Why I love gears...

Layman’s Introduction to Gears

Ninad Watwe

What are gears?

- Rigid power transmission devices that transfer rotary motion, AND lets you play with it…
  - You can change the speed (and hence torque)
  - You can change the direction
    - And do all of this with positive engagement
      - Usually with a rather high transmission efficiency!!!
- They provide a constant velocity ratio by virtue of the underlying geometry

Types of Gears

- Spur Gears
- Helical Gears
  - Herring Bone Gears
- Bevel Gears
  - Spiral Bevel
- Hypoid
- Worm-Wheel

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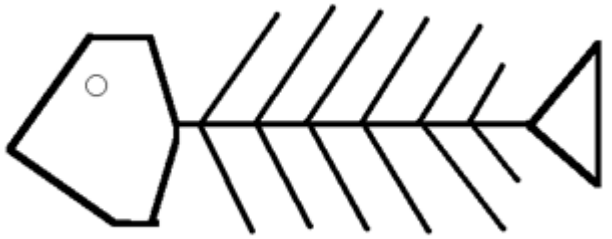

Images from: Google Images

Types of Gears

- Spur Gears
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  - Spiral Bevel
- Hypoid
- Worm-Wheel (<- This is used in slew drives)

Images from: Google Images

We will talk about the spur gears in this presentation!

All I need is…

This is all one needs, to completely define a gear:

- PCD  
- m 

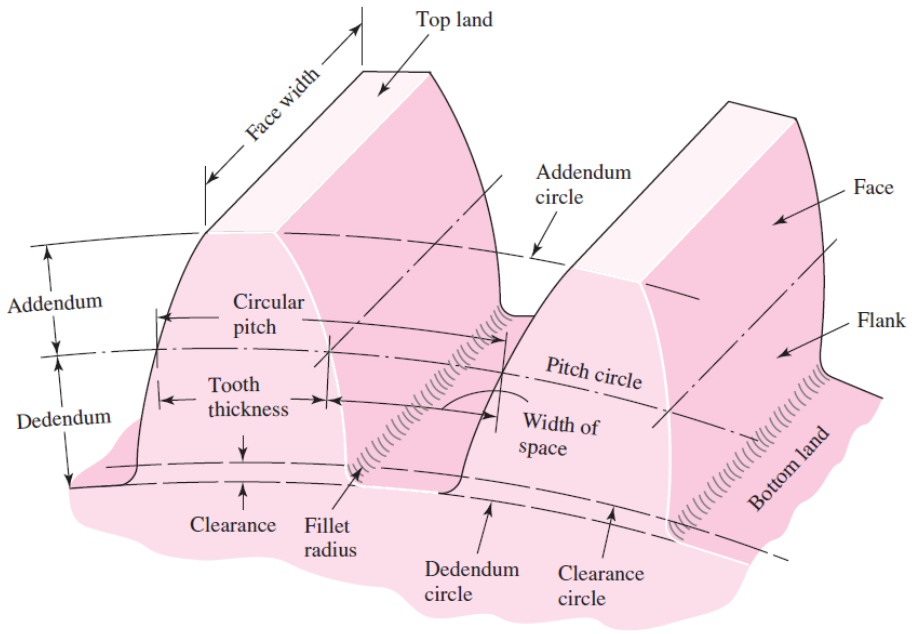
Images from: Google Images

Achtung!

Only gears of the same module mesh.

But a module does not completely define the shape of the tooth (you also need to know the number of teeth in the said gear).

