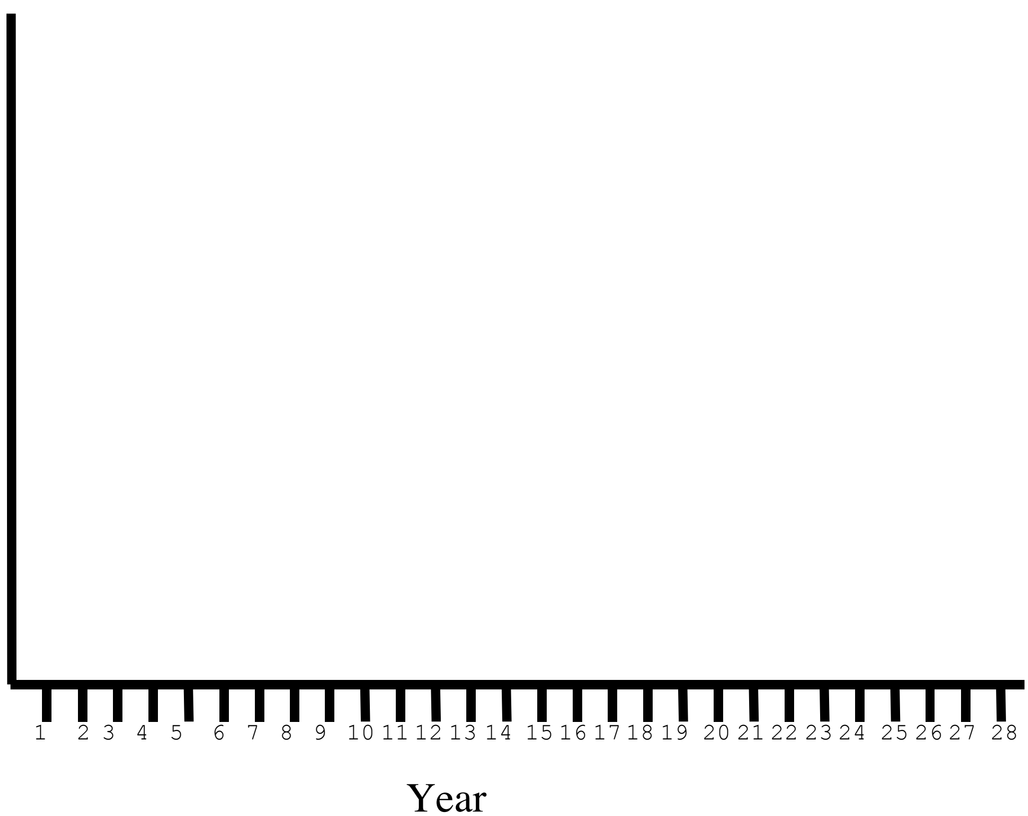
One Well's History

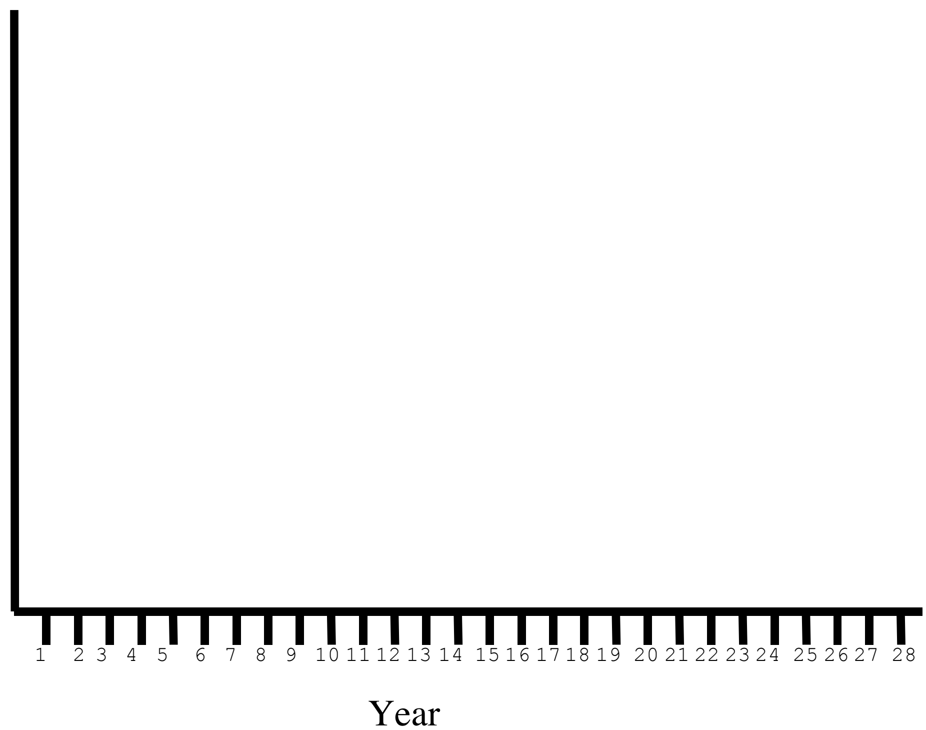
The Glory Hole was discovered in a small Midwestern city in the early 20th century by one Grant Gypsum. Gypsum didn't have much money, and at first all the drilling was done by hand, yielding a modest amount of oil. After 3 years Grant had made enough to enlarge the size of the well, and every 2 years for the next 6 the extraction technology continued to improve. Year 10 brought with it an economic crisis and little use for oil, leaving Gypsum flustered and without enough money to operate the well beyond a trickle. Fortunately, the next 4 years saw the popularization of personal automobiles, and Gypsum found his well more active than ever before. In the 15th operational year some very interesting changes began to take place. In the following decade there were 2 gas tax increases, a war, and a surge of urbanization around Gypsum's home. 25 years after Gypsum struck oil he packed up all his belongings, sold the Glory Hole to an entrepreneurial family from Louisiana and piloted his Ranger to the Florida Keys, leaving his enterprise behind.

