Phase 1: System Understanding & Conceptual Design

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Executive Summary

- Examines a Unicam style overhead cam valve train
- Identifies system function, components and potential failure modes
- Critical system in a four-stroke engine

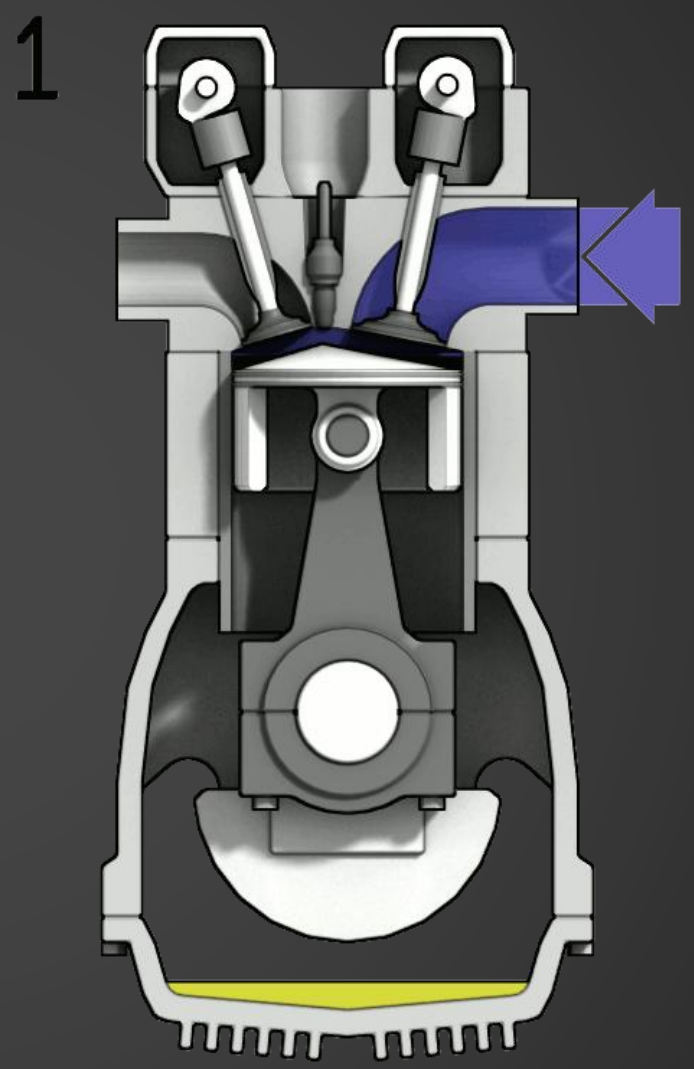
Four-Stroke Engine Overview

1. Intake Stroke - Intake valve opens, piston moves down, drawing in the air-fuel mixture.

2. Compression Stroke - Both valves are closed, piston moves up, compressing the air-fuel mixture.

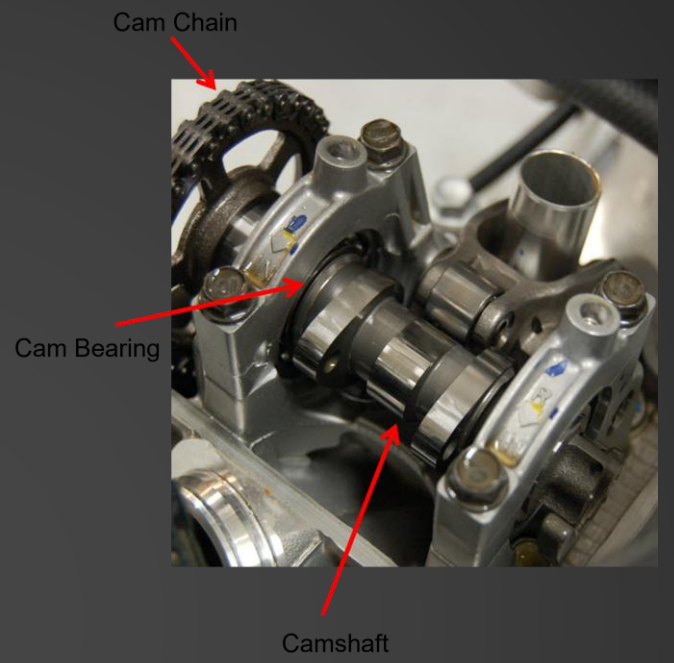
3. Combustion Stroke - Spark plug ignites the compressed mixture, forcing the piston downward and generating torque on the crankshaft.

