Project self-evaluation. List all three members of your design group, including yourself. Rate each team member’s level of effort and teamwork during the design and construction process, on a scale of 1 (didn’t do anything whatsoever, didn’t even show up for our meetings) to 10 (was full of ideas, came to all or our meetings, did a lot of the fabrication, was a great teammate). Give a one-sentence justification of each rating. A person’s rating should not be dependent on whether his/her ideas or work actually ended up on the final device.

Problem 1. (Total 15 pts) We described the structured design process as having four steps. The first step was task clarification, the second was conceptual design, and the fourth was detail design.

(a) (5 pts) What’s the third step in the structured design process? Describe briefly what you do in the third step.

(b) (5 pts) In which step would you expect to develop formal drawings to send to, say, the manufacturing division of a company? Explain briefly.

(c) (5 pts) In which step would you expect to use a ‘decision matrix’? Explain briefly.

[A] Embodiment design – this is where you develop the final configuration after you’ve made major design choices in the conceptual design step.

[B] Detail design – this is where you finalize design specifications for e.g. sending the product out for fabrication

[C] Conceptual design – a decision matrix helps you choose among different design concepts.

[3 pts : answer]
[2 pts : explanation]
Problem 2. (Total 20 pts) On HW 8 we discussed the pluses and minuses of building a dam in the Grand Canyon for both power generation and water storage. Let's focus on power generation. In practice, in this country the decision to build a dam often comes down to a choice between a dam and a coal-fired power plant (in fact there's a huge coal plant not far from the Glen Canyon Dam). Let's weigh the choice between a dam in the Grand Canyon and a coal-fired plant using the decision matrix below.

<table>
<thead>
<tr>
<th></th>
<th>Clean energy? (10)</th>
<th>Other environ. impact (8)</th>
<th>Cost (6)</th>
<th>Other econ. impact (6)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>207</td>
</tr>
<tr>
<td>Coal plant</td>
<td>3</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>188</td>
</tr>
</tbody>
</table>

(a) (6 pts) First fill in the weights assigned to the categories of whether the energy produced is clean, other environmental impact (e.g. on wildlife, or in the form of mining), cost, and other economic impact (e.g. on tourism or industry). I've already assigned a weight of '10' to the clean energy category, so for example if you think cost considerations are twice as important as whether the energy is clean, give a '20'. Explain your chosen weights briefly below.

E.g. "OTHER ENVIRONMENTAL IMPACT" IS SLIGHTLY LESS IMPORTANT THAN CLEAN ENERGY PRODUCTION, SO IT GETS 8/10

ETC.

(6 pts: REASONABLE EXPLANATIONS)

(b) (8 pts) Now fill in a rating for each option (dam or coal-fired plant) in each category on a scale of 1 to 10. Higher scores means the option is more favorable in a given category. For example, a '10' in 'Other environmental impact' means that the the option has very little negative impact; a '10' in 'Cost' means that the option has very reasonable cost (make educated guesses in categories you're unfamiliar with). Explain your chosen scores for the 'Other environmental impact' and 'Other economic impact' categories briefly below.

E.g. DAME: ADVERSELY AFFECTS MARINE LIFE AND NATURAL FLOODING CYCLES → 4/10 OTHER ENVIR

Probably increases tourism, provides jobs → 7/10 OTHER ECON.

COAL PLANT: EXTRA IMPACT OF MINING IS SMALL SINCE SO MANY COAL PLANTS ALREADY EXIST, SO PRETTY BAD → 8/10 OTHER ENVIR

WON'T HELP TOURISM, WILL PROVIDE SOME JOBS → 5/10 OTHER ECON.

(8 pts: REASONABLE EXPLANATIONS)
(Problem 2 continued.)

(c) (6 pts) Which option has a higher total score (computed by summing up, for each option, the products of weight and score for each category)? Is it possible to move the second-place option into first place by changing its score in just one of the categories? If so, what one change would be adequate?

\[ \text{Total: } \text{DAM} = 10 \cdot 1.1 + 8.4 + 8.4 + 6.7 = 206 \quad \leftarrow \text{DAM `wins'} \]
\[ \text{coal} = 10.3 + 8.8 + 8.8 + 5.6 = 188 \quad \leftarrow (3 \text{ pts: computation}) \]

So coal can come out on top with 19 + more points,

e.g. if its "clean energy" score went from

3 to 5 (giving 2.10 = 20 more pts).  

\[ (3 \text{ pts: proper change}) \]
Problem 3. (Total 20 pts) Suppose you have a slab of aluminum in the form of a square cylinder, where the cross-sectional side length is $W = 3$ inches and the whole piece is $L = 18$ inches long, as shown below. Let’s explore how you might transform this raw material into some different objects.

