



## Rotating Bodies and Angular Momentum

### *The Highland Games*

**Narrator:**

The Callander Highland Games are an annual event. Attracting competitors from all around the world, these traditional games include: the stone, weight for height, hammer, shafted hammer and, of course, the caber. Whatever the event, the same mathematical principles apply. Let's start with tossing the caber? The first thing to note is it's nothing to do with how far you can throw it. The competitor must make the caber land directly ahead.

**Colin Bryce:**

My technique is you must get it up on your shoulder, high up in the arms, run with it, you've got perhaps nine tenths of it above you, run with it as fast as you can, plant your feet as quickly as possible, get ahead of the caber almost and flick it towards your face. The light end flicks over the heavy end, and you get what's called the twelve o'clock.

**Narrator:**

You have to give it enough angular momentum, so it will flip over before it lands. Like the baton and the mace, the design makes it easier. The caber is wider and so heavier at one end. If you lift it by the lighter end then the force applied by pushing up, is further from the centre of mass, and so the torque is greater. But if the torque is not large enough then the angular velocity is not sufficient for the caber to flip over.

**Highland Games PA Commentator:**

What we can do now is to draw with that...

**Judy:**

So it's all about maximising angular momentum?

**Dave Cobner:**

Yes, that's exactly right. And the same thing applies with the shafted hammer - its maximum angular momentum being generated so that at the point of release the shafted hammer will travel as far as possible.

**Highland Games PA Commentator:**

Strong over head but...

**Colin Bryce:**

To throw the shafted hammer you've got to be rooted to the ground, which very much helps. Traditionally they used to throw it one, two, three, and then they'd swing it off; now we root ourselves to the ground because we can get our hips, and drive with our legs as we as we go through it, and generate speed like that, trying to lift it up in the air as opposed to pull it round the corner, gives you longer arms, further away from the head, the greater the speed of the head.

**Narrator:**

The weight on the end of the hammer means that the centre of mass is as far from the competitor as possible; this enables the hammer to gain a large velocity which it will keep once it is released. By literally rooting their feet to the ground, the competitor gets as much torque as possible, and as much angular momentum as they can.

**Highland Games PA Commentator:**

155 kilos on the wire...319 pounds...

**Narrator:**

The Highland Games provide many opportunities to study these basic laws of rotational motion.

**Highland Games PA Commentator:**

....he's a Yorkshire man ...

**Narrator:**

And many other sports also include angular momentum, angular velocity and the moment of inertia, as well as torques. But whatever the motion, can mathematics help us get better at what we do? How important are mathematics and mechanics in sport?

**Dave Cobner:**

Whether you look at the performer, the coach or the sports scientist, they all look to understand technique to gain maximum benefit. If you understand the cause and effect relationships, which is what mechanics is all about, then coach and performer can work towards maximising performance. The scientist strives to understand the phenomenon, the coach and the performer strive to make it happen.

**Colin Bryce:**

You think about maths in a lot of situations. It helped me a lot with the caber. I always tried to throw it out as if it were something for distance. But when someone, you know, made me realise the higher you hold it and the faster you flick it towards your face, the quicker it will flick over.

**Hayley Allen:**

We do a lot of bio-mechanical work. I also do a lot of coaching that helps a lot with diving 'cos you can see what other people are doing wrong, and you think oh yeah, and apply it to yourself, so definitely you need mechanics behind what you're doing.

**Mike Edge:**

Understanding science and maths to the coach is absolutely vital. You have to understand what's going on physiologically in the body. You have to understand what's going on bio-mechanically in the body, but you also have to understand what's going on psychologically.