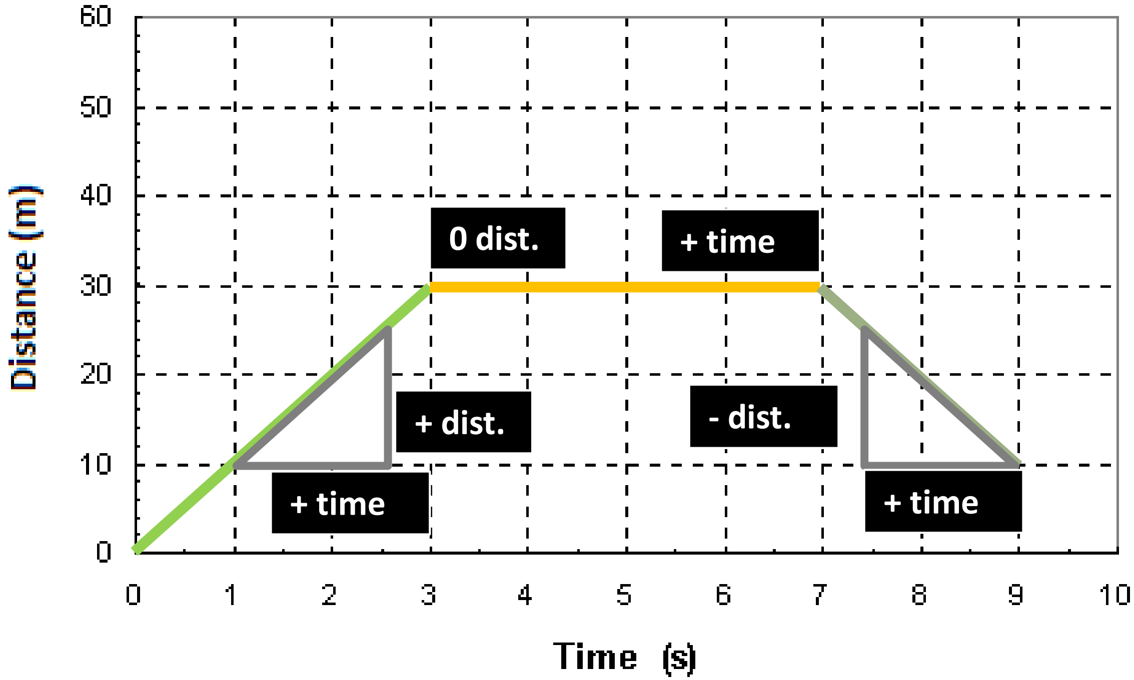
Cam Motion and Design

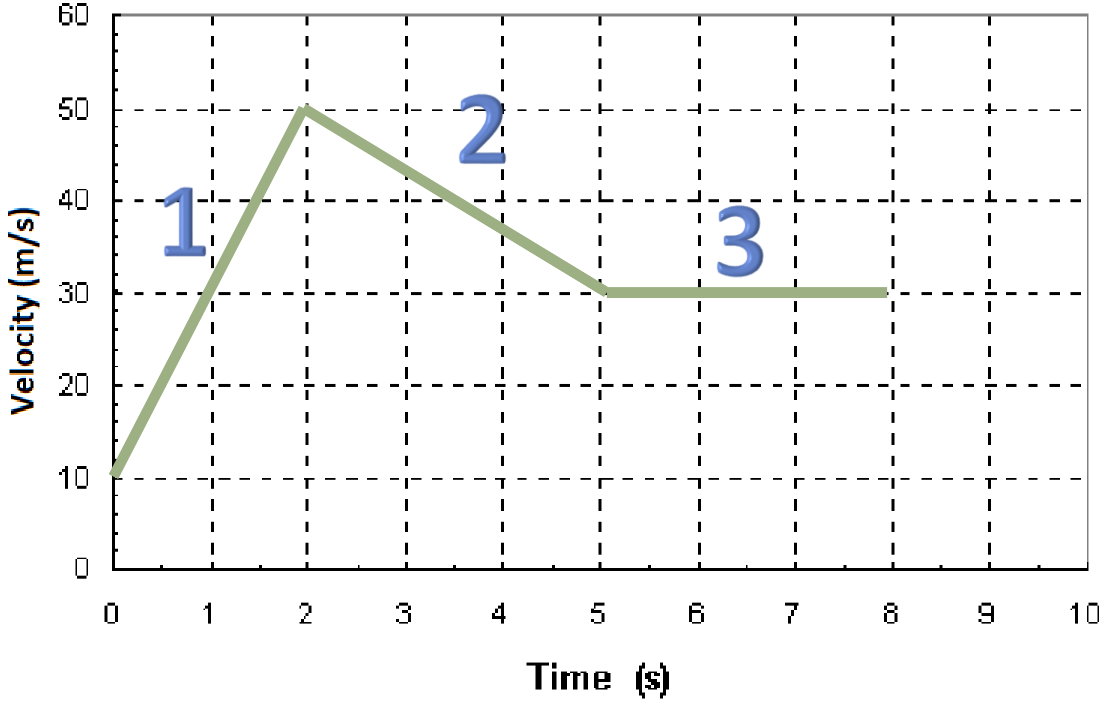
IED Activity 4.5

Review Graphing Motion in ONE Direction



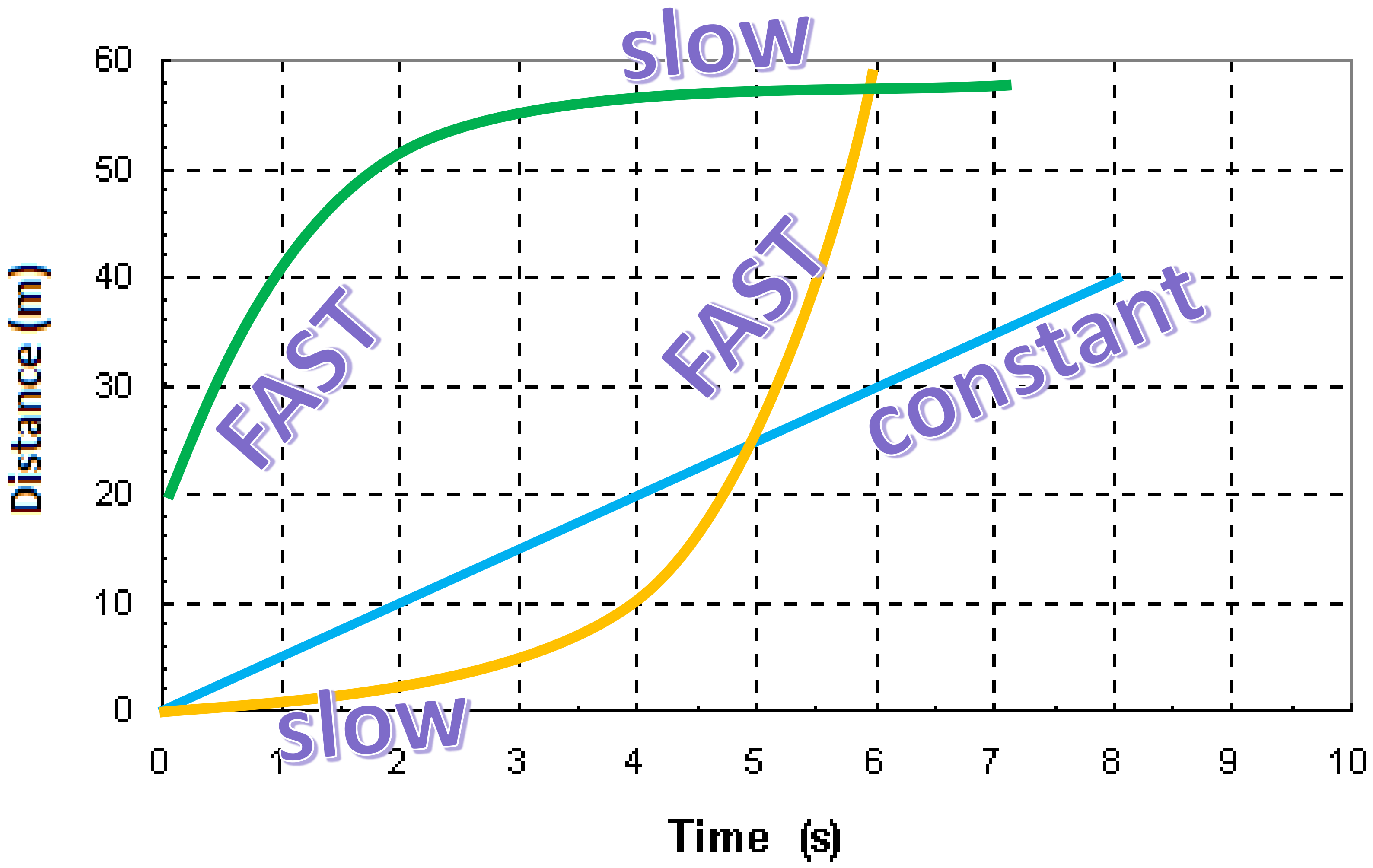
- Distance ALWAYS goes on the VERTICAL (Y-axis)
- Time ALWAYS goes on the HORIZONTAL (X-axis)
- **SLOPE (m/s)**
  - $\frac{change\ in\ rise\ (y-axis)}{change\ in\ run\ (x-axis)}$
  - **Slope is speed (m/s)**
  - **Positive slope: moving in the forward (positive) direction**
  - **Negative slope: moving in the reverse (negative) direction**
  - **Flat slope: slope is 0, object is NOT moving**

