Re: Why does measuring tape bend one way?

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From: Edward Green (*spamspamspam3_at_netzero.com*)
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Nick Rouse wrote:

> *I think it is because the initial bend in the direction that it*
> *normally coils up in tries to put the centre line of the tape*
> *into tension and the edges into compression. Because the*
> *tape is thin compared to the length over which the compressive*
> *force is acting and the edge is unconstrained it very soon*
> *becomes unstable and buckles. I suspect (but can't pin down*
> *exactly why) an outward (flattening) buckle is energetically*
> *more favourable than an inward curling buckle.*
>
> *In the classical analysis of a column failing under compression*
> *you compare the energy needed to deform the column into a*
> *slight curve with the energy released by the compressive force*
> *moving as the deformation allows the force to move. If the*
> *deformation energy is less than energy released by the compressive*
> *force the deformation continues. Different deformation modes have*
> *different ratios of these two forces and the most energetically*
> *favoured will dominate but nearly all modes tend to show a greater*
> *ratio of released energy to deformation energy the greater the degree*
> *of deformation and conversely the ratio falls to zero for the initial*

> *infinitesimal deformation. This implies that once a column starts to*
> *buckle it will collapse catastrophically but that the initiation of*
> *deformation is dependant on imperfections to take it to the*
> *point at which the deformation starts to grow . The greater the*
> *compressive force the smaller the imperfection that will take the*
> *system to the point where further deformation is energetically*
> *favourable. Generally the simplest modes of deformation involving*
> *the fewest changes in curvature will be the most energetically*
> *favourable. Complex modes with many curve changes will require*
> *a greater compressive force before imperfections bring such modes*
> *to the critical point.*
>
> *To return to the tape, It takes only a small bending force before*
imperfections
> *allow the tape to start flattening and once the tape has started to*

flatten it
> *becomes ever easier to flatten it more and easier to bend it in its*
coiling
> *direction.*
> *If you try to bend the tape in the opposite direction you are trying*
to
> *put the edges in tension and the centre into compression. because the*

> *centre part of the tape is constrained on both sides, the lowest*
energy mode
> *of deformation will still be a complex one, probably involving the*
formation
> *of a dimple with an S shaped curve in two directions. It will*
therefore take
> *a greater bending force before likely imperfections make such*
deformations
> *likely*
>
> *Nick Rouse*

I owe you a slight apology. I had previously said that Philip Holman's reply was the only one which seemed plausible and about on the right level. I don't know about "on the right level", but your discussion is very nice, and suggests the tools to take the thing a step beyond intuition!

Now, to add something, I notice in actual experiment that slowly bending a length of measuring tape in the hard direction causes a slight flattening in the area of subsequent buckling, followed by a sharp snap to the buckled position; slowly releasing the bending moment eventually causes a snap back to the unbuckled shaped. The system is bistable (obviously), and exhibits hysterisis.