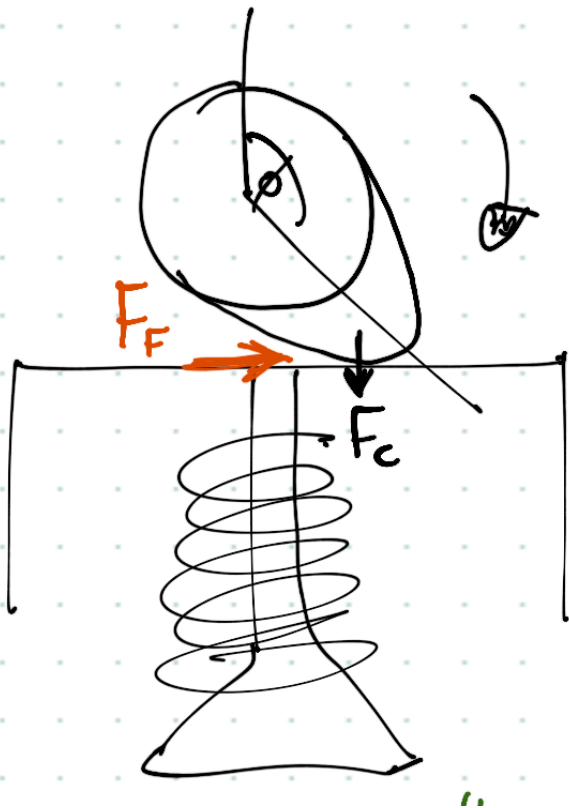
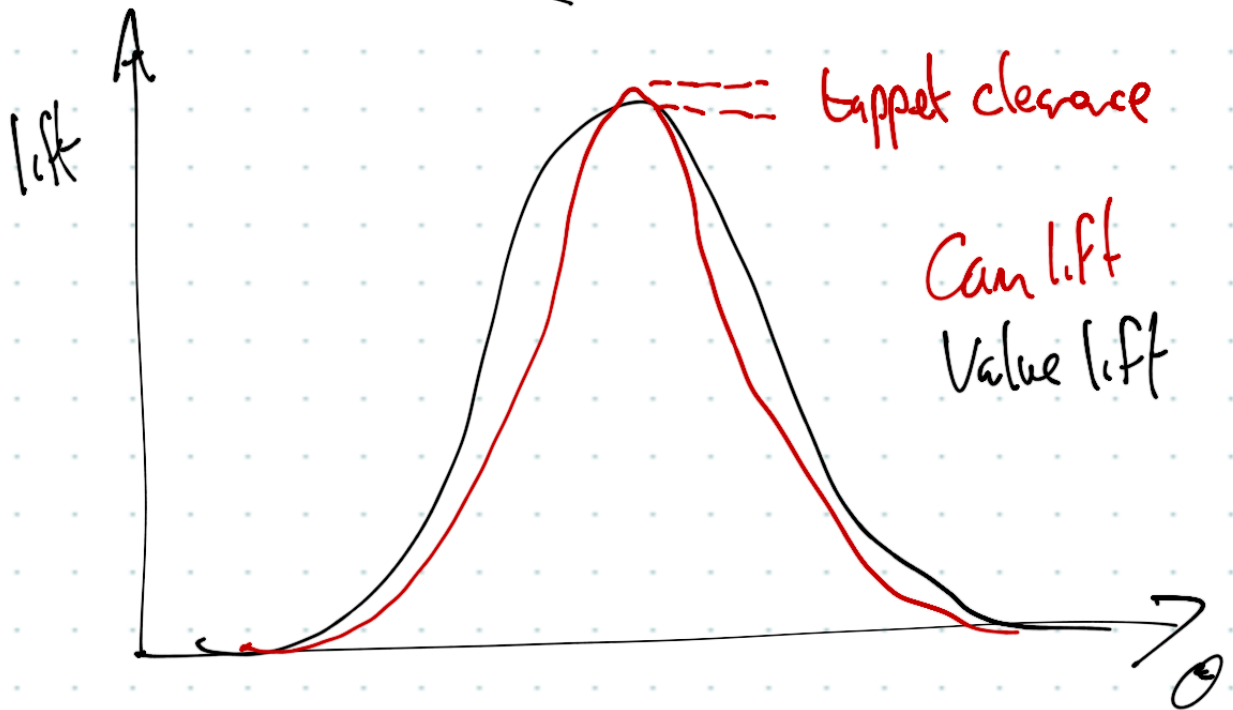


