
| *Author(s):* *Michael Lucky Voiselle* | | | *Lesson Title:* *BICYCLE EFFICIENCY* | | | |
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| *Grade Span* | | | *ICLE Application Model* | | | |
| *K-4* | *5-8* *XX* | *9-12* | *A* | *B* | *C* | *D* *XX* |

**Instructional Focus:**

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| **Speaking**<br>Students speak for a variety of purposes and audiences with sophistication and complexity appropriate to the grade level. |
| **Measurement**<br>Students use a variety of tools and techniques of measurement in a problem-solving situation. Students communicate the reasoning used in solving these problems. |
| **Habits of Mind**<br>Students develop habits of mind including curiosity, open-mindedness and persistence. |
| **Science in Personal and Social Perspectives**<br>Students apply scientific principles to personal and social issues. |

**Performance Task**

Your task is to determine the efficiency of a multi-speed bicycle. You may form groups of 4. Obtain a 10-21 gear bicycle and turn it upside down. Obtain 2 spring scales that measure 0-20kilograms and string. Use string to attach a spring scale to a pedal and the other to the back tire. See accompanying diagram (Bicycle Efficiency Chart).

Begin the experiment in 1st gear, which is the one used to make pedaling easier uphill. While it is true that you use less force from your legs in 1st gear, what do you sacrifice? (Think about the size of the sprocket.) Pull on the spring scale attached to the pedal with a fairly strong force. This is the input force. At the same time have your partner measure the force needed to keep the wheel from turning. This is the output force, which is the force that the wheel could exert on the road. Next measure the distance that the pedal moves when it makes one complete revolution. This will be the rider's input distance. The output distance is obtained by measuring the distance covered by one complete revolution of the wheel. Place a chalk mark on the bottom of the wheel where it touches the ground as well as on the ground. Push the bike until the chalk mark touches the ground again. Measure the distance from chalk mark to chalk mark for the revolution of the wheel.

Calculate the work input, the work output, and the efficiency of the bike. Consult any physics textbook for the necessary math formulas in the Work, Force, and Power chapter. Show all mathematical calculations and unit cancellations.

Repeat this process for all gears and organize your information in a well-constructed data table labeled properly. What do you find about the input and output forces, and the bike's efficiency when you use different gears? As you proceed from the lowest gear to the highest, you must have more input force to make it move. However, what is the advantage in proceeding to higher gears? (Think of larger sprockets.)

The efficiencies above were measured under ideal conditions (no road). Measure the efficiency of the same bicycle under road conditions. Let your full weight fall through the change in height when a pedal turns halfway around from its highest to its lowest position. This falling distance times your weight will measure the energy input into the bike. The kinetic energy of the bike and rider after the pedal reaches its lowest position is the energy output. Calculate the road efficiency. Show all calculations and unit cancellations. Again consult a physics textbook for the proper formulas.

Each member of your group is to explore one of the following and report the results to the group members in an oral presentation. Brainstorm with your group on each topic to determine how to proceed.

1. Find 2 other ways to measure the input and output energies of the bicycle.
2. Does the weight of the rider have an effect on the bike's efficiency? Use the heaviest and the lightest group member to ride.
3. What effect does the air pressure have on the bike's efficiency? Use full pressure and half pressure in the tires.

4. Normal truck and car tires have between 30-35pounds per square inch tire pressure. Why is a bicycle's air pressure between 60-70pounds per square inch when there is much less weight on a bicycle and rider?

Each member of the group is to summarize their results including experimental procedures and answer all questions in a well written conclusion write-up, free from spelling and grammatical errors.

**ICLE Essential Skills**

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| Know the metric system and the units of metric measure and convert metric units to English units. (s4) |
| Make observations using senses and instruments. Inferences and interpretations are arrived at based on observations. Classify observable properties and organize observations in a meaningful and logical way. (s5) |
| Exhibit good data management skills by collecting, organizing, and graphing data. (s19) |
| Understand and apply the concepts of work and power and how they relate to energy. An object experiences work when a force displaces the object; power is the time-rate of doing work. (s70) |
| Know and apply the principles of scientific inquiry. *(Implicit in this statement are the processes of prediction, estimation, developing hypotheses, drawing conclusions, evaluation, and following ethical principles and professional procedures.) (Not Ranked s*114) |
| Apply in writing the rules and conventions of grammar, usage, punctuation, paragraphing and spelling. (ela1) |
| Follow written directions carefully and accurately. (ela6) |
| Use brainstorming, role playing, and standard problem solving strategies to define a problem and suggest solutions.(ela19) |
| Prepare and deliver individual speeches by gathering information, rehearsing, making eye contact, speaking loudly enough, delivering information in a well-organized fashion, and appealing to the needs of the target audience. (ela10) |
| Present information in well-organized fashion that will be clear to the target audience. (ela 11) |
| Understand ***basic algebraic properties*** (i.e., commutative: ab = ba; associative: ab(c) = a(bc); and distributive: a(b+c) = (ab)+(ac)). (m3) |
| Use the technique of ***dimensional analysis*** to convert units of measure (e.g., convert km/hr to m/min) including drawing to scale and applying ratios. Understand and use various techniques for estimating, making and converting measure; and using these to perform dimensional analysis. (m33) |

**Scoring Guide:**

RATE CRITERIA: 3=Excellent, 2= Satisfactory, 1= Unsatisfactory, 0=Does not attempt or does not understand

| **CRITERIA** | **SCORE** |
|---|---|
| Group work and experimental procedure | _____ |
| Well constructed data table labeled correctly | _____ |
| All math calculations and unit cancellations shown | _____ |
| Conclusion write-up addresses all questions | _____ |
| Conclusion write-up was well written and free from spelling and grammatical errors | _____ |
| Oral presentation was presented well to the group | _____ |
| All 4 exploration topics included in the summary write-up | _____ |
| Student demonstrates an understanding for work input, work output, and efficiency | _____ |

**Keywords**

| English Language Arts | Mathematics | Science |
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| **Reading** | **Algebra**<br>**Computation**<br>**Math in Daily Life Problem Solving** | **Earth Science**<br>**Energy**<br>**Scientific Inquiry Technology** |
| **Writing**<br>**Spelling**<br>**Grammar**<br>**Organization**<br>**Technical Writing** | **Geometry** | **Life Science** |
| **Communications**<br>**Oral Presentation** | **Statistics** | **Chemistry** |
| **Literature** | **Calculus** | **Physics**<br>**Energy**<br>**Mechanics**<br>**Scientific Process** |
| **Other** | **Trigonometry** | **Other** |
| | **Other** | |

# Bicycle Efficiency