Show all your work.

1. (10 pts.) Find the exact intervals on which $f(x) = x^4 - x^3 - 3x^2$ is concave up and on which it is concave down.

   (NOTE: It is not necessary to find inc/dec or to graph $f$.)
2. (10 pts.) Suppose that $g(x) = \sin^2 x + \cos x$, restricted to the domain $0 \leq x \leq 2\pi$.

(a) Find the exact locations of all critical points in the domain.

(b) Sketch a graph of $g$ in which all increase and decrease intervals are *perfectly* visible. Label your axes. Don’t worry about concavity. Graph paper is provided below.
3. (10 pts.) A box with a square end and unspecified width is shown at right. Use differential approximation to find the percentage change in its volume if $x$ changes by 3%. **Show all your work.**

4. (10 pts.) Find $\lim_{x \to 0} \frac{x \cos 3x}{e^{2x} - 1}$
5. (15 pts.) The acceleration of a falling object (in m/s$^2$) is measured every 5 seconds and recorded in the following table:

<table>
<thead>
<tr>
<th>$t$ (s)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$ (m/s$^2$)</td>
<td>-10</td>
<td>-5</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) Graph the acceleration data on the graph paper provided below. Be sure to label your graph properly.

(b) Assuming initial velocity of $v(0) = 0$ m/s, compute $v(20)$.

(c) Shade an area in your graph that exactly matches your computation.
6. (15 pts) The graph of a function $f$ is shown at right. The curved portion of $f$ is a perfect quarter-circle with radius 3. Assume

$$g(x) = \int_{4}^{x} f(t) \, dt$$

(a) Compute $g(6)$
(b) Compute $g(1)$
(c) Compute $g(x)$, where $x$ is a fixed location somewhere between $-1$ and 1.
7. (10 pts.) Compute

\[ \int_{-2}^{2} (3x^2 + x^{-3} + 6 \cos x) \, dx \]

Use any methods (except asking your calculator). Be sure to show all your work.