d. [3 points] A ball is thrown down from a hovercraft cruising above *Jupiter*. The ball's height above Jupiter's surface, h, in feet, is given by:

$$h = -40t^2 - 20t + 560$$

where t is measured in seconds after the ball was released.

From the moment the ball was released, how many seconds did it take for the ball to reach the surface of Jupiter? *Show all work. Give your answer in exact form, or rounded to at least two decimal places.*

Solution: The ball is on the surface of Jupiter when its height h above the surface of Jupiter is 0 feet. Therefore, we are looking for a positive value of t such that $-40t^2 - 20t + 560$ is equal to 0. We can solve for the values of t which make this expression 0 by factoring it:

$$\begin{aligned} -40t^2 - 20t + 560 &= 0 \\ -20(2t + t - 28) &= 0 \\ 2t + t - 28 &= 0 \\ (2t - 7)(t + 4) &= 0 \\ t &= \frac{7}{2} \text{ or } t = -4 \end{aligned}$$

We don't consider $t = -4$ since it would correspond to a time before the ball was thrown, so we see that it took $t = 7/2$ seconds for the ball to reach the surface of Jupiter.
We could also have computed this answer using the quadratic formula with $a = -40$, $b = -20$, and $c = 560$. This would give us

$$\begin{aligned} t &= \frac{-(-20) \pm \sqrt{(-20)^2 - 4(-40)(560)}}{2(-40)} \\ &= \frac{20 \pm \sqrt{400 + 160(560)}}{-80} \\ &= \frac{20 \pm \sqrt{90,000}}{-80} \\ &= \frac{20 \pm 300}{-80} \end{aligned}$$

as the solutions to the equation $-40t^2 - 20t + 560 = 0$. These two solutions simplify to $\frac{20+300}{-80} = \frac{320}{-80} = -4$ and $\frac{20-300}{-80} = \frac{-280}{-80} = \frac{7}{2}$. Taking the positive value of t, $\frac{7}{2}$, gives us the same solution as factoring did above.

7/2=3.5 seconds

5. [7 points] On the axes below, sketch a graph of a **single function** $j(x)$ that satisfies all of the following properties:

- $j(x)$ has zeros at $x = 1$ and $x = 3$.
- The domain of $j(x)$ is $-6 \le x < \infty$.
- $j(x) \longrightarrow -2$ as $x \longrightarrow \infty$. In other notation: $\lim_{x \to \infty} j(x) = -2$.

- $j(x)$ is decreasing on the interval $[-6, -4]$.
- The average rate of change of $j(x)$ on the interval $-3 \le x \le -1$ is 2.
- $j(x)$ is concave down on the interval $1 < x < 3$.

Solution: There are many possible solutions. Below is just one possibility.