Question 1:

Dear Cheap Astronomy – What do you make of the Electromagnetic, or EM, drive.

Well, not much. Most discussion about the EM drive comes from journalists trying to extrapolate some kind of sense from the scant details released by the people who have either built or tested a prototype. The fact that the people directly dealing with the hardware are reluctant to explain much of its detail can be interpreted as either a) it's all hand-waving intended to divert attention from the fact that their thrust data is not statistically differentiable from background noise or b) they're really onto something and are protecting a patent application.

If it really is b) it's surprising they're even allowed to talk to the media if they've been able to convince financial backers that they're really on to something. All of which suggests that maybe they haven't been able to convince financial backers that they're really onto something.

It is undoubtedly true that testing of the EM drive has found a genuine effect that is not zero. OK, but consider that it is actually quite difficult to design any experiment that always delivers an effect that is exactly zero. What matters is just how not-zero your measured effect is.

Here at Cheap Astronomy as much as we can gather from the information that's available, the EM drive involves generating microwaves within an enclosed structure whose metallic surfaces can reflect those microwaves. The geometry of the enclosed structure is carefully designed to ensure that the microwaves bounce more often against one wall than against the opposite wall and hence the momentum inherent in those microwaves is preferentially directed one way – and so the engine or the drive is moved in the opposite direction in accordance with Newton's actions and reactions.

Now, two obvious criticisms arise from this description:

to whatever extent the microwaves' momentum is preferentially directed we are still talking about sod-all momentum. This is just microwaves in a box for heaven's sake.

the alleged physics underlying the engine's mechanism seems analogous to standing in a room built on a frictionless surface and throwing a tennis ball at one of its walls. Sure, there's a preferential direction of momentum as that ball strikes the wall, but all the preceding steps leading up to the ball striking the wall have already generated momentum in the opposite direction.

So, an external observer might see that room shifting back and forth with all the ball-throwing that's going on inside it, but there would not and could not be sustained movement in one preferential direction. Nonetheless, if someone collecting data inadvertently took measurements at particular times where the room was moving forward, less often than when they took measurements while the room was moving back – they might then conclude that, within a narrow time window, there was preferential momentum in one direction. So given the potential foibles inherent in this experiment, you would want to wait until you saw a pretty substantial and sustained effect before you putting out press releases.

Even accepting that it is possible to preferentially direct the momentum of microwaves, the question then becomes to what extent that preferential momentum can overcome the inertia of the mass that it's meant to drive. And you've then got to ask whether the miniscule effect you generate in a lab experiment can be scaled up to starship proportions and be able to overcome the inertia of a freaking starship.

Here at Cheap Astronomy we feel obliged to conclude that, on balance, the EM drive sounds like a farcical notion that's only staying afloat because it generates media stories. Of course, we are always happy to be proved wrong, but at the same time, we are only happy to prove wrong by some much more-convincing data than has been released so far.

And… maybe we all need to take a step back and consider that this is just microwaves in a box – for heaven's sake.

Question 2:

Dear Cheap Astronomy – Why is everyone so sure that time travel is impossible?

Well, no-one thinks that time travel into the future is impossible – we are all doing it at one second per second. And you can travel further into the future by going at a really, really fast speed – although this is not because you get there ahead of anyone else, it's just that you don't age as much during the journey. Nonetheless, it is true that travelling backwards in time is generally considered impossible.

You might think that since space and time is really just spacetime – that is, two aspects of the same thing – then you should be able to travel to different times just like you can travel to different places. But, while it is extremely easy to prove that the past used to exist, believing that you can build a time machine that can travel back to it, implies that it still exists in some sense, so you can just pop back there whenever you feel like it. For that to be possible, we have to assume that as time goes forward, the Universe is like a skyscraper being built from the ground up, one floor after another floor. So, the uppermost floor is always the present, but all the earlier-built floors continue to exist long after they were used as the foundation for a next floor to be built upon.

This idea can also be drawn on paper where time is the y axis and there are three spatial axes that allow a 3 dimensional volume to grow up the page as time progresses. On such a graph, it's not difficult to identify where yesterday was – nor where Neil Armstrong took one small step back in 1969, but can we really assume those spacetime locations persist in a way that would allow them all to be accessed by time machines?

One fundamental problem with assuming that the past still exists involves energy. The four laws of thermodynamics provide a complete explanation of how the Universe evolves over time. The zeroth law describes how a thermometer that works in one place will work the same in any place. The fourth law (which is sometimes known as the third law) describes how the Universe has a quantifiable energy ground state of absolute zero.

With that context laid down, the first law then states that energy can be used to achieve work – although in doing so, that energy is just transformed, not lost. So for example, petrol makes your car work, but this is just a case of chemical energy being converted into kinetic energy, as well as some noise, friction and heat. The second law then states that entropy increases over time – so although energy is always conserved, over time more and more of it is eventually transformed into ‘free energy’ or waste heat which can no longer be used to achieve work.

So, taken together, these laws fully describe how the Universe progresses from one second to the next. They describe the Universe as being a bit like an engine that drives everything forward by converting potential energy into electro-thermal or kinetic energy with a bit of waste heat always being dissipated in the process. Notwithstanding the entropy law implies that time can only go forwards, the four laws taken together indicate that there is no leftover energy available that could be diverted towards maintaining the Universe’s past.

In other words, the idea that you can hop in your time machine and travel back to yesterday – and then walk around in yesterday enjoying the feel of the Sun on your face raises the question of just where that Sun’s warmth is coming from. That energy should have been transformed or otherwise shifted forward so as to be available for doing the work that the Sun is doing today – like now today.

So next time you think about travelling backwards in time, don’t just ask how about the time machine will work and don’t worry about causality paradoxes– like going back to kill your grandfather, or your neighbour’s cat’s grandfather or Schrodinger’s cat’s grandfather – instead why not ask why the past should be considered a destination for you to travel to.