RBE 1001
Power Transmission

WORCESTER POLYTECHNIC INSTITUTE 1865 WPI

Big Stuff

- **"e" = "Gear-train", aka "speed ratio"**
- **Defined: (N_{drs}/N_{drn})** ***(N: number of teeth)***
- **Equal *exactly* to: *(n_{out}/n_{in}) (n: angular speed)***
- **Also to: *(T_{in}/T_{out}) * η_{sys}*** ***(η: efficiency)***

e = Product of Drivers / Product of Driven

= Speed out / Speed in

= (Torque in / Torque out) * Sys efficiency

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Transmission Essentials

- **Unless you are VERY lucky…you will need ‘em**
- **Transmissions can:**

  1) Modify speed vs torque

  2) Change direction of rotation

  3) Physically separate motor from device
- **They will ALWAYS**

  4) Reduce power through losses

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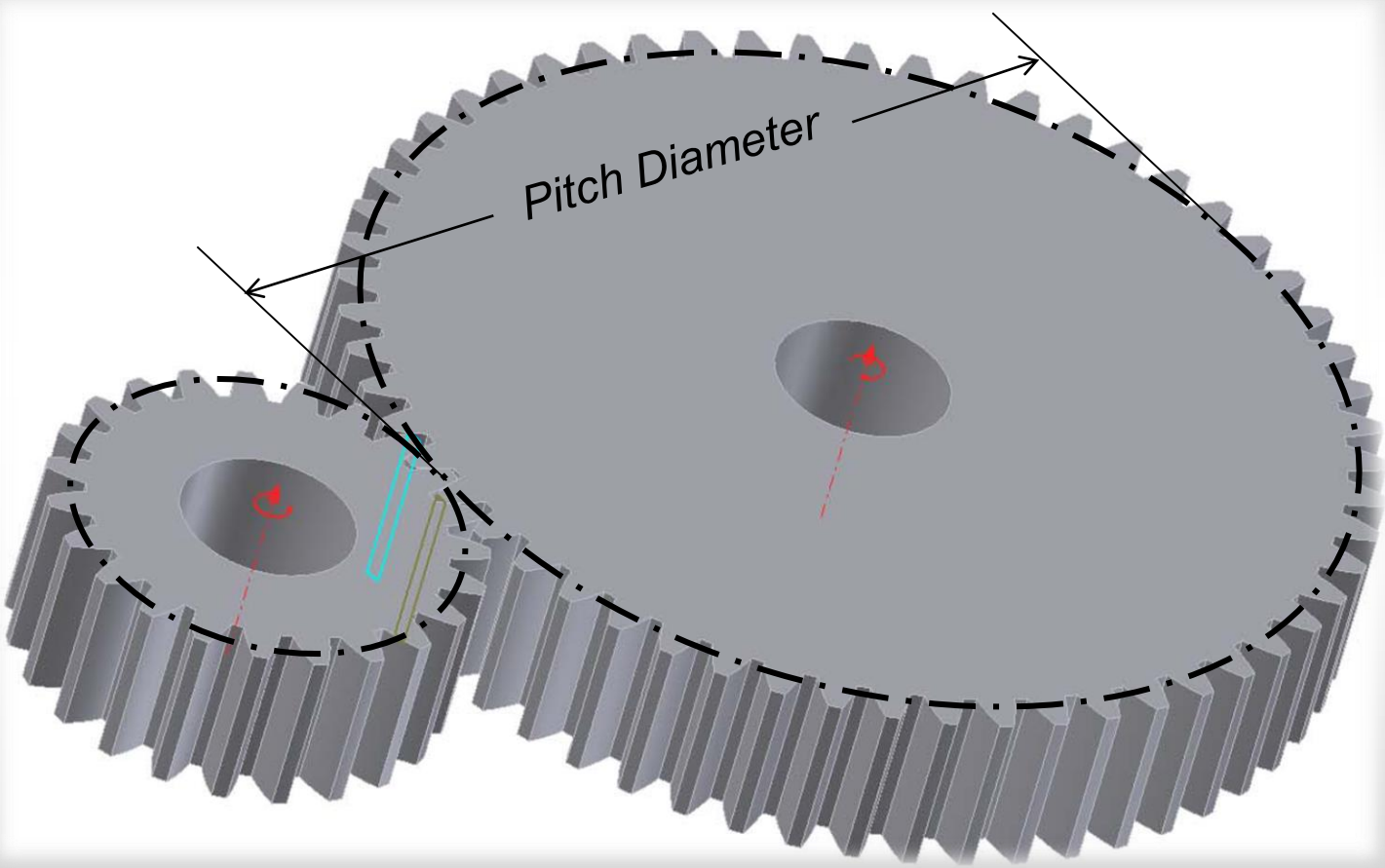
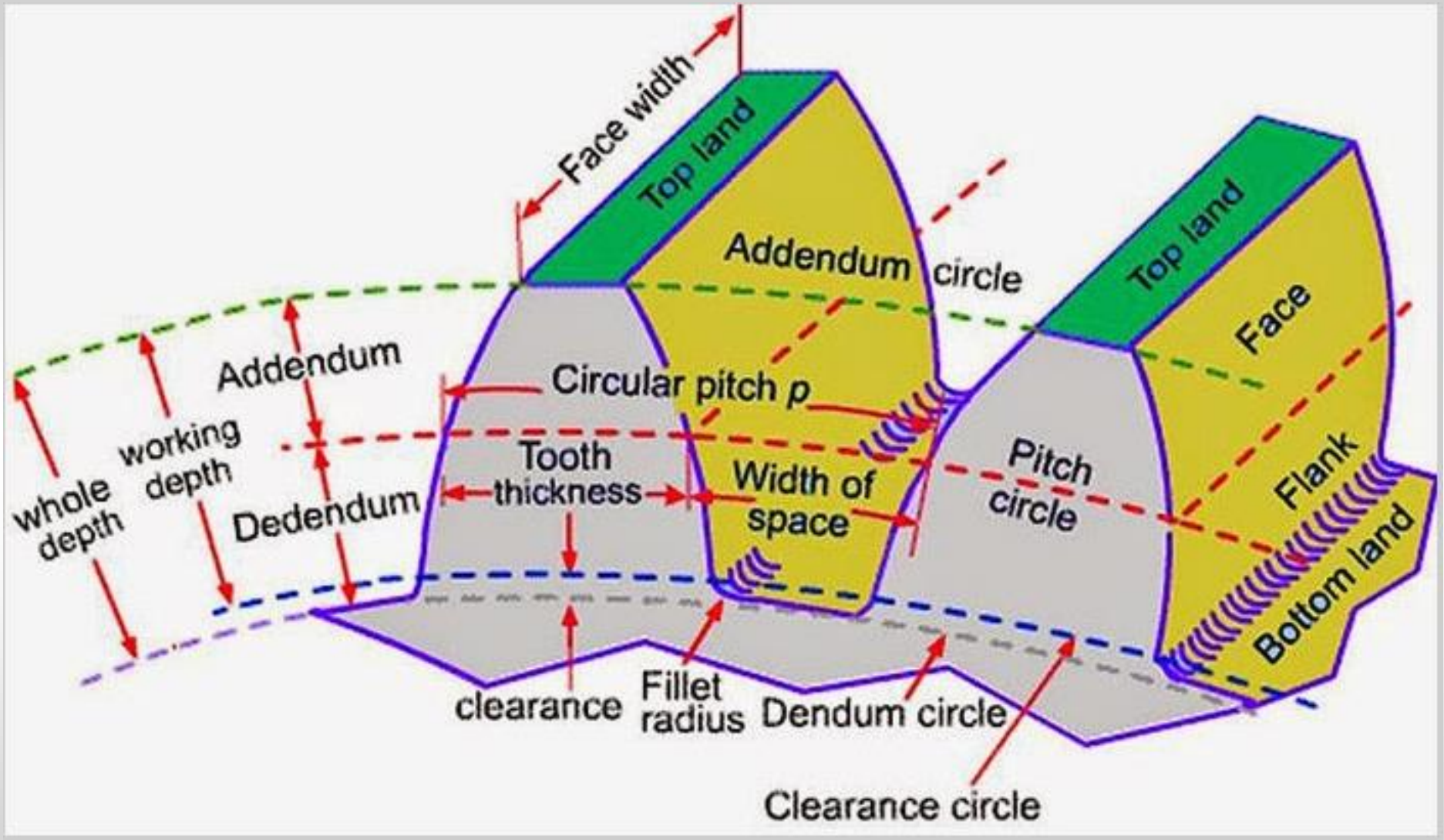
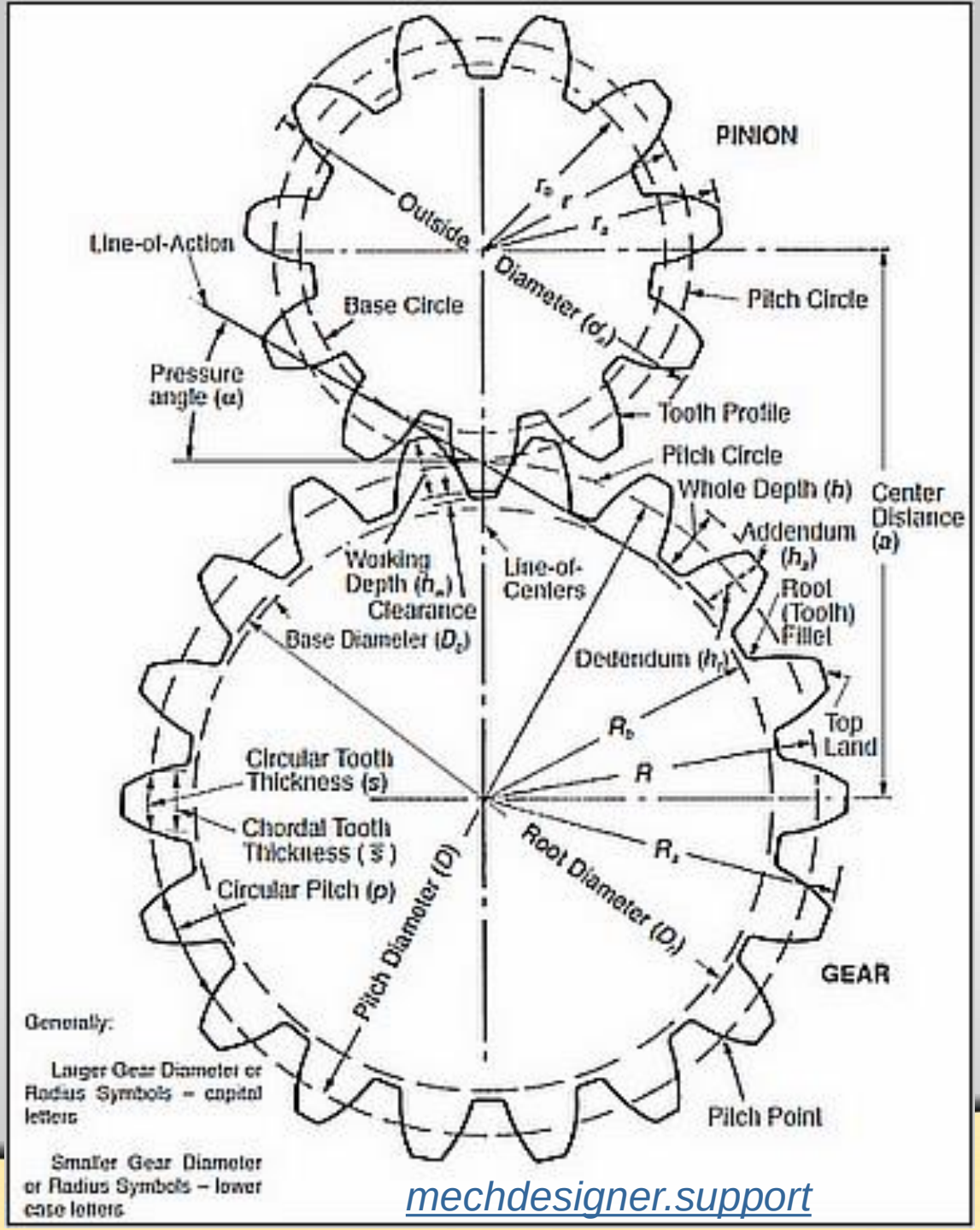
Spur Gears



