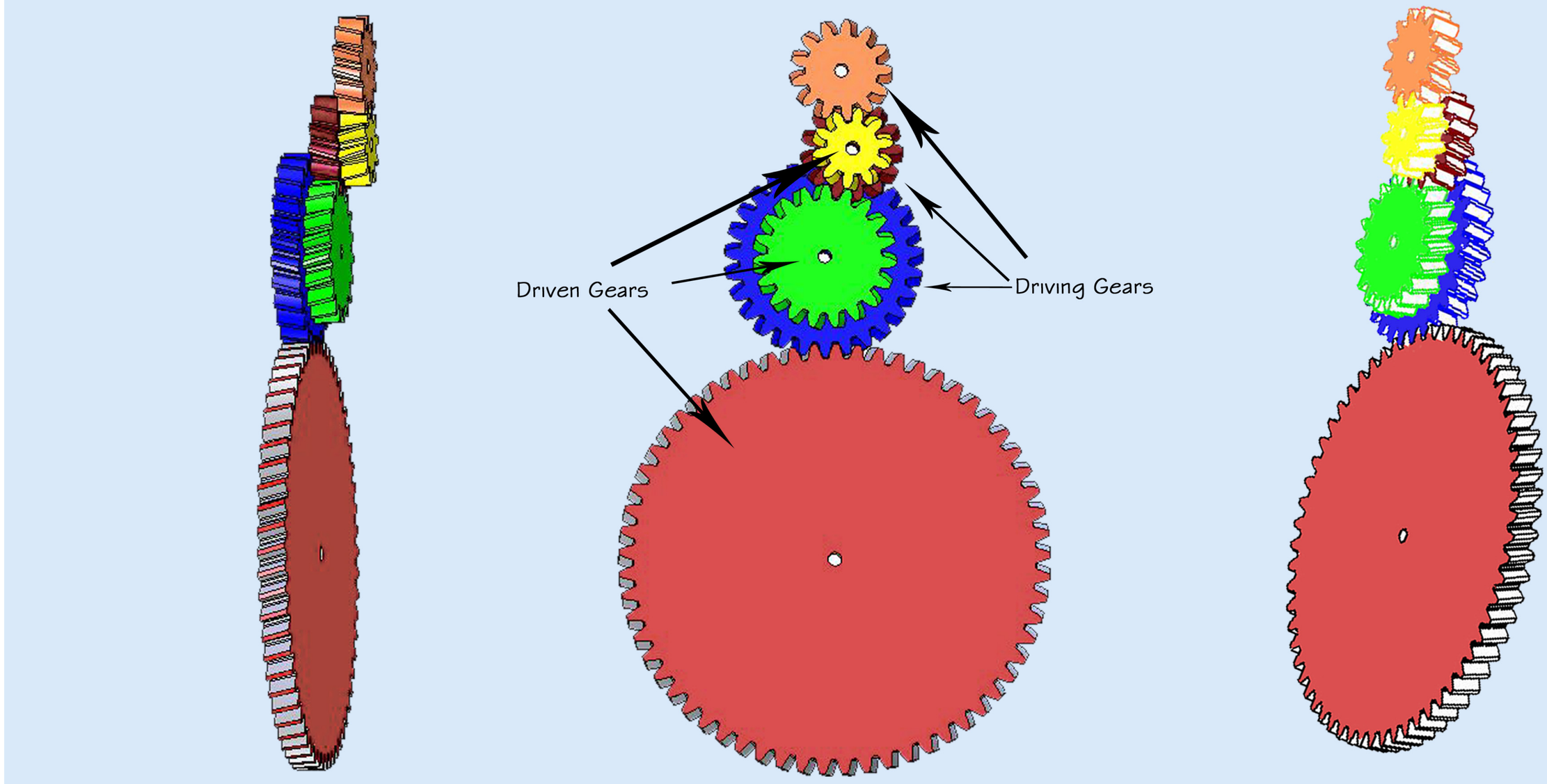
DESIGN OF MULTI-STAGE GEAR TRAINS

Multi-stage gear trains are desirable when a specific gear ratio is needed.
With the proper process one can obtain a precision ratio to six decimal places.