Valvetrain Continued



F_c = Contact force

F_F = Friction force

$$F_c - \text{Spring force} = M \frac{d^2y}{dt^2}$$

So

$$F_c = \text{Spring force} + M \frac{d^2y}{dt^2}$$

$$F_c = K(y + y_0) + M \frac{d^2y}{dt^2}$$

initial compression

Position x generally :

Velocity $v = \frac{dx}{dt}$

acceleration $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

for lift

y
 $\frac{dy}{dt}$
 $\frac{d^2y}{dt^2}$

Sometimes we write these as

$$x = x$$

$$\dot{x} = \frac{dx}{dt}$$

$$\ddot{x} = \frac{d^2x}{dt^2}$$

$$y = y$$

$$\dot{y} = \frac{dy}{dt}$$

$$\ddot{y} = \frac{d^2y}{dt^2}$$

$$F_c = K(y + y_0) + M \frac{d^2y}{dt^2}$$

M = Moving mass

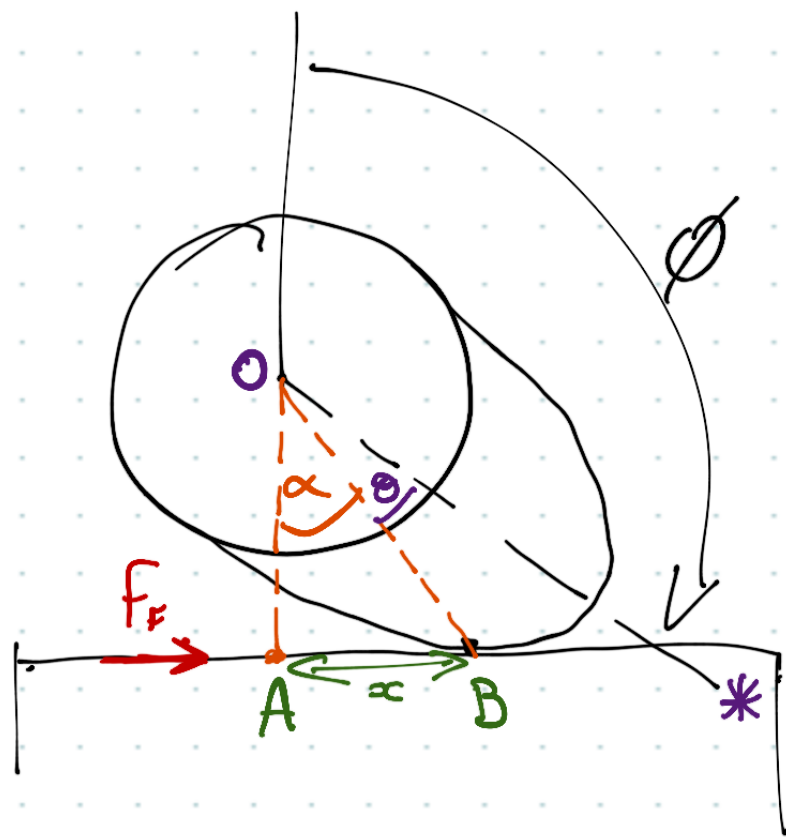
F_f = Friction .

