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.

In the space below, use LaTeX to write/compute the following values: * $R(\mathbf{x}, \mathbf{y}, \theta_1, \theta_2)$: 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 $R(\mathbf{x}, \mathbf{y}, \theta_1, \theta_2) = \frac{1}{n} \sum_{i=1}^{n} (\mathbf{y}_i - \hat{\mathbf{y}}_i)^2$

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

$\frac{\partial R}{\partial \theta_1} = \frac{1}{n} \sum_{i=1}^{n} 2(\theta_1 x_i + \sin(\theta_2 x_i) - y_i) * x_i$

$\frac{\partial R}{\partial \theta_2} = \frac{1}{n} \sum_{i=1}^{n} 2(\theta_1 x_i + \sin(\theta_2 x_i) - y_i) * \cos(\theta_2 x_i) * x_i$

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 path that the static learning rate takes is much more jagged, with each successive gradient jumping around in various directions. The decaying learning rate is much more direct, that is, the gradient generally descends down in one direction.

0.0.1 Question 4b

Is this model reasonable? Why or why not?

No because the win probability is stuck in the range 0.5-0.8. This means no matter what points a team scores, the probility of a team winning is stil very high, which can be problematic when it comes time to classify.

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.

This is a binary response variable, meaning the response is either a 0 or 1. The underlying relationship is thus not linear and is better suited when fitted by another model. A simple linear model will also be problematic because it's possible that the output will go beyond the range of [0,1], which wouldn't make sense, and it's also very sensitive to outliers.

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.

Making θ_2 more negative makes the s-curve lose it shapes until it becomes linear on the winning probability 0 (predicts 0 for all points). The opposite is true as θ_2 becomes more positive, the curve gradually starts to get more linear until it lies on the winning probability of 1 (predicts 1 for all points).

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?

Not including the intercept term, FGM, FG3_PCT, and FT_PCT have the biggest positive effects. FG_PCT and PTS have the biggest negative effects. Using my very limited basketball knowledge, I'm assuming the three parameters with the biggest positive effects (field goals, 3 point field goal, free throw percentage) makes sense in contributing to higher scores and thus a higher prediction value; these three attributes seem to be associated with higher scores. FG_PCT (field goal percentage), which has the biggest negative effect at -2.1902e+01, is the ratio of field goals made to field goals attempted which makes sense in having a negative effect because it factors attempted field goals – teams may have a low FG_PCT ratio but still have a high overall score.

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

In [65]:
```
grader.check_all()
```

Out[65]:
```
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 zipfile for you to submit. **Please save before exporting!**

In [66]:
```
# Save your notebook first, then run this cell to export your submission.
grader.export()
```

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