On the graph provided below, sketch a plot of the *annual production rate* against the year of its operation. Use appropriate labels on the axes. (What sort of *scale* might be reasonable??)
Add brief explanations for any "features" (esp between years 15 and 25)



How would you find Q(inf): the total number of barrels that could be drawn from the well?

On the graph provided below, sketch a plot of the total number of barrels the glory hole produced so far against the year of its operation. This is not the "annual production rate", it's the *cumulative production to date.* Again, label the y-axis, and this time be careful this curve matches your previous one. (How are they related?)



How would you find Q (inf) from *this* graph?

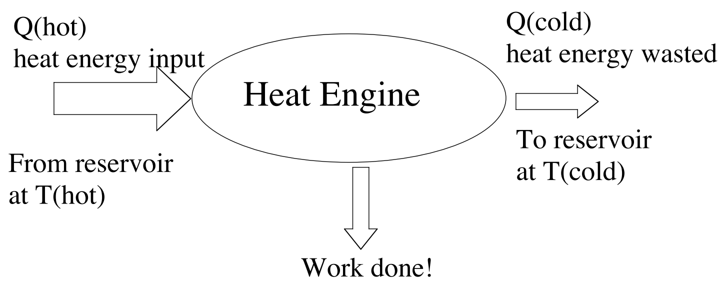
Heat engines and efficiency.

Perhaps the most important aspect of heat engines is comprehending efficiency…

In a crude way, efficiency can be universally defined as

Efficiency = what you get out / what you put in

Any heat engine can be drawn schematically like this:



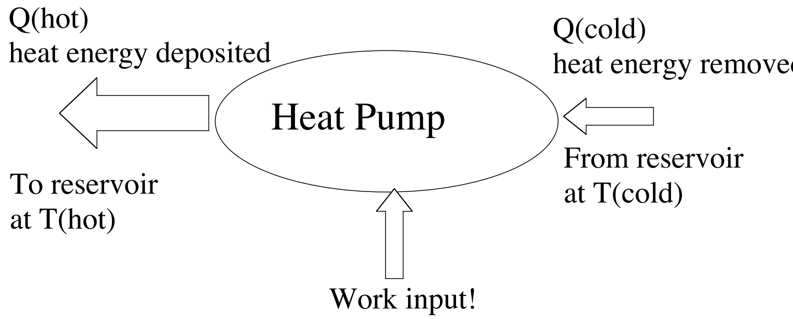
Look at the diagram, think about "Conservation of Energy", and write an equation relating the three energies Q(hot), W (work done), and Q(cold) . (Get the signs right!)

