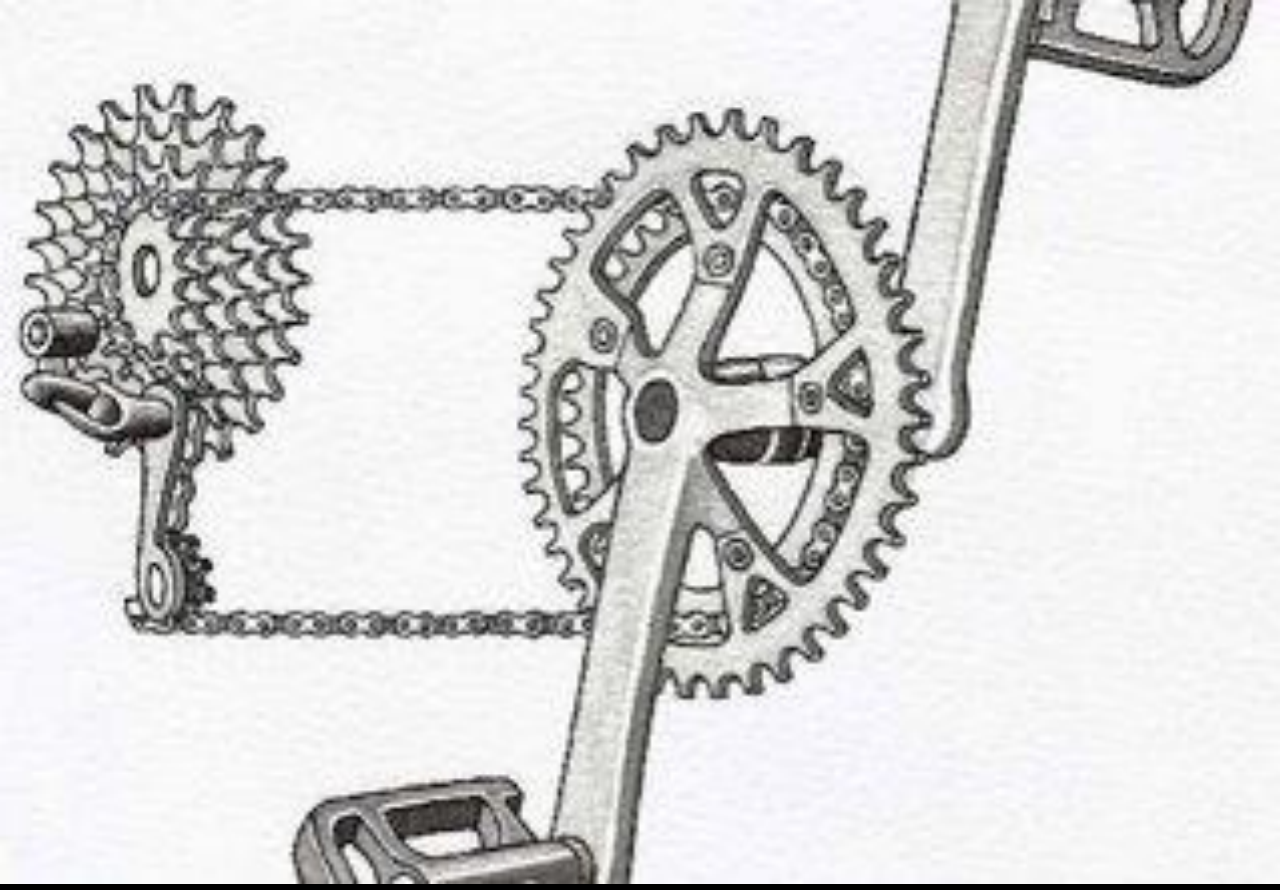

KINEMATICS FOR BIKE GEARS

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THE PROBLEM STATEMENT

Chandu is completely addicted to very large bicycles and wants to figure out what type of gear system he should have on his 100^{th} bike. He has hired us as help to do that. He wants a single pedal gear and 3 rear gears for it, as well as with 3 large wheels of his choice.

