Learning Activity (complex): Identifying Gears On A Bicycle

Purpose: Although it is not common knowledge, the numbers on bicycle gear shifts only identify which pedal gear and sprocket gear are being engaged, not the actual gear ratio. The purpose of this exercise is to calculate the gear(velocity) ratio for each combination on a multi- gear bike, and then to test the theory with an experiment.

3 different pedal gears

Background Knowledge: The sprockets are the set of gears on the back-wheel of a bicycle. The smaller the sprocket, the faster it will revolve for every full cycle of the pedal gear.

There are usually 2 or 3 pedal gears to choose from. It is harder to turn a larger pedal gear, but since less force is needed to turn the sprocket gear, the energy transferred translates into a greater speed for the rear wheel.

7 different sprocket gears

The pedal gear/sprocket ratio is, in terms familiar to us, equal to the gear or velocity ratio:

Gear or velocity ratio =

$$\frac{C_{input}}{C_{output}} = \frac{d_{input}}{d_{output}} = \frac{n_{input}}{n_{output}}$$

$$\frac{n_{input}}{n_{output}} = \frac{teeth\ on\ pedal\ gear}{teeth\ on\ sprocket\ gear}$$

Data and Analysis:

1. Count the number of teeth on each of the gears on a 10 or 21 speed bicycle.(it will vary from one type of bicycle to another.) Record them in the table below.
2. For each combination of pedal and sprocket gears, calculate the gear ratio.

		Gear (in decreasing diameter)	**3**	**2**	**1**	
			Number of teeth on pedal gear (front)			
Gear (in decreasing diameter)						
1	**Number of teeth on sprocket gear (wheel)**					**Gear ratios**
2						
3						
4						
5						
6						
7						

3. In the table on the next page, list the gears in increasing order of velocity ratios. To identify the position, list the number of the pedal gear (1, 2 or 3, where 1 is the gear with the least number of teeth). Then after the dash, list the number of the sprocket gear.(Careful: here the order is reversed. The bicycle manufacturers list "1" for the sprocket gear with the ***largest*** number of teeth). For example, the lowest gear(actual gear #1 in column 2) is the one with the lowest velocity ratio and it s created by the combination of the smallest pedal gear with the largest sprocket gear. So in the first column, simply write "1-1".

position	Actual Gear (corresponding to increasing gear ratios)	Gear ratio(wheel rotations per pedal cycle) (based on bicycle with gear teeth in previous table)	Metres traveled per pedal rotation = gear ratio*tire circumference (based on a 0.711m diameter wheel)	Pedal rotations per km= 1000m/(m/rotation)	Km/h based on 1 pedal rotation per second
1-1	1				

4. Complete the rest of the table by following the formulas at the head of each column.

5. Is it always easy to predict the actual gear ratio from the position of the two gears? Explain.

6. How much faster does the highest gear ratio allow the bike to travel compared to the lowest gear ratio?

Verifying Gear Ratios Experimentally

For four different gears, check that the number of rotations of the rear wheel does indeed match the velocity ratio based on the number of gear teeth.

There are a number of ways that this can be done.

Method A

(1) Switch to a certain gear and take note of the pedal and sprocket gear positions.
(2) Pedal one full cycle, quickly brake, and measure the distance traveled. Make sure you use the same reference points(example front of the front wheel to new position in front of that same wheel)
(3) Repeat for other gears.

Method B

(1) If few bikes are available, and it is impractical for you to ride your bike around school, then place a few demo bikes upside down

(2) Use chlak to mark off the initial position of the tire.

(3) One problem is that if you use a full turn of the pedal, the wheel will gain a lot of momentum, and it will be difficult to measure how far it rotates. So instead, starting from a horizontal position, gently turn the pedal only for ¼ of a full turn(90^o)

(4) Brake quickly(if you turn gently and count the spokes to keep track of how far the wheel rotated from the chalked position. Usually there are 36 spokes, one for every 10^o of the 360^o circle.

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(5) Complete the table below:

Apparent gear	Real gear	Gear ratio(theoretical)	**Measured rotations per ¼ pedal turn***	**Actual Rotations per full turn(gear ratio)**

(6) How do the number of actual rotations compare to the calculated gear ratios? Can you account for the differences?

Conclusion

In your conclusion, summarize what you learned regarding the difference between bicycle gear positions and actual gear ratios. Mention how well the experimentally measured ratios agreed with the theoretical calculated ratios.

SAMPLE DATA for Learning Activity 3

		Gear **(in decreasing diameter)**	3	2	1	
			Number of teeth on pedal gear (front)			
Gear **(in decreasing diameter)**			**48**	**38**	**28**	
1	**Number of teeth on sprocket gear** **(wheel)**	**34**	1.41	1.12	0.82	**Gear ratios**
2		**24**	2.00	1.58	1.17	
3		**22**	2.18	1.73	1.27	
4		**20**	2.40	1.90	1.40	
5		**18**	2.67	2.11	1.56	
6		**16**	3.00	2.38	1.75	
7		**14**	3.43	2.71	2.00	

Position	**Actual Gear** **(corresponding to increasing gear ratios)**	**Gear ratio(wheel rotations per pedal cycle)** (based on bicycle with gear teeth in previous table)	**Metres traveled per pedal rotation = gear ratio*tire circumference (based on a 0.711m diameter wheel)**	**Pedal rotations per km= 1000m/(m/ rotation)**	**Km/h** based on 1 pedal rotation per second
1-1	**1**	0.82	1.83	546	**6.6**
2-1	**2**	1.12	2.50	400	**9.0**
1-2	**3**	1.17	2.61	383	**9.4**
1-3	**4**	1.27	2.84	353	**10.2**
1-4	**5**	1.40	3.13	320	**11.3**
3-1	**6**	1.41	3.15	318	**11.3**
1-5	**7**	1.56	3.48	287	**12.5**
2-2	**8**	1.58	3.53	283	**12.7**
2-3	**9**	1.73	3.86	259	**13.9**
1-6	**10**	1.75	3.91	256	**14.1**
2-4	**11**	1.90	4.24	236	**15.3**
1-7	**12**	2.00	4.47	224	**16.1**
3-2	**13**	2.00	4.47	224	**16.1**
2-5	**14**	2.11	4.71	212	**17.0**
3-3	**15**	2.18	4.87	205	**17.5**
2-6	**16**	2.38	5.32	188	**19.1**
3-4	**17**	2.40	5.36	187	**19.3**
3-5	**18**	2.67	5.96	168	**21.5**
2-7	**19**	2.71	6.05	165	**21.8**
3-6	**20**	3.00	6.70	149	**24.1**

3-7	**21**	3.43	7.66	131	**27.6**

Notice that gears on this particular bike allow a cyclist to increase (flat ground comparison) his speed by a factor of 7.66/1.83 = 4.19 when he switches from the lowest to the highest gear ratio.

Verifying Gear Ratios Experimentally

Apparent gear	Real gear	Gear ratio(theoretical)	**Rotations per ¼ pedal turn***	**Actual Rotations per full turn(gear ratio)**
2-1	2nd	1.12	11/36=	44/36 = 1.2
2-2	8th	1.58	14/36=	56/36 = 1.6
2-3	9th	1.73	15/36=	60/36 = 1.7
2-4	11th	1.90	18/36=	72/36 = 2.0