Slope and Velocity



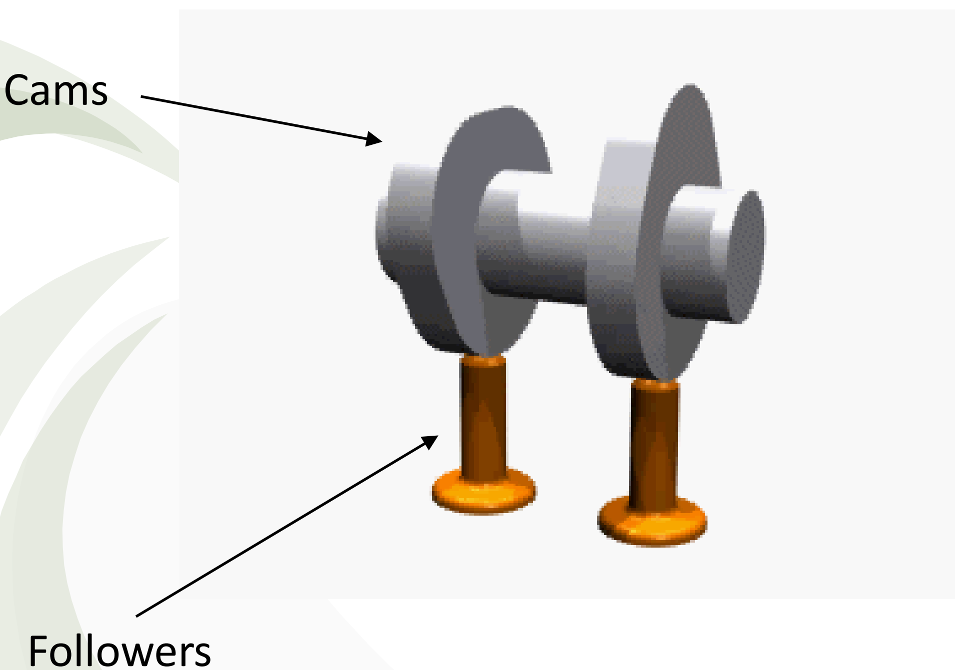
- Section 1
  - Moving forward (or positive direction) quickly. It has a steep slope.
- Section 2
  - Moving backward (or negative direction) more slowly. It has a shallow slope.
- Section 3
  - No movement. The slope is 0 and the line is flat.

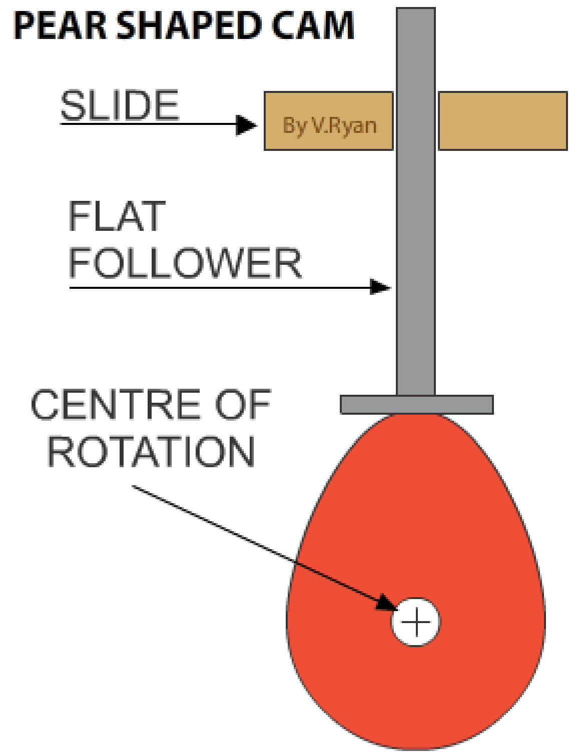
Graphing Distance vs. Time



Cam and Follower

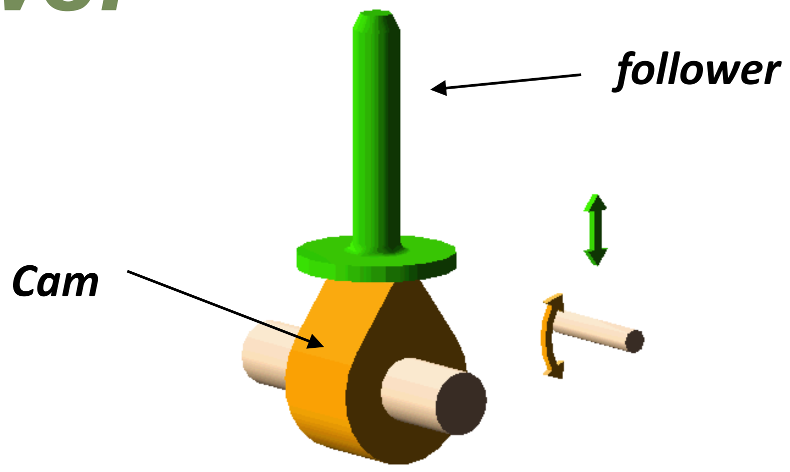
The ***cam and follower*** is a device which can convert rotary motion (circular motion) into linear motion (movement in a straight line, in ONE direction).

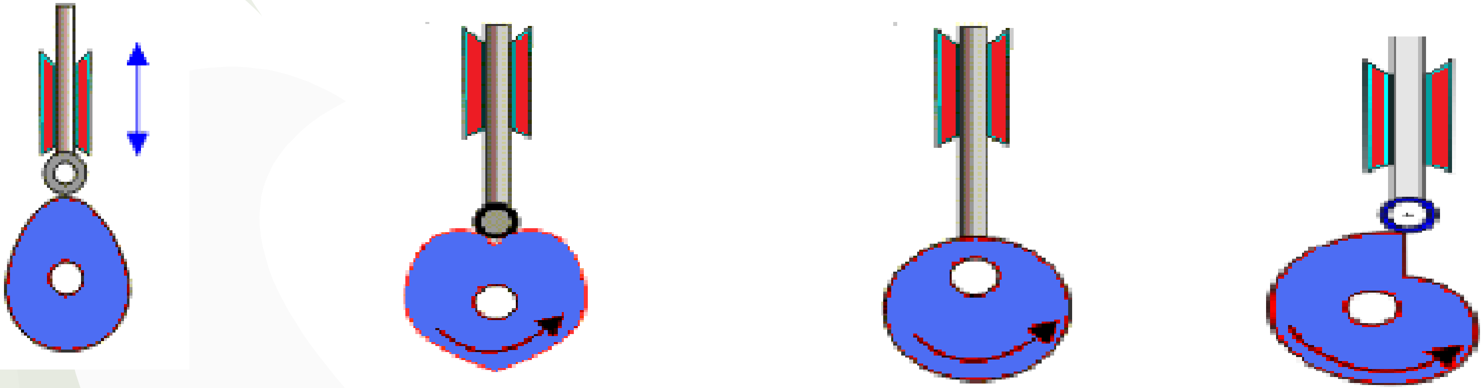




Cam and Follower

- *The cam can have various shapes. These are know as cam profiles.*



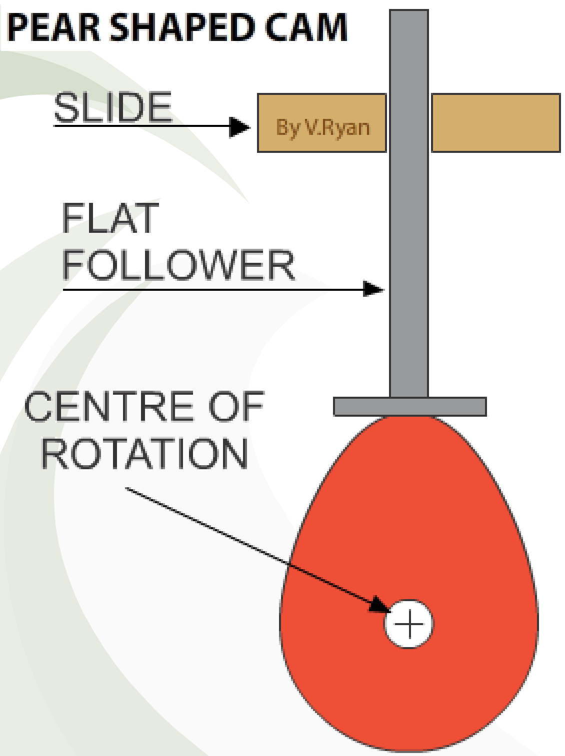


Pear *Heart* *Circular* *Drop*

Cam Shapes

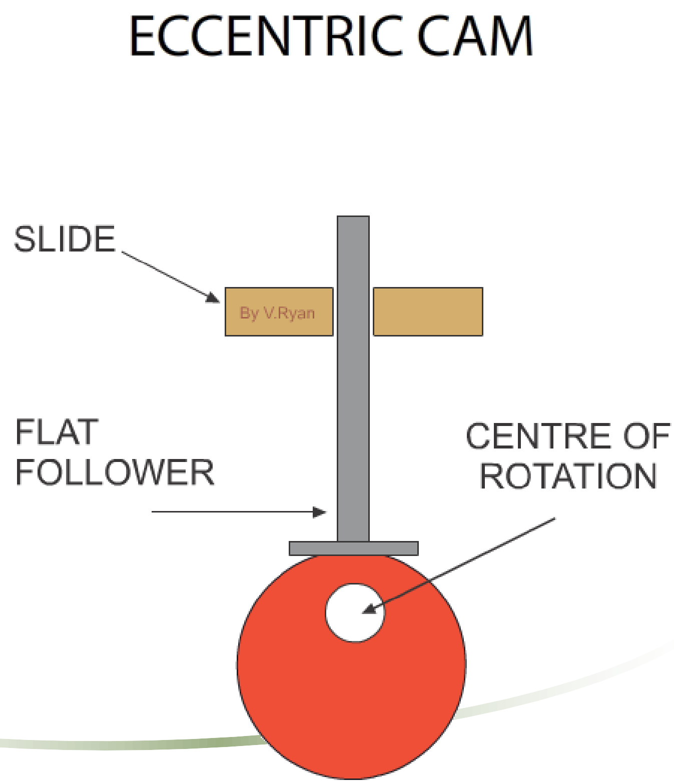
PEAR

Pear shaped cams are used on the shafts of cars. The follower remains motionless for about half of the cycle of the cam and during the second half it rises and falls.