PROBLEM INSPIRATION / EXPLANATION

- Why were we inspired to do this?
  - It was one of the prompts and we like bikes so we will be doing the bike

- We will be using bike that has one big gear in the middle of the bike and 3 different giant tire sizes as well as 3 different gear sizes in the back for the rear tire

- Using rotational kinematics to figure out how the different size tires and gears affect the speed of the bike

ASSUMPTIONS/RELATED CONCEPTS

ASSUMPTIONS

Air Resistance is negligible

Spokes (sticks that connect the center to the outer rim) do not matter

Number of teeth on gear does not matter

Everything is turning clockwise

Nothing slips

Mass is uniform

Only two gears at a time

The bike is being propped up (Ignore friction of ground)

RELATED CONCEPTS

Rotational Kinematics/Kinetics

Bikes

Gears

KNOWNS AND UNKNOWNS

KNOWN

Pedal speed: 6.3rad/s

Pedal gear radius: 0.216m

Rear gear radii: 0.05m,0.07m,0.09m

Wheel radii: 0.508m,0.609m,0.680m

UNKNOWN

Speed of each wheel with their respective set of gears

VARIABLES

Coefficient of Kinetic/Rolling friction: 0.002

Angular speed: ω (rad/s)

Angular acceleration: α (rad/s^2)

Radius: r (meters)

SCHEMATIC OF BIKE

Constant angular velocity from pedal:

6.3 rad/s

Front gear size:

216mm radius

Bike tire sizes:

660mm radius

609mm radius

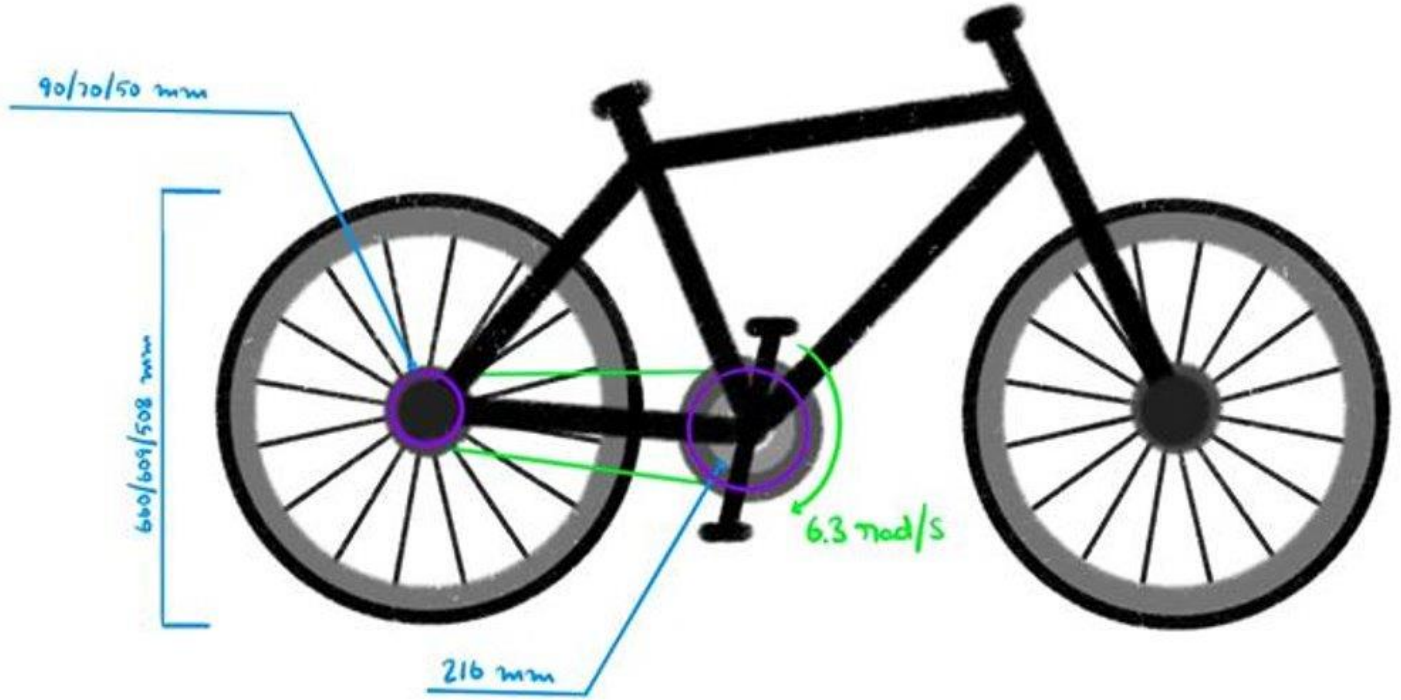
508mm radius

Rear gear sizes:

