The Sun

A perfectly efficient solar panel, held facing the Sun, will generate a power (energy per second) of 1370 watts if it has an area of 1 m^2.

1. How much energy per second is absorbed by the roof of your car? Suppose your car is black. (Convert this to horsepower: 1 hp = 750 W)

2. How much energy per second is absorbed by the entire planet Earth? Earth has a radius of 6360 km. (Assume Earth is 0% reflective for simplicity.)

3. Suppose in the far distant future we want to absorb ALL of the Sun's energy and not let one photon leak out into interstellar space. So, this future civilization decides to build a giant spherical shell enclosing the entire inner Solar System, just outside Earth's orbit (orbital radius 1 AU = 150 million km). How much energy per second does the shell absorb?

4. What is the luminosity of the sun?

5. Suppose the Sun produced no energy, and just radiated internal heat. How long would it take to cool? The specific heat of coal is about 2000 joules per kilogram per degree, and the Sun is 2×10^{30} kg in mass.

6. Suppose the Sun was powered by gasoline combustion. How long could it burn? Gasoline produces about 50 million joules per kilogram of stuff burned

7. Suppose the Sun was powered by gravitational contraction. How long could it burn? Use the (very rough) approximation for gravitational potential energy of E = mgh, where g is the gravity at the Sun's surface now as determined by Newton's law of gravity, and assume the Sun cannot contract by more than its current radius.

8. Suppose the Sun was powered by hydrogen fusion, which converts about 1% of the original hydrogen's mass into pure energy according to $E = mc^2$. How long could it burn?

9. The estimate you came up with in #8 should be different from the figure of 10 billion years given in lecture. Why does the Sun live "only" 10 billion years?

Original worksheet by D. Perley