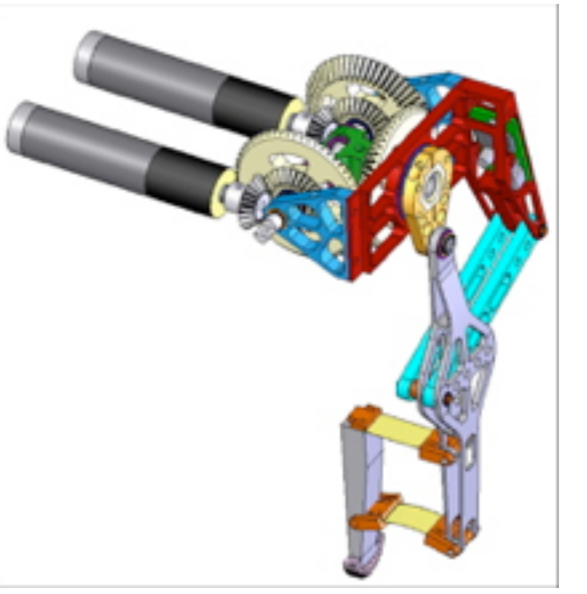
ME112: Mechanical Systems

Lecture 2, Jan 6 2016



Part I:

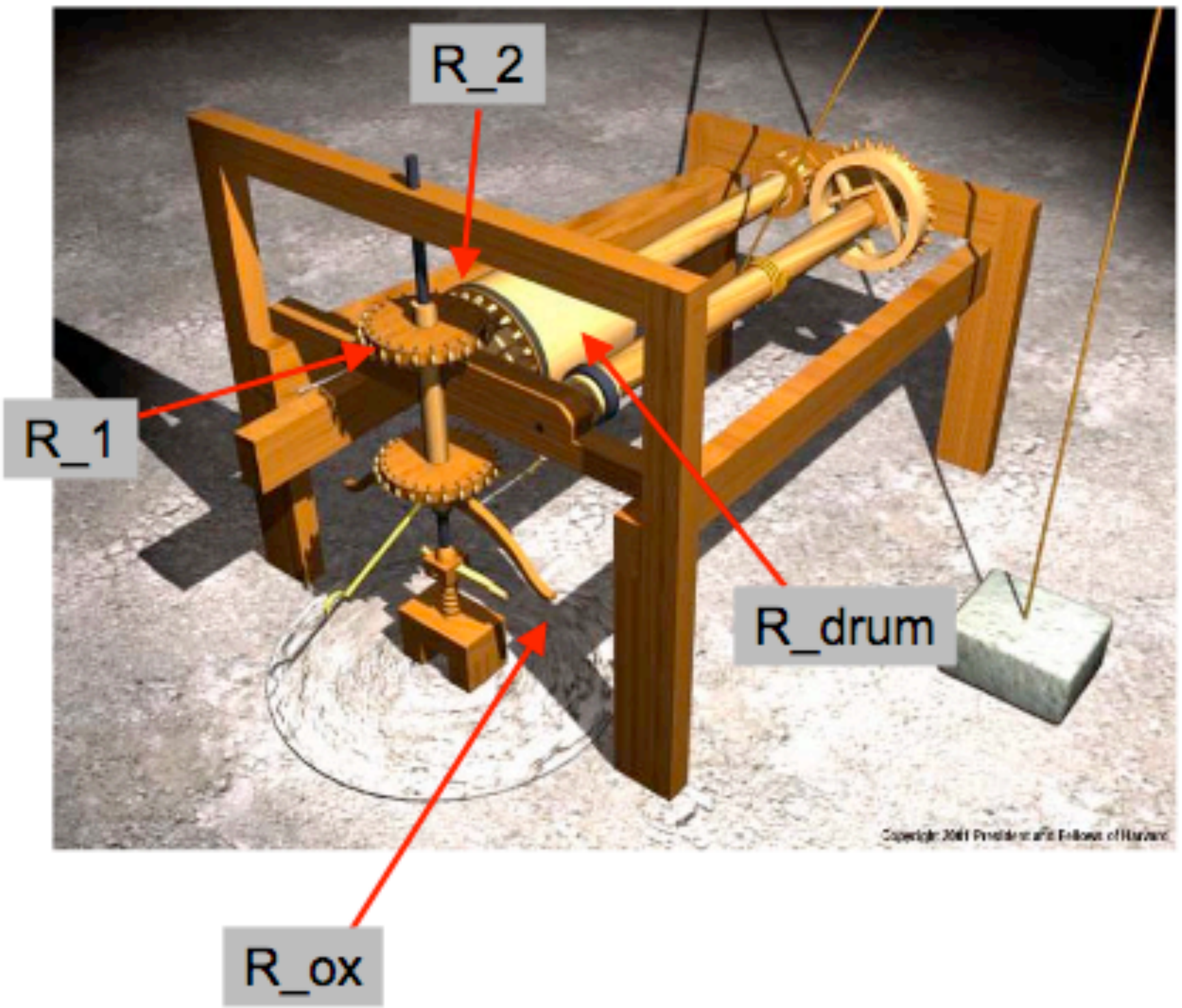
- Lab signups, logistical issues?
- Brunelleschi and his machine
- Assignment 1 questions, discussion