Anatomy of a gear

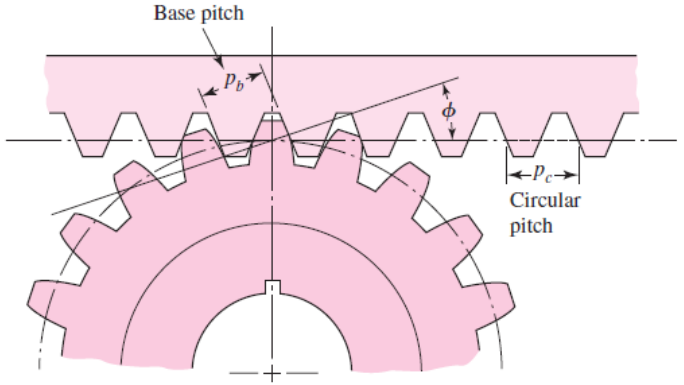


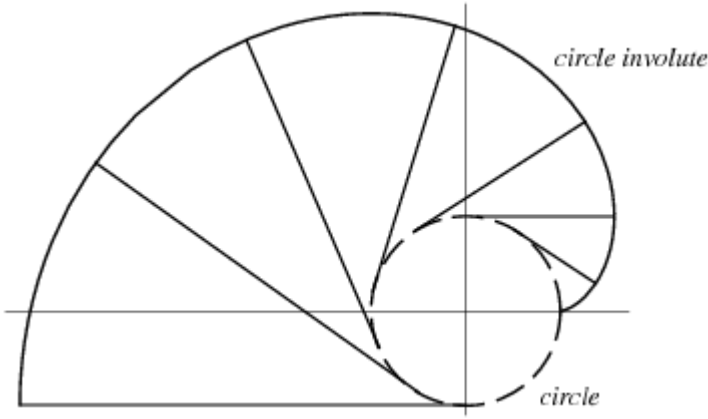
- Addendum = 1m
- Dedendum=1.25m
- n = PCD / m
- Clearance = 0.05m
- Face width = 10m to 12m

IF EVER YOU ARE HELD AT GUN POINT, AND THE ROBBER ASKS YOU WHAT GEARS YOU USE, YOU SAY: "THE STANDARD SPUR GEAR PROFILE USED IS A 20° FULL DEPTH INVOLUTE GEAR PROFILE!"

Why the Involute rules

- **Conjugate profile:** Profile that will mesh with a given shape to transmit a constant angular velocity
- **Conjugate of an Involute is an Involute,** and the involute of an infinite gear is a straight line
- The angle of line of action to the tangent of meshing pitch circles is the **pressure angle**





Images from: Google Images& Shigley's

The Velocity Ratio

- The velocity of the input and output gear is in **proportion to the number of teeth** on either gears
- So in effect, it is the **ratio of the PCD**

- The involute ensures that the velocity ratio is maintained even if the centre distance is off
- There is no slip or error in speed transmission, because gears are positively engaged

How gears are made

- Casting
- Moulding / sintering
- Shaping
- Cutting
- Hobbing

How gears are made

- Casting (Cheap but rough)
- Moulding / sintering (when you want lots of small gears)
- Shaping (Gives you accurate high precision gears)
- Cutting (when you need gears, and cant afford hobs)
- Hobbing (Fastest and most widely used)

- Steel gears are usually also case hardened and ground for accuracy, wear strength and long life

How gears are made

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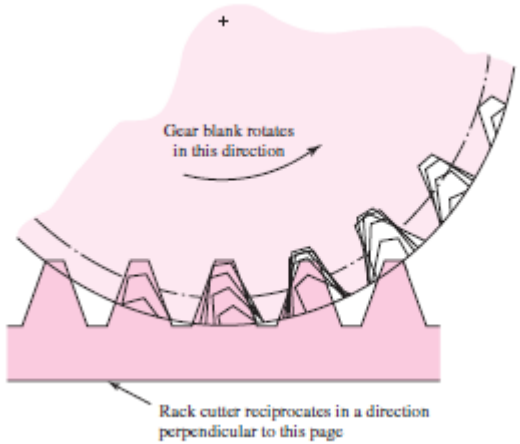

