Question 1:

Dear Cheap Astronomy – Do we have the ability to measure the exact amount of heat arriving at the Earth from the sun?

Here on Earth, we often talk about light as being what we can see and heat as being what we can feel. But, really any wavelength of electromagnetic radiation can raise the temperature of something that absorbs it. A microwave oven heats things with high amplitude radio waves and even though high frequency ionising radiation, like ultraviolet, X and gamma rays, tend to destroy the things that they radiate, they will still heat them up as they destroy them. So, in a nutshell, it's best just to talk about the Sun's energy output.

When all electromagnetic wavelengths are taken together, the Sun's surface emits about 63 million watts of energy per square meter. By the time that energy reaches Earth, after traveling 150 million kilometres and being spread out over that distance, that solar flux has diminished to around 1,360 watts per square meter when it hits the Earth's upper atmosphere.

That figure of 1,360 watts per square meter is what's known as the solar constant – a measure of the solar flux that strikes one square meter of area positioned exactly one astronomical unit from the Sun and exactly perpendicular to the mean direction of solar radiation. So really the solar constant is a standard measurement and it's actually never constant, because the Sun's output always varies slightly over time. That variation is mostly about the Sun's fluctuating magnetic field, which underlies the solar cycle, where it takes around 11 years to move from a solar minimum (very few sunspots) to a solar maximum (lots of sunspots) and over that 11 year period the strangely-named solar constant increases by about 0.1% and then drops by about that same proportion over the next 11 years. Beyond that, we know the Sun's output is very slowly increasing. When it first ignited around 5 billion years ago its luminosity was only 70% of what it is now. In another billion years from now it will be about 6% hotter than it is now – and that will be enough to evaporate the oceans and spell the end of Earth's habitability. Of course, all this is determined on paper, it's a barely measureable change – we just know it's happening and that the end is, very slowly, approaching.

Down here on the surface it does seem as though the Sun's output fluctuates wildly, even though it doesn't. Of most importance to our experience of temperature on the surface is the axial tilt of the planet. For example, at 45 degrees latitude, the Sun is up for 15 and a half hours at one solstice and just 8 and three quarter hours at the other solstice – which is a whopping 54% difference in day length. But, that's not actually what matters. If day length was what mattered then the hottest places on Earth would be the poles in their respective summer times, when they receive 24 hours of daylight. What actually matters is the angle of incidence of solar radiation. In those long polar summer days, the Sun is barely above the horizon, so most of its straight line radiation misses the Earth's surface. At the equator, despite there only being 12 hours of sunlight per day, the Sun is straight overhead, meaning its radiation is always directed right at the surface – and so it's always hotter.

Regardless of the angle of incidence, some of the solar energy that arrives at the Earth bounces off the outer atmosphere, some of it penetrates and then bounces off clouds and back into space and some of it interacts with and is absorbed by the atmosphere, thereby heating the atmosphere. As a consequence of all that, the surface of the Earth only receives about half of the incoming solar radiation that hits the upper atmosphere and even then a lot of that is reflected back from the surface. But that energy reflected back still has to make it back from the surface out through the atmosphere. This is why all that stuff about greenhouse gases really does matter. If you pump more CO_2 into the atmosphere, it really does get hotter – and that is easily measureable.

Question 2:

Dear Cheap Astronomy – are astronauts allowed to take their own tech gear aboard the ISS?

There are no absolute rules on this. With most ISS astronauts also undertaking research work, some have been approved to take their own tech gear but this is probably more the exception than the rule. Any tech gear adds launch mass and there is already a lot of tech aboard the ISS, including lots of proprietary hardware for running lots of proprietary operating systems and proprietary software, so there's limited need for anyone to take their own off-the-shelf tablet or notebook and those represent a potential security hazard for the ISS if they may be carrying any malware. It's also the case that some electronics just can't take the higher radiation levels that are routine aboard the ISS. The traditional workhorses of the ISS have been IBM and Lenovo Thinkpads, which seemed to handle the radiation relatively well and if they didn't, having a standard platform meant it was an easy to swap out a faulty hard disk and/or reload a disk image. Those workhorses are still there, but in recent years, the growing diversity of researchers needing diverse tech to run their research means that many combinations of hard and software are now available on board, including Apple ipads, Surface pros, augmented reality headsets just for example. Mind you, some of the original systems that support the spacecraft aspects of the ISS still run off 086 and 386 chips and their software runs on a Linux operating system – so there really are generations of tech, old and new, on board.

There's not much point in taking your smart phone aboard since there's no phone coverage – any commercial satellites in line of sight that could carry a call will be pointed at the ground. There is wifi on the ISS but there's also IP phones and any apps that your phone could run, will run just as well on an on-board tablet. Also, there's a general nervousness about some commercial mobile phone batteries, with some known overheat and/or explode. Nonetheless, there are certified safe-for-flight smartphones on-board, both Apple and Android. For example, as we've covered in the fabulous Cheap Astronomy miniseries Science on the ISS, the SPHERES, the three floating robots with onboard processors and CO_2 gas thrusters also have expansion ports that you can connect a smart phone to, which then provide those SPHERES with visual data through the camera, orientation data from the accelerometer and extra processing power.

Astronauts could ask to fly with their own game consoles, but it's unlikely they would unless there's some kind of research angle to it. It's a full time job being an astronaut so you wouldn't have a lot of time for games and it's never a good look to be gaming in the office anyway. It's more common for astronauts to watch movies or play music or of course listen to podcasts. To achieve that, they can just list what they need and have those files uploaded from Earth onto a server on the ISS and then run them from one or more of the various on-board devices available.

The ISS has power points, though not ones you may be familiar with. These are called UOPs, utility outlet ports, designed with safety in mind, so they won't create sparks and UOPs need special cords and plugs as well, which ensure tiny flakes of molten metal don't break off plug prongs and then float around the cabin – which is apparently a genuine risk with electrical systems in microgravity. The ISS's electrical systems run off DC power which comes from solar panel charged batteries – which is delivered as 120V in the US segment and 28V in the Russian segment.

Small devices can be charged from low voltage USB port are OK, though even though those will probably be checked for space-worthiness first. Of course, if you are a space tourist on a short flight and a multimillion dollar ticket there'll be less restrictions imposed, though probably still some – so no lighter fluid, pressurised containers or firearms. It's just like how things were in the pre-pandemic days when we all used to fly around in planes.