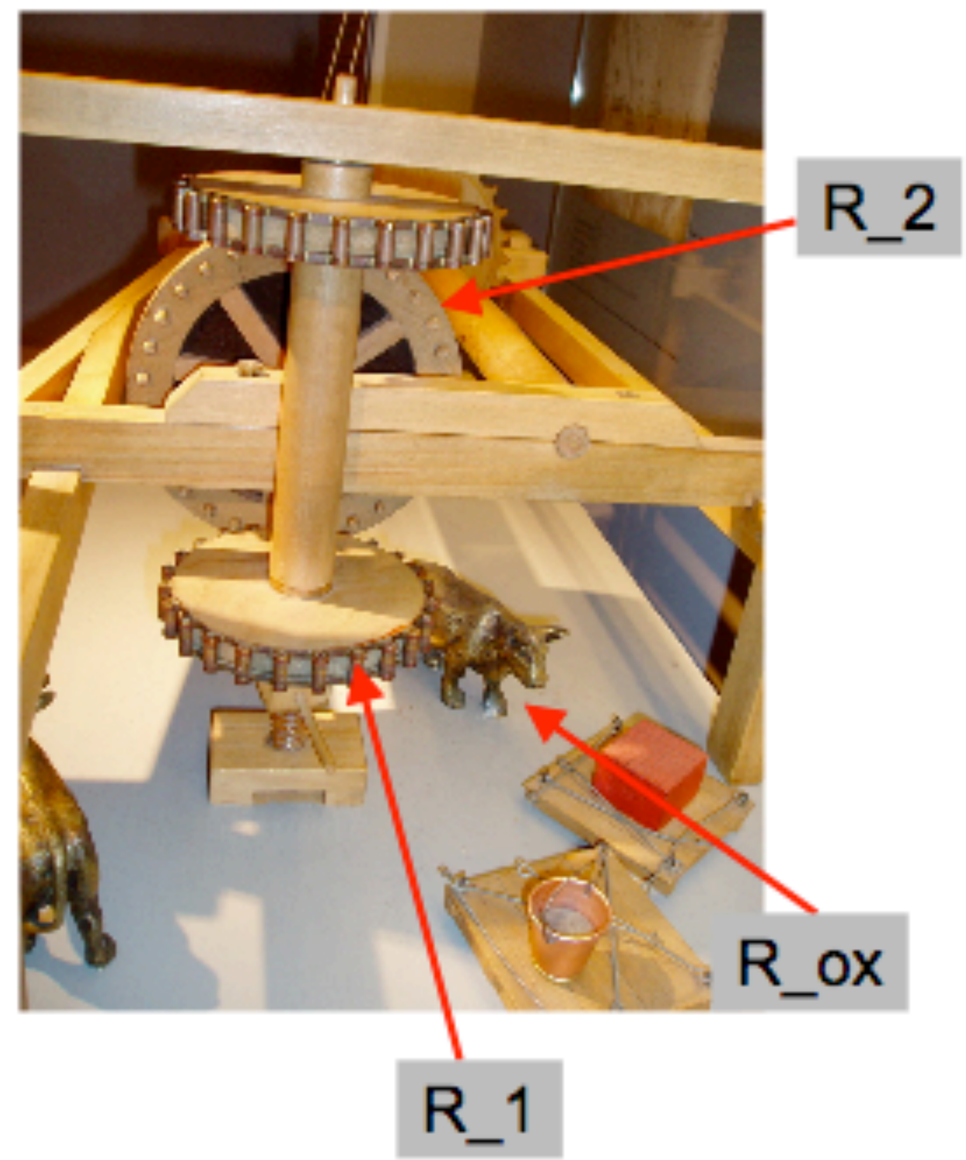
Part II:

- Modern gear kinematics
- Involute profiles
- Contact ratio
- Gear terminology

Assignment 1: Read for Wednesday. Think of a couple good questions. We'll talk about it more. Due online Friday.

Example 1: Consider Brunelleschi's giant 3-speed reversing hoist as an example of an input/output system – the same machine used in Assignment 1.





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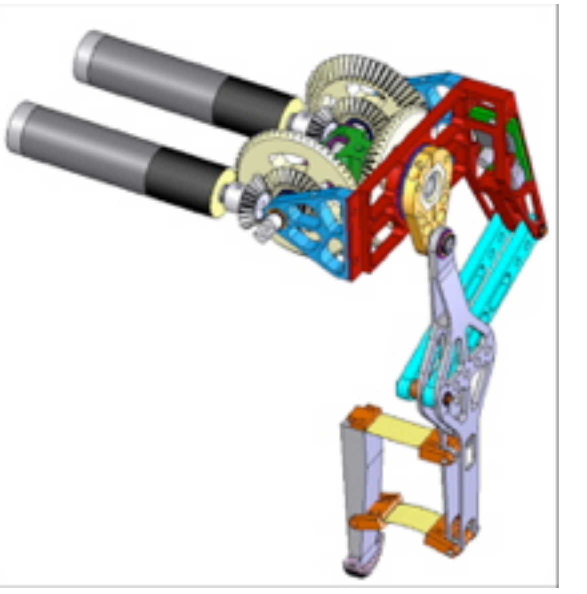

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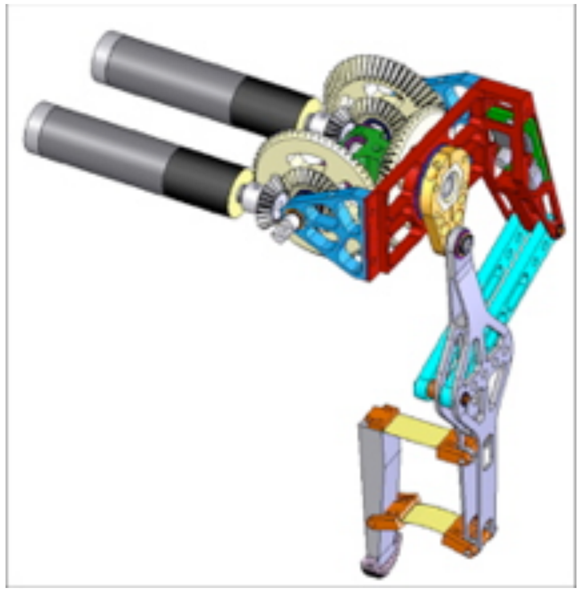
Renaissance vs modern gearing



