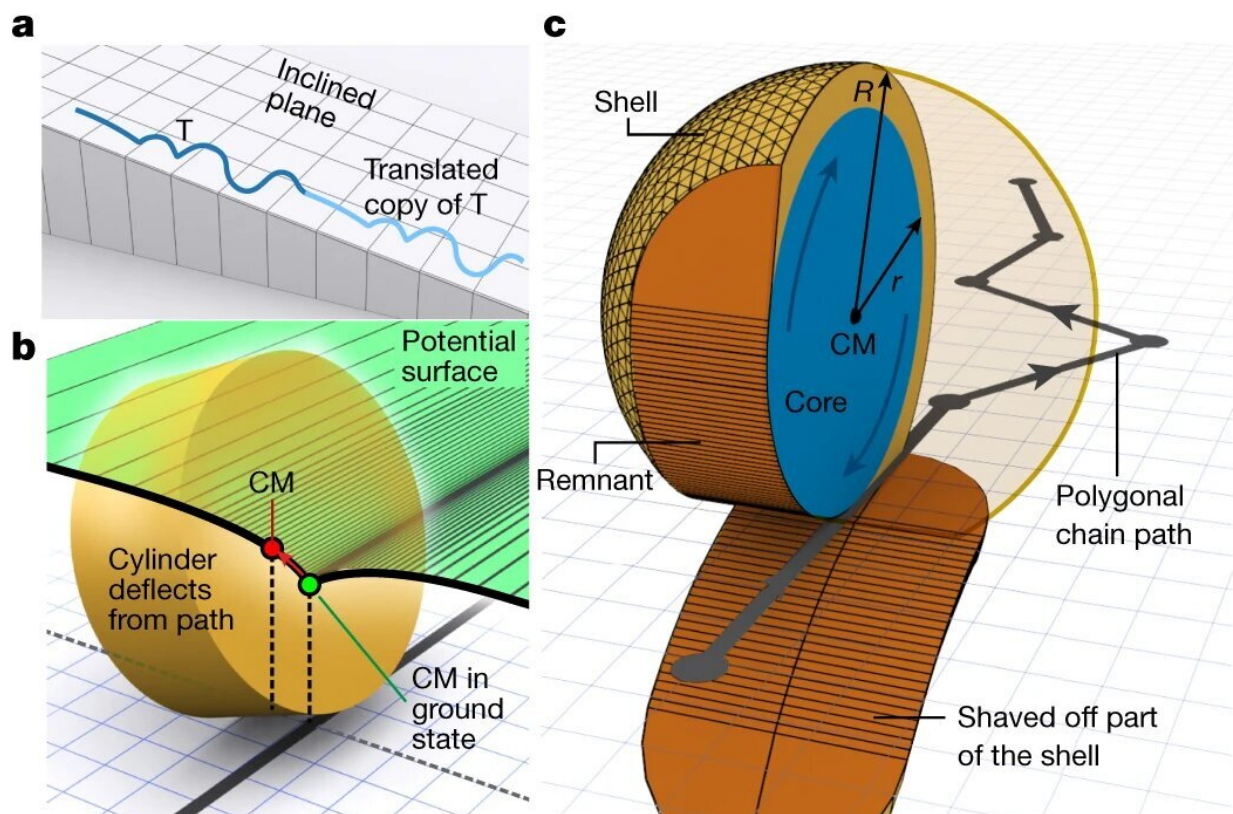


An algorithm that shapes objects to cause them to roll down ramps following a desired path

August 12 2023, by Bob Yirka



Rolling paths and trajectoid shapes. **a**, An arbitrary curve T (dark blue) drawn on an inclined plane (grid) serves as one period of an infinite translationally symmetric trajectory T_∞ to be traced by the trajectoid. **b**, A cylinder (gold) rolling along the plane (blue grid) must tilt sideways, as shown, to deviate from its preferred linear path of rolling (thick grey line on the grid). Such a tilt inevitably raises the cylinder's CM (red dot) along a cycloid-like curve (solid black) away from CM's original level (green dot): the preferred linear path

corresponds to a trench in the gravitational potential landscape (green surface, also see Extended Data Fig. 6). For an illustration in frontal projection, see Extended Data Fig. 1a. **c**, The design of a trajectoid shape starts with a rigid core (blue) of radius r surrounded by a massless concentric shell (gold colour) of radius $R > r$. This composite structure, shown here in central cross-section, is forcibly moved in infinitely small steps such that the spherical core rolls along the target path (grey polygonal chain) without slipping or pivoting (Supplementary Video 1). To allow such rolling, the shell is ‘shaved’ to leave a patch of cylindrical surface (orange). The point CM is the centre of mass of the core, and therefore of the whole assembly. **d**, Trajectoids for a linear path using different ratios R/r consist of a cylindrical part (orange) of radius r and two surviving spherical segments of the shell (gold). **e**, Trajectoids for the curvilinear path (same as in Fig. 2a and experimentally realized in Fig. 4d) using different ratios R/r . At $R/r=1.01$, the body is still roughly spherical but for higher values shown, the shape becomes complex (and does not change for $R/r \gtrsim 2.80$) and has improved stability due to deeper potential energy trench (**b** and Extended Data Fig. 1a). Credit: *Nature* (2023). DOI: 10.1038/s41586-023-06306-y

A team of physicists and mathematicians at the Institute for Basic Science's Center for Soft and Living Matter, in South Korea, working with a colleague from the University of Geneva, has developed an algorithm that can be used to find the shape of an object to cause it to roll down a ramp following a desired path.

In their paper published in the journal *Nature*, the group describes how they developed their [algorithm](#), and possible uses for it. Elisabetta Matsumoto and Henry Segerman with the Georgia Institute of Technology and Oklahoma State University, respectively, have published a *News & Views* piece in the same journal issue outlining the work done by the team on this new effort.

In this new effort, the research team started with an interesting puzzle—one that begins by envisioning a sphere rolling down a ramp. If

the sphere is imagined to be made of clay, it can be manipulated (deformed) as it rolls to make it conform to a given [path](#).

If the sphere is then rolled down the ramp again, it will follow the previous path due to the new deformities in its shape. The researchers noted that the paths that could be taken by the sphere could be nearly limitless due to the nearly limitless possible deformations.

That realization led them to wonder if the deformations that form in such a sphere could be correlated mathematically with its path. And if so, if such math could be used to create an algorithm that could be used to 3D print a sphere with deformations that would force it to follow a predetermined path.

It turned out the answer to both questions was yes. The team used math and physics principles to create formulas that described deformations to a given object that would result in the object following a desired path down an inclined plane. They then created a computer program that could be used to create such an object in the [real world](#), using 3D printing.

The team named the objects trajectoids. Each had a solid metal ball-bearing inside to give it weight. They also found that they could create trajectoids that traveled over a given path twice, and named them "two-period trajectoids."

The research team suggests their formulas and algorithm could be used in robotics applications and also in physics research associated with the angular moment of an electron—or in [quantum research](#) centered around the study of evolution of a quantum bit.

More information: Yaroslav I. Sobolev et al, Solid-body trajectoids shaped to roll along desired pathways, *Nature* (2023). [DOI](#):

[10.1038/s41586-023-06306-y](https://doi.org/10.1038/s41586-023-06306-y)

Elisabetta Matsumoto et al, Shaped to roll along a programmed periodic path, *Nature* (2023). DOI: [10.1038/d41586-023-02335-9](https://doi.org/10.1038/d41586-023-02335-9)

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