Gear Terminology





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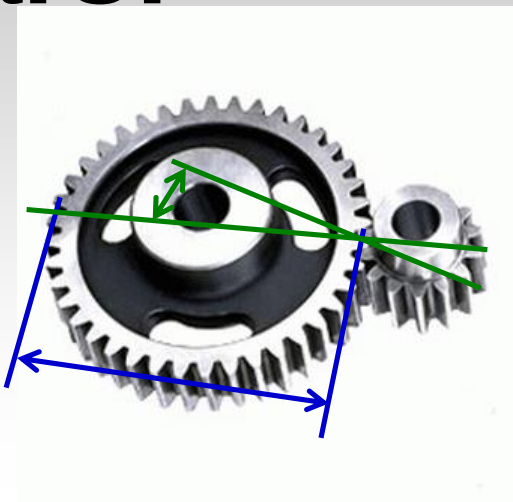
Gears, gears, gears!



- **Parameters (ANSI)**
  - **(Diametral) Pitch:**

    P = Number of Teeth / Pitch Diameter
    - **Integer number, normally divisible by 4**
    - **EG: 32, 28, 24, 20, etc**
    - **Larger the P, the smaller/weaker the teeth**
  - **Pressure Angle: the actual off-tangent angle force transmission**
    - **Typically 14.5 or 20 degrees**
    - **14.5 degrees weaker, more efficient**

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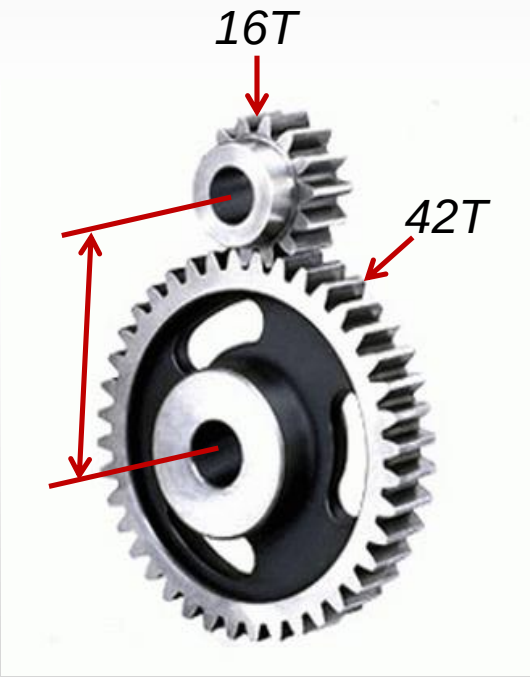
Spur Gear Design Details

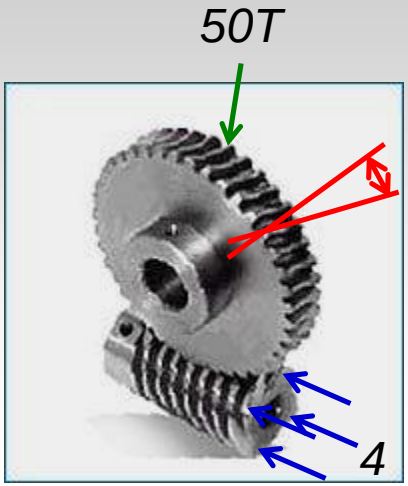
- **Gear sizes**
  - **Recommend 12T to Infinity! (rack)**
    - **Smaller (“pinions”) are weak from under-cutting—esp 14.5 degree PA**
  - **All gears with same P and PA will fit**
- **Transmission axle separation**
  - **An exact, easily computed distance**

