# Physics Invention Sequences Users' Guide:  Work

## WORK INVENTION SEQUENCE

**Includes:** *car washing index(product quantity), weight lifting index (pre-gravitational potential energy), job difficulty index (pre-work, numerically more challenging)*

**Teacher Notes:** If you teach energy before momentum, this is the students' first encounter with a product quantity.  It is surprisingly difficult to step away from a unit rate, for which they are primed, to explore using other operations.

**Levels:**  This sequence is appropriate for all levels, from middle school physical science (car washing and weight lifting) through calculus-based physics (all three).
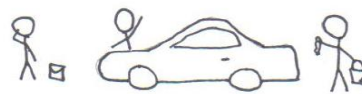
**Car Washing Inefficiency Index**

You're the manager of a chain of four Seattle-area car washes in which teams of employees wash the cars by hand. You want to find out which locations are the most *inefficient,* so that the teams there can be retrained. The teams don't all have the same number of people, however, so how can you determine which location is the most inefficient?

Shown below are times for how long it took to wash a Toyota Camry. You have data for two different teams from each of the four locations. Invent a procedure for computing a *car washing inefficiency index.* Bigger index values should correspond to more inefficient teams. Teams from the same location should have the same index value.

**Wash Time: 10.2 minutes**

**Wash Time: 6.8 minutes**

**Seattle Center**

**Wash Time: 9 minutes**

**Wash Time: 12 minutes**

**Golden Gardens**

**Wash Time: 11.8 minutes**

**Wash Time: 5.9 minutes**

**Fremont
(center of the universe)**

**Wash Time: 8.4 minutes**

**Wash Time: 10.5 minutes**

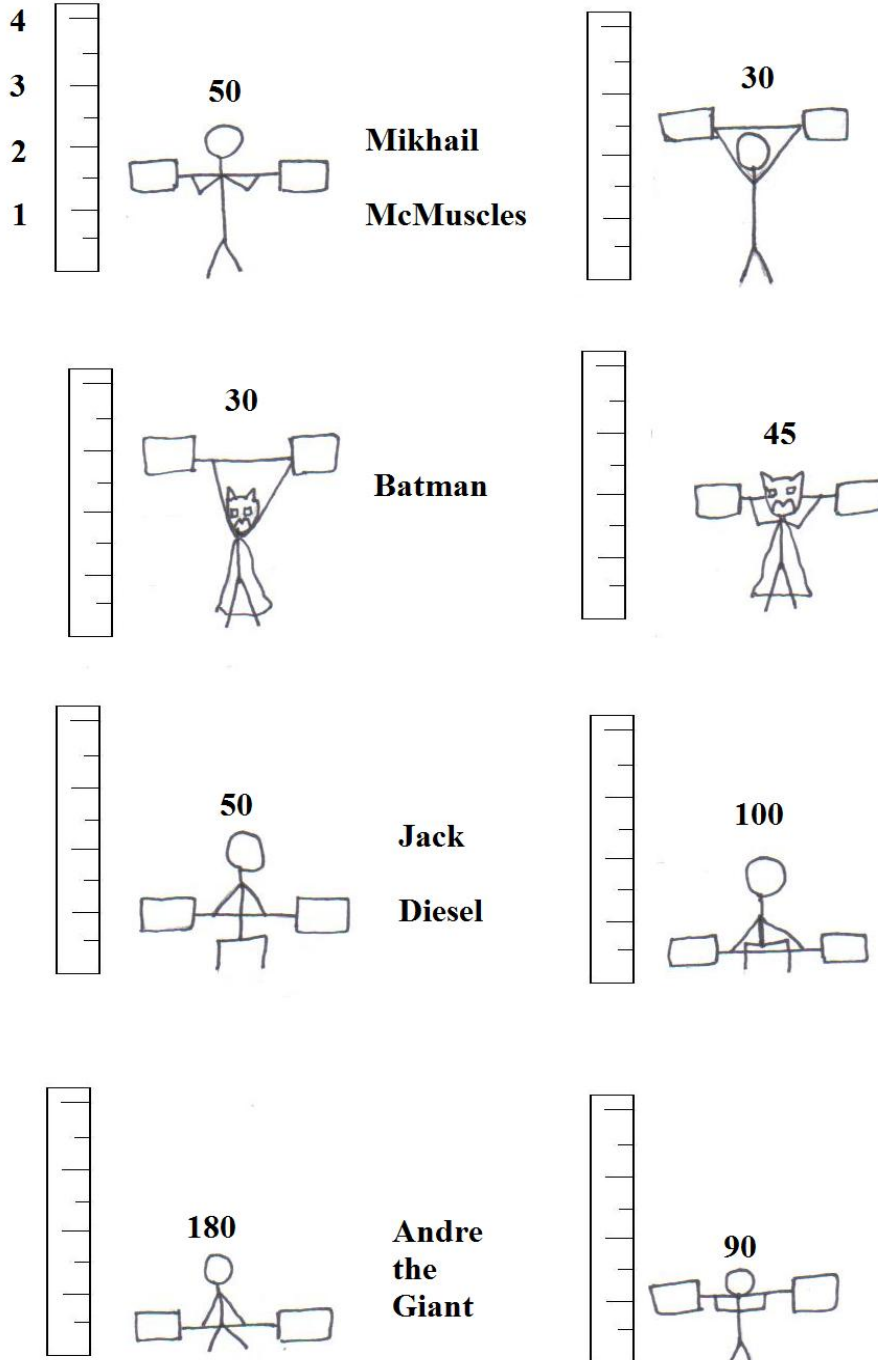**U-District**

**Weightlifting Index**

Several of your friends have been bragging about how strong they are. To settle the matter, they have decided to hold a weightlifting contest. The problem is that they don't agree on how to score the competition, since they all lift different amounts of weight and they lift the weights to different heights. So, you've been recruited as a judge. Invent a procedure for computing a *weightlifting index* for each competitor. Remember: a bigger index value should correspond to a stronger competitor.

4
3    50
2    **Mikhail**
1    **McMuscles**

30

30    **Batman**

45

50    **Jack Diesel**

100

180    **Andre the Giant**

90