Now think about the definition of efficiency.
Which variable, Q(Hot), Q(cold), or Work is "what you get out". Which is "what you put in"?

Write an equation for efficiency in terms of Q(Hot), Q(Cold), and or W.
Then use your energy conservation relation to *eliminate* W from this expression.

Alternatively, you can write the above expression in terms of temperatures by noting the Carnot ratio Q(C)/Q(H) = T(C)/T(H) . I claim you can completely eliminate Q(C) and Q(H) from your efficiency expression, to get a formula purely in terms of T(C) and T(H). Try it!

If you reverse all the arrows, you have a heat pump (or refrigerator)



The energy efficiency rating **EER = "what you want" / "what you pay for".**
Which variable: Q(H), Q(C), or Work do you think is "what you want" in a refrigerator?
Which is "what you pay for"

Now find the EER of a refrigerator in terms of ONLY the heat flows Q(H) and Q(C).

Again one can write the expression for EER in terms of temperatures by using the Carnot ratio Q(C)/Q(H) = T(C)/T(H) . Try it!

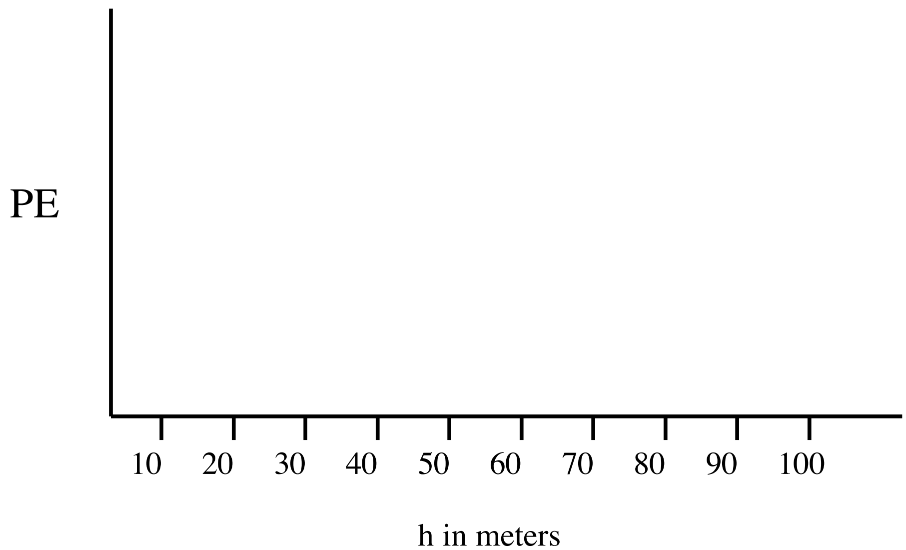
Example: If you wish to refrigerate your perishables at 280K and live at 300K what is the maximum EER your fridge could boast?

For every 1 watt of power used to operate the refrigerator how many watts go to removing heat energy from the food. How many go to the room?

To think about:
1) How would one go about increasing energy efficiency ratings?
2) in the absence of an air conditioner you decide to cool your abode by leaving the refrigerator door open—how successful is your technique in cooling the room? Explain.
3) Can you heat your house by leaving the oven door ajar? Why or why not?

Dam It!

The construction of a new hydroelectric plant near where you live has been proposed, and as a curious landowner you decide it would be in your best interest to do a bit of exploring… The retention lake (pond) will be 100m X 500m, and the turbines are located right at the base of the pond. Make a plot of the pond potential energy against "head", h. (Label your vertical axis accurately)



Assuming the generator is 75% efficient, plot the electric energy generated against h on the same graph (as a dashed line.)

If the pond fills to a depth of 50 meters, and then the contents were steadily drained through the generator over the course of one year, what would the plants average power output be?