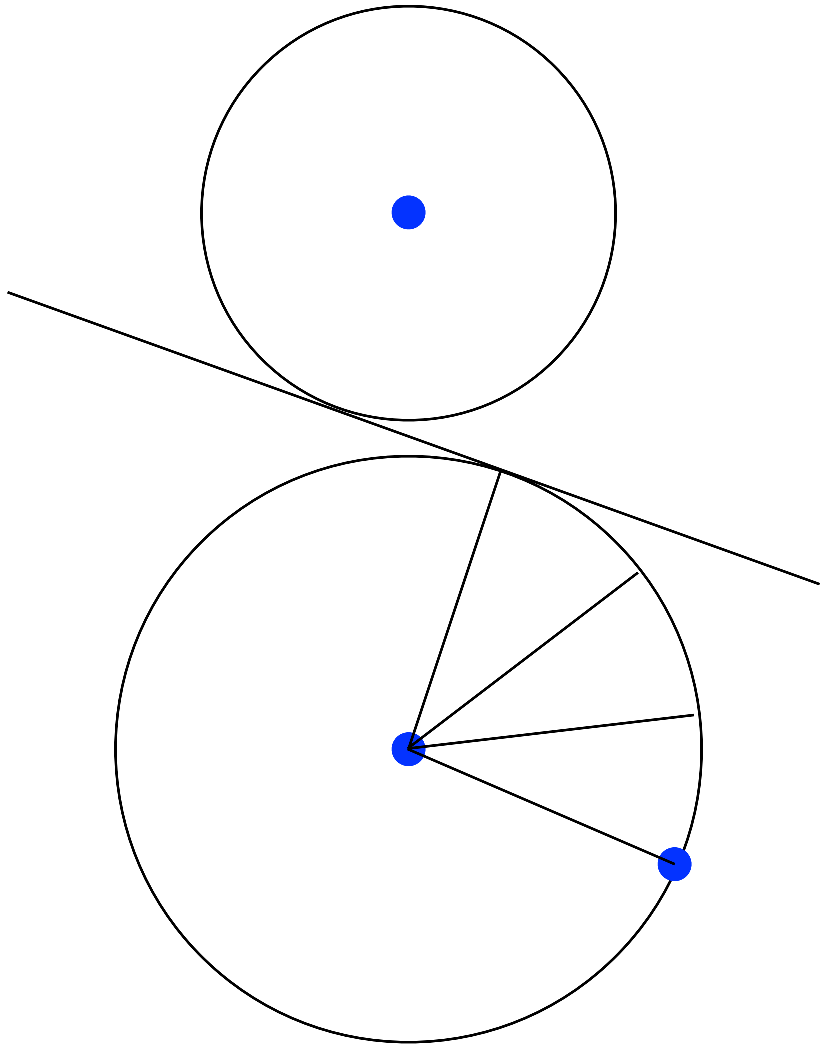
Cog wheel (lantern and peg):

http://science.howstuffworks.com/transport/engines-equipment/gear1.htm

Involute:

http://www-mdp.eng.cam.ac.uk/web/library/enginfo/textbooks_dvd_only/DAN/gears/meshing/meshing.html

