CME 252: Homework 2
Due: Saturday, October 17, 11:59pm

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Check your solutions with `grade_hw2.py`.

Submit your completed `hw2.py` to this Dropbox File Request link: https://www.dropbox.com/request/TehA2ACBUuXOz7a6XMOy

Problem 1: Convex Functions

Determine if each of the following functions is "convex", "concave", "both", or "neither".

In function `prob1()` of `hw2.py`, set the keys of the `answer` dictionary to the appropriate string: `"convex"`, `"concave"`, `"both"`, or `"neither"`.

The script `grade_hw2.py` will **only** check that you've changed the values to something other than `None`, so as not to give away the answer.

1. $1 + x$
2. logistic loss: $\log(1 + e^{-x})$ (Hint: Use 2nd derivative test.)
3. for $x \in \mathbf{R}^n$: $\max_i x_i - \min_i x_i$
4. $\cosh(x) = \frac{e^x + e^{-x}}{2}$
5. $\frac{1}{1+x^2}$ with domain $\mathbf{R}$
6. $\frac{1}{1+x^2}$ with domain $\mathbf{R}_+$

Problem 2: Regression

Given $x, y \in \mathbf{R}^n$, find coefficients $w \in \mathbf{R}^4$ to fit the model

$$y \approx w_0 + w_1 x + w_2 x^2 + w_3 \sin(x)$$

with the least-squares loss function $\ell(z) = z^2$.

Fill in `prob2(x,y)` to return w as a NumPy array. The following bit of NumPy code may be helpful:

```
np.vstack([np.ones(n), x, x**2, np.sin(x)]).T
```

Problem 3: Regression

Given $x, y \in \mathbf{R}^n$, find coefficients $w \in \mathbf{R}^4$ to fit the model

$$y \approx w_0 + w_1 x + w_2 x^2 + w_3 \sin(x)$$

to minimize the worst-case error. That is, solve the problem

$$\text{minimize}_w \quad \max_i |w_0 + w_1 x_i + w_2 x_i^2 + w_3 \sin(x_i) - y_i|.$$

Fill in `prob3(x,y)` to return w as a NumPy array.