CIRCULAR (ECCENTRIC)

Circular cams or eccentric cams produce a smooth motion. These cams are used in steam engines.

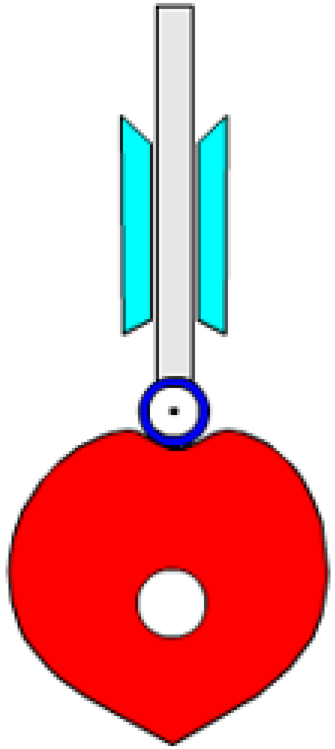


Cam Shapes

HEART

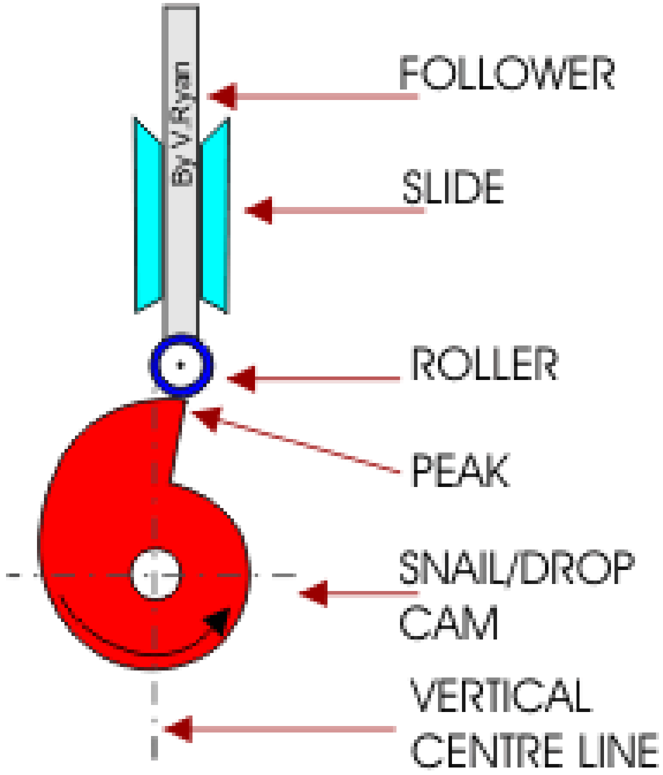
Heart shaped cams allow the follower to rise and fall with 'uniform' velocity.

- BEWARE OF "CORNERS"

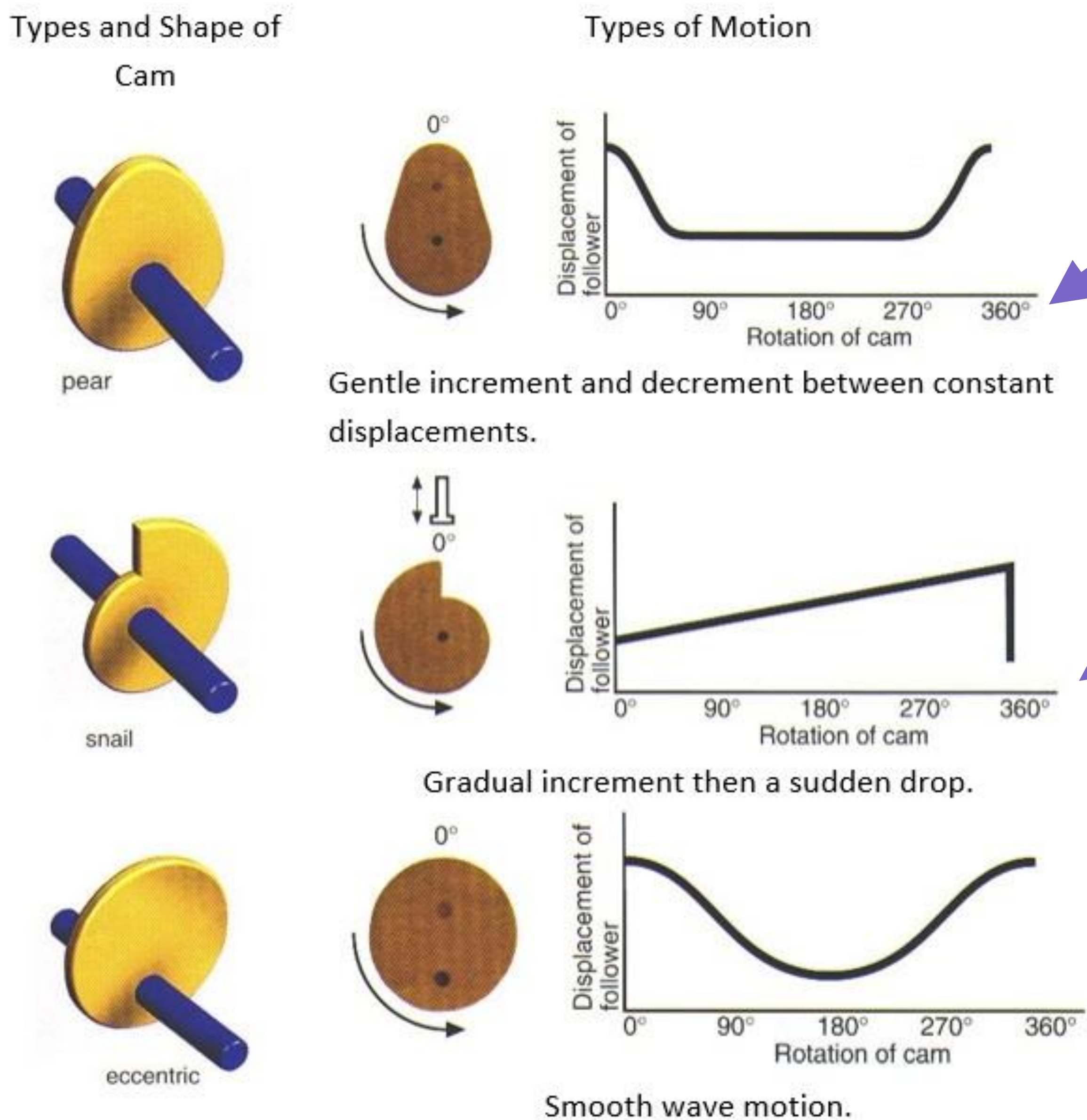


SNAIL (DROP)

Smooth motion with 'uniform' velocity, followed by a sudden drop.

