NCEA Level 3 Calculus (Differentiation)
10. Parametric Functions (Homework)

Reading: What are some reasons astronauts need to study mathematics?

Imagine you're on a spaceship in orbit around the moon. You have a fuel leak and are running out of power. When do you fire the ship's thrusters, and for how long and in what direction, in order to be able to return to Earth safely?

Obviously, this is not a question that astronauts usually face (except maybe on Apollo 13) but hopefully it illustrates the way in which mathematics (in this case, calculus, algebra, etc.) and science (in this case, the physics of orbits), which has mathematics at its heart, relates to everything that goes on in a space flight mission. All the science and engineering that goes into designing, building and flying spacecraft is based on mathematics. Without mathematics, there would be no way to predict beforehand how the spacecraft would react to different conditions and how it would move in its orbit.

I imagine that astronauts probably don't directly use much more than simple mathematics when on a flight - important calculations are done by computers - but to have some idea of what a spacecraft is doing and how it is operating, without placing complete blind faith in the people who built it, requires a knowledge of mathematics.

Also, in addition to flying and maneuvering a spacecraft, astronauts are often involved in conducting scientific experiments aboard the spacecraft, which would involve mathematics in other ways too.

From `http://curious.astro.cornell.edu/about-us/145-people-in-astronomy/careers-in-astronomy/general-questions/896-how-do-astronauts-use-math-in-their-jobs-beginner`

Questions

1. In each case find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$.
   (a) $x = t^4 - 2t^302t^2$, $y = t^3 - t$
   (b) $x = \cos t + 2\cos 2t$, $y = \sin t + 2\sin 2t$
2. Find an equation for the tangent to the curve $x = 1 + \sqrt{t}$, $y = e^{t^2}$ at the point $(2, e)$ by substituting one function into the other to eliminate the parameter.
3. (a) Use graphing software (e.g. `http://graphfree.com/`, change 'plot type' to 'parametric') to graph the curve $x = 4(\cos t)^3$, $y = 4(\sin t)^3$. This curve is called an *astroid* (as opposed to an asteroid).
   (b) Use calculus to find the slope of the tangent to the astroid in terms of t.
   (c) Use calculus to find the locations of the cusps (points).