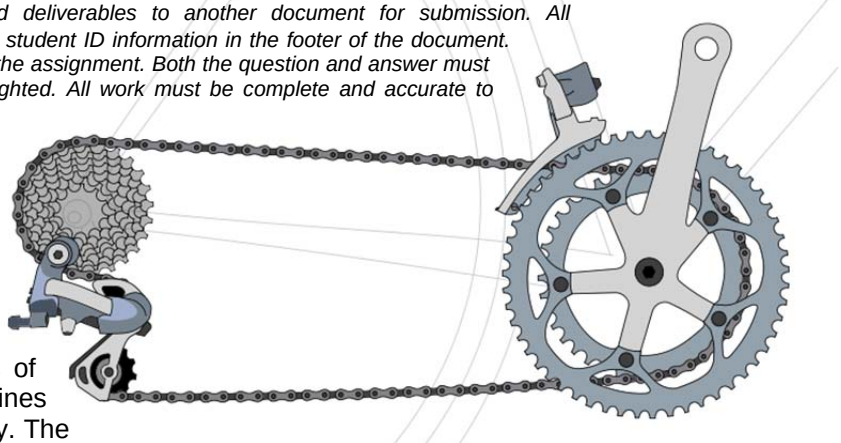
Objective: At the completion of this exercise, you will demonstrate the proper application of belts/pulleys and chains/sprockets when building drives and transmissions. You will compare and contrast belt and chain drives while experimenting with various sprocket and pulley wheel sizes. In addition, you'll describe the advantages and disadvantages of "slippage" in belt and chain drive design.

Deliverables: *Copy and paste the required deliverables to another document for submission. All deliverables must be word processed with the required student ID information in the footer of the document. The header of the document should contain the title of the assignment. Both the question and answer must be included in the deliverable with the answers highlighted. All work must be complete and accurate to receive credit.*

1. Detailed definitions for each of the terms found in the Nomenclature section.
2. Detailed answers to the queries listed in the Questions section.
3.



Information: Think about riding a 10-speed bicycle through the hills and hollers of the wide-open countryside. The sun shines warmly your face on a remarkable spring day. The tall grass seems to whisper in the air as a soft breeze blows across an adjacent wheat field. You're stopped at the base of a hill studying the long and winding path as it gradually scales the incline that lies ahead.

You mistakenly start out in 5th gear pushing down with all your might just to get yourself moving. You quickly shift down into 3rd gear where you don't have to struggle nearly as much to peddle. As the grade of the road increases it's getting harder to peddle so you shift down again… and then again. You're now in 1st gear and you're peddling like crazy. It's certainly easier to peddle, but you're just crawling along going nowhere fast. Panting like German shepherd, you crest the ridge and start downhill, you shift up into 5th gear and now you're rolling along at an incredible clip, but your legs are moving like Wile E. Coyote chasing the Roadrunner. You decide to shift the front derailleur to the outer ring and suddenly you're peddling much slower while careening downhill at close to light speed. Weeeeee!

What a marvelous machine a 10-Speed bike is. Although biking enthusiasts know how to use gear combinations well enough to tackle even the steepest hills, not many riders know how gears, sprockets, chains and belts work to reduce the effort needed to get work done.

When effort is applied to a bike's crank with the chain on the smaller ring, less effort is required to produce torque, but you'll have to peddle more times to travel a certain distance. This setting on a 10-Speed bike is used for gears 1 through 5. These are the low gears typically used for climbing hills. When the chain is moved to the outer ring on the crank, more effort is required to produce torque. It's harder to peddle, but you'll peddle fewer times to travel the same distance. This larger outer ring on the crank covers gears 6 through 10 on a 10-speed bike and is used to obtain some exhilarating downhill speed.

So… The mechanical advantage of any simple machine is the relationship between input effort and output force. Mechanical advantage on the 10-speed bike is achieved by combining different sizes of wheels. Since (simple machine) "The Wheel" also includes components like pulleys, sprockets, cogs, and gears it's important to come up with a systematic way to determine the size of the wheels we're combining to more complex machines. We can us

wheel measurements like the circumference, diameter, and radius but most often we simply count the number of teeth on a sprocket, cog or gear to represent its size. The chain simply transfers the effort exerted on the crank ring to the gear cassette on the bike's back wheel. The relationship between the chain and the sprocket or cog is their matching pitch. The pitch is the spacing of the teeth on the bike's cogs and the links of the chain. On modern bicycles, the pitch is ½". The pitch of the chain and the sprocket must match for the drive train to work.

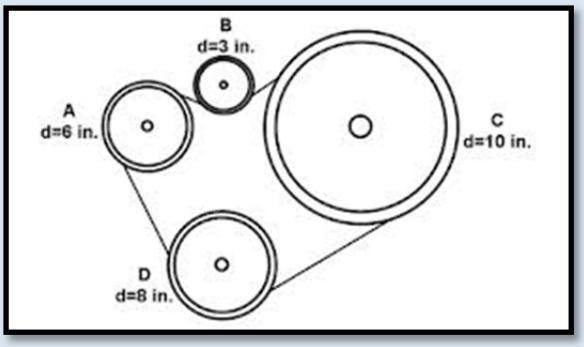
Belt drive systems are very similar to chain drives. The major difference between chains and belts is that belts are designed to slip and they break easier than chains. Belts are also lighter and quieter, but again… The primary difference is slippage. Belts slip… Chains don't. In fact, many drive belts are designed with teeth to keep them from slipping unless there's a malfunction. Then they break. Engineers use belts in their designs as a safety precaution. After all, it's much cheaper to replace a broken belt than the components they're driving.

