Chapter 11 HW Problem

In this problem you are given a mathematical function for which to design a mechanical function generator. The problem includes the selection of initial and final points for the input and output links, and development of a MATLAB function for linkage synthesis. You will construct a working model of your function generator, then create an ADAMS model to obtain accurate input/output data. Finally, you will create another MATLAB function for structural error analysis. You will email both functions to me, and submit your analysis and working model for grading.

1 Synthesizing the Mechanism

In this problem you will use Freudenstein's Equation to synthesize a linkage to generate a mathematical function. Your methodology will follow my writeup of that material.

1.1 Function.

The specific function you generate will be one of the following:

First letter of your last name	Function	Range
a,k,u	$\log 10x$	$1 \leq x \leq 2$
b,l,v	$\sin x$	$0 \leq x \leq \pi/2$
c,m,w	$\tan x$	$0 \leq x \leq \pi/4$
d,n,x	e^x	$0 \leq x \leq 1$
e,o,y	$1/x$	$1 \leq x \leq 2$
f,p,z	$x^{1.5}$	$0 \leq x \leq 1$
g,q	x^2	$0 \leq x \leq 1$
h,r	$x^{2.5}$	$0 \leq x \leq 1$
i,s	x^3	$0 \leq x \leq 1$
j,t	x^2	$-1 \leq x \leq 1$

1.2 Precision Points

Use Chebyshev Spacing to select the three precision points used in the solution of the link lengths.

1.3 Arbitrary Parameters

You are free to select the initial and final values for link angles θ_2 and θ_4 but try to have a range of at least **60 DEGREES** for each.

1.4 Synthesizing the Linkage

You are to write a MATLAB function `freud.m` to perform automated synthesis of the linkage. The format of the function shall be

```
>> function [r,c2,c4] = freud(fn,xi,xf,t2i,t2f,t4i,t4f)

  [r,c2,c4] = FREUD(fn,xi,xf,t2i,t2f,t4i,t4f) performs three-point kinematic
  synthesis of a four-bar mechanism using Freudenstein's Equation.  Function
  handle "fn" computes the mathematical function.  xi and xf specify the range
```

```
of the independent variable, and Chebyshev spacing is used to determine the
three precision points for the dependent variable.  Angles t2i, t2f, t4i,
and t4f (DEG) specify the limits of motion of links 2 and 4.
Returned 4x1 vector r contains the link lengths, with r(1) = 1, while
returned vectors c2 and c4 contain the scaling & bias parameters to go
to/from [x y] space to [t2 t4] space to check the accuracy.
```

This function is not long: mine contained only 24 lines of M-code.

1.5 Design Iteration

Iterate the design until you achieve satisfactory results. Try to avoid any one link being much longer than the others. I have not done all these designs; I'm assuming since they are in the text they are feasible (not necessarily a good assumption).

1.6 Model Construction

Construct a working model of your function generator, including input and output scales. Try to be as accurate and neat as possible. You can scale the entire linkage up or down as needed.

1.7 Error Analysis

In this section you need an *EXACT* implementation of your linkage from which to collect its input/output characteristics. The structural error is the difference between the actual mathematical function and the operation of your linkage.

1.7.1 ADAMS Simulation

The first step is to construct an ADAMS/View model of your linkage, positioned at the initial position. This should be similar to the previous four-bar linkages we have built in ADAMS, except for the inclusion of *MEASURES*. Create them just like in the example I did. You may need to modify a `MEASURE` in the ADAMS/Postprocessor to reflect the joint angle measurement convention of text Figure 11.25.

1.7.2 Data Collection and MATLAB Processing

After you perform a simulation, you should plot the joint angle data (can be done in ADAMS or MATLAB), but to compute the error you need to save the joint angle data to a file for subsequent processing by MATLAB. Follow the methods in my example, and write the following MATLAB function to compute the structural error:

```
>>function [x,y,ya] = struc_err(fn,data,c2,c4)

  [x,y,ya] = struc_err(fn,data,c2,c4) computes the structural error
  of a four-bar function-generating mechanism.  Function handle "fn"
  defines the prescribed mathematical function.  Parameter "data" is a
  2-column array with link 2 angle (DEG) in column 1, and link 4 angle (DEG)
  in column 2.  Parameters "c2" and "c4" are the 2x1 arrays of scaling and
  bias coefficients which map from variable space to link angle space.  The
  "structural error" is simply the difference between the actual function
  y values and the ones from the linkage.  Returned vectors "x", "y", and
  "ya" are the function dependent variable, exact independent variable, and
  approximate independent variable (from your linkage).
```

This function is even shorter: mine contained only 5 lines of M-code!

2 Submission of Results

You will submit three distinct articles:

1. Linkage synthesis writeup (including ADAMS simulation)
2. Two MATLAB functions via `email`
3. Function generator working model

2.1 Linkage Synthesis Writeup

This should follow my example, and should contain whatever analysis, plots, and results you feel is appropriate. You should include a screenshot of your ADAMS/View model. You will submit this at the beginning of class on Monday, March 1.

2.2 MATLAB Functions

You will submit the two MATLAB functions:

```
function [r,c2,c4] = freud(fn,xi,xf,t2i,t2f,t4i,t4f)
```

```
function [x,y,ya] = struc_err(fn,data,c2,c4)
```

As is typical in MATLAB, you should save these functions with filenames `freud.m` and `struc_err.m`, respectively. You will `email` me both files as attachments before 12:00 on Monday, March 1. Mail them to `starr@unm.edu`.

2.3 Function Generator Working Model

Build a model using cardboard, thumbtacks, *etc.* Make up input and output scales, like mine. Be sure and label yours with the function and your name. Submit your models at the beginning of class on Monday, March 1.