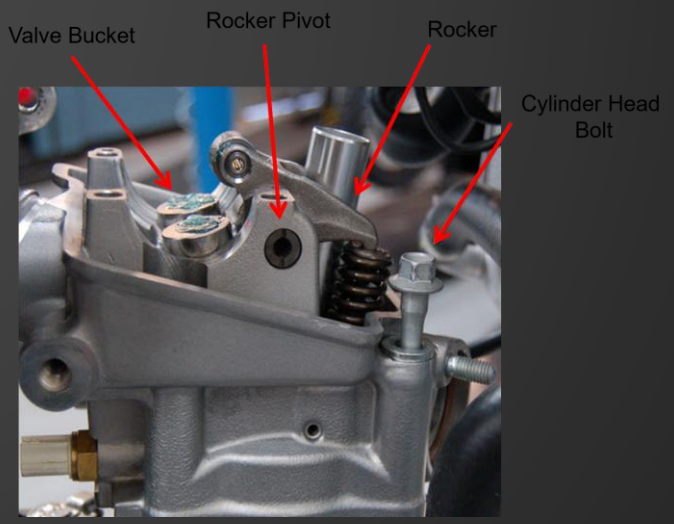
4. Exhaust Stroke - Exhaust valve opens, piston moves up again, pushing exhaust gases out of the cylinder.



System Function

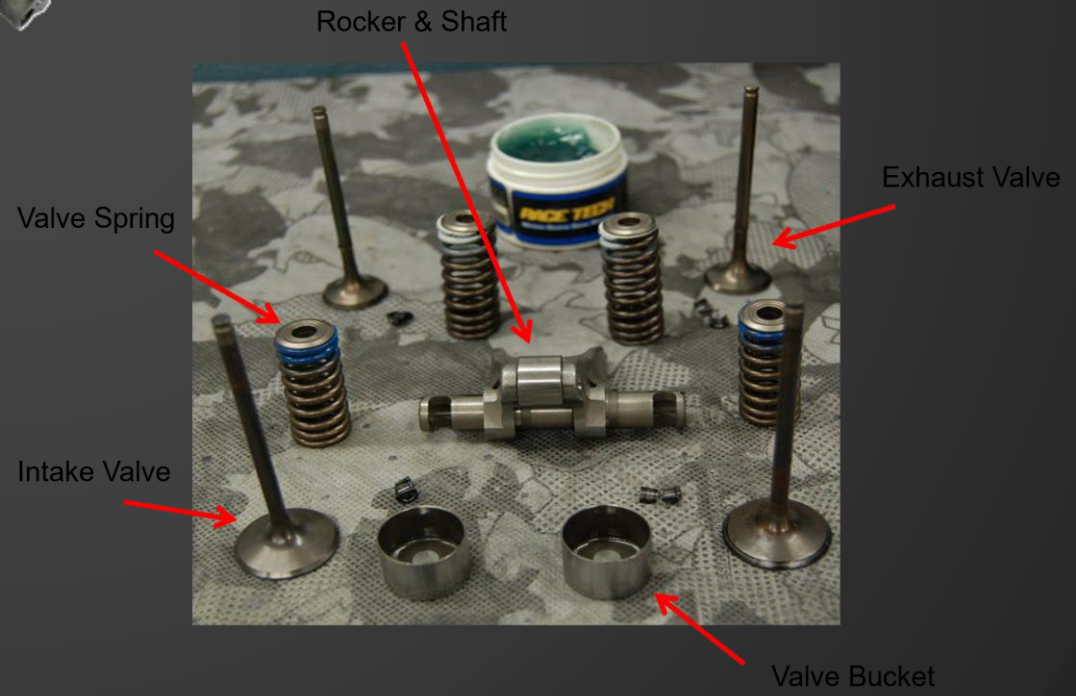
- Converts crankshaft rotation into valve motion
- Controls valve lift, timing, and seating
- Camshaft actuates intake valves directly, while exhaust valves are actuated via rocker arm
- Use of a single camshaft reduces rotating mass





Major Components

- Cylinder Head
- Camshaft
- Rocker
- Valves
- Valve Springs
- Valve Buckets
- Cam Bearings
- Cam Chain



Kinematics

- The camshaft geometry controls the valve motion
  - *Intake Valves:*
    - $L_{valve} = L_{camshaft}$
    - Where: L = Lift
  - *Exhaust Valves:*
    - $L_{valve} = R * L_{camshaft}$
    - Where: R = Rocker Ratio
      - *Ratio of rocker arm lever lengths*
- The camshaft completes one revolution per 2 revolutions of the crankshaft
  - $\omega_{camshaft} = \frac{1}{2}\omega_{crankshaft}$