### Job Difficulty Index

Some friends are complaining about their summer jobs. Each person thinks he works the hardest out of everyone. All their jobs are different, so it's difficult to tell. You've been asked to decide once and for all whose job is the most difficult. Invent a job difficulty index for the workers, and rank them from hardest to easiest job. Some information has already been provided in the table below.

| Name | Job | Force (Monday) | Distance (Monday) | Force (Tuesday) | Distance Tuesday) | Job Difficulty Index |
|------|-----|------|------|------|------|------|
| Burley | Lifts ice blocks in a meat packing plant | $1.8 \times 10^3$ | 70.5 | $1.41 \times 10^3$ | 90 | |
| Lug | Pushes a luggage cart at the airport | | 360 | $6.0 \times 10^3$ | | $1.44 \times 10^5$ |
| Monty | Rolls old computers to a storage facility | $2.5 \times 10^3$ | 100 | | 500 | |
| Rollo | Rolls oil drums up a ramp to a truck bed | | 270 | | 180 | $4.455 \times 10^5$ |
| Missing Number | CONFIDENTIAL | $2.5 \times 10^4$ | | | 120 | N |

D. Follow up questions:

1. Explain in everyday language what the numeric value of the weightlifting index tells you about each competitor. (*Hint*: What would the index mean if the competitor lifted one unit of weight, or, alternatively, one unit of distance?)

2. Which competitor(s) won the competition?

3. If Batman had attempted to lift 150 weight units how high would he have lifted it?

4. What weight could Mikhail McMuscles lift to 1.25 height units?

5. Explain in everyday language how you decided whose was the most difficult job.

6. The ability to change a system is the product of the amount of force exerted and the distance through which the force is exerted. This is referred to as *work* in physics. How are the weightlifting and job difficulty indices similar to work?

7. The weightlifting competitors are thinking of trying out for the cheerleading team. Applicants must be able to lift 30 weight units to 3 height units. Which applicants should go to the tryouts and which should look for other activities?

8. At Burley's meat-packing plant they decided to double the width of the ice blocks, making them twice as heavy. Assuming Burley's job difficulty index doesn't change, what else *will* change about the job? How will it change?

9. Discuss the meaning of the value of Missing Number's job difficulty index.

10. Explain in everyday language what the numeric value of the *job difficulty index* tells you about the job.