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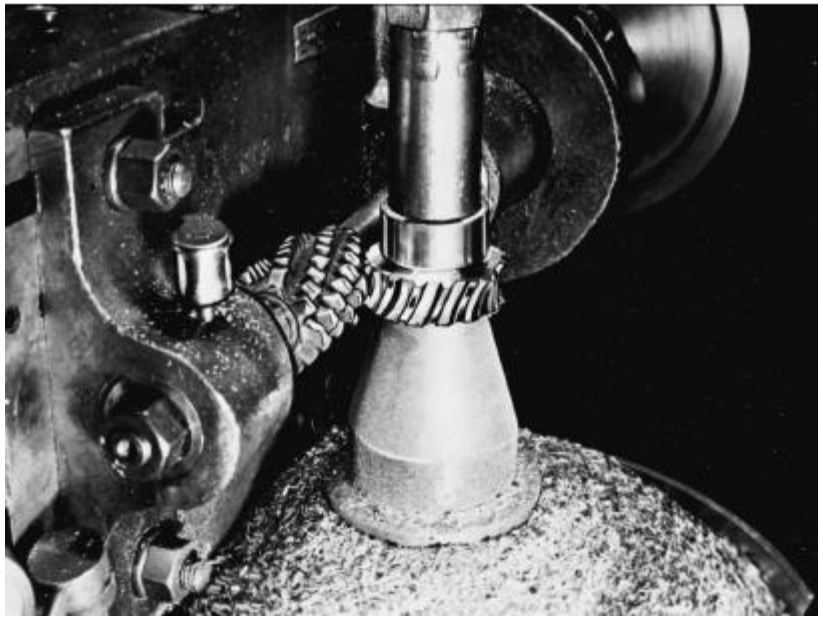
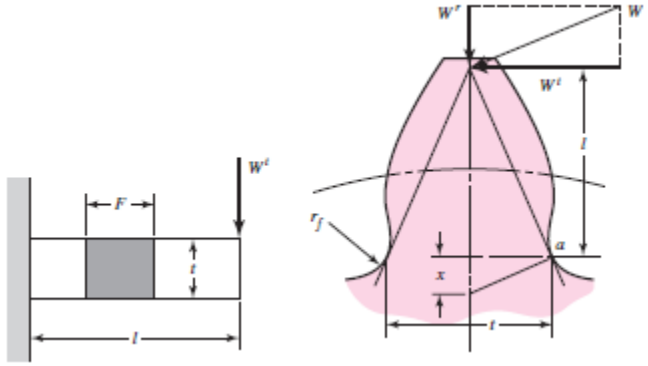


Images from: Shigley’s

Design Criteria



Spur gears are designed for:

- Beam strength in bending

(Lewis' bending strength equation)

- Wear Strength

(based on the hardness of the material in BHN)

The pinion is usually the weaker of the two, so a pinion is designed based on what "controls" the design

Smaller the module, greater the "contact ratio"

Images from: Shigley's

Gear “Trains”

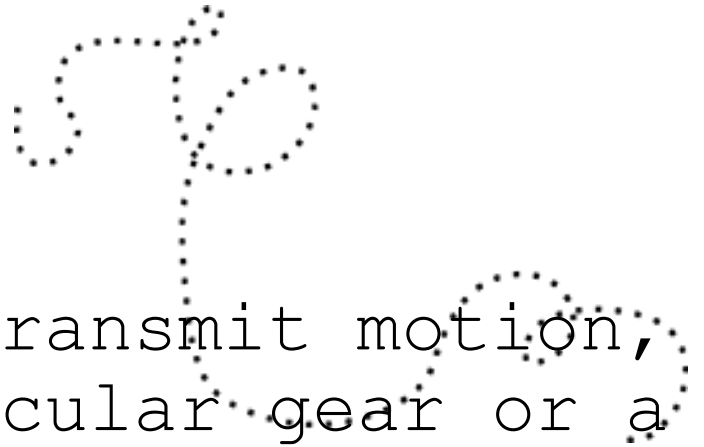
- A set of spur gears can be used in various ways to achieve various ends in various constraints; the way they are arranged, are known as gear trains
- The designer has to not only design the gear in strength, but also design the gear train that will:
    - Fit in the given space
    - Will give the required reduction from the prime mover to the output
    - Will not break
    - Will have noise under control
    - Will fit in the cost

Why I Love Gears

- "…engineering is a noble pursuit and necessary to sustain life, but art is what we are alive for…"

Images from: Google Images

Tracing loci



When complicated gear trains transmit motion, if you look at a point on a particular gear or a part of a linkage, it traces pretty sweet curves.

It’s not the coolest hobby, I admit.

Images from: Google Images

My Code

- Wrote a code in MATLAB to simulate Joe Friedman's Cycloid Drawing Machine
- "Play" around with it for "fun" to create traces of cycloids using geometry

```
clear all;
clc
% close all;
%%Cycloid Drawing Machine
m=5; %%module (mm)

%%Define the Main Gear
%%Teeth=150;
Mt=150;
Mc=[0 0];
figure;
hold on;
%%Driving gear
%%teeth=50;
Dt=75;
Dr=75; %%times the module (value of Dr has to be less than half of the number of teeth)
if Dr> (0.5*Dt)
    disp('Correcting the length of the arm...');
    Dr=Dr-(0.5*Dt);
    if Dr> (0.5*Dt)
        disp('the arm is longer than the gear..')
        Dr=0.5*Dt;
        disp('arm length is corrected to be equal to the pitch radius of the gear!')
    end
end

%%machine parameter
rd=Dr*m;

%%angle of the line joining the centre of the main gear and driving gear w.r.t positive x axis in degrees is angle(
angled=-45;
dcentre=[0.5*(Mt+Dt)*m*cosd(angled) 0.5*(Mt+Dt)*m*sind(angled)];

%%Pivot Point **this can be floating as well as fixed**
%%floating point means it is mounted on an additional gear in the gear train
```