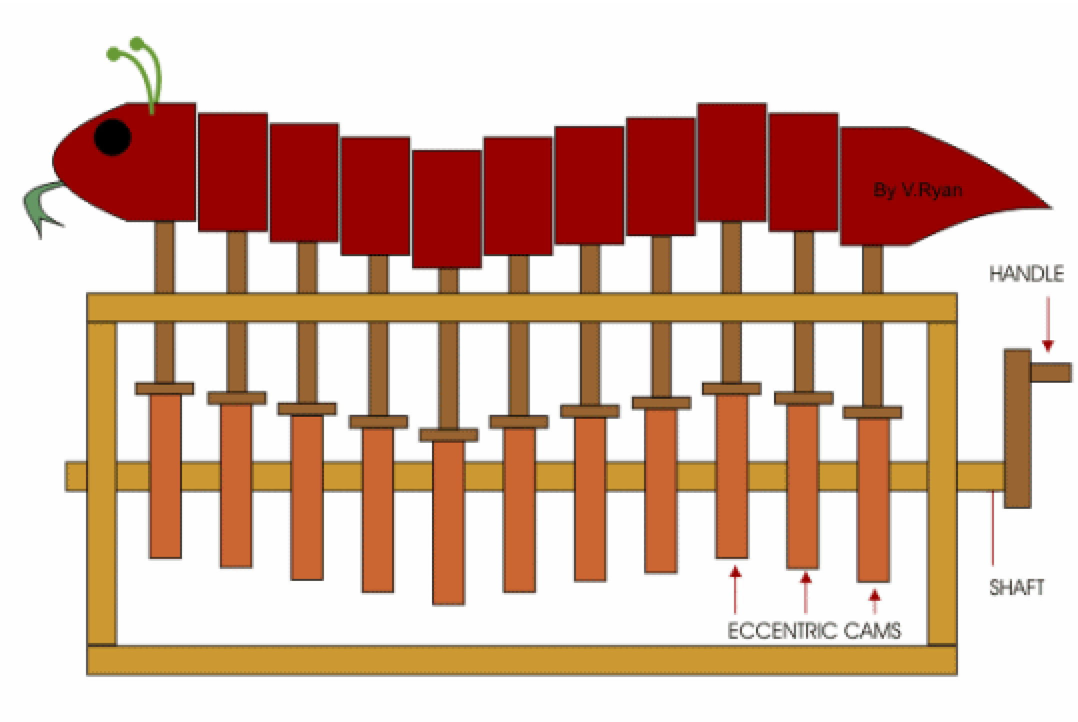


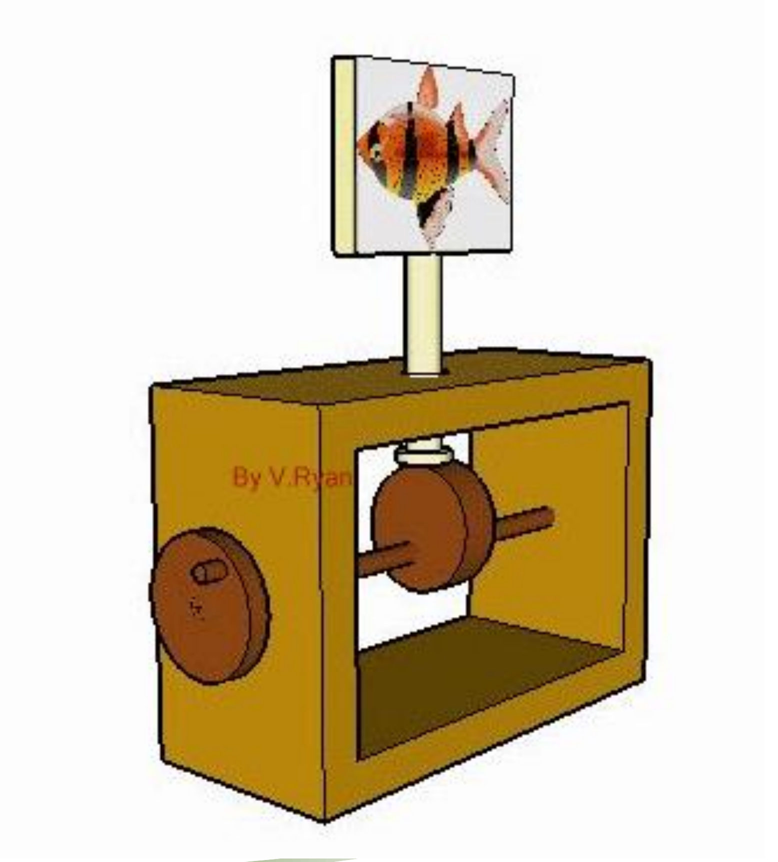
Cam Motion Profiles



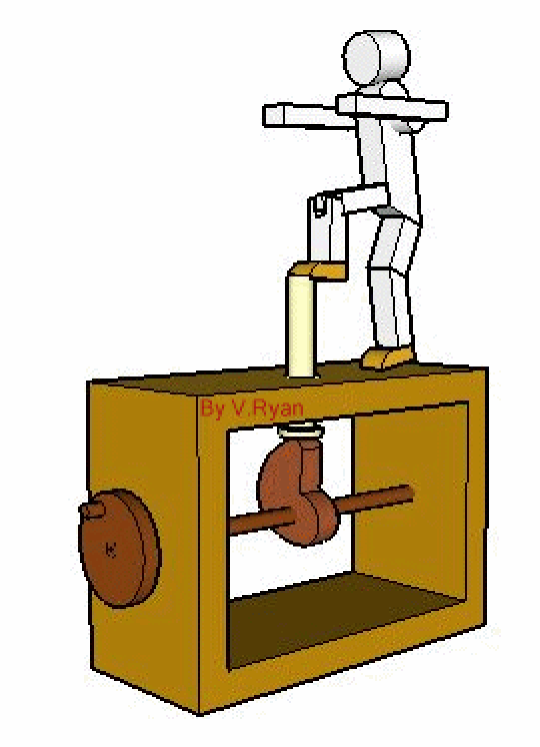
- Cam Motion Profiles show relationship between distance and **ANGLE**. NOT TIME.
- However, same principles apply. Steeper the slope, the faster the follower will be moving

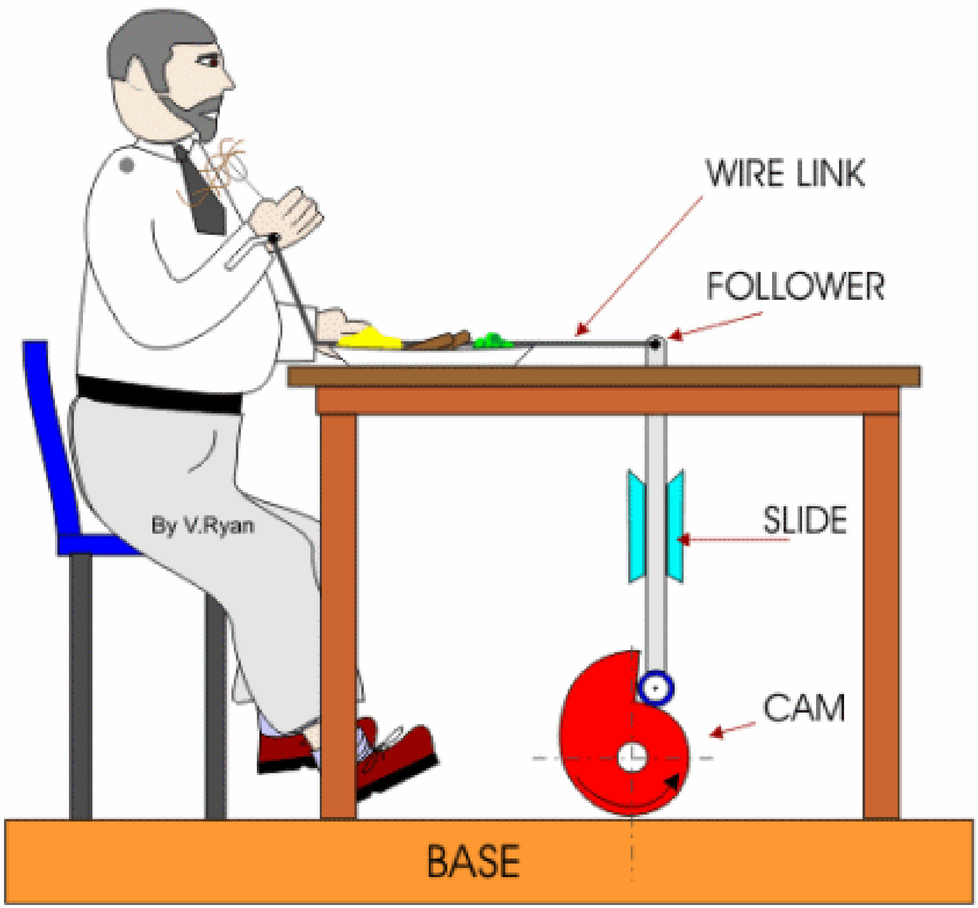
Eccentric Cam Samples





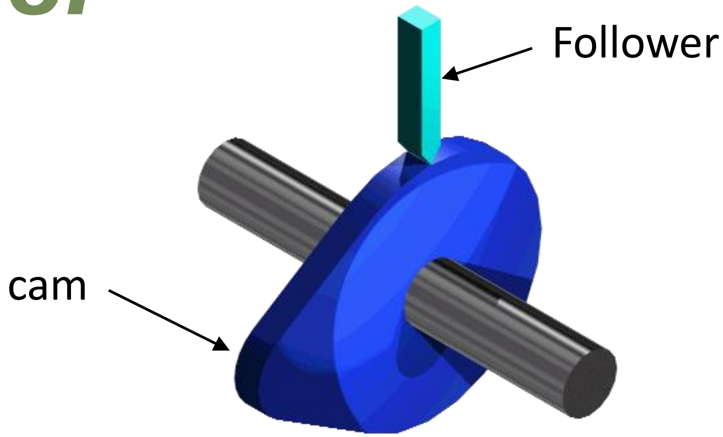
Snail Cam Samples

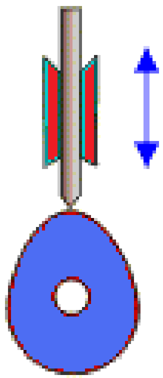




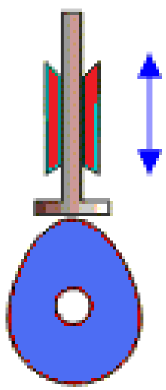
Cam and Follower

- A follower is a component which is designed to move up and down as it follows the edge of the cam.

