Created by Jason van Tol

Power, Energy, Time – Worksheet

Power is the amount of energy expended in a given amount of time. In other words: $P = \frac{E}{t}$
So, for a given amount of energy, the quicker you use it (i.e. the smaller t is), the more power you generate (dividing by a smaller number gives a larger result); conversely, the slower you use a certain amount of energy (i.e. the larger t is), the less power you generate (since dividing by a larger number gives a smaller result). The standard unit of measurement for power is the Watt (abbreviated W); for energy the standard measurement is the Joule (abbreviated J), though the calorie is also commonly used, as is the Watt-hour (can you see why a Watt-hour is a unit of energy?). Also, the standard unit of time is the second, but sometimes other units are used too. A few examples will help illustrate these points.

Example 1:
In the last year, from July 2015 to July 2016, the school used 132, 245 kWh of energy. The solar panels on the roof of the science lab produce about 3,600W of power on a sunny day. How long would the solar panels have to generate that power in order to meet all of the school's energy needs?

Set out the variables and write the pertinent equations on the left, then show your working on the right:

P=3,600W E=132,245kWh t=? $P = \frac{E}{t}$	$P = \frac{E}{t}$	Therefore, multiplying both sides by t gives:
	Pxt=$\frac{E\times \cancel{t}}{\cancel{t}}$	The t's cancel yielding:
	Pxt=E	Now dividing both sides by P gives:
	t=$\frac{E}{P}$	Now that we've made t the subject of the equation, substitute in the given values
	t=$\frac{132{,}245{,}000Wh}{3{,}600W}$	Carrying out the calculation gives:
	t=36,735 h	Rounding to the nearest whole answer. The unit of time in this example is hours – can you see why?

So, do you think the school can get all of its yearly energy from the solar panels on the roof? Why (not)? Give reasons.

Example 2:
According to Nutrition Australian guidelines, the average 15 year-old girl needs 9.6 MJ of energy per day – that is 9.6 million Joules. Boys need slightly more at 10.9 MJ of energy per day, or 10.9 million Joules. Given these figures, and supposing such teenagers use exactly their recommended daily intake of energy, how much power do they generate in one day? Express your answer in Watts.

Set out the variables and write the pertinent equations on the left, then show your working on the right:

For a girl: P=? E=9.6 MJ t=1 day =24 hrs =1,440 min =86,400 s $P = \frac{E}{t}$	$P = \frac{E}{t}$	The equation is already solved for P, so substitute the numbers:
	P=$\frac{9{,}600{,}000J}{86{,}400s}$	
	P=111 W	Rounding to the nearest Watt.
	So a girl generates about 111 W of power in one day. How much does a boy generate?	

Example 3:

An average fridge's power rating is about 100W (compare that to a girl's power rating above). How much energy does it consume in one day?

Set out the variables and write the pertinent equations on the left, then show your working on the right:

P=100W	$P = \frac{E}{t}$	Multiply both sides by t
E=?	Pxt=$\frac{E\times \cancel{t}}{\cancel{t}}$	The t's cancel yielding:
t=1 day	Pxt=E	Now E is the subject of the equation so sub in the numbers:
=24 hrs	E=(100W)x(86,400s)	
=1,440 min	E=8,640,000 J	
=86,400 s		
$P = \frac{E}{t}$	So assuming the fridge runs all day, it uses about 8.6 MJ of energy in a day. Compare this energy to the average energy intake of a 15 year-old boy and girl in Example 2. Is the assumption made a good one?	

Now you try, showing all working and using correct units:

1. a) For example 1 above, calculate how much energy the solar panels on the roof of the science lab produce in one day. State any assumptions you make.

b) For example 1 above, the solar panels produce about one third the amount of power on a cloudy day as on a sunny day. Calculate how much energy they produce on a cloudy day and state any assumptions.

2. a) For example 2 above, calculate how much power an average fifteen year-old boy generates in one day.

b) An adult male over 70 needs about 9.5MJ of energy per day. How much power does he generate in a day? Why do you think he needs less than a teenage boy?

3. a) Have you ever seen a bicycle powered light bulb? If not, you can google 'bicycle powered light bulb' to see some images. If you were to use such a bike connected to a 60W light bulb, how long could you run it, given your average daily energy intake in example 2 (9.6 MJ for girls, 10.6 for boys)? Give your answer in hours.

b) Suppose the bike were connected to a 2,400W electric heater. How many hours could you run it?

Answers:
1. a) 28.8kWh, or 103.7MJ, assuming 8 hours of sunshine, b) 9.6kWh, or 34.6MJ, assuming 8 hours of sunshine.
2. a) 126W, b) 110W, metabolism slows as you age.
3. a) 44.4 hrs for a girl, 49.1 hrs for a boy, b) 1.1hrs for a girl, 1.2 hrs for a boy.