![Diagram](image_url)

(a) (5 pts) Suppose you want to transform your slab of aluminum into the shape shown below, complete with holes that go all the way through the slab:

![Diagram](image_url)

How would you accomplish this manually (no computer-controlled tools) in the machine shop? Identify which machine(s) you’d use and describe briefly how you’d use it/them.

- Use a mill to cut the notch by moving the part sideways over its full length  \(-3\) pts
- Use a drill press to drill the holes \(-2\) pts  
  (Mill works too)

(b) (5 pts) Now suppose you want to make this thing, which has a long slot that goes all the way through it:

![Diagram](image_url)

Identify which manual machine(s) you’d use to make this, and describe briefly how you’d use it/them.

- Use a mill to drill a hole with the proper width, then translate the part sideways to make the slot  \(-3\) pts
- Use a drill press to drill the holes  \(-2\) pts
(Problem 3 continued.)

(c) (5 pts) Finally consider this:

![Diagram](image)

Identify which manual machine(s) you'd use to make this, and describe briefly how you'd use it/them.

3 pts

**USE A LATHE. SPIN THE PART ON ITS LONG AXIS AND CUT AWAY MATERIAL TO FORM THE CIRCULAR CROSS-SECTION.**

2 pts

(d) (5 pts) On a trip to the library, you find these two publications that discuss machining:


Say whether each of these publications is a journal article or a book, and explain how you know.

**First: Journal Article.** It has journal and article titles, a volume #, and a range of pages.

**Second: Book.** One title only, publisher, total # of pages.

2 pts: Answers

3 pts: Explanations
Problem 4. (Total 25 pts)

(a) (5 pts) You are given a properly normalized histogram that displays the average study time per week for engineering students. The x-axis is given in units of hours. The bin that spans from 7.75 to 8.25 hours has height 0.26. What percentage of engineering students studies between 7.75 and 8.25 hours per week?

\[ \text{Probability is given by bin area. This bin has area } 0.5 \times 0.26 = 0.13 \]

\[ \text{13% of eng. students studies 7.75 to 8.25 hrs/wk.} \]

(b) (5 pts) The mean grade on a certain exam is 34 out of 50, and the standard deviation is 7.1. Then, one student who scored 34 on the exam is expelled from the university for cheating. Does the mean go up, down, or is it unchanged? Does the standard deviation go up, down, or remain unchanged? Explain your answers.

- Mean is unchanged:
  \[ \frac{\sum_{i=1}^{N-1} C_i + 34}{N} = 34 \Rightarrow \frac{\sum_{i=1}^{N-1} C_i = 34(N-1)}{\sum_{i=1}^{N-1} C_i} = \frac{34}{N-1} \]

- Std. dev goes up:
  \[ \sigma = \left[ \frac{\sum_{i=1}^{N} (C_i - 34)^2}{N} \right]^{1/2} \]

(c) (15 pts) The following vector shows the margins of victory in the last 20 Super Bowl football games:

\[ M = (45, 1, 13, 35, 17, 23, 10, 14, 7, 15, 7, 27, 3, 27, 3, 3, 11, 12, 3, 4) \]

- Draw two properly normalized bin histograms for these data, for bin widths \( \Delta = 4 \) points and \( \Delta = 10 \) points. Make the first bin in each case span from \([0.5, 0.5 + \Delta]\), have the second bin go from \([0.5 + \Delta, 0.5 + 2\Delta]\), etc.

- Explain briefly what you think the shape of the histogram of these values should look like (consider, for example, whether large margins of victory in any kind of game are more or less likely than small margins). Based on this, which bin width, \( \Delta = 4 \) points or \( \Delta = 10 \) points, looks like it is better for displaying the data? Explain.