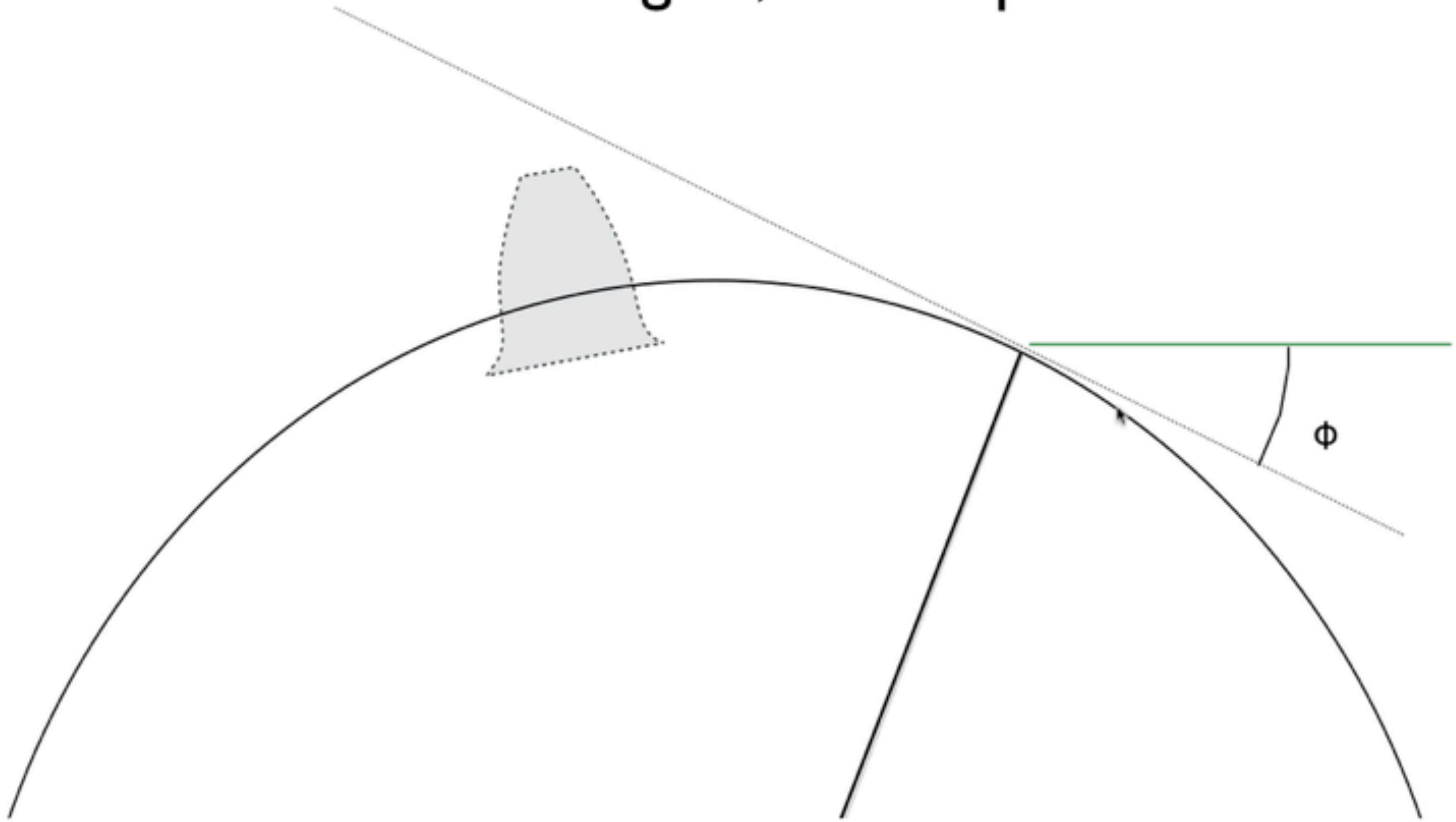
Two rotating cylinders



https://www.youtube.com/watch?v=4QM0juVXW54

Building the Involute Curve:

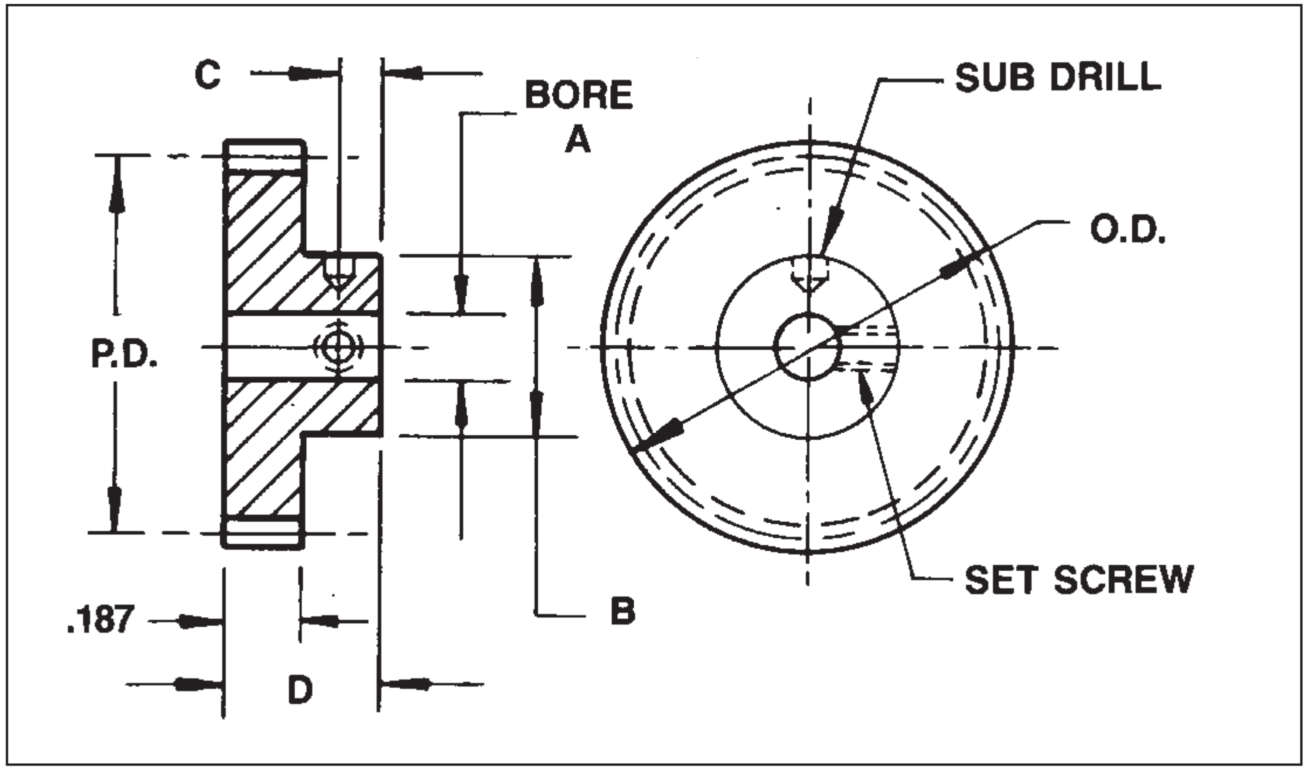
consider a reference frame
fixed in the gear, not in space