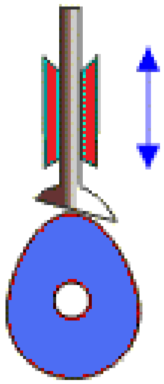




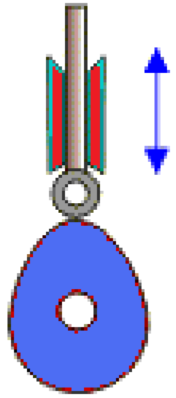
Knife edge Follower



Flat foot follower



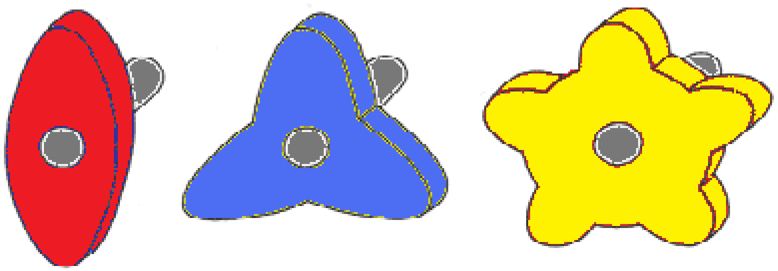
Off set follower



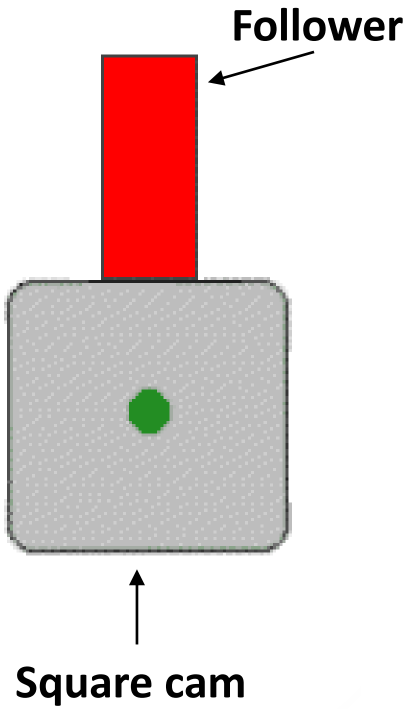
Roller follower

‘Lobed’ Cam and Follower

- The 'bumps' on a cam are called lobes.
- The square cam illustrated has four lobes, and lifts the follower four times each revolution.
- Used for small displacements, and quick, repeated motions.

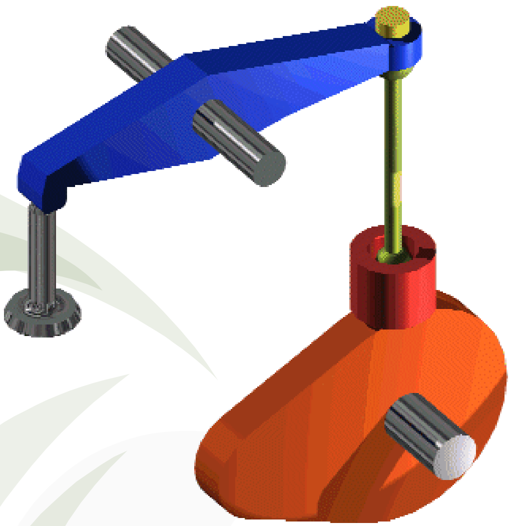


Examples of other rotary cam profiles.

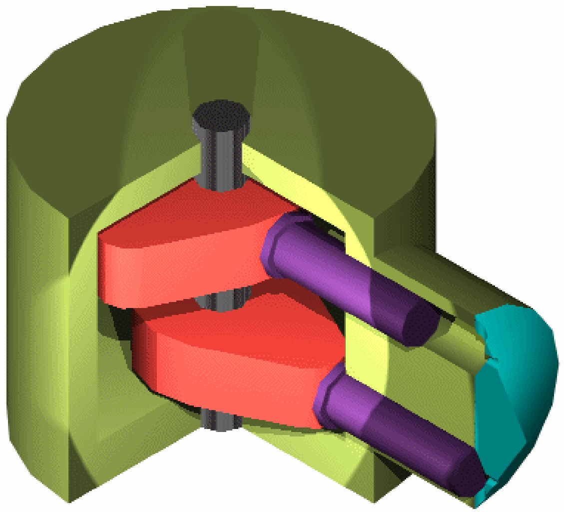


Cam and Follower

Examples of a Rotary cams in operation.



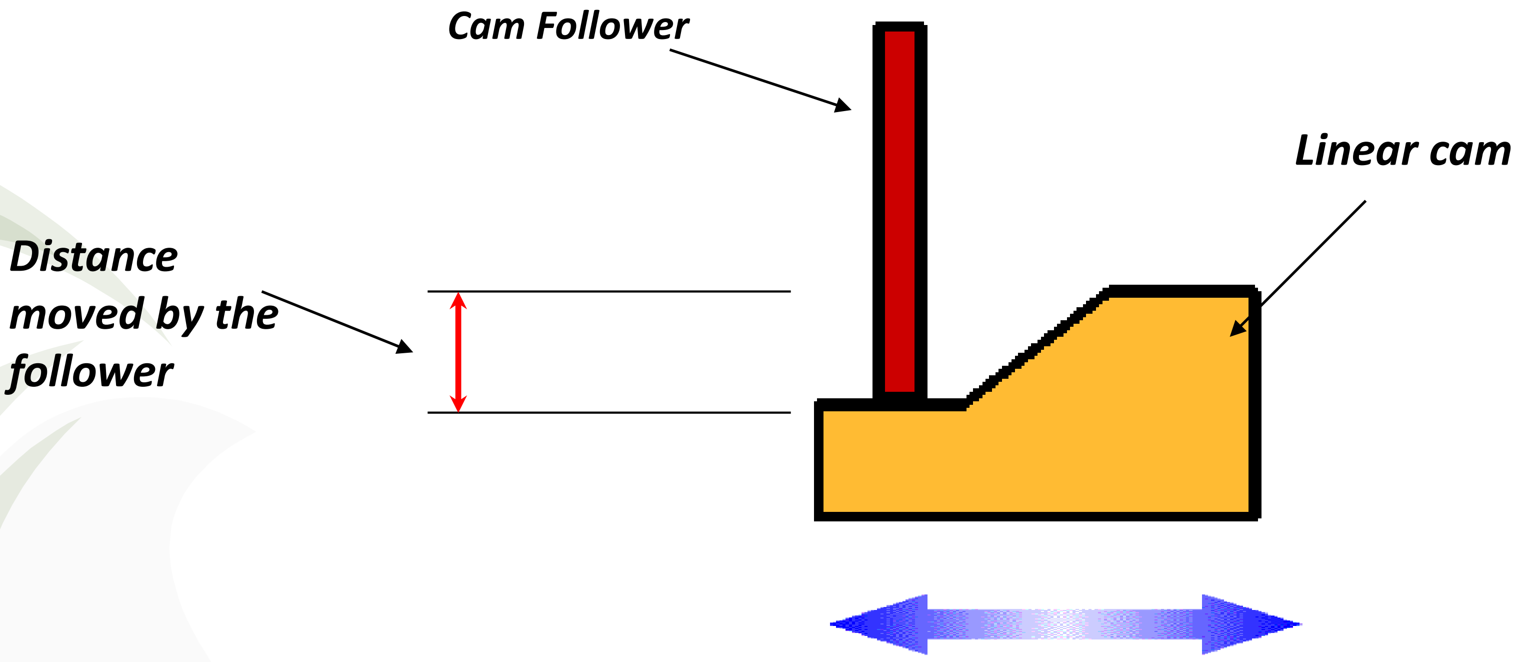
Control the movement of the engine valves.



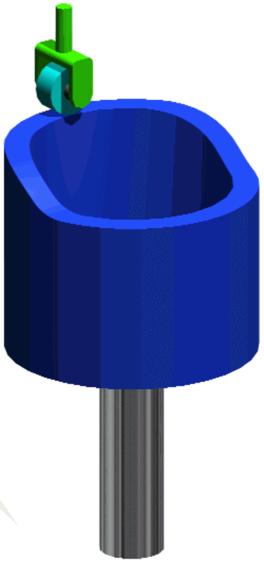
Cams used in a pump.

Cam and Follower

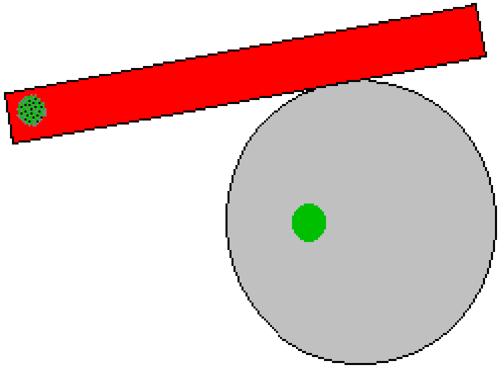
- *The linear cam moves backwards and forwards in a reciprocating motion.*



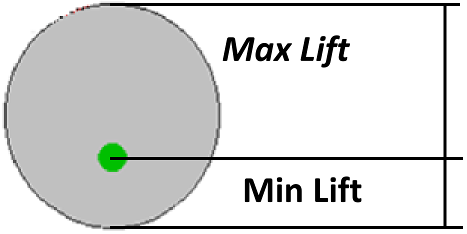
Cam and Follower



- *Cams can also be cylindrical in shape*
- *Below a cylindrical cam and roller follower.*