  D = (Total number of teeth/P) / 2
  - **EG: 16T & 42T, 24 Pitch gears**

  D = ((16 + 42) / 24) / 2 = 1.208 inches
- **Can be 95-98% efficient/stage**



Other Gear Stuff



- **Worm Gears**
  - **Antibackdrive (Helix angle dependent, Window--yes; Van Door--no)**
  - **Woefully inefficient: η = .25-.75**
  - **Very compact**

  e = Number leads on worm / Teeth on Worm Gear

  = 4 / 50 = .08
  - **DO NOT USE FOR HI-POWER**
  - **Requires VERY secure bearing support**

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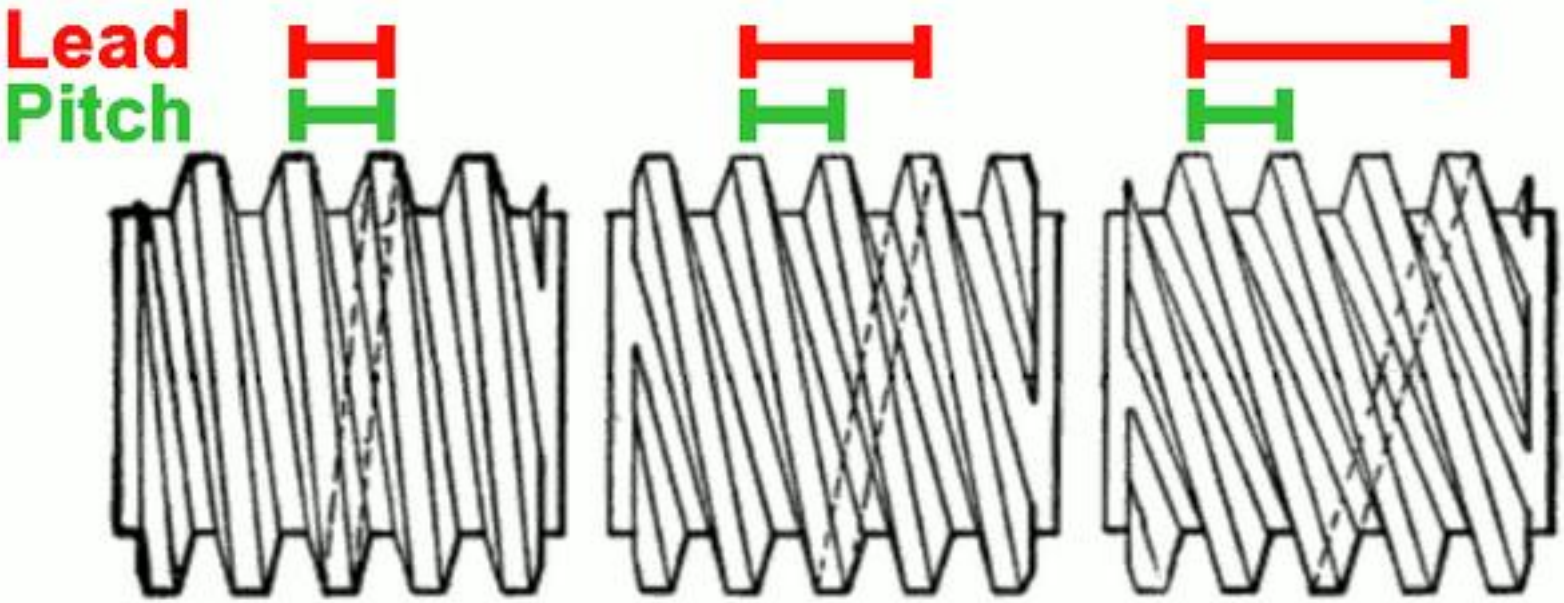
Multiple Thread Screws