SPUR GEAR-48 PITCH — 3/16" Face Width ▪ 20° Pressure Angle

Pin Hub — 3/16", 1/4" Bores

PIC Gear Catalog



Material: 303 Stainless Steel
2024-T4 Aluminum
(Anodized Before Cutting)

Gear Data			Stainless Steel Part No. Bore Size		Aluminum Part No. Bore Size	
No. Teeth	P.D.	O.D.	.1873	.2498	.1873	.2498
21	.4375	.479	G5-21	—	G6-21	—
22	.4583	.500	G5-22	—	G6-22	—
23	.4791	.521	G5-23	—	G6-23	—
24	.5000	.542	G5-24	—	G6-24	—
25	.5208	.563	G5-25	—	G6-25	—
26	.5416	.583	G5-26	—	G6-26	—
27	.5625	.604	G5-27	G7-27	G6-27	G8-27
28	.5833	.625	G5-28	G7-28	G6-28	G8-28
29	.6041	.646	G5-29	G7-29	G6-29	G8-29
30	.6250	.667	G5-30	G7-30	G6-30	G8-30
32	.6666	.708	G5-32	G7-32	G6-32	G8-32
34	.7083	.750	G5-34	G7-34	G6-34	G8-34
36	.7500	.792	G5-36	G7-36	G6-36	G8-36
38	.7916	.833	G5-38	G7-38	G6-38	G8-38
40	.8333	.875	G5-40	G7-40	G6-40	G8-40
42	.8750	.917	G5-42	G7-42	G6-42	G8-42