Joe Friedman's Kickstarter: https://www.kickstarter.com/projects/1765367532/cycloid-drawing-machine

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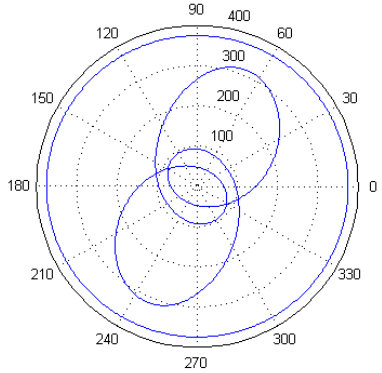

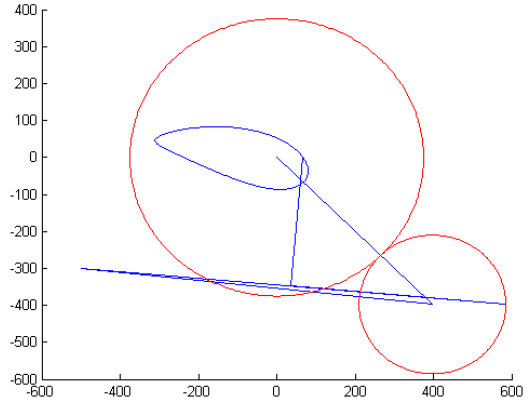

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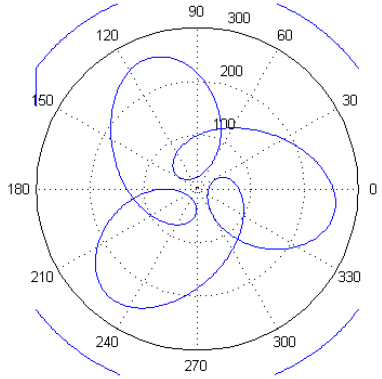

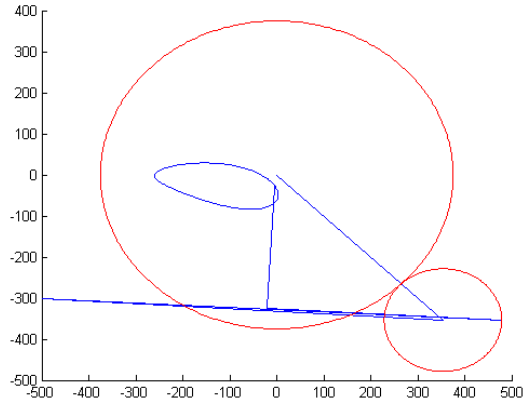

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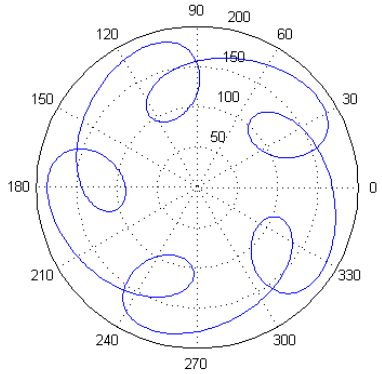