Cam rise and Fall

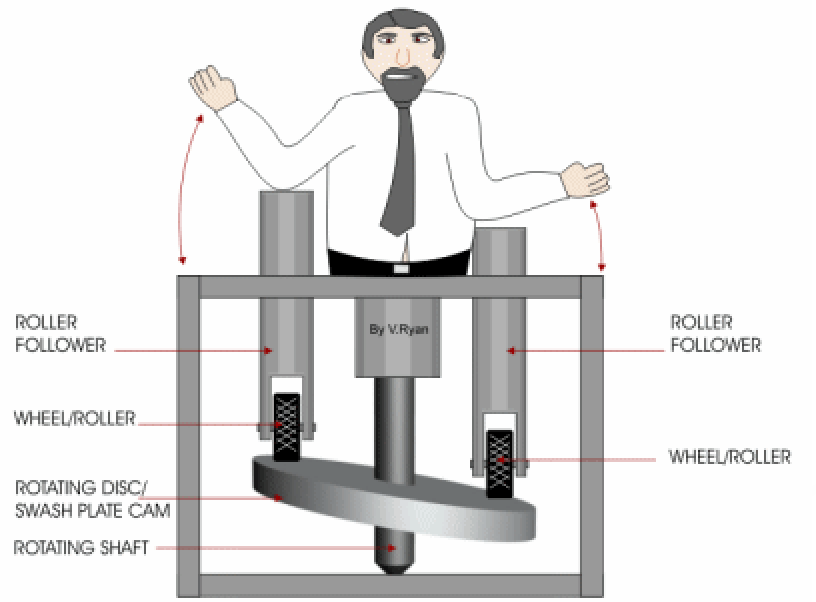


- *The cam follower does not have to move up and down - it can be an oscillating lever as shown above.*

Swash Plate Cam

- A swash plate cam is usually a disc that rotates around a shaft. The disc is set at an angle so that the follower moves up and down as the disc rotates.

  The example below shows how two followers can be used resting on the same swash plate cam. Each follower has a wheel or roller that allows smooth movement.

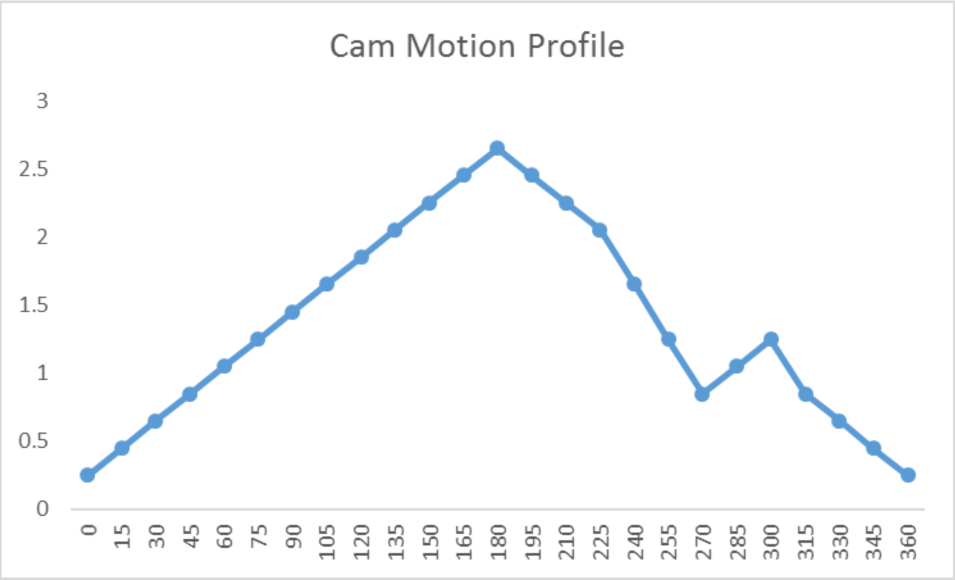


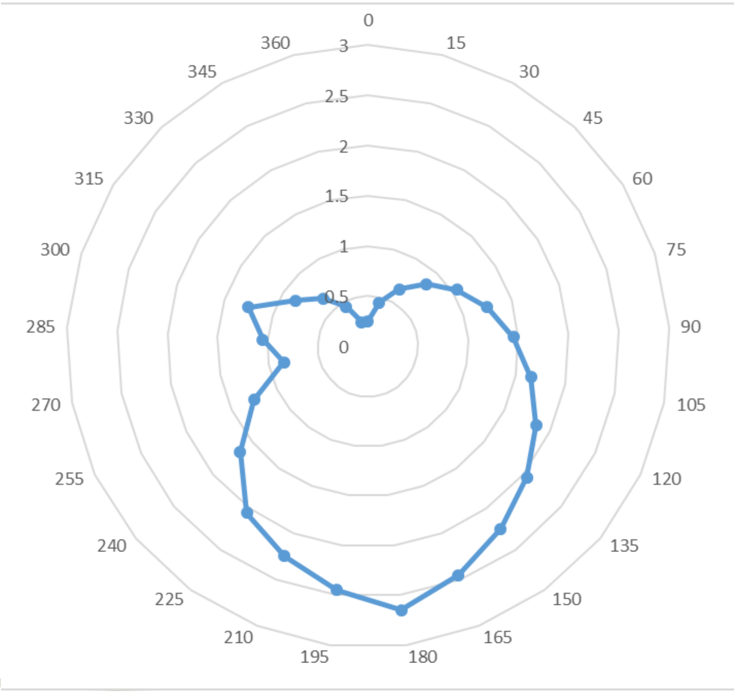
How to Develop a Cam Profile

1) Determine the constraints of the cam and follower
   - How far do they NEED to move, and how far are they ABLE to move.
2) Determine Base radius of cam
   - This controls the “rest” or “starting” position of the follower
3) Decide the type or “feel” of the motion you want for your cam
   - Using the standard motion profiles from earlier, sketch the path of your cam on a **Displacement vs. Degree of Rotation Graph.**
   - Transfer the points from the displacement/degree graph to a **Displacement-Polar Graph.**

Suggestions for Cam Profile Development

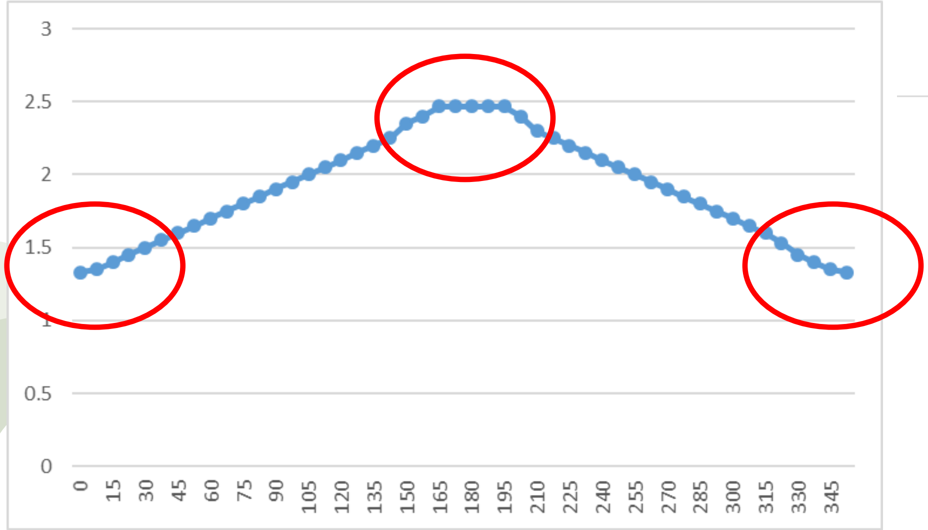
1. AVOID quick changes in motion, speed, or direction. This will create “corners in your cam.

