Please answer the below questions succinctly:

1. (20 points) Rescorla-Wagner model: Write a computer program (in Matlab or any other programming language) that learns first-order conditioning according to the Rescorla-Wagner learning rule. Show a learning curve and an extinction curve for three different learning rates: 0.1, 0.5, 0.9. You do not have to hand in your code, only the plot and its explanation.

2. (30 points, breakdown below) Temporal-Difference learning model: Write a computer program (in Matlab or any other programming language) that learns according to the Temporal-Difference learning rule.
   a. (10 points) First order conditioning: condition CS1 to a US and plot the learning curve for the three learning rates you used in question 3. Compare to the plots from question 3.
   b. Second order conditioning: condition a CS2 to the already conditioned CS1, and show the value of the second order stimulus (CS2) throughout training
      i. (5 points) What happens if the US is also given in each training trial?
      ii. (5 points) What happens if the US is not given in any training trial?
      iii. (5 points) What happens if you combine CS1 → US trials with CS2 → CS1 trials?
      iv. (5 points) Explain the differences between i,ii,iii

      (in all cases you don't have to hand in code, but only plots and explanations)

3. (10 points) The XOR problem: Animals were conditioned with three types of trials (randomly interleaved):

   (1) CS1 → US

   (2) CS2 → US

   (3) CS1+CS2 → no US

   After conditioning the animals showed a conditioned response to each of the stimuli when presented separately, but not to the simultaneous presentation of both. Can the Rescorla-Wagner theory explain this learning? Can Temporal-Difference learning explain it? What causes the problem?

   Bonus (5 points) - Suggest an idea that will improve the models and allow them to deal with such learning

4. (10 points) Serial compound representation: To explain phenomena that happen within a conditioning trial, the trial must be divided into different time-bins, each with its own learned value. This is sometimes called a "serial compound representation" or a "tapped delay line" due to origins in different disciplines. Explain how does such a breakdown of the trial explain why animals are slower to acquire conditioning with longer CS-US intervals? You can explain theoretically and/or using simulations.

   Bonus (5 points) - can this representation explain why trace conditioning is slower than delay conditioning?

5. (10 points) Inhibitory conditioning and dopamine: In an inhibitory conditioning experiment the experimenter alternated trials in which A was paired with a juice reinforcer, and trials in which AB were paired with no reinforcer. The experimenter also recorded the activity of dopaminergic neurons in the conditioned animals. What dopaminergic response (above baseline, blow baseline or at baseline) would you expect at the time of presentation of A alone? What about the presentation of AB together? What dopaminergic response would you expect at the time of the US following A? What about the no US following AB? Finally, what response would you expect if you showed B alone, with no US following it, at the time of presentation of B? explain.
   (to see what really happened in such an experiment, read the assigned paper by Tobler, Dickinson and Schultz!)

   Bonus (5 points): What dopaminergic response would you expect in a B only trial, at the time of no US (that is, at the time when normally a US would have appeared for A)? Think carefully.