(over)
(Extra workspace for Problem 4.)

\[ \Delta = 4 \]

\[
\begin{array}{cccccc}
0.5 & 4.5 & 8.5 & 12.5 & 16.5 & 20.5 & 24.5 & 28.5 & 32.5 & 36.5 & 40.5 & 44.5 & 48.5 \\
\end{array}
\]

Population: 6 2 3 3 1 1 2 1

\[ \Delta = 10 \]

\[
\begin{array}{cccccc}
10.5 & 20.5 & 30.5 & 40.5 & 50.5 \\
\end{array}
\]

Pop.: 9 6 3 1 1

[ 5 pts: Form ]

[ 4 pts: Normalization ]

\[ \quad \]

- Especially between good teams (which should be well matched) we expect small margins to be most likely, and increasing margins to be consistently less likely. The \( \Delta = 10 \) histogram displays this better.

\[ \quad \]

\[ \quad \]

7 5 pts
Problem 5. (Total 20 pts) Consider the plot below where there looks to be an approximate linear relation between the data points:

![Plot](image)

Suppose the x-axis values for the data are stored in the vector \( X \) in your Matlab workspace, and the y-axis values are in the vector \( Y \).

(a) (10 pts) Suppose that you manage a widget factory with very lax attendance rules, and the x-axis in the above plot represents the number of employees you had at work on a given day, and the y-axis represents the number of widgets they produced. One day \( N \) workers come to work. If you want to get a good estimate of how many widgets these \( N \) workers will produce, would it be better to do a linear interpolation on the plotted data, or a linear regression? Explain. Write the appropriate, very short, Matlab script to do this.

- **LINEAR REGRESSION WOULD BE THE BETTER CHOICE.**

  - You don't necessarily 'trust' your data: you may have a data point that says \( N_0 \) workers made \( Y_0 \) widgets on some day, but that doesn't guarantee that if \( N_0 \) workers show up on some other day, they'll make exactly \( Y_0 \) widgets.

  - Linear regression will give a good estimate for the production of \( N \) workers w/o assuming that your existing data points are exactly correct.

- **MATLAB COMMAND: 'POLYFIT'**

  \[ P = \text{POLYFIT}(x, y, 1); \]

  \[ \hat{Y}_N = \text{POLYVAL}(P, N); \]

  Estimated \( Y \) for \( N \) workers
(Problem 5 continued.)

(b) (10 pts) Now suppose that you're the sales manager for a start-up widget company, and the 
x-axis represents days in chronological order, and the y-axis represents the number of widgets 
sold on the particular day. You should have records for every day, but a computer crash means 
that you only have the data shown on the plot. If you want to estimate what your widget sales 
were on some day $X0$ for which you don't have sales data, would it be better to do a linear 
interpolation on the plotted data, or a linear regression? Explain. Write the appropriate, very 
short, Matlab script to do this.

- **Linear Interpolation is Best** 3 pts

  -> In this case your data points are exact - you're just trying 
  to fill in gaps. 3 pts

- **Matlab Command:** `interp1` 1 pt

  $\gg y0 = \text{interp1}(x,y,x0,\text{"linear"};$ 3 pts
  
  OK to 
  omit this: 
  `interp1` defaults 
  to linear interpolation
Problem 6. (20 pts) Consider an empty rectangular room as shown in a top view below. The width of the room, \( w \), is the same as its height. There is a door in one of the long walls and a large square window in one of the short walls. The door reaches almost to the ceiling, while the window is centered in its wall. Make two drawings: first draw the room in one-point perspective from the vantage point 'A', then draw the room in three-point perspective from the vantage point 'B'. In each case imagine that the vantage point is just below the ceiling, and indicate on your drawings where your vanishing point(s) are.

10 pts each:

- 4 pts general perspective (line types)
- 2 pts room borders
- 2 pts window
- 2 pts door
Problem 7. (Total 30 pts) A certain math class is populated almost evenly by math majors and non-math majors among \(N\) total students. In the interest of fairness, the instructor decides to compute grades for the two groups separately. At the end of the semester, she compiles two data vectors. In the vector \(M = [M_1 \ M_2 \cdots M_N]\), \(M_i\) has value 1 if student \(i\) is a math major, and \(M_i = 2\) if student \(i\) isn't a math major. The second vector, \(G\), also has length \(N\), and gives the numerical course grade for each student \(i\).

(a) (15 pts) Suppose you'd like to know (and display) the mean grade for the math majors, and the mean grade for the non-math majors. Draw a flowchart that accomplishes this task. The vectors \(M\) and \(G\) and the number \(N\) are already defined and can be input to the flowchart.