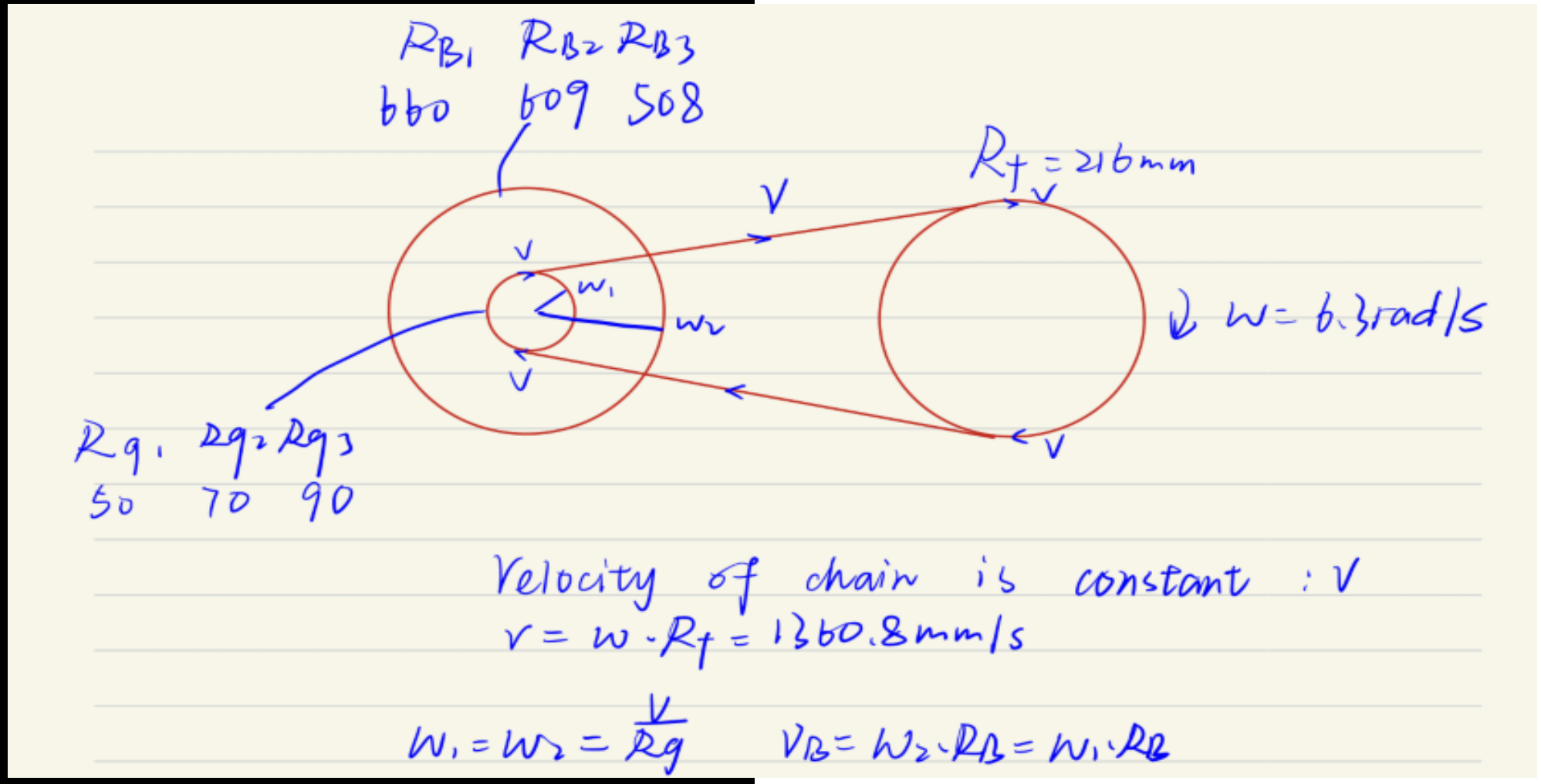
90mm radius

70mm radius

50mm radius



SCHEMATIC OF GEAR SYSTEM



Velocity of chain is constant : V

$v = w \cdot R_f = 1360.8 mm/s$

$w_1 = w_2 = \frac{V}{R_g}$ $V_B = w_2 \cdot R_B = w_1 \cdot R_B$

CALCULATIONS FOR FIRST TIRE (0.508M)

Calculate the speed of the smallest tire with all three different rear gears here