So we could calc

θ	Lift	F_c	$F_f = M F_c$

$$\mu = 0.1$$

lubricated
Sliding
friction



$\phi = \text{Phi} = \text{Cam angle}$

$\theta = \text{Theta}$

$= *$ to contact point

$\alpha = \text{angle from contact to vertical}$

$AB = x = \text{distance from contact to cam}$

$$x = OA \cdot \tan \alpha$$

$$\alpha = [180 - (\theta + \phi)]$$

Max Value

we calculated previously the θ Value that gave the maximum OA

ϕ	lift	F_c	$F_F = \mu F_c$	$x = AO \tan \alpha$	Distance moved per degree
1					$= x_2 - x_1$
2					
3					

$\Rightarrow$ Work Done per deg
 $F_F \times (x_2 - x_1)$

So we use $x_2 - x_1$ with F_F (force $\times$ dist) to get the work done.

So work done per degree

$$WD = F_F \times (x_2 - x_1)$$

$$= |\mu F_c (x_2 - x_1)|$$

Absolute value
 $|-3| = 3$
in excel
 $\text{Abs}[\dots]$

 This means 'Absolute Value'

or you can use:

$$\sqrt{(\text{Work Done} / \circ)^2}$$

This gives us the total energy loss per
Can rotation when calculated
over 360° of Can rotation

In terms of time ... / Engine = 2 × Cam Speed

$$\text{Cam RPM} = \frac{1}{2} \text{ Engine RPM}$$

So work Done per Second = Total work Done per Cam revolution × number of Cam revolutions per second.

$$\text{WD/sec} = \text{Total WD/Cam Rev} \times \frac{\text{Engine RPM}}{2 \times 60}$$

$$= \underline{\text{Power loss from 1 lobe}}$$

Power loss can be quite significant ...

How do we reduce it?

Reduce friction ↓

Superfinishing :

Cent parts in ceramics

Surface Roughness :

~ R_A Value
 R_z Value



DLC Coatings?

=> Diamond like Coating

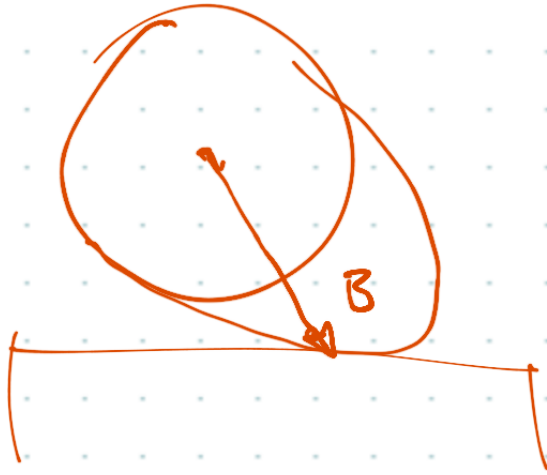


about 3 microns thick

Surface becomes really
Smooth from Superfinishing

Rockwell hardness testing gets a
Value towards Diamond.

we estimate $\mu = 0.05$



Contact Sliding velocity
Controls the behavior
of the hydrodynamic film

Sliding velocity between
Cam and followers effects the rate of change
of α



Example water wedge in front of Surfboard/ski:

The oil wedge prevents metal to metal contact
and depends on the viscosity of the oil

Old Engines need thicker oil

→ oils

Racing $\rightarrow$ how to cheat ---

for example : Some race series define a maximum valve lift :

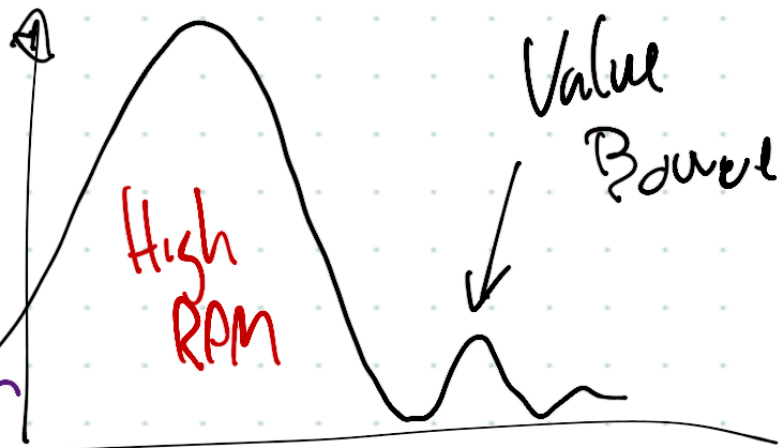


Very aggressive ramp

$\rightarrow$ Hits the valve so hard it moves to a higher lift due to float :