(b) (15 pts) Write a Matlab script that computes and displays the mean grade for math majors and the mean grade for non-math majors. You may assume that the vectors \(M\) and \(G\) are already defined in the Matlab session. Include comments in your script so that your programming logic is clear.
1. \( N = \text{LENGTH} (M); \)
2. \( TM = 0; \)
3. \( TNM = 0; \)
4. \( NM = 0; \)
5. \textbf{FOR} \( i = 1: N \)
   6. \textbf{IF} \( M(i) = 1 \) \text{ Go HERE for Math Majors }
   7. \( NM = NM + 1; \)
   8. \( TM = TM + C(i); \)
   9. \textbf{ELSE} \text{ Here for Non-Math Majors }
   10. \( TNM = TNM + C(i); \)
11. \textbf{END FOR} \( i \)
12. \textbf{END} \( \)
13. \( AM = TM/NM; \)
14. \( ANM = TNM/(N-NM); \)
15. \( \text{PRINTF ('THE MATH MAJOR MEAN GRADE IS \%f \', AM}); \)
16. \( \text{PRINTF ('THE NON-MATH MAJOR MEAN GRADE IS \%f \', ANM}); \)
Problem 8. (Total 30 pts)

(a) (7 pts) Consider the following Matlab script:

```matlab
>> clear
>> p = [1 3 1 3 5 6 8 3 2 5];
>> i = 1;
>> while p(i) < 6
    >> y(i) = p(i);
    >> i = i + 1;
>> end
>> i=4;
>> if y(i) == (p(i-1)+2)
    >> y(i) = y(i) + 2;
else
    >> y(i) = 1;
end
```

What is y after the program runs?

\[
\begin{bmatrix} 1 & 3 & 1 & 5 & 5 \end{bmatrix}
\]

(3 pts if answer \[ \begin{bmatrix} 1 & 3 & 1 & 5 & 5 \end{bmatrix} \]; 1 pt for any attempt)

(b) (7 pts) Now consider this Matlab script:

```matlab
>> clear
>> A = [3 4 7 9 2 5];
>> B = [1 8 9 6 3 1];
>> N = length(A);
>> for i = 1:N
    >> C(i) = A(i)+B(i);
>> end
>> for i = 1:(N-1)
    >> diff(i) == C(i+1)-C(i-1);
>> end
```

This script won’t run. What’s the problem?

- In second for-loop, when \( i = 1 \), \( C(i-1) \) doesn’t exist.
- Also: in second loop "diff(i) = " should be "diff(i) = ".

(7 pts for either one)
(Problem 8 continued.)

(c) (16 pts) Write a Matlab script that takes a vector \( A \), which is already defined in your workspace, finds and displays the lowest value in the vector, and also displays the number of times that value occurs in the vector. Do not use any internal Matlab functions except \texttt{length}. Include comments in your script so that your programming logic is clear.

(it's possible to do this task in a single for loop - this example will use two for clarity)

1. \% FIRST PART - FIND MINIMUM VALUE
2. \texttt{N = length(A);}
3. \% 'LOW' VARIABLE KEEPS TRACK OF LOWEST VALUE THROUGH LOOP
4. \texttt{LOW = A(1);}
5. \texttt{FOR \ i = 2:N}
6. \texttt{\textbf{IF} \ A(i) < LOW}
7. \texttt{\textbf{LOW} = A(i);} \hspace{1cm} 2 pts general syntax
8. \texttt{\textbf{END}} \hspace{1cm} 6 pts determination of minimum value
9. \texttt{\textbf{END}} \hspace{1cm} 6 pts counting of occurrences of minimum val.
10. \% NOW COUNT OCCURRENCES OF 'LOW', IN 'NUMBER' VARIABLE
11. \texttt{\textbf{NUMBER} = 0;}
12. \texttt{\textbf{FOR} \ i = 1:N}
13. \texttt{\textbf{IF} \ A(i) = LOW}
14. \texttt{\textbf{NUMBER} = NUMBER + 1}
15. \texttt{\textbf{END}} \hspace{1cm} 2 pts output
16. \texttt{\textbf{END}}
17. \texttt{\textbf{PRINTF(' LOWEST VALUE OF \%d OCCURS \%d TIMES \n', LOW, NUMBER)}}