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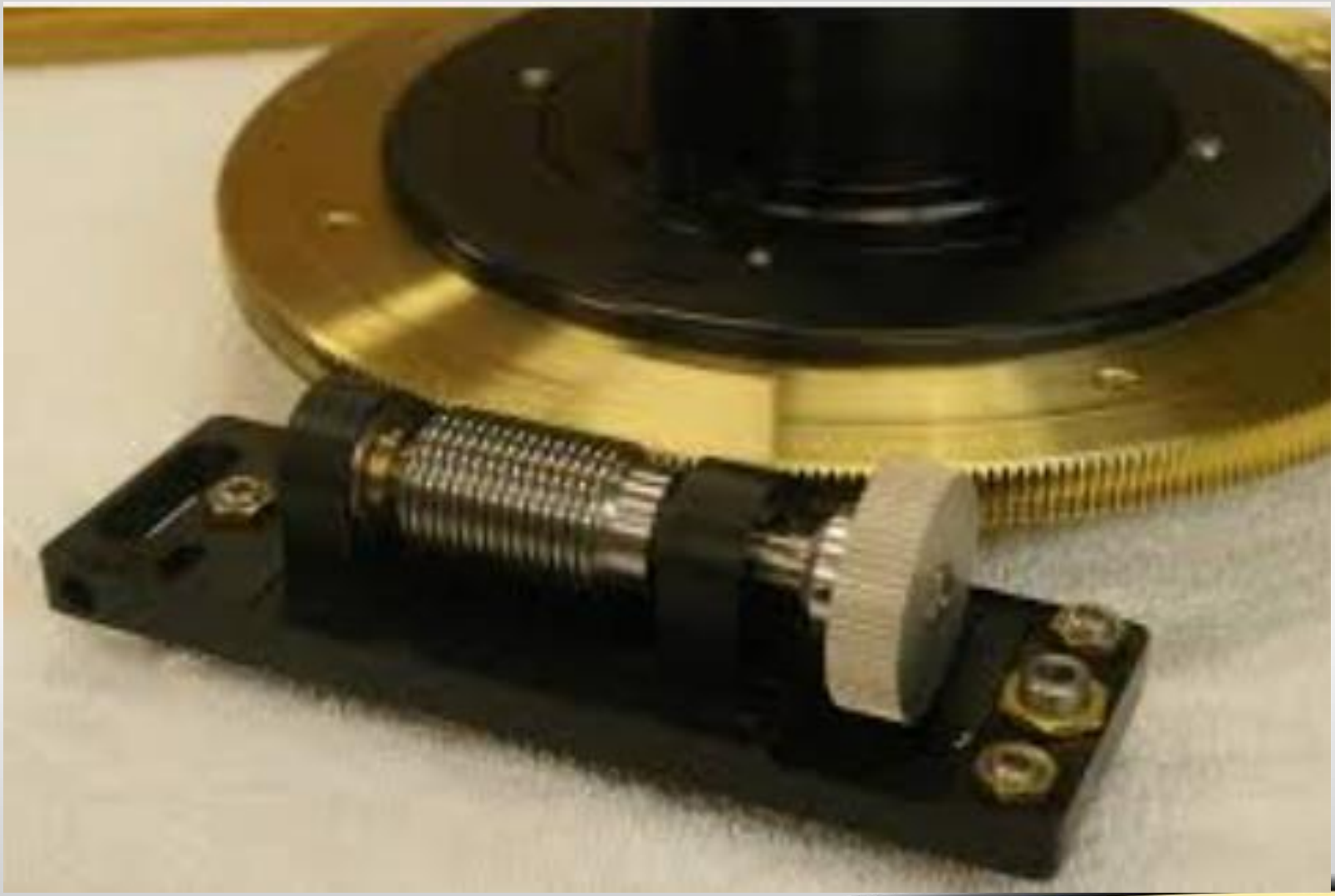
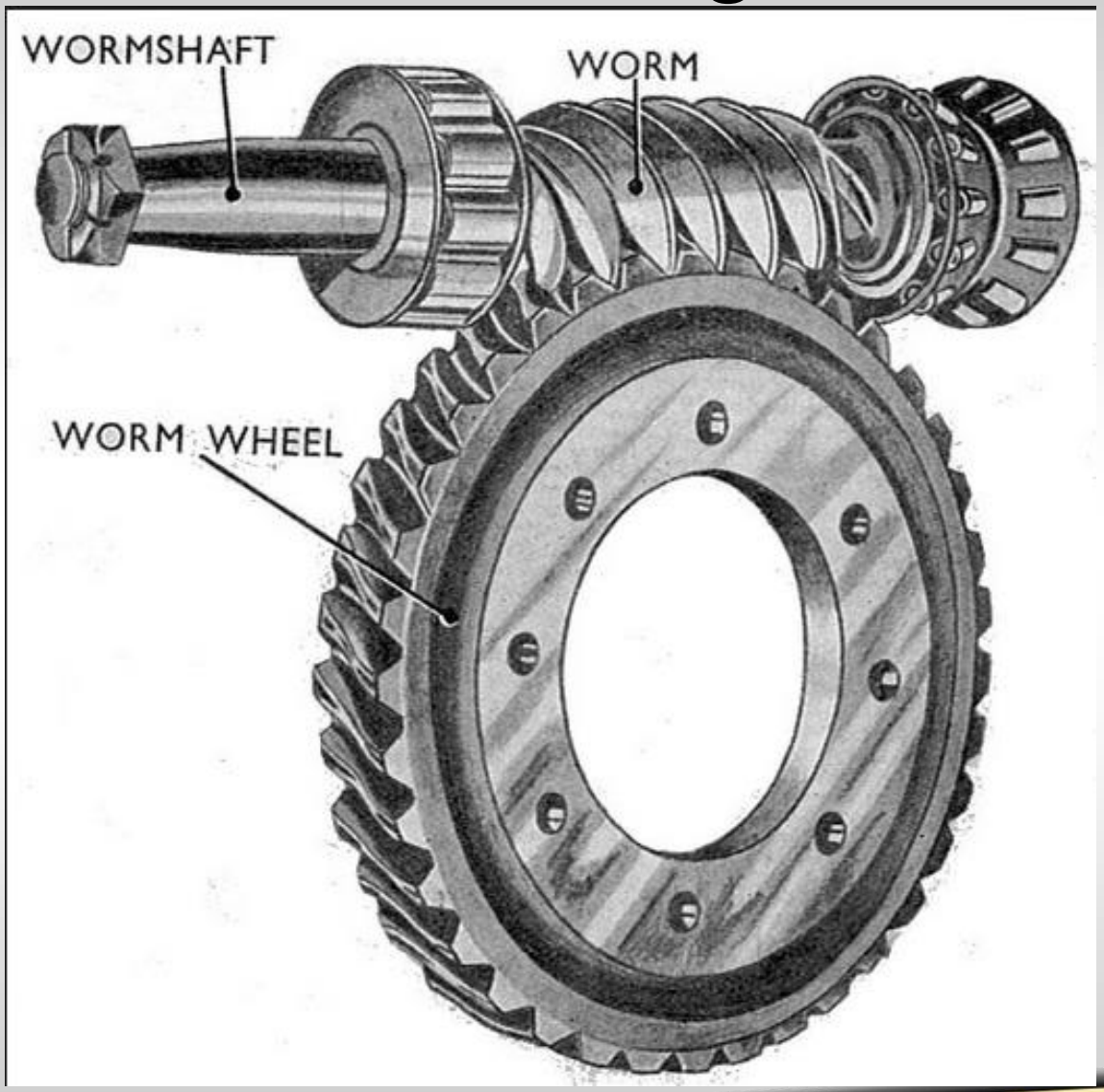
Worm Gear with Shallow Helix Angle