At high RPM you can also use valve Bounce

The valve hits the seat and Bounces ----
 $\Rightarrow$ Increased Duration

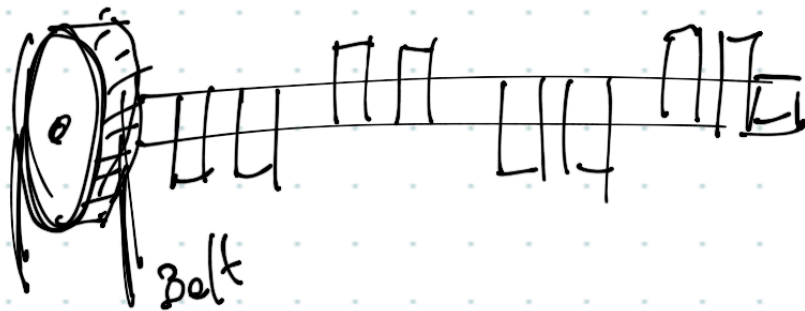


Other useful stuff $\rightarrow$ Reduce Mass
We could use a hollow can

This will result in higher Stress



$$\text{Torque to turn lobe} \\ = F_c \times x \quad \text{Nm}$$

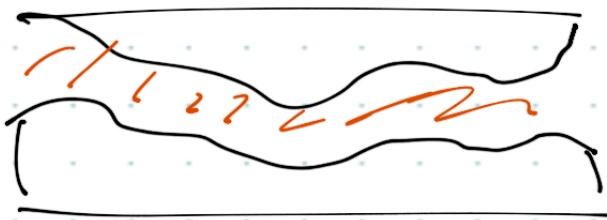


As you try to make the can lighter
The can will twist more

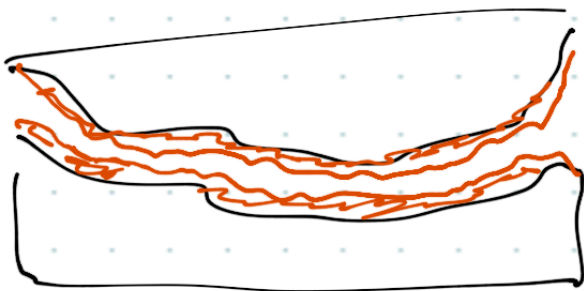
Lubrication : Oils

Most oils are a 'Base oil' + Additives

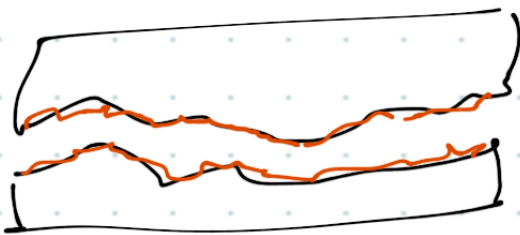
Most surfaces are not flat



Best case —
Full film lubrication



Mixed film lubrication



Boundary lubrication
→ worst case

API Base oil Categories :

Base oil Category	Sulfur	Saturates	Viscosity
Mineral oil { I II III	$>0.03\%$	$<90\%$	80-120
	$<0.03\%$	$>90\%$	80-120
	$<0.03\%$	$>90\%$	>120

I is Solvent Refined

II is hydrotreated

III is hydrocracked

Synthetic {	IV	→ PAO Synthetics
	V	→ Stuff not in I → IV

Viscosity → Drop a ball, see how fast it falls ...