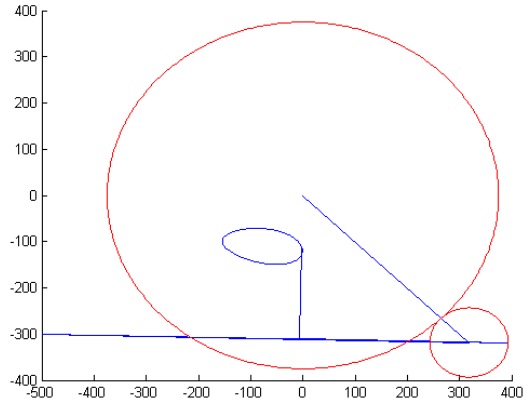

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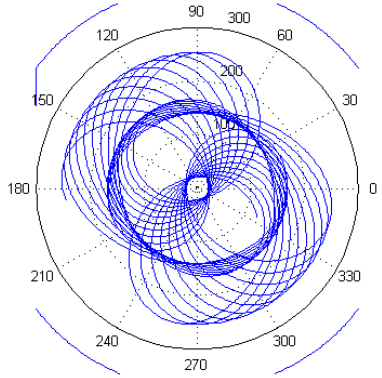
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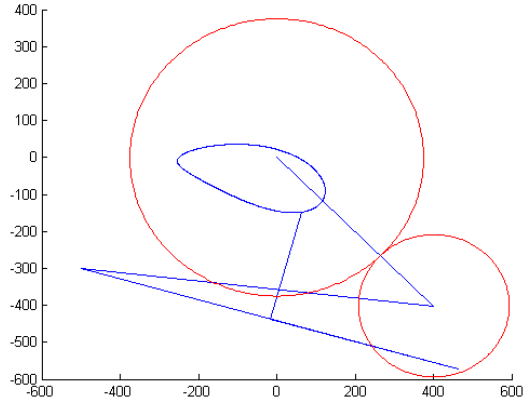
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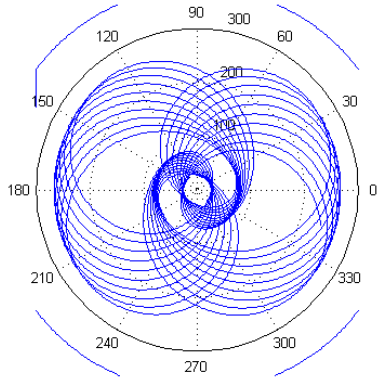
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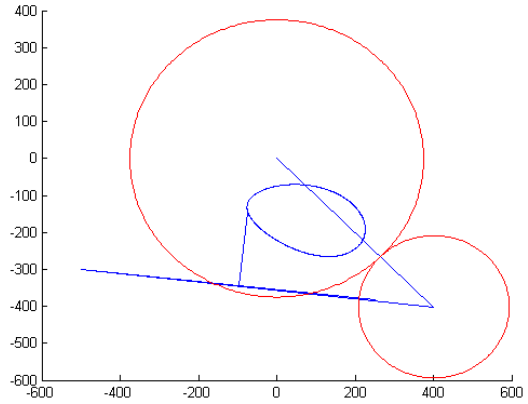
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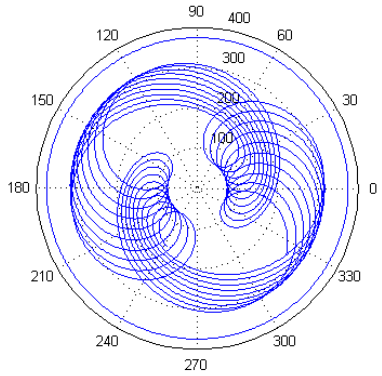
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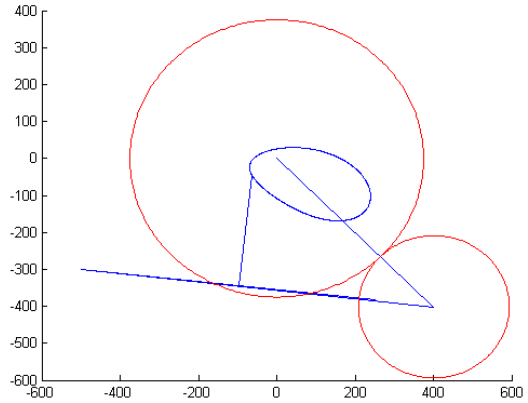
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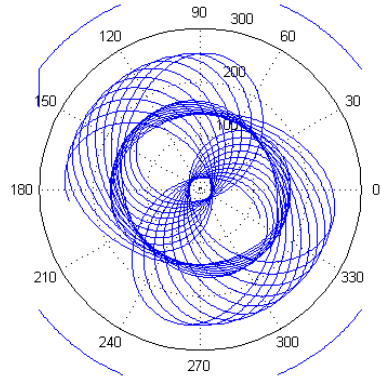
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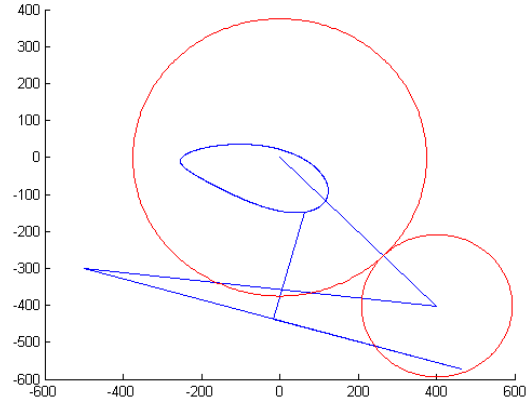