Worm Gear with Large Helix Angle



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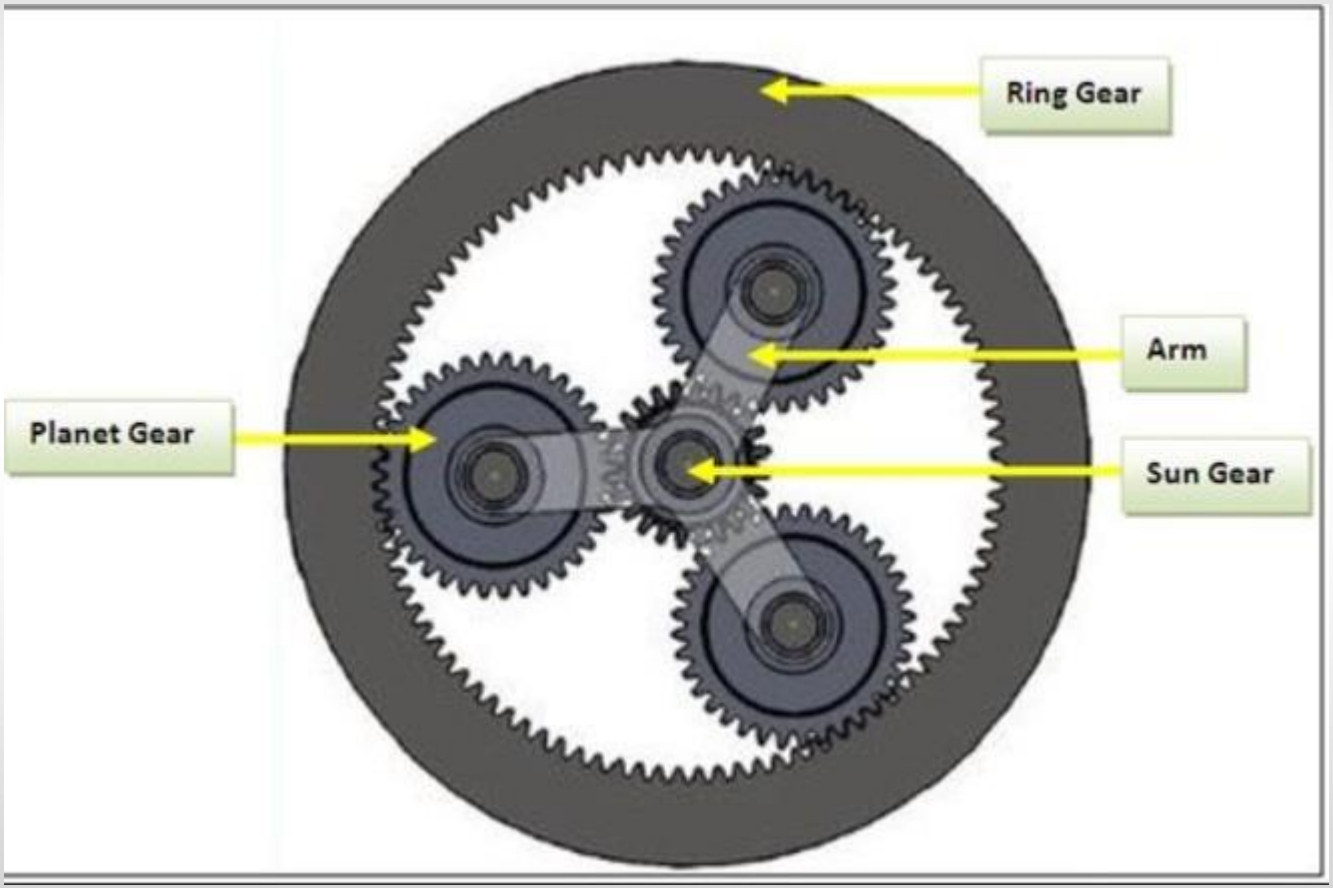
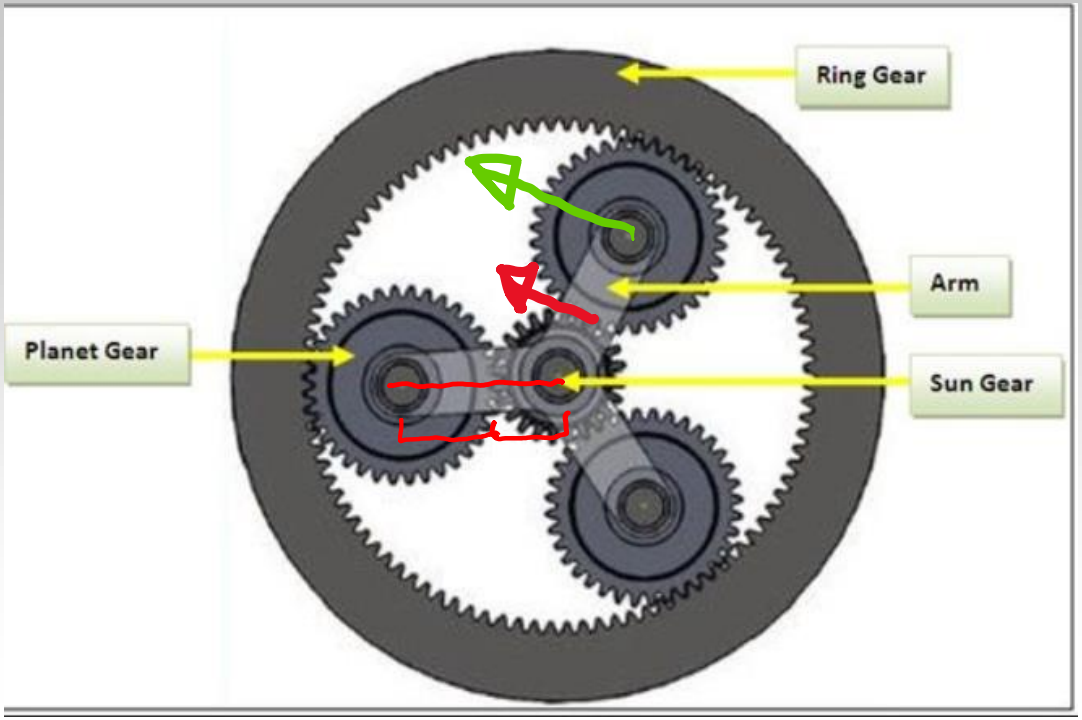
Planetary Gears