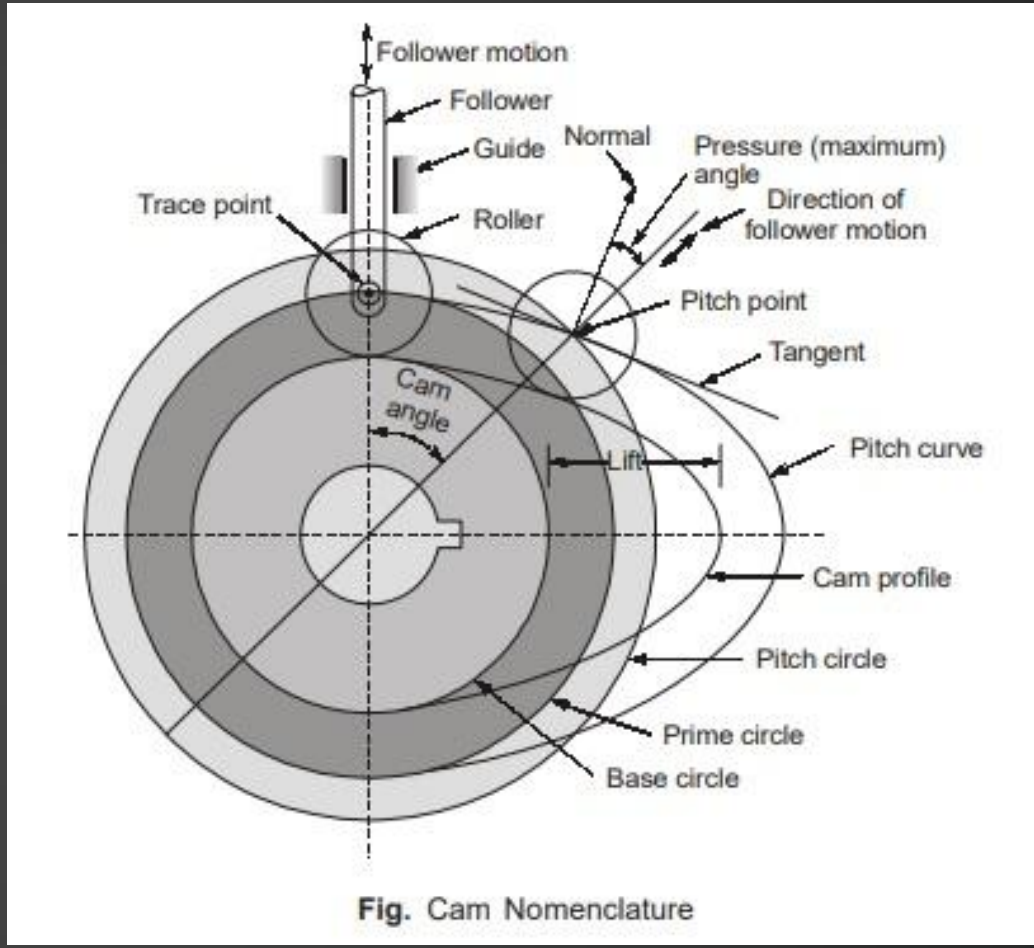
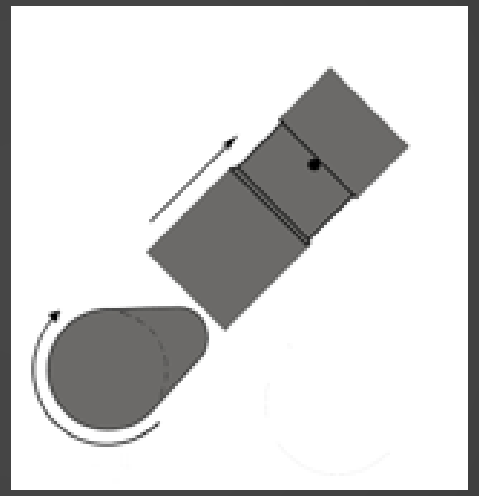


Fig. Cam Nomenclature

Failure Modes

- Spring Fatigue – Loss of closing force, can lead to fracture
- Valve Float – Loss of contact with cam, generally occurs at high RPM. Can cause valve to contact piston.
- Cam Lobe / Follower Contact Fatigue – Pitting, spalling or scuffing of the cam lobes or followers, can affect the cam profile.



Critical Design Parameters

- Camshaft Geometry – Base circle, lobe shape, gear diameter
- Rocker Geometry – Pivot location, lever arm lengths
- Valve Geometry – Head diameter, overall length
- Springs – Wire diameter, free length