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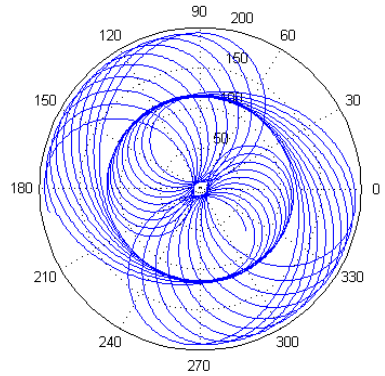
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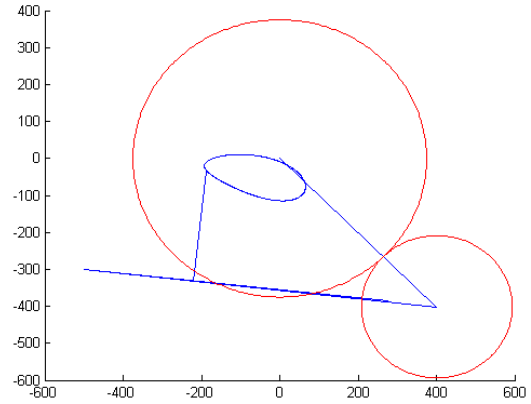
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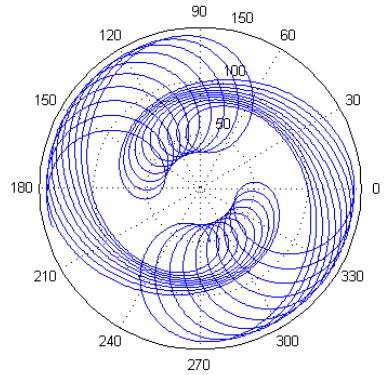
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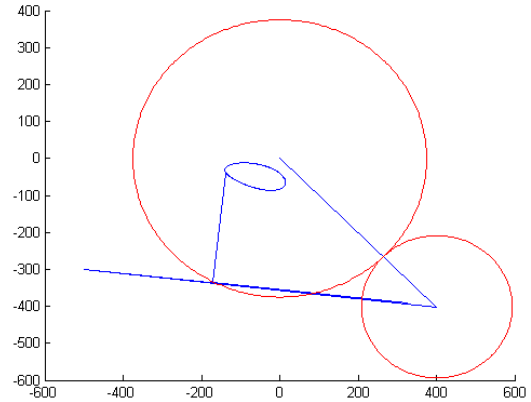
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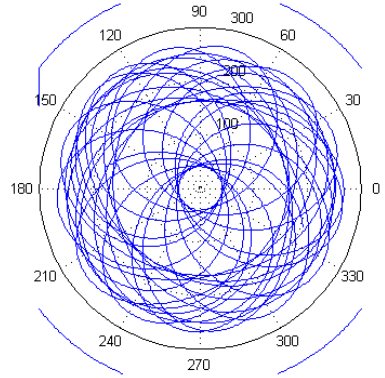
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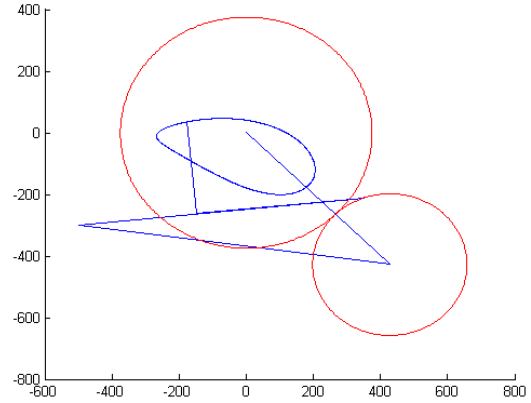
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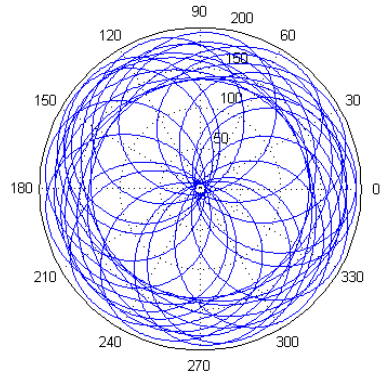
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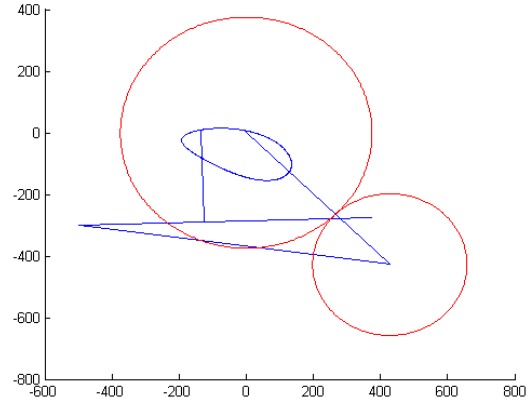
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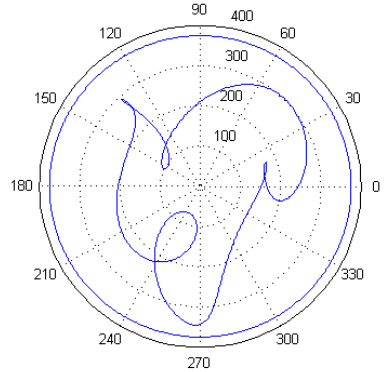