1.Big gear :

$$V_{B11} = \omega_2 * R_{B3} = \frac{V}{R_{g3}} * R_{B3} = 7.681 m/s$$

2.Medium gear:

$$V_{B12} = \omega_2 * R_{B3} = \frac{V}{R_{g2}} * R_{B3} = 9.876 m/s$$

3.Small gear:

$$V_{B13} = \omega_2 * R_{B3} = \frac{V}{R_{g1}} * R_{B3} = 13.826 m/s$$

CALCULATIONS FOR SECOND TIRE (0.609M)

Calculate the speed of the medium tire with all three different rear gears here

1.Big gear: $$V_{B21} = \omega_2 * R_{B2} = \frac{V}{R_{g3}} * R_{B2} = 9.208 m/s$$

2.Medium gear: $$V_{B22} = \omega_2 * R_{B2} = \frac{V}{R_{g2}} * R_{B2} = 11.839 m/s$$

3.Small gear: $$V_{B23} = \omega_2 * R_{B2} = \frac{V}{R_{g1}} * R_{B2} = 16.575 m/s$$

CALCULATIONS FOR THIRD TIRE (0.68M)

Calculate the speed of the largest tire with all three different rear gears here

1.Big gear: $$V_{B31} = \omega_2 * R_{B1} = \frac{V}{R_{g3}} * R_{B1} = 9.979 m/s$$

2.Medium gear: $$V_{B32} = \omega_2 * R_{B1} = \frac{V}{R_{g2}} * R_{B1} = 12.830 m/s$$

3.Small gear: $$V_{B33} = \omega_2 * R_{B1} = \frac{V}{R_{g1}} * R_{B1} = 17.963 m/s$$

CALCULATION SUMMARY

w_i= 6.3 rad/s

r_i = 216 mm

r_1 = 508 mm

r_2 = 609 mm

r_3 = 660 mm

	Small Gear	Medium Gear	Large Gear
Radius of gear	r_{g1} = 50 mm	r_{g2} = 70 mm	r_{g3} = 90 mm
Angular Velocity Equation	$w_i * r_i = w_1 * r_{g1}$	$w_i * r_i = w_2 * r_{g2}$	$w_i * r_i = w_3 * r_{g3}$
Angular Velocity	w_1 = 27.216 rad/s	w_2 = 19.44 rad/s	w_3 = 15.12 rad/s

	Small Tire	Medium Tire	Large Tire
Velocity equation with Small gear	$w_1 * r_1$ = 13.826 m/s	$w_1 * r_2$ = 16.575 m/s	$w_1 * r_3$ = 17.963 m/s
Velocity equation with Medium gear	$w_2 * r_1$ = 9.876 m/s	$w_2 * r_2$ = 11.839 m/s	$w_2 * r_3$ = 12.830 m/s
Velocity equation with Large gear	$w_3 * r_1$ = 7.681 m/s	$w_3 * r_2$ = 9.208 m/s	$w_3 * r_3$ = 9.979 m/s

CONCLUSION

In conclusion, Chandu knows how his chosen gears will affect the different wheel sizes he wants. We learned that as the gear gets smaller, the speed of the corresponding wheel increases. As the wheel size increases, so does the speed of it with any gear

Thus, the fastest set of gear and tire is tire 3 with the smallest gear

SOURCES

http://www.energiazero.org/risparmio_energetico/rolling%20friction%20and%20rolling%20resistance.pdf#:~:text=Rolling%20Frictio n%20Coefficients%20Some%20typical%20rolling%20coefficients%3A%20Rolling,tire%20on%20asphalt%20road%200.005%20dirty%20tram%20rails

Example 10-1

https://www.yellowjersey.co.uk/the-draft/bike-gears-explained/#:~:text=The%20rear%20cassette%20is%2011,cog%20determine%20the%20gear%20ratio.

https://www.brightcarbon.com/blog/make-text-superscript-subscript-powerpoint/

https://www.real-world-physics-problems.com/bicycle-physics.html

https://www.explainthatstuff.com/bicycles.html

1. Setup – Someone who sets up the problem in a way that can be solved and sets up meetings for the group
2. Calculations – Someone who does all the calculations for the problem and keeps notes of meetings
3. Diagrams/Schematics/Equations – Someone who makes diagrams/schematics/maps to make it easy to show the problem and its solutions; also writes the important equations neatly to make them presentable
4. Organize – Somebody who puts all of this together in a format that can be easily presented in 10 min, and can generate interesting questions from the audience

ROLES

Jonah: 1,2,3,4

Preston: 1,2,3,4

Chandu: 3,4

Ziang: 2,3,4

Wanliang: 2,3,4