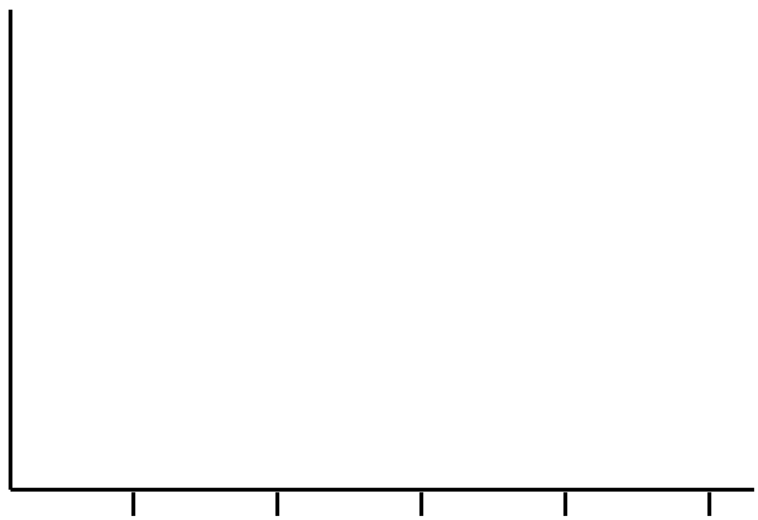
To think about: Would this answer change if all the water was emptied in the first month? If so how? If not, why not?

Could this plant serve a community the size of boulder?

The Windy City

You've bought a house in the mountains, and hope to go "off grid" using a windmill to power your electrical needs. You can afford a windmill with a 6 meter diameter blade. (How big is that compared to your house?) Let see if this is going to be big enough - make a plot of output windmill power against wind velocity… Choose a horizontal scale appropriate for the mountains near Boulder.

Get the scale on your vertical axis labeled correctly, that's the one you're interested in!



If you used a formula from the book - how does the fact that the house will be at 8000 feet (where air is 'thinner') impact the graph (qualitatively)?

To think about: What sort of "average steady wind" would you need to run your house? Is this windmill big enough?

Conserving Energy - Cans

If it takes about 7000 BTU of energy to create an aluminum can, approximately how many BTU's do you consume in a year of soda indulgence? (Don't drink pop? Assume a typical American...)

It takes about one third as much energy to produce a can out of a preexisting one, approximately how many BTU's are conserved annually by your use of *recycled* aluminum cans?

Scale this number to all Americans. How much energy (in BTU's) are *saved* by using all recycled aluminum.

Is it a big enough number to be interesting?

Conserving Energy - Lightbulbs.
75 W incandescent bulbs cost about $1. (You *might* find them for $0.50 if you try) 15 W compact fluorescent (CF) bulbs cost about $8. (You can find 'em cheaper too...) They are roughly equally bright ! *(Ask, if you're curious how that can be!)*

You need a bulb for the hallway in your apartment - you'll leave it on all night, every night (for safety, or perhaps just laziness). **Which would you buy?** (Answer honestly, your gut reaction? You need a bulb, you're at the store... which will it be?)

This seems like a no-brainer. Only a tree-hugging eco freak would spend $8 when they could spend $.50, right? Surely nobody would buy the the CFC.... (?) Let's see.
How much energy does the 75 W bulb consume in two years? (in kW*hr)

How much does it cost (in electric bills) to run the 75 W light for this long?

How much energy does the 15 W CF bulb consume in two years? How much does THIS one cost?
(Note: 15 = (1/5) * 75... Can you answer without doing a lot of calculation?)

Incandescent bulbs last about 750 hrs. After two years of constant night-time burning, **how many bulbs have you run through? How much money have you spent (total, on bulbs and electricity) for the incandescents?**

CF bulbs last about 10,000 hrs. After two years of constant night-time burning, **how many bulbs have you run through? How much money have you spent (total, on bulbs and electricity) for the CF's?**

Assuming you pay the electric bills (or care about the person who does), which bulb will you buy the next time you're faced with this decision? (*Really?*)