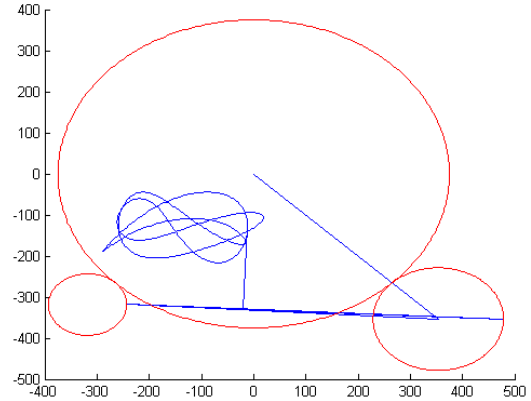

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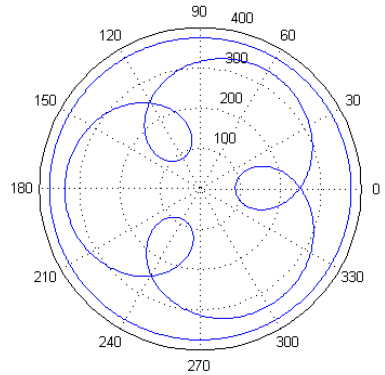

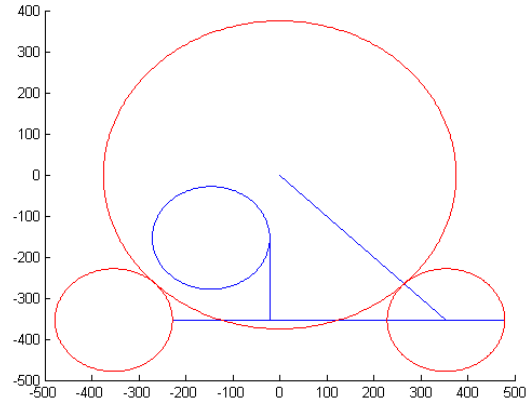

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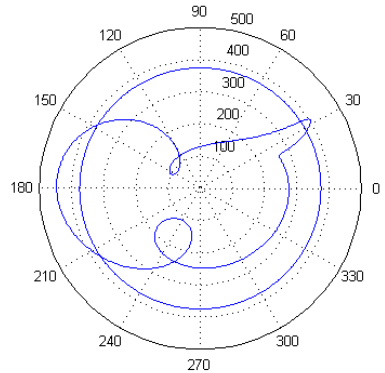

