Knowing Energy: Stair Climb

Energy Revealed
Learner Worksheet Answer Key
Level 1-2: Grades 3-8
Level 3-4: Grades 9-12

Reminder:

- 2.2 pounds = 1 kilogram
- 9.8m/s^2 = force of gravity

Level 1 Questions/Activities:

1. **How many Kilograms do you weigh? (Multiply this number by 9.8 m/s^2)**
   Assume a weight of 50kg for solutions.

2. **What is the height of the stairs?**
   10 feet or 3 m assumed.

3. **How many seconds does it take you to run up the stairs? (Must be in seconds)**
   10 seconds assumed.

4. **How many Watts do you develop to climb the stairs? (hint: $Watts\ (W) = \frac{weight\ (N) \times height\ (m)}{time\ (s)}$, remember weight here is in Newtons, where $Newtons\ (N) = 9.8\ m/s^2 \times\ your\ own\ weight\ (kg)$)**

$$\text{Watts (W)} = \frac{(9.8\ \text{m}/s^2\ \times\ 50\ \text{kg})\ \times\ 3\ \text{m}}{10\ \text{seconds}}$$

$$\text{Watts (W)} = 147\ \text{Watts}$$

*This may not match the video numbers exactly, round numbers used here.

Level 2 Questions/Activities:

<u>Note:</u> Complete level 1 questions/activities first if you haven't already done so.

1. **Climb the stairs in double the time and see how many Watts you develop.**

   $$\text{Watts (W)} = \frac{(9.8\ \text{m/s}^2\ \times\ 50\ \text{kg})\ \times\ 3\ \text{m}}{20\ \text{seconds}} = 73.5\ \text{Watts}$$

2. **Run the stairs in half the time (if possible, to see how many Watts you develop).**

   $$\text{Watts (W)} = \frac{(9.8\ \text{m/s}^2\ \times\ 50\ \text{kg})\ \times\ 3\ \text{m}}{5\ \text{seconds}} = 294\ \text{Watts}$$

3. **Does the number of Watts required change with your time, explain how you can understand this with a real-world example?**
   Yes, it changes in a linear manner, this is intuitive through perceived effort doing the activity (i.e., higher heart rate).

Level 3 Questions/Activities:

<u>Note:</u> Complete levels 1-2 questions/activities first if you haven't already done so.

1. **If a larger and smaller person runs up the stairs at the same time, who do you think develops the most power? Explain your thinking.**

   $$\text{Watts (W)} = \frac{(9.8\ \text{m/s}^2\ \times\ 75\ \text{kg})\ \times\ 3\ \text{m}}{10\ \text{seconds}} = 220.5\ \text{Watts}$$

   Compared to a 50 kg person who only generates 147 Watts.

2. **If one horsepower = 746 Watts, how much horsepower do you develop climbing the stairs?**
   Using the original 147 Watts, hp = 147/746 = 0.20 HP

Level 4 Questions/Activities:

Note: Complete levels 1-3 questions/activities first if you haven't already done so.

1. **Does it require more or less power (W) and energy (kWh) to climb the stairs one at a time or two at a time?**
   It is the same, there is no number in the equation to say how the stairs are climbed. Therefore, the calculation is a sum of the total height, which is 10 m.

2. **If it was possible, would riding a bike allow you to develop more power?**
   A bike will not allow you to generate more power although it may allow for great efficiency since a bicycle can glide, even up a hill.

3. **BONUS: how much faster would a person weighing 100 lbs have to run up the stairs in order to exert the same amount of power as someone weighing 150 lbs given the larger person climbs the stairs in 10 seconds?**
   Convert the weights 100 lbs = 45 kg, 150 lbs = 68 kg
   Calculate the energy (Watts) produced by the larger person: $\text{Watts (W)} = \frac{(9.8\ \text{m/s}^2 \times 68\ \text{kg}) \times 3\ \text{m}}{10\ \text{seconds}} = 199.92\ \text{W}$
   We know it takes 199.92 W of energy for the larger person; we can now find the time required for the smaller person (at the same amount of energy exerted):
   $199.92\ \text{W} = \frac{(9.8\ \text{m/s}^2 \times 45\ \text{kg}) \times 3\ \text{m}}{\text{time (s)}}$, rearrange for time
   $\text{Time (s)} = \frac{1{,}323\ \text{Nm}}{199.92\ \text{W}} = 6.62\ \text{seconds}$

   Therefore, it would take the smaller person to move up the stairs in 6.62 seconds to exert the same amount of energy as the larger person (meaning they would have to move up the stairs 3.38 seconds faster than the larger person)