Question 1:

Dear Cheap Astronomy – What's the best way to redirect an asteroid's path for mining purposes?

Let's start by saying CAs plan to somewhat indiscriminately crash $#!+ on the Moon is not actually that indiscriminate. It's not realistic to think you can shift an object several kilometres in diameter out of the asteroid belt and onto a precise trajectory that will have it collide with the Moon – at least not without some implausible engineering and fuel supply. And of course, if you miss and crash it into Earth, that's a mass extinction event. Indeed, even crashing such an object into the Moon would be a bad idea. The Moon would absorb the impact, but there would be a substantial amount of debris flung upwards, which is likely to circle the Moon and then fall back to the surface causing trouble for any lunar bases. It's also likely some shrapnel would achieve lunar escape velocity and might then make its way to Earth, being the next biggest gravity well around. Most chunks would burn up in the atmosphere, but before that a cloud of them could become a problem for orbiting satellites and other spacecraft. So, crashing something on the Moon that's much bigger than 100 metres in diameter is not just implausible with our current technologies, it's also a bad idea.

Of course, it's not automatically a good idea to start swinging lots of 100 metre diameter objects around to collide with the Moon either – since if you miss, Earth is next big gravity well around and something that big won't burn up in the atmosphere. It won't cause a mass extinction event either, but unless it strikes in the deep ocean or in a desert, mass destruction, mayhem and mortality could result. This sort of logic has never stopped mining operations on Earth, which are responsible for a long list of environmental catastrophes and deaths, not only of miners, but of nearby communities, notably through the collapse of tailings dams. Despite these catastrophes no-one is we should put a stop to mining as a consequence. Of course, we are not suggesting the occasional catastrophe represents, we're just saying everything has some risk and the trick is to mitigate those risks. The advantage of CSOT mining is that it is at least happening a long, long way from large concentrations of humanity and from ecosystems and if something does go amiss, you'll still have plenty of lead time to avoid a potential catastrophe.

Anyhow, the essential principle of redirecting asteroids is to remember that everything in the Solar System is in a solar orbit and the diameter of that orbit is a product of an orbiting body's velocity – so faster takes you further away from the Sun, slower brings you closer in. Either way you going to have to expend energy to change an object's current velocity and hence orbit. There are some low-energy cost ideas like painting the asteroid to increase its reflectivity and hence increase the push of sunlight that shines on it, since a white solar sail always gains more momentum than a black sail does. But this approach will just generates a fractional change in trajectory and is not going to useful in directing an object to a specific target. Similarly a brute force approach like exploding a nuke near it, could send it or bits of it spinning off in a number of unpredictable direction. The painting approach might be something to consider in the future when we have some cis-lunar infrastructure in place (that's space-geek talk for stuff around the Moon). Such infrastructure might herd and sort objects sent from distant locales and you would want that infrastructure in place before you start adding more near-Earth objects to the already-worrying population that exists out there now.

So first steps we might take in the 21st century will involve redirecting already near-Earth objects of modest size to crash on the Moon. This not only kicks off our first attempts at space mining, but also works on reducing the worrying population of near-Earth objects to that are out there now. And since we gotten this far without actually talking about how the heck we are going to manage this much, you've probably there's going to be a part 2 to this episode.

Question 2:

Dear Cheap Astronomy – Part 2 of What's the best way to redirect an asteroid's path for mining purposes?

So, to recap. It's unlikely we are going to achieve zero population growth anytime soon, so we'll eventually need more resources. While eventually might be a long time coming – we'll need to put the skills and infrastructure in place so that we're ready when eventually does come. And come on, putting all that future angst to one side, there's money to be made out there – well, eventually.

But to space mine, you also need to space refine – it's not going to profitable to ship and then land unprocessed ore on Earth, since you are just going to discard most of it. Maybe one day we will have giant ore processing refineries touring the solar system, but we'll need start small by building a central refinery somewhere where you can land asteroids, or more precisely crash them, since you will want to pull them to pieces anyway, so why waste fuel on retroburning for a soft landing. The crashing part rules out Earth as an option – and so QED what we should do is crash shit on the Moon. Just 100 metre diameter shit to start with, but if we can manage that the rest of humanity's future should follow – and if we can't manage that well then it's just some dopey idea you heard on a cheap podcast.

Anyhow, to redirect the path of asteroids, we could do what the recent DART mission has done and fly a spacecraft into an asteroid – not to explode, but to transfer its momentum to the asteroid and hence change its trajectory. You could do this several times over and hence keep adjusting the asteroid's course as you go and when it does eventually crash on the Moon you could then retrieve and recycle all the scrap metal embedded in it.

However, there are still fuel costs with that approach, since you have to accelerate a projectile up to speed so it can impart a useful amount of momentum to the asteroid when it impacts. An alternative is to attach some thrusters onto the asteroid, essentially turning it into a steerable spacecraft. Those thrusters would later detach for reuse when the asteroid was on its final approach to crash land. This is potentially more fuel-efficient method and doesn't require any destructive impacts since the thrusters would be remote-controlled spacecraft that just nuzzle up the asteroid and then push forward. A 100 metre diameter rock isn't going have that much gravity, so once the little thrusters have done their job, they could just float away with a brief retrofire – which would also impart a final push upon the asteroid.

Another option with a low mass asteroid, is that you could start the refining process on the asteroid itself by separating dross from the economically valuable material and use a mass driver to fling chunks of that dross in the direction opposite to the direction you want the asteroid to go in. A mass driver is space geek talk for any device that can propel a ballistic payload. So, it might be a big catapult or a magrail launcher, for example.

This is technically more difficult, but also much more fuel efficient than robot thrusters – since not only are you using in-situ material for propellant, but you are also reducing the mass of the asteroid as you go. And if it's too hard for a robot to distinguish what's dross from what's valuable material, maybe you just sacrifice a proportion of the rock to get whatever is left of it to the Moon.

Anyhow, there's some options, the last one probably needing 22nd century technology, but the rest might be managed earlier – we can build robotic spacecraft with rocket engines today. The fuel and energy cost of any of these maneuvers is partly a function of time – if you're in no rush, a few small course corrections might be enough to get the job done over the course of a year or two – remembering that we are starting with near Earth objects which are mostly in year-long duration solar orbits anyway. The first rock crashed on the Moon would probably cost billions and billions, but with the technique ironed out you might then do another 10 or 20 at the same cost. It's a step into an engineered future.