**ICE: THE SPACE THETER** **Maths21a, O. Knill**

Curves like $\vec{r}(t) = (t + \sin(t), \cos(t))$ or $\vec{r}(t) = (\cos(t) + 1/2\cos(3t), \sin(t) + 1/2\sin(3t))$ are called **epicycles**. The pedals of a bicycle move on an epicycle as well as a payload in a futuristic MXER slingshot technology (see text).

In this ICE, we compute the arc length of the epicycle

$$\vec{r}(t) = (t + \sin(t), \cos(t))$$

1) Compute the speed $|\vec{r}'(t)|$ of the epicycle.

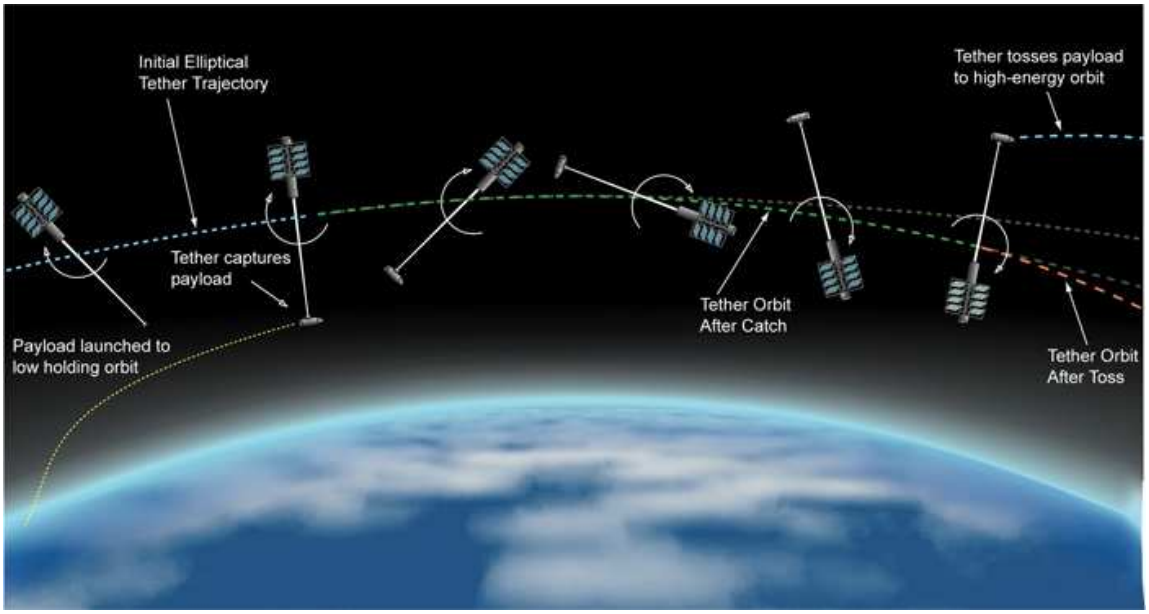
2) Write down the length integral.

3) Use the fact that $1 + \cos(t) = 2\cos(t/2)^2$ to solve the integral.

Momentum-eXchange/Electrodynamic Reboost tether technology (MXER) would implement cart-wheeling cable in orbit around the Earth. Rotating like a giant sling, the cable would swoop down and pick up spacecraft in low orbits, then hurl them to higher orbits or even lob them onward to other planets.

It could pick payloads up from a reusable launch vehicle in low Earth orbit and toss them to geosynchronous orbit. This idea could act as a Hypersonic Airplane Space Tether Orbital Launch system, or be utilized to handle other launch systems other than hypersonic airplanes.
By eliminating the need to launch an upper-stage rocket along with each satellite, the MXER Tether System would allow satellites to be boosted into space atop smaller, less expensive rockets. Propulsion costs for space missions would drop by a factor of ten or more, he said. The planned slingshot is 9.3 miles (15 kilometers) of tether line.
How is the thether accelerated. The idea is "electrodynamic tether propulsion": When a wire moves through a magnetic field, an electrical current results. As this current flows through the wire, it experiences a push from any external magnetic field. For a space tether, that magnetic field is found naturally around the Earth. The force exerted on the tether by the magnetic field can be used to raise or lower a satellite's orbit, depending on the direction of the current's flow.

This propellant-free propulsion idea not only draws power from the space environment, it could open up the possibility of using orbiting in-space tethers as "space tugboats", or enabling fuel-free raising and lowering of satellite orbits. Furthermore, the tether experiment open the door for a variety of concepts, from catching and tossing payloads from one orbit to another to elevators that offer "next floor, space" service from Earth.

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