No. teeth	P.D.	O.D.
34	0.7083	0.750

$b = ?$

$P = ?$

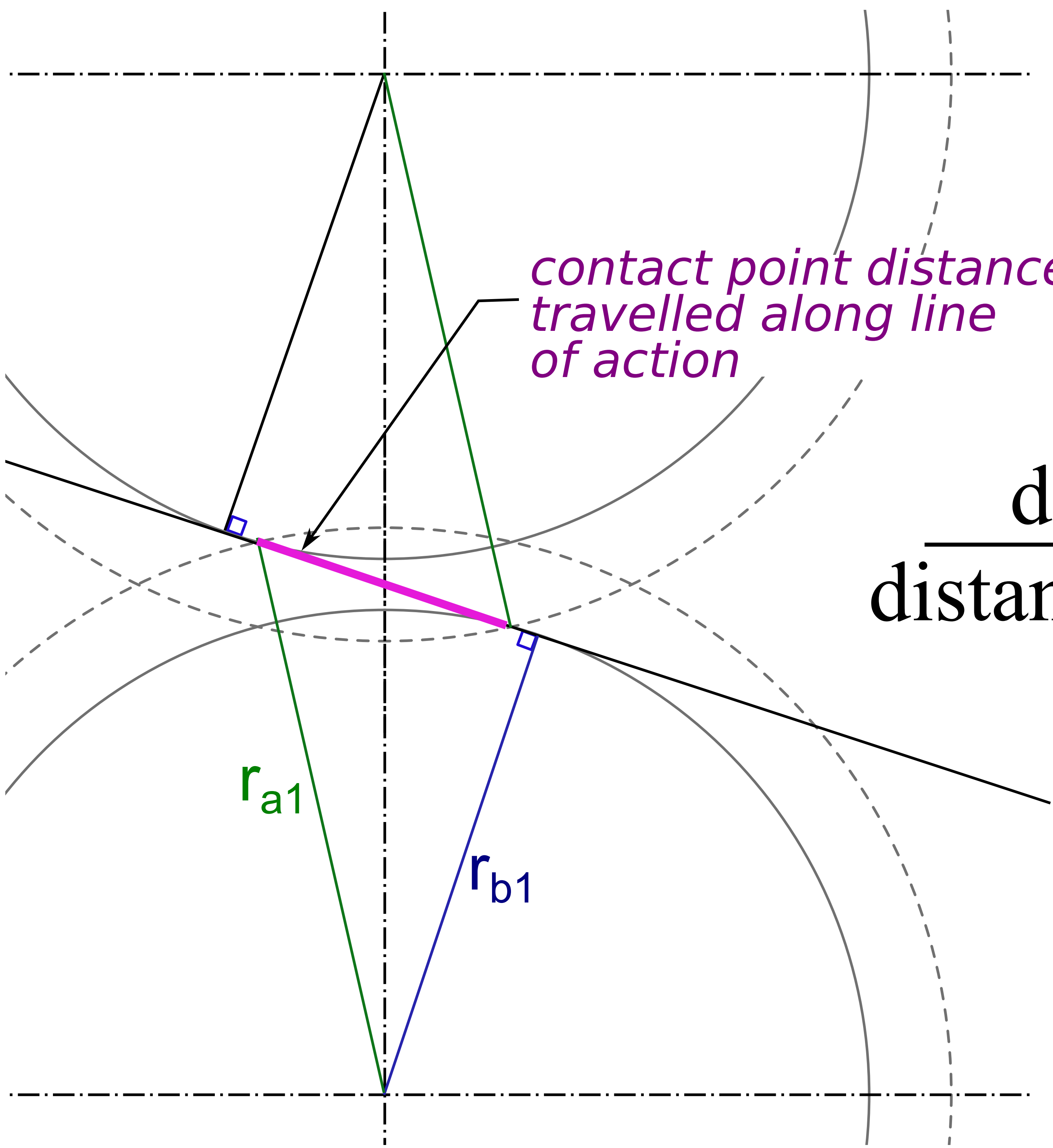
$N = ?$

phi $= ?$

$r_a = ?$ check: $(34+2)/48 = 2*r_a$

Contact ratio

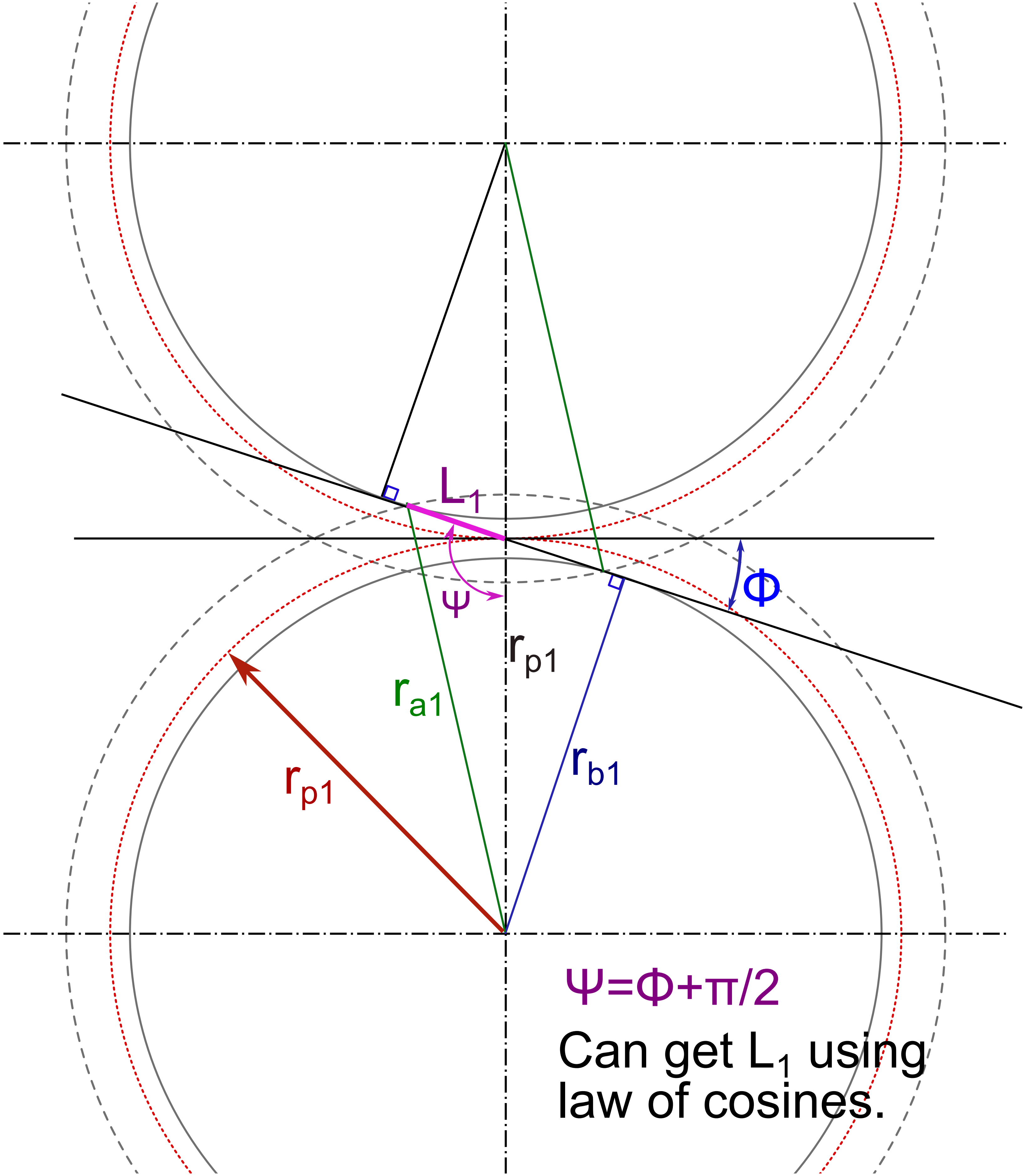
- *How smoothly is load transferred from one pair of teeth to the next?*
- *Do we have more than one pair of teeth in contact at all times?*



$$\frac{\text{distance travelled}}{\text{distance between contacts}}$$

depends on pitch

Contact ratio



(similar for L_2)

$\Psi = \Phi + \pi/2$

Can get L_1 using law of cosines.

Lets try it!

Python or Matlab or Spreadsheet….

```
# Some gear pair calculations
import numpy as np #math stuff

Pitch = 24.        # Diametral pitch (teeth per inch of diameter)
phi_deg = 20.      # Pressure angle in degrees
phi = np.pi*(phi_deg/180)

# Gear 1
N1 = 24
dp1 = N1/Pitch;         rp1 = 0.5*dp1     # pitch diameter, radius
da1 = (N1+2)/Pitch;     ra1 = 0.5*da1     # addendum (outer) diameter, radius
db1 = dp1*np.cos(phi); rb1 = 0.5*db1     # base diameter, radius

# Gear 2
N2 = 24
dp2 = N2/Pitch;         rp2 = 0.5*dp2     # pitch diameter, radius
da2 = (N2+2)/Pitch;     ra2 = 0.5*da2     # addendum (outer) diameter, radius
db2 = dp2*np.cos(phi); rb2 = 0.5*db2     # base diameter, radius

speedratio = 1.0*N1/N2  #Force to floating point

# Check contact ratio
C = rp1 + rp2
Pbase = np.pi*np.cos(phi)/Pitch

numerator = np.sqrt(ra1**2-rb1**2) + np.sqrt(ra2**2-rb2**2) - C*np.sin(phi)
denominator = Pbase

ContactRatio = numerator/denominator
# Ideally, ContactRatio > 1.5
```

Lets try it!

Any design rules can be broken,
if you know what you are doing.