = 2, b = 4$ or $a = 4, b = 2$. When $a = 4$, this yields the line with the larger slope: $y = 6x - 13$.

10. **E.** $f'(x) = 6x^2 - 14x + 4 = 0 \longrightarrow 3x^2 - 7x + 2 = 0 \longrightarrow (3x-1)(x-2) = 0$. Testing points on intervals shows that $x = -1/3$ is a maximum and $x = 2$ is a minimum.

11. **D.** The derivative of a^x is $a^x \ln(x)$. So $f'(x) = \pi^{x^2} \ln \pi \cdot 2x$.

12. **A.** $h'(x) = g'(f(x)+3x)\cdot(f'(x)+3)$. Thus $h'(2) = g'(f(2)+6)\cdot(f'(2)+3) = g'(3)\cdot(-1+3) =$

$(-2)(2) = -4$

13. **B.** It is not necessary to integrate the function because it is odd on equal but opposite bounds and therefore the integral is 0.

14. **B.** The appropriate substitution to make is $(x-2) = 4\sin(u)$. Thus, $dx = 4\cos(u)du$. So the new integral becomes $\int_0^{\frac{\pi}{6}} \frac{16\sin^2(u) \cdot 4\cos(u)du}{16\cos(u)} = \int_0^{\frac{\pi}{6}} 4\sin^2(u)du = 2u - \sin 2u$ from $u = 0$ and $u = \frac{\pi}{6}$. Evaluating gives $\frac{\pi}{3} - \frac{\sqrt{3}}{2}$

15. **C.** Make the u-sub $u = x^3 + 2x$. Thus $du = 3x^2 + 2$. The integral has the form $\int_3^{33} \frac{2du}{u} = 2(\ln(33) - \ln(3)) = 2\ln(11)$

16. **A.** The acceleration of the particle is given by $s''(t) = 12t - 12 = 0 \longrightarrow t = 1$. The velocity at $t = 1$ is given by $s'(1) = 6 - 12 + 4 = -2$.

17. **C.** Because each piece is continuous, we can plug in $x = 2$ for both pieces and since the values are the same, the limit exists. Because $f(2) = 0$, the same as the limit, $f(x)$ is continuous at 3. However, the derivatives $3x^2$ and 1 do not match at $x = 2$, so it is not differentiable.

18. **D.** $f(0) = \frac{A}{1+B} = 30$. Using this, we can plug into $f'(0) = \frac{.4(30)B}{(1+B)} = 9 \longrightarrow \frac{12B}{1+B} = 9 \longrightarrow B = 3$ and $A = 120$. So as $t \to \infty$, we get that $f(t) = 120$.

19. **E.** We can use L'Hospitals rule on each of these limits. $A = 1, B = \frac{-\pi}{3}, C = \frac{1}{2}$

20. **D.** Since $y = x^3$, we know that $x = y^{1/3}$. Thus, $V = \pi \int_0^h (y^{\frac{2}{3}}dy) \longrightarrow \frac{dV}{dt} = \frac{dV}{dh}\frac{dh}{dt} = (\pi h^{\frac{2}{3}})(\frac{dh}{dt})$. We're given dV/dt and h, so using $\frac{dV}{dt} = \frac{dV}{dh}\frac{dh}{dt} \longrightarrow 32\pi = (4\pi)(\frac{dh}{dt})$

21. **B.** Consider $\lim_{n\to\infty} \left|\frac{a_{n+1}}{a_n}\right|$. In order for the series to converge, this expression must be less than 1. Thus $-1 < \frac{x}{\pi^2} < 1$ The endpoints cannot be included because both $1+1+1+...$ and $1-1+1-...$ diverge.

22. **B.** The equation of the line tangent to this curve is $y = x$. Since $y = x$ outgrows $y = e^{-x}\sin(x)$ when $x > 0$, we need only to consider when $x < 0$. When $x = -\frac{\pi}{2}, e^{-x}\sin x$ is below $y = x$ which was already tangent at $x = 0$, but since $y = e^{-x}\sin(x)$ has to come back up to $y = 0$ at $x = -2\pi$, it will intersect once more.

23. **B.** Plug in the assumed solution into the equation: $r(r-1)x^r + 3rx^r - 8x^r = 0 \longrightarrow r^2 - r + 3r - 8 = 0 \rightarrow r = 2, r = -4$. Since only the positive answer was asked for, $r = 2$

24. **A.** $f'(x) = \dfrac{(x^2+1)^{\frac{1}{2}}(2x) - (x^2+3)(1/2)(x^2+1)^{-\frac{1}{2}}(2x)}{x^2+1} = \dfrac{(x^2+1)^{-\frac{1}{2}}((x^2+1)(2x) - (x^2+3)(x))}{x^2+1} = 0 \longrightarrow 2x^3 + 2x - x^3 - 3x = 0 \longrightarrow x = 0, -1, 1$. However, endpoints are not included in satisfying Rolle's Theorem.

25. **C.** To revolve a curve around the x-axis, evaluate $\pi \int_{\frac{1}{2}}^{\infty} \left(\frac{1}{x}\right)^2 dx$. Integrating this gives $\pi\left(-\frac{1}{\infty} + 2\right) = 2\pi$

26. **A.** $dy = (4x - 4 + 36/x^2)dx$. $dx = 1$ at $x = 3$. Thus, $dy = (12 - 4 + 4)(1) = 12$. And we have that $f(3) = 18 - 12 + 1 - 12 = -5$. So the approximation of $f(4) \approx f(3) + dy \longrightarrow f(4) \approx -5 + 12 = 7$

27. **B.** Because the derivatives of $\cos(x)$ form a cycle of 4, the 2008th derivative of $\cos(x)$ is $\cos(x)$. So the 2009th derivative is $-\sin(x)$. At $\frac{\pi}{3}$, this evaluates to $-\frac{\sqrt{3}}{2}$

28. **A.** The area of a triangle is given by $A = .5ab\sin(C)$. Differentiating this with respect to time yields $\frac{dA}{dt} = .5ab\cos(C)\frac{dC}{dt} \longrightarrow \frac{dA}{dt} = .5(4)(6)(1/2)\frac{\pi}{12} = \frac{\pi}{2}$. You MUST use the radian measure for dC/dt.

29. **A.** $F'(x) = \dfrac{\tan(\pi x^2)}{1+x^2}2x$. So plugging in $-\frac{1}{2}$ gives $\dfrac{\tan(\pi/4)}{1+.25}(-1) = -4/5$.

30. **D.** In order to get the area, list the coordinates in order as given and multiply diagonally. Add the first and fourth columns, find the positive difference, and divide by two to get the area of the polygon.

	1	2	
10	5	0	0
0	$2t^2$	t^2	$5t^2$
$3t^2$	3	6	$12t^2$
6	1	2	6
$16 + 3t^2$			$17t^2 + 6$

So the area is $7t^2 - 5$. Differentiating gives $14t$. At $t = 3$, dA/dt = 42.