Planetary



For fixed ring gear:



$$v = \omega_p r_p = \omega_c r_c = \omega_c (r_s + r_p)$$

$$v = \omega_s r_s = 2\omega_p r_p = 2\omega_c (r_s + r_p) = \omega_c (2r_p + r_s + r_s)$$

r_{ring}

$$\omega_s r_s = \omega_c (r_r + r_s) \Rightarrow \boxed{\frac{\omega_c}{\omega_s} = \frac{r_s}{r_s + r_r}}$$

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Planetary Gear-train

- **Most common application for speed reduction, with ring gear fixed:**

$$e = N_{SUN} / (N_{SUN} + N_{RING})$$

“Roller” Chain and Sprockets

- Parameters (ANSI)
  - Chain Number:
    - 1st digit = pitch in 1/8 inches
    - 2nd digit = “roller” (0), “lightweight” (1), or “bushed” (5)
    - EG: #25: ¼ inch pitch without rollers, #35: 3/8 inch pitch without rollers
  - Strength (breaking/working):
    - #25 = 875/140 lbs
    - #35 = 2100/480 lbs
  - “Working” implies industrial duty/life expectancy

More Chain Stuff

- Quick links
  - "Master links": connect inner to inner
    - 75% of intrinsic chain strength
  - "Half links": connect inner to outer
    - 65% of intrinsic chain strength

Chain Design Details

- **Sprocket sizes**
  - **Recommend 12T to 75T**
    - **Smaller causes vibration & excess wear**
    - **Larger leads to chain loss**
    - **Ratios should be kept less than 8:1**
- **Chain Wrap**
  - **120 degree minimum for any drive or driven sprocket**
  - **Change routing, add idlers if necessary**
- **Design in adjusters for long runs**
  - **Adjustment range should ideally be 2 pitch lengths (to avoid half-links). Actual chain lengths should be in even number of pitches, otherwise an offset link is required.**

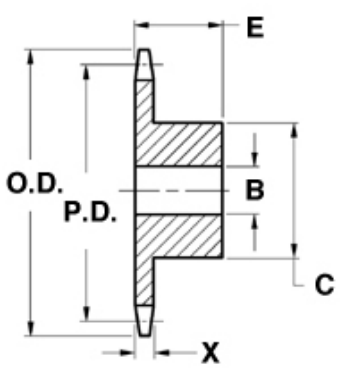
Chain Design Details

SDP/SI
STOCK DRIVE PRODUCTS/STERLING INSTRUMENT
Stock Drive Products
Sterling Instrument
Setting Ideas Into Motion