Multi-Stage Gear Train Basics

There is no simple solution to achieve a desired output ratio from a multi-stage gear. The method described below is a rather complex matrix of arbitrary values used to calculate the necessary components of the gear train. There are many applications for multi-stage gear trains in machine design and manufacturing processes when precise timing is necessary.

Three-Stage Gear Train



Achieving a Desired Train Ratio:

Step 1: Find integers such that $\frac{a}{b} = TV$

Step 2: Arbitrarily choose S as any # greater than 1

Step 3: Calculate h

$$h = \frac{S}{a - (b * TV)}$$

if TV > 1 substitute $(\frac{1}{TV})$

Step 4: Round h up or down to yield h'

Step 5: Solve for TV'

$$TV' = \frac{(a * h') - s}{b * h'}$$

Step 6: Factor Numerator and Denominator separately to give # of teeth in the driving and driven gears respectively. For S # of stages Numerator and Denominator should factor into S # of factors.

* Prime #'s are desirable and # of teeth should not exceed 120 or go below 10.

Train Ratio (R)

$$R = \frac{\text{input RPM}}{\text{output RPM}}$$

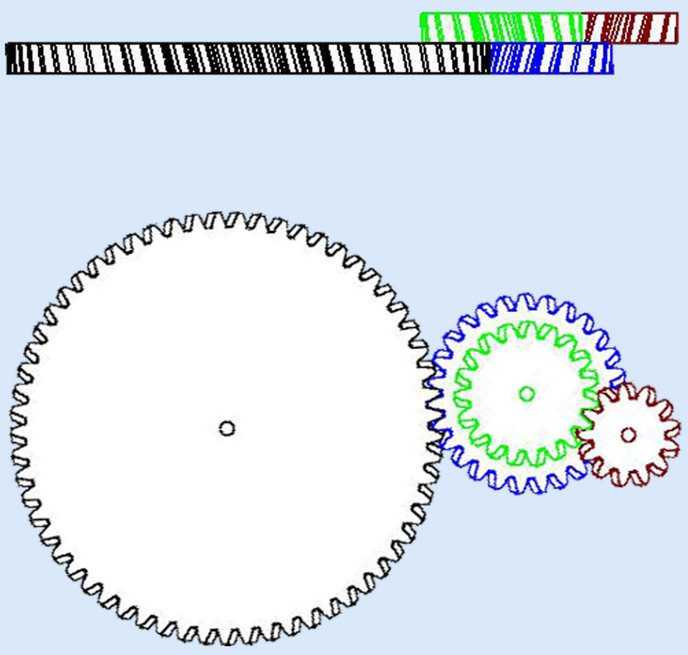
Train Value (TV)

$$TV = \frac{1}{R}$$

S = # of stages

a,b = arbitrary integer values

Two-Stage Gear Train



Adam Mattison
Matthew Shaw
Drew Stephens

Example Train Ratio:

TV = 2.54 TV > 1
so TV' = $\frac{1}{2.54}$ = .3937008

Step 1: $\frac{a}{b} = TV'$
$\frac{24}{61} = .3937$
so a = 24 & b = 61

Step 2: S = 2 for two stages

Step 3: $h = \frac{S}{a - (b * TV')} = -126.99$

Step 4: h' = -127

Step 5: $TV' = \frac{(a * h') - s}{b * h'}$
$= \frac{3050}{7747}$

Step 6: 3050 factors to 61 * 50
7747 factors to 127 * 61
127 is prime but exceeds 120 so iterate back to step 2: increasing S to 3

Step 2: S = 3 or 3 stages
Step 3: h = -190.49
Step 4: h' = -190
Step 5: $TV' = \frac{4563}{11590}$
Step 6: 4563 factors to 13 * 13 * 27
11590 factors to 61 * 19 * 10

(The three stage gear works if allowable.)

* # of Teeth in Driving Gears are 13,13,27

* # of Teeth in Driven Gears are 61,19,10