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

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

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 gradient descent with decay learning rate can observed to take less steps, therefor it will converge faster than the static learning rate.

0.0.1 Question 4b

Is this model reasonable? Why or why not?

This model is not reasonable because the probability of winning based on the points in the visulation is too high. For example having around a 68% probability of winning when scoring only 75 points is unreasonable.

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.

The models are pretty bad because it is difficult to predict whether a team won or not simply based on how many points they scored. Simply put, however many points the team scored the opposing team could have scored more.

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.

Lower values of θ_2 decreases the win probability of the prediction curve and higher values increase the win probability.

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 [66]:
```
theta_19_hat
```

Out[66]:
```
array([ 2.1239e+00, -4.5115e-01, -2.1898e+01,  9.2304e-01, -3.5553e-03,
        2.7252e+00,  8.8270e-01, -7.1648e-02,  2.1081e+00,  3.0481e-01,
        3.2550e-01,  4.8715e-02,  1.9556e-02,  3.8726e-01,  6.9643e-02,
       -3.1119e-01, -5.5789e-02, -7.5458e-01,  5.1914e+00])
```

In [67]:
```
useful_numeric_fields.columns
```

Out[67]:
```
Index(['FGM', 'FGA', 'FG_PCT', 'FG3M', 'FG3A', 'FG3_PCT', 'FTM', 'FTA',
       'FT_PCT', 'OREB', 'DREB', 'REB', 'AST', 'STL', 'BLK', 'TOV', 'PF',
       'PTS', 'BIAS'],
      dtype='object')
```

The attributes that have the biggest positive effect are FGM and FT_PCT, the attributes with biggest negative effect are FG3M. While I expected field goals made and free throw percentage to have a big positive effective I was surprised that 3 field goal made had the biggest negative effect. This is because I thought making 3 point field goal would have a big positive effect because it each 3 point field goal made could give a team a substantial lead.

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

In [68]:
```
grader.check_all()
```

Out[68]:
```
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 [69]:
```
# Save your notebook first, then run this cell to export your submission.
grader.export("hw7.ipynb")
```

```
<IPython.core.display.HTML object>
```