QTC METRIC GEARS
QTC METRIC GEARS
Supplying North America
with Metric Gears

Power Grid Search
Click Here to Clear
Pitch Dia. (P.D.) Inch
Pitch
Bore Size (B) Inch
Face Width (X) Inch
No. Of Teeth
Material
Overall Width (E) Inch
Hub Dia. (C) Inch

Stock Drive Products/Sterling Instrument > Sprockets > Roller Chain > With Hub (inch)



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Chain Design Details

- **Use the following equation to determine the center-to-center distance between the sprocket axles:**

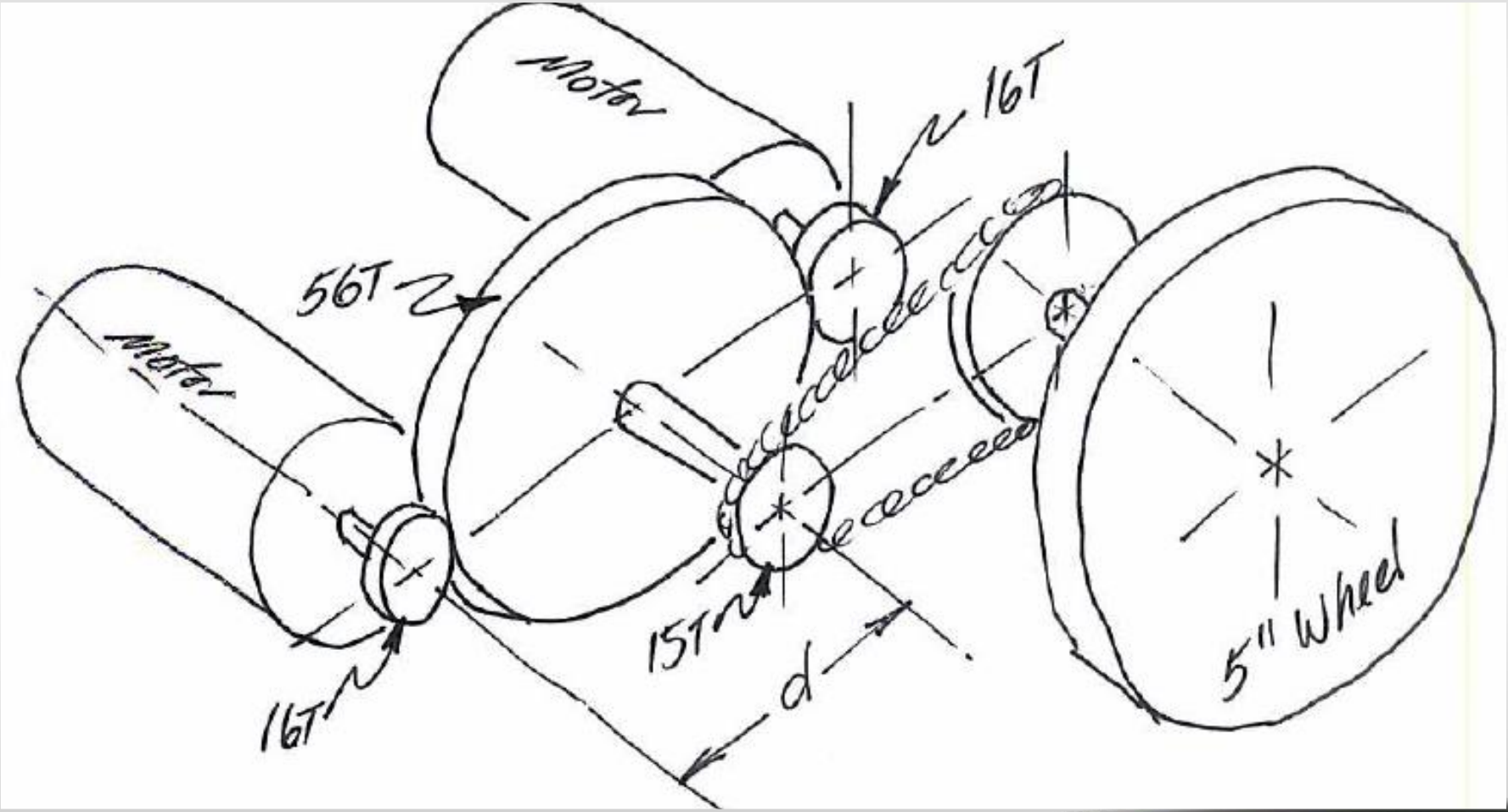
$$\frac{L}{p} = \frac{2C}{p} + \frac{N_1 + N_2}{2} + \frac{(N_2 - N_1)^2}{4\pi^2(C/p)}$$

L = chain length
p = chain pitch (center-to-center distance between chain rollers)
C = center distance
N_1 = number of teeth on small sprocket
N_2 = number of teeth on large sprocket

General Suggestions

- **Control top speed of operation by suitable gearing not by reduced voltage**
- **Avoid powered anti-backdrive**
- **Chains are efficient; gears are compact**

Combiner Transmission



Concept Questions

1) What is effect of the two motors on the speed ratio equation?

2) What are the components of the system efficiency?

3) What if your combiner used two different speed motors?

4) What if you use position control for *both* motors?

Questions?