Question 2a Recall the optimal value of θ should minimize our loss function. One way we've approached solving for θ is by taking the derivative of our loss function with respect to θ, like we did in HW5.

Write/derive the expressions for following values and write them with LaTeX in the space below.

- $R(\mathbf{x}, \mathbf{y}, \theta_1, \theta_2)$: our loss function, the empirical risk/mean squared error
- $\frac{\partial R}{\partial \theta_1}$: the partial derivative of R with respect to θ_1
- $\frac{\partial R}{\partial \theta_2}$: the partial derivative of R with respect to θ_2

Recall that $R(\mathbf{x}, \mathbf{y}, \theta_1, \theta_2) = \frac{1}{n} \sum_{i=1}^{n} (\mathbf{y}_i - \hat{\mathbf{y}}_i)^2$

- $R(\mathbf{x}, \mathbf{y}, \theta_1, \theta_2) = \frac{1}{n} \sum_{i=1}^{n} (\mathbf{y}_i - \theta_1 \mathbf{x} - \sin(\theta_2 \mathbf{x}))^2$
- $\frac{\partial R}{\partial \theta_1} = \frac{1}{n} \sum_{i=1}^{n} 2(\mathbf{y}_i - \theta_1 \mathbf{x} - \sin(\theta_2 \mathbf{x})) * (-\mathbf{x})$
- $\frac{\partial R}{\partial \theta_2} = \frac{1}{n} \sum_{i=1}^{n} 2(\mathbf{y}_i - \theta_1 \mathbf{x} - \sin(\theta_2 \mathbf{x})) * (-\cos(\theta_2 \mathbf{x})) * (\mathbf{x})$

In 1-2 sentences, describe what you notice about the path that theta takes with a static learning rate vs. a decaying learning rate. In your answer, refer to either pair of plots above (the 3d plot or the contour plot).

The static learning rate gradient descent approaches the minimum by bouncing back and forth until it reaches the optimal value. On the othr hand, the decaying learning rate smooths out until it reaches the optimal value, instead of bouncing a lot back and forth.

0.0.1 Question 4b

Is this model reasonable? Why or why not?

The model is not reasonable. Consider the portion of the graph where teams are losing 100% of the time. Teams scoring below 80 pts generally have lost most of the games, however according to our model these teams have around a 70% of chance of winning. Furthermore, the chance of winning a game is favorable as soon as a team scores 1 point, which is not reflected in our data and logically cannot be true.

0.0.2 Question 4c

Try playing around with other theta values. You should observe that the models are all pretty bad, no matter what θ you pick. Explain why below.

As discussed earlier the reason why this model will not work is that it is centered around 0 pts. Since it is not possible to receive negative points, our model cannot give probabilities less than 50% for lower scoring teams. Thus, the model is saying that as soon as a team scores a point they will more often than not win, which from the distribution. of data points in the graph above is not true. For higher theta values, the model predicts a win for lesser amount of points scored while for lower theta values, the model predicts the team must score a lot more points to win (which is possibly true). Nevertheless, centering around 0 makes this model unreasonable.

0.0.3 Question 5b

Using the plot above, try adjusting θ_2 (only). Describe how changing θ_2 affects the prediction curve. Provide your description in the cell below.

For every increase of θ_2 by 1, we shift the graph opver by 20 points. Thus θ_2 affects the center of the graph, where the probabilities start to shift from higher probability of losing to higher probability of winning.

0.0.4 Question 7c

Look at the coefficients in `theta_19_hat` and identify which of the parameters have the biggest effect on the prediction. For this, you might find `useful_numeric_fields.columns` useful. Which attributes have the biggest positive effect on a team's success? The biggest negative effects? Do the results surprise you?

In [ ]:
```
useful_numeric_fields.columns
```

Biggest Contributers: FGM, FG3_PCT, FT_PCT Biggest Setbacks: FG_PCT, PTS, FGA

The statistics with a positive affect on the team include FGM(field goals made), FG3_PCT(3pt field goals percentage made) and FT_PCT(free throw percentage). These factors make sense to the team winning as those with a higher percentage of scores and higher field goals made would win a higher percentage of time.

The statistics with a negstive affect on teams winning are FG_PCT(Field goal percentage), PTS(points) and FGA(field goal attempted). These results suprise me a bit as Field goal percentage could determine if a team would win or not, however it does make sense that PTS and FGA are not good indicators as higher attempts does not inidicate if they scored better, and PTs are generally close between teams.

To double-check your work, the cell below will rerun all of the autograder tests.

In [234]:
```
grader.check_all()
```

Out[234]:
```
q1:

    All tests passed!


q2b:

    All tests passed!


q3a:

    All tests passed!


q3b:

    All tests passed!
```

```
q4a:

    All tests passed!

q5a:

    All tests passed!

q5c:

    All tests passed!

q6a:

    All tests passed!

q6b:

    All tests passed!

q6c:

    All tests passed!

q6d:

    All tests passed!

q7a:

    All tests passed!

q7b:

    All tests passed!
```

0.1 Submission

Make sure you have run all cells in your notebook in order before running the cell below, so that all images/graphs appear in the output. The cell below will generate a zip file for you to submit. **Please save before exporting!**

In [ ]:
```
# Save your notebook first, then run this cell to export your submission.
grader.export("hw7.ipynb")
```