The mechanical advantage in belt drive systems is determined the same as those using chains. If teeth are part of the design, you can determine the gear ration by simply counting teeth. Otherwise, you can measure the wheel's circumference, diameter, or radius to obtain the information necessary to calculate mechanical advantage. Understanding how to calculate the mechanical advantage of chain and belt drive systems will help you determine the torque required to operate the system as well as the speed it will deliver.

The Math:

Terms -

Equations -



When peddling a 10 speed bike there's a lot of physics at work. The pedal crank itself is a lever of the third class. As the length of the crank increases the mechanical advantage and in-turn the torque that's applied to the front ring of the chain drive. Typically, the front ring is comprised of two sprockets. One sprocket has 39 teeth and the other 52. Since the pitch of the typical bike is ½ inch, the ring with 52 teeth is larger in diameter than the one with 39. The front derailleur selects between gears one through five using the 39 tooth ring and gears 6 through 10 using the 52 tooth ring. The cluster gears found at the back bicycle is called the cassette. The number of teeth found on the five gears in the cassette range from 14 teeth to 28 teeth. Again, the more teeth at the same half inch pitch results in a larger diameter sprocket and the better the mechanical advantage. When using sprockets are gears the formula for calculating mechanical advantage is represented by the term driven/driving. If our 10 speed bicycle was in first gear the number of teeth on the driven gear would be 28 and the number of teeth on the driving gear would be 39. This results in a mechanical advantage of .718 meeting that if we put 100 pounds of torque on the pedal crank the amount of force applied to the axle would be .718 multiplied by 100 pounds or 71.8 pounds. If our 10 speed was in fifth gear are driven gear would be 14 teeth that are driving gear would be 39 teeth. The mechanical advantage would be equal to .359 and the output torque to the axle would be equal to 35.9. Significantly lower torque than in first gear.

Gear	Teeth	39 Tooth Ring	52 Tooth Ring
1	28	1.39	1.86
2	24	1.63	2.17
3	20	1.95	2.60
4	17	2.29	3.06
5	14	2.79	3.71

Research Resources: *The WWW changes all the time. If the listed links do not work, first inform your instructor then use a search engine to research information regarding the described subject.*

Web Site	Description
http://www.technologystudent.com/gears1/pulley1.htm	Describes a system of pulleys and belts
http://www.technologystudent.com/gears1/chain1.htm	Describes a system of sprockets and chains

Nomenclature: *Research and develop a detailed (two to three sentences) definition for each of these terms. It's important to realize that many words have multiple definitions. Some of which may have nothing to do with this course of study. Make sure your definitions fall within the context of this lesson.*

- *Belt*
- *Chain*
- *Sprocket*
- *Slippage*
-
-

Questions:

1. Research and develop a detailed definition for each of the terms found in the Nomenclature section.
2. Compare and contrast gears and sprockets.
3. Compare and contrast belts and chains.
4. What are some advantages and disadvantages of slippage?

Procedure:

In this activity, you'll conduct a hands-on experiment regarding this topic area. You'll closely examine…

Required Materials and Equipment: *Get these materials and tools from your instructor.*

- *Mindstorms NXT Trainer*
- *Tetrix Robotics Trainer*
- *Chains and Sprockets Set*

Steps: Refer to figures as you construct… Complete each of the following steps in the assigned order:

1. ( ) Refer to the first webpage above. Build a similar system of pulleys and belts.
2. ( ) Determine, on your model, which is the driver pulley and which is the driven pulley and calculate the velocity ratio. Repeat with twice with varying sized pulleys
3. ( ) Record all calculations on the data table provided.
4. ( ) Refer to the second webpage above. Build a similar system of sprockets and chains.
5. ( ) Determine which is the driver sprocket and which is the driven sprocket and calculate the gear ratio. Repeat with various sized sprockets.
6. ( ) Record all calculations on the data table provided.
7. ( ) Using what you have learned above, construct two vehicles; one with a belt drive and one with a chain drive.
8. ( ) Calculate and measure the mechanical advantage of each.

Gear (Sprocket) Ratio

Distance moved by the driver (effort)	Distance moved by the driven (load)	Effort/Load	Ratio

Velocity Ratio of Pulleys

Diameter of Driven Pulley (A)	Diameter of Driver Pulley (B)	A/B	Ratio

Discussion:

In your vehicles, which system provided the greater mechanical advantage? Why? Would you use a belt or chain drive in a full sized vehicle? Use your data to support your answer.

Conclusion: In completing this exercise you have demonstrated that you can apply the principles of belts and chains when building drives and transmissions. By building vehicles using both belt and chain drives, you then were able to calculate and measure the mechanical advantage of the vehicle's drive train. Gear/Velocity ratios give you the information you need to be able choose the mechanisms to help you move mountains.