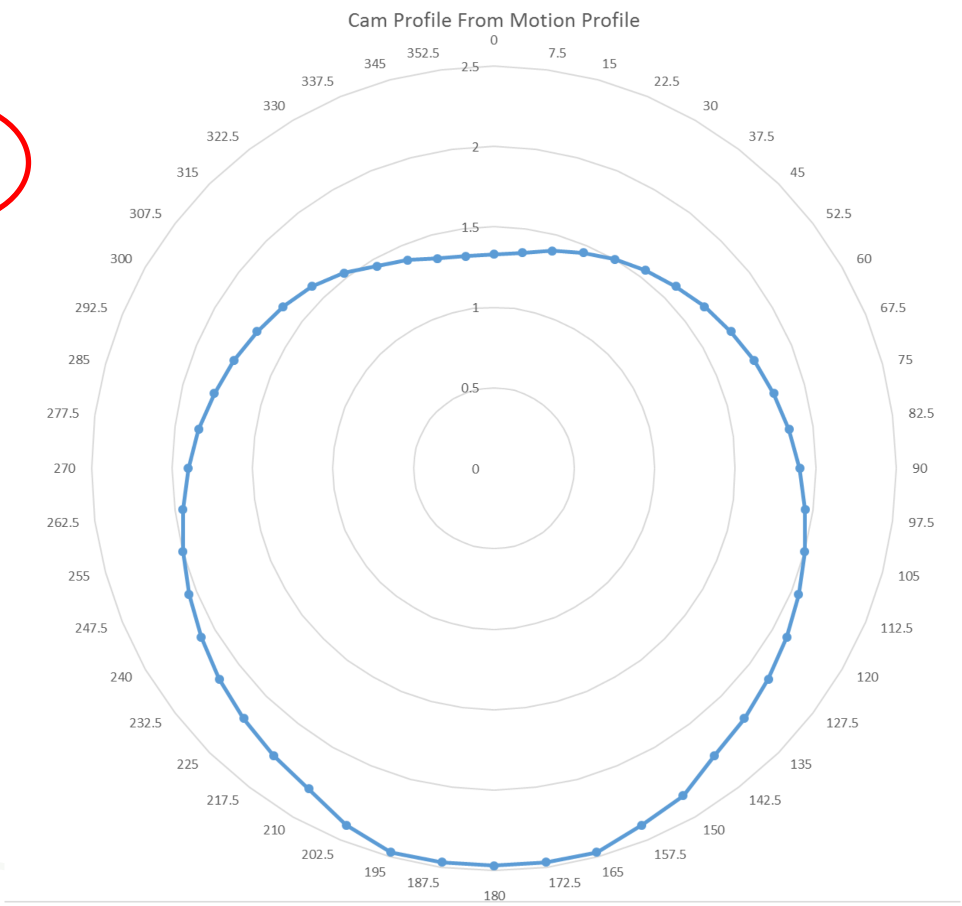




Suggestions for Cam Profile Development

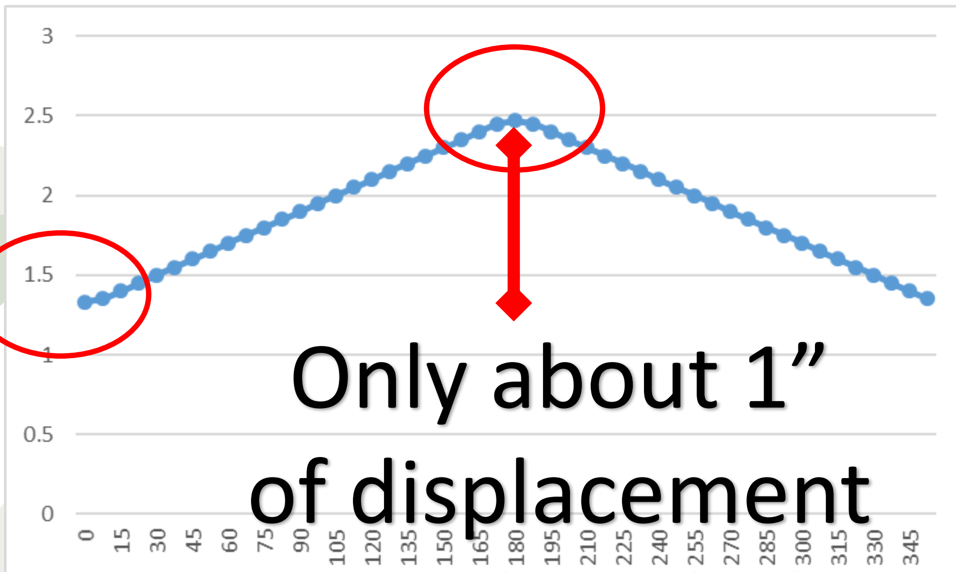
2. Give your cam enough "rest" between motion, direction, speed changes



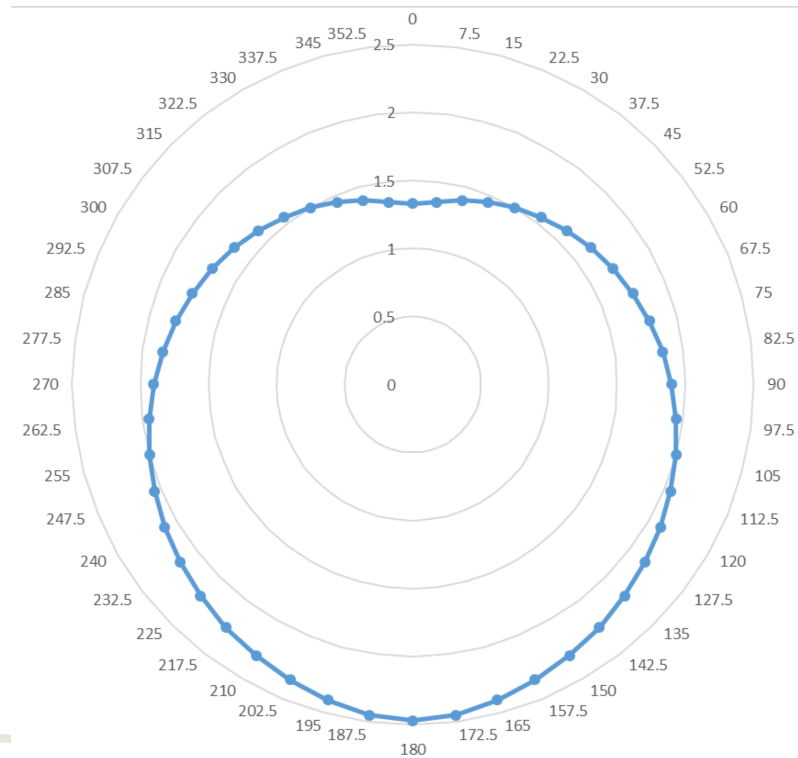


Suggestions for Cam Profile Development

3. Make changes in motion, speed, direction small to help reduce corners as well



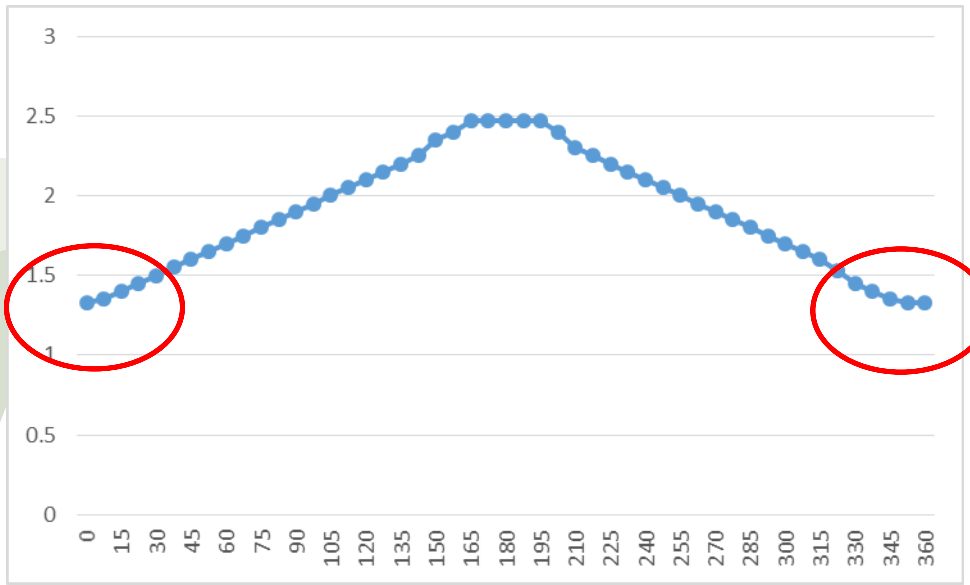
Only about 1”
of displacement
over the whole
path of travel.

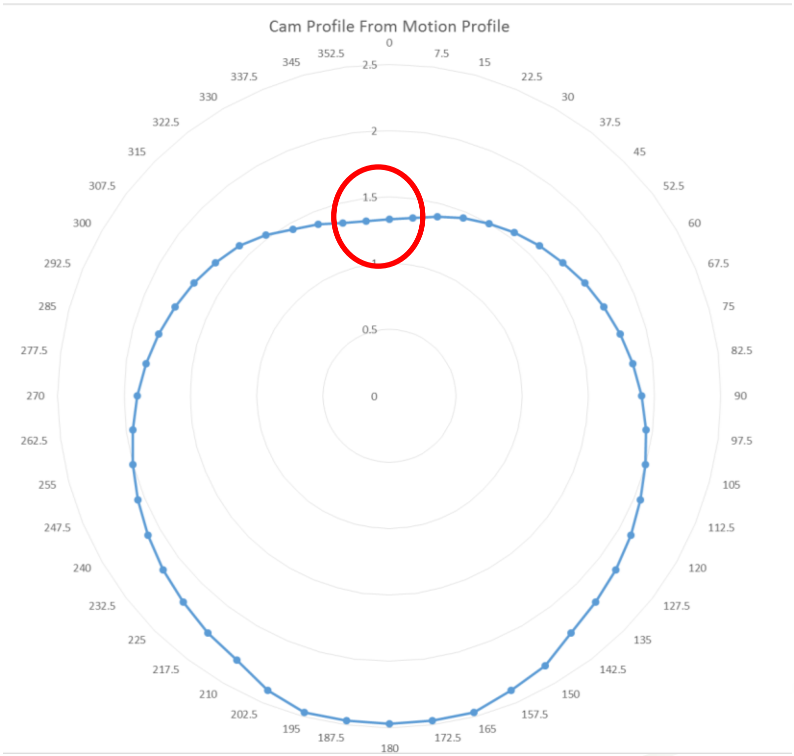


Suggestions for Cam Profile Development

4. **MAKE SURE YOUR DISPLACEMENT IS EQUAL AT THE BEGIN AND END OF YOUR ROTATION!!!!!!**

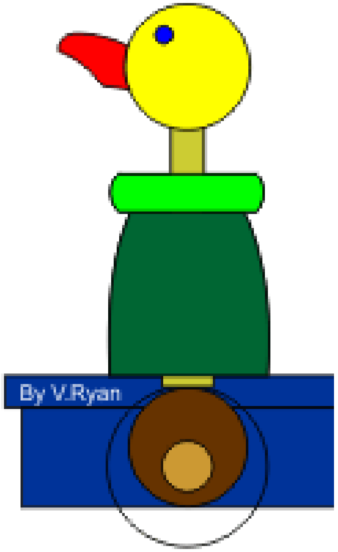
- *Displacement at 0 is equal to displacement at 360*

