Question 1:

Dear Cheap Astronomy – Are there really primordial black holes?

Well... theoretically. The idea behind primordial black holes is that the in the early dense Universe, random quantum fluctuations could have created little hiccups in the otherwise rapidly density-reducing expansion the Universe was undergoing, leading to the formation of black holes. However, the key words here are could have – and it's always worth donning your skeptical goggles whenever quantum fluctuations are called upon to explain some weird $#&@ physics concept with no other evidence to back it up.

It is the case that the cosmic microwave background, while remarkably uniform in most respects does display density variations, which may underlie the current distribution of light and dark matter in the Universe. So, it's reasonable to assume there were genuine quantum fluctuations in the early Universe – and particularly during the very early rapid expansion phase those fluctuations could have had a big influence on the way the subsequent Universe unfolded. If they did form at all, primordial black holes would most likely have formed towards the end of rapid inflation, the idea being that the outward movement of things decelerated there may have been local clumping as stuff ran into the back of other stuff – maybe.

Stephen Hawking was a proponent of primordial black holes, hypothesizing that they might have come in a range of sizes from very small to very large, although the small ones probably evaporated early on due to Hawking radiation. Others have suggested larger ones might have been the seeds of the super-massive black holes found at the centre of most galaxies – since current thinking is that galaxies formed around central black holes rather than the galaxies coming first and their central SMBHs coming later.

Supermassive black holes clearly exist, whatever their origin maybe, but the court is still out on the existence of mid-range primordial black holes. Although black holes are certainly dark, they are not a good candidate for dark matter since they are not transparent – so they can occult distant objects when they pass in front of them and they should produce gravitation-lensing effects. If black holes made up the majority of dark matter they would need to be as ubiquitous and widely distributed as dark matter is, so for example, you would look over at the Andromeda galaxy and see lots of visual distortions rather than clear, steady image we do see. This is why all MACHOs – massive compound halo objects, like black holes, neutron stars, brown dwarves and the like, have been pretty-much ruled out as making more than a small contribution to the total amount of dark matter in the Universe. MACHOs might be dark – but they're not invisible, because they're not transparent.

We do find small numbers of microlensing anomalies across various sky surveys, not in numbers anywhere near being able to account for dark matter, but there definitely are some. But of these days most of them are being picked up by exoplanet surveys and the general feeling is that's what they are – exoplanets. Rogue exoplanets flung out of their stellar system will, from a distance, be dark, pinpoint masses – which we would have no way of distinguishing from primordial black holes – except we know the first class of objects exist and the other class are hypothetical.

Recently a primordial black hole has been proposed to explain the allegedly strange orbits of a number of trans-Neptunian objects, which might otherwise caused by the hypothetical planet 9 – so until there's observational evidence of what's really going on out there, it's largely a case of pick your preferred hypothetical object.

So, that's pretty much the current state of primordial black hole science. You don't really need them to solve any major cosmological mysteries and while it's true that they could have formed in the early Universe, it's not clear that they necessarily had to. And it's very unlikely they are present in large numbers in the current Universe since their presence would be detectable if they were.

Question 2:

Dear Cheap Astronomy – What do you make of the helical drive?

Well, not much – but in this case the author of the idea deserves credit for acknowledging it might be up there with the EM drive and cold fusion, but he thought it was an idea worth putting out there for review. Various journalists have picked up the story by claiming that the helical drive violates laws of physics – which is certainly not this case, it would only violate the laws of physics if it worked.

The basic problem your up against in flying through empty space is that there's nothing to grab onto. You can readily drive a car on Earth and drive a solar car on Earth without carrying fuel or propellant because you are essentially pulling yourself along the surface of the road using energy to rotate your wheels. You can do much the same in an electric plane, which has no fuel or propellant, it just pulls itself through the atmosphere. But, in empty space, fuel or no fuel, there's nothing to grab onto and pull yourself along, so you only option is throw something out the back, so that Newton's third law (the one about actions and opposite reactions) works to push you forward.

Nonetheless, the idea of a space engine that doesn't need propellant is compelling since it reduces the mass you have to fly. So, it is always worth at least thinking about new ways forward (small astronomy joke there).

The idea behind the helical drive is to move mass around inside your spaceship. The helical drive is basically a particle accelerator which moves small charged particles around a track that shaped like a helix, where the particles move slower in one part of the accelerator than in another part. And if those particles always move faster on one side than on the other – and if they're moving really fast –like 0.99% of the speed of light fast, then their increased relativistic mass at the higher speed should generate more momentum in one direction than the other.

But nah, it doesn't work. It sounds like it might work if you just consider two separate states of inertia. But to make one state of inertia where particles move fast and another state of inertia where the particles don't move as, the particles will have to be accelerated at one point and then decelerated at another point, to get you the speed difference and the relativistic mass difference. So, there'll be a period over which you are accelerating a non-relativistic mass and then decelerating a relativistic mass – so in the end the balances of forces and relativistic and non-relativistic momentums all just balance out to give a net effect of zero. It's implied in the helical drive design that the geometry of the path of the accelerated particles is what ensures that all the speeding and slowing operates to create momentum in one preferential direction, but that doesn't really make sense. At the end of the day all the pushing and the pulling is between the spacecraft and those inner moving particles, the geometry of vectors involved doesn't really matter. You might achieve something like the effect of a reaction wheel, which change the attitude of the spacecraft – turning it on its side say, but you can't push and pull against your own spacecraft to change its direction or its speed through a vacuum. And if all you want to do is turn your spacecraft upside down, why not just put some reaction wheels on board, which are existing technology, whereas a space-going helical-shaped particle accelerator is not.

So from our cheap analysis of the situation, the person who proposed this idea thought there was something useful in the relativistic mass gained by accelerating particles up to the speed of light but they perhaps hadn't considered all the pre and post steps involved in achieving and sustaining that state. There is some similarity between the helical drive idea and one of the so-called Mach effects, specifically the Woodward effect. There are different underlying mechanisms, but the Woodward and the helical drive both rely on arguments about relativistic physics operating in specific states of inertia, while their critics argue that once you add in the effects of the acceleration and subsequent deceleration needed to enter and depart those states, the net effect is zero. That sounds about right to us.