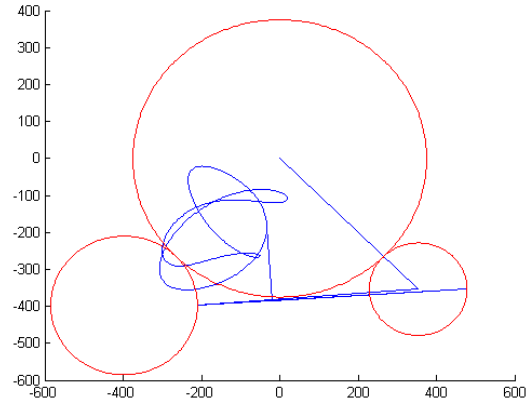

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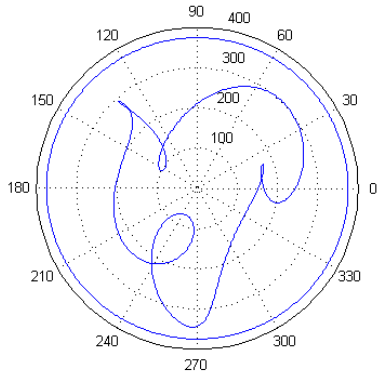

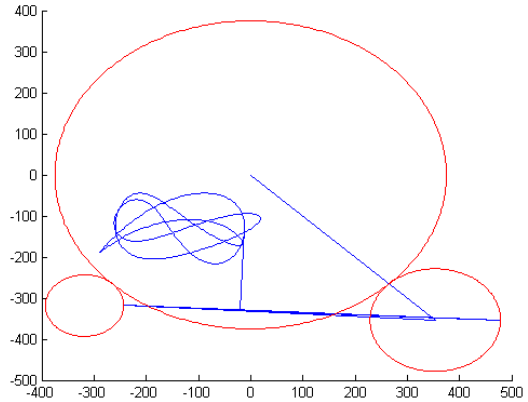

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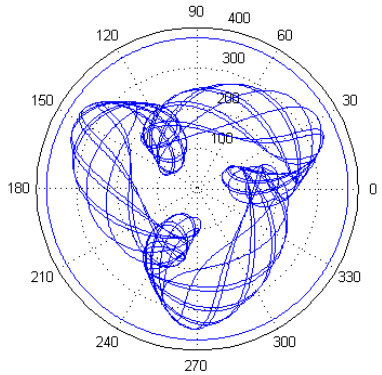

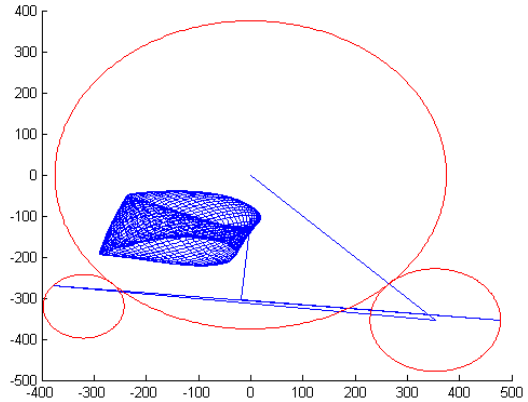

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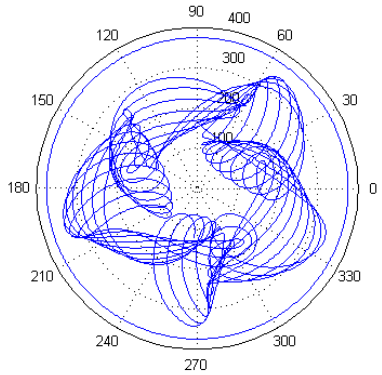

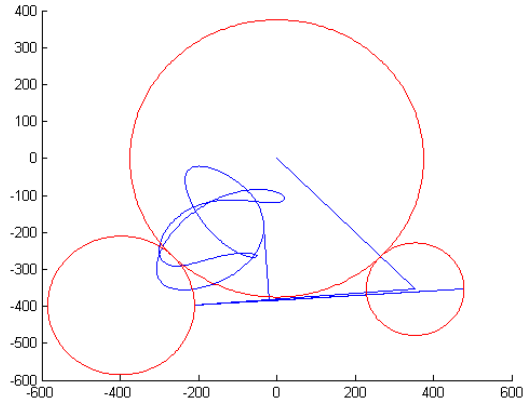

Just in case you are interested

ninadhw.github.io

Image Sources:

- Google Images
- Shigley’s Mechanical Engineering Design; Budynas, Nisbett; 9th Ed.

Thank You!