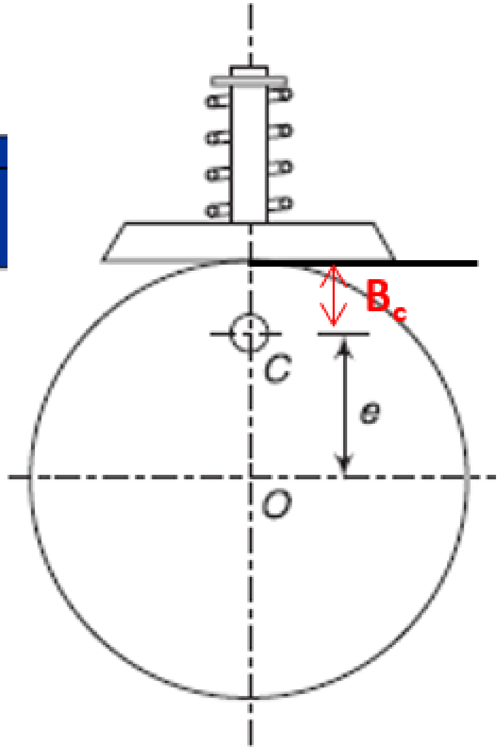




Special Motion Profiles

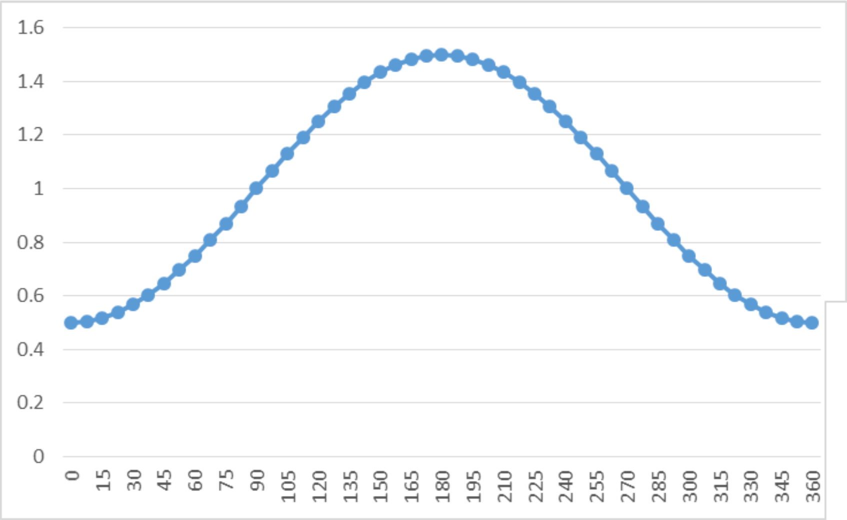
- **Simple Harmonic Motion**
  - Rhythmic Up-and-Down Pattern
  - Created by Eccentric Cams
  - Motion profile determined by
    - **Cam Displacement = e – e cos (θ) + B_c**
    - e (eccentricity) = Distance between center of cam and axis of rotation
    - θ *(Theta) = the angle of rotation*
      - *Counterclockwise is positive*
- **B_c** *is base cam radius*
- *MAX DISPLACEMENT IS* **B_c + 2e**
- MIN DISPLACEMENT IS **B_c**
- **CAM RADIUS = e + B_c**
- **CAM DIAMETER = 2 (e + B_c)**

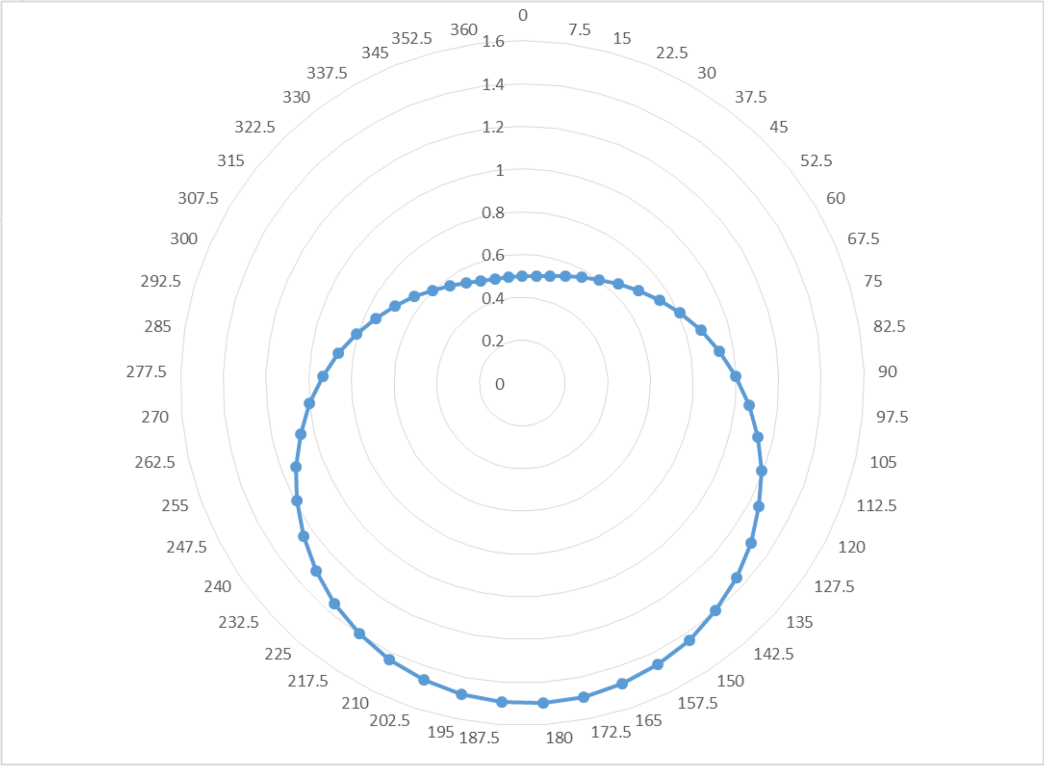




(a)

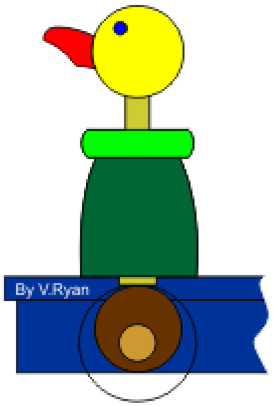
Eccentric Cam Profile with Harmonic Motion

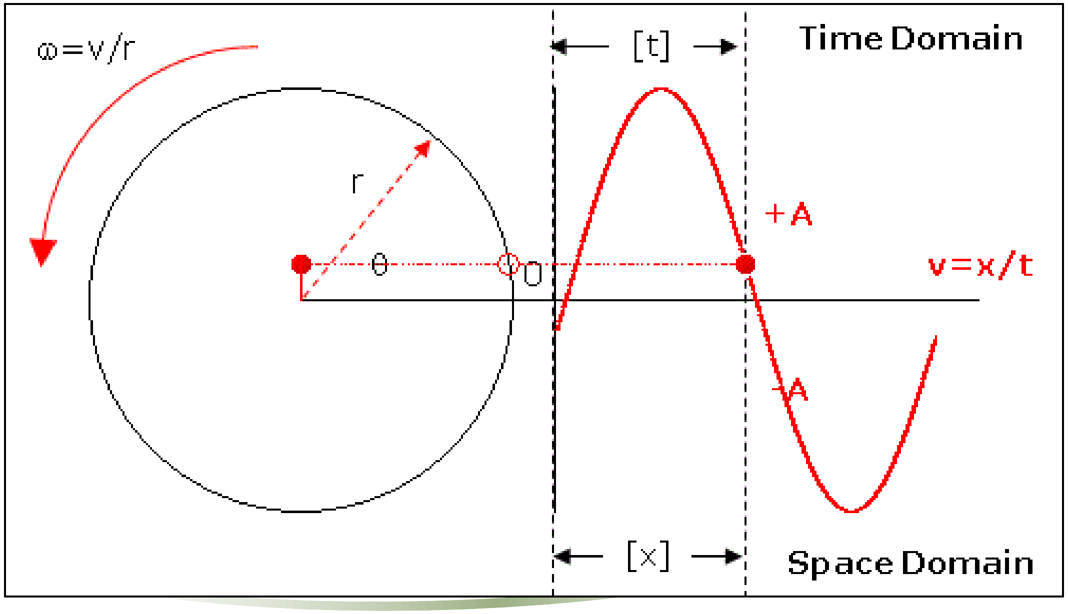




Special Motion Profiles

- **Harmonic Rise or Fall**
  - Steady movement up or down
  - Steady Motion profile determined by
    - **Cam Displacement = A sin ($f \cdot \theta$) + B_c**
    - *A (amplitude) = MAX rise of follower from Base Radius*
    - *f* = frequency dilation factor
      - *f = 1 (normal)*
      - *f > 1 (stretched)*
      - *f < 1 (compressed)*
    - θ *(Theta) = the angle of rotation*
      - *Counterclockwise is positive*
- **B_c** *is base cam radius*
- MAX DISPLACEMENT IS A + **B_c**
- MIN DISPLACEMENT IS **B_c**





Constant (Harmonic) Rise with Linear Fall